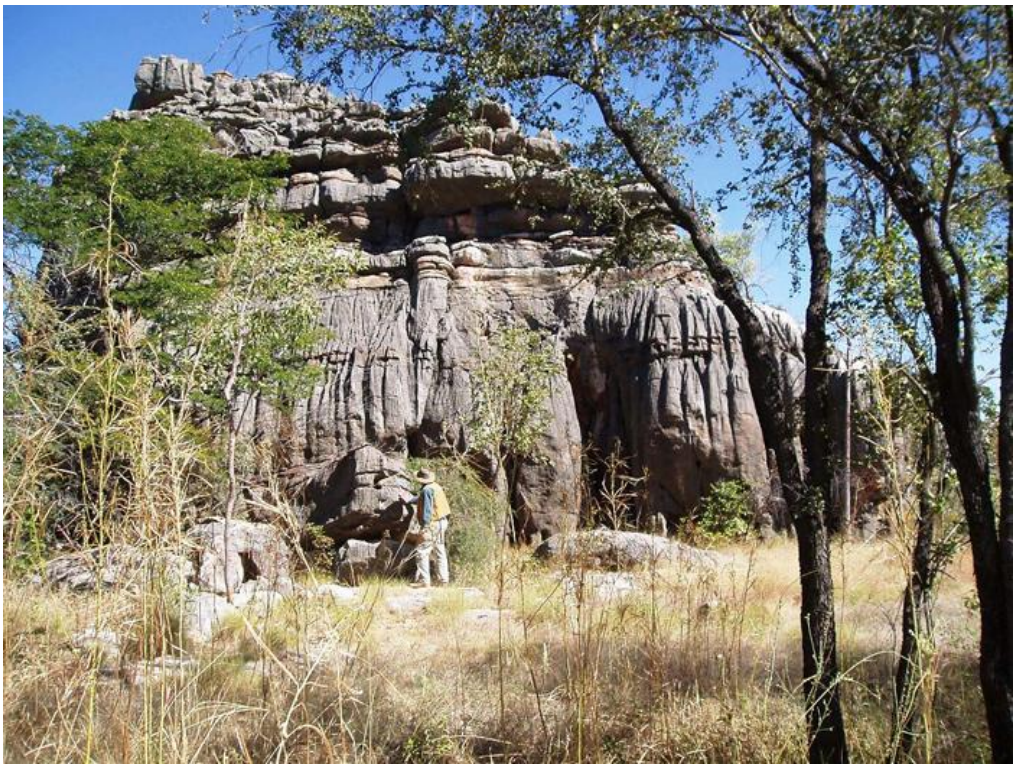
CLEARING PERMIT SUPPORT INFORMATION

Sorby Management Pty Ltd

SORBY HILLS SILVER LEAD ZINC PROJECT



APPLICATION FOR A CLEARING PERMIT (PURPOSE PERMIT) FOR THE SORBY HILLS SILVER LEAD ZINC PROJECT

KIMBERLEY, WESTERN AUSTRALIA

December 2011

Prepared by Sorby Management Pty Ltd with the assistance of Animal Plant Mineral Pty Ltd

animal plant mineral

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1 BACKGROUND INFORMATION

1.1 Ownership

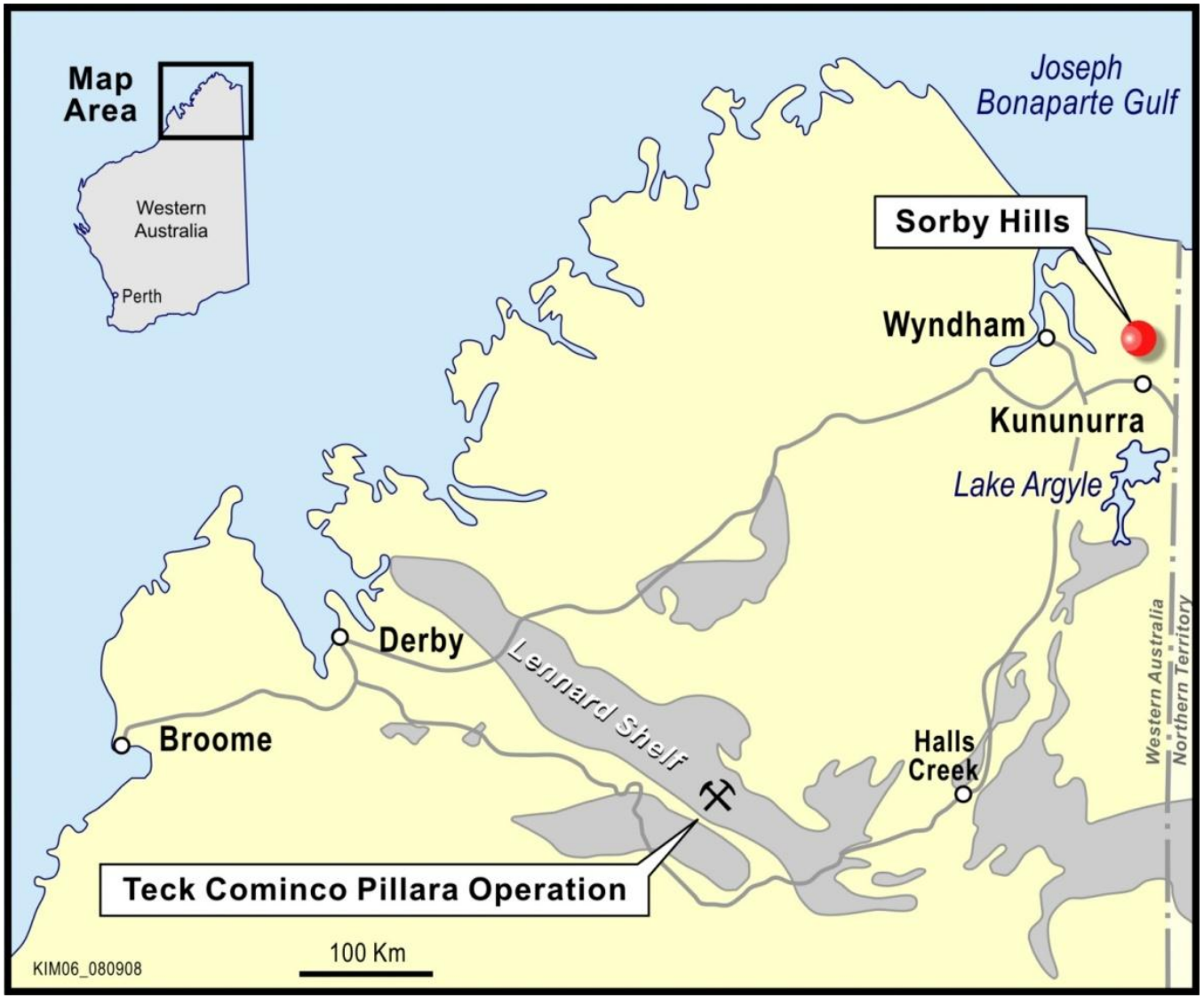
The Sorby Hills Project is being developed by the Sorby Hills Joint Venturers being KBL Mining Limited (KBL) (formerly Kimberley Metals Limited) of Australia (75%) and Yuguang (Australia) Pty Ltd a wholly owned subsidiary of China's largest lead producer, Henan Yuguang Gold and Lead Co., Ltd (HYG&L) (25%). The Manager of the Joint Venture is Sorby Management Propriety Limited (SMPL), which is 100% owned by KBL.

The tenements associated with the Sorby Hills Project are currently held by KBL. Transfers of a 25% interest in these tenements have been executed by KBL in favour of Yuguang (Australia) Pty Ltd and these are currently with the Office of State Revenue for stamping. Tenements related to the Sorby Hills Project Mine Site are situated on unallocated Crown Land Lot 373 on Deposited Plan 51355. This land was previously covered by a pastoral lease and is currently stocked under a grazing permit issued by the Department of Regional Development and Lands. Prior to the commencement of mining activities, the grazing licence will be rescinded and the land de-stocked.

A summary of the key contacts and tenement information associated with the Sorby Hills Project is presented below; the site location is illustrated in Figure 1-1: General Location Map.

Proponent:	Sorby Management Pty Ltd
Address:	Level 3, 2 Elizabeth Plaza North Sydney, NSW, 2060
Joint Venture Partners:	KBL Mining Ltd and Yuguang (Australia) Pty Ltd
Tenement Holders:	KBL Mining Ltd. pending transfers to KBL Mining Limited (75%) and Yuguang (Australia) pty Ltd (25%)
Key Contact:	Edgar Newman Project Manager – Sorby Management Pty Ltd Ph: (02) 9927 2006 Fax: (02) 9927 2050 Mobile: 0458 881 445 Email: ednewman@kimberleymetals.com.au
	Or
	Sharon Arena Principal HSE Adviser - Animal Plant Mineral Pty Ltd Ph: (08) 9397 1998 Fax: (08) 6296 5199 Mobile: 0419 934 461 Email: sharon@animalplantmineral.com.au

This Clearing Permit relates to activities on tenements M80/197 and M80/286.



Date: October 2011	Project: SMPL Sorby Hills	NORTH	**Figure 1-1: General location map.**

1.2 Project objectives

SMPL maintains a high degree of community focus and will develop the Sorby Hills Project in line with best practice community, environmental and safety standards.

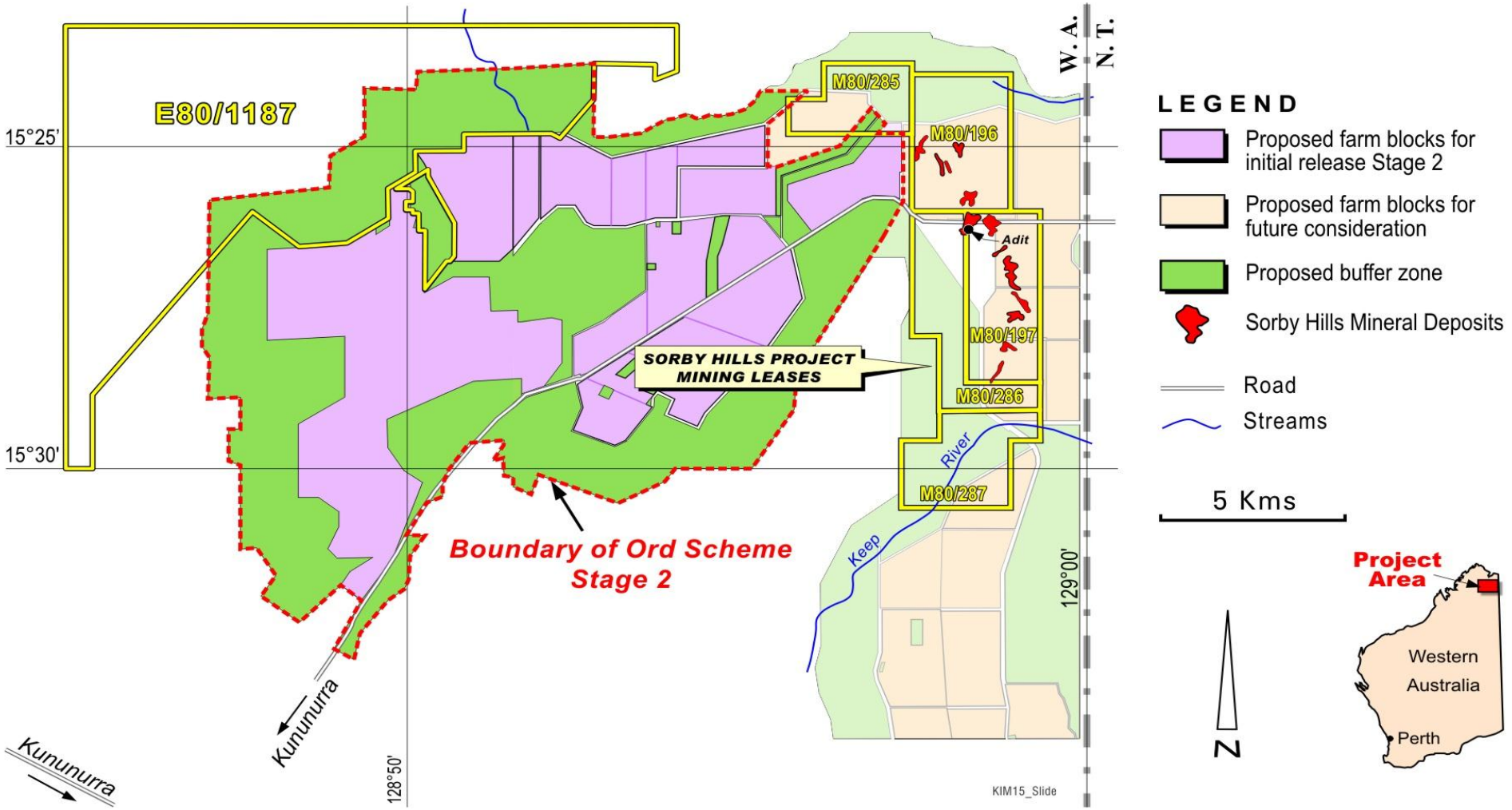
Critical dates for the Sorby Hills Project include:

February 2012	Feasibility
April 2012	Project approvals
May 2012	Commence construction
December 2012	Commissioning
First Quarter 2013	Production
2027	Closure

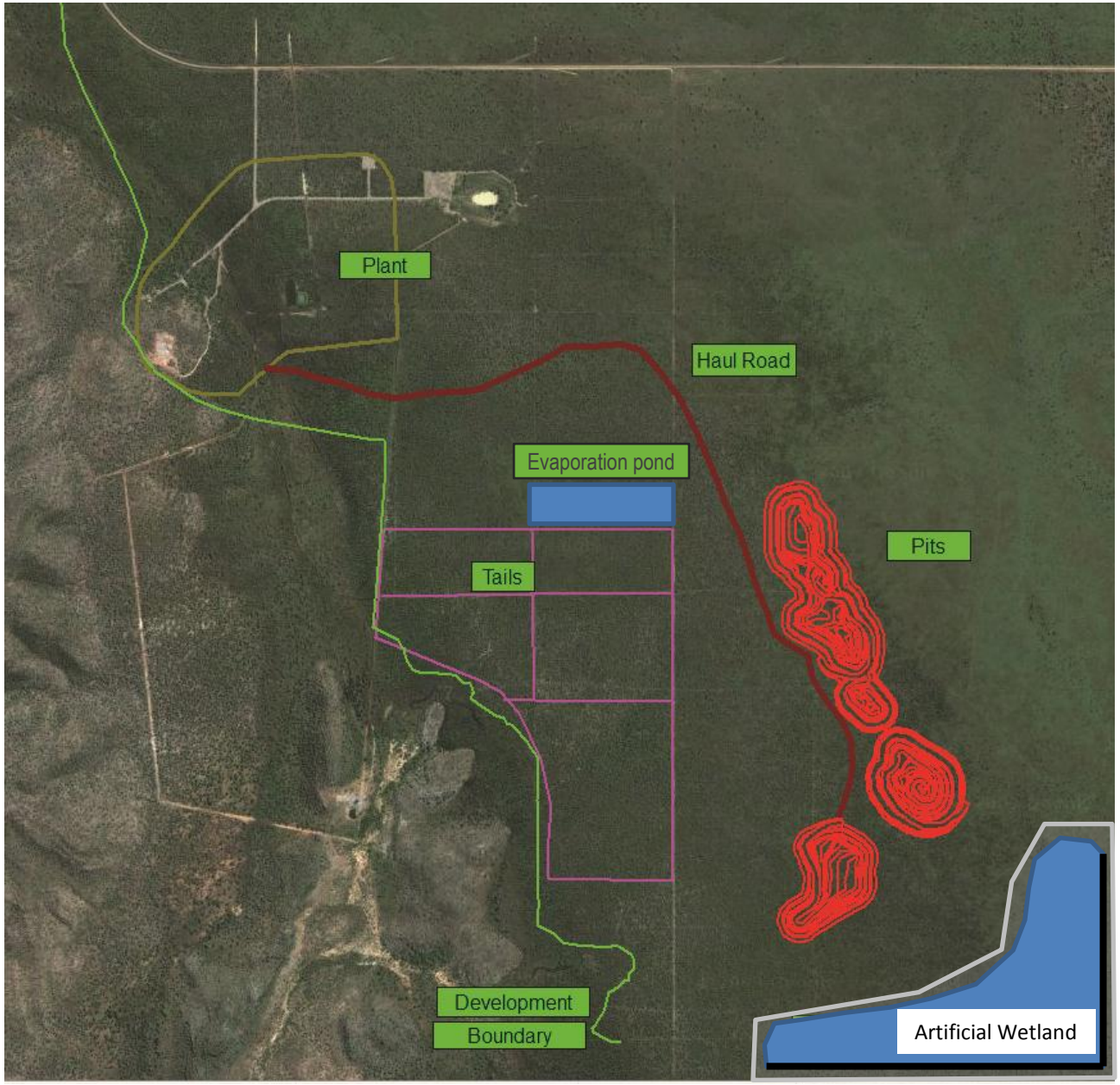
1.3 Location and site layout plans

This application relates to clearing on tenements M80/197 and M80/286, in the north-east Kimberley region of Western Australia (WA) close to the Northern Territory (NT) border. The Sorby Hills Mine Site is located approximately 50km by road north-east from the regional centre of Kununurra. The relevant Sorby Hills Project tenements lie to the east of the currently proposed Ord Irrigation Expansion Project Stage Two, with a common boundary on the north-western edge of the Sorby Hills Project (tenement M80/196). (See Figure 1-2: Location Map showing Tenement Boundaries and Proximity to the Ord River Expansion Project Stage 2).

A site layout plan for the Sorby Hills Project Site is provided as Figure 1-3: Site Layout Plan. These plans illustrate the location and scale of site infrastructure (overlaid on topographic data and aerial photography).



Date: October 2011	Project: SMPL Sorby Hills	NORTH	**Figure 1-2: Location Map showing Tenement Boundaries and Proximity to the Ord River Expansion Project Stage 2**



Auth: M Ladyman	Project: SMPL Sorby Hills	APM animal plant mineral	NORTH
Date: October 2011	Datum: GDA94 MGA Zone 52		

Figure 1-3: Site layout plan

1.4 History

The Sorby Hills deposit was discovered in 1971 by Elf Aquitaine. Aquitaine extensively and systematically explored the project area for carbonate hosted lead and zinc deposits during the 1970s and 1980s with various joint venture partners. The exploration focused on delineating economic lead and zinc resources within the platform carbonate lithologies of the Bonaparte Basin. Exploration consisted of geochemical surveys, various geophysical surveys and extensive drilling. Base of Overburden geochemical sampling by auger or RAB drilling was used very effectively over most of the project area; the programs targeted the prospective stratigraphy along the main Sorby trend in all of the current mining leases to some extent. Geophysical surveys were used comprehensively. The most effective methods for delineating mineralisation and structure were gradient array and dipole-dipole Induced Polarisation surveys, of which there is complete coverage over the main Sorby trend. Drilling programs at the Sorby Hills Project have been quite intensive and comprehensive; approximately 888 holes were completed for approximately 95,000m from 1972 to 1988 and of these drill holes approximately 374 were diamond holes.

Post 1990 little work was completed and the project was shelved in the late 1990s due to uncertainty surrounding the Ord River expansion scheme. In 2006 CBH Resources Ltd (CBH) reactivated the Sorby Hills Project; in 2007 CBH commissioned a review of the economic potential of the Sorby Hills deposits which suggested that the deposits had potential for economic extraction. The results led to a new phase of exploration which included a desktop review of historic data, a small scale diamond drilling program (13 holes), construction of a wireframe resource model and conceptual mining study. KBL acquired the Sorby Hills Project in 2008 and entered into a Joint Venture Agreement with HYG&L's Australian subsidiary, Yuguang (Australia) Pty Ltd for the project in 2010; in late 2010 a 99 hole Reverse Circulation (RC) and Diamond Drilling program was completed. SMPL is a wholly owned of KBL and is the Manager of the Sorby Hills Joint Venture and thereby is the proponent currently managing the Sorby Hills Project.

The Sorby Hills Project area is situated on land that was once covered by pastoral leases and as such pastoral tracks, cattle yards and other limited infrastructure is present on the tenements. At present cattle graze in the project area but the land will be de-stocked prior to mining. Some remnant disturbed areas and access tracks plus a core storage area are present on the Sorby Hills Project mining tenements from previous exploration.

The tenement M80/197 and M80/286 lies within the traditional lands of the Miriuwung Gajerrong people. Although the Sorby Hills tenements pre-date the *Native Title Act 1992*, a Heritage Protection Agreement was developed between the previous owners of the Sorby Hills tenements and the Miriuwung Gajerrong Corporation (MG Corporation); as part of this agreement SMPL will develop an Indigenous Land Use Agreement (ILUA) with the MG Corporation. SMPL is committed to providing contracting opportunities, employment and training for the Traditional Owners.

1.5 Existing facilities

There is little infrastructure currently on site. There is an access road linking the Sorby Hills Project site to the Weaber Plain Road, as well as pastoral and exploration tracks across the tenements. The limited infrastructure includes cattle yards, a dam, water and production bores, a small cattle loading ramp, a diesel pump, a core storage site and some disturbed areas and pads resulting from previous exploration. It is planned to utilise these existing degraded areas for the Project's Plant Site and other support infrastructure.

SMPL plan to utilise the Weaber Plain Road, Mills Road, Ivanhoe Road, Victoria Highway and Great Northern Highway to haul concentrate from the Sorby Hills Project Mine Site to the laydown facilities at Wyndham port. There will however be minimal utilisation of other public services for the project. Power will be generated on site and water will be sourced from mine dewatering and recycled water from the processing plant.

2 EXISTING ENVIRONMENT

2.1 Regional setting

The Sorby Hills Project area is situated at the north-eastern extent of the Sorby Hills Ranges. Tenement M80/286 encompasses a portion of the Ranges and associated foot slopes; to the east of the hills in tenements M80/286 and M80/197 the environment is predominantly broad flood plains of red-grey clay pan (cracking clay) soils with Bauhinia trees. Floodwaters draining off the eastern rangelands flow south-east towards Knox Creek, however residual water bodies can remain present for extended periods at the base of the ranges.

Mapping for the Interim Biogeographic Regionalisation for Australia (IBRA version 6.1) programme placed the Sorby Hills Project area in the Victoria Bonaparte Bioregion. This bioregion comes under the Tropical and Subtropical Grasslands, Savannas and Shrublands Ecoregion which stretches across northern Australia into northern New South Wales (NSW). The Victoria Bonaparte Bioregion continues into the NT as far as Bradshaw (Department of Sustainability, Environment, Water, Population and Communities, 2011). Within the Victoria Bonaparte Bioregion the vegetation over lowland parts of the survey area has been mapped as 'Tussock grasslands' while upland areas come under 'Tropical Eucalyptus woodland/grasslands'. Tussock grasslands covered an estimated 631,088ha (8.7%) of the bioregion prior to European settlement. By about 1997 this area was little changed at 631,032ha (8.7%). Tropical Eucalyptus woodland/grasslands covered an estimated 4,696,792ha (64.6%) of the bioregion prior to European settlement. By about 1997 this area had been slightly reduced to 4,678,368ha equating to 64.4% (Australian Government, 2011).

The project area lies in the Gardner Botanical District within the Northern Botanical Province of WA (Beard, 1975) and encompasses the Pinkerton and Ivanhoe Land Systems (Department of Agriculture and Food, 2009).

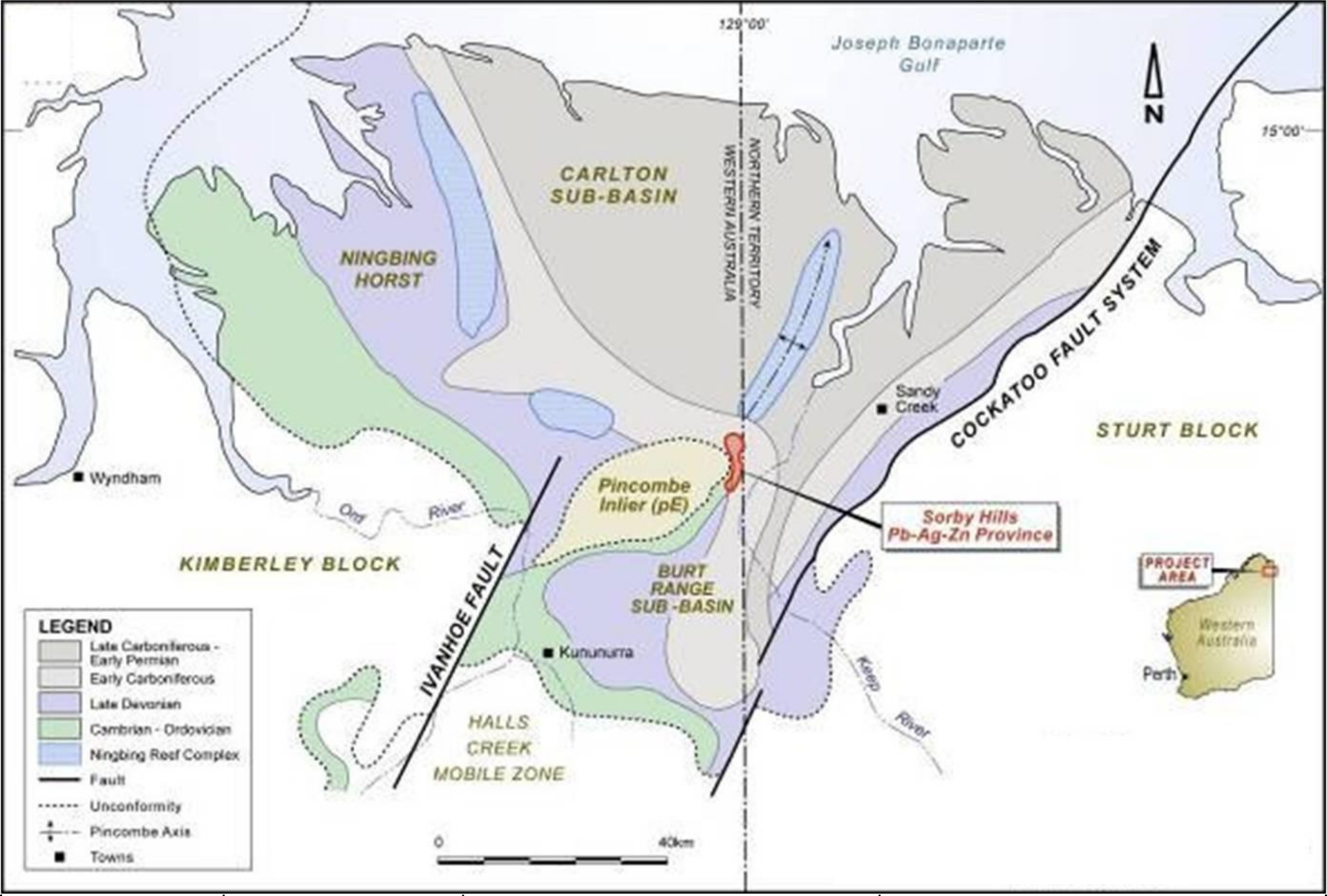
2.2 Geology and soils

The Sorby Hills mineralisation consists of thirteen discrete carbonate hosted Ag Pb Zn deposits (pods), Pods A – J, Beta Pod East, Beta Pod West and Alpha pod. The pods form a linear north to south belt extending over 8km, sub parallel to the eastern margin of the Pincombe Inlier and within the Burt Range Formation of the Bonaparte Basin (Figure 2-1: Geological setting of the Sorby Hills mineralisation).

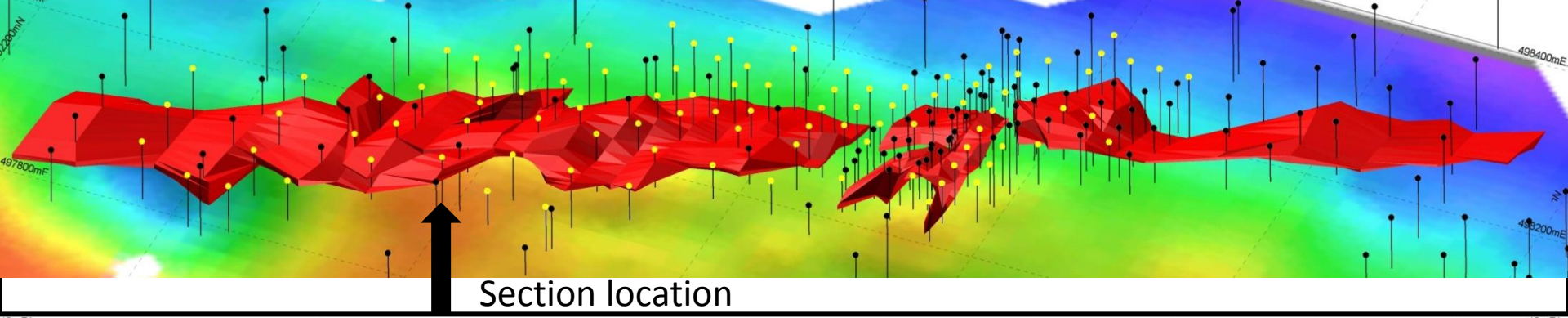
The Bonaparte Basin unconformably overlies the north-eastern margin of the Proterozoic Kimberley block. It is a northward-opening basin of which 10% is currently above sea level; the sediments vary from Cambrian to Tertiary in age. The oldest part of the onshore basin is the Antrim Plateau flood basalts which unconformably overlies the Palaeoproterozoic basement of the Halls Creek orogen. Clastic sediments of the Late Cambrian and Ordovician Carlton Group locally overlie the basalts, after which there is a period of non-deposition and/or erosion from the Ordovician to the Middle Devonian. The onshore basin is dominated by Middle Devonian to early Carboniferous carbonate and clastic sediments, commencing with the Frasnian Cockatoo Group, dominated by sandstones (quartz arenites). During the Famennian, mixed carbonate-clastic sedimentation deposited the Ningbing Group reef complex and the Buttons Formation in the Sorby Hills area. Reef growth was terminated in the Carboniferous, when shelf carbonates and clastics of the Tournaisian Burt Range Formation were deposited in the Sorby Hills area. The Tournaisian carbonates are overlain transgressively by Visean basinal black shales of the Milligans Formation. Above this there is an unconformable -contact with the Carboniferous – Permian Kulshill Group composed of fluvio-glacial sandstones.

Three of the thirteen ore pods have been targeted for sequential mining by SMPL; these are the C, D and E pods. Geological cross sections are presented in Figure 2-2 Geological Sections.

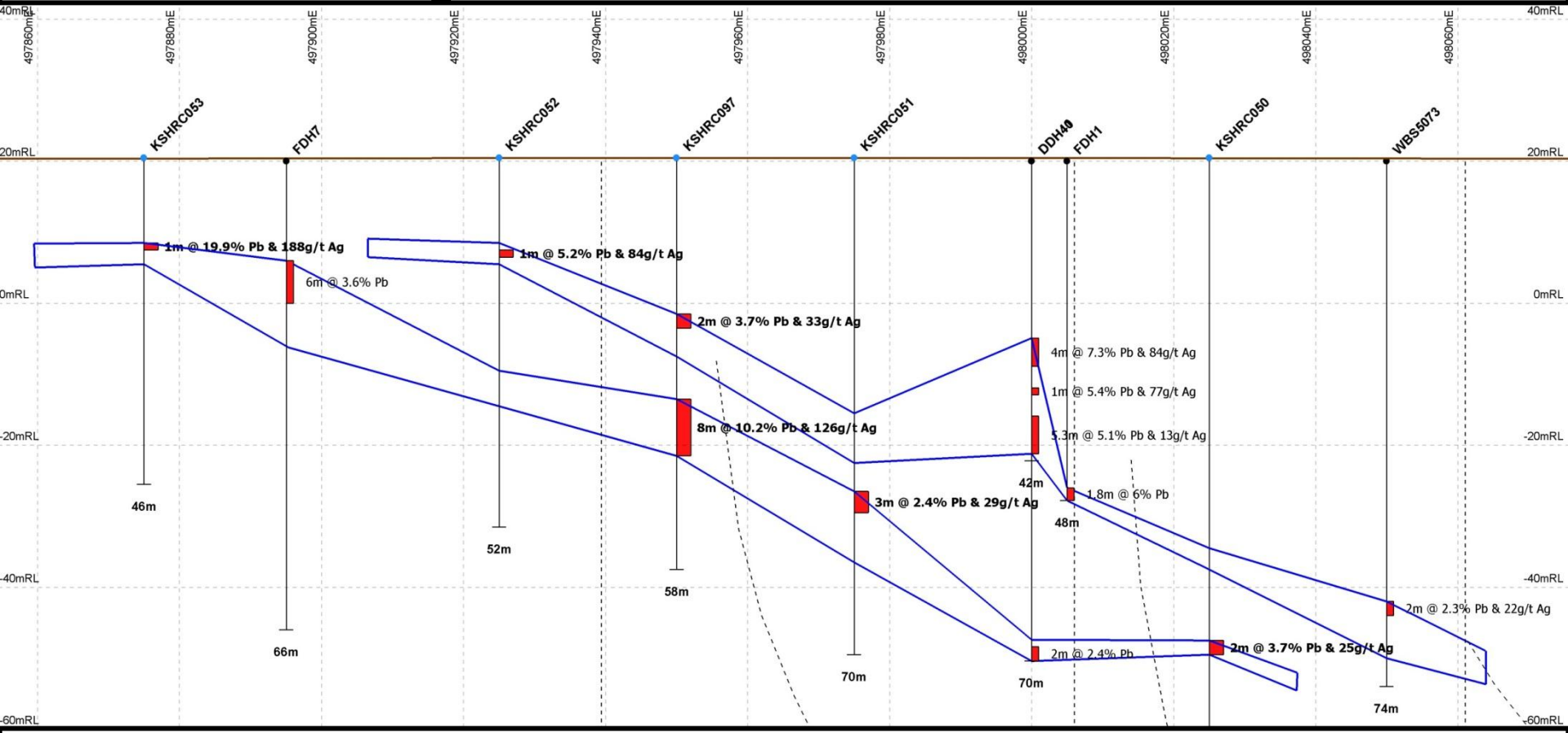
Outlines of the C, D and E pods in relation to the Sorby Hills Project tenements and planned infrastructure are shown in Figure 2-3: Drill Program 2011.



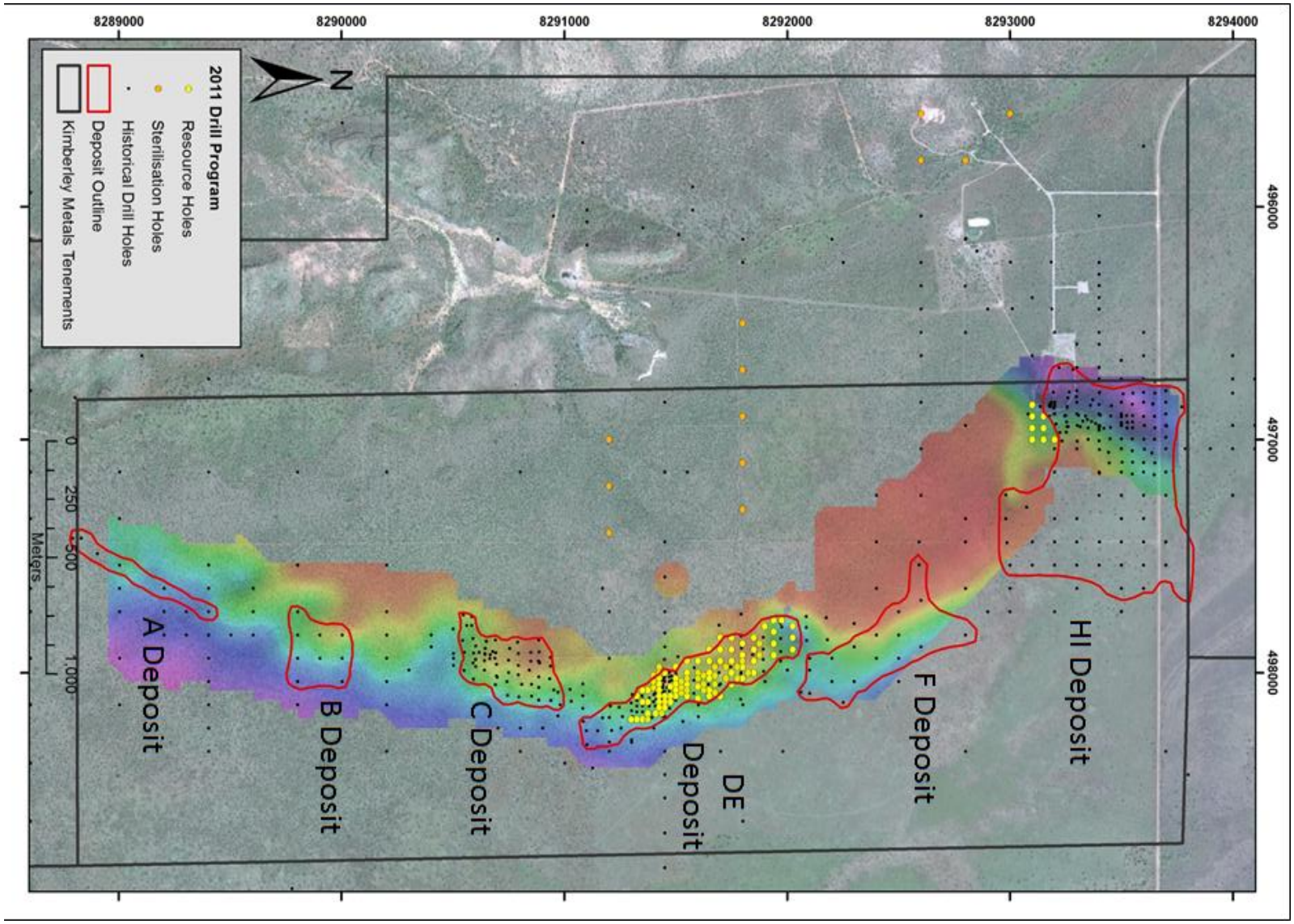
Date: October 2011	Project: SMPL Sorby Hills	NORTH	**Figure 2-1: Geological Setting**



Section location



Auth: T.Smith	Project: SMPL Sorby Hills	NORTH	**Figure 2-2: Deposit Sections (8291800mN)**
Date: October 2011	Datum: GDA94 MGA Zone 52		



Date: October 2011	Project: SMPL Sorby Hills		**Figure 2-3: Drill Program 2011**

The soil materials of the Sorby Hills Project area were investigated in August 2011 to enable SMPL to gain an understanding of the physical and chemical nature of the materials to determine if there would be any key issues during the handling of the soils during mining and their use in rehabilitation. Deep trenches were excavated to enable samples to be collected at intervals, providing information on major soil profiles to a depth of 2.2m.

Soil profiles were assessed in accordance with McDonald and Isbell (2009), using characteristics including: degree of horizonation; nature of contacts between horizons; presence and abundance of coarse fragments and mottling; fabric and structure; field texture; and plant root abundance.

The Study Area consisted of a flat alluvial plain dominated by a single soil mapping unit (SMU) of cracking clay otherwise known as heavy texture soils, or Vertisols, under current Australian classification schemes. Based on the evolutionary history of the area, these soils are known to be derived from alluvial sediments deposited by the Ord and Keep River paleochannels (Kinhill, 2000). The distribution of SMU 1 covers the territory east of the Pincombe Range, across a broad topographically subdued plain (eastern Weaber Plain) bound by prominent surface drainage channels: Keep River (East) Knox (South), and Border Creeks (North).

The observational and laboratory survey work further characterised this soil unit into two principle materials: greyish brown cracking clay and brown clay. The greyish brown clay comprised the surface soils of the area and is characterised by a high clay content, cracks resulting in higher infiltration and high soil strength. The brown clay comprised the soils generally below 100cm. The brown clay had high clay content and moderate soil strength however cracking was rare.

Overall, the topsoils of the project area are generally nutrient poor and while the surficial soils have good water retention characteristics that potentially present an ideal growth medium for revegetation, these materials will need to be managed to maintain their characteristics. The subsoils, below 110cm, are more structurally unstable with very high alkalinity, EC and sodicity which present poor growth medium for revegetation.

2.3 Flora and fauna

2.3.1 Regional Vegetation

The Sorby Hills Project area falls within the Victoria Bonaparte Bioregion as mapped for the Interim Biogeographic Regionalisation for Australia (IBRA version 6.1). The Victoria Bonaparte Bioregion comes under the tropical and subtropical grasslands, savannas and shrublands ecoregion as defined by the World Wildlife Fund and described by SEWPaC (2011).

A map of the vegetation of the Australian Tropical Savannas was produced by the Queensland Environmental Protection Agency in 2001 (Fox et al. 2001). A total of 439 vegetation associations fell within 26 broad vegetation groups. Under this assessment, the majority of the Sorby Hills area is divided into two areas:

- Map Unit C10: '*Eucalyptus microtheca* (coolibah) or *Eucalyptus gymnoteles* (coolibah) and/or *Eucalyptus* spp. +/- *Excoecaria parvifolia* (gutta percha) grassy low woodland.' This alliance occurs on gently sloping floodplains and backplains, often with braided channels. Soils are generally light to heavy grey and brown clays and cracking clays, gradational mottled yellow structured clay soils and some loams. Fox *et al*. (2001) included under Unit C10 patches of land from the mouth of the Fitzroy River south of Derby east to the Normanby River in northern Queensland. The unit accounts for a total of 18,551km^2 and incorporates twelve vegetation types from previous mapping projects including eight from Beard (1979).

- Map Unit D14: '*Eucalyptus tetrodonta* (Darwin stringybark) and/or *Eucalyptus miniata* (Darwin woollybutt) +/- *Corymbia* spp. +/- *Livistona* spp. (fan palms) woodland with a ground layer of tussock grasses and *Triodia bitextura* (curly spinifex)'. This alliance occurs on undulating plains with deep soils on dissected and remnant plateaus over Mesozoic sandstone and laterite. In some parts the soils are shallower and the laterite becomes exposed, and there are some occurrences on broken sandstone plateaus with shallow sandy soil. The soils include red earthy sands with ironstone gravel, red clay-loam and sandy red earths that may have ironstone gravel. Fox *et al*. (2001) included under Unit D14 patches of land from Cape Leveque at the entrance to King Sound north of Broome east to the Wilton River in Arnhem Land. The unit accounts for a total of 20,006km^2 and incorporates six vegetation types from previous mapping projects, including three from Beard (1979).

The alliance represented by Map Unit C10 was further broken down into associations. In the survey area the association was recorded as Map Unit C21. The area of land mapped as primarily Map Unit C21 within Map Unit C10 totalled 1,085,228Ha. The portion of the Sorby Hills study area mapped as Map Unit C21 totalled approximately 1045Ha.

Map Unit D14 was further broken down into associations. In the survey area the association was recorded as Map Unit D26 - *'Eucalyptus brevifolia* (snappy gum) low open-woodland with *Triodia* spp. (spinifex) hummock grass or sometimes a hummock grassland without trees'. The area of land mapped as Map Unit D26 within Map Unit D14 is 1,528,117Ha. The portion of the Sorby Hills study area mapped as Map Unit D26 totalled approximately 120Ha.

Two vegetation units described by Beard (1979) are present in the project area:

- High grass savanna of scattered low *Bauhinia cunninghamii* and *Eucalyptus microtheca* over a mid-dense (30-70%) cover of bunch grasses esp. *Dichanthium fecundum*, Sorghum spp. and *chrysopogon* spp. on cracking clay soils. This vegetation is restricted to a few hundred square kilometres of country north of the Ord River irrigated area and continuing eastwards across the NT border.

- Upland high grass savanna of open (10-30%) *Corymbia dichromophloia* and *Eucalyptus miniata* over a mid-dense (30-70%) cover of bunch/hummock grasses esp. *Tiodia* spp. and *Sorghum* spp. Beard found this general vegetation type to be very widespread across the northern Kimberley.

2.3.2 Site Specific Botanical Surveys

The vegetation units identified within the survey area encompassed a range of community types related to landscape, soils and disturbance. Eight vegetation units were recognised, including one forest, one shrubland and six woodland units. The description of these is shown in Table 2-1: Vegetation Units.

The vegetation mapping of the project footprint is shown in Figure 2-4: Distribution of Vegetation Unit.

The Kimberley has 11 recognised Threatened Ecological Communities (TECs) however the vegetation within the survey area does not resemble any of these.

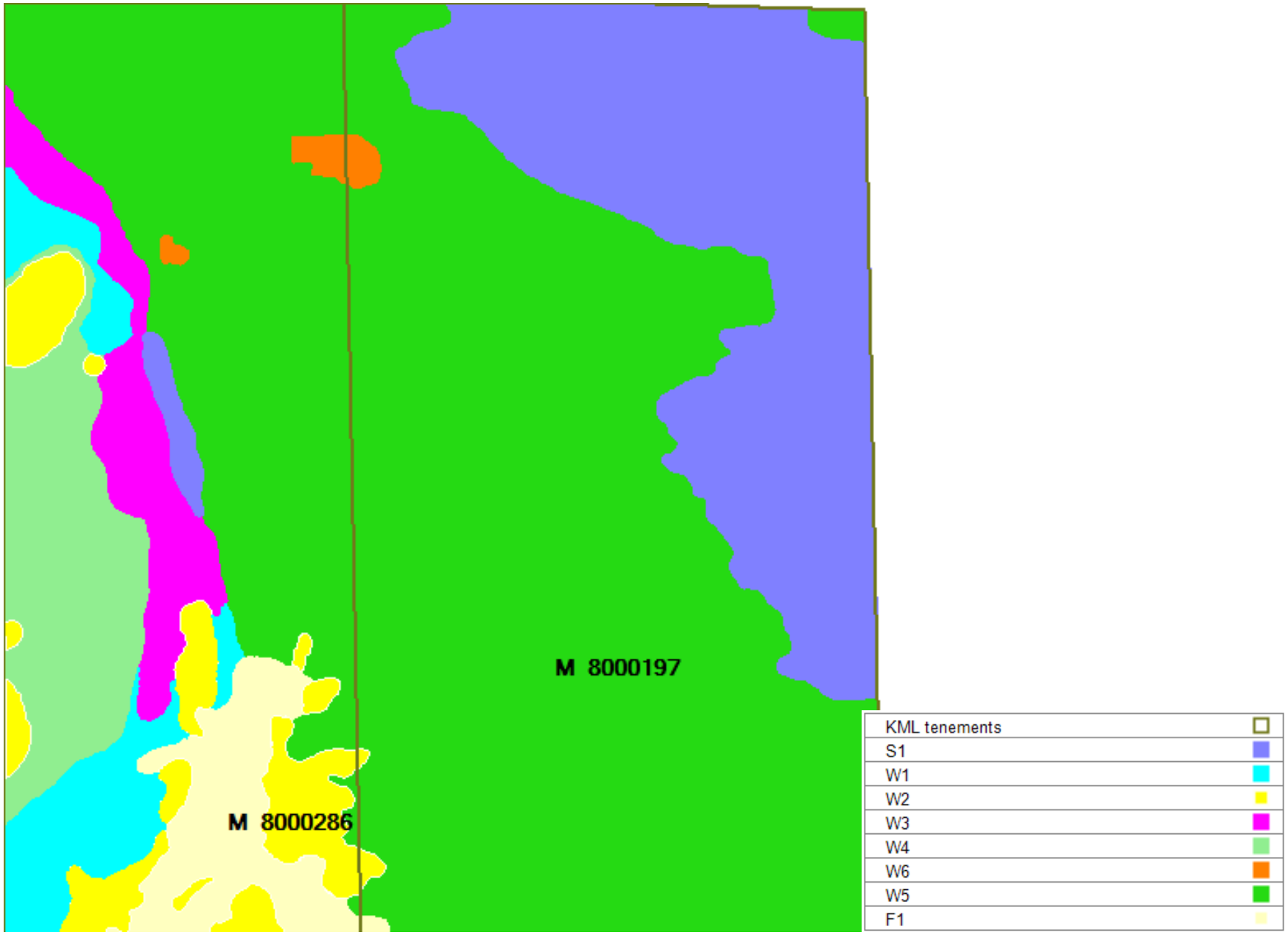
There are 16 Priority Ecological Communities (PECs) listed for the Kimberley region. The project footprint supports two areas that may be classified as the 'Monsoon vine thickets of limestone ranges' in the upland parts of the project area which are Priority 1 (Figure 2-5: Areas that may be classified as Priority 1 PECs 'Monsoon vine thickets of limestone ranges). Priority 1 PECs are poorly-known ecological communities that occur in small and isolated patches of which all or most are not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas or active mineral leases) and for which current threats exist.

A total of 334 taxa (species, subspecies and varieties) from 69 families and 201 genera were recorded in the course of the survey. Representation was greatest among the Fabaceae (53 taxa), Poaceae (52 taxa), Cyperaceae (24 taxa) and Malvaceae (22 taxa) families. A summary of vascular plant taxa by family, by site and by percentage cover is provided in the flora report (Appendix 1: Flora Survey Report).

Table 2-1: Vegetation Units

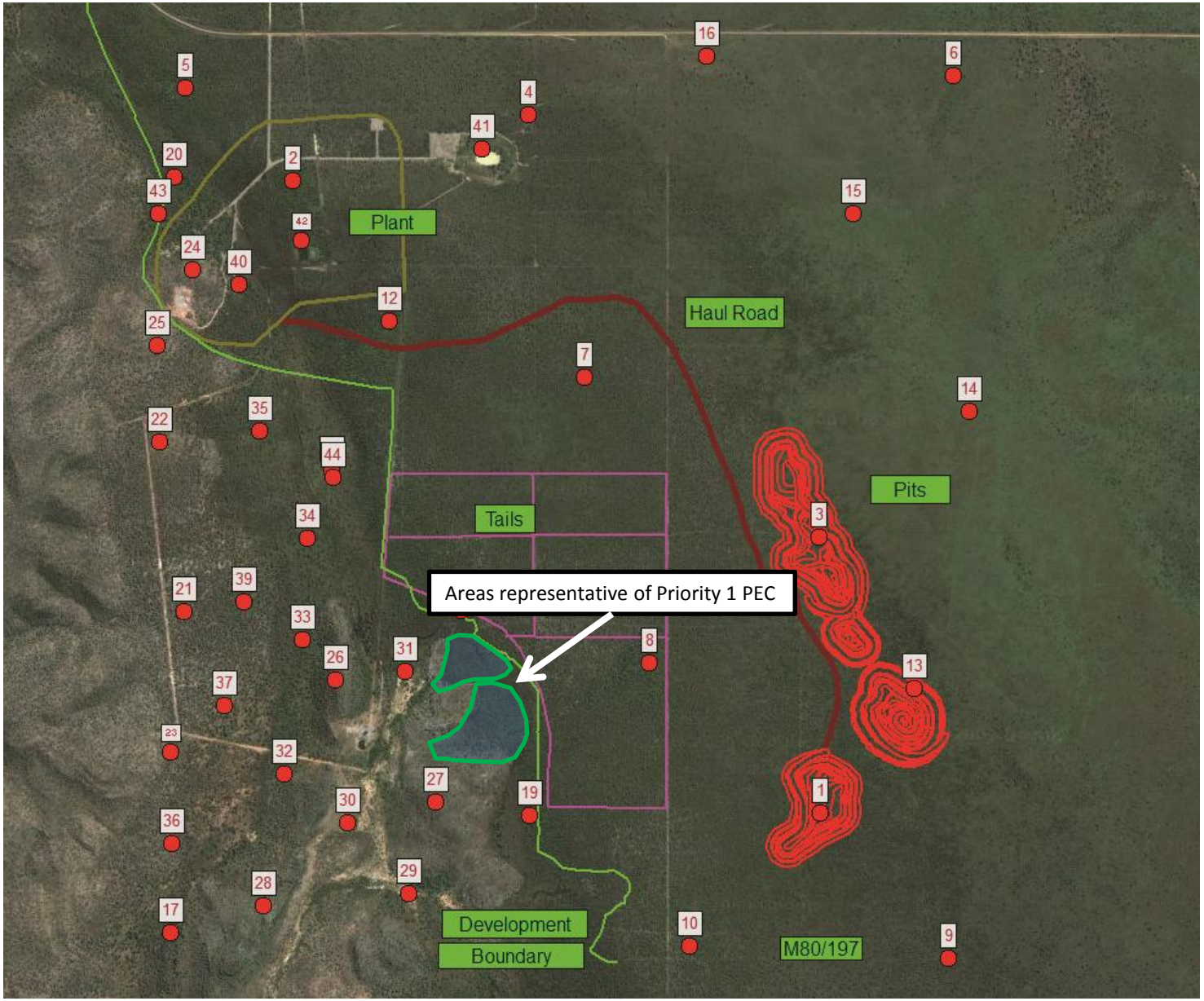
Vegetation Unit	Vegetation Description	Tenement
F1	Open Forest of Eucalyptus pruinosa subsp. pruinosa, Eucalyptus microtheca, Corymbia confertiflora and Melaleuca minutifolia over patchy Open Shrubland of Bauhinia cunninghamii, Acacia colei var. colei and Atalaya hemiglauca over mixed Grassland/Low Shrubland of Aristida pruinosa, *Sida acuta, Heteropogon contortus, * Sida cordifolia and Eragrostis schultzii (P3). This vegetation was restricted to the pale brown/grey loams, clays and clay loams of a valley system in the south-west corner of the survey area.	M80/286 M80/197
S1	Open to Sparse Shrubland of Terminalia volucris and Bauhinia cunninghamii over Closed Tussock Grassland of Themeda triandra, Iseilema vaginiflorum, Ophiurus exaltatus, Sorghum plumosum and Arundinella nepalensis with isolated trees (Corymbia bella, Vachellia valida and Bauhinia cunninghamii). This vegetation was recorded on seasonally waterlogged grey/brown 'blacksoil' clays in the north-east of the survey area.	M80/286 M80/197
W1	Woodland or Open Forest of Eucalyptus tetrodonta, Eucalyptus brevifolia and Corymbia confertiflora over Open to Sparse Shrubland of *Hyptis suaveolens, Buchanania oblongifolia, Grevillea spp. and Acacia spp. over mixed Grassland/Forbland of Eragrostis schultzii (P3), *Cynodon dactylon, Eriachne obtusa, Heteropogon contortus, Stemodia lythrifolia, Blumea saxatilis and Cyperus pulchellus. Vegetation Unit W1 was found on brown and grey loamy sands, sandy loams and clay loams on flat or gently sloping country at the base of limestone hills.	M80/286
W2	Woodland or Open Forest of Corymbia dichromophloia, Corymbia confertiflora, Erythrophleum chlorostachys, Buchanania oblongifolia, Owenia vernicosa and Terminalia platyphylla over Grassland/Hummock Grassland of Chrysopogon sp. , Triodia bitextura, Chrysopogon setifolius, Sehima nervosum and Eriachne avenacea. Vegetation Unit W2 grew in brown loams on the limestone hills that occupied much of the western part of the survey area.	M80/286 M80/197
W3	Woodland or Open Forest of Corymbia collina and Corymbia confertiflora over Closed Grassland/Forbland of Pseudopogonatherum irritans, Eriachne obtusa, Ludwigia perennis, Fuirena ciliaris, Fimbristylis tetragona, Bacopa floribunda and Drosera indica (s.l.). This vegetation was found on a brown and grey-brown loams, clay loams and sandy loams lining the western boundary of the 'blacksoil' flats.	M80/286
W4	Woodland or Open Forest of Eucalyptus tetrodonta, Eucalyptus brevifolia and Corymbia dichromophloia over Sparse Shrubland of Erythrophleum chlorostachys, Grevillea refracta, Dodonaea	M80/286

Vegetation Unit	Vegetation Description	Tenement
	hispidula var. phylloptera and Buchanania oblongifolia over Grassland of Chrysopogon sp., Sorghum stipoideum, Eriachne obtusa, Triodia bitextura and Eragrostis schultzii (P3) . This vegetation was found on brown and grey loams, sandy loams and loamy sands on the scree slopes and flats around the feet of the limestone hills running down the western side of the survey area.	
W5	Woodland and Open Woodland of Bauhinia cunninghamii, Excoecaria parvifolia and Eucalyptus tectifica over Open to Sparse Shrubland of Terminalia volucris, Atalaya hemiglauca Vachellia valida over mixed Grassland/Forbland and Closed Grassland/Forbland of Ludwigia perennis, Iseilema vaginiflorum, Chionachne hubbardiana, Ophiurus exaltatus, Panicum decompositum and Oryza australiensis. This vegetation was recorded on seasonally waterlogged grey/brown 'blacksoil' clays in the centre and south-east of the survey area.	M80/286 M80/197
W6	Open Woodland of Bauhinia cunninghamii, Excoecaria parvifolia and Vachellia valida over mixed Shrubland/Grassland/Forbland of Sorghum plumosum, *Calotropis procera, Vigna lanceolata etc. This vegetation was found in two locations which had been subject to earthworks for dam construction and pit excavation in the past. The flora was a mix of exotics, native disturbance opportunists and Unit W5 or S1 species.	M80/286 M80/197



Date: October 2011	Project: SMPL Sorby Hills	animal plant mineral	NORTH

Figure 2-4: Distribution of Vegetation Units



Date: October 2011	Project: SMPL Sorby Hills		**Figure 2-5: Areas that may be classified as Priority 1 PECs 'Monsoon vine thickets of limestone ranges'.**

None of the surveys conducted to date have found any plant taxon gazetted as Declared Rare Flora, pursuant to the *Wildlife Conservation Act 1950*, or listed as 'Threatened' under Schedule 1 of the EPBC Act.

Twelve priority floras were collected during the survey. Priority species are those on which not enough is known in relation to the species to determine its conservation status. The priority species identified within the project area are listed in Table 2-2: Priority Species. The site locations from where they were collected are listed in Table 2-3: Location of Priority Species and shown in Figure 2-6: Flora survey sites as reference points for Flora Species of Conservation Significance.

In addition to the Priority species, there are three plants that may be considered to be new species and another three plants, the collection of which is considered an extension of their known ranges. The full definitions of the Priority levels are described in the attached flora report (Appendix 1: Flora Survey Report).

Table 2-2: Priority Species

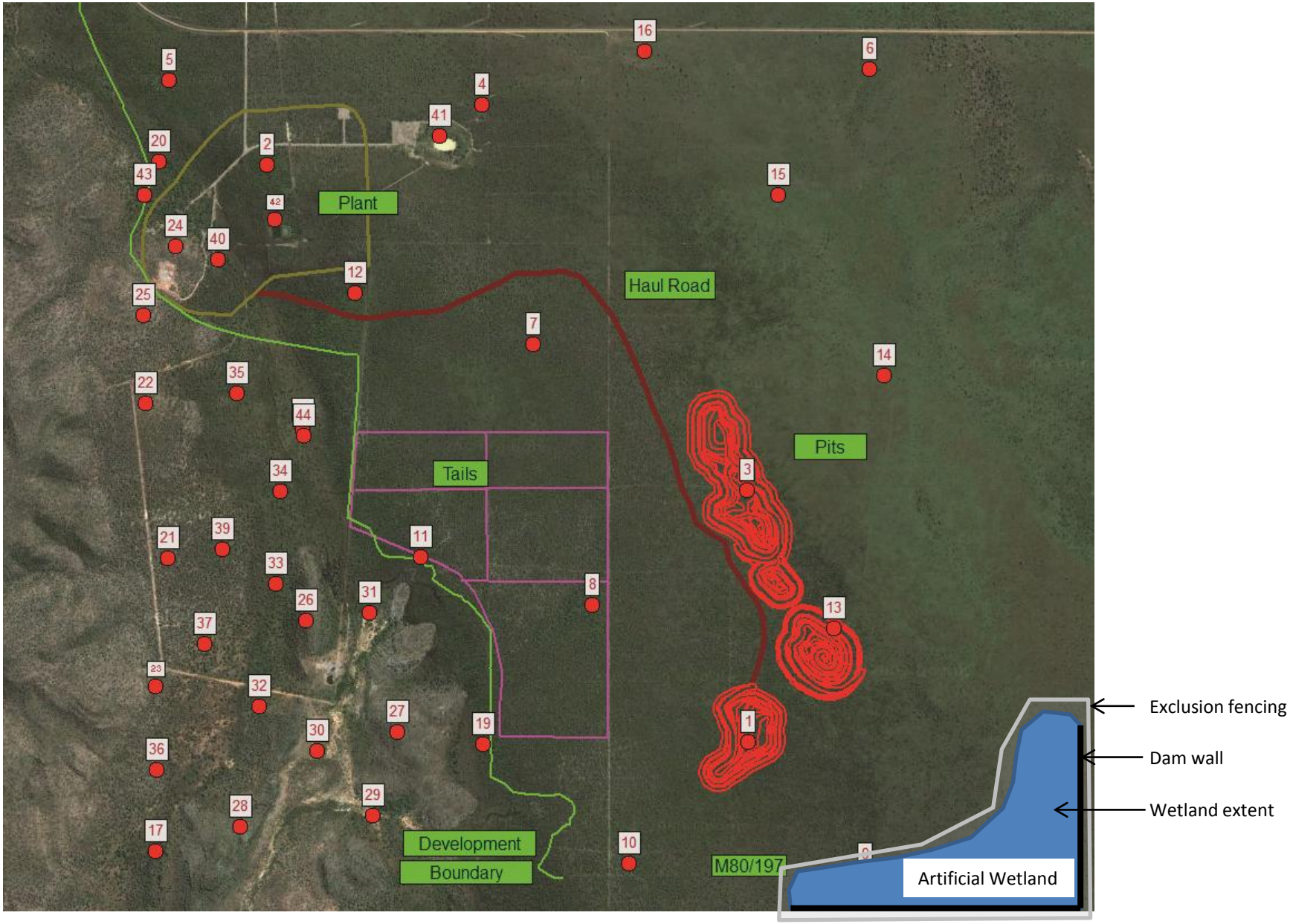
Priority	Name	Location
P1	Croton arnhemicus	The Western Australian Herbarium has two collections of this plant, one from the Carson escarpment just west of the Drysdale River National Park in the Northern Kimberley Bioregion, and the other from Three Mile Valley 3.5 km east of Wyndham in the Victoria Bonaparte Bioregion. Within the survey area it was found in two quadrats in Unit W1 and W4 vegetation.
P1	Diospyros calycantha	The Western Australian Herbarium has only one collection of this plant, from the Mitchell Plateau in the Northern Kimberley Bioregion. The new record from the Sorby Hills Project area represents a significant range extension. Within the survey area it was found in four quadrats in Unit S1, W1, W2 and W5 vegetation.
P1	Fimbristylis pachyptera	The Western Australian Herbarium has three collections of this plant, one from Eva Creek, 100km north of Fitzroy Crossing, and the other two from Mitchell Plateau area – all in the Northern Kimberley Bioregion. Within the survey area it was found in two quadrats, both in Unit W2 vegetation.
P1	Goodenia byrnesii	The Western Australian Herbarium has nine collections of this plant, from nine locales across the Kimberley, namely: the Broome Peninsula and Mount Anderson both in the Dampierland Bioregion, Beverley Springs Homestead in the Northern Kimberley Bioregion, Ivanhoe Station in the Victoria Bonaparte Bioregion and Argyle Downs Station in the Ord Victoria Plain Bioregion. Within the survey area it was collected opportunistically from a limestone hill (Unit W2 vegetation).
P1	Goodenia durackiana	The Western Australian Herbarium has three collections of this plant, one from near the Beverley Springs Station Homestead in the Northern Kimberley Bioregion, one from the headwaters of the Ord River in the Central Kimberley Bioregion and one from the Kimberley Research Station north of Kununurra in the Victoria Bonaparte Bioregion. Within the survey area it was found in nine blacksoil clay quadrats in Unit S1 and W5 vegetation.

Priority	Name	Location
P1	*Goodenia malvina*	The Western Australian Herbarium has ten collections of this plant from four locales, namely: near the Beverley Springs Homestead in the Northern Kimberley Bioregion, the headwaters of the Ord River in the Central Kimberley Bioregion, the blacksoil plains north of Kununurra and the Weaber Plain a few kilometres west of the survey area – both in the Victoria Bonaparte Bioregion. Within the survey area it was found in four blacksoil clay quadrats in Unit S1, W5 and W6 vegetation.
P1	*Hydrolea zeylanica*	The Western Australian Herbarium has just one collection of this plant, from near the Glenelg River in the Northern Kimberley Bioregion. The new record from the Sorby Hills Project area represents a significant range extension. Within the survey area it was found in just one quadrat in Unit W5 vegetation.
P1	*Jacquemontia sp. Keep River* (J.L. Egan 5051)	The Western Australian Herbarium has five collections of this plant from four well separated populations across the Kimberley from Koolan Island in the Central Kimberley Bioregion, to Stockyard Creek Bay in the Northern Kimberley Bioregion, to west of Kununurra and Ragged Range in the Victoria Bonaparte Bioregion. Within the survey area it was found in two quadrats in Unit W2 vegetation.
P1	*Polygala sp. Rhianthoides shoulders* (M.H. Andrews 398)	The Western Australian Herbarium has one collection of this plant, from the Weaber Plain about 17 km south-west of the survey area in the Victoria Bonaparte Bioregion. Within the survey area it was found in one quadrat in Unit S1 vegetation.
P2	*Fimbristylis laxiglumis*	The Western Australian Herbarium has one collection of this plant, from the Ord River Plain about 13km north of Kununurra in the Victoria Bonaparte Bioregion, but has also been collected across the NT border. Within the survey area it was found in ten blacksoil clay quadrats in Unit S1 and W5 vegetation.
P2	*Minuria macrorhiza*	The Western Australian Herbarium has fifteen collections of this plant from ten locales across the Northern Kimberley, Central Kimberley Bioregion and the Victoria Bonaparte Bioregions. Within the survey area it was found in four quadrats in Unit W1 and W4 vegetation.
P3	*Eragrostis schultzii*	The Western Australian Herbarium has two collections of this plant, one from the Drysdale River in the Northern Kimberley Bioregion, and the other from near the NT border 36 km south-east of Kununurra in the Victoria Bonaparte Bioregion. Within the survey area it was found in thirteen quadrats in Unit F1, W1, W2, W3 and W4 vegetation.

Table 2-3: Location of Priority Species

Species	Conservation Significance	Easting	Northing	Site
Flora Species of Conservation Significance Inside the Development Boundary				
Goodenia durackiana	P1	498000	8290750	1
Fimbristylis laxiglumis	P2	498000	8290750	1
Goodenia durackiana	P1	496009	8293116	2
Fimbristylis laxiglumis	P2	496009	8293116	2
Goodenia durackiana	P1	497995	8291781	3
Goodenia durackiana	P1	496900	8293366	4
Goodenia durackiana	P1	498500	8293510	6
Polygala sp. Rhianthoides shoulders (M.H. Andrews 398)	P1	498500	8293510	6
Fimbristylis laxiglumis	P2	497111	8292380	7
Goodenia malvina	P1	497354	8291314	8
Goodenia durackiana	P1	498484	8290204	9
Fimbristylis laxiglumis	P2	498484	8290204	9
Fimbristylis cf. *dichotoma* (desert form)	Range extension	498484	8290204	9
Goodenia malvina	P1	496645	8291508	11
Fimbristylis laxiglumis	P2	496645	8291508	11
Hydrolea zeylanica	P1 & range extension	496377	8292592	12
Hibiscus aff. *calcicola*	?new species	496377	8292592	12
Goodenia durackiana	P1	498357	8291215	13
Fimbristylis laxiglumis	P2	498357	8291215	13
Goodenia durackiana	P1	498560	8292254	14
Fimbristylis laxiglumis	P2	498560	8292254	14
Diospyros calycantha	P1 & range extension	498126	8292996	15
Goodenia malvina	P1	498126	8292996	15
Fimbristylis laxiglumis	P2	498126	8292996	15
Fimbristylis cf. *dichotoma* (desert form)	Range extension	498126	8292996	15
Fimbristylis laxiglumis	P2	497572	8293586	16
Goodenia durackiana	P1	496160	8292030	18
Eragrostis schultzii	P3	495563	8293133	20
Fimbristylis pachyptera	P1	495631	8292785	24
Eragrostis schultzii	P3	495631	8292785	24

Species	Conservation Significance	Easting	Northing	Site
Eragrostis schultzii	P3	495808	8292728	40
Goodenia malvina	P1	496727	8293239	41
Flora Species of Conservation Significance Outside the Development Boundary				
Goodenia byrnesii	P1	496235	8291240	opp
Diospyros calycantha	P1 & range extension	495549	8290299	17
Goodenia sp. cf. *brachypoda*	P1 or ?new species	495549	8290299	17
Eragrostis schultzii	P3	495549	8290299	17
Spermacoce aff. *leptoloba*	?new species	495549	8290299	17
Diospyros calycantha	P1 & range extension	496904	8290739	19
Fimbristylis laxiglumis	P2	496904	8290739	19
Minuria macrorhiza	P2	495600	8291503	21
Polygala triflora	under taxonomic review	495600	8291503	21
Minuria macrorhiza	P2	495552	8290976	23
Fimbristylis pachyptera	P1	495500	8292500	25
Jacquemontia sp. Keep River (J.L. Egan 5051)	P1	496175	8291247	26
Jacquemontia sp. Keep River (J.L. Egan 5051)	P1	496550	8290788	27
Diospyros calycantha	P1 & range extension	495900	8290400	28
Eragrostis schultzii	P3	496447	8290449	29
Eragrostis schultzii	P3	496219	8290714	30
Minuria macrorhiza	P2	495755	8291151	31
Eragrostis schultzii	P3	496435	8291278	31
Eragrostis schultzii	P3	495978	8290894	32
Minuria macrorhiza	P2	495558	8290636	36
Eragrostis schultzii	P3	495558	8290636	36
Croton arnhemicus	P1	495755	8291151	37
Eragrostis schultzii	P3	495755	8291151	37
Polygala triflora	under taxonomic review	495755	8291151	37
Eragrostis schultzii	P3	495827	8291540	38
Eragrostis schultzii	P3	495722	8291903	39
Fimbristylis aff. *Carolinii*	?new species	495722	8291903	39
Croton arnhemicus	P1	495503	8292997	43
Eragrostis schultzii	P3	495503	8292997	43



Date: October 2011	Project: SMPL Sorby Hills	NORTH	**Figure 2-6: Flora survey sites as reference points for flora species of conservation significance**

An assessment of the condition of the vegetation was also undertaken during the survey. The methodology of Keighery (1994) was used as the basis for the condition rating. The overall condition of the vegetation within the survey area ranged from Excellent to Completely Degraded.

Figure 2-7: Vegetation Condition shows a map of the project area and the condition ratings.

The main impacts to the vegetation were from weeds, grazing, old earthworks and vehicular disturbance. In total, 31 introduced (weed) species were identified during the survey including three that are listed by the Department of Agriculture and Food as Declared Plants for the Shire of Wyndham-East Kimberley (SWEK). The location of these species has been recorded and listed in Table 2-4: Weed Species Found on the Sorby Hills Project Area.

Table 2-4: Weed Species Found on the Sorby Hills Project Area

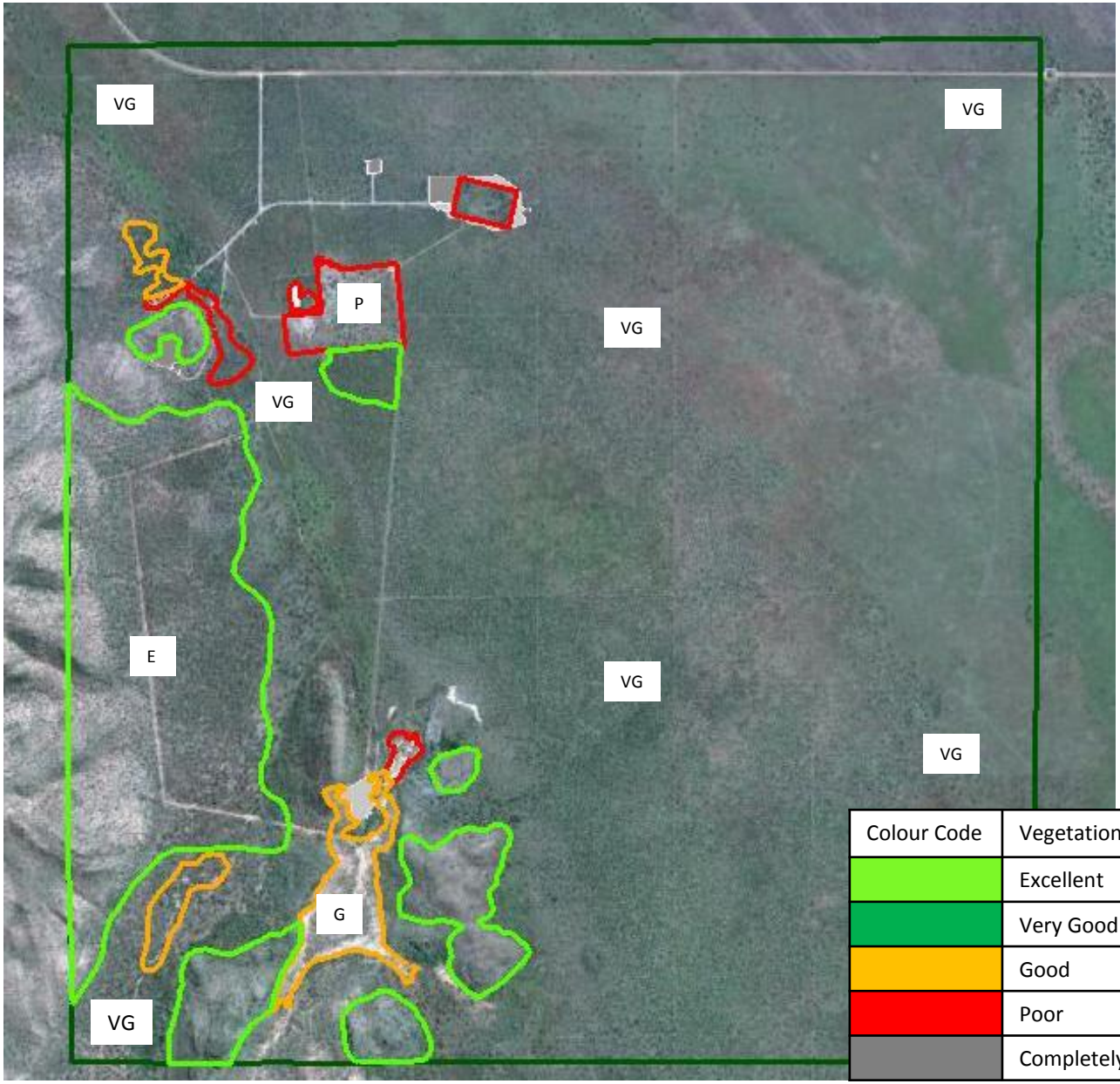
Species	Easting	Northing	Site
Aerva javanica	496727	8293239	41
Alysicarpus vaginalis	496050	8291398	33
Bidens bipinnata	497354	8291314	8
Calotropis procera	496042	8292895	42
Cardiospermum halicacabum var. *halicacabum*	495549	8290299	17
Citrullus lanatus			Opportunistic
Corchorus olitorius	497995	8291781	3
Corchorus olitorius	496900	8293366	4
Corchorus olitorius	497111	8292380	7
Corchorus olitorius	498484	8290204	9
Corchorus olitorius	496377	8292592	12
Corchorus olitorius	498357	8291215	13
Crotalaria juncea	496160	8292030	18
Crotalaria juncea	496900	8293366	4
Crotalaria juncea	495604	8293467	5
Crotalaria juncea	498357	8291215	13
Cucumis melo	498500	8293510	6
Cucumis melo	498560	8292254	14
Cucumis melo	498126	8292996	15
Cucumis melo	496900	8293366	4
Cucumis melo	495604	8293467	5
Cucumis melo	498357	8291215	13

Species	Easting	Northing	Site
Cynodon dactylon	497572	8293586	16
Cynodon dactylon	495549	8290299	17
Cynodon dactylon	495558	8290636	36
Cynodon dactylon	496727	8293239	41
Digitaria ciliaris	495549	8290299	17
Digitaria ciliaris	495563	8293133	20
Echinochloa colona	495549	8290299	17
Echinochloa colona	495604	8293467	5
Echinochloa colona	496645	8291508	11
Echinochloa colona	498357	8291215	13
Echinochloa colona	496042	8292895	42
Emilia sonchifolia	495549	8290299	17
Eragrostis minor	498560	8292254	14
Eragrostis minor	498126	8292996	15
Eragrostis minor	497572	8293586	16
Eragrostis minor	497354	8291314	8
Euphorbia hirta	495549	8290299	17
Euphorbia hirta	496050	8291398	33
Gomphrena celosioides	495558	8290636	36
Gomphrena celosioides	495600	8291503	22
Gomphrena celosioides	495552	8290976	23
Gomphrena celosioides	495827	8291540	38
Hyptis suaveolens	496219	8290714	30
Hyptis suaveolens	496435	8291278	31
Hyptis suaveolens	495978	8290894	32
Hyptis suaveolens	495808	8292728	40
Hyptis suaveolens	495503	8292997	43
Hyptis suaveolens	495631	8292785	24
Hyptis suaveolens	495563	8293133	20
Macroptilium lathyroides	496042	8292895	42
Malvastrum americanum	496447	8290449	29

Species	Easting	Northing	Site
Malvastrum americanum	496050	8291398	33
Melochia pyramidata	498500	8293510	6
Melochia pyramidata	498126	8292996	15
Melochia pyramidata	497572	8293586	16
Melochia pyramidata	495549	8290299	17
Melochia pyramidata	497995	8291781	3
Melochia pyramidata	496900	8293366	4
Melochia pyramidata	498484	8290204	9
Melochia pyramidata	498357	8291215	13
Mitracarpus ?hirtus	496435	8291278	31
Mitracarpus ?hirtus	495978	8290894	32
Myriophyllum sp.	495563	8293133	20
Passiflora foetida	496175	8291247	26
Passiflora foetida	496050	8291398	33
Passiflora foetida	496727	8293239	41
Senna obtusifolia	498126	8292996	15
Sida acuta	496447	8290449	29
Sida acuta	496219	8290714	30
Sida acuta	496435	8291278	31
Sida acuta	495978	8290894	32
Sida acuta	495549	8290299	17
Sida acuta	495558	8290636	36
Sida acuta	495808	8292728	40
Sida acuta	495563	8293133	20
Sida acuta	496050	8291398	33
Sida acuta	496068	8291780	34
Sida acuta	495755	8291151	37
Sida acuta	495827	8291540	38
Sida cordifolia	496447	8290449	29
Sida cordifolia	496219	8290714	30
Sida cordifolia	496435	8291278	31

Species	Easting	Northing	Site
Sida cordifolia	495978	8290894	32
Sida cordifolia	495558	8290636	36
Sida cordifolia	495808	8292728	40
Sida cordifolia	495503	8292997	43
Sida cordifolia	496550	8290788	27
Sida cordifolia	496050	8291398	33
Sida cordifolia	496068	8291780	34
Sida cordifolia	495755	8291151	37
Sporobolus jacquemontii	495808	8292728	40
Sporobolus jacquemontii	495503	8292997	43
Sporobolus jacquemontii	496050	8291398	33
Stylosanthes hamata	496447	8290449	29
Stylosanthes hamata	496219	8290714	30
Stylosanthes hamata	496435	8291278	31
Stylosanthes hamata	495978	8290894	32
Stylosanthes hamata	495549	8290299	17
Stylosanthes hamata	495558	8290636	36
Stylosanthes hamata	496550	8290788	27
Stylosanthes hamata	495900	8290400	28
Stylosanthes hamata	495563	8293133	20
Stylosanthes hamata	496050	8291398	33
Stylosanthes hamata	496068	8291780	34
Stylosanthes hamata	495600	8291503	21
Stylosanthes hamata	495552	8290976	23
Stylosanthes hamata	495755	8291151	37
Stylosanthes hamata	495827	8291540	38
Stylosanthes hamata	498357	8291215	13
Stylosanthes hamata	496727	8293239	41
Tribulus terrestris			Opportunistic
Tridax procumbens	495549	8290299	17
Vachellia farnesiana			

Species	Easting	Northing	Site
Vachellia farnesiana	498560	8292254	14
Vachellia farnesiana	496727	8293239	41



Colour Code	Vegetation Condition	
	Excellent	E
	Very Good	VG
	Good	G
	Poor	P
	Completely Degraded	CD

Date: October 2011

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NORTH

Figure 2-7: Vegetation condition

2.3.3 Fauna

The fauna surveys for the Sorby Hills Project were designed to meet the criteria of a Level 2 survey as defined by the EPA Guidance Statement No. 56 on terrestrial fauna surveys for environmental impact assessment (EPA 2004). The fauna surveys and their relevant reports include the following:

- Terrestrial fauna assessment describing non-volant (ground-dwelling) vertebrate fauna (Appendix 2)
- Ornithological assessment describing all avifauna species (Appendix 3)
- Echolocation survey to describe bat species present (Appendix 4)
- Subterranean fauna assessment describing stygofauna and troglofauna (Appendix 5).

Based on a broad habitat assessment conducted at the inception of the Sorby Hills Project, it was determined that no survey work for short range endemic invertebrate fauna was required due to the obvious lack of discontinuous or disjunct fauna habitat types that may promote endemism. This approach was discussed and approved by the DEC Environmental Management Branch in March, 2011 (pers comm. Brad Durrant).

Sampling for non-volant (ground dwelling) terrestrial vertebrate fauna was undertaken on three occasions, from April to late May 2011. Over this period the conditions in the project area changed from recent post-wet to dry season conditions enabling sufficient sampling of the different faunal groups. Echolocation surveys for bat species were conducted over the same period.

Ornithological assessments were undertaken in April and November 2011, to adequately sample EPBC listed threatened and migratory bird species. The project specific field data was supplemented with data from a further 23 collection events in the area between the period of May 2009 and November 2011.

A number of other fauna surveys have been conducted in the project area and in the surrounding Weaber and Knox Creek plains in 2009 by APM and other consultants in 2005 and 1996. In 1996 Ecologia Environmental Consultants undertook a broadscale survey of what was then known as the Ord Expansion and M2 Project. This area encompassed the Keep River floodplain and adjacent parts, Spirit Hills station, Knox Creek Plains, Weaber Plains, Carlton Plains, Mantinea Flats and the Ivanhoe/West Bank area. In 2005, HLA Envirosciences was commissioned to undertake follow-up herpetological survey work across many of these areas. The results of these surveys have been integrated into all of the fauna reports produced for the Sorby Hills Project.

The Kimberley is regarded as being a National Biodiversity Hotspot with 230 plant, 16 fish, 10 frog, 31 reptile, 2 bird and 6 mammal species known to be endemic to the region (McKenzie et al. 2009).

Database searches reveal significant variation in the known species richness in different areas around the east Kimberley, highlighting the limited previous survey work undertaken in the area. Up to 509 vertebrate species are known to occur in the region; however, only 310 species

have been reported for the localised area around Sorby Hills. A very high proportion of these expected species are birds.

Approximately 102 species of reptile, amphibian and non-volant (non-flying) mammals are expected to occur in the project area based on known habitat requirements. This represents half of the known reptiles, amphibians and mammals known to occur across the broader Kimberley (McKenzie et al. 2009), and is a reasonable estimate of expected occurrence given that the project area does not include large areas of rugged and heavily dissected ranges.

Tributaries associated with Keep River and Knox Creek would support at least 15 species of freshwater fishes (mainly catfishes, grunters and gudgeons). However, database searches did not reveal any species that have been previously collected in the Sorby Hills area.

A total of 25 reptile, 15 amphibian, 8 non-volant mammal fauna and 4 fish species were trapped or recorded during the Sorby Hills 2011 survey. The table below (Table 2-5: Richness and abundance for fauna trapped in the local area) shows richness and abundance of fauna collected over a number of surveys in the local area and therefore provides a more accurate reflection of what species may occur in the project area.

Table 2-5: Richness and abundance for fauna trapped in the local area

	Naturemap	Sorby	Packsaddle	Mantinea	Westbank	HLA	Ecologia
Abundance							
Mammal		14	37	18	14	0	0
Amphibians		370	386	164	49	266	118
Reptiles		160	119	124	102	407	206
Richness							
Mammal	18	7	7	4	5	0	0
Amphibians	21	15	12	8	6	15	16
Reptiles	63	25	22	17	21	43	29

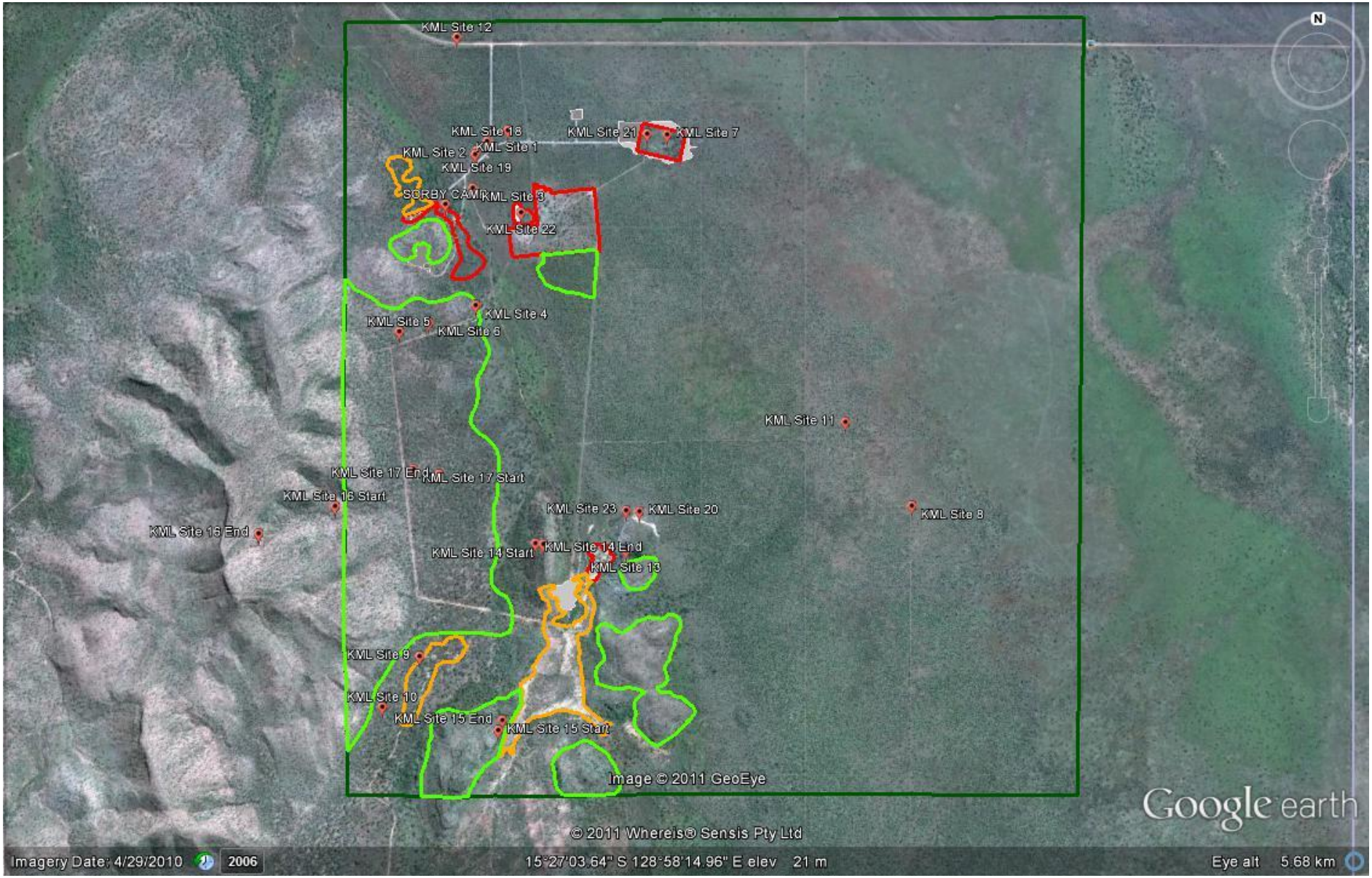
A total of 11 fauna survey sites were systematically sampled at Sorby Hills across a variety of habitats of varying condition (Figure 2-8: Fauna Survey Site over Vegetation Condition). The table below (Table 2-6: Site rankings based on ecological indices) ranks the 11 sites in relation to fauna species richness, abundance and diversity used to assess the value of the sites for terrestrial vertebrate fauna. The sites were then scored and summed to identify the most valuable fauna sites in the Sorby Hills area based on species richness abundance and diversity (Table 2-7: Habitat value).

Table 2-6: Site rankings based on ecological indices

Rank	Site	Richness	Site	Abundance	Site	Diversity
1	Site 7	15	Site 7	80	Site 7	2.174491
2	Site 4	14	Site 4	70	Site 2	2.147085
3	Site 1	12	Site 1	52	Site 6	2.126473
4	Site 2	12	Site 6	47	Site 3	2.035863
5	Site 6	12	Site 3	43	Site 11	1.873746
6	Site 3	11	Site 2	37	Site 4	1.803761
7	Site 8	8	Site 8	25	Site 8	1.777846
8	Site 11	8	Site 11	24	Site 1	1.750853
9	Site 10	5	Site 9	9	Site 10	1.609438
10	Site 9	4	Site 10	5	Site 9	1.21489
11	Site 5	2	Site 5	2	Site 5	0.693147

Table 2-7: Habitat value

Site Number	Rank
Site 7	15
Site 4	8
Site 1	6
Site 2	6
Site 6	6



Date: October 2011	Project: SMPL Sorby Hills			**Figure 2-8: Fauna survey sites over vegetation condition**

NORTH

Plates A and B, from Fauna Sites 7 and 4 respectively are shown in Figure 2-9: Vegetation within Fauna Survey Site 7 (Plate A) and Site 4 (Plate B).

Site 7 had the highest habitat value ranking. The site comprised an Open Woodland of *Bauhinia cunninghamii*, *Excoecaria parvifolia* and *Vachellia valida* over mixed Shrubland/Grassland/Forbland of *Sorghum plumosum*, **Calotropis procera*, *Vigna lanceolata* etc. The area, despite being representative of the floodplain habitat, had been subject to earthworks for dam construction and pit excavation in the past. As such the flora was a mix of exotics, native disturbance opportunists and typical cracking clay woodland species. Although the area has previously been disturbed, the exclusion of cattle from the site resulted in a notable increase in tussock grasses when compared to the surrounding area. The presence of a permanent water body adds to the habitat value of the site and contributes to the overall species richness. The fact that the site supports many species in high numbers contributes to its overall diversity, with large numbers of frog species (*Limnodynastes convexiusculus, L. depressus, Litoria nasuta, Cyclorana australis*), skinks (*Carlia munda*), and snakes (*Tropidonophis mairii*). Site 7 most accurately represents the fauna assemblages that the broad floodplains would support in the absence of heavy grazing.

Site 4 was the next most valuable habitat within the project area. It had a very similar species richness and similar abundance to Site 7. However, it had lower species diversity due to high numbers of the northern toadlet, *Uperoleia borealis* and the Giant Frog *Cyclorana australis*.

Site 4 represents a good example of the very valuable habitat that occurs at the interzone between the undulating plains and foothills of the sandstone ranges and the floodplains. The quality of the habitat has been enhanced by the exclusion of cattle. The area is dominated by Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia dichromophloia* over Sparse Shrubland of *Erythrophleum chlorostachys, Grevillea refracta, Dodonaea hispidula* var. *phylloptera* and *Buchanania oblongifolia* over Grassland of *Chrysopogon* sp.*, Sorghum stipoideum, Eriachne obtusa, Triodia bitextura* and *Eragrostis schultzii* (P3).



Plate A: Fauna Site 7



Plate B: Fauna Site 4

Date: October 2011	Project: SMPL Sorby Hills	APM animal plant mineral	NORTH	**Figure 2-11: Vegetation within Fauna Survey Site 7 (Plate A) and Site 4 (Plate B)**

2.3.3.1 Non-Volant Fauna Species of Conservation Significance

Database searches and previous surveys reveal approximately 35 ground dwelling fauna species of conservation significance listed under the following three ranks of conservation significance:

1. EPBC, Wildlife Conservation Act or DEC Priority, NT Near Threatened;
2. NT DIPE;
3. Locally or Regional Significant

Though not all of the above categories provide statutory protection to the fauna listed, all fauna listed under these categories are included in the table as they represent poorly understood fauna known to occur in the region. Collection records from previous surveys (ecologia, Kinhill and HLA) are also included in Table 2-8: Fauna of Conservation Significance to highlight the relevant occurrence of each of the fauna in the region. Rare or specially protected fauna are not often recorded during single survey events, so their presence and significance can usually only be appreciated in a regional context.

Table 2-8: Fauna of Conservation Significance

Level of Conservation Significance	Sorby Hills	Ecologia	Kinhill	HLA	APM
EPBC, Wildlife Conservation Act or DEC Priority, NT Near Threatened (NTNT).					
Acanthophis praelongus Northern Death Adder NTNT				√	
Chelosania brunnea Chameleon Dragon NTNT					
Crocodylus johnstoni Freshwater Crocodile S		√			√
Hydromys chrysogaster Water-rat P4					
Leggadina lakedownensis Short-tailed Mouse P4					√
Ramphotyphlops troglodytes P1					
Varanus panoptes subsp. *panoptes* NTNT		√		√	√
NT DIPE					
Uperoleia trachyderma					
Uperoleia borealis	√	√			√
Uperoleia inundata					
Uperoleia lithomoda				√	

Level of Conservation Significance	Sorby Hills	Ecologia	Kinhill	HLA	APM
Limnodynastes depressus	√	√	√		√
Limnodynastes tasmaniensis					
Cyclorana australis	√	√		√	√
Cyclorana cryptotis	√				
Cyclorana vagitus		√			
Chelodina sp.		√			
Tympanocryptis uniformis		√			
Ctenotus rimacola camptris	√			√	
Ctenotus inornatus	√	√		√	√
Ctenotus joanae		√			
Menetia sp.					
Morethia nov. Sp		√			
Ramphotyphlops sp.		√			
Ramphotyphlops sp. 2					
Locally or Regional Significant					
Pseudantechinus ningbing		√			
Planigale ingrami	√				√
Rattus colletti		√			
Ctenotus tantillus		√		√	√
Suta ordensis					
Notaden melanoscaphus	√	√		√	√
Uperoleia borealis	√	√			√
Uperoleia trachyderma					

2.4 Hydrology

2.4.1 Surface Water

Within the Project Area surface flows are generally sluggish due to the flat nature of the alluvial plain. The majority of surface water draining the western side of the Pincombe and Spring Ranges (including Sorby Hills) flows into Border Creek, with the Weaber Plain/Keep River Rd preventing any surface water draining into the proposed mining area. The upstream catchment for the Project Area (eastern side of Sorby Hills) is therefore relatively small, with all surface water reporting to Knox Creek (and then Keep River), approximately 3km south and south-east of the Sorby Hills Project Area.

During the wet season the surface portion of the alluvial clays becomes saturated and swells, resulting in waterlogging and ponding conditions on the surface. Onsite observations during the wet season, and following cyclonic events, has identified that the alluvial plain is covered with approximately 20-30cm of surface water, with very slow flow to Knox Creek. Hydrological modelling of intense rainfall events (i.e. 1:100yr 72hr Average Recurrence Interval (ARI) storm event) shows that during this period the water level within the alluvial plain, in the vicinity of the Sorby Hills Project Area, is likely to rise to approximately 1m above the ground surface, with these ponded conditions likely to remain for an extended period after the storm event (i.e. >5 days after) due to the low permeability of the underlying alluvial clays and the low slope gradient towards Knox Creek. Further information relating to surface water and flood assessment appears as Appendix 6.

2.4.2 Groundwater

The Sorby Hills Project area has a geology dominated by Carbiniferous aged dolomitic formations which overlie the Devonian basement stratigraphy. Whilst the Carboniferous sediments are permeable, the basement Devonian geology complex is distinctly less permeable. As a result of this geological setting, three groundwater aquifers occur within the site:

- An upper alluvial aquifer within the surficial alluvial sediments, which is considered unconfined
- An intermediate confined aquifer within the D3 dolomite unit
- A deeper confined aquifer within D2/D1 dolomite units.

Within the current pit area only the two deeper aquifers have been found to occur. Variability in hydraulic conductivity of the ground water in these aquifers suggests that these are faulted/fractured rock aquifers. The alluvial aquifer typically exists in the sandy to gravelly alluvium that occurs further north of the pits.

Groundwater levels are highest at the southern end of the mining tenements where they range from 14.4m Australian Height Datum (AHD) to 8.2m AHD adjacent to Knox Creek. Groundwater quality is generally neutral pH and brackish, with EC (Electrical Conductivity) at the end of pumping ranging between 1100µS/cm and 2700µS/cm. The cation/anion balance of the groundwater shows no dominant water type other than an overall predominance associated with sodium, magnesium, calcium, sulphate and bicarbonate. With the exception of EC, Pb, Zn

and to a lesser extent total phosphorus and aluminium, the water quality is generally within freshwater guidelines. Further information relating to hydrogeology of the Sorby Hills Project can be found in Appendix 7.

2.5 Climate

The Sorby Hills area has a tropical monsoonal climate with distinct wet and dry seasons, separated by brief transition periods. The Kimberley region is subject to a hot and humid wet season from November to April (summer), with highly variable rainfall resulting from monsoonal depressions and tropical cyclones, and a warm dry season extending from May to October (winter). The region receives about 90% of its annual rainfall during the summer wet season, with torrential rain events often leading to wide-scale flooding. The dry season experiences infrequent rainfall, with consecutive dry months common. Evaporation rates are high, with the average annual pan evaporation exceeding the average annual rainfall by a factor of 3.3.

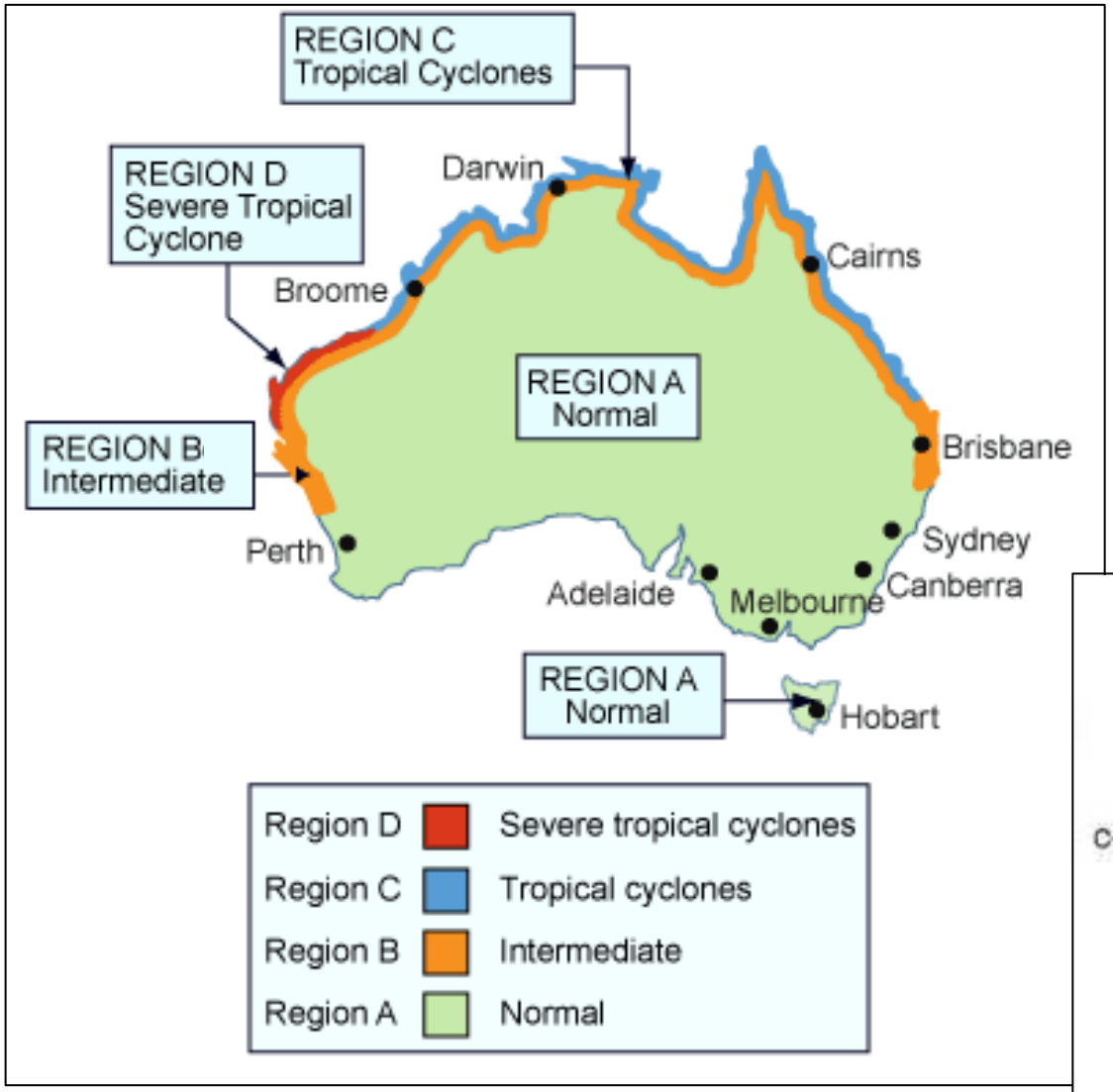
The Bureau of Meteorology has been recording rainfall and temperature since 1944 at the Kimberley Research Station, 36.5km south-west of the Sorby Hills Project Mine Site. Average monthly temperature and rainfall data for the period up to August 2010 is presented in Table 2-9: Kimberley Research Station Meteorological Data. SMPL installed an onsite weather station in September 2011 to continually monitor the climatic aspects of the project site; parameters being recorded include wind speed and direction, temperature, rainfall, solar radiation, humidity and evaporation rate.

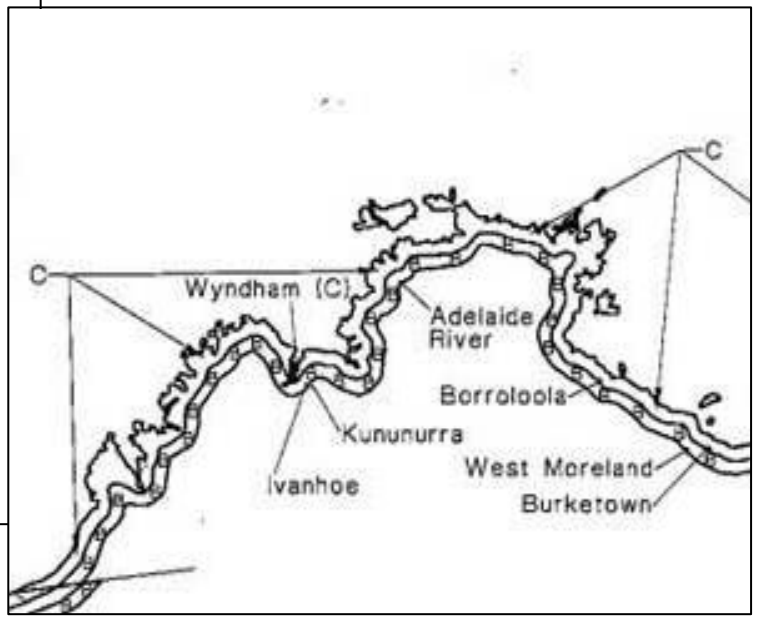
Table 2-9: Kimberley Research Station Meteorological Data

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Mean Max Temp (°C)	36.2	35.0	35.6	35.4	33.2	30.6	30.7	33.1	36.5	38.6	39.0	37.6	35.1
Mean Min Temp (°C)	24.6	24.4	23.5	20.8	18.1	15.3	14.3	15.6	19.5	22.9	24.7	24.9	20.7
Mean Rainfall (mm)	203.3	207.9	133.1	41.1	8.6	4.1	3.8	0.4	2.6	22.4	60.8	144.8	834.7

Australian Bureau of Meteorology http://www.bom.gov.au/climate/averages/tables/cw_004032.shtml

The Sorby Hills Mine Site is within a cyclone area and is categorised as Wind Region B, as defined by and illustrated in Figure 2-10: Australian Wind Regions. Wind Region B is characterised by a regional basic wind velocity of 49mps.





Date: October 2011	Project: SMPL Sorby Hills		NORTH	**Figure 2-10: Australian Wind Regions**

2.6 Social Environment

The Sorby Hills Project site lies within the traditional lands of the Miriuwung Gajerrong people. Although the tenements pre-date Native Title, a Heritage Protection Agreement was developed between the previous owners of the Sorby Hills tenements and the Miriuwung Gajerrong Corporation (MG Corporation), as part of this agreement SMPL will develop an Indigenous Land Use Agreement (ILUA) with the MG Corporation.

An Aboriginal Heritage Desktop Analysis was undertaken by Land Access Solutions (LAS) for the Sorby Hills Project area (See Appendix 8). The Department of Indigenous Affairs (DIA) Heritage Register identifies five sites that lie wholly or partly within the Sorby Hills tenement areas. Of these registered sites, only the buffer zone of Site 15427 (Jingil Complex) will be intersected by the northern edge (approximately 300m) of the relevant tenements (M80/197 and M80/286); there is limited public information for DIA Site 15427 as it is a closed site (See Appendix 9).

Detailed archaeological and ethnographic surveys have been conducted of the areas proposed to be impacted by the Sorby Hills Project (See Appendix 10). The surveys were conducted concurrently with participants from the Mirriuwung Gajerrong people and were coordinated through the MG Corporation. The archaeological survey was conducted from 19 to 21 October 2011 and the ethnographic survey was conducted with senior men on 20 October 2011 and with senior women on 21 October 2011.

The ethnographic survey was conducted in two parts; the first part had the participation of the older men from the Mirriuwung Gajerrong people and the second part employed the participation of the older women. This ensured that the men were able to determine if there were going to be any “men only” sites within the footprint of the mining and infrastructure area. In consultation and discussion with the Mirriuwung Gajerrong people the disturbance boundary for the project footprint was moved to exclude a small limestone hill. As a result of this boundary change, the Traditional Owners advised that they approved the development of the mine within the new boundary area. The MG Corp also confirmed this position in written correspondence (see Appendix 11).

The archaeological survey incorporated both a desktop analysis of previous survey work conducted in the area and a site inspection of the entire project disturbance footprint. The footprint that was surveyed considered the amendments to the boundaries as a result of discussions with the older men from the Mirriuwung Gajerrong people. No archaeological material was collected in the areas inspected during this survey.

The tenements were not identified in National or World Heritage Lists.

The nearest townships to the Sorby Hills Project are Kununurra and Wyndham. Extensive consultation with key stakeholders, including the local community, has occurred within these towns. Consultation has included meetings and phone conversations, presentations to various groups, distribution of a community information pamphlet to 378 households in Wyndham and 1126 households in Kununurra and inclusion of an informative half-page advertisement in the local newspaper, the Kimberley Echo. Appendix 12 contains examples of community engagement materials and a stakeholder consultation register.

3 PROJECT DESCRIPTION

3.1 Areas of disturbance

The Sorby Hills Mining tenure area covers 12,612.40ha, with this proposal covering an area of 1,782.27ha (tenements M80/197 and M80/286) and a total disturbance footprint of 639.45ha (excluding firebreak clearing, which may involve up to 100ha of additional clearing).

The table below (Table 3-1: Indicative Areas of Disturbance*) indicates the clearing requirements for each tenement associated with the Sorby Hills Project Mine Site.

In addition to the above clearing, a 50m wide firebreak will be constructed around the perimeter of the site, which is approximately 20km in length. A firebreak will also be developed around species protection areas within the site. It is anticipated that up to 100ha of clearing may occur as part of this process; 60ha in M80/197 and 40ha in M80/286.

Table 3-1: Indicative Areas of Disturbance*

DISTURBANCES (ha)	M80/197	M80/286
Open Pits	84ha	-
Tailings Facilities	125ha	22ha
Evaporation area	34ha	49ha
ROM Pad	-	4ha
Plant Site and support infrastructure including ROM pad, process plant, office,workshops	-	60ha
Explosives Magazine	-	0.25ha
Hypersaline pipeline corridors (>15, 000TDS)	-	2.2ha (2.2km x 10m)
Fresh water pipeline corridors (<15, 000TDS)	2.5ha (2.5km x 10m)	1ha (1km x 10m)
Haul roads	12.5ha (2.5km x 50m)	5ha (1km x 50m)
Access Tracks	6ha (1.5km x 40m)	12ha (3km x 40m)
Soil Stockpiles	15ha	10ha
Flood Bunds and Diversion Channel	90ha	70ha
Landfill Site	-	2ha
Artificial Wetland	33ha	-
Total	**402ha**	**237.45ha**
Tenement Area	***993.91ha***	***788.36ha***

*Areas are indicative only and may vary. The total clearing for mine infrastructure however will not exceed 639.45 without the appropriate approvals.

3.2 Sorby Hills Mining Operations

The Sorby Hills mining operation for the C, D and E pods is planned over a period of 14 years at an ore production rate of 400,000 to 600,000Tpa. The mining technique will be consistent with a typical open cut, drill and blast operation.

Initially the C, D and E pods will be mined sequentially as separate entities in three small pits commencing with D pod; as mining progresses the three ore bodies will be contained within one larger pit. A 3D modelling image of the final pit design, showing the three separate ore bodies in one pit, is provided in Figure 3-1: Final Pit Design Model.

Mining will be carried out predominantly during dayshift, with some night operations occurring. The mining technique will consist of:

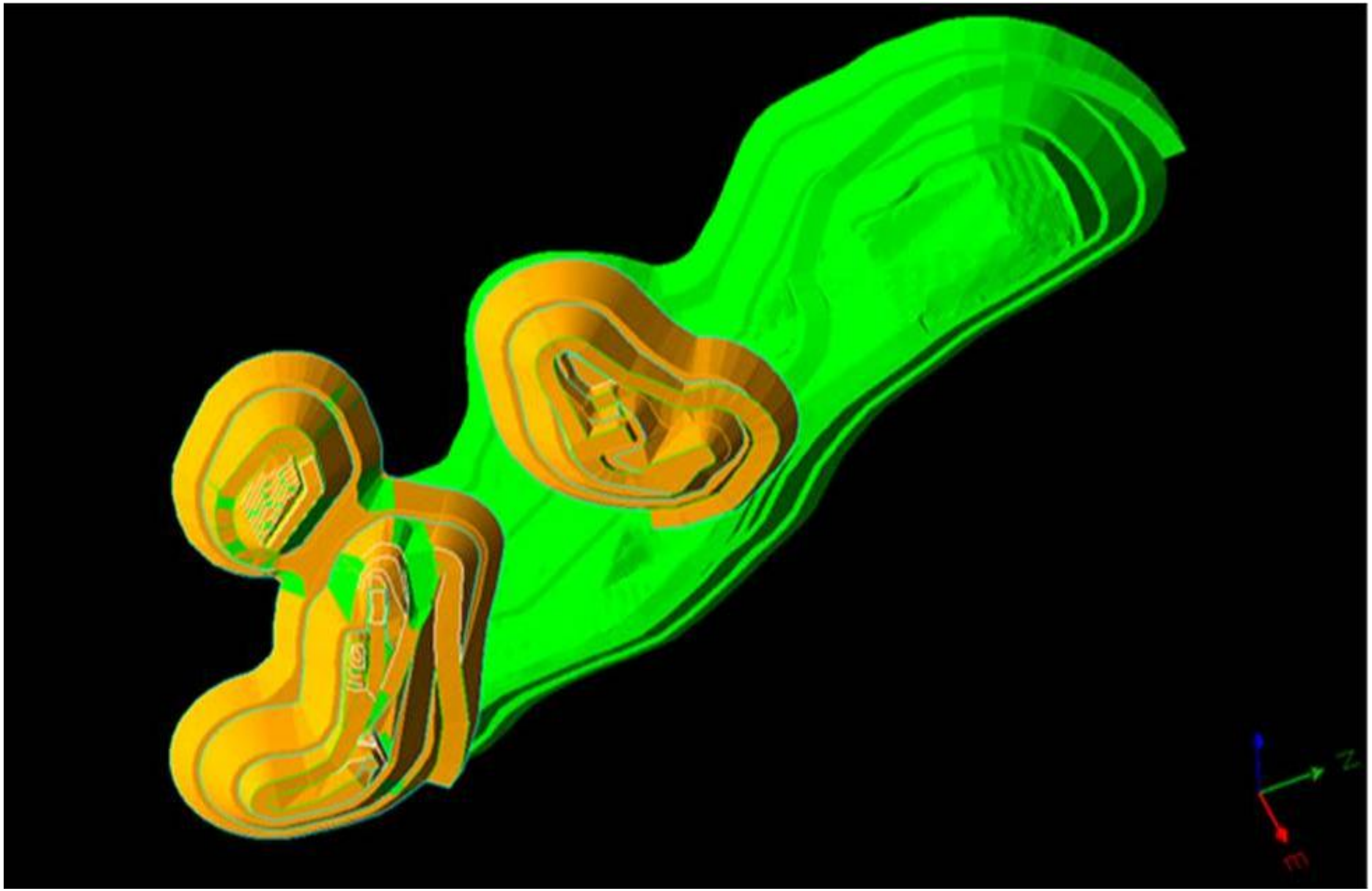
- Overburden (topsoil and clay) removal; two D10 dozers, four 631 scrapers and one 16H grader have been estimated to be required for this purpose.

- Drill and blast operation to drill, load and blast in pre-defined patterns. Drill crew and plant will consist of a single blast hole drill rig (Sandvick DP1100 or similar capacity drill rig) with operator, one bomb ute and shot firer and an explosives mobile manufacturing unit (MMU) with operator. Blasting will only take place at designated blast times during dayshift and only when conditions are favourable. Explosives will be stored in an explosives magazine in compliance with the *Explosives and Dangerous Goods Act 2004*, the *Dangerous Goods Safety (Explosives) Regulations 2007* and *Australian Standard AS 2187.1:1998, Explosives – Storage, transport and use, Part 1.* Explosives will be stored remote from the mining operations.

- Site geologist and pit technicians will assess broken (blasted) ground to identify and delineate ore, low grade material and waste prior to load and haul commencing in the area.

- The load and haul mining fleet will include a 120T excavator loading four 90T haul trucks, which will transfer ore, low grade material and waste to the respective stockpile areas. Extraction will be predominantly carried out using conventional mining technique. Ore and low grade material will be trucked along the haul road and tipped on the ROM pad. Waste material will be used in road and TSF embankment construction, as well as for flood bunds along the western edge of the site and around the perimeter of the open cuts. All waste is anticipated to be consumed during development of these structures therefore no designated waste dumps will be required for this project.

- The mining fleet will also include support machinery; a 35kL water cart will be required for dust suppression, a grader will be utilised for general earthworks and maintenance of the truck circuit and a 40T excavator will be on site to pull and maintain the batters, excavate drains and in pit sumps, and provide backup for the 120T excavator.



Date: October 2011	Project: SMPL Sorby Hills	NORTH	**Figure 3-1: Final pit design model**

The overburden in the project area consists of black soil ranging from 5-25m in thickness; shallow slope angles of 20-25° will be used in this material. The first bench immediately below the black soil cover will be designed as a wide accessible bench; this will be necessary for cleaning as the black soil material may accumulate on the bench and create a hazard. Once into the hard rock below the soil cover the slope angles will be adjusted to a 40-45° angle and will be consistent with a typical pit design.

A detailed rock mechanics analysis of the project area was undertaken in 1979 (Mount Isa Mines) for a preliminary feasibility study. Although this analysis was aimed largely at an underground venture for I pod, the deposits are fairly uniform across the project and the results are also applicable to open cut proposals. To further advance the geotechnical work completed to date, an addition assessment will be completed prior to commencement of mining operations.

There is a groundwater aquifer in the mineralised dolomites and a dewatering system will be required to enable mining. SMPL will construct periphery dewatering bores and install a typical in pit sump. Further detail is provided in section 4.4 of the Mining Proposal.

3.3 Support Infrastructure

A layout of the proposed facilities and access roads at the Sorby Hills Project Mine Site is presented in Figure 1-3: Site Layout Plan. The support infrastructure on the site will include:

- A site office which will contain around 12 offices, meeting rooms, storage areas and crib facilities for staff
- The existing 1.5km long access track from the Weaber Plain Road to the site facilities will be upgraded and widened from 20m to 40m width; road works will be carried out in line with Main Roads WA (MRWA) specifications
- Four 24m x 12m workshops with associated hydrocarbon management systems and wash down areas
- A 50m x 50m hardstand area (included within the Plant Site) for storage of concentrate transport containers. SMPL will have approximately 180 to 200 containers for the project
- Diesel storage and refuelling area for 200KL (four 50kL tanks) of diesel for power generation and Mine Site equipment
- Seven 500kW diesel powered generator sets; five fixed generators associated with the Plant, workshops and offices, and two mobile generators for dewatering requirements
- Small potable water storage tank for offices and crib facilities; potable water will be sourced from rain water and an external (outside the mineral field) water bore
- A laydown and storage area for use during construction of the facilities; existing pads and degraded areas within the proposed Plant Site will be utilised for this purpose

- Landfill site.

Works Approval applications have been submitted to DEC for the landfill site and the storage of hydrocarbons; the applications are currently being assessed.

Entry to the Sorby Hills Project site will be via the existing access track from the Weaber Plain Road, which will be widened and upgraded in line with MRWA specifications. The ore transport routes for the Sorby Hills Project are in two stages:

- Pits to ROM pad and crusher bins for Processing;
- Post Process ore concentrate transported off-site to the laydown facilities at Wyndham Port via the site access road, Weaber Plain Road, Mills Road, Ivanhoe Road, Victoria Highway and Great Northern Highway.

The haul roads from the pits to the ROM pad will be double lane haul roads built to required specifications. The haul road will have an unsealed surface and will be constructed by a cut and fill process using soil and shale material obtained from levelling the Plant Site, with additional material sourced from waste rock stripping as required. Similar material was used in 1979 to construct access tracks in the area; there have been no issues with these roads indicating the suitability of this material for road construction. The haul road will be 3.5km long and 50m wide at the base allowing for a 40m wide road surface. The haul road will be raised to prevent flooding of the road surface during the annual wet season.

The trucking of concentrate from the Sorby Hills Project site to the Wyndham Port laydown facilities will be a 120km (one way) trip on a sealed road network (Figure 3-2: Proposed Transport Route from Sorby Hills Project to Wyndham Port).

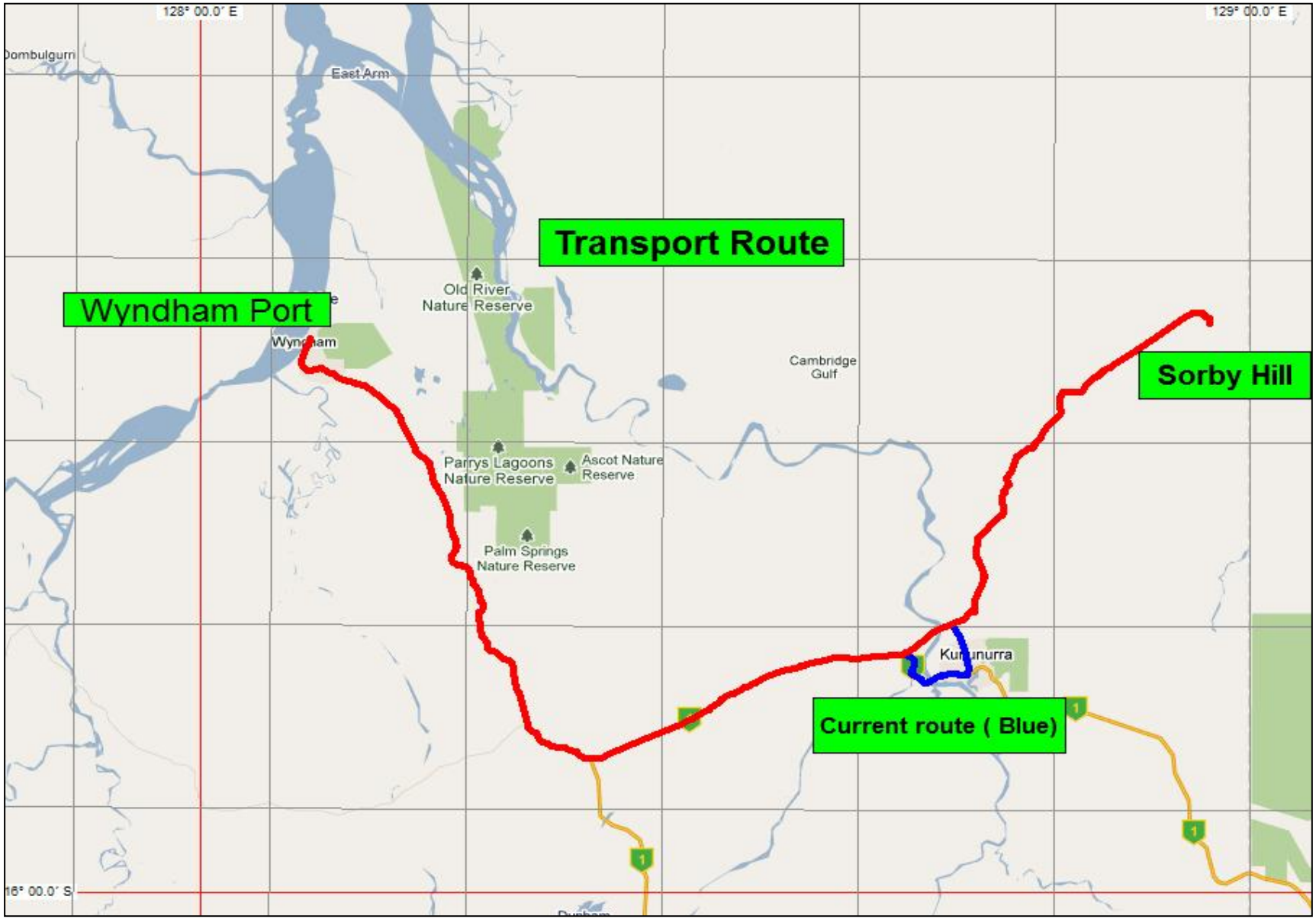
The proposed MRWA Kununurra Heavy Vehicles Route would result in an alternative transport link that could be used by SMPL haul trucks, allowing the township of Kununurra to be bypassed. SMPL will support this project and utilise the route should it become available. There will however be minimal utilisation of other public services for the project.

The Sorby Hills Mine Site is essentially ‘self sufficient’, generating power and water at the site.

Power generation for the processing plant will most likely be through diesel powered generator sets. In addition there may be the possibility of sourcing a gas supply from the Weaber Gas Field (Advent Energy) by the time the Sorby Hills Project is operational, in which case the existing diesel generator sets will be modified to operate with natural gas. Power usage will be approximately 8624MWHrsPa and will require five 500kW generator sets on site. It is anticipated that during normal operations three generator sets will be required, with the fourth used during start up and the additional generator set as a back-up. In addition two 500kW generator sets will be required to facilitate mine dewatering pumps.

Process water will be sourced from mine dewatering and recycled water from the processing plant. Potable water will most likely be sourced from rainwater and a groundwater production bore situated away from the mineralised field.

Dewatering bores will direct excess pit water to the artificial wetland south-east of the proposed pits on M80/197, or to the evaporation basin to the north of the TSF.



Date: October 2011	Project: SMPL Sorby Hills	NORTH	**Figure 3-2: Proposed transport route from the Sorby Hills Project to the Wyndham port**

4 PRINCIPLES FOR ASSESSING CLEARING PERMIT APPLICATIONS

Land clearing activities associated with the Sorby Hills Mine Site are considered below against the ten clearing principles outlined in Schedule 5 of the *Environmental Protection Amendment Act 2003* (WA) (*Environmental Protection Amendment Act)*, which address issues associated with biodiversity, land degradation and ground and surface water quality.

It is not anticipated that the project will create any significant environmental or social impacts when considered against these ten principles.

Principle 1 Native vegetation should not be cleared if it comprises a high level of biological diversity.

The proposed development is unlikely to be at variance with this principle.

Conservation to maintain diversity in the Sorby Hills project area will focus on the retention of comprehensive, adequate and representative habitats as per the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia, 1996). Conservation of these areas will be aligned with the WA and NT government conservation reserve initiatives and those proposed in the Ord Final Agreement.

As such, the mine plan has been tailored to avoid impact to Sorby Hills (an extension of the proposed Pincombe Range Conservation Reserve) and the valuable and diverse interzone habitat between the foothills and the flood plains that supports an array of local fauna species and a high diversity of plant species, some of which are of conservation significance. Very little infrastructure is proposed for construction in the foothills and that which is proposed is to be constructed on areas that are already cleared or degraded.

On the floodplain, within the Sorby Hills project area, sites where cattle were excluded showed reasonable levels of biological diversity. Destocking and the management of fire on the floodplains within the mining leases will enhance the biological diversity of the floodplains and offset any impacts associated with the relatively small amount of clearing in this habitat.

No Declared Rare Flora was recorded within the Sorby Hills project area. Approximately half of the Priority flora species recorded will remain undisturbed due to the avoidance of clearing in the foothills and interzone. SMPL propose further botanical survey work to better identify the abundance and extent of flora species of conservation significance in the proposed impact area. Following this work in April 2012, the current design plan can be modified to further reduce impact on flora of conservation significance if necessary.

Principle 2 Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to WA.

The proposed development is unlikely to be at variance with this principle.

Many of the fauna that occupy the project area show very typical Torression zoogeographic affinities, with distributions that extend from the far North-West Kimberley across the northern most land masses beneath the Joseph Bonaparte Gulf and into the NT. Therefore, no fauna are

expected to occur in the Sorby Hills Project area that are endemic to WA. Even species that have specific habitats and few historical records, such as the Ord Snake that occupies only cracking claypan habitat, all have distributions that extend into the NT.

Principle 3 Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.

The proposed development is unlikely to be at variance with this principle.

An assessment of the DEC NatureMap tool identified one Threatened (DRF) species, *Typhonium sp. Kununurra* (A.N. Start ANS 1467). This plant is known from one population located approximately 35km south-west of the survey area. No Declared Rare Flora species, pursuant to subsection 2 of section 23F of the *Wildlife Conservation Act* were recorded within the disturbance footprint for the development of the Sorby Hills Project. No plant taxa pursuant to section 179 of the *EPBC Act* were located in the areas surveyed and are proposed to be cleared.

The NatureMap search also produced 55 Priority taxa within 45km of the survey area. The survey identified 12 species of priority plants, possible new species and plants found outside their previously known ranges. Table 2-2: Priority Species provides a description of the 12 species that were identified during the survey. The locations of these specimens are shown in Table 2-3: Location of Priority Species.

The majority for flora species of conservation significance will remain undisturbed due to the avoidance of clearing in the foothills and interzone, and the planning and positioning of mine infrastructure based on the outcomes of the botanical survey work. SMPL propose further botanical survey work in April 2012, the results of which can be used to further modify the design of the mine site infrastructure if necessary.

Principle 4 Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.

The proposal is not likely to be at variance to this principle.

A search of the DEC's Native Vegetation map viewer identified no Threatened Ecological Communities within the application area.

There are three PECs potentially occurring in the Sorby Hills area:

- Monsoon vine thickets of limestone ranges
- Oryza australiensis (wild rice) grasslands on alluvial flats of the Ord River
- Camaenid land snails of limestone hills of the Jeremiah and Ningbing Ranges

Botanical survey work specific to the project area did not record occurrences of wild rice (*Oryza australiensis*).

The alignment of the development boundary guarantees the protection of the habitats representative of the Monsoon vine thickets of limestone ranges which, in turn, provides for the protection of habitats supporting Camaenid land snails.

Principle 5 Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

This proposal is not likely to be at variance to this principle.

As part of the Ord River Irrigation Area – Weaber Plain Development Project the Weaber Plain area will have 10,805ha set aside as a buffer zone and conservation area. The mosaic of vegetation that occurs on the Weaber Plains is very similar in composition to that of the Knox Creek Plain.

Thus it is reasonable to suggest that as the Ord Irrigation Expansion program continues across the remaining stages, a similar percentage of plains habitat (50%) will be preserved. This would include the Knox Creek area.

In addition to the 10,805ha buffer area managed by the Ord Irrigation Expansion Project, and the area to remain undisturbed in the project tenement boundaries, the signing of the Ord Final Agreement ILUA has resulted in the establishment of six reserves in the surrounding ranges and the Packsaddle Swamp conservation area. In total this area covers some 188,200ha. Within these reserves, habitat identical to that which exists within the Sorby Hills Project will be preserved.

Principle 6 Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.

The proposal is not likely to be at variance to this principle.

The project area lies along a topographic gradient that is at its highest elevation in the north-west corner, sloping down to the north-east and to the south. The area is also seasonally very heavily inundated. Thus the vegetation that occurs in the project area is continually subject to inundation and subsequent drainage along intermittent and indiscriminate drainage patterns. The largest water course occurring in proximity to the project area is Knox Creek which flows from west to east beyond the southern boundary of the project area. No major creeks or drainage lines are to be directly impacted by the development.

A number of minor drainage lines may occur on the lowland slopes of the project area. Where these minor drainage lines occur and are to be intersected by the mining operations or installation of infrastructure SMPL will consider installing culverts or floodways to facilitate natural drainage patterns.

Principle 7 Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

The proposal is not likely to be at variance to this principle.

Most of the lowland country was quite heavily grazed; however the high productivity of the 'blacksoil' clays appeared to make the vegetation resilient to trampling, grazing and weed invasion. As the vegetation structure and floristics appeared only slightly impacted, most of this country is rated 'Very Good'.

The largest areas forecast for clearing are within these lowland areas. SMPL will endeavour to contain disturbance to that which is essential.

Lowland areas from which cattle had been excluded was deemed 'Excellent'. These areas were fenced off demonstrating that destocking could have a net positive impact on the environment subsequent to mining.

Three declared weed species, **Senna obtusifolia*, **Sida acuta* and **Sida cordifolia*, were recorded within the survey areas. These three species are all classed as P1 under the *Agricultural and Related Resources Protection Act 1976* (WA) and **Senna obtusifolia* is also classed as a P2 species. Management will be introduced to ensure that the movement of the P1 species is prohibited in accordance with the legislation. The area where the P2 species was identified will be treated in accordance with guidance to attempt to eradicate the species as recommended by the Department of Agriculture and Food. Weed hygiene practices for clearing and vehicle movements will be introduced to restrict the spread of these weed species to other areas of the project and region. Regular monitoring of the infested areas and the project site will be conducted to ensure that management measures are effective.

A valley system in the south-west of the survey area, as well as some woodlands north of an old coring pad in the north-west had been invaded by the large weeds**Sida acuta, *Sida cordifolia* and **Hyptis suaveolens.* These areas nevertheless retained their original structure and a substantial number of native species, and were therefore rated 'Good'. This area is not likely to be impacted as it occurs predominantly on the upland areas west of the development boundary.

In two places earthworks for a dam and a pit had permanently altered the substrate and vegetation structure, allowing weeds such as **Calotropis procera* to become subdominant. Around the old coring pad and a drovers' campsite in the north-west of the area **Hyptis suaveolens* dominates the understorey. These three areas are rated 'Poor'. A few patches of ground had been cleared for dams, lay down areas etc. and were virtually free from vegetation. These were rated 'Completely Degraded'. Many of these degraded areas are areas that are targeted for development to minimise the overall impact on the surround higher quality vegetation.

Land clearing practices involve the removal of vegetation and surface soils from pre-defined areas for the construction of mining areas and related infrastructure, including tailings facility, roads and miscellaneous infrastructure. Clearing will be undertaken through a staged approach to avoid unnecessary exposed areas that are susceptible to erosion and dust generation. Following construction, areas that are no longer be required for ongoing operations will be progressively rehabilitated.

Overall, the proposed construction works will involve minimal disturbance to vegetation and fauna habitats within the project area and will limit unnecessary exposed areas as much as possible. Progressive rehabilitation of disturbed areas will be required to stabilise short-term impacts such as dust generation and erosion and to return areas to pre-disturbance status. Land degradation within the project area is likely to be minimal providing clearing and any other disturbance activities comply with the EMP.

Principle 8 Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

The proposal is not likely to be at variance to this Principle.

The Project does not lie within any Conservation Areas as listed by the Department of Environment and Conservation. There are no World Heritage Areas or internationally recognised conservation areas within the project footprint.

A search of the Protected Matters Tool returned one place on the Register of the National Estate, an indigenous place outside of the project area and while located within reasonable proximity to the project falls within the boundary of the NT. The search also produced two state and territory reserves, the Points Spring Nature Reserve about 8km north-west of the survey area and some proposed extensions to the NT's Keep River National Park which would extend it up to the WA border.

Western Australian and NT government conservation reserve initiatives and those proposed in the Ord Final Agreement have recently resulted in the nomination of six rangeland conservation areas, one of which is Pincombe Range, immediately adjacent to the Sorby Hills project area. The self-imposed development exclusion boundary provides a buffer between the proposed conservation reserve and the project area. Therefore there is unlikely to be appreciable impact to the adjacent or nearby conservation areas.

Principle 9 Native vegetation should not be cleared if the clearing of native vegetation is likely to cause deterioration in the quality of surface or underground water.

The proposal is not likely to be at variance to this Principle.

There are no recorded acid sulphate soils within the disturbance footprint and clearing is unlikely to result in an increased risk of salinity.

The area does not have any large rivers or creeks that will be impacted by the implementation of the project. Some minor surface water drainage lines will be impacted by the development of the project however these impacts are expected to be minimal and easily managed.

Disruptions will occur to surface flows as the establishment of the mine, tailings facility, roads and associated infrastructure will necessitate diverting natural drainage around these areas to ensure that clean waters from the adjacent environment are not contaminated by the development.

SMPL will implement surface water management techniques that will assist in reducing the risk of deterioration of surface water quality. In addition, SMPL will undertake a surface water sampling program as part of the construction and operational activities. With implementation of surface water and ground water management there is unlikely to be appreciable impact to surface or ground water.

Principle 10 Native vegetation should not be cleared if the clearing of native vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.

The proposal is not likely to be at variance to this Principle.

The region around Sorby Hills receives about 90% of its annual rainfall during the summer wet season, with torrential rain events often leading to wide-scale flooding. The project will involve the incorporation of flood management techniques to redirect surface water flows. Drainage design will incorporate natural drainage lines and prevent the pooling of surface water run-off.

It is unlikely that the proposed clearing will cause or exacerbate the incidence or intensity of flooding.

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6 APPENDICES

Appendix 1: Flora Survey Report

SORBY MANAGEMENT PTY LTD



SORBY HILLS PROPOSED SILVER LEAD ZINC MINE FLORA AND VEGETATION ASSESSMENT

SEPTEMBER 2011

Authors

Dr Chris Hancock and Dr Mitchell Ladyman

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This report was completed for Sorby Management Pty Ltd

KML11002 – Sorby Hills Biological Assessment Survey

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EXECUTIVE SUMMARY

A detailed flora and vegetation survey of approximately 1200ha, incorporating the Sorby Hills Silver, Lead and Zinc prospect and associated proposed infrastructure areas was undertaken for Sorby Management Pty Ltd in May and June 2011. A total of 334 taxa (species, subspecies and varieties) from 69 families and 201 genera were recorded in the course of the survey. No Declared Rare (Threatened) Flora species, pursuant to subsection 2 of section 23F of the *Wildlife Conservation Act (1950,)* were located during the survey. No plant taxa pursuant to section 179 of the *EPBC Act 1999* were located in the areas surveyed. Nine Priority 1 plants, two Priority 2 plants and one Priority 3 plant were recorded however, and up to three or four of the plants collected require further investigation to ascertain whether or not they are new (previously uncollected) species.

Eight vegetation units were recognised, none of which resembled any of the Threatened Ecological Communities (TECs) listed under the federal *Environment Protection and Biodiversity Conservation Act* 1999, nor any of the TECs listed by the Department of Environment and Conservation (2011b). However the vegetation of a number of small areas corresponded to the Priority 1 Priority Ecological Community (PEC) 'Monsoon vine thickets of limestone ranges' (Department of Environment and Conservation 2011c). Although not listed as a TEC or PEC, the lowland country accounting for most of the survey area forms part of the alluvial plain systems of the Ord and Weaber Plains and as such is considered to be among the rare features of the Victoria Bonaparte Bioregion.

Of the 31 introduced (weed) species recorded, three were listed as Priority 1 Declared Plants by the Department of Agriculture and Food (2011) for the Shire of Wyndham-East Kimberley. Any future work at this site will therefore require the implementation of measures to prevent the spread of these species beyond the site. One of the plants **Senna obtusifolia* is also classed as Priority 2, which means that any development plans for the survey area would need to include measures eradicate the **Senna obtusifolia* population.

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1. INTRODUCTION

1.1 INTRODUCTION AND SCOPE OF WORK

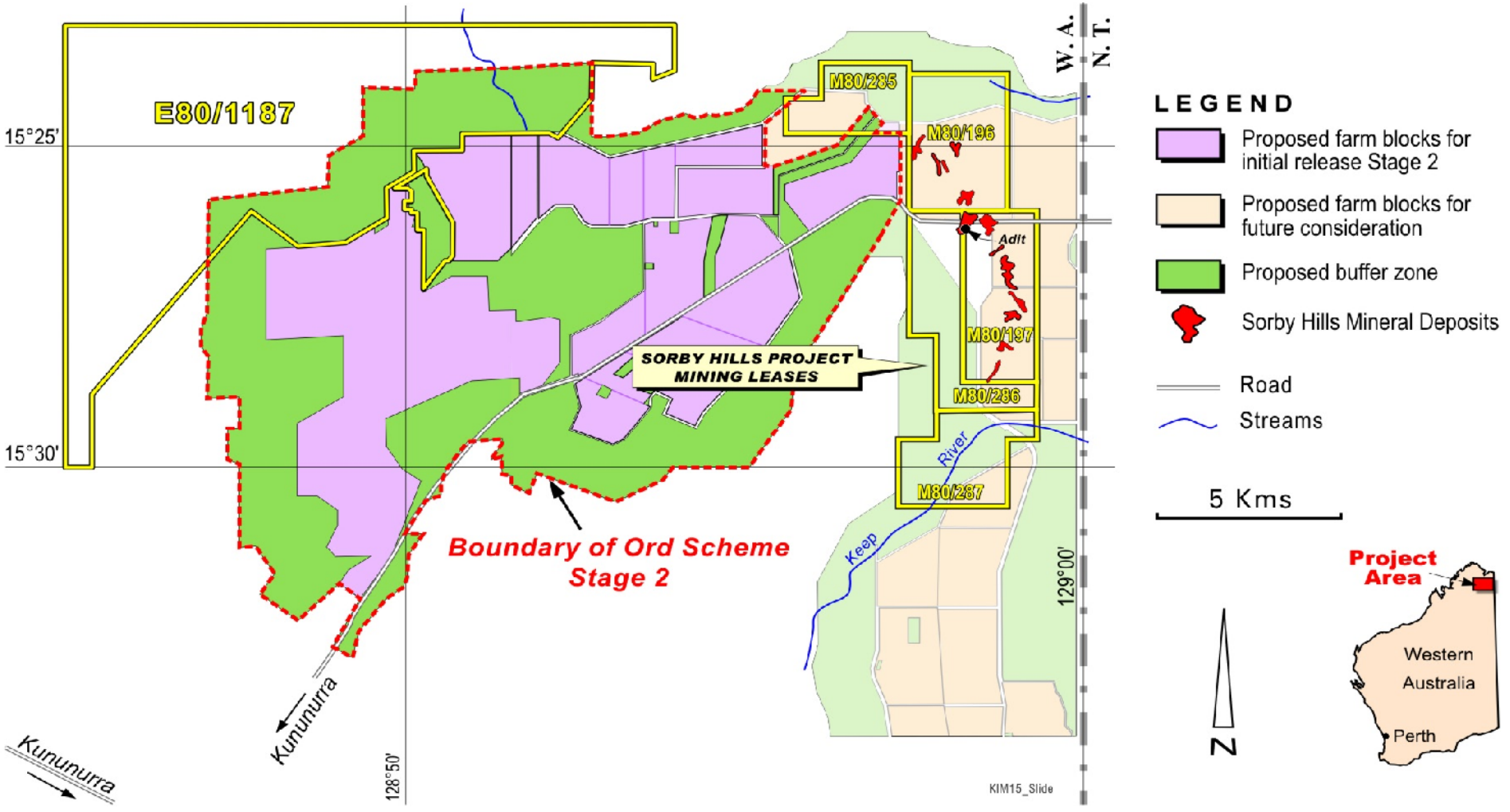
APM was engaged by Sorby Management Propriety Limited (SMPL) on 4 April 2011 to undertake the biological assessment surveys and environmental approvals for the Sorby Hills Silver Lead Zinc project (Sorby Hills). A general location map is provided in Figure 1. The results of the flora and vegetation survey undertaken in 2011 are reported herein (the project).

An extensive field flora and vegetation survey was carried out within mining tenements M80/197 and M80/286 (the project area). Specifically, the target areas over which the surveys were focussed were:

- Pods C, D, E and F on M80/197; and
- Site infrastructure on M80/286 which comprised;
    - Site office;
    - Run of Mine;
    - Processing Plant;
    - Workshop; and
    - Tailings facility.

The field assessment was designed in accordance with Guidance Statement 51 (EPA 2004) and Environmental Protection Authority (EPA) Position Statement No 3. (EPA 2002) and included:

- a desk-top investigation of the project area, including a review of on-line databases and reports available in the public domain;
- a review of matters of national environmental significance that are protected under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* that potentially occur within the vicinity of the project area;
- a discussion of the likely occurrence of conservation significant species listed under the *Wildlife Conservation Act 1950* in the project area;
- a review of the currently listed Priority Ecological and Threatened Ecological Communities of the Kimberley region to determine if these communities are present in the project area; and
- the identification of any environmental issues relating to flora and vegetation that may require the current proposed mine impact footprint to be altered.



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral NORTH	**Figure 1: General location map.**
Date: October 2011	Datum: GDA94 MGA Zone 52		

1.2 BACKGROUND AND SUPPORTING INFORMATION

The project area is located in the Victoria Bonaparte 1 sub-region of Western Australia, defined by Thackway and Cresswell (1995) as:

> "The Phanerozoic strata of the Bonaparte Basin in the north-western part are mantled by Quaternary marine sediments supporting Samphire – *Sporobolus* grasslands and mangal, and by red earth plains and black soil plains with an open savanna of high grasses. Plateau and abrupt ranges of Proterozoic sandstone, known as the Victoria Plateau, occur in the south and east, and are partially mantled by skeletal sandy soils with low tree savannas and hummock grasslands. In the south-east are limited areas of gently undulating terrain on a variety of sedimentary rocks supporting low snappy gum over hummock grasslands and also of gently sloping floodplains supporting *Melaleuca minutifolia* low woodland over annual sorghums. The climate is dry hot tropical, semi-arid summer rainfall. In the south (of the sub-region within Western Australia), red and black-soil plains with savanna woodlands, emergent quartz-sandstone ranges with tree-steppe over hummock grassland and limestone ranges with open-savanna vine thickets. The area of the Victoria Bonaparte 1 sub-region (the part of the sub-region is represented in Western Australia) is 1, 932, 467 ha."

The Biodiversity Audit of Western Australia (Dept. of CALM 2003) identifies a number of rare features of the Victoria Bonaparte regions. Only two are relevant to the Sorby Hills project and these are the alluvial plain system of the Ord and Weaber Plains and the potential for areas to support populations of Wild Rice.

The project area lies in the Gardner Botanical District within the Northern Botanical Province of Western Australia (Beard 1979). The vegetation of the Kimberley has been mapped and is accessible at http://savanna.cdu.edu.au/information/map_maker.html. The landscape supports hummock, tussock and bunch grasslands, shrublands, woodlands, riverine forest, rainforest patches and paperbark thickets along the margins of some water ways. The tropical savanna is diverse across the Kimberley, however insufficient comprehensive mapping has been carried out to discriminate savanna vegetation types on a fine scale across broad areas (McKenzie et al. 2009).

The recently published Ord Stage 2 EIS (Stratagen 2011) encapsulates a significant amount of work on the biological and non-biological attributes of the area and this information is available in the public domain. However, the biological components of these surveys are still dependent upon flora and fauna reporting undertaken more than 15 years ago.

2. METHODS

2.1 CONTRIBUTING AUTHORS

The strategy for the biological assessment of the Sorby Hills project was developed and managed by APM Principal Biologist Dr Mitch Ladyman.

The field flora and vegetation component of this survey and associated reporting was undertaken by Dr Chris Hancock, Ms Anna Price and Ms Corinne Chambers. Plant identifications were carried out by Kimberley expert botanist, Mr Russell Barrett.

2.2 SURVEY CONDITIONS

Conditions were ideal for the flora and vegetation survey. The survey was undertaken at the end of one of the wettest summer rainfall seasons on record.

The total average accumulated rainfall for February, March and April is 370.4 (Table 1). However, 854 mm had fallen in the three months prior to the current survey.

Table 1: Average Temperature and Rainfall Data for Kununurra (Bureau of Meteorology)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	36.4	35.5	35.4	35.5	32.9	30.5	30.3	33.6	36.4	38.3	38.8	38.0	35.1	21	1965 1986
Mean minimum temperature (°C)	25.2	24.9	24.1	21.4	19.1	15.9	15.0	17.4	20.8	23.7	25.4	25.7	21.6	21	1965 1986
Rainfall															
Mean rainfall (mm)	196.6	213.0	136.2	21.2	10.0	1.3	3.9	0.1	2.8	25.5	70.9	105.3	796.8	30	1962 1997
Decile 5 (median) rainfall (mm)	181.1	210.9	102.9	8.8	0.0	0.0	0.0	0.0	0.0	13.1	57.6	101.6	778.7	27	1962 1997
Mean number of days of rain ≥ 1 mm	10.4	10.6	7.2	1.8	0.7	0.2	0.2	0.1	0.3	1.9	4.1	6.9	44.4	27	1962 1997

2.3 SURVEY METHODOLOGY

2.3.1 FLORA

Plants may be accorded Rare or Priority status when they are known only from a small number of populations, and when at least some of those populations are deemed to be under threat. Declared Rare (Threatened) Flora are protected under section 23F of the *Wildlife Conservation Act 1950-1979,* and it is an offence to "take" Rare Flora without ministerial permission. Section 23F defines "to take" as "…to gather, pick, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means." Plants and ecological communities considered to have national conservation significance may also be listed under the *EPBC Act 1999,* and may not be damaged or destroyed without the permission of the Federal Minister for the Environment. Definitions of conservation codes for flora are provided in Appendix 1.

Species considered to be of national conservation significance are protected under the *EPBC Act 1999*. Under this Act, activities that may have a significant impact on a species of national conservation significance must be referred to the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) for assessment.

2.3.2 FLORA AND VEGETATION SURVEY

This biological assessment survey fulfils the criteria for a Level 2 survey according to EPA Guidance Statement No. 51 on terrestrial flora and vegetation surveys for environmental impact assessment (EPA, 2004). It includes a 'desktop' review of flora and ecological communities of conservation significance from the study area, and a detailed survey that comprised sampling of flora, vegetation classification and vegetation condition assessment.

The survey area is roughly square and approximately 1200ha in area. It is comprised of parts of tenements M80/197 and M80/206.

2.3.2.1 DESKTOP ASSESSMENT

Prior to commencing the fieldwork, a number of database searches were undertaken. A search of the DEC's Threatened (Declared Rare) Flora database and the Western Australian Herbarium Specimen database were carried within a 45 km radius of a point in the middle of the project area (128° 58' 18'' E, 15° 27' 25'' S). A search was also undertaken using the DEC's online search tool, NatureMap (DEC, 2011d) for any Threatened or Priority flora within a 40 km radius of the same point. The results of the searches presented in Appendices 2 and 3 respectively. Together the database searches produced one Threatened (Declared Rare) Flora (DRF) species and 55 Priority Plants for the area. At the Western Australian Herbarium,

specimens of these plants were examined, described and photographed. The pictures and descriptions were used to aid recognition in the field.

An online search for matters of national significance and matters protected by the *EPBC Act 1999*, e.g. heritage areas, Register of National Estate, Ramsar and important wetlands was undertaken using the Protected Matters Search Tool (DSEWPC, 2011). The radial search covered the area to a distance of 10km from the centre of the survey area (128° 58' 18'' E, 15° 27' 25'' S). The search results are included as Appendix 4.

The conservation value of the area, and therefore the potential future impacts, were also assessed in the context of the biogeographical regionalisation of Australia (Thackway and Cresswell, 1995). Bioregions are large, geographically distinct areas of land with common characteristics such as physiography, climate, vegetation and animal communities. They represent lowest order of resolution between different flora and fauna habitats. There are 85 bioregions and 403 sub-regions in Australia, and they are described in the Australian Natural Resources Atlas (Australian Government, 2011) and the Biodiversity Audit of Western Australia (DEC, 2002). A description of the relevant bioregion (Victoria Bonaparte) was read in order to identify regional and local issues of conservation significance.

The study area was also assessed in the context of vegetation mapping programs carried out by Beard (1979) and Fox et al. (2001), as well as the Rangeland Land System Mapping for Western Australia dataset (Department of Agriculture and Food 2009).

2.3.2.2 FIELDWORK

The fieldwork was undertaken from the 10th to the 17th May 2011, and the 26th May to the 3rd June 2011 with 43 sampling sites being accessed by foot, quad bike and 4WD vehicle.

Prior to commencing the fieldwork, most sampling points were selected based on aerial photographs supplied by SMPL such that the entire study area and all structural vegetation types were covered. Some points were moved during the course of the study and extra sites were added in order to better sample certain vegetation types.

Each sampling site consisted of a 50m x 50m quadrat, except where plant communities were restricted to narrower areas such as a drainage lines or ridge tops. At each sampling location the following details were recorded:

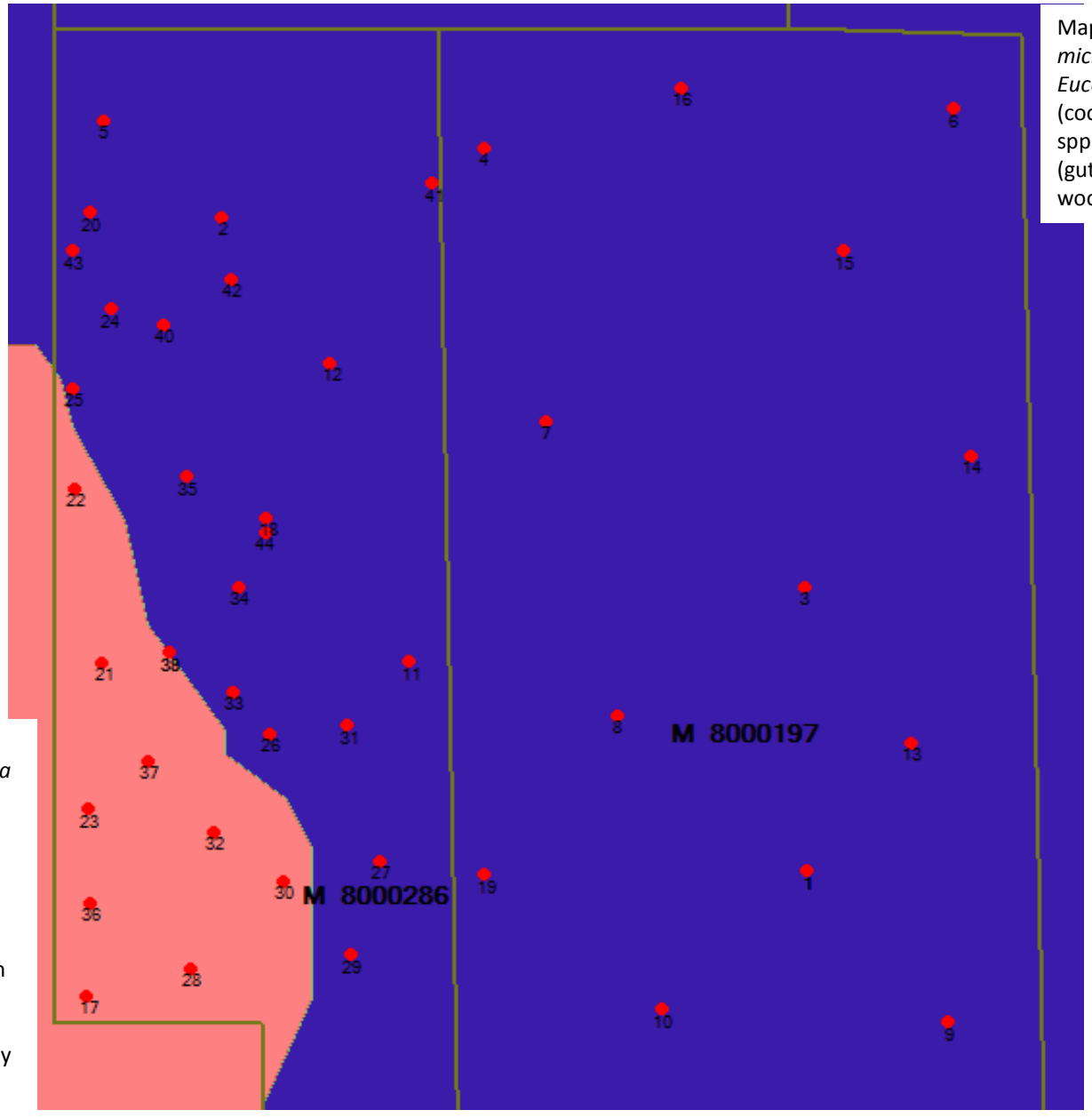
- soil type and colour
- geographic co-ordinates (GDA94, MGA Zone 52L)
- percentage litter cover
- percentage bare ground

- amount and type of any outcropping
- landscape unit
- aspect
- time since fire
- height and percentage cover of each stratum
- height and percentage cover of each vascular plant species
- vegetation condition according to the modified Keighery scale (Table 2)

Table 2: Vegetation Condition Rating Scale (adapted from Keighery 1994)

Vegetation Condition	Description
E - Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
VG - Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
G - Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
P - Poor	Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
VP - Very Poor	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.
D - Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

Plants with unknown or uncertain identities were collected and pressed on site; these plants were compared with confirmed specimens housed at the Western Australian Herbarium to ensure correct identifications. Sampling point locations are listed in Appendix 5, and shown on Figure 2. The environmental data are summarised in Appendix 6.



Map Unit C10. '*Eucalyptus microtheca* (coolibah) or *Eucalyptus gymnoteles* (coolibah) and/or *Eucalyptus* spp. +/- *Excoecaria parvifolia* (gutta percha) grassy low woodland.'

Map Unit D14 '*Eucalyptus tetrodonta* (Darwin stringybark) and/or *Eucalyptus miniata* (Darwin woollybutt) +/- *Corymbia* spp. +/- *Livistona* spp. (fan palms) woodland with a ground layer of tussock grasses and *Triodia bitextura* (curly spinifex)'.

Auth: M Ladyman	Project: SMPL Sorby Hills	APM animal plant mineral NORTH	**Figure 2: Sampling Point Locations over Tropical Savanna CRC Vegetation Mapping**
Date: October 2011	Datum: GDA94 MGA Zone 52		

2.3.2.3 FLORISTIC DATA ANALYSIS

Classification of plant communities was carried out based on a species by site matrix with singletons removed and foliage projective cover values converted to the six point Braun-Blanquet scale. From the options available in the multivariate analysis package PC-ORD (MJM Software Design), Ward's method of hierarchical grouping was chosen using relative Euclidian distance (Ward 1963). This is one of two methods recommended by McCune and Grace (2002) as a way of avoiding space distortion and chaining among samples.

PC-ORD was also used to estimate the proportion of the flora sampled, using the first order jackknife estimator (Heltshe and Forrester 1983, Palmer 1990), second order jackknife estimator (Burnham and Overton 1979, Palmer 1991) and Chao2 estimators (Chao 1984, 1987).

3. RESULTS

3.1 DESKTOP ASSESSMENT

3.1.1 REGIONAL REPRESENTATION

3.1.1.1 IBRA BIOREGIONS

Mapping for the Interim Biogeographic Regionalisation for Australia (IBRA version 6.1) programme placed the Sorby Hills project area in the Victoria Bonaparte Bioregion. This bioregion comes under the Tropical and Subtropical Grasslands, Savannas and Shrublands Ecoregion which stretches across northern Australia into northern NSW. The Victoria Bonaparte Bioregion continues into the Northern Territory as far as Bradshaw (Department of Sustainability, Environment, Water, Population and Communities 2011a). Within the Victoria Bonaparte Bioregion the vegetation over lowland parts of the survey area has been mapped as 'Tussock grasslands' while upland areas come under 'Tropical Eucalyptus woodland/grasslands'. Tussock grasslands covered an estimated 631,088ha (8.7%) of the bioregion prior to European settlement. By about 1997 this area was little changed at 631,032 ha (8.7%). Tropical Eucalyptus woodland/grasslands covered an estimated 4,696,792 (64.6%) of the bioregion prior to European settlement. By about 1997 this area had been slightly reduced to 4,678,368 (64.4%) (Australian Government, 2011).

Rare features of the Victoria Bonaparte Bioregion include:

- Extensive mangrove community of the False Mouths of the Ord.
- Ramsar listed wetlands of the Ord Floodplain and Lake Kununurra.
- Cambridge Gulf and associated river systems.
- 'Wet' tropical river of the lower Ord River since damming.
- The man-made wetlands of Lake Kununurra.
- Alluvial plain systems of the Ord and Weaber Plains.
- Black butcherbird population associated with the mangrove communities of the False Mouths of the Ord.
- The Devonian reef system of Ningbing Range with its particular vegetation associations (rainforest patches) and extensive cave systems.
- The coastal plain heading from Cape Domett to Northern Territory border. This is comprised of salt flats, grasslands, coastal creeks, rainforests on dune ridges and rainforests associated with mound springs.

- A large flatback turtle rookery at Cape Domett.
- Very large Miniopterus schreibersii roost site within the gorges of the Cockburn Range.
- Fox and rabbit free and essentially uninhabited.

The low lying portion of the Sorby Hills survey area would be included under the alluvial plain systems of the Ord and Weaber Plains.

In addition, there are geological elements in the project area that are very similar to the Ningbing Range. Small pockets of tropical vine thicket were located in the project area and there is evidence of cavernous networks with the rock outcrops.

3.1.1.2 BEARD'S VEGETATION SURVEY OF WESTERN AUSTRALIA

Earlier mapping by Beard (1979) included the survey area in the Cambridge Gulf Lowlands Physiographic Province within the larger Ordland Physiographic Division. Ordland includes much of the east Kimberley from Joseph Bonaparte Gulf south to the Tanami Desert. The Cambridge Gulf Lowlands comprise the northern part of Ordland, stretching from the West Arm of Admiralty Gulf to the Northern Territory border. Beard included the Cambridge Gulf Lowlands in his Gardner Botanical District, a large area between Collier Bay and the Northern Territory encompassing both the Northern Kimberley and Victoria Bonaparte bioregions. Within the Sorby Hills survey area he recognized two vegetation types:

1. High grass savanna of scattered low *Bauhinia cunninghamii* and *Eucalyptus microtheca* over a mid-dense (30-70%) cover of bunch grasses esp. *Dichanthium fecundum, Sorghum* spp. and *Chrysopogon* spp. on cracking clay soils. This vegetation was restricted to a few hundred square kilometres of country north of the Ord River irrigated area and continuing eastwards across the Northern Territory border.

2. Upland high grass savanna of open (10-30%) *Corymbia dichromophloia* and *Eucalyptus miniata* over a mid-dense (30-70%) cover of bunch/hummock grasses esp. *Triodia* spp. and *Sorghum* spp. Beard found this general vegetation type to be very widespread across the north Kimberley, and mapped most of the Gardner Botanical District under it.

3.1.1.3 THE VEGETATION OF THE AUSTRALIAN TROPICAL SAVANNAS

In 2001 the Queensland Environmental Protection Agency published a map and technical report bringing together vegetation mapping programs from Queensland, the Northern Territory and Western Australia to produce a consistent map for all of northern Australia (Fox *et al*. 2001). The report grouped and arranged northern Australian vegetation types into a three tiered hierarchy. The 439 vegetation associations (units) from the various state and territory surveys were compared and collated to produce 249 generalised units applicable across state and territory borders. These units were sorted into 125 alliances and sub-alliances, which were in turn grouped into 26 'broad vegetation groups'.

Under the Fox *et al*. (2001) system the vegetation of the Sorby Hills survey area was divided into the two alliances (or map units) described below:

1. Map Unit C10. '*Eucalyptus microtheca* (coolibah) or *Eucalyptus gymnoteles* (coolibah) and/or *Eucalyptus* spp. +/- *Excoecaria parvifolia* (gutta percha) grassy low woodland.' This alliance occurs on gently sloping floodplains and backplains, often with braided channels. Soils are generally light to heavy grey and brown clays and cracking clays, gradational mottled yellow structured clay soils and some loams. Fox *et al*. (2001) included under Unit C10 patches of land from the mouth of the Fitzroy River south of Derby east to the Normanby River in northern Queensland. The unit accounts for a total of 18,551 km^2 and incorporates twelve vegetation types from previous mapping projects including eight from Beard (1979).

   The alliance represented by Map Unit C10 was further broken down into associations. In the survey area the association was recorded as Map Unit C21, though this association was not described in the report.

   The area of land mapped as primarily Map Unit C21 within Map Unit C10 across the tropics totalled 1,085,228 Ha. The portion of the Sorby Hills study area mapped as Map Unit C21 totalled about 1045 Ha.

2. Map Unit D14 '*Eucalyptus tetrodonta* (Darwin stringybark) and/or *Eucalyptus miniata* (Darwin woollybutt) +/- *Corymbia* spp. +/- *Livistona* spp. (fan palms) woodland with a ground layer of tussock grasses and *Triodia bitextura* (curly spinifex)'. This alliance occurs on undulating plains with deep soils on dissected and remnant plateaus over Mesozoic sandstone and laterite. In some parts the soils are shallower and the laterite becomes exposed, and there are some occurrences on broken sandstone plateaus with shallow sandy soil. The soils include red earthy sands with ironstone gravel, red clay-loam and sandy red earths that may have ironstone gravel. Fox *et al.* (2001) included under Unit D14 patches of land from Cape Leveque at the entrance to King Sound north of Broome east to the Wilton River in Arnhem Land. The unit accounts for a total of 20,006 km^2 and incorporates six vegetation types from previous mapping projects, including three from Beard (1979).

The alliance represented by Map Unit D14 was further broken down into associations. In the survey area the association was recorded as Map Unit D26 - *'Eucalyptus brevifolia* (snappy gum) low open- woodland with *Triodia* spp. (spinifex) hummock grass or sometimes a hummock grassland without trees'.

The area of land mapped as Map Unit D26 within Map Unit D14 across the tropics totalled 1,528,117 Ha. The portion of the Sorby Hills study area mapped as Map Unit D26 totalled about 120 Ha.

3.1.1.4 RANGELAND LAND SYSTEM MAPPING

The Rangeland Land System Mapping for Western Australia dataset (Department of Agriculture and Food 2009) was consulted to further facilitate a broad assessment of the regional representation of vegetation that occurs in the study area. A land system is defined as 'an area or group of areas, throughout which there is a recurring pattern of topography, soils and vegetation' (Christian and Stewart 1953). The two land systems included in the study area are:

1. **Pinkerton – Hills, ranges and plateaux with eucalypt woodlands and tall grasses.** Rugged plateaux, hills and ridges on sedimentary rock supporting stringybark-bloodwood woodland over upland tall grass. This land system covers 1,537,195 ha of land in Western Australia. The vegetation alliance Unit D14 (Fox *et al*. 2001) was found on this land system.

2. **Ivanhoe – Alluvial plains with tussock grasslands.** Many small to medium areas of gently sloping alluvial "black soil" plains with some timbered "red" soil in the central and northern parts of the area. This land system covers 125,825 ha of land in Western Australia. The vegetation alliance Unit C10 (Fox *et al*. 2001) was found on this land system.

3.2 DESKTOP INTERPRETATION

3.2.1 THREATENED ECOLOGICAL COMMUNITIES

In the Kimberley region there are eleven recognised Threatened Ecological Communities (TECs), namely:

- Roebuck Bay mudflats. Species-rich faunal community of the intertidal mudflats of Roebuck Bay;

- Monsoon thickets. Monsoon (vine) thickets on coastal sand dunes of Dampier Peninsula;

- Theda Soak. Assemblages of Theda Soak rainforest swamp;
- Walcott Inlet. Assemblages of Walcott Inlet rainforest swamps;
- Roe River. Assemblages of Roe River rainforest swamp;
- Dragon Tree Soak. Assemblages of Dragon Tree Soak organic mound spring;
- Bunda Bunda. Assemblages of Bunda Bunda organic mound spring;
- Big Springs. Assemblages of Big Springs organic mound springs;
- North Kimberley mounds. Organic mound spring sedgeland community of the North Kimberley Bioregion;
- Black Spring. Black Spring organic mound spring community; and
- Mandora Mounds. Assemblages of the organic springs and mound springs of the Mandora Marsh area.

The vegetation types of the survey area did not resemble any Kimberley TECs.

3.2.2 PRIORITY ECOLOGICAL COMMUNITIES

There are sixteen Priority Ecological Communities (PECs) listed for the Kimberley region:

- Perched spring-fed peat-based swamps on hillslopes of the Durack Range area
- Assemblages of Point Spring and Long Swamp rainforest swamps
- Assemblages of the wetlands associated with the organic mound springs on the tidal mudflats of the Victoria-Bonaparte Bioregion
- Monsoon vine thickets of limestone ranges
- *Oryza australiensis* (wild rice) grasslands on alluvial flats of the Ord River
- Inland Mangrove (*Avicennia marina*) community of Salt Creek
- Plant assemblages on vertical sandstone surfaces
- Invertebrate community of Napier Range Cave
- Invertebrate assemblages of the cliff foot springs around Devonian reef system
- Dwarf pindan heath community of Broome coast
- *Corymbia paractia* dominated community on dunes

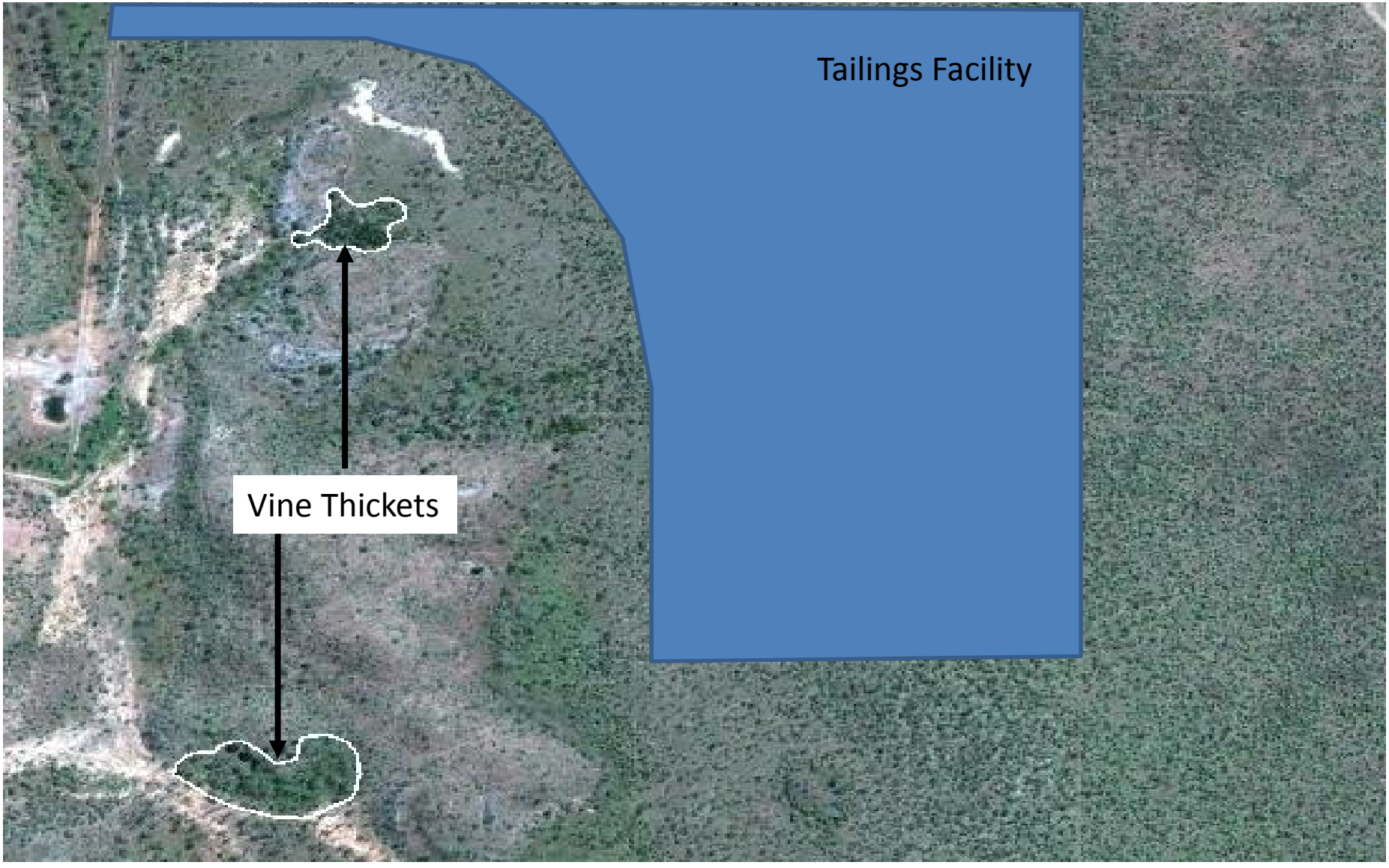
- Invertebrate community of Tunnel Creek
- Camaenid land snails of limestone hills of the Jeremiah and Ningbing Ranges
- Assemblages of Disaster Bay organic mound springs
- Assemblages of Lolly Well Springs wetland complex
- Nimalaica clay pan community

The project area supports a number of small pockets of vegetation that could be classified as the PEC 'Monsoon vine thickets of limestone ranges'. This occupies about 2 hectares of country centred around the point 496623mE; 8291249mN (MGA94 Zone 52L) (Figure 3).

3.2.3 PROTECTED MATTERS SEARCH TOOL

The Protected Matters Search Tool did not return any botanical or geographical 'matters of national environmental significance' nor 'other matters protected by the EPBC Act' close to the survey area. It did return one place that's on the Register of the National Estate. This was the Weaber Range sites complex, an 'indigenous place' in the Northern Territory. The search also produced two state and territory reserves close to the project area. These were the Point Spring Nature Reserve about 8km north-west of the survey area, and some proposed extensions to the Northern Territory's Keep River National Park which would extend it up to the Western Australian border (DSEWPC, 2011).

The Protected Matters Search Tool listed four invasive plant species as being likely to occur in the vicinity of the study area: **Brachiaria mutica* (Para grass), **Cenchrus ciliaris* (Buffel grass), **Cryptostegia grandiflora* (Rubber vine) and **Parkinsonia aculeata* (Jerusalem thorn).



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral NORTH	**Figure 3: Monsoon Vine Thickets of Limestone Ranges.**
Date: October 2011	Datum: GDA94 MGA Zone 52		

3.2.4 THREATENED AND PRIORITY FLORA

Searches by the DEC Threatened Species and Communities Branch and an in-house search using the NatureMap tool identified one Threatened (DRF) species, *Typhonium* sp. Kununurra (A.N. Start ANS 1467). This plant is only known from one population, which is about 35 km south-west of the survey area on the western side of the Ord River. The searches also produced 55 Priority plant taxa within 45km of the study area. Threatened and Priority Flora are listed in Table 3.

Table 3: Threatened and Priority Flora Collected within 40 – 45km of the Survey Area

Priority Code	Species	Habitat	Database		
			Declared Rare & Priority Flora List	WA Herbarium Specimen	NatureMap (40km)
T	*Typhonium* sp. Kununurra (A.N. Start ANS 1467)	Dark grey clay, black soil. Sites which are waterlogged in summer and inundated after rain.	*	*	*
1	*Bonamia brevifolia*	Black cracking clay. Plains.	*		
1	*Calycopeplus collinus*	Limestone, sandstone. Gorges, ridges.	*	*	*
1	*Cyperus digitatus*	Waters' edge.		*	
1	*Desmodium flagellare*	Cracking clay.	*	*	*
1	*Echinochloa kimberleyensis*	Black soils. Swamps.		*	*
1	*Enteropogon minutus*	Heavy black soil. Gentle slopes, river flats, creek beds.	*	*	*
1	*Fuirena nudiflora*	Sand. Swamps, creek beds.	*		
1	*Goodenia brachypoda*	Red sandy loam.		*	*
1	*Goodenia durackiana*	Black clay. Grassland.	*	*	*
1	*Goodenia malvina*	Cracking black clay. Seasonally wet areas.	*	*	*
1	*Goodenia strangfordii*	Heavy & seasonally wet soils.	*		
1	*Helicteres dentata* var. *procumbens*	-	*		
1	*Heliotropium alcyonium*	-	*	*	*
1	*Heliotropium cupressinum*	Stony sandy soils, sandstone.		*	*
1	*Heliotropium tachyglossoides*	Cockatoo sand.	*	*	

Priority Code	Species	Habitat	Database		
			Declared Rare & Priority Flora List	WA Herbarium Specimen	NatureMap (40km)
1	*Hullsia argillicola*	Heavy clay soils. In seasonally inundated regions eg swamps, cracking clay plains, paddocks.	*	*	
1	*Ipomoea gracilis*	Black cracking clay or black sand. Irrigated areas.	*	*	*
1	*Ipomoea racemigera*	-	*		
1	*Ipomoea* sp. Kalumburu (A.A. Mitchell 3869B)	Black soil. Floodplain.	*	*	*
1	*Jacquemontia* sp. Keep River (J.L. Egan 5051)	-	*		
1	*Lepturus copeanus*	Soil pockets in cracks in dolomite. Hills.	*	*	*
1	*Micraira* sp. Purnululu (M.D. Barrett & R.L. Barrett 1507)	-		*	*
1	*Polygala* sp. Rhianthoides shoulders (M.H. Andrews 398)	-	*	*	*
1	*Solanum pugiunculiferum*	Heavy soils. Margins of seasonal wetlands or lagoons.	*	*	
1	*Sphenoclea zeylanica*	Grey clay to black peaty clay. Monsson thickets, mound spring.	*	*	*
1	*Triodia fissura*	Quartz-sandstone. Growing in narrow fissures on steep or near vertical rock faces.	*		
1	*Triodia prona*	Lower slopes of sandstone mountain range.	*		
1	*Triodia racemigera*	Sandstone. Steep rocky slopes, crevices, cliffs & ridges.	*	*	*
1	*Triodia triticoides*	Rocky sandstone & limestone hillslopes.	*	*	*
1	*Utricularia tubulata*	Ephemeral swamps.	*	*	
1	*Zornia areolata*	-	*	*	
2	*Blumea pungens*	Sandstone hills & plateaus.		*	
2	*Dolichandrone filiformis*	Sandstone, sandy soils.	*	*	*
2	*Eucalyptus ordiana*	Skeletal soils over sandstone or quartzite. Steep rocky outcrops.	*		

Priority Code	Species	Habitat	Database		
			Declared Rare & Priority Flora List	WA Herbarium Specimen	NatureMap (40km)
2	*Fimbristylis laxiglumis*	Black clay.		*	*
2	*Melaleuca viminalis*	-	*		
2	*Platysace saxatilis*	Sand, sandstone. Valleys and hills, in crevices in the rock face, on sides of gorges, on cliffsides.	*	*	
2	*Solanum carduiforme*	Clayey sand or sandstone.		*	*
2	*Zeuxine oblonga*	In a bog near springs under a closed canopy rainforest.	*	*	*
3	*Acacia jasperensis*	Sandstone outcrops.	*	*	
3	*Acacia richardsii*	Sandstone. Hills, creek beds, rocky areas.	*	*	*
3	*Brachychiton tuberculatus*	Red or yellow sand. Undulating plains.	*	*	*
3	*Eleocharis ochrostachys*	Swamps.		*	
3	*Eragrostis schultzii*	Often in low-lying habitats.	*		
3	*Euphorbia stevenii*	Clay, sandy soils.	*	*	*
3	*Fuirena incrassata*	Sand, sandy clay. Swamps, creek beds, claypans, semi-saline lakes.			*
3	*Goodenia purpurascens*	Clay, mud. Swamps & seasonally wet depressions.		*	*
3	*Goodenia sepalosa* var. *glandulosa*	Red sand or loam.	*		
3	*Phragmites karka*	-	*	*	*
3	*Psilotum nudum*	Sandstone. Damp shaded rock walls or ledges.			*
3	*Schoenus punctatus*	Watercourses.			*
3	*Stylidium prophyllum*	Sandy, black silty or clayey sandy soils, loam. Seasonally wet floodway depressions & seepage areas.	*		
3	*Utricularia muelleri*	Seasonal swamps.	*	*	
3	*Whiteochloa capillipes*	-	*	*	*
4	*Ficus lilliputiana*	Sandstone. Rocky sites.	*	*	

3.3 FIELD SURVEY ASSESSMENT AND INTERPRETATION

3.3.1 FLORA

A total of 334 taxa (species, subspecies and varieties) from 69 families and 201 genera were recorded in the course of the survey. Representation was greatest among the Fabaceae (53 taxa), Poaceae (52 taxa), Cyperaceae (24 taxa) and Malvaceae (22 taxa) families. A summary of vascular plant taxa by family is provided in Appendix 7 and by site and percentage cover in Appendix 8.

3.3.1.1 PLANTS OF CONSERVATION SIGNIFICANCE

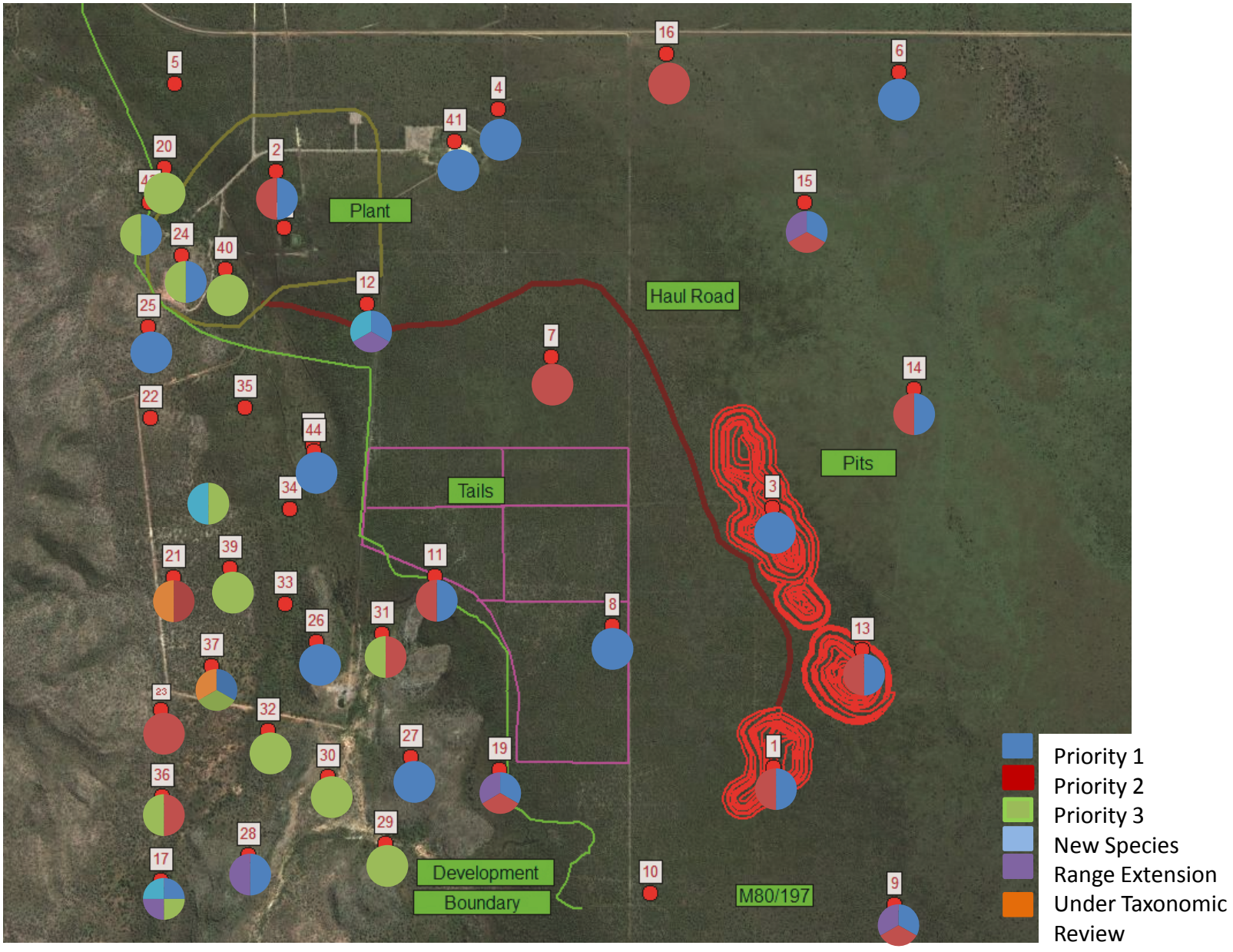
No Declared Rare Flora species, pursuant to subsection 2 of section 23F of the *Wildlife Conservation Act (1950)* were located during the survey. No plant taxa pursuant to section 179 of the *EPBC Act 1999* were located in the areas surveyed. Several plants of conservation interest were collected in the course of the survey however. These included Priority taxa, possible new species, and plants found outside their previously known ranges. The locations of these specimens are shown in Figure 4, with GPS locations given in Appendix 9. The species are discussed in the following sections with reference to their known distributions according to *Florabase*.

3.3.1.1.1 PRIORITY FLORA

1. *Croton arnhemicus* (P1). The Western Australian Herbarium has two collections of this plant, one from the Carson escarpment just west of the Drysdale River National Park in the Northern Kimberley Bioregion, and the other from Three Mile Valley 3.5 km east of Wyndham in the Victoria Bonaparte Bioregion. Within the survey area it was found in two quadrats in Unit W1 and W4 vegetation.

2. *Diospyros calycantha* (P1). The Western Australian Herbarium has only one collection of this plant, from the Mitchell Plateau in the Northern Kimberley Bioregion. The new record from the Sorby Hills project area represents a significant range extension. Within the survey area it was found in four quadrats in Unit S1, W1, W2 and W5 vegetation.

3. *Fimbristylis pachyptera* (P1). The Western Australian Herbarium has three collections of this plant, one from Eva Creek, 100km north of Fitzroy Crossing, and the other two from Mitchell Plateau area – all in the Northern Kimberley Bioregion. Within the survey area it was found in two quadrats, both in Unit W2 vegetation.



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral	**Figure 4: Flora survey sites as reference points for flora species of conservation significance**
Date: October 2011	Datum: GDA94 MGA Zone 52	NORTH	

4. *Goodenia byrnesii* (P1). The Western Australian Herbarium has nine collections of this plant, from nine locales across the Kimberley, namely: the Broome Peninsula and Mount Anderson both in the Dampierland Bioregion, Beverley Springs Homestead in the Northern Kimberley Bioregion, Ivanhoe Station in the Victoria Bonaparte Bioregion and Argyle Downs Station in the Ord Victoria Plain Bioregion. Within the survey area it was collected opportunistically from a limestone hill (Unit W2 vegetation).

5. *Goodenia durackiana* (P1). The Western Australian Herbarium has three collections of this plant, one from near the Beverley Springs Station Homestead in the Northern Kimberley Bioregion, one from the headwaters of the Ord River in the Central Kimberley Bioregion and one from the Kimberley Research Station north of Kununurra in the Victoria Bonaparte Bioregion. Within the survey area it was found in nine blacksoil clay quadrats in Unit S1 and W5 vegetation.

6. *Goodenia malvina* (P1). The Western Australian Herbarium has ten collections of this plant from four locales, namely: near the Beverley Springs Homestead in the Northern Kimberley Bioregion, the headwaters of the Ord River in the Central Kimberley Bioregion, the blacksoil plains north of Kununurra and the Weaber Plain a few kilometres west of the survey area – both in the Victoria Bonaparte Bioregion. Within the survey area it was found in four blacksoil clay quadrats in Unit S1, W5 and W6 vegetation.

7. *Hydrolea zeylanica* (P1). The Western Australian Herbarium has just one collection of this plant, from near the Glenelg River in the Northern Kimberley Bioregion. The new record from the Sorby Hills project area represents a significant range extension. Within the survey area it was found in just one quadrat in Unit W5 vegetation.

8. *Jacquemontia* sp. Keep River (J.L. Egan 5051) (P1). The Western Australian Herbarium has five collections of this plant from four well separated populations across the Kimberley from Koolan Island in the Central Kimberley Bioregion, to Stockyard Creek Bay in the Northern Kimberley Bioregion, to west of Kununurra and Ragged Range in the Victoria Bonaparte Bioregion. Within the survey area it was found in two quadrats in Unit W2 vegetation.

9. *Polygala* sp. Rhianthoides shoulders (M.H. Andrews 398) (P1). The Western Australian Herbarium has one collection of this plant, from the Weaber Plain about 17 km south-west of the survey area in the Victoria Bonaparte Bioregion. Within the survey area it was found in one quadrat in Unit S1 vegetation.

10. *Fimbristylis laxiglumis* (P2). The Western Australian Herbarium has one collection of this plant, from the Ord River Plain about 13km north of Kununurra in the Victoria Bonaparte Bioregion, but has also been collected across the Northern Territory border. Within the survey area it was found in ten blacksoil clay quadrats in Unit S1 and W5 vegetation.

11. *Minuria macrorhiza* (P2). The Western Australian Herbarium has fifteen collections of this plant from ten locales across the Northern Kimberley, Central Kimberley Bioregion and the Victoria Bonaparte Bioregions. Within the survey area it was found in four quadrats in Unit W1 and W4 vegetation.

12. *Eragrostis schultzii* (P3). The Western Australian Herbarium has two collections of this plant, one from the Drysdale River in the Northern Kimberley Bioregion, and the other from near the Northern Territory border 36 km south-east of Kununurra in the Victoria Bonaparte Bioregion. Within the survey area it was found in thirteen quadrats in Unit F1, W1, W2, W3 and W4 vegetation.

3.3.1.1.2 POSSIBLE NEW SPECIES

The collection included three plants considered by Mr Russell Barrett to possibly be new species. These were: *Fimbristylis* aff. *carolinii , Hibiscus* aff. *calcicola* and *Spermacoce* aff. *leptoloba.* In addition, the name *Polygala triflora* is likely to recognised in Australia following the re-designation of specimens held at various Australian herbariums, including the two collected during the Sorby Hills survey (R. Barrett, pers. comm.).

3.3.1.1.3 RANGE EXTENSION

Plants which are not unusual may nevertheless be considered to have conservation significance if their presence at a particular location is "...at the extremes of range, recently discovered range extensions, or isolated outliers of the main range." (EPA 2004).

Three plants from the Sorby Hills survey qualified as significant under this criterion: *Diospyros calycantha* (P1), *Hydrolea zeylanica* (P1) and *Fimbristylis* cf. *dichotoma* (desert form). The first two plants already had conservation significance as Priority taxa, while *Fimbristylis* cf. *dichotoma* (desert form) while not necessarily unusual had not been found in this area before.

3.3.1.2 WEEDS

Thirty-one introduced (weed) species were recorded (see Appendices 7). Three of these were listed by the Department of Agriculture and Food (2011) as Declared Plants for the Shire of Wyndham-East Kimberley. These were **Senna obtusifolia, *Sida acuta* and **Sida cordifolia*. The locations at which Declared Plants were recorded are given in Table 4.

Table 4: Site Location of Declared Plants

Declared Plant	Location
* *Senna obtusifolia* (Sicklepod, Javabean)	498126mE; 8292996mN (MGA94, Zone 52L)
**Sida acuta* (Sida)	Widespread, especially in vegetation Units F1, W1, W3 and W4
**Sida cordifolia* (Sida)	Widespread, especially in vegetation Units F1, W1, W3 and W4

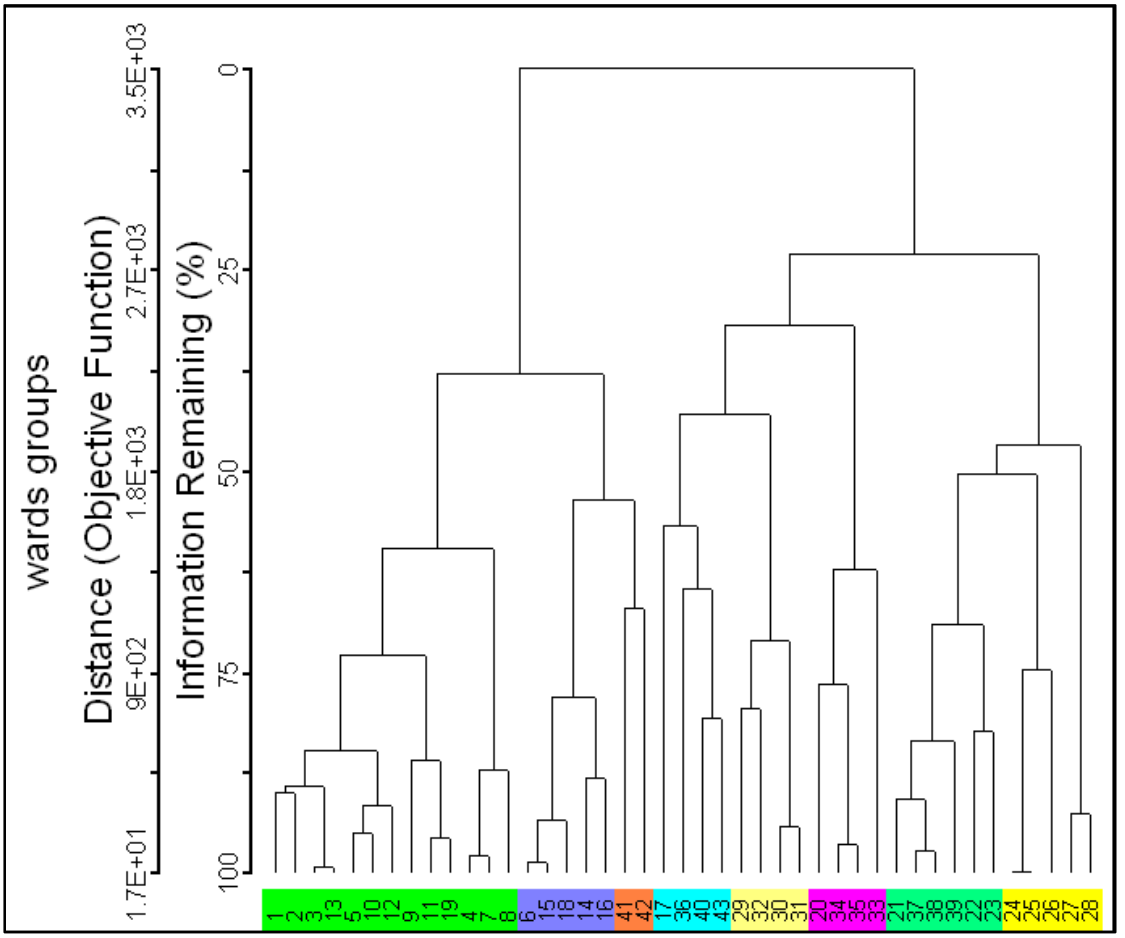
3.3.2 VEGETATION

3.3.2.1 VEGETATION UNITS (COMMUNITY TYPES)

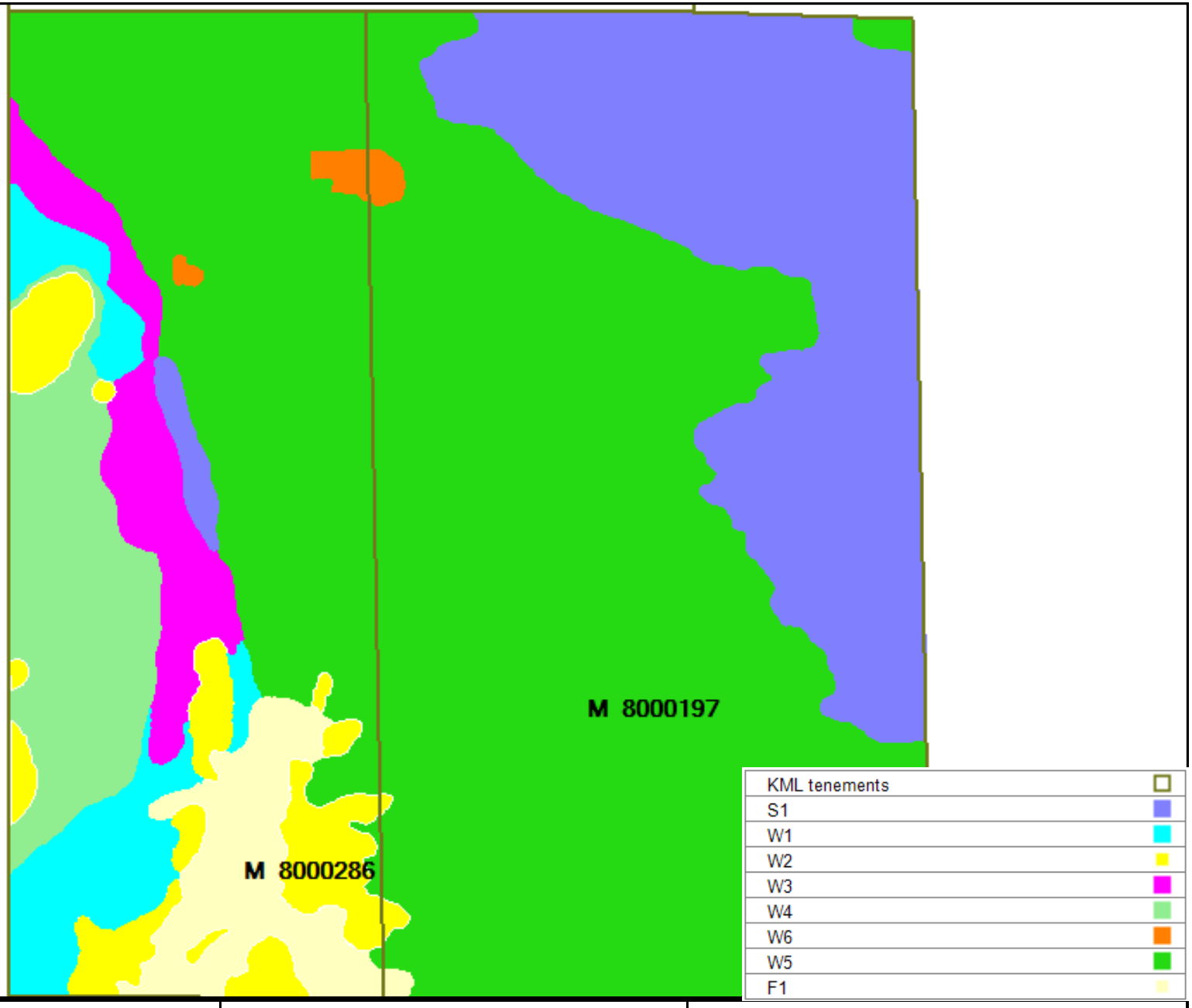
The vegetation of the survey area encompassed a range of community types related to landscape, soils and disturbance. Using Ward's method, eight vegetation units were recognized – one Forest, one Shrubland and six Woodland units. A dendogram showing groupings of sampling sites into vegetation units is provided in Figure 5, and the distributions of vegetation units across the survey area are presented in Figure 6.

Figure 5: Grouping of Sites into Vegetation Units by Ward's Method

Vegetation units from left to right are: W5 (lime green), S1 (lilac), W6 (orange), W1 (blue), F1 (cream), W3 (pink), W4 (green), W2 (yellow)



The vegetation units are described below using National Vegetation Information System (NVIS) structural formation terminology (ESCAVI 2003). SD refers to the standard deviation of species richness per site.



Auth: T.Smith	Project: SMPL Sorby Hills	apm animal plant mineral NORTH	**Figure 6: Distribution of Vegetation Units**
Date: October 2011	Datum: GDA94 MGA Zone 52		

Unit F1: Open Forest of *Eucalyptus pruinosa* subsp*. pruinosa, Eucalyptus microtheca, Corymbia confertiflora* and *Melaleuca minutifolia* over patchy Open Shrubland of *Bauhinia cunninghamii, Acacia colei* var. *colei* and *Atalaya hemiglauca* over mixed Grassland/Low Shrubland of *Aristida pruinosa, *Sida acuta, Heteropogon contortus, * Sida cordifolia* and *Eragrostis schultzii* (P3). This vegetation was restricted to the pale brown/grey loams, clays and clay loams of a valley system in the south-west corner of the survey area. Mean species richness per site was 34.0 (SD=6.0).



Plate A: Vegetation Unit F1

Unit S1: Open to Sparse Shrubland of *Terminalia volucris* and *Bauhinia cunninghamii* over Closed Tussock Grassland of *Themeda triandra, Iseilema vaginiflorum, Ophiurus exaltatus, Sorghum plumosum* and *Arundinella nepalensis* with isolated trees (*Corymbia bella, Vachellia valida* and *Bauhinia cunninghamii*). This vegetation was recorded on seasonally waterlogged grey/brown 'blacksoil' clays in the north-east of the survey area. Mean species richness per site was 39.0 (SD=2.9).



Plate B: Vegetation Unit S1

Unit W1: Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia confertiflora* over Open to Sparse Shrubland of **Hyptis suaveolens, Buchanania oblongifolia, Grevillea* spp. and *Acacia* spp. over mixed Grassland/Forbland of *Eragrostis schultzii* (P3), **Cynodon dactylon, Eriachne obtusa, Heteropogon contortus*, *Stemodia lythrifolia, Blumea saxatilis* and *Cyperus pulchellus.* Vegetation Unit W1 was found on brown and grey loamy sands, sandy loams and clay loams on flat or gently sloping country at the base of limestone hills. Mean species richness per site was 45.0 (SD=20.5).



Plate C: Vegetation Unit W1

Unit W2: Woodland or Open Forest of *Corymbia dichromophloia, Corymbia confertiflora, Erythrophleum chlorostachys, Buchanania oblongifolia, Owenia vernicosa* and *Terminalia platyphylla* over Grassland/Hummock Grassland of *Chrysopogon* sp. , *Triodia bitextura, Chrysopogon setifolius, Sehima nervosum* and *Eriachne avenacea.* Vegetation Unit W2 grew in brown loams on the limestone hills that occupied much of the western part of the survey area. Mean species richness per site was 31.8 (SD=4.0).



Plate D: Vegetation Unit W2

Unit W3: Woodland or Open Forest of *Corymbia collina* and *Corymbia confertiflora* over Closed Grassland/Forbland of *Pseudopogonatherum irritans, Eriachne obtusa, Ludwigia perennis, Fuirena ciliaris, Fimbristylis tetragona, Bacopa floribunda* and *Drosera indica* (s.l.) . This vegetation was found on a brown and grey-brown loams, clay loams and sandy loams lining the western boundary of the 'blacksoil' flats. Mean species richness per site was 34.2 (SD=10.2).



Plate E: Vegetation Unit W3

Unit W4 : Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia dichromophloia* over Sparse Shrubland of *Erythrophleum chlorostachys, Grevillea refracta, Dodonaea hispidula* var. *phylloptera* and *Buchanania oblongifolia* over Grassland of *Chrysopogon* sp.*, Sorghum stipoideum, Eriachne obtusa, Triodia bitextura* and *Eragrostis schultzii* (P3) . This vegetation was found on brown and grey loams, sandy loams and loamy sands on the scree slopes and flats around the feet of the limestone hills running down the western side of the survey area. Mean species richness per site was 33.3 (SD=3.4).



Plate F: Vegetation Unit W4

Unit W5 : Woodland and Open Woodland of *Bauhinia cunninghamii, Excoecaria parvifolia and Eucalyptus tectifica* over Open to Sparse Shrubland of *Terminalia volucris, Atalaya hemiglauca Vachellia valida* over mixed Grassland/Forbland and Closed Grassland/Forbland of *Ludwigia perennis, Iseilema vaginiflorum, Chionachne hubbardiana, Ophiurus exaltatus, Panicum decompositum* and *Oryza australiensis*. This vegetation was recorded on seasonally waterlogged grey/brown 'blacksoil' clays in the centre and south-east of the survey area. Mean species richness per site was 38.0 (SD=6.6).



Plate G: Vegetation Unit W5

Unit W6: Open Woodland of *Bauhinia cunninghamii, Excoecaria parvifolia* and *Vachellia valida* over mixed Shrubland/Grassland/Forbland of *Sorghum plumosum, *Calotropis procera, Vigna lanceolata* etc. This vegetation was found in two locations which had been subject to earthworks for dam construction and pit excavation in the past. The flora was a mix of exotics, native disturbance opportunists and Unit W5 or S1 species. Mean species richness per site was 26.0 (SD=7.1).



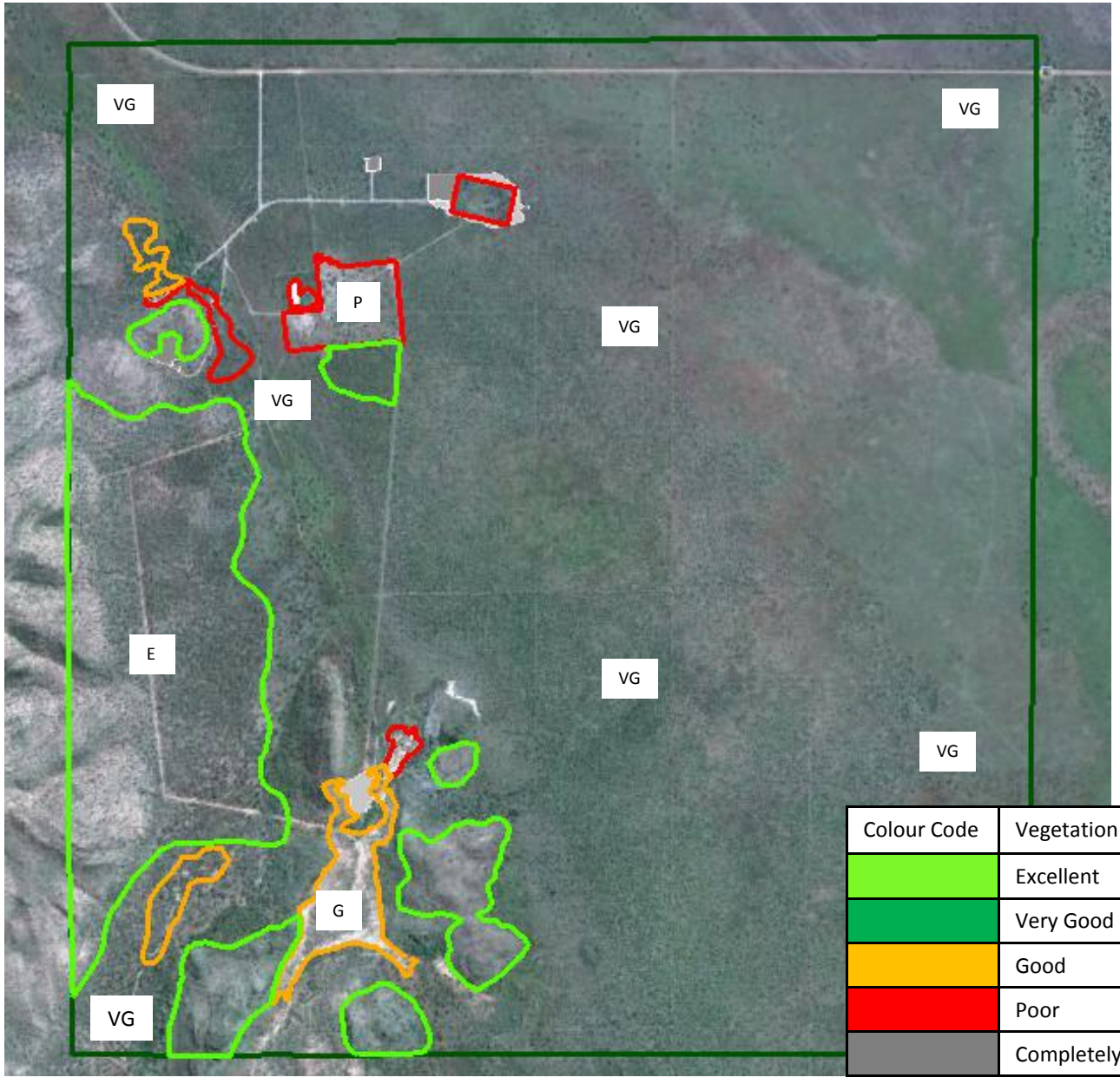
Plate H: Vegetation Unit W6

3.3.2.2 VEGETATION CONDITION

In terms of the condition rating scale (Table 2) the vegetation condition ranged from Excellent (E) to Completely Degraded (D) across the survey area (see Figure 7). The main impacts were from weeds, grazing, old earthworks and vehicular disturbance. The cattle favoured low-lying areas; therefore much of the upland country away from vehicle tracks remained basically undisturbed and was deemed 'Excellent'.

Most of the lowland country was quite heavily grazed; however the high productivity of the 'blacksoil' clays appeared to make the vegetation resilient to trampling, grazing and weed invasion. As the vegetation structure and floristics appeared only slightly impacted, most of this country was rated 'Very Good'. One lowland area from which cattle had been excluded was deemed 'Excellent'. This area was fenced off and occurred south of the main camp. A valley system in the south-west of the survey area, as well as some woodlands north of an old coring pad in the north-west had been invaded by the large weeds**Sida acuta, *Sida cordifolia* and **Hyptis suaveolens.* These areas nevertheless retained their original structure and a substantial number of native species, and were therefore rated 'Good'.

In two places earthworks for a dam and a pit had permanently altered the substrate and vegetation structure, allowing weeds such as **Calotropis procera* to become subdominant. Around the old coring pad and a drovers' campsite in the north-west of the area **Hyptis suaveolens* dominated the understorey. These three areas were rated 'Poor'. A few patches of ground had been cleared for dams, lay down areas etc and were virtually free from vegetation. These were rated 'Completely Degraded'.



Colour Code	Vegetation Condition	
	Excellent	E
	Very Good	VG
	Good	G
	Poor	P
	Completely Degraded	CD

Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral	**Figure 7: Vegetation condition**
Date: October 2011	Datum: GDA94 MGA Zone 52	NORTH	

4. DISCUSSION

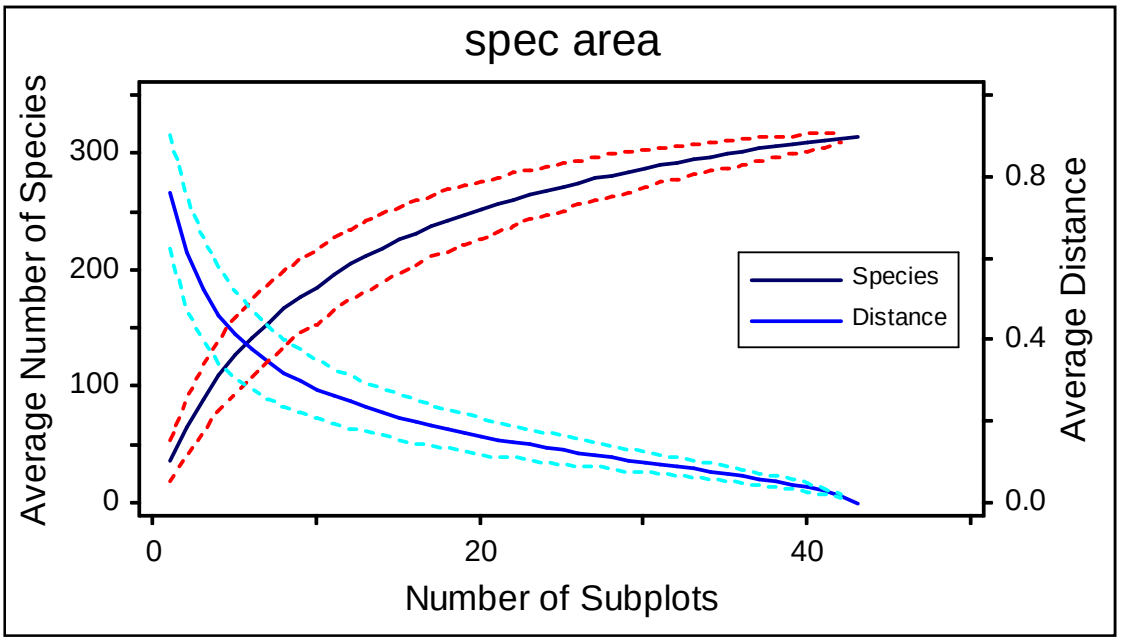
The survey produced 315 taxa from the 43 quadrats, with a further 19 taxa being recorded opportunistically. Based on the quadrat data, PC-ORD's estimates of the total species richness were:

- First-order jackknife estimate = 382.3954
- Second-order jackknife estimate 393.2697
- Chao2 estimate, classic form = 355.3474
- Chao2 estimate, bias corrected = 353.1907

These estimates would mean that the 334 taxa recorded in the survey represented something in the order of 85-95% of area's total flora for this season. As can be seen from the species-area curve (Figure 8), extra quadrats would have been expected to yield one or two new taxa each.

Figure 8: Averaged Species Accumulation Curve.

Average distance refers to the Sørensen distance between the centroid of the subsample and the whole sample. Dotted lines indicate one standard deviation.



In terms of Guidance Statement 51 (Environmental Protection Authority 2004) the intensity of the survey would qualify as 'detailed', as it entailed establishing 43 large quadrats across the survey area and all the vegetation types were sampled multiple times.

4.1 DECLARED PLANTS

Weeds that have the potential to become serious problems are listed as Declared Plants under the Agriculture and Related Resources Protection Act 1976. The act stipulates five categories of Declared Plant, depending on the threats posed and management objectives. The five Declared Plant categories are given in Table 5. All three Declared Plants recorded in this survey (**Senna obtusifolia, *Sida acuta* and **Sida cordifolia*) are classed as P1 for the Shire of Wyndham-East Kimberley, and **Senna obtusifolia* is also classed as P2. Therefore any development plans for the survey area would need to include measures to prevent the spread of all three weeds beyond the site boundaries and to eradicate the **Senna obtusifolia* population. Methods for managing and eradicating Declared Plants can be found on the Department of Agriculture and Food website at: http://agspsrv95.agric.wa.gov.au/dps/version02/01_plantsearch.asp

Table 5: Declared Plant Categories and Treatment Requirements

Priority	Requirements
P1 Prohibits movement	Prohibits movement of plants or their seeds within the State. This prohibits the movement of contaminated machinery and produce including livestock and fodder.
P2 Aim is to eradicate infestation	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 Aims to control infestation by reducing area and/or density of infestation	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.
P4 Aims to prevent infestation spreading beyond existing boundaries of infestation	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.

4.2 THREATENED AND PRIORITY PLANTS

Although no Threatened (Declared Rare) plants were recorded in the survey, the summer waterlogged blacksoil habitat covering most of the survey area could be suitable for the Threatened species *Typhonium* sp. Kununurra (A.N. Start ANS 1467), a small (20cm) plant which has been collected similar country 35km from the survey area.

Several Priority plants were identified. Most of these were classed as Priority 1, meaning they are only known from a few (generally less than five) records. Priority Plants were found throughout the survey area in all vegetation types, with most quadrats containing at least one priority plant species. The high incidence of Priority plants in the survey area may reflect a genuine scarcity of priority plant populations, inadequate sampling of these taxa across the Kimberley - or a mixture of both factors.

It is not possible to compare the frequency of records of flora of conservation significance from the Sorby Hills project area with other adjacent surveys for Weaber Plains (as part of the Ord Expansion project) as the flora survey work undertaken for this project was undertaken more than 15 years ago. Since then the flora of the Kimberley and its conservation status has been thoroughly reviewed and updated. More recent surveys in the area would very likely reveal a similar frequency of collections of flora of conservation significance.

The location of the project is regarded as an interzone between a number of lower order botanical regions and, as a consequence, the flora is relatively diverse. The collections were also made over a very broad cross-section of flora habitats, from elevated rugged sandstone ranges to flooded cracking clay plains.

Specimens of all priority plant taxa collected in the Sorby Hills flora survey have been lodged at the Western Australian Herbarium to help improve knowledge of the geographic ranges and variations of these plants.

4.3 POSSIBLE NEW SPECIES

Plants which could be new species or which are under taxonomic review have been forwarded to taxonomist Russell Barrett. Once these have been examined, and if necessary described, their conservation status can be evaluated.

4.4 THREATENED OR PRIORITY ECOLOGICAL COMMUNITIES

The vegetation on upland parts of the survey area (Units W1, W2, W3, W4 & F1) is part of a widespread association (1,528,117 Ha) within a larger alliance that stretches across the Kimberley and Arnhem Land. It does not correspond to any of Threatened Ecological Communities (TECs) listed under the federal *Environment Protection and Biodiversity Conservation Act* 1999, nor any of the TECs listed by the Department of Environment and Conservation (2011b,c). It did however include two small patches of dense vegetation that could be deemed the Priority Ecological Community (PEC) 'Monsoon vine thickets of limestone ranges'.

The lowland vegetation (Units S1, W5 &W6) is part of a widespread association (1,085,228 Ha) within a larger alliance that has a patchy distribution across northern Australia from the west Kimberley to northern Queensland. It does not correspond to any of Threatened Ecological Communities (TECs) listed under the federal *Environment Protection and Biodiversity Conservation Act* 1999, nor any of the TECs or Priority Ecological Communities (PECs) listed by the Department of Environment and Conservation (2011b,c). However this vegetation is included in the alluvial plain systems of the Ord and Weaber Plains and as such is considered to be among the rare features of the Victoria Bonaparte Bioregion. Within the Ord River catchment much of this country has already been cleared for agriculture, and more is earmarked for clearing under future stages of the Ord Irrigation Expansion Project. As the extent of natural vegetation on the alluvial blacksoils of the Ord River catchment diminishes, the conservation value of remaining native vegetation will increase.

Any future activities in the area should avoid disturbing patches of dense vegetation considered to be the PEC 'monsoon vine thickets of limestone ranges'.

4.5 SURVEY LIMITATIONS

The timing of the survey, after the end of the usual wet season (October – April) might normally have compromised the results, however there had been very heavy late season rains with 354mm falling at nearby Kununurra over the three months preceding the survey (Bureau of Meteorology 2011) and the vegetation was lush with most herbs and grasses still in flower.

Most of the survey area was fairly easily accessible from graded tracks, though in places it was sometimes necessary to walk a few hundred metres to reach sampling sites.

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APPENDIX 1 – DEFINITIONS OF CONSERVATION CODES FOR FLORA

Appendix 1 – Conservation Codes for Western Australian Flora

Under the Wildlife Conservation Act, the Minister for the Environment may declare species of flora to be protected if they are considered to be in danger of extinction, rare or otherwise in need of special protection. Schedules 1 and 2 deal with those that are threatened and those that are presumed extinct respectively.

T: Threatened Flora (Declared Rare Flora — Extant)
Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950). Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild

EN: Endangered – considered to be facing a very high risk of extinction in the wild

VU: Vulnerable – considered to be facing a high risk of extinction in the wild.

X: Presumed Extinct Flora (Declared Rare Flora — Extinct)
Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950).

Species that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Species that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

Priority One: Poorly-known species
Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

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Priority Two: Poorly-known species
Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

Priority Three: Poorly-known species
Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Priority Four: Rare, Near Threatened and other species in need of monitoring

- *Rare*. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.
- *Near Threatened*. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.
- Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five: Conservation Dependent species
Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

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APPENDIX 2 – DEC THREATENED SPECIES BRANCH AND WA HERBARIUM SEARCH RESULTS

Department of
Environment and Conservation
Our environment, our future

Your Ref:
Our Ref: **03-0511FL**
Enquiries: Joshua Gilovitz
Phone: (08) 9334 0123
Fax: (08) 9334 0278
Email: joshua.gilovitz@dec.wa.gov.au

Animal Plant Mineral
68 Westgrove Drive
Ellenbrook, WA, 6069

Attention: Chris Hancock

Dear Chris Hancock,

REQUEST FOR RARE FLORA INFORMATION

I refer to your request of 02 May 2011 for Threatened Flora information in the Sorby Hills, east Kimberley area. The search was conducted within a 45km radial buffer area around the coordinate you submitted.

A search was undertaken for this area of **(1)** the Department's *Threatened (Declared Rare) Flora* database (for results, *if any*, see "DEFL" – coordinates are GDA94), **(2)** the *Western Australian Herbarium Specimen* database for priority species opportunistically collected in the area of interest (for results, *if any*, see "WAHERB"- coordinates are GDA94 – see condition number 9 in the attached 'Conditions in Respect of Supply' and **(3)**, the Department's *Declared Rare and Priority Flora List* [this list is searched using 'place names'. This list which may also be used as a species target list, contains species that are declared rare (Conservation Code R or X for those presumed to be extinct), poorly known (Conservation Codes 1, 2 or 3), or require monitoring (Conservation Code 4) – for results, *if any*, see "DP List"]. The results are attached electronically to this email.

Attached also are the conditions under which this information has been supplied. Your attention is specifically drawn to the seventh point, which refers to the requirement to undertake field investigations for the accurate determination of rare flora occurrence at a site. *The information supplied should be regarded as an indication only of the rare flora that may be present and may be used as a target list in any surveys undertaken.*

The information provided does not preclude you from obtaining and complying with, where necessary, land clearing approvals from other agencies.

An invoice for $300 (plus GST) to supply this information will be forwarded.

It would be appreciated if any populations of rare flora you encounter in the area could be reported to this Department to ensure their ongoing management.

If you require any further details, or wish to discuss rare flora management, please contact Dr Ken Atkins, Manager, Species and Communities Branch, on (08) 9334 0455.

Yours faithfully

Joshua Gilovitz
.....
for Keiran McNamara
DIRECTOR GENERAL

4 May 2011

Species and Communities Branch
17 Dick Perry Ave, Technology Park, Kensington
Phone: (08) 9334 0455 Fax: (08) 9334 0278
Locked Bag 104, Bentley Delivery Centre, Bentley, Western Australia 6983

www.dec.wa.gov.au

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

RARE FLORA INFORMATION

CONDITIONS IN RESPECT OF SUPPLY OF INFORMATION

1. All requests for data to be made in writing to the Director General, Department of Environment and Conservation, Attention: Threatened Flora Database Officer, Species and Communities Branch.

2. The data supplied may not be supplied to other organisations, nor be used for any purpose other than for the project for which they have been provided, without the prior written consent of the Director General, Department of Environment and Conservation.

3. Specific locality information for Declared Rare Flora is regarded as confidential, and should be treated as such by receiving organisations. Specific locality information for DRF may not be used in public reports without the written permission of the Director General, Department of Environment and Conservation. Publicly available reports may only show generalised locations or, where necessary, show specific locations without identifying species. The Department is to be contacted for guidance on the presentation of rare flora information.

4. Note that the Department of Environment and Conservation respects the privacy of private landowners who may have rare flora on their property. Rare flora locations identified in the data as being on private property should be treated in confidence, and contact with property owners made through the Department of Environment and Conservation.

5. Receiving organisations should note that while every effort has been made to prevent errors and omissions in the data provided, they may be present. The Department of Environment and Conservation accepts no responsibility for this.

6. Receiving organisations must also recognise that the database is subject to continual updating and amendment, and such considerations should be taken into account by the user.

7. **It should be noted that the supplied data do not necessarily represent a comprehensive listing of the rare flora of the area in question. Its comprehensiveness is dependant on the amount of survey carried out within the specified area. The receiving organisation should employ a botanist, if required, to undertake a survey of the area under consideration.**

8. Acknowledgment of the Department of Environment and Conservation as source of the data is to be made in any published material. The unique reference number that is given upon the request for information should be quoted. Copies of all such publications are to be forwarded to the Department of Environment and Conservation, Attention: The Manager, Species and Communities Branch.

9. The development of the PERTH Herbarium database was not originally intended for electronic mapping (eg. GIS ArcView). The latitude and longitude coordinates for each entry are not verified prior to being databased. It is only in recent times that collections have been submitted to PERTH with GPS recorded in latitude and longitude coordinates. Therefore, be aware when using this data in ArcView that some records may not plot to the locality description given with each collection.

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THE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

DECLARED RARE AND PRIORITY FLORA LIST

for Western Australia

CONSERVATION CODES

R: Declared Rare Flora - Extant Taxa

Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

X: Declared Rare Flora - Presumed Extinct Taxa

Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.

1: Priority One - Poorly known Taxa

Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

2: Priority Two - Poorly Known Taxa

Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

3: Priority Three - Poorly Known Taxa

Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

4: Priority Four - Rare Taxa

Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Note, the need for further survey of poorly known taxa is prioritised into the three categories depending on the perceived urgency for determining the conservation status of those taxa, as indicated by the apparent degree of threat to the taxa based on the current information.

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ABBREVIATIONS USED IN THREATENED FLORA DATABASE PRINTOUTS

VESTING

AAP	Aboriginal Planning Authority
AGR	Chief Executive, Dep. of Agriculture
ALT	Aboriginal Land Trust
APB	Agricultural Protection Board of WA
BGP	Botanical Gardens & Parks Authority
BSA	Boy Scouts Association
CC	Conservation Commission – NPNCA - LFC
CGT	Crown Grant in Trust
COM	Commonwealth of Australia
CRO	Crown Freehold-Govt Ownership
CRW	Crown
DAG	Dep. of Agriculture
DOW	Dep. of Water
DPI	Dep. of Planning & Infrastructure
EXD	Exec Direc CALM
FES	Fire and Emergency Services Aust.
HOW	Dep. of Housing/State Housing Commission
ILD	Industrial Lands Develop. Auth
LAC	LandCorp
MAG	Minister for Agriculture
MBC	Metropolitan Cemeteries Board
MED	Ministry of Education
MHE	Minister for Health
MIN	Minister for Mines
MPL	Ministry for Planning
MPR	Minister for Prisons
MRD	Main Roads WA
MTR	Minister for Transport
MWA	Minister for Water Resources
MWO	Minister for Works
NAT	Natural Trust of Australia WA
NON	Not Vested
PLB	Pastoral Lands Board
PRI	Private/Freehold
RAI	Public Transport Authority
REL	Religious Organisation
SEC	Synergy (ex Western Power)
SHI	Shire
SPC	State Planning Commission
SWA	State of Western Australia
TEL	Telstra
UNK	Unknown
WAT	Water Corporation
WEL	Minister Community Welfare
WRC	Water & Rivers Commission
XPL	Ex-Pastoral Lease

PURPOSES

ABR	Aboriginal Reserve
ACC	Access Track
AER	Aerodrome
AIR	Airport
ARS	Agricultural Research Station
BAP	Baptist Union of WA
CAM	Camping
CAR	Caravan park
CEM	Cemetery
CFA	Conservation of Fauna
CFF	Conservation Of Flora & Fauna
CFL	Conservation of Flora
CHU	Church
CPK	Car Park
CMN	Communications
COM	Common
CON	Conservation Park
DEF	Defence
DRA	Drain
EDE	Educational Endowment
EDU	Educational purposes UWA
ENE	Enjoyment of Natural Environ.
EXC	Excepted from sale
EXL	Exploration Lease
EXP	Experimental Farm
FIR	Firing Range
FOR	State Forest
GE	General Lease
GHA	Grain Handling
GOL	Golf
GRA	Gravel Pit
GVT	Government Requirements
HAR	Harbour Purposes
HEP	Heritage Purposes
HER	Heritage trail
HOS	Hospital
KEN	Kennels
LPR	Landscape Protection
MIN	Mining lease
MUN	Municipal Purposes
NPK	National Park
NRE	Nature Reserve
OTH	Other
PAR	Parkland (& Recreation)
PAS	Pastoral lease
PFF	Protection of Flora & Fauna
PFL	Protection of Flora
PIC	Picnic ground
PLA	Plantation
POS	Public Open Space
PRS	Prison site
PUR	Purchase Lease
PUT	Public Utility
QUA	Quarry
RAD	Radio Station
RAC	Racecourse
REC	Recreation
REH	Rehabilitation/Re-establish Native Plants
RRE	Railway Reserve
RUB	Rubbish
SAN	Sand
SCH	School-site
SET	Settlers requirements
SHI	Shire Requirements
SHO	Showgrounds
SNN	Sanitary
SOI	Soil Conservation
STO	Stopping place
TIM	Timber
TOU	Tourism
TOW	Town-site
TRA	Training Ground
TRI	Trig station
UCL	Unallocated Crown Land
UNK	Unknown
VER	Road Verge
VPF	Vermin Proof Fence
WAT	Water
WLS	Wildlife Sanctuary
WOO	Firewood

DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DECLARED RARE AND PRIORITY FLORA LIST
16 September 2010

SPECIES / TAXON	CONS CODE	DEC REGION	DISTRIBUTION	FLOWER PERIOD
Acacia jasperensis	3	K,*	Berkeley River, Kununurra, N.T.	
Acacia richardsii	3	K,*	Kununurra, Keep River N.P., Northern Carr Boyd Ranges, Gardner Plateau, N.T.	Mar-Aug
Bonamia brevifolia	1	K	Kununurra	Dec
Brachychiton tuberculatus	3	K	Ord River, Kununurra	Aug-Nov
Calycopeplus collinus	1	K	Kununurra, Beverley Springs Stn.	Mar
Desmodium flagellare	1	K	Kununurra, Ord River Basin	
Dolichandrone filiformis	2	K,*	Lake Argyle, Drysdale River N.P., NT	Dec
Enteropogon minutus	1	K	Ivanhoe Stn.	
Eragrostis schultzii	3	K	Drysdale River, Kununurra	
Eucalyptus ordiana	2	K	Kununurra	Jan,Jun,Jul
Euphorbia stevenii	3	P,K	Karijini N.P., Kununurra	
Ficus lilliputiana	4	K,*	Ord River, Lake Argyle, Hidden Valley, Kununurra, Northern Territory	Apr-Oct
Fuirena nudiflora	1	GLD,K,*	Rawlinson Range, Kununurra, NT, Qld	Jun
Goodenia durackiana	1	K	Ord River, Kununurra	Mar
Goodenia malvina	1	K	Kununurra, Ord River, Beverley Springs Stn.	Jan-May
Goodenia sepalosa var. glandulosa	3	K	Derby, Lake Argyle, Robinson River, Fitzroy Crossing, Yeeda	May
Goodenia strangfordii	1	K	Kununurra, Sturt Creek	Sep
Helicteres dentata var. procumbens	1	K,*	Kununurra, N.T.	Nov
Heliotropium alcyonium	1	K	Kununurra	Feb-May
Heliotropium tachyglossoides	1	K	Kununurra	Jan-Apr
Hullsia argillicola	1	K	Kununurra	Jan-Mar
Ipomoea gracilis	1	K,*	Kununurra, NT	Mar-May
Ipomoea racemigera	1	K	Kununurra	
Ipomoea sp. Kalumburu (A.A. Mitchell 3869B)	1	K	Kununurra, Kalumburu	
Jacquemontia sp. Keep River (J.L. Egan 5051)	1	K	Kununurra	-
Lepturus copeanus	1	K	Weaber Plain	
Melaleuca viminalis	2	K	Prince Regent River N.R., Kununurra	
Phragmites karka	3	K,P	Millstream, Doongan Stn., Dampier Peninsula, Kununurra, Charnley River	
Platysace saxatilis	2	K*	Hidden Valley, Kununurra, NT	Mar-May,Sep
Polygala sp. Phianthoides shoulders (M.H. Andrews 398)	1	K	Kununurra	
Solanum pugiunculiferum	1	K	Kununurra	Jul-Aug
Sphenoclea zeylanica	1	K,*	Carlton Hill Stn., Moochalabra Dam, Kununurra, NT, QLD	
Stylidium prophyllum	3	K	Mt Hart Stn, Beverley Springs Stn, Kununurra	May-Jun
Triodia fissura	1	K	Kununurra	
Triodia prona	1	K	Kununurra	Mar
Triodia racemigera	1	K	Kununurra, Lake Argyle	Dec-May
Triodia triticoides	1	K,P	Ord River, Kununurra, Newman	Apr

DECLARED RARE AND PRIORITY FLORA LIST
16 September 2010

SPECIES / TAXON	CONS CODE	DEC REGION	DISTRIBUTION	FLOWER PERIOD
Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	K	Kununurra	
Utricularia muelleri	3	K	Kalumburu, Camballin, Brolga Swamp, Airfield Swamp, Kununurra, NT, QLD	May-Jun
Utricularia tubulata	1	K	Kununurra, Mitchell Plateau	Feb-Mar, Jun
Whiteochloa capillipes	3	P,K	Kununurra, Madora Stn, Hamersley Stn, Lacrosse Island	
Zeuxine oblonga	2	K	Kununurra	
Zornia areolata	1	K	Kununurra	

APPENDIX 2: DEC THREATENED SPECIES BRANCH AND WA HERBARIUM SEARCH RESULTS

OID_	SHEET_NO	SPECIES	CONSCODE	SITE	VEGETATION	LOCALITY	LAT	LONG_	DATE_	N10
	PERTH 02609282	Goodenia malvina	1			Kununurra area	-15.76166	128.735	02 1972	
	PERTH 01615181	Acacia jasperensis	3		With Eucalyptus cliftoniana, Plectrachne.	Hidden Valley, 3.2 km E of Kununurra, Kimberley	-15.76861	128.75167	01 07 1976	
	PERTH 06957994	Acacia jasperensis	3	On side of small valley, amongst sandstone boulders.	Associated with Pandanus, Melaleuca acacioides, Eucalyptus papuana.	Spirit Hills Conservation area, S of Nancys Gorge	-15.47583	129.345	20 08 1996	
	PERTH 03761835	Acacia leptocarpa	1	Black soil plain.		Carlton Hill Station	-15.08472	129	19 10 1993	
	PERTH 1616242	Acacia richardsii	3			Hidden Valley, 3.2 km E of Kununurra, Kimberleys	-15.78333	128.76667	01 07 1976	
	PERTH 757543	Acacia richardsii	3			Kununurra, Kimberleys	-15.76166	128.735	08 07 1974	
	PERTH 392383	Acacia richardsii	3	Roadside.		Kellys Knob, Kununurra	-15.76666	128.73333	03 10 1979	
	PERTH 1216856	Acacia richardsii	3	Sandstone hill.		Kellys Knob, Kununurra	-15.75	128.75	07 11 1989	
	PERTH 801879	Acacia richardsii	3			Keep River National Park	-15.83333	129.1	1985	
	PERTH 727245	Acacia richardsii	3	On sandstone hill.		Kellys Knob, Kununurra	-15.76666	128.71667	03 11 1981	
	PERTH 391999	Acacia richardsii	3	Valley floor among sandstone.		Hidden Valley, Kununurra	-15.78333	128.76667	29 01 1982	
	PERTH 392375	Acacia richardsii	3			Hidden Valley, Kununurra	-15.78333	128.76667		
	PERTH 392391	Acacia richardsii	3	In fissures of sedimentary rocks.	Terminalia sp., Persoonia falcata and Eucalyptus brachyandra.	Kellys Knob Lookout, Kununurra, East Kimberley	-15.76666	128.73333	02 12 1980	
	PERTH 392405	Acacia richardsii	3	Amongst metamophic rocks near lower look-out of Kellys Knob.		Kellys Knob, Kununurra, East Kimberley	-15.76666	128.73333	02 06 1980	
	PERTH 392413	Acacia richardsii	3	On sandstone hill.		Kellys Knob, Kununurra	-15.76666	128.73333	28 01 1982	
	PERTH 392448	Acacia richardsii	3			Near Hookers Farm, Ivanhoe Crossing Road, Ord River Valley, E Kimberley	-15.7	128.7	03 08 1974	
	PERTH 632309	Acacia richardsii	3			Hidden Valley, Kununurra	-15.26666	128.75	24 08 1982	
	PERTH 392421	Acacia richardsii	3	Sandstone hill.		Kellys Knob, Kununurra	-15.76666	128.73333	28 01 1982	
	PERTH 05886449	Acacia richardsii	3			Mirima National Park, IBRA Region: VB,	-15.76842	128.75664	30 04 2000	
	PERTH 769452	Acacia richardsii	3	On massive sandstone.		Kelly's Knob Lookout, Kununurra	-15.76805	128.74167	14 08 1981	
	PERTH 998915	Acacia richardsii	3	On valley floor.		Mirima (Hidden Valley) National Park near Kununurra	-15.76666	128.73333	23 06 1989	
	PERTH 05782503	Acacia richardsii	3	Over rough sandstone.		At the end of the road on the W side of Kelly's Knob, Kununurra,	-15.76666	128.75	03 01 2001	
	PERTH 06957986	Acacia setulifera	1	On floor of small valley on sandstone.	With Eucalyptus miniata, Grevillea prasina.	Spirit Hills Conservation area, S of Nancys Gorge	-15.47944	129.34639	20 08 1996	
	PERTH 06861768	Blumea pungens	2			Spirit Hills Conservation Area; near Nancy's Gorge	-15.4675	129.33972	21 08 1996	
	PERTH 1073834	Brachychiton tuberculatus	3	On Cockatoo sands.	Woodland with Eucalyptus tetrodonta dominant.	59 km N Kununurra	-15.25	128.73333	09 09 1976	
	PERTH 1073818	Brachychiton tuberculatus	3	On Cockatoo sands.	Woodland with Erythrophloeum, Bauhinia, Petalostigma, Cochlospermum and Acacia.	ca 50 km N Kununurra	-15.33333	128.73333	09 09 1976	
	PERTH 05645158	Brachychiton tuberculatus	3	Plain, gentle slope to hills. Red ?clay-loam.	Open Eucalyptus tectifica over dense Themeda triandra grassland. Associated species: Eucalyptus bigalerita, E. greeniana, E. confertiflora, Sorghum timorense, Eriachne obtusa, Grewia spp.	Knox Creek plain, 35 km NE Kununurra	-15.62944	128.95861	18 01 1997	
	PERTH 07130759	Brachychiton tuberculatus	3	River flat, sandy.	Shrubs and low eucalypt woodlands, Boabs,	Valentine Spring, Kununurra Road, Kununurra	-15.76666	128.73333	23 07 2002	
	PERTH 08186294	Brachychiton tuberculatus	3	Plain. Red brown sand. Collection site: rangeland. Burnt ca >3 years ago.	Open woodland of Corymbia ? grandifolia subsp. lamprocardia, Acacia colei, Petalostigma pubescens over tussock grassland of Sorghum ? stipoideum.	Ca 24 km N of Kununurra	-15.54519	128.7234	25 05 2009	
	PERTH 08186375	Brachychiton tuberculatus	3	Plain. Orange sand. Collection site: rangeland. Burnt ca >3 years ago.	Woodland of Eucalyptus tetrodonta and Acacia difficilis over tussock grassland of Sorghum ? stipoideum, Ablidgaardia schoenoides and Crotalaria cunninghamii.	Ca 24 km N of Kununurra	-15.5492	128.7019	30 06 2009	
	PERTH 08186391	Brachychiton tuberculatus	3	Plain. Orange grey sandy silt. Collection site: rangeland. Burnt ca >3 years ago.	Woodland of Corymbia flavescens, Eucliptus tectifica, Melaleuca viridiflora and Brachychiton tuberculatus over tussock grassland of Abildgaardia schoenoides, Sorghum ? stipoideum, Triodia ? bitextura and Eriachne sp.	Ca 17 km NE of Kununurra	-15.6715	128.8513	30 06 2009	
	PERTH 01565716	Calycopeplus collinus	1	On rugged limestone slope of gorge.	With E. cliftoniana, Grevillea and Triodia.	Limestone hills W of Weaber Range, c. 50 km N of Kununurra and c. 13 km NW of Point Springs, NE Kimberley	-15.31194	128.735	08 03 1978	
	PERTH 07157525	Cyperus digitatus	1	Growing at the waters edge.		Ord River Irrigation Area, eastern side of Ivanhoe Crossing, IBRA Region: VB	-15.68967	128.68769	23 11 2000	
	PERTH 02627159	Desmodium flagellare	1	Black cracking clay soil.		Kimberley Research Station, Kununurra	-15.65472	128.705	07 03 1963	
	PERTH 03753263	Dolichandrone filiformis	2	Sandy banks.		Skull Creek, E Kimberley	-15.21833	128.95222	04 08 1937	
	PERTH 06261388	Dolichandrone filiformis	2	Sandy riverine soil, 7a.	Dense Bauhinia cunninghamii and Terminalia oboyata over grasses.	Upstream of Legune Crossing	-15.39852	129.08678	07 06 1999	
	PERTH 00353515	Echinochloa kimberleyensis	1	Edge of shallow billabong on grey cracking clay plain.		Keep River National Park	-15.76666	129.1	25 02 1981	
	PERTH 06064453	Echinochloa kimberleyensis	1	Swampy area.	Eucalypus microtheca, Excoecaria parvifolia.	8 km NNE of Kununurra, 5 km from Cave Cave Paintings turnoff on road to Kimberley Research Station, Gardner District	-15.71666	128.73333	21 03 1980	
	PERTH 02266970	Eleocharis ochrostachys	3	Permanent swamp.	Dominated by Melaleuca viridiflora.	Keep River National Park	-15.83333	129.1	26 02 1981	
	PERTH 04909100	Enteropogon minutus	1	Gentle slopes and bed of shallow creek in black soil plain.	Woodland of Eucalyptus microtheca and Exocaria parvifolia with an understorey of Chrysopogon fallax.	Ca 60 km NE of Kununurra, 8.5 km E of Point Springs and on the E side of a N/S fence, Weaber Plain	-15.40888	128.96083	08 10 1996	
	PERTH 04860332	Euphorbia stevenii	3	Kununurra clay.	Ploughed area, weed infested.	Block 68, Kununurra	-15.76166	128.735	10 03 1978	
	PERTH 01566830	Euphorbia stevenii	3	Cununurra clay.	Ploughed area, weed infested.	Block 68, Sugar can experimental area, Department of Agriculture, Kununurra	-15.76166	128.735	10 03 1978	
	PERTH 3249743	Euphorbia stevenii	3	Margins of cropped black soil plain.	Between crop of maize and sentinel cotton crop.	Dessert Seeds, Block 243 King location about 15km NE of Kununurra	-15.64944	128.74111	20 07 1993	
	PERTH 03195953	Euphorbia stevenii	3	Channel banks in black soil plain.	Hertfield.	Dessert seeds block on Weaber Plains road 14 km N of Kununurra	-15.6725	128.85389	04 03 1993	
	PERTH 06226027	Euphorbia stevenii	3	Black cracking clay.	Low Woodland of Eucalyptus microtheca over a low grassland.	Along central track through block near junction with adjoining property on east	-15.55278	128.74663	12 06 1999	
	PERTH 05453445	Euphorbia stevenii	3	Previously cropped cracking black clay plain.	Mixed weeds in poor chickpea crop.	Pacific Seeds Farm on Cave Springs Road, Ord River Irrigation area, N of Kununurra	-15.63638	128.81139	23 06 1998	
	PERTH 06224497	Euphorbia stevenii	3	Cracking clay soil on the Knox Creek Plain, east of Kununurra. Soil Unit 7f, drainage line.	Moderately dense Terminalia oblongata, Eucalyptus microtheca and Excoecaria parvifolia Woodland over tussock grassland dominated by Panicum decompositum.	North section of Knox Creek Plain track	-15.46733	129.02526	19 05 1999	
	PERTH 4444752	Ficus lilliputiana	4	Crevice in vertical sandstone rock face.		Hidden Valley about 3 km E of Kununurra	-15.77833	128.75972	01 03 1995	
	PERTH 07132115	Ficus lilliputiana	4	Moist rockface.		Hidden Valley, Kununurra	-15.76666	128.75	19 02 1982	
	PERTH 01490613	Fimbristylis laxiglumis	2	Kununurra black clay in rice bays.		Kimberley Research Station	-15.65472	128.705	13 04 1963	
	PERTH 06261035	Fimbristylis laxiglumis	2	Black cracking clay.	Eucalyptus microtheca and Excoecaria parvifolia Woodland over tall grasses dominated by Sorghum spp.	Green Location, Carlton Road, north of Kununurra	-15.54041	129.26644	12 06 1999	
	PERTH 06260810	Fimbristylis laxiglumis	2	Black cracking clay.	Tall grassland with emergent Eucalyptus microtheca.	Near southern end of proposed development on NS track through Knox Creek Plain	-15.62896	129.00457	18 05 1999	
	PERTH 08186308	Goodenia brachypoda	1	Plain. Grey brown silt. Collection site: rangeland. Burnt ca >5 years ago.	Open forest of Corymbia ? opaca, Corymbia ? bella, Adansonia gregorii, Brachychiton diversifolius subsp. diversifolius and Ficus aculeata var. indecora over grassland of Sorghum ? stipoideum.	Westbank ca 11 km N-NW of Kununurra	-15.675	128.6706	16 06 2009	
	PERTH 08186359	Goodenia brachypoda	1	Plain. Yellow red sandy clay. Collection site: rangeland. Burnt ca >3 years ago.	Woodland of Corymbia grandifolia subsp. lamprocardia, Adansonia gregorii and Brachychiton diversifolius subsp. diversifolius over tussock grassland of Sorghum ? stipoideum.	Ca 17 km N-NW of Kununurra	-15.6309	128.6763	22 05 2009	
	PERTH 08186383	Goodenia brachypoda	1	Plain. Orange silt. Collection site: rangeland. Burnt ca >5 years ago.	Low open woodland of Eucalyptus pruinosa subsp. tenuata over closed grassland of Heteropogon contortus.	Westbank ca 10 km N-NW of Kununurra	-15.71359	128.671	05 07 2009	
	PERTH 08186405	Goodenia brachypoda	1	Plain. Orange brown silt. Collection site: rangeland. Burnt ca >5 years ago.	Scattered trees of Corymbia greeniana and Bauhinia cunninghamii over grassland of Heteropogon contortus.	Mantinea ca 30 km NW of Kununurra	-15.5634	128.5987	14 06 2009	
	PERTH 01607251	Goodenia durackiana	1	On black cracking clay soil.	With mixed grassland.	Kimberley Research Station, Kununurra	-15.65472	128.705	06 03 1963	
	PERTH 02609274	Goodenia malvina	1	In black sand, irrigated. Cotton fields.		Kununurra	-15.76166	128.735	16 05 1967	
	PERTH 02609282	Goodenia malvina	1			Kununurra area	-15.76166	128.735	02 1972	
	PERTH 1645080	Goodenia malvina	1	Black clay.	Tall Sorghum.	Weaber Plain, NNE of Kununurra	-15.45	128.91667	26 04 1977	
	PERTH 04861051	Goodenia malvina	1	Cununurra clay.	Old rice bay, weed infested.	Kimberley Experimental Farm, Dept. of Agriculture, Kununurra,	-15.76166	128.735	17 03 1978	
	PERTH 01632507	Goodenia malvina	1			Kununurra	-15.76166	128.735	15 03 1972	
	PERTH 1645099	Goodenia malvina	1	Black clay.	Tall sorghum.	Weaber Plain, NNE of Kununurra	-15.45	128.91667	26 04 1977	
	PERTH 06221270	Goodenia malvina	1	Black cracking clay.	Open Woodland of Eucalyptus microtheca and Acacia ditricha over grassland.	Southern section of Keep River Plain,	-15.50797	128.8345	20 05 1999	
	PERTH 01638807	Goodenia malvina	1	On black cracking clay soil.		Kimberley Research Station, Kununurra	-15.65472	128.705	07 03 1963	
	PERTH 02604449	Goodenia purpurascens	3	In black clay.	Among tall Sorghum.	Weaber Plain, NNE of Kununurra	-15.45	128.91667	26 04 1977	
	PERTH 04739841	Heliotropium quinonium	1			Vicinity of Kimberley Research Station, near Kununurra, East Kimberleys,	-15.65	128.7	1969	
	PERTH 1985841	Heliotropium cupressinum	1	On lower reaches of steep slopes.	Mixed woodland.	Middle Spring, 18 km (by air) NW of Kununurra	-15.63333	128.66667	08 05 1983	
	PERTH 06272517	Heliotropium cupressinum	1	On outcropping quartzitic sandstone.		Middle Springs, Deception Range, NW of Kununurra	-15.63333	128.66667	13 06 1993	
	PERTH 4512073	Heliotropium tachyglossoides	1			Kununurra	-15.78333	128.73333	14 05 1971	
	PERTH 04906864	Hulfsia argillicola	1	Block 68. Cununurra clay.	Ploughed area, weed infested.	Kununurra	-15.76166	128.735	10 03 1978	
	PERTH 03639916	Ipomoea gracilis	1	Roadside, brown clay.		3 km N Kununurra	-15.75	128.71667	10 09 1974	
	PERTH 03639908	Ipomoea gracilis	1	Black sand, irrigated.	Cotton crops.	Kununurra	-15.76166	128.735	16 05 1967	
	PERTH 03639940	Ipomoea gracilis	1			Kununurra	-15.76166	128.735	03 1967	
	PERTH 04901819	Ipomoea gracilis	1	Along track. Cununurra clay.		Kununurra - Block 48	-15.76166	128.735	11 03 1978	
	PERTH 03639932	Ipomoea gracilis	1	On mud bank.	Irrigated rice fields.	Kimberley Research Station, Ord River	-15.65472	128.705	17 04 1958	
	PERTH 03639894	Ipomoea gracilis	1	On black cracking clay soil.	With mixed grassland.	Kimberley Research Station, Kununurra	-15.65472	128.705	06 03 1963	
	PERTH 06169716	Ipomoea sp. Kalumburu (A.A. Mitc	1	Road margin on black soil plain.	Mixed weedy grasses and herbs.	Near Scott Bros block, Stock Route Road, 19.8 km from Kununurra Post Office on a bearing of 349 deg., Kununurra, E Kimberley	-15.59467	128.71541	04 04 2001	
	PERTH 04909119	Lepturus copeanus	1	Pockets of soil developed in cracks in dolomite hill.	Mixed shrubland with Sorghum stipoideum.	Ca 50 km NE of Kununurra on E side of Folly Rock, Weaber Plain	-15.44277	128.84472	10 10 1996	
	PERTH 00562076	Lepturus xerophilus	1	Limestone. Rocky cave in limestone hills.		Ningbing Range, 42 km NNE of Carlton Hills Homestead, northeastern Kimberley	-15.14083	128.72694	11 03 1978	
	PERTH 08103798	Micraira sp. Purnululu (M.D. Barre	1	Growing on flat sandstone plateau.		N of Keep River National Park	-15.62222	129.24	09 12 2000	
	PERTH 00398926	Phragmites karka	3	bank		Kimberley Research Station, Ord River	-15.65472	128.705	17 04 1958	
	PERTH 00833827	Phragmites karka	3	sandy beside river		Just below Ivanhoe crossing, Ord River	-15.69138	128.68972	19 06 1986	
	PERTH 836370	Phragmites karka	3	clay-loam floodplain, eroded in many areas	riparian forest Nauclea orientalis, Pandanus spiralis ?, Terminalia platyphylla, Ficus spp., Melaleuca spp., Cenchrus spp., Heteropogon contortus, etc.	NE Kimberley, Ivanhoe crossing on Ord River	-15.7	128.68333	20 07 1984	
	PERTH 03202593	Platysace saxatilis	2			Kununurra	-15.76166	128.735	08 09 1965	
	PERTH 03202623	Platysace saxatilis	2	Ruiniform sandstone towers.	With occasional Eucalyptus pyrophora.	Hidden Valley near Kununurra township, NE Kimberley	-15.78333	128.76667	22 07 1984	
	PERTH 05483263	Platysace saxatilis	2	In valley on sand.	In woodland.	Hidden Valley, Kununurra, Gardner Botanical District	-15.78333	128.76667	26 04 1985	
	PERTH 04458931	Platysace saxatilis	2	Vertical faces of sandstone hills.	Sparse hummock grassland.	Hidden Valley, c. 3 km E of Kununurra	-15.77833	128.75972	01 03 1995	
	PERTH 03202615	Platysace saxatilis	2	Among sandstone rock formations on sandy soil. On cliffside.	Eucalypt woodland.	On E edge of Kununurra on NE side of Mount Cyril (Hidden Valley)	-15.78333	128.75	18 05 1983	
	PERTH 1838784	Platysace saxatilis	2	On sandstone cliff.		Hidden Valley, just E of Kununurra	-15.76666	128.75	24 04 1977	
	PERTH 03202631	Platysace saxatilis	2	In crevices on side of gorge.		Pretty Valley, Kununurra	-15.76166	128.735	13 06 1968	
	PERTH 05707161	Platysace saxatilis	2	Growing in a crevice on a sandstone rock-face.		Mirima National Park. IBRA Region: VB	-15.76106	128.75375	17 11 1999	
	PERTH 03461926	Platysace saxatilis	2	Dissected sandstone, in crevices.		Hidden Valley	-15.75	128.75	04 07 1984	
	PERTH 1838776	Platysace saxatilis	2	Growing in rock crevices of sandstone.		Hidden Valley, 3 km N of Kununurra, NE Kimberley	-15.78333	128.76667	30 05 1986	
	PERTH 03202607	Platysace saxatilis	2	Growing on sandstone cliff.		Hidden Valley	-15.76861	128.75167	03 11 1981	
	PERTH 03462242	Platysace saxatilis	2	On roadside rockfaces with S exposure.		Hidden Valley near Kununurra	-15.78333	128.73333	24 04 1977	
	PERTH 08045755	Polygala sp. Rhianthoides shoulde	1	Blacksoil at base of small sandstone outcrop.	Grassland with Terminalia, Corchorus, Acacia, Abutilon, Trichosanthes, Cyanotis, Marsilea, Cyperus, Passiflora, Ipomoea, Bonamia, Ludwigia, Asteraceae, Decaisnina, Corymbia bella.	Point Spring / Cave Spring / Weaber Plain Road, 32.9 km N of Kununurra from Great Northern Highway	-15.52669	128.81833	12 02 2006	
	PERTH 04156749	Psilotum nudum	3	On wet shaded ledges of sinkhole in sandstone.		The Grotto, a natural sinkhole on Kununurra-Wyndham road, East Kimberley	-15.7	128.75	06 08 1974	
	PERTH 08186278	Schoenus punctatus	3	Watercourse. Red sand. Collection site: rangeland. Burnt ca >3 years ago.	Woodland of Corymbia ? grandifolia subsp. lamprocardia, Eucalyptus microtheca, E. pruinosa subsp. ternata and Melaleuca argentea over tussock grassland of Eriachne glauca var. barbinodis, Sorghum ? stipoideum, Fimbristylis punctata, Fimbristylis sp., Sch	Ca 18 km NE of Kununurra	-15.68669	128.8465	01 07 2009	
	PERTH 08186316	Schoenus punctatus	3	Plain. Light grey and red silty sand. Collection site: rangeland. Burnt ca >3 years ago.	Open woodland of Eucalyptus tectifica over mixed sedges and grasses of Schoenus punctatus, Sorghum ? stipoideum, Triodia bitextura, Xyris complanata and Platyzoma microphyllum.	Ca 18 km NE of Kununurra	-15.65079	128.8765	30 06 2009	
	PERTH 08053278	Solanum cardiuforme	2	In sandy gully.	At edge of Eucalyptus/palm woodland. With S. dioicum Tanami (CTM 772).	Keep River National Park: Jarnarm Escarpment: Nigli Gap Walk	-15.75944	129.08186	26 05 2004	
	PERTH 02113937	Solanum pugiunculiferum	1	Black soil.		Kununurra,	-15.76166	128.735	10 1990	
	PERTH 03752445	Solanum pugiunculiferum	1	Levee backslopes, red alluvial silt.		Carlton/Ivanhoe area, Kununurra,	-15.76166	128.735	10 08 1982	
	PERTH 01872168	Solanum pugiunculiferum	1			Carlton,	-15.8	128.75	05 08 1982	
	PERTH 06961711	Sphenoclea zeylanica	1	Close to river.		IBRA Region: VB. Kununurra - Frank Wise Institute	-15.65016	128.69556	26 09 2001	
	PERTH 06064310	Triodia racemigera	1	Sandstone hill.	Growing with Cymbopogon procerus, C. bombycinus.	Kelly's Knob, Kununurra, Gardner District	-15.76666	128.73333	28 03 1980	
	PERTH 00484210	Triodia racemigera	1	in crevices on weathered sandstone		Keep River National Park	-15.76666	129.1	23 02 1981	
	PERTH 484199	Triodia racemigera	1	Exposed slope undeer sand stone cliff.		Near Kimberley Research Station, Ord River	-15.65472	128.705	12 04 1958	
	PERTH 00484229	Triodia racemigera	1	in crevices on weathered sandstone		Keep River National Park	-15.76666	129.1	23 02 1981	
	PERTH 05227763	Triodia racemigera	1	Pockets of soil in sandstone hills.	Sparse hummock grassland of which this is the dominant species.	Hidden Valley about 3 km E of Kununurra	-15.77833	128.75972	01 03 1995	
	PERTH 980692	Triodia triticoides	1	Sandstone hills.		Kimberley Research Station, Ord River	-15.65472	128.705	28 01 1949	
	PERTH 987018	Triodia triticoides	1	Sandstone hills.		Kimberley Research Station, Ord River	-15.65472	128.705	28 01 1949	
	PERTH 482889	Triodia triticoides	1	Sandstone hills.		Kimberley Research Station	-15.65472	128.705	28 01 1949	
	PERTH 987026	Triodia triticoides	1	Sandstone hills.		Kimberley Research Station, Ord River	-15.65472	128.705	28 01 1949	
	PERTH 01256890	Triodia triticoides	1	Sandstone hills.		Kimberley Research Station	-15.65472	128.705	28 01 1949	
	PERTH 06771998	Typhonium sp. Kununurra (A.N. S	0	Gilgai black soil, dark grey clay. Water logged in summer and with areas that are inundated after rain. Growing on mound just above inundation level.	One mature clump Low open woodland of Bauhinia cunninghamii over perennial grasses. Associated species include Ophioglossum costatum, Polymeria sp.A Kimberley Flora, Commelina ensifolia, Murdania graminea, Chrysopogon fallax.	ca 5 km NW of Kununurra	-15.73523	128.68069	28 12 2001	
	PERTH 06772048	Typhonium sp. Kununurra (A.N. S	0	Gilgai black soil, dark grey clay. Water logged in summer and with areas that are inundated after rain. Growing on mound just above inundation level.	Low open woodland of Bauhinia cunninghamii over perennial grasses. Associated species include Ophioglossum costatum, Polymeria sp.A Kimberley Flora, Commelina ensifolia, Murdania graminea, Chrysopogon fallax.	ca 5 km NW of Kununurra	-15.73523	128.68069	28 12 2001	
	PERTH 03780435	Utricularia muelleri	3	In deep water (0.5 m) at centre of swamp.	Ephemeral swamp supporting dense closed grassland to 1 m. Outer perimeter fringed with trees 5 m of Melaleuca viridiflora with Eucalyptus microtheca scattered in the wetter parts of the swamp.	Ephemeral swamp ("Racecourse Swamp") 3 km S of township Kununurra, N Kimberley	-15.76666	128.75	06 05 1982	
	PERTH 02385317	Utricularia tubulata	1	Annual swamp deep water 0.75 m. Ephemeral swamp containing water at time of visit. Soil sandy alluvium.	Dense closed grassland to 1 m high. Outer perimeter fringed with trees 5 m of Melaleuca viridiflora with Eucalyptus microtheca scattered in the wetter parts of the swamp.	Ephemeral Swamp (Racecourse Swamp) 3 km S of township, Kununurra, N Kimberley	-15.76666	128.75	23 03 1982	
	PERTH 06219276	Whiteochloa capillipes	3	Disturbed cockatoo sand plain.	Aristida hygrometrica grassland.	On the N side of Ord River Co-op ca 6 km N of Kununurra on Weaber Plains Road	-15.70606	128.73625	14 03 1997	
	PERTH 07028938	Zeuxine oblonga	2	In bog situation near springs.	Closed canopy rainforest.	Point Springs Nature Reserve	-15.40795	128.89032	07 09 2003	
	PERTH 07833717	Zeuxine oblonga	2	Shallow permanantly wet fresh spring fed water swamp in about 0.05 m of water.	Terminalia sericocarpa woodland.	Point Springs, 43.34 km from Kununurra Post Office on a bearing of 21 degrees, E Kimberley	-15.40944	128.88389	30 08 2004	
	PERTH 08179867	Zornia areolata	1	Plain. Grey silt. Burnt ca 5 years.	Woodland of Corymbia sp., Melaleuca sp. over grassland of Sorghum ?stipoideum, Aristida holathera var. holathera and Fimbristylis cardiocarpa.	Survey area at Westbank, ca 10 km NNW of Kununurra	-15.66141	128.67385	15 06 2009	

APPENDIX 2: DEC THREATENED SPECIES BRANCH AND WA HERBARIUM SEARCH RESULTS

OID_	SHEET	SPNAME	CONSVCODE	POPID1	POPID2	GDA94LAT	GDA94LONG	VESTING	PURPOSE1	PURPOSE2	STATUS	OWNERDATE
	30797	Acacia richardsii	3	1		-15.76767	128.75664	CC	NPK			30/04/2000 0:00
	30801	Acacia richardsii	3	2		-15.764	128.741	SHI	REC			3/01/2001 0:00
	30849	Brachychiton tuberculatus	3	1		-15.62944	128.95861	PLB	PAS			18/01/1997 0:00
	29082	Desmodium flagellare	1	1		-15.65472	128.705	NON	UCL			7/03/1963 0:00
	18711	Echinochloa kimberleyensis	1	1		-15.51981	128.58508	PLB	PAS			7/01/2002 0:00
	29595	Fimbristylis laxiglumis	2	2		-15.52778	128.74167	DPI	GE			12/06/1999 0:00
	31403	Fuirena incrassata	3	2		-15.53833	128.75625	DPI	OTH			17/08/1999 0:00
	29183	Goodenia durackiana	1	2		-15.65278	128.71028	AGR	ARS			6/03/1963 0:00
	30701	Platysace saxatilis	2	1		-15.76981	128.74806	CC	NPK			18/05/1983 0:00
	29481	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	1	A	-15.73522	128.68069	PRI				28/12/2001 0:00
	31137	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	1	B	-15.73606	128.67958	PRI				9/01/2002 0:00
	31139	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	1	C	-15.73764	128.67756	PRI				9/02/2008 0:00
	31143	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	1	D	-15.73853	128.67881	NON	UCL			13/03/2008 0:00
	31148	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	3	A	-15.73403	128.67467	PRI				21/12/2007 0:00
	31149	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	3	B	-15.73183	128.67522	PRI				27/01/2008 0:00
	31151	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	5		-15.64994	128.68308	PLB	PAS			15/03/2008 0:00
	31152	Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	6		-15.6675	128.69867	PLB	PAS			15/03/2008 0:00

APPENDIX 3 – NATUREMAP SEARCH RESULTS

NatureMap Species Report

Created By Guest user on 02/05/2011

Method 'By Circle'
Centre 128°58' 18" E,15°27' 24" S
Buffer 40km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	4884	*Abelmoschus ficulneus*			
2.	3678	*Abrus precatorius (Crabs Eyes)*			
3.	16979	*Abrus precatorius subsp. precatorius*			
4.	16919	*Abutilon hannii*			
5.	4894	*Abutilon indicum (Indian Lantern Flower)*			
6.	11325	*Abutilon indicum var. australiense*			
7.	17013	*Acacia colei var. colei*			
8.	3302	*Acacia difficilis*			
9.	3313	*Acacia dunnii (Elephant Ear Wattle)*			
10.	3365	*Acacia hemignosta (Clubleaf Wattle)*			
11.	3372	*Acacia holosericea (Candelbra Wattle)*			
12.	18225	*Acacia lamprocarpa*			
13.	3429	*Acacia lycopodiifolia*			
14.	13401	*Acacia neurocarpa*			
15.	3472	*Acacia orthotricha*			
16.	3491	*Acacia platycarpa (Pindan Wattle)*			
17.	14977	*Acacia plectocarpa subsp. plectocarpa*			
18.	3520	*Acacia richardsii*		P3	
19.	3580	*Acacia translucens (Poverty Bush)*			
20.	19641	*Acacia tumida var. tumida*			
21.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
22.	25536	*Accipiter fasciatus (Brown Goshawk)*			
23.	2645	*Achyranthes aspera (Chaff Flower)*			
24.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
25.	24831	*Acrocephalus australis subsp. gouldi*			
26.	-1576	*Actitis hypoleucos*			
27.	-5845	*Adenanthera pavonina*			Y
28.	5224	*Adenia heterophylla*			
29.	-4099	*Adenostemma laevina*			
30.	-6712	*Adenostemma lavenia var. lavenia*			Y
31.	12772	*Adenostemma viscosum*			
32.	25544	*Aegotheles cristatus (Australian Owlet-nightjar)*			
33.	3680	*Aeschynomene indica (Budda Pea)*			
34.	6564	*Alstonia spectabilis*			
35.	2652	*Alternanthera nodiflora (Common Joyweed)*			
36.	2654	*Alternanthera sessilis*			Y
37.	17147	*Alysicarpus muelleri*			
38.	11035	*Amaranthus induratus*			
39.	2670	*Amaranthus tricolor*	Y		
40.	2671	*Amaranthus viridis (Green Amaranth)*	Y		
41.	-1652	*Amaurornis cinerea*			
42.	5276	*Ammannia auriculata*			
43.	5277	*Ammannia baccifera*			
44.	5278	*Ammannia multiflora*			
45.	4849	*Ampelocissus acetosa (Djabaru)*			
46.	35308	*Ampelocissus sp. Kununurra (M.D. Barrett MDB 1525)*			
47.	30831	*Amphibolurus gilberti (Ta-Ta or Gilbert's Dragon)*			
48.	30832	*Amphibolurus gilberti subsp. gilberti*			
49.	11874	*Amyema sanguinea var. sanguinea*			
50.	24316	*Anas superciliosa (Pacific Black Duck)*			
51.	17651	*Andropogon gayanus*	Y		
52.	-1591	*Anhinga novaehollandiae*			
53.	6829	*Anisomeles malabarica*			
54.	-11402	*Annona squamosa*			Y
55.	24317	*Anseranas semipalmata (Magpie Goose (Pied Goose))*			
56.	25317	*Antaresia childreni (Children's Python)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
57.	-1612	*Anthus novaeseelandiae*			
58.	-7101	*Antidesma bunius*			Y
59.	4589	*Antidesma ghaesembilla (Yangu)*			
60.	24719	*Aprosmictus erythropterus (Red-winged Parrot)*			
61.	24285	*Aquila audax (Wedge-tailed Eagle)*			
62.	3694	*Arachis hypogaea (Peanut)*	Y		Y
63.	25558	*Ardea ibis (Cattle Egret)*			
64.	25559	*Ardea intermedia (Intermediate Egret)*			
65.	-1578	*Ardea modesta*			
66.	24341	*Ardea pacifica (White-necked Heron)*			
67.	24610	*Ardeotis australis (Australian Bustard)*		P4	
68.	209	*Aristida exserta*			
69.	211	*Aristida hygrometrica (Northern Kerosene Grass)*			
70.	212	*Aristida inaequiglumis (Feathertop Threeawn)*			
71.	215	*Aristida latifolia (Feathertop Wiregrass)*			
72.	221	*Aristida pruinosa (Gulf Feathertop Wiregrass)*			
73.	-7574	*Aristolochia elegans*			
74.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
75.	25567	*Artamus leucorynchus (White-breasted Woodswallow)*			
76.	24355	*Artamus minor (Little Woodswallow)*			
77.	24356	*Artamus personatus (Masked Woodswallow)*			
78.	8781	*Asparagus racemosus*			
79.	-7180	*Aspergillus niger*			Y
80.	25320	*Aspidites melanocephalus (Black-headed Python)*			
81.	227	*Astrebla elymoides (Weeping Mitchell Grass)*			
82.	230	*Astrebla squarrosa (Bull Mitchell Grass)*			
83.	7161	*Asystasia gangetica*	Y		
84.	4740	*Atalaya hemiglauca (Whitewood)*			
85.	27588	*Australiaena streimannii*			
86.	6828	*Avicennia marina (White Mangrove)*			
87.	24318	*Aythya australis (Hardhead)*			
88.	17660	*Azadirachta indica*	Y		
89.	-12151	*Balansia sclerotica*			
90.	1813	*Banksia dentata (Tropical Banksia)*			
91.	12061	*Barringtonia acutangula subsp. acutangula*			
92.	6830	*Basilicum polystachyon*			
93.	12757	*Bauhinia cunninghamii*			
94.	-5846	*Bauhinia sp.*			
95.	5183	*Bergia ammannioides*			
96.	5184	*Bergia pedicellaris*			
97.	7855	*Bidens pilosa (Cobbler's Pegs)*	Y		
98.	72	*Blechnum orientale*			
99.	12759	*Blumea axillaris*			
100.	7865	*Blumea saxatilis*			
101.	7866	*Blumea tenella*			
102.	-4145	*Blyxa sp.*			
103.	2770	*Boerhavia coccinea (Tar Vine)*			
104.	2771	*Boerhavia dominii*			
105.	2772	*Boerhavia gardneri*			
106.	25324	*Boiga irregularis (Brown Tree Snake)*			
107.	6605	*Bonamia linearis*			
108.	6606	*Bonamia media*			
109.	6608	*Bonamia pannosa*			
110.	4427	*Boronia lanuginosa (Red Boronia)*			
111.	16388	*Boronia wilsonii*			
112.	239	*Bothriochloa bladhii (Forest Bluegrass)*			
113.	16329	*Bothriochloa bladhii subsp. bladhii*			
114.	240	*Bothriochloa ewartiana (Desert Bluegrass)*			
115.	241	*Brachyachne convergens (Spider Grass)*			
116.	13010	*Brachychiton diversifolius subsp. diversifolius*			
117.	12715	*Brachychiton fitzgeraldianus*			
118.	12751	*Brachychiton tuberculatus*		P3	
119.	25334	*Brachyurophis roperi*			
120.	29703	*Buchanania oblongifolia*			
121.	4718	*Buchanania obovata (Wild Mango)*			
122.	13682	*Buchnera asperata*			
123.	7047	*Buchnera linearis (Blackrod)*			
124.	7048	*Buchnera ramosissima (Blackrod)*			
125.	-6353	*Buchnera sp.*			
126.	-5725	*Buellia sp.*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
127.	34118	*Bufo marinus (Cane Toad)*	Y		
128.	750	*Bulbostylis barbata*			
129.	24359	*Burhinus grallarius (Bush Stone-curlew)*		P4	
130.	18073	*Byblis filifolia*			
131.	25713	*Cacatua galerita (Sulphur-crested Cockatoo)*			
132.	25716	*Cacatua sanguinea (Little Corella)*			
133.	-1590	*Cacomantis pallidus*			
134.	25599	*Cacomantis variolosus (Brush Cuckoo)*			
135.	-6902	*Caesalpinia ferrea*			Y
136.	3744	*Cajanus cajan (Pigeon Pea)*	Y		
137.	11059	*Cajanus latisepalus*			
138.	10972	*Cajanus marmoratus*			
139.	3746	*Cajanus viscidus*			
140.	2873	*Calandrinia uniflora*			
141.	18377	*Caldesia oligococca var. oligococca*			
142.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*			
143.	-6132	*Callicarpa sp.*			
144.	8466	*Callitris columellaris (White Cypress Pine)*			
145.	27627	*Caloplaca cupulifera*			
146.	16491	*Calycopeplus collinus*		P1	
147.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
148.	5436	*Calytrix achaeta*			
149.	5457	*Calytrix exstipulata (Kimberley Heather)*			
150.	11617	*Canarium australianum var. glabrum*			
151.	2975	*Capparis jacobsii*			
152.	2980	*Capparis sepiaria*			
153.	-7417	*Capparis sp.*			
154.	2982	*Capparis umbonata (Wild Orange)*			
155.	5293	*Carallia brachiata*			
156.	4743	*Cardiospermum halicacabum (Balloon Vine)*	Y		
157.	11707	*Cardiospermum halicacabum var. halicacabum*	Y		
158.	6567	*Carissa lanceolata (Conkerberry)*			
159.	25012	*Carlia amax*			
160.	25015	*Carlia munda*			
161.	1161	*Cartonema parviflorum (Wiridjagu)*			
162.	15120	*Cartonema spicatum var. humile*			
163.	-6530	*Casimiroa edulis*			Y
164.	-12329	*Cassia siamea*			Y
165.	2949	*Cassytha capillaris*			
166.	2950	*Cassytha filiformis (Love Vine)*			
167.	11328	*Cathormion umbellatum subsp. moniliforme*			
168.	4851	*Cayratia trifolia (Yugali)*			
169.	-1685	*Cecropis daurica*			
170.	1744	*Celtis philippensis*			
171.	258	*Cenchrus ciliaris (Buffel Grass)*	Y		
172.	259	*Cenchrus echinatus (Burrgrass)*	Y		
173.	260	*Cenchrus elymoides*			
174.	29721	*Cenchrus setiger (Birdwood Grass)*	Y		
175.	25600	*Centropus phasianinus (Pheasant Coucal)*			
176.	-10047	*Centrosema molle*			
177.	13680	*Centrosema pascuorum*	Y		
178.	30	*Ceratopteris thalictroides*			
179.	-11081	*Cercospora apii*			
180.	-1657	*Ceyx azureus*			
181.	-1624	*Chalcites basalis*			
182.	-1588	*Chalcites minutillus*			
183.	-1615	*Chalcites osculans*			
184.	25583	*Chalcophaps indica (Emerald Dove)*			
185.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
186.	18358	*Chamaecrista absus var. absus*			
187.	25338	*Chelodina rugosa (Northern Long-necked Turtle)*			
188.	2485	*Chenopodium auricomum (Queensland Bluebush)*			
189.	264	*Chionachne cyathopoda (River Grass)*			
190.	265	*Chionachne hubbardiana (River Grass)*			
191.	24863	*Chlamydosaurus kingii (Frill-necked Lizard)*			
192.	266	*Chloris barbata (Purpletop Chloris)*	Y		
193.	270	*Chloris pumilio*			
194.	3765	*Christia australasica*			
195.	274	*Chrysopogon latifolius (Broadleaf Ribbongrass)*			
196.	275	*Chrysopogon pallidus (Ribbongrass)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
197.	27662	*Chrysothrix candelaris*			
198.	24834	*Cincloramphus mathewsi (Rufous Songlark)*			
199.	24288	*Circus approximans (Swamp Harrier)*			
200.	24289	*Circus assimilis (Spotted Harrier)*			
201.	24565	*Cissomela pectoralis (Banded Honeyeater)*			
202.	25756	*Cisticola exilis (Golden-headed Cisticola)*			
203.	24835	*Cisticola exilis subsp. exilis*			
204.	-1609	*Cisticola juncidus*			
205.	2983	*Cleome cleomoides (Justago)*			
206.	2985	*Cleome oxalidea*			
207.	2986	*Cleome tetrandra*			
208.	11886	*Cleome tetrandra var. tetrandra*			
209.	2988	*Cleome viscosa (Tickweed)*			
210.	6729	*Clerodendrum floribundum (Lollybush)*			
211.	13691	*Clerodendrum floribundum var. ovatum*			
212.	-12241	*Clerodendrum sp.*			
213.	25582	*Climacteris melanura (Black-tailed Treecreeper)*			
214.	3769	*Clitoria ternatea*	Y		
215.	5214	*Cochlospermum fraseri (Kapok Bush)*			
216.	-6976	*Colletotrichum graminicola*			
217.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
218.	24611	*Colluricincla harmonica subsp. brunnea*			
219.	24615	*Colluricincla woodwardi (Sandstone Shrike-thrush)*			
220.	13712	*Commelina ciliata*			
221.	1165	*Commelina ensifolia (Wandering Jew)*			
222.	24566	*Conopophila rufogularis (Rufous-throated Honeyeater)*			
223.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
224.	25569	*Coracina papuensis (White-bellied Cuckoo-shrike (Little Cuckoo-shrike))*			
225.	12767	*Corchorus aestuans*			
226.	4858	*Corchorus fascicularis (Grubweed)*			
227.	4860	*Corchorus macropetalus*			
228.	4861	*Corchorus olitorius (Jute)*	Y		
229.	4863	*Corchorus pumilio*			
230.	4864	*Corchorus sidoides (Flannel Weed)*			
231.	18415	*Corchorus sidoides subsp. sidoides*			
232.	4865	*Corchorus tridens*			
233.	13467	*Corchorus trilocularis*			
234.	6677	*Cordia dichotoma*			
235.	25593	*Corvus orru (Torresian Crow)*			
236.	-1666	*Corvus sp.*			
237.	17073	*Corymbia aspera*			
238.	17088	*Corymbia cliftoniana*			
239.	17080	*Corymbia confertiflora*			
240.	19125	*Corymbia dichromophloia*			
241.	17089	*Corymbia greeniana*			
242.	17102	*Corymbia ptychocarpa subsp. ptychocarpa*			
243.	11624	*Corynotheca micrantha var. gracilis*			
244.	25701	*Coturnix ypsilophora (Brown Quail)*			
245.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
246.	25595	*Cracticus tibicen (Australian Magpie)*			
247.	25596	*Cracticus torquatus (Grey Butcherbird)*			
248.	24425	*Cracticus torquatus subsp. latens*			
249.	25397	*Crinia bilingua (Bilingual Froglet)*			
250.	1490	*Crinum angustifolium*			
251.	34067	*Cristilabrum bubulum*		T	
252.	34068	*Cristilabrum buryillum*		T	Y
253.	34069	*Cristilabrum grossum*		T	Y
254.	34070	*Cristilabrum isolatum*		T	
255.	34071	*Cristilabrum monodon*		T	Y
256.	34072	*Cristilabrum primum*		T	Y
257.	34074	*Cristilabrum simplex*		T	
258.	34076	*Cristilabrum spectaculum*		T	
259.	24858	*Crocodylus johnstoni (Freshwater Crocodile)*		S	
260.	767	*Crosslandia setifolia*			
261.	20182	*Crotalaria aridicola subsp. densifolia*			
262.	3773	*Crotalaria crispata (Kimberley Horse Poison)*			
263.	3774	*Crotalaria cunninghamii (Green Birdflower)*			
264.	20176	*Crotalaria cunninghamii subsp. cunninghamii*			
265.	3777	*Crotalaria goreensis (Gambia Pea)*	Y		
266.	3780	*Crotalaria juncea (Sunnhemp)*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
267.	3783	*Crotalaria medicaginea*			
268.	20179	*Crotalaria medicaginea var. neglecta*			
269.	12324	*Crotalaria montana*			
270.	20180	*Crotalaria montana var. angustifolia*			
271.	3785	*Crotalaria novae-hollandiae (New Holland Rattlepod)*			
272.	11231	*Crotalaria novae-hollandiae subsp. novae-hollandiae*			
273.	3787	*Crotalaria verrucosa (Blueflower Rattlepod)*			
274.	4610	*Croton tomentellus*			
275.	4798	*Cryptandra intratropica*			
276.	30887	*Cryptoblepharus exochus*			Y
277.	30890	*Cryptoblepharus ruber*			
278.	25291	*Cryptophis pallidiceps (Northern Small-eyed Snake)*			
279.	25048	*Ctenotus inornatus*			
280.	25055	*Ctenotus militaris*			
281.	25061	*Ctenotus pantherinus subsp. calx*			
282.	25062	*Ctenotus piankai*			
283.	25068	*Ctenotus rimacola subsp. camptris*			
284.	25070	*Ctenotus robustus*			
285.	25079	*Ctenotus tantillus*			
286.	33031	*Cucumis maderaspatanus*			
287.	7371	*Cucumis melo (Ulcardo Melon)*	Y		
288.	17433	*Cullen badocanum*			
289.	17447	*Cullen pustulatum*			
290.	1166	*Cyanotis axillaris*			
291.	19063	*Cyanthillium cinereum*			
292.	25371	*Cyclorana australis (Giant Frog)*			
293.	25372	*Cyclorana cryptotis (Hidden-ear Frog)*			
294.	25373	*Cyclorana cultripes (Knife-footed Frog)*			
295.	25374	*Cyclorana longipes (Long-footed Frog)*			
296.	25377	*Cyclorana vagitus (Wailing Frog)*			
297.	54	*Cyclosorus interruptus*			
298.	24322	*Cygnus atratus (Black Swan)*			
299.	1628	*Cymbidium canaliculatum*			
300.	279	*Cymbopogon ambiguus (Scentgrass)*			
301.	282	*Cymbopogon procerus (Lemon Grass)*			
302.	6584	*Cynanchum floribundum (Dumara Bush)*			
303.	6585	*Cynanchum pedunculatum*			
304.	283	*Cynodon dactylon (Couch)*	Y		
305.	774	*Cyperus bifax (Downs Nutgrass)*			
306.	780	*Cyperus compactus*			Y
307.	784	*Cyperus conicus*			
308.	12811	*Cyperus cunninghamii subsp. cunninghamii*			
309.	12810	*Cyperus cunninghamii subsp. uniflorus*			
310.	789	*Cyperus difformis (Rice Sedge)*			
311.	796	*Cyperus haspan*			
312.	797	*Cyperus holoschoenus*			
313.	798	*Cyperus iria*			
314.	802	*Cyperus macrostachyos*			
315.	12806	*Cyperus microcephalus subsp. chersophilus*			
316.	12807	*Cyperus microcephalus subsp. microcephalus*			
317.	804	*Cyperus nervulosus*			
318.	810	*Cyperus rotundus (Nut Grass)*	Y		
319.	813	*Cyperus sexflorus*			
320.	817	*Cyperus tenuispica*			
321.	818	*Cyperus vaginatus (Stiffleaf Sedge)*			
322.	820	*Cyperus viscidulus*			
323.	821	*Cyperus zollingeri*			
324.	25547	*Dacelo leachii (Blue-winged Kookaburra)*			
325.	288	*Dactyloctenium aegyptium (Coast Button Grass)*	Y		
326.	290	*Dactyloctenium radulans (Button Grass)*			
327.	-11443	*Dalbergia melanoxylon*			Y
328.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
329.	10823	*Datura inoxia*	Y		
330.	14174	*Decaisnina angustata*			
331.	25004	*Delma tincta*			
332.	25294	*Demansia papuensis (Great Black Whipsnake)*			
333.	25299	*Demansia vestigiata (Lesser Black Whipsnake)*			
334.	25325	*Dendrelaphis punctulata (Green Tree Snake)*			
335.	24324	*Dendrocygna arcuata (Wandering Whistling Duck (Chestnut Whistling Duck))*			
336.	24325	*Dendrocygna eytoni (Plumed Whistling Duck)*			

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337.	11407	*Dendrophthoe acacioides subsp. acacioides*			
338.	2393	*Dendrophthoe glabrescens*			
339.	3851	*Desmodium brownii*			
340.	3853	*Desmodium filiforme*			
341.	3854	*Desmodium flagellare*		P1	
342.	17771	*Desmodium glareosum*			
343.	3856	*Desmodium muelleri*			
344.	19333	*Desmodium scorpiurus*	Y		
345.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
346.	302	*Dichanthium aristatum (Angleton Grass)*	Y		
347.	303	*Dichanthium fecundum (Curly Bluegrass)*			
348.	13740	*Dichanthium sericeum subsp. polystachyum*			
349.	11964	*Dichanthium sericeum subsp. sericeum*			
350.	7166	*Dicliptera armata*			
351.	7167	*Dicliptera ciliata*			
352.	17654	*Dicranopteris linearis var. linearis*			
353.	309	*Digitaria bicornis (Finger Grass)*			
354.	311	*Digitaria ciliaris (Summer Grass)*	Y		
355.	316	*Digitaria longiflora*			
356.	319	*Digitaria papposa*			
357.	-8556	*Dinebra retroflexa*			
358.	1508	*Dioscorea bulbifera (Ganmanggu)*			
359.	2395	*Diplatia grandibractea*			
360.	25228	*Diporiphora arnhemica*			
361.	24892	*Diporiphora bennettii*			
362.	24894	*Diporiphora lalliae*			
363.	24895	*Diporiphora magna*			
364.	38462	*Dodonaea hispidula var. phylloptera*			
365.	7114	*Dolichandrone filiformis*		P2	
366.	7115	*Dolichandrone heterophylla (Lemonwood)*			
367.	24470	*Dromaius novaehollandiae (Emu)*			
368.	17517	*Drosera brevicornis*			
369.	3093	*Drosera burmanni (Tropical Sundew)*			
370.	3103	*Drosera indica (Indian Sundew)*			
371.	14919	*Drosera ordensis*			
372.	2504	*Dysphania plantaginella*			
373.	328	*Echinochloa colona (Awnless Barnyard Grass)*	Y		
374.	16093	*Echinochloa esculenta*	Y		
375.	333	*Echinochloa kimberleyensis*		P1	
376.	8450	*Eclipta prostrata*	Y		
377.	343	*Ectrosia leporina (Hare's-foot Grass)*			
378.	345	*Ectrosia schultzii (Hare's Foot Grass)*			
379.	11453	*Ectrosia schultzii var. schultzii*			
380.	-1623	*Egretta garzetta*			
381.	-1577	*Egretta novaehollandiae*			
382.	-1587	*Egretta picata*			
383.	14301	*Ehretia saligna var. saligna*			
384.	-1600	*Elanus axillaris*			
385.	24291	*Elanus scriptus (Letter-winged Kite)*			
386.	824	*Eleocharis brassii*			
387.	826	*Eleocharis dulcis (Chinese Water Chestnut)*			
388.	-1573	*Elseyornis melanops*			
389.	355	*Elytrophorus spicatus (Spikegrass)*			
390.	30713	*Emilia sonchifolia var. sonchifolia*	Y		
391.	25348	*Emydura australis*			
392.	365	*Enneapogon polyphyllus (Leafy Nineawn)*			
393.	12749	*Enneapogon purpurascens (Purple Nineawn)*			
394.	17957	*Enteropogon minutus*		P1	Y
395.	-1644	*Entomyzon cyanotis*			
396.	-1569	*Eolophus roseicapillus*			
397.	7966	*Epaltes australis*			
398.	25578	*Ephippiorhynchus asiaticus (Black-necked Stork)*			
399.	15733	*Eragrostis fallax*			
400.	388	*Eragrostis leptocarpa (Drooping Lovegrass)*			
401.	395	*Eragrostis speciosa (Handsome Lovegrass)*			
402.	398	*Eragrostis tenellula (Delicate Lovegrass)*			
403.	404	*Eriachne ciliata (Slender Wandarrie Grass)*			
404.	410	*Eriachne glauca (Pan Wandarrie Grass)*			
405.	11338	*Eriachne glauca var. barbinodis*			
406.	12055	*Eriachne glauca var. glauca*			

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407.	414	*Eriachne obtusa (Northern Wandarrie Grass)*			
408.	416	*Eriachne pauciflora*			
409.	-5935	*Eriachne sp.*			
410.	420	*Eriachne sulcata*			
411.	1154	*Eriocaulon cinereum*			
412.	19076	*Eriochloa crebra*			
413.	3871	*Erythrina vespertilio (Yulbah)*			
414.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
415.	3662	*Erythrophleum chlorostachys (Ironwood)*			
416.	4365	*Erythroxylum ellipticum*			
417.	24632	*Erythrura gouldiae (Gouldian Finch)*		T	
418.	5561	*Eucalyptus bigalerita (Northern Salmon Gum)*			
419.	5564	*Eucalyptus brachyandra (Tropical Red Box)*			
420.	35345	*Eucalyptus camaldulensis subsp. obtusa (Blunt-budded River Red Gum)*			
421.	5599	*Eucalyptus confluens (Kimberley Gum)*			
422.	5714	*Eucalyptus microtheca (Coolibah)*			
423.	5715	*Eucalyptus miniata (Woollybutt)*			
424.	15185	*Eucalyptus obconica*			
425.	15197	*Eucalyptus pantoleuca*			
426.	5785	*Eucalyptus tectifica (Darwin Box)*			
427.	5789	*Eucalyptus tetrodonta (Darwin Stringybark)*			
428.	-1658	*Eudynamys orientalis*			
429.	11011	*Eulalia aurea*			
430.	4614	*Euphorbia alsiniflora (Namana)*			
431.	31375	*Euphorbia bifida*			
432.	4623	*Euphorbia coghlanii (Namana)*			
433.	13754	*Euphorbia comans*			
434.	4626	*Euphorbia drummondii (Caustic Weed)*			
435.	4629	*Euphorbia hirta (Asthma Plant)*	Y		
436.	13282	*Euphorbia maconochieana*			
437.	4641	*Euphorbia schizolepis*			
438.	4646	*Euphorbia stevenii (Caustic Bottletree)*		P3	
439.	24368	*Eurostopodus argus (Spotted Nightjar)*			
440.	25591	*Eurystomus orientalis (Dollarbird)*			
441.	11416	*Evolvulus alsinoides var. decumbens*			
442.	-1598	*Excalfactoria chinensis*			
443.	11063	*Excoecaria parvifolia (Guttapercha Tree)*			
444.	11169	*Exocarpos latifolius (Broad-leaved Cherry)*			
445.	-11647	*Exserohilum holmii*			Y
446.	-4588	*Exserohilum rostratum*			Y
447.	25621	*Falco berigora (Brown Falcon)*			
448.	25622	*Falco cenchroides (Australian Kestrel)*			
449.	24473	*Falco hypoleucos (Grey Falcon)*		P4	
450.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
451.	24476	*Falco subniger (Black Falcon)*			
452.	31578	*Ficus aculeata var. indecora (Ranji)*			
453.	-4302	*Ficus benjamina*			Y
454.	19642	*Ficus cerasicarpa*			
455.	19621	*Ficus lilliputiana forma pilosa*			
456.	1753	*Ficus platypoda (Native Fig)*			
457.	1755	*Ficus racemosa (Stem-fruit Fig)*			
458.	11635	*Ficus racemosa var. racemosa*			
459.	1758	*Ficus tinctoria*			
460.	14284	*Ficus tinctoria subsp. tinctoria*			
461.	11572	*Ficus virens var. sublanceolata*			
462.	12096	*Ficus virens var. virens*			
463.	841	*Fimbristylis caespitosa*			
464.	849	*Fimbristylis denudata*			
465.	851	*Fimbristylis dichotoma (Eight Day Grass)*			
466.	12156	*Fimbristylis laxiglumis*		P2	
467.	859	*Fimbristylis littoralis*			
468.	862	*Fimbristylis microcarya*			
469.	872	*Fimbristylis pauciflora*			
470.	873	*Fimbristylis phaeoleuca (Sedge)*			
471.	877	*Fimbristylis punctata*			
472.	880	*Fimbristylis schultzii*			
473.	-5215	*Fimbristylis sp.*			
474.	-7112	*Flacourtia inermis*			Y
475.	-6048	*Flacourtia jangomas*			Y
476.	35558	*Flaveria trinervia (Speedy Weed)*	Y		

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477.	3884	*Flemingia pauciflora*			
478.	4654	*Flueggea virosa*			
479.	12013	*Flueggea virosa subsp. melanthesoides*			
480.	896	*Fuirena ciliaris*			
481.	16248	*Fuirena incrassata*		P3	
482.	25301	*Furina ornata (Moon Snake)*			
483.	-6765	*Galactia sp.*			
484.	15240	*Gardenia dacryoides*			
485.	-6158	*Gardenia pryiformis subsp. pyriformis*			
486.	7328	*Gardenia pyriformis (Malara)*			
487.	17560	*Gardenia pyriformis subsp. pyriformis*			
488.	17561	*Gardenia resinosa subsp. resinosa*			
489.	-10570	*Gardenia sp.*			
490.	-3846	*Geastrum sp.*			
491.	24952	*Gehyra australis*			
492.	24954	*Gehyra nana*			
493.	-1684	*Genus sp.*			
494.	24401	*Geopelia cuneata (Diamond Dove)*			
495.	24402	*Geopelia humeralis (Bar-shouldered Dove)*			
496.	25585	*Geopelia striata (Peaceful Dove)*			
497.	24403	*Geopelia striata subsp. placida*			
498.	11065	*Germainia truncatiglumis*			
499.	-1651	*Gerygone albogularis*			
500.	-1584	*Gerygone chloronota*			
501.	25113	*Glaphyromorphus isolepis*			
502.	24481	*Glareola maldivarum (Oriental Pratincole)*			
503.	2835	*Glinus lotoides (Hairy Carpet Weed)*			
504.	12681	*Glochidion sumatranum*			
505.	3937	*Glycine arenaria*			
506.	3942	*Glycine tomentella (Woolly Glycine)*			
507.	18362	*Gomphrena affinis subsp. affinis*			
508.	18205	*Gomphrena brachystylis subsp. brachystylis*			
509.	18363	*Gomphrena canescens subsp. canescens*			
510.	2681	*Gomphrena diffusa*			
511.	2682	*Gomphrena flaccida (Gomphrena Weed)*			
512.	2683	*Gomphrena leptoclada*			
513.	6158	*Gonocarpus leptothecus*			
514.	7496	*Goodenia bicolor*			
515.	12513	*Goodenia brachypoda*		P1	
516.	12519	*Goodenia durackiana*		P1	
517.	7521	*Goodenia lamprosperma*			
518.	12550	*Goodenia malvina*		P1	
519.	7540	*Goodenia purpurascens*		P3	
520.	7548	*Goodenia sepalosa*			
521.	13163	*Goodenia sepalosa var. sepalosa*			
522.	-4826	*Goodenia sp.*			
523.	19754	*Goodenia sp. Dampier Peninsula (B.J. Carter 675)*			
524.	4910	*Gossypium australe (Native Cotton)*			
525.	4913	*Gossypium hirsutum (Upland Cotton)*	Y		
526.	24443	*Grallina cyanoleuca (Magpie-lark)*			
527.	1950	*Grevillea agrifolia (Blue Grevillea)*			
528.	19427	*Grevillea agrifolia subsp. agrifolia*			
529.	19566	*Grevillea decurrens*			
530.	1990	*Grevillea dimidiata (Caustic Bush)*			
531.	2058	*Grevillea parallela*			
532.	2072	*Grevillea prasina*			
533.	2076	*Grevillea pteridifolia (Silky Grevillea)*			
534.	19570	*Grevillea pyramidalis subsp. leucadendron*			
535.	15675	*Grevillea refracta subsp. glandulifera*			
536.	16476	*Grevillea refracta subsp. refracta*			
537.	2099	*Grevillea striata (Beefwood)*			
538.	4868	*Grewia breviflora*			
539.	4872	*Grewia retusifolia (Dog's Balls)*			
540.	24484	*Grus rubicunda (Brolga)*			
541.	-5264	*Guazuma ulmifolia*			
542.	-6391	*Guizotia abyssinica*			Y
543.	2960	*Gyrocarpus americanus (Helicopter Tree)*			
544.	1463	*Haemodorum brevicaule*			
545.	2129	*Hakea arborescens (Common Hakea)*			
546.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			

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547.	25541	*Haliastur indus (Brahminy Kite)*			
548.	24295	*Haliastur sphenurus (Whistling Kite)*			
549.	24297	*Hamirostra melanosternon (Black-breasted Buzzard)*			
550.	-4394	*Harpullia zanguebarica*			Y
551.	4510	*Harrisonia brownii*			
552.	17554	*Heliotropium alcyonium*		P1	Y
553.	16843	*Heliotropium brachythrix*			
554.	17302	*Heliotropium cupressinum*		P1	
555.	-6172	*Heliotropium dichotoma x euodes*			Y
556.	17294	*Heliotropium dichotomum*			
557.	17303	*Heliotropium euodes*			
558.	10992	*Heliotropium glabellum*			
559.	6714	*Heliotropium paniculatum*			
560.	17312	*Heliotropium ramulipatens*			
561.	-4105	*Heliotropium sp.*			
562.	4920	*Herissantia crispa*			
563.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
564.	24963	*Heteronotia planiceps*			
565.	443	*Heteropogon contortus (Bunch Speargrass)*			
566.	5151	*Hibbertia oblongata*			
567.	20463	*Hibiscus aphelus*			
568.	29317	*Hibiscus austrinus var. austrinus*			
569.	4933	*Hibiscus leptocladus*			
570.	4934	*Hibiscus meraukensis (Merauke Hibiscus)*			
571.	4937	*Hibiscus pentaphyllus*			
572.	-7172	*Hibiscus sp.*			
573.	-1601	*Hieraaetus morphnoides*			
574.	25734	*Himantopus himantopus (Black-winged Stilt)*			
575.	24177	*Hipposideros ater subsp. gilberti (Dusky Leafnosed-bat)*			
576.	24178	*Hipposideros stenotis (Northern Leafnosed-bat)*		P2	
577.	5215	*Hybanthus aurantiacus*			
578.	5219	*Hybanthus enneaspermus*			
579.	166	*Hydrilla verticillata (Water Thyme)*			
580.	24215	*Hydromys chrysogaster (Water-rat)*		P4	
581.	-1642	*Hydroprogne caspia*			
582.	7170	*Hygrophila angustifolia*			
583.	6876	*Hyptis suaveolens (Hyptis)*	Y		
584.	453	*Imperata cylindrica (Kunai Grass)*			
585.	3973	*Indigofera colutea (Sticky Indigo)*			
586.	3976	*Indigofera haplophylla*			
587.	3978	*Indigofera hirsuta (Hairy Indigo)*			
588.	3980	*Indigofera linifolia*			
589.	19447	*Indigofera pilifera*			
590.	3987	*Indigofera trita*			
591.	31035	*Indigofera trita subsp. trita*			
592.	6618	*Ipomoea abrupta*			
593.	11783	*Ipomoea carnea subsp. fistulosa*	Y		
594.	6625	*Ipomoea diamantinensis*			
595.	6628	*Ipomoea gracilis*		P1	
596.	6633	*Ipomoea muelleri (Poison Morning Glory)*			
597.	6634	*Ipomoea nil*			
598.	6637	*Ipomoea polymorpha*			
599.	-5664	*Ipomoea sp.*			
600.	18407	*Ipomoea sp. Kalumburu (A.A. Mitchell 3869B)*		P1	
601.	-1575	*Irediparra gallinacea*			
602.	455	*Ischaemum australe (Large Bluegrass)*			
603.	13894	*Ischaemum australe var. australe*			
604.	461	*Iseilema fragile*			
605.	465	*Iseilema vaginiflorum (Red Flinders Grass)*			
606.	24152	*Isoodon macrourus (Northern Brown Bandicoot)*			
607.	25562	*Ixobrychus flavicollis (Black Bittern)*			
608.	13012	*Jacksonia forrestii*			
609.	13553	*Jacquemontia pannosa*			
610.	6501	*Jasminum didymum*			
611.	11315	*Jasminum didymum subsp. didymum*			
612.	6502	*Jasminum molle*			
613.	7118	*Josephinia eugeniae (Josephinia Burr)*			
614.	-4047	*Lagerstroemia sp.*			Y
615.	-1641	*Lalage sueurii*			
616.	24367	*Lalage tricolor (White-winged Triller)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
617.	1050	*Lemna aequinoctialis*			
618.	-10283	*Lenzites acuta*			
619.	19124	*Leptochloa fusca subsp. fusca*			
620.	19067	*Leptochloa fusca subsp. uninervia*	Y		
621.	472	*Leptochloa neesii (Umbrella Canegrass)*			
622.	23998	*Lepturus copeanus*		P1	Y
623.	25126	*Lerista borealis*			
624.	25138	*Lerista griffini*			
625.	3613	*Leucaena leucocephala (Leucaena)*	Y		
626.	25005	*Lialis burtonis*			
627.	25321	*Liasis mackloti subsp. fuscus*			
628.	25239	*Liasis olivaceus subsp. olivaceus*			
629.	25658	*Lichenostomus flavescens (Yellow-tinted Honeyeater)*			
630.	24574	*Lichenostomus flavescens subsp. flavescens*			
631.	24579	*Lichenostomus plumulus (Grey-fronted Honeyeater)*			
632.	25660	*Lichenostomus unicolor (White-gaped Honeyeater)*			
633.	24581	*Lichenostomus virescens (Singing Honeyeater)*			
634.	25661	*Lichmera indistincta (Brown Honeyeater)*			
635.	24582	*Lichmera indistincta subsp. indistincta*			
636.	25413	*Limnodynastes convexiusculus (Marbled Frog)*			
637.	25414	*Limnodynastes depressus (Flat-headed Frog)*			
638.	12481	*Lindernia cleistandra*			
639.	-4150	*Lindernia sp.*			
640.	58	*Lindsaea ensifolia*			
641.	19112	*Lindsaea ensifolia subsp. ensifolia*			
642.	25380	*Litoria caerulea (Green Tree Frog)*			
643.	25381	*Litoria coplandi (Rock Frog)*			
644.	25385	*Litoria inermis (Bumpy Rocket Frog)*			
645.	25386	*Litoria meiriana (Rockhole Frog)*			
646.	25389	*Litoria nasuta (Striped Rocket Frog)*			
647.	25390	*Litoria pallida (Pale Rocket Frog)*			
648.	25391	*Litoria rothii (Northern Laughing Tree Frog)*			
649.	25392	*Litoria rubella (Little Red Tree Frog)*			
650.	25393	*Litoria splendida (Splendid Tree Frog)*			
651.	37480	*Lobelia arnhemiaca*			
652.	37520	*Lobelia douglasiana*			
653.	25683	*Lonchura castaneothorax (Chestnut-breasted Mannikin)*			
654.	24634	*Lonchura castaneothorax subsp. castaneothorax*			
655.	24635	*Lonchura flaviprymna (Yellow-rumped Mannikin)*			
656.	11567	*Lophostemon grandiflorus subsp. riparius*			
657.	6135	*Ludwigia octovalvis (Willow Primrose)*			
658.	6136	*Ludwigia perennis*			
659.	29598	*Luffa aegyptiaca var. leiocarpa (Loofah)*			
660.	7376	*Luffa graveolens*			
661.	21	*Lygodium microphyllum (Climbing Maidenhair)*			
662.	-5606	*Macalpinomyces ewartii*			
663.	24180	*Macroderma gigas (Ghost Bat)*		P4	
664.	-6980	*Macrophomina phaseolina*			
665.	17403	*Macroptilium lathyroides var. semierectum*	Y		
666.	24129	*Macropus agilis (Agile Wallaby)*			
667.	24135	*Macropus robustus subsp. erubescens (Euro, Biggada)*			
668.	4658	*Mallotus nesophilus*			
669.	25651	*Malurus lamberti (Variegated Fairy-wren)*			
670.	25653	*Malurus melanocephalus (Red-backed Fairy-wren)*			
671.	4962	*Malvastrum americanum (Spiked Malvastrum)*	Y		
672.	-5628	*Manilkara hexandra*			Y
673.	-12940	*Manilkara sp.*			Y
674.	24583	*Manorina flavigula (Yellow-throated Miner)*			
675.	16537	*Marsdenia angustata*			
676.	16540	*Marsdenia geminata*			
677.	73	*Marsilea angustifolia (Narrow-leaf Nardoo)*			
678.	76	*Marsilea hirsuta (Nardoo)*			
679.	77	*Marsilea mutica*			
680.	25759	*Megalurus timoriensis (Tawny Grassbird)*			
681.	5867	*Melaleuca acacioides (Coastal Paperbark)*			
682.	5875	*Melaleuca argentea (Silver Cadjeput)*			
683.	5901	*Melaleuca dealbata (Karnbor)*			
684.	5939	*Melaleuca minutifolia (Tea Tree)*			
685.	15691	*Melaleuca nervosa subsp. crosslandiana*			
686.	5965	*Melaleuca sericea*			

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687.	5989	*Melaleuca viridiflora (Broadleaf Paperbark)*			
688.	12472	*Melastoma affine*			
689.	12361	*Melicope elleryana*			
690.	24585	*Melithreptus albogularis (White-throated Honeyeater)*			
691.	25664	*Melithreptus cyanotis (Blue-faced Honeyeater)*			
692.	24588	*Melithreptus cyanotis subsp. albipennis*			
693.	5053	*Melochia pyramidata*	Y		
694.	24220	*Melomys burtoni (Grassland Melomys)*			
695.	24736	*Melopsittacus undulatus (Budgerigar)*			
696.	25184	*Menetia greyii*			
697.	25185	*Menetia maini*			
698.	24598	*Merops ornatus (Rainbow Bee-eater)*			
699.	6647	*Merremia gemella*			
700.	29181	*Micraira sp. Purnululu (M.D. Barrett & R.L. Barrett 1507)*		P1	
701.	-1636	*Microcarbo melanoleucos*			
702.	7080	*Microcarpaea minima*			
703.	25693	*Microeca fascinans (Jacky Winter)*			
704.	31374	*Microstachys chamaelea*			
705.	25542	*Milvus migrans (Black Kite)*			
706.	36337	*Mimosa pigra*	Y		
707.	13721	*Mimulus uvedaliae*			
708.	13720	*Mimulus uvedaliae var. uvedaliae*			
709.	24190	*Miniopterus schreibersii subsp. orianae (Common Bentwing-bat)*			
710.	25545	*Mirafra javanica (Horsfield's Bushlark (Singing Bushlark))*			
711.	-6159	*Mitracarpus hirtus*			
712.	6519	*Mitrasacme connata*			
713.	15062	*Mitrasacme epigaea*			
714.	15074	*Mitrasacme scrithicola*			
715.	489	*Mnesithea rottboellioides*			
716.	1171	*Monochoria vaginalis*			
717.	25194	*Morethia ruficauda subsp. ruficauda*			
718.	7335	*Morinda citrifolia*			
719.	19717	*Moringa oleifera*	Y		
720.	-1610	*Motacilla sp.*			
721.	1167	*Murdannia graminea (Baniyu)*			
722.	24223	*Mus musculus (House Mouse)*	Y		
723.	25610	*Myiagra inquieta (Restless Flycatcher)*			
724.	25611	*Myiagra rubecula (Leaden Flycatcher)*			
725.	24449	*Myiagra rubecula subsp. concinna*			
726.	-8620	*Najas sp.*			
727.	7337	*Nauclea orientalis (Leichardt Pine)*			
728.	7173	*Nelsonia campestris*			
729.	25684	*Neochima phaeton (Crimson Finch)*			
730.	25685	*Neochima ruficauda (Star Finch)*			
731.	68	*Nephrolepis biserrata*			
732.	3614	*Neptunia dimorphantha (Sensitive Plant)*			
733.	3616	*Neptunia major*			
734.	3617	*Neptunia monosperma*			
735.	12368	*Nesaea arnhemica*			
736.	5283	*Nesaea repens*			
737.	24327	*Nettapus pulchellus (Green Pygmy-goose)*			
738.	6971	*Nicotiana benthamiana (Tjuntiwari)*			
739.	25747	*Ninox connivens (Barking Owl)*			
740.	25748	*Ninox novaeseelandiae (Boobook Owl)*			
741.	4112	*Nomismia rhomboidea*			
742.	38421	*Notoleptopus decaisnei*			
743.	25198	*Notoscincus ornatus subsp. wotjulum*			
744.	24799	*Numenius minutus (Little Curlew)*			
745.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
746.	24742	*Nymphicus hollandicus (Cockatiel)*			
747.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
748.	-10726	*Oidium sp.*			
749.	2363	*Olax aphylla*			
750.	13341	*Oldenlandia argillacea*			
751.	12498	*Oldenlandia corymbosa*			
752.	7338	*Oldenlandia crouchiana*			
753.	12499	*Oldenlandia spermacocoides*			
754.	24138	*Onychogalea unguifera (Northern Nailtail Wallaby, Karrabul)*			
755.	6651	*Operculina aequisepala*			
756.	6652	*Operculina brownii (Potato Vine)*			

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757.	496	*Ophiuros exaltatus (Canegrass)*			
758.	2362	*Opilia amentacea*			
759.	30942	*Opisthodon ornatus (Ornate Burrowing Frog)*			
760.	34092	*Ordtrachia elegans*		T	Y
761.	24607	*Oriolus flavocinctus (Yellow Oriole)*			
762.	24608	*Oriolus sagittatus (Olive-backed Oriole)*			
763.	497	*Oryza australiensis (Australian Wild Rice)*			
764.	498	*Oryza rufipogon (Red Rice)*			
765.	6130	*Osbeckia australiana*			
766.	4518	*Owenia reticulata (Native Walnut)*			
767.	4519	*Owenia vernicosa (Emu Apple)*			
768.	-7307	*Oxalis sp.*			
769.	-12641	*Pachira aquatica*			Y
770.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
771.	24624	*Pachycephala rufiventris subsp. rufiventris*			
772.	-1611	*Pandion cristatus*			
773.	503	*Panicum decompositum (Native Millet)*			
774.	505	*Panicum laevinode*			
775.	508	*Panicum mindanaense*			
776.	-12437	*Panicum sp.*			
777.	511	*Panicum trachyrhachis*			
778.	512	*Panicum trichoides*			
779.	24627	*Pardalotus rubricatus (Red-browed Pardalote)*			
780.	25682	*Pardalotus striatus (Striated Pardalote)*			
781.	3673	*Parkinsonia aculeata (Parkinsonia)*	Y		
782.	6574	*Parsonsia velutina*			
783.	531	*Paspalum scrobiculatum (Scrobic)*			
784.	14096	*Passiflora foetida var. hispida*	Y		
785.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
786.	-9297	*Peltula sp.*			
787.	537	*Pennisetum glaucum (Pearl Millet)*	Y		
788.	539	*Pennisetum pedicellatum*	Y		
789.	-5492	*Pericladium grewiae*			
790.	546	*Perotis rara (Comet Grass)*			
791.	-11665	*Persicaria attenuata x glabra*			
792.	2263	*Persoonia falcata (Wild Pear)*			
793.	4671	*Petalostigma pubescens*			
794.	4672	*Petalostigma quadriloculare (Quinine Tree)*			
795.	-1638	*Petrochelidon ariel*			
796.	-1640	*Petrochelidon nigricans*			
797.	24140	*Petrogale brachyotis (Short-eared Rock-wallaby)*			
798.	25507	*Petrophassa albipennis (White-quilled Rock Pigeon)*			
799.	25697	*Phalacrocorax carbo (Great Cormorant)*			
800.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
801.	25699	*Phalacrocorax varius (Pied Cormorant)*			
802.	24411	*Phaps histrionica (Flock Bronzewing (Flock Pigeon))*		P4	
803.	25667	*Philemon argenticeps (Silver-crowned Friarbird)*			
804.	24591	*Philemon argenticeps subsp. argenticeps*			
805.	25668	*Philemon citreogularis (Little Friarbird)*			
806.	-6460	*Phoma glomerata*			Y
807.	556	*Phragmites karka (Tropical Reed)*		P3	
808.	-6831	*Phyllachora sp.*			
809.	4680	*Phyllanthus maderaspatensis*			
810.	4684	*Phyllanthus reticulatus*			
811.	-9590	*Phyllanthus sp.*			
812.	20652	*Physalis angulata*	Y		
813.	6494	*Planchonella pohlmaniana*			
814.	5290	*Planchonia careya (Mangaloo)*			
815.	24101	*Planigale ingrami (Long-tailed Planigale)*			
816.	24102	*Planigale maculata (Common Planigale)*			
817.	7299	*Plantago debilis*			
818.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
819.	24842	*Platalea regia (Royal Spoonbill)*			
820.	24749	*Platycercus venustus (Northern Rosella)*			
821.	14995	*Platysace rupestris*			
822.	47	*Platyzoma microphyllum (Braid Fern)*			
823.	6909	*Plectranthus congestus*			
824.	24843	*Plegadis falcinellus (Glossy Ibis)*			
825.	6491	*Plumbago zeylanica (Native Plumbago)*			
826.	25703	*Podargus strigoides (Tawny Frogmouth)*			

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827.	-1702	*Poecilodryas cerviniventris*			
828.	24643	*Poephila acuticauda (Long-tailed Finch)*			
829.	25688	*Poephila personata (Masked Finch)*			
830.	2897	*Polycarpaea breviflora*			
831.	2902	*Polycarpaea involucrata*			
832.	2903	*Polycarpaea longiflora*			
833.	14920	*Polycarpaea violacea*			
834.	4574	*Polygala longifolia*			
835.	34975	*Polygala sp. Rhianthoides shoulders (M.H. Andrews 398)*		P1	Y
836.	6653	*Polymeria ambigua (Morning Glory)*			
837.	6655	*Polymeria calycina*			
838.	13966	*Polymeria longifolia*			
839.	15934	*Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)*			
840.	-3891	*Polyporus udus*			Y
841.	25706	*Pomatostomus temporalis (Grey-crowned Babbler)*			
842.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
843.	2876	*Portulaca bicolor*			
844.	2880	*Portulaca digyna*			
845.	2881	*Portulaca filifolia*			
846.	2884	*Portulaca oleracea (Purslane)*	Y		
847.	2885	*Portulaca oligosperma*			
848.	2886	*Portulaca pilosa (Djanggara)*			
849.	-8081	*Portulaca sp.*			
850.	20426	*Potamogeton tepperi*			
851.	113	*Potamogeton tricarinatus (Floating Pondweed)*			
852.	1764	*Pouzolzia zeylanica*			
853.	6735	*Premna acuminata (Ngalinginkal)*			
854.	25200	*Proablepharus tenuis*			
855.	24104	*Pseudantechinus ningbing (Ningbing Pseudantechinus)*			
856.	25261	*Pseudechis australis (Mulga Snake)*			
857.	586	*Pseudochaetochloa australiensis*			
858.	24234	*Pseudomys delicatulus (Delicate Mouse)*			
859.	24239	*Pseudomys nanus (Western Chestnut Mouse)*			
860.	25303	*Pseudonaja ingrami (Ingram's Brown Snake)*			
861.	587	*Pseudopogonatherum contortum*			
862.	590	*Pseudoraphis spinescens (Spiny Mudgrass)*			
863.	1	*Psilotum nudum*		P3	
864.	-1597	*Psitteuteles versicolor*			
865.	-9888	*Psoroma sp.*			
866.	8191	*Pterocaulon serrulatum*			
867.	8194	*Pterocaulon verbascifolium*			
868.	24172	*Pteropus alecto (Black Flying-fox)*			
869.	25725	*Ptilonorhynchus nuchalis (Great Bowerbird)*			
870.	2713	*Ptilotus corymbosus*			
871.	2725	*Ptilotus fusiformis*			
872.	2761	*Ptilotus spicatus*			
873.	30822	*Pygopus steelescotti*			
874.	-7308	*Pyxine sp.*			
875.	5297	*Quisqualis indica*			
876.	25274	*Ramphotyphlops diversus*			
877.	25278	*Ramphotyphlops guentheri*			
878.	25314	*Ramphotyphlops ligatus*			
879.	25316	*Ramphotyphlops unguirostris*			
880.	24597	*Ramsayornis fasciatus (Bar-breasted Honeyeater)*			
881.	3061	*Raphanus raphanistrum (Wild Radish)*	Y		
882.	3063	*Rapistrum rugosum (Turnip Weed)*	Y		
883.	24245	*Rattus rattus (Black Rat)*	Y		
884.	24246	*Rattus tunneyi (Pale Field-rat)*			
885.	24247	*Rattus villosissimus (Long-haired Rat)*			
886.	24179	*Rhinonicteris aurantius (Orange Leafnosed-bat)*		T	
887.	-1654	*Rhipidura albiscapa*			
888.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
889.	34006	*Rhipidura rufifrons (Rufous Fantail)*			
890.	25616	*Rhipidura rufiventris (Northern Fantail)*			
891.	4191	*Rhynchosia minima (Rhynchosia)*			
892.	7174	*Rostellularia adscendens*			
893.	12088	*Rostellularia adscendens var. clementii*			
894.	5285	*Rotala diandra*			
895.	5287	*Rotala occultiflora*			
896.	17890	*Ruellia tuberosa*	Y		

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897.	-8443	*Santalum album*			
898.	2357	*Santalum lanceolatum (Northern Sandalwood)*			
899.	12754	*Sarcostemma esculentum*			
900.	13150	*Scaevola browniana subsp. browniana*			
901.	13149	*Scaevola browniana subsp. grandior*			
902.	598	*Schizachyrium crinizonatum*			
903.	962	*Schoenoplectus dissachanthus*			
904.	964	*Schoenoplectus lateriflorus*			
905.	1010	*Schoenus punctatus*		P3	
906.	7095	*Scoparia dulcis (Scoparia)*	Y		
907.	24200	*Scotorepens greyii (Little Broad-nosed Bat)*			
908.	25605	*Scythrops novaehollandiae (Channel-billed Cuckoo)*			
909.	6601	*Secamone elliptica*			
910.	12313	*Senna oligoclada*			
911.	-4248	*Senna planiticola*			
912.	10818	*Senna planitiicola*			
913.	12319	*Senna venusta*			
914.	4196	*Sesbania cannabina (Sesbania Pea)*			
915.	4198	*Sesbania formosa (White Dragon Tree)*			
916.	4199	*Sesbania simpliciuscula*			
917.	12003	*Sesbania simpliciuscula var. simpliciuscula*			
918.	-4689	*Sesbania sp.*			
919.	605	*Setaria apiculata (Pigeon Grass)*			
920.	612	*Setaria surgens (Pigeon Grass)*			
921.	4965	*Sida acuta*	Y		
922.	32984	*Sida acuta subsp. acuta*			
923.	4973	*Sida cordifolia*	Y		
924.	4977	*Sida fibulifera (Silver Sida)*			
925.	9097	*Sida rhombifolia (Paddy's Lucerne)*	Y		
926.	18149	*Sida rohlenae subsp. rohlenae*			
927.	15227	*Sida sp. A Kimberley Flora (P.A. Fryxell & L.A. Craven 3900)*			
928.	4989	*Sida spinosa (Spiny Sida)*			
929.	30948	*Smicrornis brevirostris (Weebill)*			
930.	6993	*Solanum carduiforme*		P2	
931.	7001	*Solanum dioicum (Gilu)*			
932.	7004	*Solanum echinatum*			
933.	7021	*Solanum lucani*			
934.	1765	*Soleirolia soleirolii (Babys Tears)*	Y		
935.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
936.	616	*Sorghum bicolor (Grain Sorghum)*	Y		
937.	619	*Sorghum plumosum (Plume Canegrass)*			
938.	620	*Sorghum stipoideum (Annual Sorghum)*			
939.	622	*Sorghum timorense*			
940.	35236	*Sorghum x drummondii (Sudan Grass)*	Y		
941.	28343	*Spermacoce argillacea*			
942.	28344	*Spermacoce constricta*			
943.	28345	*Spermacoce dolichosperma*			
944.	28346	*Spermacoce gibba*			
945.	13960	*Spermacoce leptoloba*			
946.	28347	*Spermacoce occidentalis*			
947.	28348	*Spermacoce phaeosperma*			
948.	-5820	*Spermacoce phaerosperma*			
949.	19984	*Sphenoclea zeylanica*		P1	
950.	629	*Sporobolus australasicus (Fairy Grass)*			
951.	-7334	*Stachytarpheta mutabilis*			
952.	4731	*Stackhousia intermedia*			
953.	12489	*Stemodia lathraia*			
954.	7101	*Stemodia lythrifolia (Bunu Bunu)*			
955.	-10097	*Stemodia sp.*			
956.	12491	*Stemodia tephropelina*			
957.	24482	*Stiltia isabella (Australian Pratincole)*			
958.	8239	*Streptoglossa macrocephala*			
959.	24925	*Strophurus ciliaris subsp. ciliaris*			
960.	6536	*Strychnos lucida (Strychnine Bush)*			
961.	7727	*Stylidium floodii*			
962.	7797	*Stylidium schizanthum*			
963.	-10121	*Stylidium sp.*			
964.	17413	*Stylidium turbinatum*			
965.	4212	*Stylosanthes guianensis (Stylo)*	Y		
966.	12353	*Stylosanthes hamata (Verano Stylo)*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
967.	4214	*Stylosanthes humilis (Townsville Stylo)*	Y		
968.	12354	*Stylosanthes scabra*	Y		
969.	25306	*Suta ordensis (Ord Snake)*			
970.	12113	*Syzygium eucalyptoides subsp. bleeseri*			
971.	1506	*Tacca leontopetaloides (Gandungai)*			
972.	1507	*Tacca maculata (Langanggu)*			
973.	25705	*Tachybaptus novaehollandiae (Australasian Grebe (Black-throated Grebe))*			
974.	24207	*Tachyglossus aculeatus (Echidna)*			
975.	25552	*Tadorna radjah (Radjah Shelduck)*			
976.	30872	*Taeniopygia bichenovii (Double-barred Finch)*			
977.	30870	*Taeniopygia guttata (Zebra Finch)*			
978.	24175	*Taphozous georgianus (Common Sheathtail-bat)*			
979.	4253	*Templetonia hookeri*			
980.	4264	*Tephrosia conspicua*			
981.	4265	*Tephrosia coriacea*			
982.	4276	*Tephrosia phaeosperma (Leini)*			
983.	4277	*Tephrosia polyzyga*			
984.	4279	*Tephrosia remotiflora*			
985.	4280	*Tephrosia rosea (Flinders River Poison)*			
986.	-9168	*Tephrosia sp.*			
987.	15947	*Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)*			
988.	34716	*Tephrosia sp. Pentecost River (I.D. Cowie 4168)*			
989.	4287	*Tephrosia virens*			
990.	5298	*Terminalia arostrata (Crocodile Tree)*			
991.	5304	*Terminalia fitzgeraldii*			
992.	5305	*Terminalia grandiflora (Yalu)*			
993.	5307	*Terminalia latipes*			
994.	17025	*Terminalia microcarpa*			
995.	5310	*Terminalia platyphylla (Wild Plum)*			
996.	5311	*Terminalia platyptera*			
997.	5314	*Terminalia volucris (Rosewood)*			
998.	668	*Thaumastochloa major*			
999.	5274	*Thecanthes punicea*			
1000.	5275	*Thecanthes sanguinea*			
1001.	673	*Themeda triandra*			
1002.	24844	*Threskiornis molucca (Australian White Ibis)*			
1003.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
1004.	-7315	*Thunbergia laurifolia*			
1005.	25202	*Tiliqua multifasciata (Central Blue-tongue)*			
1006.	25208	*Tiliqua scincoides subsp. intermedia*			
1007.	-5610	*Tilletia pseudochaetochloae*			
1008.	-10783	*Tilletia whiteochloae*			
1009.	2942	*Tinospora smilacina (Snakevine)*			
1010.	-1613	*Todiramphus pyrrhopygius*			
1011.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
1012.	2828	*Trianthema patellitecta*			
1013.	2829	*Trianthema pilosa*			
1014.	2830	*Trianthema portulacastrum (Giant Pigweed)*	Y		
1015.	4367	*Tribulopis affinis*			Y
1016.	4368	*Tribulopis angustifolia*			
1017.	4382	*Tribulus ranunculiflorus*			
1018.	4383	*Tribulus terrestris (Caltrop)*	Y		
1019.	11401	*Trichodesma zeylanicum var. latisepalum*			
1020.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
1021.	24754	*Trichoglossus haematodus subsp. rubritorquis (Red-collared Lorikeet)*			
1022.	24756	*Trichoglossus versicolor (Varied Lorikeet)*			
1023.	12032	*Trichosanthes cucumerina var. cucumerina*			
1024.	8252	*Tridax procumbens (Tridax)*	Y		
1025.	24806	*Tringa glareola (Wood Sandpaper)*			
1026.	24809	*Tringa stagnatilis (Marsh Sandpiper)*			
1027.	17883	*Triodia bynoei*			
1028.	696	*Triodia pungens (Soft Spinifex)*			
1029.	697	*Triodia racemigera (Rock Spinifex)*		P1	
1030.	703	*Triodia triticoides*		P1	
1031.	16232	*Triumfetta clivorum subsp. clivorum*			
1032.	17528	*Triumfetta kenneallyi*			
1033.	-5414	*Triumfetta pannosa*			Y
1034.	4881	*Triumfetta plumigera*			
1035.	-8730	*Triumfetta sp.*			
1036.	-1690	*Turnix maculosus*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1037.	24848	*Turnix pyrrhothorax (Red-chested Button-quail)*			
1038.	6602	*Tylophora flexuosa*			
1039.	98	*Typha domingensis (Bulrush)*			
1040.	20710	*Typhonium sp. Kununurra (A.N. Start ANS 1467)*		T	
1041.	-1626	*Tyto javanica*			
1042.	25437	*Uperoleia borealis (Northern Taodlet)*			
1043.	25447	*Uperoleia trachyderma (Blacksoil Toadlet)*			
1044.	-3904	*Uredo operculinae*			
1045.	-4218	*Uredo sp.*			
1046.	715	*Urochloa mosambicensis (Sabi Grass)*	Y		
1047.	716	*Urochloa mutica*	Y		
1048.	717	*Urochloa piligera*			
1049.	718	*Urochloa pubigera*			
1050.	720	*Urochloa reptans*			
1051.	-12026	*Urochloa sp.*			
1052.	-9969	*Ustilago scitaminea*			Y
1053.	29527	*Vachellia ditricha*			
1054.	29529	*Vachellia valida*			
1055.	17793	*Vallisneria annua*			
1056.	25577	*Vanellus miles (Masked Lapwing)*			
1057.	25209	*Varanus acanthurus (Spiny-tailed Monitor)*			
1058.	25221	*Varanus mitchelli (Mitchell's Water Monitor)*			
1059.	25222	*Varanus panoptes subsp. panoptes*			
1060.	25214	*Varanus scalaris (Spotted Tree Monitor)*			
1061.	4846	*Ventilago viminalis (Supplejack)*			
1062.	25309	*Vermicella intermedia*			
1063.	25310	*Vermicella multifasciata*			
1064.	6075	*Verticordia cunninghamii (Tree Featherflower)*			
1065.	6122	*Verticordia verticillata (Featherflower)*			
1066.	24203	*Vespadelus caurinus (Western Cave Bat)*			
1067.	-6929	*Vetiveria zizanioides*			Y
1068.	4323	*Vigna lanceolata (Maloga Vigna)*			
1069.	4324	*Vigna radiata (Mung Bean)*			
1070.	13597	*Vigna trilobata*	Y		Y
1071.	-12817	*Vigna unguiculata subsp. sequipedalis*			Y
1072.	6745	*Vitex velutinifolia*			
1073.	5106	*Waltheria indica*			
1074.	8283	*Wedelia asperrima (Yellow Daisy)*			
1075.	725	*Whiteochloa airoides*			
1076.	726	*Whiteochloa biciliata (Mauve Sandgrass)*			
1077.	727	*Whiteochloa capillipes*		P3	
1078.	728	*Whiteochloa cymbiformis*			
1079.	6578	*Wrightia saligna*			
1080.	6124	*Xanthostemon paradoxus (Xanthostemon)*			
1081.	729	*Xerochloa barbata (Rice Grass)*			
1082.	1142	*Xyris complanata*			
1083.	733	*Yakirra majuscula*			
1084.	29095	*Zaleya galericulata subsp. galericulata*			
1085.	29060	*Zeuxine oblonga*		P2	
1086.	4847	*Ziziphus mauritiana (Zornia)*	Y		
1087.	4326	*Zornia albiflora*			
1088.	4328	*Zornia muriculata subsp. angustata*			
1089.	19033	*Zornia prostrata*			
1090.	12680	*Zornia prostrata var. prostrata*			
1091.	24857	*Zosterops luteus (Yellow White-eye)*			
1092.	24248	*Zyzomys argurus (Common Rock-rat)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX 4 – EPBC PROTECTED MATTERS SEARCH REPORT

Australian Government
Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report: Coordinates

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 19/08/11 13:33:32



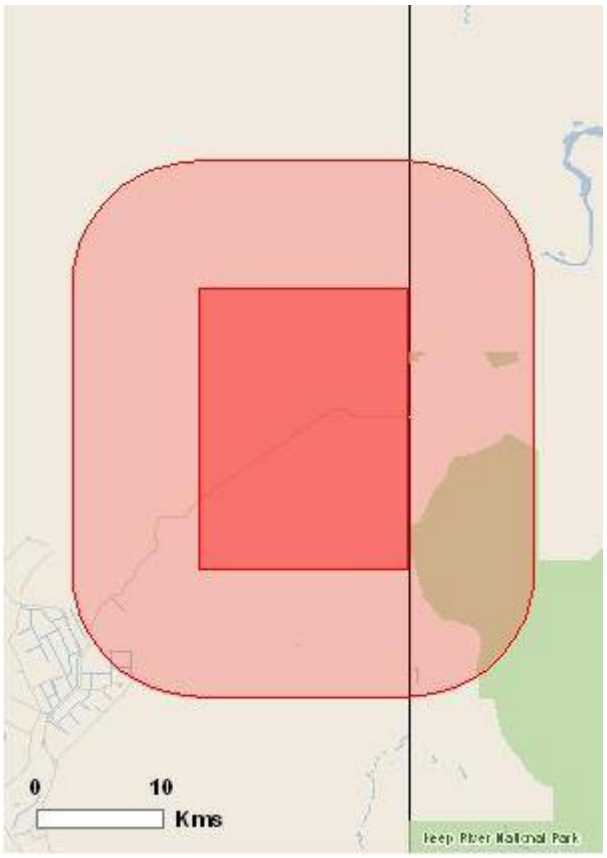
Summary

Details

Matters of NES
Other matters protected by the EPBC Act
Extra Information

Caveat

Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 10.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance (Ramsar Wetlands):	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	None
Threatened Species:	9
Migratory Species:	17

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	13
Whales and Other Cetaceans:	None

Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	2
State and Territory Reserves:	2
Regional Forest Agreements:	None
Invasive Species:	10
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Wetlands of International Significance (RAMSAR Sites)		**[Resource Information]**
Name	Proximity	
Ord river floodplain	Upstream from Ramsar site	

Threatened Species		**[Resource Information]**
Name	Status	Type of Presence
BIRDS		
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Malurus coronatus coronatus Purple-crowned Fairy-wren (western) [64442]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
MAMMALS		
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat [132]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll [331]	Endangered	Species or species habitat likely to occur within area
Xeromys myoides Water Mouse, False Water Rat [66]	Vulnerable	Species or species habitat may occur within area

SHARKS		
Pristis microdon		
Freshwater Sawfish [66182]	Vulnerable	Species or species habitat likely to occur within area

Migratory Species [Resource Information]

Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Marine Species		
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Coracina tenuirostris melvillensis		
Melville Cicadabird [26187]		Species or species habitat may occur within area
Erythrura gouldiae		
Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei		
Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Poecilodryas superciliosa cerviniventris		
Derby White-browed Robin [26190]		Species or species habitat likely to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Rostratula benghalensis s. lat.		

Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Rostratula benghalensis s. lat.		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area
Reptiles		
Crocodylus johnstoni		
Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	Status
Natural	
Parts of the Kimberley WA	Indicative Place
Indigenous	
Weaber Range Sites Complex NT	Registered

State and Territory Reserves [Resource Information]

Point Spring, WA

Keep River Extension (proposed), NT

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Frogs		
Bufo marinus		
Cane Toad [1772]		Species or species habitat likely to occur within area
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Plants		
Brachiaria mutica		
Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Hymenachne amplexicaulis		
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Mimosa pigra		
Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Parkinsonia aculeata		
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat may occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at

the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:
- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:
- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:
- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-15.34214 128.84934,-15.34214 128.99925,-15.5444 128.99925,-15.5444 128.84934,-15.34214 128.84934

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts

-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 5 – FLORA AND VEGETATION SURVEY SAMPLING POINT LOCATIONS

Site	Easting	Northing
1	498000	8290750
2	496009	8293116
3	497995	8291781
4	496900	8293366
5	495604	8293467
6	498500	8293510
7	497111	8292380
8	497354	8291314
9	498484	8290204
10	497507	8290250
11	496645	8291508
12	496377	8292592
13	498357	8291215
14	498560	8292254
15	498126	8292996
16	497572	8293586
17	495549	8290299
18	496160	8292030
19	496904	8290739
20	495563	8293133
21	495600	8291503
22	495600	8291503
23	495552	8290976
24	495631	8292785
25	495500	8292500
26	496175	8291247
27	496550	8290788
28	495900	8290400
29	496447	8290449
30	496219	8290714
31	496435	8291278
32	495978	8290894
33	496050	8291398
34	496068	8291780
35	495886	8292180
36	495558	8290636
37	495755	8291151
38	495827	8291540
39	495722	8291903
40	495808	8292728
41	496727	8293239
42	496042	8292895
43	495503	8292997

APPENDIX 6 – FLORA AND VEGETATION SURVEY ENVIRONMENT DATA

Date:	10/05/2011	Site:	1	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	498000	8290750	772

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	C	brown/grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	11	2-5	2
	% Cover	5	15	60

Observations	Some grazing and trampling

Field description of	

Collection No.	Species	% Cover	Ht (cm)
21	**Cardiospermum halicacabum var. halicacabum*	0.1	C
20	**Corchorus olitorius*	0.5	70
9	*Abelmoschus ficulneus*	0.2	120
2	*Atalaya variifolia*	2	500
4	*Bauhinia cunninghamii*	3	1000
19	*Buchnera linearis*	35	80
23	*Commelina ensifolia*	0.1	10
14	*Commelina reticulata*	5	10
31	*Crinum angustifolium*	0.1	10
24	*Cyanotis axillaris*	0.1	10
13	*Cyperus tenuispica*	0.1	10
28	*Desmodium muelleri*	0.1	C
17	*Dichanthium sericeum subsp. sericeum*	2	200
8	*Elytrophorus spicatus*	0.2	15
5	*Eucalyptus ?tectifica*	2	1100
33	*Gomphrena brachystylis subsp. brachystylis*	0.1	20
12	*Fimbristylis laxiglumis (P2)*	0.1	30
29	*Goodenia durackiana (P1)*	0.2	10
7	*Hibiscus austrinus var. austrinus*	0.1	150
11	*Hygrophila angustifolia*	0.2	100
18	*Iseilema vaginiflorum*	5	80
15	*Ludwigia perennis*	1	50
32	*Neptunia monosperma*	0.1	50
25	*Nesaea arnhemica*	0.1	20
34	*Oryza australiensis*	0.5	200
30	*Panicum decompositum*	10	60
26	*Phyllanthus maderaspatensis*	0.1	30
6	*Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)*	10	10
22	*Rhynchosia minima*	0.1	C
35	*Sorghum plumosum*	1	20
3	*Terminalia volucris*	8	8
1	*Vachellia valida*	5	500
27	*Vigna lanceolata (s.l.)*	0.1	50
10	*Wedelia asperrima*	0.2	110

Date:	10/05/2011	**Site:**	2	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	496009	8293116	781

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	brown/grey		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		1	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Medium	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	11	6	2
	% Cover	2	12	90

Observations	

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
9	*Abelmoschus ficulneus*	0.1	70
47	*Aeschynomene indica*	0.1	30
36	*Alternanthera nodiflora*	0.1	20
2	*Atalaya variifolia*	0.1	60
	Bauhinia cunninghamii	2	1100
48	*Buchnera linearis*	0.2	220
19	*Chionachne hubbardiana*	2	60
38	*Commelina reticulata*	3	20
	Crinum angustifolium	0.1	20
40	*Cucumis maderaspatanus*	0.1	C
45	*Cyanotis axillaris*	0.2	20
	Cyperus tenuispica	0.5	15
53	*Decaisnina angustata*	0.1	P
	Elytrophorus spicatus	2	20
	Fimbristylis laxiglumis (P2)	0.1	30
29	*Gomphrena brachystylis subsp. brachystylis*	0.1	10
	Hibiscus austrinus var. austrinus	5	200
	Hygrophila angustifolia	10	50
	Iseilema vaginiflorum	10	60
49	*Leptochloa neesii*	0.2	100
	Ludwigia perennis	50	130
46	*Marsilea hirsuta*	0.1	15
42	*Nelsonia campestris*	0.5	15
32	*Neptunia monosperma*	0.1	20
25	*Nesaea arnhemica*	0.1	30
43	*Panicum decompositum*	0.5	50
52	*Paspalum scrobiculatum*	0.1	50
26	*Phyllanthus maderaspatensis*	0.1	20
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	1	10
37	*Rotala diandra*	0.5	20
41	*Scleria novae-hollandiae*	0.1	40
51	*Spermacoce argillacea*	0.1	30
	Terminalia volucris	10	600
	Vachellia valida	2	600
50	*Vachellia valida*	0.1	50
27	*Vigna lanceolata (s.l.)*	0.1	30
	Wedelia asperrima	0.1	70
34	*Oryza australiensis*	0.1	C

Date:	11/05/2011	**Site:**	3	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	497995	8291781	783

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	grey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
	1	1	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Meduim	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	8	2	1
	% Cover	5	5	90

Observations	Moderate trampling from cattle

Field description of	Woodland more open than at sites 1 & 2

Collection No.	**Species**	**% Cover**	**Ht (cm)**
20	**Corchorus olitorius*	0.1	40
58	**Melochia pyramidata*	0.1	20
9	*Abelmoschus ficulneus*	0.1	60
	Atalaya variifolia	0.1	50
	Bauhinia cunninghamii	1	700
60	*Buchnera linearis*	0.1	C
61	*Cayratia trifolia*	0.1	C
11	*Chandeliers opposite*	1	50
19	*Chionachne hubbardiana*	20	60
	Commelina ensifolia	0.1	20
14	*Commelina reticulata*	5	20
31	*Crinum angustifolium*	0.1	20
40	*Cucumis maderaspatanus*	0.1	C
45	*Cyanotis axillaris*	0.1	20
63	*Cynanchum puberulum*	0.1	C
55	*Gomphrena brachystylis subsp. brachystylis*	0.1	50
13	*Cyperus tenuispica*	1	10
8	*Elytrophorus spicatus*	1	15
56	*Excoecaria parvifolia*	3	800
57	*Fimbristylis rara*	0.1	50
54	*Flemingia pauciflora*	0.2	20
29	*Goodenia durackiana (P1)*	0.1	10
7	*Hibiscus austrinus var. austrinus*	0.2	200
18	*Iseilema vaginiflorum*	0.1	20
15	*Ludwigia perennis*	30	60
	Marsilea hirsuta	0.1	10
62	*Mimulus uvedaliae*	0.1	40
	Neptunia monosperma	0.1	100
25	*Nesaea arnhemica*	0.1	40
59	*Operculina aequisepala*	0.1	20
26	*Phyllanthus maderaspatensis*	0.1	20
6	*Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)*	2	15
41	*Scleria novae-hollandiae*	0.1	60
35	*Sorghum plumosum*	5	300
	Spermacoce argillacea	0.1	60
	Terminalia volucris	1	500
	Vachellia valida	3	120
	Vachellia valida	3	C
	Vigna lanceolata (s.l.)	0.1	80
10	*Wedelia asperrima*	0.1	60
34	*Oryza australiensis*	1	70

Date:	11/05/2011	**Site:**	4	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	496900	8293366	787

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	grey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		1	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Meduim	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	8	5	1.5
	% Cover	5	20	90

Observations	Moderate trampling by cattle

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Corchorus olitorius*	0.2	50
76	**Cucumis melo*	0.1	C
58	**Melochia pyramidata*	0.2	30
66	**Vachellia farnesiana*	0.2	120
	Abelmoschus ficulneus	0.1	70
69	*Buchnera linearis*	0.1	40
71	*Ammannia auriculata*	0.1	20
72	*Ammannia baccifera*	0.2	15
79	*Aristida latifolia*	0.2	110
68	*Asparagus racemosus*	0.1	C
	Atalaya variifolia	0.1	100
	Bauhinia cunninghamii	5	750
78	*Blumea diffusa*	0.1	20
67	*Capparis lasiantha*	0.1	100
61	*Cayratia trifolia*	0.1	C
	Gomphrena brachystylis subsp. brachystylis	0.2	50
19	*Chionachne hubbardiana*	20	40
	Commelina reticulata	1	20
	Crinum angustifolium	0.1	20
45	*Cyanotis axillaris*	0.1	20
77	*Cyperus difformis*	0.1	40
	Cyperus tenuispica	1	20
17	*Dichanthium sericeum subsp. sericeum*	0.1	200
64	*Ehretia saligna*	0.1	20
8	*Elytrophorus spicatus*	1	20
	Fimbristylis depauperata	0.1	40
81	*Fimbristylis microcarya*	0.1	40
65	*Flueggea virosa subsp. melanthesoides*	0.1	150
29	*Goodenia durackiana (P1)*	0.1	10
	Hibiscus austrinus var. austrinus	0.2	20
80	*Ipomoea eriocarpa*	0.1	C
18	*Iseilema vaginiflorum*	50	80
	Ludwigia perennis	2	60
	Marsilea hirsuta	1	15
62	*Mimulus uvedaliae*	0.1	20
	Nelsonia campestris	0.1	20
	Neptunia monosperma	0.1	80
80A	*Operculina brownii*	0.1	C
84	*Ophiurus exaltatus*	2	220
20	*Panicum decompositum*	5	50
43	*Panicum decompositum*	0.1	`40
26	*Phyllanthus maderaspatensis*	0.1	20
6	*Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)*	2	10
74	*Ptilotus spicatus*	0.1	30
73	*Rostellularia adscendens*	0.1	20
83	*Sehima nervosum*	0.1	200
82	*Stemodia debilis*	0.1	20
75	*Tephrosia virens (s.l.)*	0.1	25
	Terminalia volucris	20	400
44	*Trichodesma zeylanicum var. latisepalum*	0.1	100
1	*Vachellia valida*	0.1	60

Date:	12/05/2011	**Site:**	5	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	495604	8293467	789

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	grey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
			3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	8		1.5
	% Cover	30		95

Observations	minor cattle trampling

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
85	**Echinochloa colona*	0.1	30
	Abelmoschus ficulneus	0.1	100
47	*Aeschynomene indica*	0.1	50
90	*Amyema sp.*	0.1	P
	Atalaya variifolia	0.1	150
4	*Buchnera linearis*	1	800
	Cathormion umbellatum subsp. moniliforme	0.1	250
61	*Cayratia trifolia*	0.1	C
	Chandeliers opposite	1	80
	Chionachne hubbardiana	5	40
14	*Commelina reticulata*	2	30
87	*Corchorus fascicularis*	0.1	30
88	*Cucumis maderaspatanus*	0.1	C
	Cyanotis axillaris	0.1	20
53	*Decaisnina angustata*	0.1	P
	Gomphrena brachystylis subsp. brachystylis	0.2	220
	Elytrophorus spicatus	0.2	20
56	*Excoecaria parvifolia*	25	750
54	*Flemingia pauciflora*	0.1	20
	Hibiscus austrinus var. austrinus	0.2	200
	Iseilema vaginiflorum	70	150
	Ludwigia perennis	5	150
89	*Merremia hederacea*	0.1	C
	Mimulus uvedaliae	0.1	20
	Neptunia monosperma	0.1	60
84	*Ophiurus exaltatus*	0.2	200
	Panicum decompositum	3	80
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	2	15
86	*Sesbania simpliciuscula var. simpliciuscula*	0.1	20
	Terminalia volucris	1	500
	Trichodesma zeylanicum var. latisepalum	0.1	80
1	*Vachellia valida*	3	600
	Vachellia valida	0.1	50
	Vigna lanceolata (s.l.)	0.1	60
	Wedelia asperrima	0.1	50
	Oryza australiensis	1	150
		1	C

Date:	12/05/2011	**Site:**	6	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	498500	8293510	791

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	grey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
			3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	11	3	1-8
	% Cover	2	10	95

Observations	Minor cattle trampling

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Cucumis melo*	0.1	C
	**Melochia pyramidata*	0.1	30
	Abelmoschus ficulneus	0.1	80
	Ammannia baccifera	0.2	20
154	*Arundinella nepalensis*	3	80
	Buchnera linearis	0.2	150
	Bauhinia cunninghamii	1	1100
78	*Blumea diffusa*	0.2	20
	Cayratia trifolia	0.1	C
	Chionachne hubbardiana	5	70
	Commelina reticulata	0.5	50
	Crinum angustifolium	0.1	20
	Cyperus difformis	0.1	30
104	*Cyperus nervulosus*	0.1	20
	Cyperus tenuispica	2	15
	Gomphrena brachystylis subsp. brachystylis	0.1	P
102	*Desmodium muelleri*	0.1	C
	Dichanthium sericeum subsp. sericeum	10	120
97	*Ficus aculeata var. aculeata*	0.2	200
57	*Fimbristylis rara*	0.1	40
	Flemingia pauciflora	0.1	30
29	*Goodenia durackiana (P1)*	0.1	20
99	*Grewia retusifolia*	0.2	110
	Hibiscus austrinus var. austrinus	0.1	20
	Iseilema vaginiflorum	20	110
	Ludwigia perennis	0.5	100
	Ophiurus exaltatus	10	200
	Phyllanthus maderaspatensis	0.1	20
98	*Polygala sp. Rhianthoides shoulders (M.H. Andrews 398)*	0.1	20
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	1	20
	Rhynchosia minima	0.1	C
	Sorghum plumosum	10	300
105	*Spermacoce argillacea*	0.1	15
	Terminalia volucris	0.2	150
106	*Themeda triandra*	30	120
	Vachellia valida	1	1000
	Vachellia valida	0.1	40
100	*Vigna lanceolata (s.l.)*	0.1	C
101	*Vigna radiata var. ?*	0.1	C
	Wedelia asperrima	0.1	50

Date:	12/05/2011	Site:	7	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	497111	8292380	792-794

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	grey/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		1	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Medium	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	10	5	1.5
	% Cover	5	25	90

Observations	Moderate cattle trampling

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Corchorus olitorius*	0.1	30
	Abelmoschus ficulneus	0.1	80
154	*Arundinella nepalensis*	1	50
107	*Asparagus racemosus*	0.1	60
	Atalaya hemiglauca	1	400
	Buchnera linearis	5	900
	Blumea diffusa	0.1	20
110	*Bridelia tomentosa*	0.1	C
109	*Capparis lasiantha*	0.1	50
	Cayratia trifolia	0.1	C
	Chandeliers opposite	1	70
	Chionachne hubbardiana	50	60
	Commelina reticulata	1	25
	Crinum angustifolium	0.1	20
111	*Cynanchum puberulum*	0.1	C
	Gomphrena brachystylis subsp. brachystylis	0.1	30
	Cyperus tenuispica	2	20
	Elytrophorus spicatus	5	15
112	*Euphorbia mitchelliana (s.l.)*	0.1	20
	Fimbristylis depauperata	0.1	30
	Fimbristylis laxiglumis (P2)	0.2	40
	Flemingia pauciflora	0.2	40
113	*Grewia retusifolia*	0.1	50
	Hibiscus austrinus var. austrinus	0.1	20
	Iseilema vaginiflorum	15	70
	Ludwigia perennis	1	100
	Marsilea hirsuta	0.1	20
	Neptunia monosperma	0.2	60
25	*Nesaea arnhemica*	0.1	30
108	*Operculina brownii*	0.2	20
	Panicum decompositum	5	50
	Phyllanthus maderaspatensis	0.1	25
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	1	10
	Ptilotus spicatus	0.1	20
	Rhynchosia minima	0.2	C
	Spermacoce argillacea	0.1	20
	Terminalia volucris	24	450
	Vachellia valida	24	C
	Vigna lanceolata (s.l.)	0.1	40
	Wedelia asperrima	0.1	60

Date:	13/05/2011	**Site:**	8	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	497354	8291314	

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	grey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		5	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Medium	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	11	7	2
	% Cover	5	25	60

Observations	Moderate cattle trampling

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
128	**Bidens bipinnata*	0.1	80
127	**Eragrostis minor*	0.1	10
	Abelmoschus ficulneus	0.1	90
124	*Abutilon hannii*	0.1	180
69	*Achyranthes aspera*	0.1	30
	Buchnera linearis	0.1	30
	Ammannia auriculata	0.1	20
	Ammannia baccifera	0.1	20
	Atalaya hemiglauca	10	700
115	*Atalaya variifolia*	0.2	50
	Bauhinia cunninghamii	5	1100
123	*Bergia pedicellaris*	0.1	20
	Blumea diffusa	0.1	20
110	*Bridelia tomentosa*	0.1	C
	Chandeliers opposite	0.1	40
	Gomphrena brachystylis subsp. brachystylis	5	50
	Commelina reticulata	0.1	25
	Cucumis maderaspatanus	0.1	C
	Cyanotis axillaris	0.1	10
63	*Cynanchum puberulum*	0.1	C
	Cyperus tenuispica	0.1	20
	Dichanthium sericeum subsp. sericeum	1	200
	Elytrophorus spicatus	0.1	20
125	*Euphorbia maconochieana*	0.1	20
	Flemingia pauciflora	0.1	25
126	*Flueggea virosa subsp. melanthesoides*	0.5	180
130	*Goodenia malvina (P1)*	0.1	20
	Grewia retusifolia	2	60
	Iseilema vaginiflorum	5	70
132	*Jasminum molle*	0.1	20
	Nesaea arnhemica	0.1	50
121	*Operculina aequisepala*	0.1	C
108	*Operculina brownii*	0.1	C
	Ophiurus exaltatus	30	180
	Panicum decompositum	10	50
	Phyllanthus maderaspatensis	0.2	30
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	0.1	10
129	*Premna acuminata*	0.1	C
	Ptilotus spicatus	0.1	30
	Rhynchosia minima	1	C
83	*Sehima nervosum*	1	150
122	*Stemodia debilis*	0.1	20
131	*Strychnos lucida*	0.1	250
	Terminalia volucris	15	600
	Trichodesma zeylanicum var. latisepalum	0.1	70
	Vachellia valida	0.1	40
	Vigna lanceolata (s.l.)	0.1	180
	Wedelia asperrima	0.2	100

Date:	13/05/2011	**Site:**	9	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	498484	8290204	800

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	grey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		2	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	10	5	2
	% Cover	15	15	90

Observations	Minor cattle trampling

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Corchorus olitorius*	0.1	150
	**Melochia pyramidata*	0.1	40
	Abelmoschus ficulneus	0.1	120
	Aeschynomene indica	0.1	50
	Ammannia baccifera	0.1	10
90	*Buchnera linearis*	0.1	P
	Aristida latifolia	0.1	50
	Atalaya variifolia	5	400
	Cayratia trifolia	0.1	C
	Chandeliers opposite	5	80
	Chionachne hubbardiana	0.2	40
	Commelina reticulata	1	30
	Crinum angustifolium	0.1	25
	Cyperus tenuispica	0.2	15
	Decaisnina angustata	0.1	P
	Gomphrena brachystylis subsp. brachystylis	0.2	200
	Elytrophorus spicatus	0.1	20
	Eucalyptus ?tectifica	10	1000
	Excoecaria parvifolia	3	900
114	*Fimbristylis cf. dichotoma (desert form)*	0.1	40
12	*Fimbristylis laxiglumis (P2)*	0.1	40
	Goodenia durackiana (P1)	0.1	15
	Hibiscus austrinus var. austrinus	0.2	200
	Iseilema vaginiflorum	0.1	20
	Ludwigia perennis	2	100
	Marsilea hirsuta	0.1	15
	Neptunia monosperma	0.2	80
	Ophiurus exaltatus	65	200
	Panicum decompositum	3	50
	Phyllanthus maderaspatensis	0.1	20
	Sorghum plumosum	0.1	300
	Spermacoce argillacea	0.1	40
	Terminalia volucris	10	450
	Vachellia valida	2	600
117	*Vigna lanceolata (s.l.)*	0.1	C
116	*Wedelia asperrima*	0.1	100
	Oryza australiensis	1	200

Date:	13/05/2011	Site:	10	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	497507	8290250	802

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	grey/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Medium	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	9	6	1-5
	% Cover	5	35	50

Observations	Moderate cattle disturbance

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	Abelmoschus ficulneus	0.1	100
119	*Aeschynomene indica*	0.1	60
	Ammannia auriculata	0.1	20
107	*Asparagus racemosus*	0.1	40
	Atalaya hemiglauca	10	600
	Buchnera linearis	2	800
	Cathormion umbellatum subsp. moniliforme	0.1	80
	Cayratia trifolia	0.1	C
	Chandeliers opposite	10	40
	Chionachne hubbardiana	5	60
	Commelina reticulata	2	20
120	*Crotalaria montana var. angustifolia*	0.1	40
	Cyperus tenuispica	0.2	20
	Decaisnina angustata	0.1	P
28	*Desmodium muelleri*	0.1	C
	Gomphrena brachystylis subsp. brachystylis	1	200
	Elytrophorus spicatus	0.2	20
	Eucalyptus ?tectifica	3	850
	Excoecaria parvifolia	5	600
118	*Grewia retusifolia*	0.1	100
	Hibiscus austrinus var. austrinus	0.1	100
	Iseilema vaginiflorum	2	90
	Ludwigia perennis	5	100
42	*Nelsonia campestris*	0.1	20
	Neptunia monosperma	0.2	60
	Ophiurus exaltatus	0.1	200
	Panicum decompositum	20	70
	Phyllanthus maderaspatensis	0.1	20
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	0.1	15
37	*Rotala diandra*	0.1	20
	Vachellia valida	0.1	30
117	*Vigna lanceolata (s.l.)*	0.1	C
	Wedelia asperrima	0.2	100
	Oryza australiensis	1	180

Date:	13/05/2011	Site:	11	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496645	8291508	806

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	grey/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	High	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	9		1
	% Cover	10	5	30

Observations	High amount of cattle trampling

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Echinochloa colona*	0.2	10
	Ammannia auriculata	0.1	20
	Bauhinia cunninghamii	0.1	400
123	*Bergia pedicellaris*	0.1	20
	Cayratia trifolia	0.1	C
	Buchnera linearis	2	50
	Chionachne hubbardiana	0.1	40
	Commelina reticulata	0.5	15
	Corchorus fascicularis	0.1	20
	Crinum angustifolium	0.1	20
	Cyanotis axillaris	0.1	15
	Cyperus tenuispica	0.2	20
136	*Eleocharis dulcis*	0.1	60
	Elytrophorus spicatus	0.1	20
	Eucalyptus ?tectifica	2	900
	Gomphrena brachystylis subsp. brachystylis	10	850
	Fimbristylis laxiglumis (P2)	0.5	40
134	*Fimbristylis littoralis*	0.5	50
	Goodenia malvina (P1)	0.1	15
	Hibiscus austrinus var. austrinus	0.5	200
	Iseilema vaginiflorum	2	60
	Ludwigia perennis	5	80
	Marsilea hirsuta	0.1	15
135	*Melochia corchorifolia*	0.1	20
	Mimulus uvedaliae	0.1	20
	Nelsonia campestris	1	15
	Neptunia monosperma	0.2	40
	Nesaea arnhemica	0.1	40
	Oryza australiensis	20	100
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	0.1	15
	Rotala diandra	0.1	20
	Vachellia valida	0.1	450
	Vigna lanceolata (s.l.)	0.1	50

Date:	14/05/2011	**Site:**	12	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	496377	8292592	808

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	gey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		5	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	E

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	9	3.5	2
	% Cover	10	10	100

Observations	No cattle. Very thick vegetation. Soil surface flat

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Corchorus olitorius*	0.1	50
233	**Crotalaria juncea*	0.1	40
	Abelmoschus ficulneus	0.1	50
	Achyranthes aspera	0.1	80
	Aeschynomene indica	0.1	50
	Buchnera linearis	0.1	20
	Atalaya hemiglauca	2	700
	Bauhinia cunninghamii	4	900
	Capparis lasiantha	0.1	40
	Cayratia trifolia	0.1	C
	Chandeliers opposite	2	120
	Chionachne hubbardiana	2	70
	Commelina reticulata	1	80
138	*Crotalaria montana var. angustifolia*	0.1	20
	Cucumis maderaspatanus	0.1	C
	Gomphrena brachystylis subsp. brachystylis	0.1	20
	Cyperus tenuispica	0.1	20
139	*Desmodium muelleri*	0.1	30
	Dichanthium sericeum subsp. sericeum	0.2	200
137	*Eleocharis dulcis*	0.2	50
	Excoecaria parvifolia	0.1	900
	Flemingia pauciflora	0.1	30
142	*Hibiscus aff. calcicola*	0.1	200
	Hibiscus austrinus var. austrinus	0.1	20
140	*Hydrolea zeylanica (P1)*	0.1	40
	Iseilema vaginiflorum	10	150
	Ludwigia perennis	45	160
	Nelsonia campestris	0.1	25
	Neptunia monosperma	2	150
	Operculina aequisepala	0.1	20
	Phyllanthus maderaspatensis	0.1	30
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	0.1	15
41	*Scleria novae-hollandiae*	1	40
	Sorghum plumosum	10	350
	Terminalia volucris	4	700
141	*Tinospora smilacina*	0.1	C
	Trichodesma zeylanicum var. latisepalum	0.1	70
	Vachellia valida	0.1	C
	Vigna lanceolata (s.l.)	0.1	50
	Vigna radiata var. ?	0.1	C
	Wedelia asperrima	0.2	120
	Oryza australiensis	30	180

Date:	14/05/2011	Site:	13	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	498357	8291215	811

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	grey/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		1	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	High	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	4-9	2-4	1.5
	% Cover	15	3	90

Observations	
Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Corchorus olitorius*	0.1	50
	**Cucumis melo*	0.1	C
146	**Echinochloa colona*	0.1	30
	**Melochia pyramidata*	0.1	20
144	**Stylosanthes hamata*	0.1	15
	Buchnera linearis	0.1	60
	Alternanthera nodiflora	0.1	50
	Aristida latifolia	0.2	120
	Atalaya hemiglauca	0.1	100
	Bauhinia cunninghamii	7	800
148	*Cathormion umbellatum subsp. moniliforme*	0.2	400
	Cayratia trifolia	0.1	C
	Chandeliers opposite	0.2	40
	Chionachne hubbardiana	2	50
	Commelina reticulata	2	20
	Gomphrena brachystylis subsp. brachystylis	0.1	20
	Cyanotis axillaris	0.1	15
145	*Cyperus bifax*	20	30
149	*Cyperus difformis*	0.1	10
	Cyperus tenuispica	0.2	15
	Elytrophorus spicatus	1	20
	Eucalyptus obconica	1	700
	Excoecaria parvifolia	5	700
	Fimbristylis depauperata	0.1	20
	Fimbristylis laxiglumis (P2)	0.1	30
	Flemingia pauciflora	0.1	20
150	*Glossostigma drummondii*	0.1	2
	Goodenia durackiana (P1)	0.1	20
147	*Heteropogon contortus*	0.5	40
	Hibiscus austrinus var. austrinus	0.5	20
	Ludwigia perennis	35	120
	Marsilea hirsuta	0.1	15
	Mimulus uvedaliae	0.1	25
	Neptunia monosperma	0.5	50
	Nesaea arnhemica	0.1	20
	Operculina aequisepala	0.1	C
	Ophiurus exaltatus	0.2	210
	Panicum decompositum	0.2	C
	Paspalum scrobiculatum	0.2	30
	Phyllanthus maderaspatensis	0.2	30
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	2	10
	Rhynchosia minima	0.1	C
	Sorghum plumosum	0.2	300
	Terminalia volucris	2	600
	Vachellia valida	0.5	60
	Vigna lanceolata (s.l.)	0.1	40
	Wedelia asperrima	0.1	90

Date:	14/05/2011	Site:	14	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	498560	8292254	813

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	grey/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Medium	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	3-5	1.5	<1.2
	% Cover	1	2	85

Observations	
Field description of	Grass plains. Scattered trees

Collection No.	Species	% Cover	Ht (cm)
	**Cucumis melo*	0.1	C
	**Eragrostis minor*	0.2	100
	**Vachellia farnesiana*	0.5	160
	Abelmoschus ficulneus	0.1	90
	Actellosa hastate	0.1	20
	Buchnera linearis	0.5	20
154	*Arundinella nepalensis*	10	90
	Atalaya hemiglauca	0.2	50
152	*Bacopa floribunda*	0.1	15
	Bauhinia cunninghamii	2	150
	Blumea diffusa	0.1	30
155	*Buchnera asperata*	0.1	20
	Cayratia trifolia	0.1	C
	Commelina reticulata	0.5	30
	Crinum angustifolium	0.1	20
	Gomphrena brachystylis subsp. brachystylis	0.1	20
	Cyperus bifax	20	30
	Cyperus difformis	1	25
104	*Cyperus nervulosus*	0.1	30
156	*Digitaria ctenantha*	0.1	40
	Elytrophorus spicatus	0.2	20
97	*Ficus aculeata var. aculeata*	0.1	120
	Fimbristylis depauperata	0.5	30
	Fimbristylis laxiglumis (P2)	0.1	20
	Flemingia pauciflora	2	40
	Goodenia durackiana (P1)	0.1	20
	Iseilema vaginiflorum	2	60
	Ludwigia perennis	15	100
	Mimulus uvedaliae	0.1	20
	Neptunia monosperma	0.5	20
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	5	20
	Rhynchosia minima	0.1	C
	Scleria novae-hollandiae	0.1	30
151	*Sehima nervosum*	1	40
	Sorghum plumosum	1	350
	Spermacoce argillacea	0.1	40
	Stemodia debilis	0.2	15
	Themeda triandra	0.2	C
	Vachellia valida	0.2	50
	Wedelia asperrima	0.1	80

Date:	14/05/2011	**Site:**	15	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	498126	8292996	815

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	grey/brown		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
			3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	VG	3-5		2
	% Cover	15		100

Observations	

Field description of	Tall grassland

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Cucumis melo*	0.1	C
	**Eragrostis minor*	0.1	50
	**Melochia pyramidata*	0.1	40
159	**Senna obtusifolia*	0.1	50
	Abelmoschus ficulneus	0.1	50
	Buchnera linearis	0.1	50
	Ammannia auriculata	0.1	20
	Atalaya hemiglauca	0.1	100
	Atalaya variifolia	0.1	50
	Bauhinia cunninghamii	0.2	600
	Cayratia trifolia	0.1	C
	Chionachne hubbardiana	1	80
	Commelina reticulata	0.1	30
	Crinum angustifolium	0.1	20
88	*Cucumis maderaspatanus*	0.1	C
	Gomphrena brachystylis subsp. brachystylis	0.1	40
	Cyperus nervulosus	0.1	30
	Cyperus tenuispica	0.1	20
160	*Diospyros calycantha (P1)*	0.1	60
	Ehretia saligna	0.1	60
	Elytrophorus spicatus	0.1	20
	Fimbristylis cf. dichotoma (desert form)	0.1	30
	Fimbristylis laxiglumis (P2)	0.1	30
	Flueggea virosa subsp. melanthesoides	0.1	20
	Goodenia malvina (P1)	0.1	40
	Hibiscus austrinus var. austrinus	0.1	150
161	*Ipomoea abrupta*	0.1	C
	Iseilema vaginiflorum	5	100
	Ludwigia perennis	0.5	110
	Nelsonia campestris	0.1	20
	Ophiurus exaltatus	45	200
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	0.2	20
	Rhynchosia minima	0.1	C
158	*Sida rohlenae subsp. occidentalis*	0.3	40
	Sorghum plumosum	15	350
	Terminalia volucris	0.2	150
	Themeda triandra	45	120
	Vachellia valida	45	C
	Vigna lanceolata (s.l.)	0.2	C
	Vigna radiata var. ?	0.3	C

Date:	14/05/2011	Site:	16	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	497572	8293586	819

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	Brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	9	3-5	1.5
	% Cover	3	1	100

Observations	

Field description of	

Collection No.	Species	% Cover	Ht (cm)
163	**Cynodon dactylon*	0.1	10
	**Eragrostis minor*	0.1	25
	**Melochia pyramidata*	0.1	50
166	*Acacia elachantha*	0.1	50
	Ammannia auriculata	0.1	20
	Buchnera linearis	0.1	20
	Arundinella nepalensis	1	40
	Bauhinia cunninghamii	1	700
	Blumea diffusa	0.1	20
	Cayratia trifolia	0.1	C
	Commelina reticulata	0.1	30
167	*Corymbia ?polycarpa*	0.1	20
	Corymbia bella	1	800
	Cyperus difformis	0.1	20
	Cyperus nervulosus	0.1	15
	Gomphrena brachystylis subsp. brachystylis	0.2	20
	Dichanthium sericeum subsp. sericeum	0.5	100
165	*Dolichandrone heterophylla*	1	900
	Ficus aculeata var. aculeata	0.1	160
	Fimbristylis laxiglumis (P2)	0.1	40
	Flemingia pauciflora	0.2	30
	Heteropogon contortus	0.1	20
	Hibiscus austrinus var. austrinus	1	190
	Iseilema vaginiflorum	0.1	20
	Ludwigia perennis	1	100
	Mimulus uvedaliae	0.1	20
	Neptunia monosperma	0.5	40
164	*Oldenlandia mitrasacmoides*	0.1	20
	Ophiurus exaltatus	10	150
	Panicum decompositum	1	20
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	5	20
	Schoenoplectus dissachanthus	0.1	20
	Sehima nervosum	2	180
	Sida rohlenae subsp. occidentalis	1	50
	Sorghum plumosum	1	350
	Stemodia debilis	0.1	20
	Terminalia volucris	0.2	150
	Themeda triandra	0.2	C
	Vachellia valida	0.2	40
	Wedelia asperrima	0.1	100

Date:	15/05/2011	Site:	17	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495549	8290299	835

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay/Loam	Light brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Valley Floor	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		15	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	16	2	0.2
	% Cover	70	10	35

Observations	SW Corner. Valley

Field description of	

Collection No.	Species	% Cover	Ht (cm)
218	**Alysicarpus vaginalis*	0.1	15
199	**Cardiospermum halicacabum var. halicacabum*	0.1	C
220	**Cynodon dactylon*	5	20
212	**Digitaria ciliaris*	0.2	20
214	**Echinochloa colona*	0.1	15
219	*Buchnera linearis*	0.1	25
221	**Euphorbia hirta*	0.1	10
	**Melochia pyramidata*	0.1	30
194	**Sida acuta*	3	40
216	**Stylosanthes hamata*	0.1	20
227	**Tridax procumbens*	0.1	15
203	*Abutilon hannii*	0.1	80
	Achyranthes aspera	0.2	25
	Atalaya variifolia	0.1	150
	Bauhinia cunninghamii	0.1	150
177	*Gomphrena brachystylis subsp. brachystylis*	0.1	100
181	*Bridelia tomentosa*	0.1	40
173	*Buchanania oblongifolia*	1	500
	Cayratia trifolia	0.1	C
184	*Celtis philippensis*	0.1	400
201	*Chamaecrista absus*	0.1	20
	Hygrophila angustifolia	0.5	30
192	*Cochlospermum fraseri*	0.1	100
222	*Corchorus tridens*	0.1	20
170	*Corymbia bella*	5	1200
172	*Corymbia confertiflora*	0.2	400
171	*Corymbia greeniana (s.l.)*	5	1500
198	*Crotalaria crispata*	0.1	15
186	*Crotalaria novae-hollandiae subsp. novae-hollandiae*	0.2	50
240	*Cymbidium canaliculatum*	0.1	20
231	*Cyperus pulchellus*	0.1	15
241	*Decaisnina angustata*	0.1	P
182	*Diospyros calycantha (P1)*	0.2	40
191	*Dolichandrone heterophylla*	0.1	50
193	*Ehretia saligna*	0.2	200
210	*Eragrostis fallax*	0.1	15
207	*Eragrostis potamophila*	0.1	25
208	*Eragrostis schultzii (P3)*	0.1	C
213	*Eragrostis tenellula*	0.2	20
175	*Erythrina vespertilio*	1	700
169	*Eucalyptus brevifolia*	20	1500
168	*Eucalyptus tetrodonta*	25	1600
179	*Exocarpos latifolius*	0.2	350
174	*Ficus aculeata var. aculeata*	0.1	400
232	*Fimbristylis cardiocarpa*	0.1	25
225	*Glycine arenaria*	0.1	C
196	*Goodenia heppleana*	0.1	10
197	*Goodenia sp. cf. brachypoda (P1)*	1	20
180	*Grevillea erythroclada*	0.1	250
	Grewia retusifolia	3	100
185	*Hakea arborescens*	0.1	250
205	*Heteropogon contortus*	2	40
226	*Ipomoea abrupta*	0.1	C
200	*Ipomoea eriocarpa*	0.1	20
187	*Jasminum molle*	0.5	60
188	*Microstachys chamaelea*	0.1	40
206	*Mitrasacme nummularia*	0.1	10
223	*Nelsonia campestris*	0.2	C
183	*Owenia vernicosa*	0.2	450
209	*Panicum mindanaense*	5	40
229	*Perotis rara*	0.1	20
176	*Persoonia falcata*	0.1	350
178	*Petalostigma pubescens*	1	500
228	*Premna acuminata*	0.1	20
	Rhynchosia minima	0.1	C
230	*Rhynchospora exserta*	0.1	25
204	*Sida rohlenae subsp. occidentalis*	1	30
202	*Spermacoce sp. nov. aff. leptoloba*	0.1	20
190	*Strychnos lucida*	0.1	100
195	*Tinospora smilacina*	0.1	C
224	*Vigna lanceolata (s.l.)*	0.1	C
217	*Zornia prostrata*	0.5	C

APPENDIX 6: FLORA AND VEGETATION SURVEY ENVIRONMENT DATA

Date:	16/05/2011	Site:	18	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496160	8292030	837

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	grey/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		1	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	13	6	1.2
	% Cover	5	5	100

Observations	
Field description of	Ungrazed. Thick grassland with trees

Collection No.	Species	% Cover	Ht (cm)
233	**Crotalaria juncea*	0.1	40
	Abelmoschus ficulneus	0.1	80
	Aeschynomene indica	0.1	50
	Arundinella nepalensis	0.1	40
107	*Asparagus racemosus*	0.1	300
	Buchnera linearis	2	600
234	*Carissa lanceolata*	0.1	50
	Chandeliers opposite	0.2	40
	Chionachne hubbardiana	0.1	50
	Commelina reticulata	0.2	80
	Corymbia bella	5	1300
	Crinum angustifolium	0.1	20
	Desmodium muelleri	0.1	20
	Dichanthium sericeum subsp. sericeum	5	150
	Elytrophorus spicatus	0.1	20
	Gomphrena brachystylis subsp. brachystylis	0.1	20
99	*Grewia retusifolia*	0.2	70
	Hibiscus austrinus var. austrinus	0.1	100
	Iseilema vaginiflorum	45	100
	Ludwigia perennis	0.1	80
	Neptunia monosperma	0.2	80
	Ophiurus exaltatus	3	200
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)	1	15
236	*Pseudopogonatherum irritans*	0.1	20
	Rotala diandra	0.1	10
	Scleria novae-hollandiae	0.1	30
	Sorghum plumosum	5	350
	Terminalia volucris	3	600
106	*Themeda triandra*	45	120
	Vachellia valida	0.2	20
235	*Vigna radiata var.?*	0.1	C
	Wedelia asperrima	0.1	100
	Oryza australiensis	0.2	120

Date:	16/05/2011	Site:	19	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496904	8290739	841

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Medium	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	10	7	2
	% Cover	5	25	40

Observations	Some open clay areas

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	Aeschynomene indica	0.1	30
	Cayratia trifolia	0.1	C
	Chandeliers opposite	2	100
	Commelina reticulata	0.2	20
	Cyperus bifax	1	30
	Buchnera linearis	1	15
160	*Diospyros calycantha (P1)*	0.2	500
	Elytrophorus spicatus	0.1	20
	Eragrostis tenellula	0.1	20
	Eucalyptus ?tectifica	5	1000
	Excoecaria parvifolia	24	700
	Fimbristylis laxiglumis (P2)	0.1	40
	Iseilema vaginiflorum	1	100
	Ludwigia perennis	2	120
89	*Merremia hederacea*	0.1	C
	Gomphrena brachystylis subsp. brachystylis	0.1	15
	Neptunia monosperma	0.2	50
	Oldenlandia galioides	0.2	2
	Ophiurus exaltatus	2	180
	Oryza australiensis	30	170
	Panicum decompositum	5	90
	Panicum decompositum	3	60
	Rotala diandra	0.1	10
	Scleria novae-hollandiae	0.1	30
	Stemodia debilis	0.1	20
	Strychnos lucida	0.2	200
	Terminalia volucris	1	600
	Vachellia valida	0.2	200

Date:	17/05/2011	Site:	20	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495563	8293133	843

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loam	Light brown		Wet

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	15		1
	% Cover	5		100

Observations	
Field description of	Grassland/herbland just south of black soil woodland

Collection No.	Species	% Cover	Ht (cm)
212	**Digitaria ciliaris*	0.1	30
249	**Hyptis suaveolens*	1	50
	**Sida acuta*	0.1	40
216	**Stylosanthes hamata*	0.1	20
256	*?Myriophyllum sp.*	0.1	10
247	*Buchnera linearis*	0.2	250
253	*Bacopa floribunda*	15	20
261	*Byblis rorida*	0.2	25
	Chandeliers opposite	0.2	40
	Corymbia bella	2	1500
246	*Corymbia collina*	1	500
	Corymbia confertiflora	0.5	850
245	*Corymbia polycarpa*	3	1500
	Desmodium muelleri	0.1	20
258	*Drosera indica (s.l.)*	5	30
208	*Gomphrena brachystylis subsp. brachystylis*	0.1	20
252	*Fimbristylis littoralis*	10	30
257	*Fimbristylis tetragona*	2	20
255	*Fuirena ciliaris*	15	25
	Hibiscus austrinus var. austrinus	0.1	50
260	*Lindernia clausa*	0.1	10
	Ludwigia perennis	15	45
259	*Mimulus uvedaliae*	0.1	15
223	*Nelsonia campestris*	0.1	20
250	*Pseudopogonatherum irritans*	35	50
254	*Rotala mexicana*	1	10
248	*Stemodia lythrifolia*	0.2	40
251	*Utricularia chrysantha*	1	25

Date:	26/05/2011	**Site:**	21	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	495600	8291503	772

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Sandy Loam	Light grey yellow		Soil dry. Dolomite rocks

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Lower slope	east	5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		5	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	E

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	14	3	1
	% Cover	30	5	60

Observations	

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
216	**Stylosanthes hamata*	0.1	20
279	*Acacia platycarpa*	0.1	40
173	*Buchanania oblongifolia*	0.2	500
289	*Buchnera asperata*	0.1	70
281	*Buchnera linearis*	0.1	40
268	*Buchnera linearis*	55	90
267	*Corymbia dichromophloia*	1	40
285	*Crosslandia setifolia*	1	15
284	*Crotalaria crispata*	0.5	30
282	*Crotalaria medicaginea var. neglecta*	0.1	25
271	*Crotalaria novae-hollandiae subsp. lasiophylla*	0.5	25
277	*Dodonaea hispidula var. phylloptera*	0.1	70
274	*Erythrophleum chlorostachys*	2	300
	Eucalyptus brevifolia	15	1400
	Eucalyptus tetrodonta	15	1200
290	*Gomphrena brachystylis subsp. brachystylis*	0.1	C
266	*Glycine arenaria*	0.1	C
291	*Glycine tomentella (s.l.)*	0.1	C
288	*Goodenia armitiana*	1	50
275	*Grevillea refracta*	1	300
264	*Haemodorum ensifolium*	0.1	110
280	*Indigofera linifolia*	0.1	20
273	*Minuria macrorhiza (P2)*	0.1	20
300	*Mitrasacme connata*	0.1	20
287	*Oldenlandia mitrasacmoides*	0.2	50
286	*Polygala triflora*	0.2	10
228	*Premna acuminata*	0.1	100
292	*Senna oligoclada*	0.1	20
272	*Sorghum stipoideum*	0.1	50
269	*Spermacoce phaeosperma*	0.1	20
278	*Tephrosia spechtii*	0.1	20
265	*Terminalia platyphylla*	0.2	800
270	*Waltheria indica*	0.1	80
276	*Wrightia saligna*	0.1	200
217	*Zornia prostrata*	0.1	C

Date:	26/05/2011	Site:	22	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495509	8292138	776

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loam	Light brown		Dolomite rocks 80%

Geomorphology:	Topography	Aspect	Slope (°)
	Lower slope	east	5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		1	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	12	4	1
	% Cover	15	15	65

Observations	
Field description of	

Collection No.	Species	% Cover	Ht (cm)
294	**Gomphrena celosioides*	0.1	10
297	*Acacia cowleana*	0.2	100
305	*Aristida hygrometrica*	0.1	30
	Buchnera linearis	0.1	40
	Chrysopogon sp.	60	60
299	*Buchnera linearis*	2	600
	Corymbia bella	5	1200
309	*Corymbia dichromophloia (s. str.)*	3	1200
	Crosslandia setifolia	0.2	15
	Erythrophleum chlorostachys	2	900
	Eucalyptus brevifolia	5	1200
	Eucalyptus tetrodonta	0.2	1000
	Goodenia armitiana	1	40
	Grevillea refracta	10	300
307	*Hybanthus aurantiacus*	0.2	25
	Gomphrena brachystylis subsp. brachystylis	1	25
300	*Mitrasacme connata*	0.1	80
	Oldenlandia mitrasacmoides	0.5	40
302	*Owenia vernicosa*	0.1	200
298	*Ptilotus corymbosus*	0.5	90
296	*Senna oligoclada*	0.2	50
293	*Solanum ?dioicum*	0.1	40
	Spermacoce phaeosperma	1	15
	Stemodia lythrifolia	0.1	20
303	*Tephrosia simplicifolia*	0.1	25
304	*Tephrosia subpectinata (s.l.)*	0.2	40
	Terminalia canescens	5	200
295	*Triodia bitextura*	1	30
	Wrightia saligna	0.1	150

Date:	27/05/2011	**Site:**	23	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	495552	8290976	786

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Sandy loam	Grey		Dolomite scree 60%

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Lower slope	east	5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		5	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	E

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	9		1
	% Cover	35		50

Observations	Scree ends 50m east of NW corner

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
294	**Gomphrena celosioides*	0.1	15
	**Stylosanthes hamata*	0.1	25
313	*Blumea saxatilis*	0.1	30
173	*Buchanania oblongifolia*	0.5	700
289	*Buchnera asperata*	0.2	40
322	*Buchnera linearis*	0.1	20
299	*Cochlospermum fraseri*	0.2	50
267	*Corymbia dichromophloia*	0.2	50
	Crosslandia setifolia	1	20
	Crotalaria novae-hollandiae subsp. lasiophylla	0.2	30
316	*Dolichandrone heterophylla*	0.1	60
314	*Eriachne ciliata*	0.1	20
320	*Eriachne obtusa*	1	30
	Erythrophleum chlorostachys	2	800
	Eucalyptus brevifolia	30	900
	Gomphrena brachystylis subsp. brachystylis	2	850
290	*Galactia tenuiflora (s.l.)*	0.5	C
	Goodenia armitiana	0.5	30
315	*Grevillea mimosoides*	0.1	40
	Grevillea refracta	0.2	60
321	*Hybanthus aurantiacus*	0.1	20
280	*Indigofera linifolia*	0.1	20
	Ipomoea eriocarpa	0.1	C
312	*Minuria macrorhiza (P2)*	0.1	20
300	*Mitrasacme connata*	0.1	50
311	*Mitrasacme nudicaulis var. nudicaulis*	0.1	20
	Oldenlandia mitrasacmoides	0.1	50
317	*Phyllanthus exilis*	0.2	20
318	*Polycarpaea longiflora*	0.1	40
298	*Ptilotus corymbosus*	0.1	20
310	*Sorghum stipoideum*	35	40
	Spermacoce phaeosperma	1	15
	Stemodia lythrifolia	0.1	40
324	*Tephrosia spechtii*	0.1	10
	Terminalia platyphylla	0.5	600
323	*Triodia bitextura*	10	40

Date:	27/05/2011	Site:	24	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495631	8292785	780

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loam	Light brown		Scree & gravel 70%

Geomorphology:	Topography	Aspect	Slope (°)
	Upper slope	east	5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	8		1
	% Cover	30		50

Observations	

Field description of	

Collection No.	Species	% Cover	Ht (cm)
249	**Hyptis suaveolens*	0.2	50
	Buchanania oblongifolia	1	500
	Buchnera asperata	0.2	30
329	*Calytrix exstipulata (s.l.)*	10	300
334	*Chrysopogon setifolius*	2	40
	Buchnera linearis	30	40
	Cochlospermum fraseri	0.5	25
328	*Corymbia confertiflora*	5	500
327	*Corymbia dichromophloia (s. str.)*	5	800
	Eragrostis schultzii (P3)	0.2	20
333	*Eriachne avenacea*	2	30
	Eriachne ciliata	0.2	20
	Eriachne obtusa	0.2	40
	Erythrophleum chlorostachys	5	800
337	*Fimbristylis pachyptera (P1)*	1	20
332	*Gomphrena brachystylis subsp. brachystylis*	0.2	20
	Goodenia armitiana	1	30
	Grevillea refracta	2	400
	Oldenlandia mitrasacmoides	0.1	30
	Owenia vernicosa	0.2	200
338	*Petalostigma pubescens*	0.2	500
330	*Polycarpaea corymbosa*	0.1	15
298	*Ptilotus corymbosus*	0.2	50
335	*Rhynchospora exserta*	0.1	20
	Spermacoce phaeosperma	5	15
308	*Stemodia lythrifolia*	0.2	20
331	*Tephrosia simplicifolia*	0.1	15
	Terminalia platyphylla	1	400
	Triodia bitextura	5	40

Date:	27/05/2011	Site:	25	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495500	8292500	784

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loam	Brown		Scree, rocks & gravel 80%

Geomorphology:	Topography	Aspect	Slope (°)
	Upper slope	east	5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Medium	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	11	4	1
	% Cover	15	5	60

Observations	Some shallow pits dug on slope

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	Acacia platycarpa	0.1	550
	Blumea saxatilis	0.1	20
	Buchanania oblongifolia	2	400
	Buchnera asperata	0.2	50
339	*Calytrix achaeta*	0.5	300
329	*Buchnera linearis*	0.2	300
	Chrysopogon setifolius	1	40
	Chrysopogon sp.	25	40
	Cochlospermum fraseri	0.2	700
	Corymbia confertiflora	3	650
327	*Corymbia dichromophloia (s. str.)*	10	1000
333	*Eriachne avenacea*	15	30
314	*Eriachne ciliata*	0.5	20
	Eriachne obtusa	5	25
	Erythrophleum chlorostachys	1	500
340	*Gomphrena brachystylis subsp. brachystylis*	0.1	500
	Eucalyptus brevifolia	1	700
337	*Fimbristylis pachyptera (P1)*	5	25
	Goodenia armitiana	0.2	30
	Grevillea refracta	1	400
	Mitrasacme connata	0.1	30
	Mitrasacme nudicaulis var. nudicaulis	0.1	20
	Oldenlandia mitrasacmoides	0.1	40
	Owenia vernicosa	0.1	20
341	*Persoonia falcata*	0.1	400
	Ptilotus corymbosus	0.2	40
	Spermacoce phaeosperma	0.2	30
	Stemodia lythrifolia	0.5	35
	Terminalia platyphylla	1	600
	Triodia bitextura	10	20

Date:	28/05/2011	Site:	26	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496175	8291247	790

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loam	Brown		Mostly rock. Little soil

Geomorphology:	Topography	Aspect	Slope (°)
	Ridge	east	5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	7		1.5
	% Cover	40		50

Observations	Co-ordinates are from the centre of the quadrat. This quadrat is 30m N & 30m S of the co-ords.It is 20

Field description of	

Collection No.	Species	% Cover	Ht (cm)
346	**Passiflora foetida*	10	C
359	*Acacia elachantha*	0.1	450
347	*Atalaya variifolia*	0.1	40
356	*Bauhinia cunninghamii*	0.2	150
	Buchanania oblongifolia	2	500
	Buchnera linearis	0.1	20
355	*Capparis umbonata*	0.1	40
	Chrysopogon setifolius	10	60
	Chrysopogon sp.	15	60
351	*Cleome viscosa*	0.1	30
	Cochlospermum fraseri	0.5	150
328	*Corymbia confertiflora*	10	700
344	*Corymbia dichromophloia (s. str.)*	15	650
348	*Cyperus conicus*	5	40
349	*Dicliptera armata*	5	40
353	*Gomphrena brachystylis subsp. brachystylis*	0.5	30
	Erythrophleum chlorostachys	10	600
340	*Erythroxylum ellipticum*	0.1	500
350	*Ficus aculeata var. aculeata*	1	40
363	*Hakea arborescens*	0.1	300
352	*Indigofera colutea*	0.1	30
357	*Jacquemontia sp. Keep River (J.L. Egan 5051) (P1)*	0.5	50
	Owenia vernicosa	0.2	500
345	*Panicum decompositum*	0.1	20
	Terminalia platyphylla	1	600
354	*Uraria lagopodioides*	0.1	C
	Wrightia saligna	0.5	400
358	*Xenostegia tridentata*	2	C

Date:	28/05/2011	**Site:**	27	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	496550	8290788	794

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Loam	Yellow/brown		Dolomite rocks 60%

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Ridge	east	5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		1	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	E

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	8		1
	% Cover	15		60

Observations	

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
380	**Sida cordifolia*	0.2	50
	**Stylosanthes hamata*	0.2	50
359	*Acacia elachantha*	0.2	100
342	*Atalaya variifolia*	0.2	50
356	*Bauhinia cunninghamii*	2	800
372	*Buchnera linearis*	0.1	20
377	*Bridelia tomentosa*	1	400
	Buchanania oblongifolia	1	400
	Buchnera asperata	0.1	30
374	*Carissa lanceolata*	0.1	100
184	*Celtis philippensis*	0.2	250
	Chrysopogon sp.	40	50
	Cochlospermum fraseri	2	500
367	*Enneapogon purpurascens*	2	30
	Eragrostis tenellula	0.1	20
379	*Gomphrena brachystylis subsp. brachystylis*	0.2	10
382	*Euphorbia mitchelliana (s.l.)*	0.1	35
360	*Euphorbia sp.*	0.2	40
368	*Evolvulus alsinoides var. villosicalyx*	0.1	15
350	*Ficus aculeata var. aculeata*	0.1	200
375	*Galactia tenuiflora (s.l.)*	3	C
370	*Grevillea mimosoides*	0.2	80
383	*Grewia breviflora*	0.2	550
	Grewia retusifolia	0.1	20
363	*Hakea arborescens*	5	600
395	*Heliotropium tenuifolium*	0.2	20
357	*Jacquemontia sp. Keep River (J.L. Egan 5051) (P1)*	0.1	30
371	*Jasminum molle*	2	120
376	*Melhania oblongifolia*	1	60
381	*Phyllanthus maderaspatensis*	0.1	20
373	*Rhynchosia minima*	0.5	C
369	*Sehima nervosum*	5	80
190	*Strychnos lucida*	0.1	300
	Terminalia canescens	0.1	300
	Terminalia platyphylla	1	500
	Wrightia saligna	1	800

Date:	29/05/2011	Site:	28	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495900	8290400	798

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loam	Brown		Rocky slabs & outcrops

Geomorphology:	Topography	Aspect	Slope (°)
	Mid slope	east	>10%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	5		1
	% Cover	35		70

Observations	

Field description of	

Collection No.	Species	% Cover	Ht (cm)
216	**Stylosanthes hamata*	0.1	30
365	*Abutilon hannii*	0.2	80
	Acacia elachantha	1	450
347	*Atalaya variifolia*	0.5	50
356	*Bauhinia cunninghamii*	1	450
377	*Buchnera linearis*	0.5	250
	Buchanania oblongifolia	2	500
	Celtis philippensis	1	300
385	*Christia australasica*	1	C
	Chrysopogon sp.	60	80
	Cochlospermum fraseri	2	450
386	*Crotalaria medicaginea var. neglecta*	0.1	25
396	*Crotalaria montana var. angustifolia*	0.1	80
387	*Decaisnina angustata*	0.1	P
392	*Diospyros calycantha (P1)*	0.2	150
360	*Gomphrena brachystylis subsp. brachystylis*	0.2	30
388	*Evolvulus alsinoides var. villosicalyx*	0.1	20
179	*Exocarpos latifolius*	0.5	300
393	*Ficus virens var. virens*	0.2	60
391	*Flueggea virosa subsp. melanthesoides*	0.2	180
383	*Grewia breviflora*	0.5	400
	Hakea arborescens	20	400
395	*Heliotropium tenuifolium*	0.1	20
389	*Heteropogon contortus*	0.1	20
	Indigofera colutea	0.1	15
364	*Indigofera trita*	0.1	20
	Ipomoea eriocarpa	0.2	C
390	*Jasminum molle*	0.5	100
	Owenia vernicosa	5	500
381	*Phyllanthus maderaspatensis*	0.1	20
369	*Sehima nervosum*	1	90
	Terminalia canescens	1	300
	Terminalia platyphylla	1	400
394	*Tinospora smilacina*	0.1	C

Date:	29/05/2011	**Site:**	29	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	496447	8290449	800

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Loam	Light red/brown		Reddish chert gravel 30%

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Valley Floor	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
		5	3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Medium	G

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	12	4	1
	% Cover	40	5	50

Observations	Some cattle paths run through quadrat

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Malvastrum americanum*	0.2	40
	**Sida acuta*	5	60
380	**Sida cordifolia*	15	60
	**Stylosanthes hamata*	0.5	30
421	*Abutilon hannii*	0.1	60
72	*Buchnera linearis*	0.1	10
407	*Aristida pruinosa*	20	60
	Atalaya hemiglauca	1	800
	Bauhinia cunninghamii	3	200
313	*Blumea saxatilis*	0.2	30
413	*Boerhavia burbidgeana*	0.2	10
	Buchanania oblongifolia	0.2	600
410	*Carissa lanceolata*	1	180
	Celtis philippensis	0.5	300
406	*Chamaecrista absus*	0.1	15
414	*Gomphrena brachystylis subsp. brachystylis*	1	15
	Corymbia confertiflora	1	1000
412	*Crotalaria medicaginea var. neglecta*	0.1	30
409	*Enneapogon polyphyllus*	0.5	20
415	*Eragrostis fallax*	0.1	50
211	*Eragrostis schultzii (P3)*	2	20
	Erythrophleum chlorostachys	1	1100
404	*Eucalyptus microtheca*	35	1200
419	*Evolvulus alsinoides var. decumbens*	0.1	20
	Exocarpos latifolius	0.2	200
350	*Ficus aculeata var. aculeata*	0.5	150
411	*Goodenia odonnellii*	0.1	10
383	*Grewia breviflora*	0.2	300
	Grewia retusifolia	0.2	100
417	*Heteropogon contortus*	10	20
49	*Leptochloa neesii*	2	20
420	*Panicum effusum*	0.1	50
418	*Perotis rara*	0.1	15
408	*Pterocaulon serrulatum*	0.1	50
	Sporobolous australasius	0.1	15
416	*Sporobolus mitchellii*	0.1	20
405	*Terminalia microcarpa*	0.1	400
422	*Vigna lanceolata (s.l.)*	0.1	C

Date:	29/05/2011	Site:	30	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496219	8290714	806

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay loam	Light yellow/brown		Chert gravel 90%

Geomorphology:	Topography	Aspect	Slope (°)
	Valley floor	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	7		1
	% Cover	30		60

Observations	
Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Hyptis suaveolens*	0.1	50
	**Sida acuta*	10	40
	**Sida cordifolia*	1	50
	**Stylosanthes hamata*	0.5	20
	Aristida pruinosa	20	50
78	*Buchnera linearis*	0.2	20
	Blumea saxatilis	0.1	25
414	*Chloris pumilio*	10	20
231	*Cyperus pulchellus*	0.1	10
	Cyperus tenuispica	0.1	10
432	*Dactyloctenium radulans*	0.1	10
436	*Dichanthium sericeum subsp. humilius*	0.5	20
426	*Ectrosia leporina*	0.1	15
211	*Eragrostis schultzii (P3)*	5	20
425	*Eriachne obtusa*	0.2	35
423	*Gomphrena brachystylis subsp. brachystylis*	25	700
411	*Goodenia odonnellii*	0.2	15
395	*Heliotropium tenuifolium*	0.1	20
417	*Heteropogon contortus*	5	30
49	*Leptochloa neesii*	5	20
424	*Melaleuca minutifolia*	5	500
25	*Nesaea arnhemica*	0.1	40
	Oldenlandia mitrasacmoides	0.5	25
420	*Panicum effusum*	0.1	20
52	*Paspalum scrobiculatum*	0.2	25
416	*Sporobolus mitchellii*	0.2	20
403	*Streptoglossa odora*	0.1	30

Date:	30/05/2011	**Site:**	31	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	496435	8291278	814

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay	Pale grey/brown		Cracking clay

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Valley floor	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
			3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Medium	P

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	10		1
	% Cover	40		70

Observations	Moderate amount of cattle activity

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Hyptis suaveolens*	0.2	50
437	**Mitracarpus ?hirtus*	0.1	30
	**Sida acuta*	25	50
	**Sida cordifolia*	15	50
	**Stylosanthes hamata*	1	25
431	*Buchnera linearis*	0.5	400
446	*Acacia tumida var. tumida*	0.1	600
	Ammannia baccifera	0.1	10
	Aristida pruinosa	1	40
	Atalaya hemiglauca	0.5	600
	Bauhinia cunninghamii	3	500
78	*Blumea diffusa*	0.1	25
439	*Centipeda minima*	0.1	20
	Chandeliers opposite	0.5	20
	Chloris pumilio	2	20
	Gomphrena brachystylis subsp. brachystylis	1	800
428	*Corymbia grandifolia subsp. longa*	1	1000
427	*Corymbia greeniana (s.l.)*	0.5	700
432	*Dactyloctenium radulans*	0.1	20
436	*Dichanthium sericeum subsp. humilius*	2	20
430	*Digitaria ctenantha*	10	20
440	*Dolichandrone heterophylla*	0.5	300
211	*Eragrostis schultzii (P3)*	10	15
423	*Eucalyptus pruinosa subsp. pruinosa*	0.1	20
	Excoecaria parvifolia	0.1	600
	Exocarpos latifolius	0.1	500
438	*Fimbristylis littoralis*	0.1	40
	Grewia breviflora	1	500
	Grewia retusifolia	0.2	100
417	*Heteropogon contortus*	2	20
424	*Melaleuca minutifolia*	1	500
435	*Neptunia dimorphantha*	0.1	5
420	*Panicum effusum*	0.2	40
236	*Pseudopogonatherum irritans*	0.5	40
433	*Senna planitiicola*	0.1	100
429	*Sporobolus mitchellii*	0.2	30
434	*Stemodia debilis*	0.1	10
394	*Tinospora smilacina*	0.1	C

Date:	30/05/2011	Site:	32	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495978	8290894	821

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay loam	Brown/grey		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	14	4	1
	% Cover	35	20	50

Observations	
Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Hyptis suaveolens*	0.1	45
	**Mitracarpus ?hirtus*	0.1	20
	**Sida acuta*	0.5	40
	**Sida cordifolia*	0.1	50
	**Stylosanthes hamata*	1	20
	Buchnera linearis	15	400
	Ammannia baccifera	0.1	20
	Atalaya hemiglauca	0.1	200
	Bauhinia cunninghamii	1	800
	Blumea saxatilis	0.2	40
444	*Brachychiton diversifolius subsp. diversifolius*	0.1	450
	Buchanania oblongifolia	0.1	250
	Chandeliers opposite	2	30
	Corymbia confertiflora	5	900
427	*Corymbia greeniana (s.l.)*	10	1100
215	*Gomphrena brachystylis subsp. brachystylis*	0.1	40
436	*Dichanthium sericeum subsp. humilius*	10	40
430	*Digitaria ctenantha*	0.1	30
211	*Eragrostis schultzii (P3)*	2	20
213	*Eragrostis tenellula*	10	20
404	*Eucalyptus microtheca*	15	1400
	Eucalyptus pruinosa subsp. pruinosa	1	800
442	*Grevillea agrifolia*	0.1	300
	Grewia breviflora	0.1	20
	Grewia retusifolia	5	50
	Hakea arborescens	3	400
417	*Heteropogon contortus*	15	40
443	*Jasminum molle*	0.2	50
	Ludwigia perennis	0.2	30
	Nesaea arnhemica	0.1	20
408	*Pterocaulon serrulatum*	0.1	40
	Terminalia platyphylla	0.5	350

Date:	30/05/2011	**Site:**	33	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	496050	8291398	826

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Clay loam	Brown		Damp

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	<5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
			3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	VG

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	15	4	1
	% Cover	35	4	90

Observations	Still wet with green grass. Slope starts approx 60m east of NW corner

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
471	**Alysicarpus vaginalis*	0.1	100
469	**Euphorbia hirta*	0.1	60
	**Malvastrum americanum*	0.1	80
	**Sida acuta*	0.2	60
	**Sida cordifolia*	0.1	70
468	**Sporobolus jacquemontii*	5	30
	**Stylosanthes hamata*	1	30
	Acacia tumida var. tumida	0.5	450
474	*Alyxia spicata*	0.1	130
463	*Aristida holathera var. holathera*	0.5	80
	Bacopa floribunda	0.5	15
	Bauhinia cunninghamii	0.2	350
	Blumea diffusa	0.1	15
	Blumea saxatilis	0.2	30
	Buchanania oblongifolia	0.5	400
451	*Gomphrena brachystylis subsp. brachystylis*	0.1	100
	Corymbia collina	0.1	250
	Corymbia confertiflora	5	800
	**Passiflora foetida*	0.2	C
465	*Cyperus conicus*	0.1	80
349	*Dicliptera armata*	0.1	30
	Digitaria ctenantha	1	40
472	*Dolichandrone heterophylla*	0.1	120
258	*Drosera indica (s.l.)*	0.1	20
473	*Ehretia saligna*	0.1	120
	Elytrophorus spicatus	0.1	15
415	*Eragrostis fallax*	5	30
462	*Eucalyptus microtheca*	30	1500
97	*Ficus aculeata var. aculeata*	1	450
438	*Fimbristylis littoralis*	0.2	20
255	*Fuirena ciliaris*	1	20
467	*Grevillea erythroclada*	0.1	350
	Grewia retusifolia	0.2	80
	Haemodorum ensifolium	0.1	100
470	*Heteropogon contortus*	20	50
	Ludwigia perennis	15	80
	Melaleuca ellipt	1	400
449	*Mimulus uvedaliae*	1	C
464	*Notoleptopus decaisnei*	0.1	40
209	*Panicum mindanaense*	1	45
475	*Petalostigma pubescens*	0.5	450
236	*Pseudopogonatherum irritans*	20	50
447	*Setaria apiculata*	0.2	40
	Sorghum plumosum	0.1	220
	Terminalia platyphylla	0.2	300
3	*Terminalia volucris*	0.5	500
	Themeda triandra	15	60
251	*Utricularia chrysantha*	0.2	30

Date:	30/05/2011	Site:	34	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496068	8291780	823

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay loam	Brown		Damp

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	14		1
	% Cover	20		90

Observations	Soil damp. Vegetation still green

Field description of	

Collection No.	Species	% Cover	Ht (cm)
194	**Sida acuta*	0.1	40
	**Sida cordifolia*	0.2	50
	**Stylosanthes hamata*	2	30
446	*Acacia tumida var. tumida*	3	900
253	*Bacopa floribunda*	0.1	15
	Buchnera linearis	0.2	700
261	*Byblis rorida*	0.1	25
451	*Chamaecrista mimosoides*	0.1	100
	Chandeliers opposite	0.2	40
	Corymbia collina	15	1400
452	*Cyperus conicus*	0.1	100
456	*Cyperus nervulosus*	0.1	15
	Digitaria ctenantha	0.1	60
254	*Dolichandrone heterophylla*	0.5	10
258	*Drosera indica (s.l.)*	2	30
448	*Gomphrena brachystylis subsp. brachystylis*	0.5	80
453	*Eriachne obtusa*	50	40
457	*Eriocaulon pusillum*	0.1	5
257	*Fimbristylis tetragona*	10	30
255	*Fuirena ciliaris*	5	20
	Grewia retusifolia	0.2	100
	Haemodorum ensifolium	0.1	110
450	*Limnophila fragrans*	0.1	15
454	*Lobelia dioica*	0.1	20
	Ludwigia perennis	1	100
238	*Melaleuca ellipt*	0.1	400
449	*Mimulus uvedaliae*	0.1	15
223	*Nelsonia campestris*	0.1	20
445	*Planchonia careya*	2	1000
236	*Pseudopogonatherum irritans*	20	20
251	*Utricularia chrysantha*	2	30
455	*Xyris complanata*	0.2	40

Date:	31/05/2011	Site:	35	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495886	8292180	828

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Sandy loam	grey/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	13		1.5
	% Cover	15		95

Observations	
Field description of	

Collection No.	Species	% Cover	Ht (cm)
446	*Acacia tumida var. tumida*	1	800
253	*Bacopa floribunda*	0.1	25
	Blumea diffusa	0.2	20
261	*Byblis rorida*	0.1	20
	Chamaecrista mimosoides	0.1	120
	Buchnera linearis	15	1300
	Cyperus conicus	0.2	100
	Drosera indica (s.l.)	0.2	30
448	*Ectrosia schultzii var. schultzii*	0.1	30
453	*Eriachne obtusa*	30	70
466	*Fimbristylis tetragona*	15	30
255	*Fuirena ciliaris*	15	20
	Grevillea agrifolia	0.1	450
467	*Grevillea erythroclada*	0.2	700
481	*Grevillea pteridifolia*		
	Gomphrena brachystylis subsp. brachystylis	0.2	130
450	*Limnophila fragrans*	0.1	15
480	*Lindernia clausa*		
	Ludwigia perennis	10	70
449	*Mimulus uvedaliae*	0.5	20
479	*Phyllanthus virgatus*	0.1	20
	Pseudopogonatherum irritans	5	90
	Rotala mexicana	2	10
447	*Setaria apiculata*	0.1	20
	Sorghum plumosum	30	200
477	*Terminalia arostrata*	0.1	600
478	*Xyris complanata*	0.2	40

Date:	1/06/2011	Site:	36	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495558	8290636	831

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Sandy loam	Light brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Lower slope	east	5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	13	4	1
	% Cover	40	10	60

Observations	Scree to western edge. Minor vehicular disturbance.

Field description of	This community only 50m wide

Collection No.	Species	% Cover	Ht (cm)
485	**Cynodon dactylon*	0.1	10
	**Gomphrena celosioides*	0.2	C
104	**Sida acuta*	0.5	50
	**Sida cordifolia*	5	60
	**Stylosanthes hamata*	1	20
484	*Buchnera linearis*	0.2	400
	Aristida holathera var. holathera	10	40
	Aristida pruinosa	1	50
	Blumea diffusa	0.2	25
	Blumea saxatilis	0.2	30
	Buchanania oblongifolia	2	400
	Buchnera asperata	0.1	30
	Corymbia confertiflora	1	1100
	Corymbia dichromophloia	0.1	50
231	*Cyperus pulchellus*	0.1	10
	Gomphrena brachystylis subsp. brachystylis	0.1	20
	Dolichandrone heterophylla	0.1	120
487	*Ectrosia leporina*	0.1	20
211	*Eragrostis schultzii (P3)*	20	20
213	*Eragrostis tenellula*	0.1	20
482	*Eriachne avenacea*	0.2	40
486	*Eriachne obtusa*	1	40
	Erythrophleum chlorostachys	15	1000
	Eucalyptus brevifolia	0.1	20
	Eucalyptus microtheca	10	1300
	Eucalyptus tetrodonta	10	1100
	Goodenia armitiana	0.1	25
488	*Goodenia odonnellii*	0.2	20
483	*Grevillea decurrens*	4	250
	Heteropogon contortus	3	20
	Minuria macrorhiza (P2)	10	20
	Mitrasacme connata	0.2	30
	Oldenlandia mitrasacmoides	0.2	30
	Owenia vernicosa	1	400
	Paspalum scrobiculatum	0.1	20
343	*Pterocaulon sphacelatum*	0.2	40
	Sporobolus mitchellii	0.1	20
	Stackhousia intermedia (s.l.)	0.1	C
	Stemodia lythrifolia	0.2	40
	Terminalia canescens	0.1	60
	Terminalia platyphylla	1	400
	Triodia bitextura	1	30
489	*Urochloa pubigera*	0.1	30
	Waltheria indica	3	45
	Zornia prostrata	0.2	C

Date:	1/06/2011	**Site:**	37	**Sampling Unit Type**	50x50m

Location:	**Datum**	**Zone**	**Easting**	**Northing**	**Photo No.**
	GDA	52L	495755	8291151	833

Soils:	**Soil texture**	**Soil Colour**	**Outcrop**	**Soil Comments**
	Loamy sand	Brown/reddish		

Geomorphology:	**Topography**	**Aspect**	**Slope (°)**
	Flat	east	5%

Litter (%):	**Logs**	**Twigs**	**Leaves**	**Bare Ground (%)**
			3	2

Disturbance:	**Years Since Fire**	**Level of Human Impact**	**Condition**
	3	Low	E

Vegetation Structure:	**Strata**	**Upper**	**Mid**	**Lower**
	Height (m)	15	5	1.5
	% Cover	30	2	70

Observations	

Field description of	

Collection No.	**Species**	**% Cover**	**Ht (cm)**
	**Sida acuta*	0.1	50
	**Sida cordifolia*	0.2	100
	**Stylosanthes hamata*	3	20
	Bauhinia cunninghamii	0.1	120
	Blumea diffusa	0.1	25
	Buchnera linearis	0.2	30
	Buchanania oblongifolia	0.2	800
	Chrysopogon sp.	60	100
497	*Cleome tetrandra (s.l.)*	0.1	25
	Corymbia dichromophloia (s. Str.)	0.1	25
198	*Crotalaria crispata*	2	15
495	*Crotalaria novae-hollandiae subsp. lasiophylla*	0.1	40
496	*Croton arnhemicus (P1)*	2	500
	Dicliptera armata	0.1	20
492	*Dodonaea hispidula var. phylloptera*	3	40
	Gomphrena brachystylis subsp. brachystylis	1	20
486	*Eriachne obtusa*	1	45
	Erythrophleum chlorostachys	1	800
	Eucalyptus brevifolia	15	1300
	Eucalyptus tetrodonta	12	1500
494	*Galactia tenuiflora (s.l.)*	0.2	C
	Goodenia armitiana	0.1	20
	Grewia retusifolia	0.1	100
	Heteropogon contortus	0.1	20
	Hybanthus aurantiacus	0.1	15
	Ipomoea eriocarpa	0.1	C
493	*Microstachys chamaelea*	0.2	30
	Minuria macrorhiza (P2)	0.1	15
	Owenia vernicosa	0.2	800
	Paspalum scrobiculatum	0.1	20
	Stackhousia intermedia (s.l.)	0.2	30
	Stemodia lythrifolia	0.1	20
	Triodia bitextura	0.5	30
	Waltheria indica	0.1	20
	Wrightia saligna	0.1	120

Date:	1/06/2011	Site:	38	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495827	8291540	835

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loamy sand	Reddish/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	15	5	1.5
	% Cover	35	5	80

Observations	
Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Gomphrena celosioides*	0.1	10
	**Sida acuta*	0.1	80
	**Stylosanthes hamata*	0.2	20
	Aristida holathera var. holathera	0.1	40
	Blumea saxatilis	0.1	25
	Buchnera linearis	3	500
	Buchnera asperata	0.1	30
502	*Cajanus marmoratus*	0.2	C
507	*Chamaecrista absus*	0.1	C
	Chrysopogon sp.	70	130
	Crosslandia setifolia	0.1	10
198	*Crotalaria crispata*	2	20
492	*Dodonaea hispidula var. phylloptera*	2	80
	Eragrostis schultzii (P3)	2	30
314	*Eriachne ciliata*	0.2	15
	Gomphrena brachystylis subsp. brachystylis	5	1200
	Eucalyptus tetrodonta	30	1500
508	*Glycine arenaria*	0.1	C
	Grevillea agrifolia	2	450
	Grewia retusifolia	0.1	80
470	*Heteropogon contortus*	0.5	50
503	*Ipomoea eriocarpa*	0.1	15
	Owenia vernicosa	0.1	600
475	*Petalostigma pubescens*	0.1	20
445	*Planchonia careya*	0.5	700
	Polycarpaea corymbosa	0.1	10
505	*Setaria apiculata*	0.2	20
506	*Spermacoce phaeosperma*	0.1	10
	Stackhousia intermedia (s.l.)	0.1	30
504	*Tephrosia remotiflora*	0.1	20
	Waltheria indica	0.5	80
	Wrightia saligna	0.1	120

Date:	2/06/2011	Site:	39	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495722	8291903	837

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loamy sand	Yellow/brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Lower slope	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		2	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	14		1.5
	% Cover	40		80

Observations	

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	Acacia cowleana	0.1	40
	Acacia platycarpa	0.1	45
	Aristida holathera var. holathera	0.1	50
510	*Blumea diffusa*	0.2	20
	Blumea saxatilis	0.2	30
	Buchnera linearis	0.2	50
	Chrysopogon sp.	50	110
	Cochlospermum fraseri	0.1	100
	Cyperus conicus	0.1	80
210	*Eragrostis fallax*	2	20
	Eragrostis schultzii (P3)	2	20
486	*Eriachne obtusa*	10	40
	Erythrophleum chlorostachys	5	1300
	Eucalyptus tetrodonta	35	1400
511	*Fimbristylis aff. carolinii (probably sp. nov.)*	0.2	30
512	*Gomphrena brachystylis subsp. brachystylis*	0.1	30
	Goodenia armitiana	0.1	30
	Grevillea agrifolia	0.2	160
483	*Grevillea decurrens*	0.2	450
	Grevillea pteridifolia	0.1	50
	Haemodorum ensifolium	0.1	70
	Ludwigia perennis	3	60
445	*Planchonia careya*	0.2	500
	Pseudopogonatherum irritans	0.1	20
	Rotala mexicana	0.1	10
	Setaria apiculata	0.3	40
	Stemodia lythrifolia	0.5	50
513	*Tephrosia subpectinata (s.l.)*	0.1	40
	Triodia bitextura	0.1	30
	Waltheria indica	0.2	20

Date:	2/06/2011	Site:	40	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495808	8292728	839

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loamy sand	Light red/grey		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
	5	5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Medium	P

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	14		1.8
	% Cover	10		60

Observations	Scree immediately west of site. *Hyptis* rampant

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Hyptis suaveolens*	20	170
	**Sida acuta*	1	40
	**Sida cordifolia*	0.1	60
	**Sporobolus jacquemontii*	5	30
	Acacia colei var. colei	0.5	80
	Buchnera linearis	0.5	700
520	*Alternanthera denticulata*	0.1	15
	Ammannia auriculata	0.5	15
	Bacopa floribunda	1	20
510	*Blumea diffusa*	0.1	20
	Blumea saxatilis	0.1	20
	Buchanania oblongifolia	1	650
514	*Calandrinia sp. quadrivalvis (papillose form)*	0.5	15
	Commelina reticulata	0.1	15
	Corymbia ?polycarpa	2	1200
	Gomphrena brachystylis subsp. brachystylis	0.1	10
	Cyperus tenuispica	2	10
	Digitaria ctenantha	1	30
	Elytrophorus spicatus	0.1	10
519	*Eragrostis potamophila*	2	50
	Eragrostis schultzii (P3)	5	20
	Eriachne obtusa	1	30
	Eucalyptus brevifolia	8	1400
518	*Fimbristylis rara*	0.1	20
	Fuirena ciliaris	0.1	15
517	*Gomphrena affinis*	0.2	20
	Grevillea agrifolia	1	450
516	*Haemodorum ensifolium*	0.2	100
515	*Jacksonia forrestii*	0.5	600
	Ludwigia perennis	1	20
	Perotis rara	0.1	15
	Pseudopogonatherum irritans	0.2	60
	Rotala mexicana	5	5
	Setaria apiculata	0.2	20
	Stemodia lythrifolia	2	30

Date:	3/06/2011	Site:	41	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496727	8293239	843

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	Brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Swamp	east	5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	High	P

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	9	4	1
	% Cover	5	20	60

Observations	Decline area - pond & banks

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Calotropis procera*	10	180
	**Cynodon dactylon*	2	15
	**Passiflora foetida*	0.1	C
	**Stylosanthes hamata*	0.5	20
	**Vachellia farnesiana*	1	400
9	*Buchnera linearis*	0.1	20
	Aerva javanica	0.1	60
	Ammannia baccifera	0.2	20
79	*Aristida latifolia*	1	50
	Atalaya hemiglauca	2	700
	Bauhinia cunninghamii	3	900
67	*Capparis lasiantha*	0.1	50
	Dichanthium sericeum subsp. sericeum	20	180
	Eragrostis tenellula	2	20
527	*Goodenia malvina (P1)*	0.1	10
	Gomphrena brachystylis subsp. brachystylis	0.2	80
	Iseilema vaginiflorum	20	50
528	*Leptochloa neesii*	2	80
32	*Neptunia monosperma*	0.1	70
25	*Nesaea arnhemica*	0.1	50
	Ophiurus exaltatus	0.2	250
	Panicum decompositum	15	50
52	*Paspalum scrobiculatum*	1	30
26	*Phyllanthus maderaspatensis*	0.1	20
6	*Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)*	0.1	10
	Rhynchosia minima	0.1	C
	Sorghum plumosum	10	400
44	*Trichodesma zeylanicum var. latisepalum*	0.1	50
1	*Vachellia valida*	0.1	60
	Vigna lanceolata (s.l.)	0.1	20

Date:	3/06/2011	Site:	42	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	496042	8292895	845

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Clay	Grey		

Geomorphology:	Topography	Aspect	Slope (°)
	Swamp	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
			3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	P

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	7	4	1.8
	% Cover	3	50	90

Observations	Man-made dam

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Calotropis procera*	10	350
530	**Echinochloa colona*	60	20
532	**Macroptilium lathyroides*	0.1	60
	Abelmoschus ficulneus	0.1	15
535	*Aeschynomene indica*	5	80
531	*Buchnera linearis*	0.1	10
	Ammannia auriculata	0.1	20
536	*Cathormion umbellatum subsp. moniliforme*	0.2	600
	Chandeliers opposite	1	50
	Commelina reticulata	0.1	20
524	*Cyperus iria*	0.1	40
533	*Eriachne avenacea*	0.2	70
	Excoecaria parvifolia	2	700
	Ludwigia perennis	1	60
529	*Marsilea hirsuta*	0.1	15
534	*Gomphrena brachystylis subsp. brachystylis*	3	80
	Oryza australiensis	10	180
	Sorghum plumosum	40	400
3	*Terminalia volucris*	0.5	400
1	*Vachellia valida*	1	700
	Vigna lanceolata (s.l.)	0.2	40

Date:	3/06/2011	Site:	43	Sampling Unit Type	50x50m

Location:	Datum	Zone	Easting	Northing	Photo No.
	GDA	52L	495503	8292997	847

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Loamy sand	Light brown		

Geomorphology:	Topography	Aspect	Slope (°)
	Flat	east	<5%

Litter (%):	Logs	Twigs	Leaves	Bare Ground (%)
		5	3	2

Disturbance:	Years Since Fire	Level of Human Impact	Condition
	3	Low	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	12	4	1.8
	% Cover	20	15	50

Observations	Infested with *Hyptis*

Field description of	

Collection No.	Species	% Cover	Ht (cm)
	**Hyptis suaveolens*	25	180
	**Sida cordifolia*	0.5	100
	**Sporobolus jacquemontii*	0.5	25
	Acacia colei var. colei	0.5	200
	Aristida holathera var. holathera	0.2	40
	Buchnera linearis	0.1	15
	Blumea saxatilis	0.2	30
	Buchanania oblongifolia	3	800
	Cochlospermum fraseri	1	150
	Corymbia confertiflora	2	1200
496	*Croton arnhemicus (P1)*	2	300
	Cyperus iria	0.1	40
	Eragrostis schultzii (P3)	5	20
	Eriachne obtusa	2	30
	Erythrophleum chlorostachys	1	700
	Gomphrena brachystylis subsp. brachystylis	10	1200
	Gomphrena affinis	0.1	35
483	*Grevillea decurrens*	1	450
	Haemodorum ensifolium	0.2	50
	Ludwigia perennis	0.1	50
	Petalostigma pubescens	5	400
	Pseudopogonatherum irritans	0.5	40
	Stemodia lythrifolia	1	40
	Waltheria indica	0.1	20
	Wrightia saligna	0.1	100

APPENDIX 7 – SUMMARY OF VASCULAR PLANT TAXA BY FAMILY

* denotes introduced (weed) species

Family	Taxon
Acanthaceae	*Dicliptera armata*
	Hygrophila angustifolia
	Nelsonia campestris
	Rostellularia adscendens
Amaranthaceae	*Achyranthes aspera*
	* *Aerva javanica*
	Alternanthera denticulata
	Alternanthera nodiflora
	Gomphrena affinis
	Gomphrena brachystylis subsp. *brachystylis*
	* *Gomphrena celosioides*
	Ptilotus corymbosus
	Ptilotus exaltatus
	Ptilotus spicatus
Amaryllidaceae	*Crinum angustifolium*
Anacardiaceae	*Buchanania oblongifolia*
Apocynaceae	*Alyxia spicata*
	* *Calotropis procera*
	Carissa lanceolata
	Cynanchum puberulum
	Wrightia saligna
Asparagaceae	*Asparagus racemosus*
Asteraceae	* *Bidens bipinnata*
	Blumea diffusa
	Blumea saxatilis
	Centipeda minima
	* *Emilia sonchifolia*
	Minuria macrorhiza (P2)
	Pterocaulon serrulatum
	Pterocaulon sphacelatum
	Streptoglossa odora
	* *Tridax procumbens*
	Wedelia asperrima
Bignoniaceae	*Dolichandrone heterophylla*
	Ehretia saligna
Boraginaceae	*Heliotropium tenuifolium*
	Trichodesma zeylanicum var. *latisepalum*
Byblidaceae	*Byblis rorida*
Campanulaceae	*Lobelia dioica*
Cannabaceae	*Celtis philippensis*
Capparaceae	*Capparis lasiantha*
	Capparis umbonata
Caryophyllaceae	*Polycarpaea corymbosa*
	Polycarpaea longiflora
Celastraceae	*Stackhousia intermedia* (s.l.)
Cleomaceae	*Cleome tetrandra* (s.l.)
	Cleome viscosa
Combretaceae	*Terminalia arostrata*
	Terminalia canescens
	Terminalia microcarpa
	Terminalia platyphylla
	Terminalia volucris
Commelinaceae	*Commelina ensifolia*
	Commelina reticulata
	Cyanotis axillaris
Convolvulaceae	*Evolvulus alsinoides* var. *decumbens*
	Evolvulus alsinoides var. *villosicalyx*
	Ipomoea abrupta
	Ipomoea diamantinensis
	Ipomoea eriocarpa
	Jacquemontia paniculata
	Jacquemontia sp. Keep River (J.L. Egan 5051) (P1)
	Merremia hederacea
	Operculina aequisepala
	Operculina brownii
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)
	Xenostegia tridentata
Cucurbitaceae	* *Citrullus lanatus*
	Cucumis maderaspatanus
	* *Cucumis melo*

APPENDIX 7: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY FAMILY

* denotes introduced (weed) species

Family	**Taxon**
Cyperaceae	*Crosslandia setifolia*
	Cyperus bifax
	Cyperus conicus
	Cyperus difformis
	Cyperus iria
	Cyperus nervulosus
	Cyperus pulchellus
	Cyperus tenuispica
	Eleocharis dulcis
	Fimbristylis aff. *carolinii* (probable new species)
	Fimbristylis cardiocarpa
	Fimbristylis cf. *dichotoma* (desert form)
	Fimbristylis depauperata
	Fimbristylis laxiglumis (P2)
	Fimbristylis littoralis
	Fimbristylis microcarya
	Fimbristylis pachyptera (P1)
	Fimbristylis rara
	Fimbristylis squarrulosa
	Fimbristylis tetragona
	Fuirena ciliaris
	Rhynchospora exserta
	Schoenoplectus dissachanthus
	Scleria novae-hollandiae
Droseraceae	*Drosera indica* (s.l.)
Ebenaceae	*Diospyros calycantha* (P1)
Elatiaceae	*Bergia pedicellaris*
Eriocaulaceae	*Eriocaulon pusillum*
	Erythroxylum ellipticum
Erythroxylaceae	*Croton arnhemicus* (P1)
Euphorbiaceae	*Bridelia tomentosa*
	* *Euphorbia hirta*
	Euphorbia kimberleyensis
	Euphorbia maconochieana
	Euphorbia mitchelliana (s.l.)
	Euphorbia sp.
	Excoecaria parvifolia
	Flueggea virosa subsp. *melanthesoides*
	Microstachys chamaelea

* denotes introduced (weed) species

Family	**Taxon**
Fabaceae	*Acacia colei* var. *colei*
	Acacia cowleana
	Acacia elachantha
	Acacia platycarpa
	Acacia tumida var. *tumida*
	Aeschynomene indica
	Albizia lebbeck
*	*Alysicarpus vaginalis*
	Bauhinia cunninghamii
	Cajanus marmoratus
	Cathormion umbellatum subsp. *moniliforme*
	Chamaecrista absus
	Chamaecrista mimosoides
	Christia australasica
	Crotalaria crispata
*	*Crotalaria juncea*
	Crotalaria medicaginea var. *neglecta*
	Crotalaria montana var. *angustifolia*
	Crotalaria novae-hollandiae subsp. *lasiophylla*
	Crotalaria novae-hollandiae subsp. *novae-hollandiae*
	Desmodium brownii
	Desmodium muelleri
	Desmodium trichostachyum
	Erythrina vespertilio
	Erythrophleum chlorostachys
	Flemingia pauciflora
	Galactia tenuiflora (s.l.)
	Glycine arenaria
	Glycine tomentella (s.l.)
	Indigofera colutea
	Indigofera linifolia
	Indigofera trita
	Jacksonia forrestii
*	*Macroptilium lathyroides*
	Neptunia dimorphantha
	Neptunia monosperma
	Rhynchosia minima
*	*Senna obtusifolia*
	Senna oligoclada
	Senna planitiicola
	Sesbania simpliciuscula var. *simpliciuscula*
*	*Stylosanthes hamata*
	Tephrosia remotiflora
	Tephrosia simplicifolia
	Tephrosia spechtii
	Tephrosia subpectinata (s.l.)
	Tephrosia virens (s.l.)
	Uraria lagopodioides
*	*Vachellia farnesiana*
	Vachellia valida
	Vigna lanceolata (s.l.)
	Vigna radiata var. ?
	Zornia prostrata

* denotes introduced (weed) species

Family	Taxon
Goodeniaceae	*Goodenia armitiana*
	Goodenia byrnesii (P1)
	Goodenia durackiana (P1)
	Goodenia heppleana
	Goodenia malvina (P1)
	Goodenia odonnellii
	Goodenia sp. cf. *brachypoda* (P1 or possible new species)
Haemodoraceae	*Haemodorum ensifolium*
Haloragaceae	*Myriophyllum* sp.
Hydroleaceae	*Hydrolea zeylanica* (P1)
Lamiaceae	* *Hyptis suaveolens*
	Premna acuminata
Lecythidaceae	*Planchonia careya*
Lentibulariaceae	*Utricularia chrysantha*
Linderniaceae	*Lindernia clausa*
Loganiaceae	*Mitrasacme connata*
	Mitrasacme exserta
	Mitrasacme nudicaulis var. *nudicaulis*
	Mitrasacme nummularia
	Strychnos lucida
Loranthaceae	*Amyema* sp.
	Decaisnina angustata
Lythraceae	*Ammannia auriculata*
	Ammannia baccifera
	Nesaea arnhemica
	Rotala diandra
	Rotala mexicana
Malvaceae	*Abelmoschus ficulneus*
	Abutilon hannii
	Adansonia gregorii
	Brachychiton diversifolius subsp. *diversifolius*
	Cochlospermum fraseri
	Corchorus fascicularis
	* *Corchorus olitorius*
	Corchorus tridens
	Grewia breviflora
	Grewia retusifolia
	Hibiscus aff. *calcicola* (possible sp. nov.)
	Hibiscus austrinus var. *austrinus*
	Hibiscus meraukensis
	* *Malvastrum americanum*
	Melhania oblongifolia
	Melochia corchorifolia
	* *Melochia pyramidata*
	* *Sida acuta*
	* *Sida cordifolia*
	Sida rohlenae subsp. *occidentalis*
	Triumfetta clivorum subsp. *clivorum*
	Waltheria indica
Marsileaceae	*Marsilea hirsuta*
Meliaceae	*Owenia vernicosa*
Menispermaceae	*Tinospora smilacina*
Moraceae	*Ficus aculeata* var. *aculeata*
	Ficus aculeata var. *indecora*
	Ficus virens var. *virens*
Myrtaceae	*Calytrix achaeta*
	Calytrix exstipulata (s.l.)
	Corymbia bella
	Corymbia collina
	Corymbia confertiflora
	Corymbia dichromophloia
	Corymbia grandifolia subsp. *longa*
	Corymbia greeniana (s.l.)
	Corymbia polycarpa
	Eucalyptus brevifolia
	Eucalyptus microtheca
	Eucalyptus obconica
	Eucalyptus pruinosa subsp. pruinosa
	Eucalyptus tectifica
	Eucalyptus tetrodonta
	Melaleuca minutifolia
	Melaleuca viridiflora
Nyctaginaceae	*Boerhavia burbidgeana*
	Boerhavia coccinea
Oleaceae	*Jasminum molle*
Onagraceae	*Ludwigia perennis*
Orchidaceae	*Cymbidium canaliculatum*
Orobanchaceae	*Buchnera asperata*
	Buchnera linearis

APPENDIX 7: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY FAMILY

* denotes introduced (weed) species

Family	Taxon
Pandanaceae	*Pandanus spiralis*
Passifloraceae	* *Passiflora foetida*
Phrymaceae	*Glossostigma drummondii*
	Mimulus uvedaliae
Phyllanthaceae	*Notoleptopus decaisnei*
	Phyllanthus maderaspatensis
	Phyllanthus virgatus
Plantaginaceae	*Bacopa floribunda*
	Limnophila fragrans
	Stemodia debilis
	Stemodia lythrifolia
Poaceae	*Aristida holathera* var. *holathera*
	Aristida hygrometrica
	Aristida latifolia
	Aristida pruinosa
	Arundinella nepalensis
	Chionachne hubbardiana
	Chloris pumilio
	Chrysopogon setifolius
	Chrysopogon sp.
	* *Cynodon dactylon*
	Dactyloctenium radulans
	Dichanthium sericeum subsp. *humilius*
	Dichanthium sericeum subsp. *sericeum*
	* *Digitaria ciliaris*
	Digitaria ctenantha
	* *Echinochloa colona*
	Ectrosia leporina
	Ectrosia schultzii var. *schultzii*
	Elytrophorus spicatus
	Enneapogon polyphyllus
	Enneapogon purpurascens
	Eragrostis fallax
	* *Eragrostis minor*
	Eragrostis potamophila
	Eragrostis schultzii (P3)
	Eragrostis tenellula
	Eriachne avenacea
	Eriachne ciliata
	Eriachne obtusa
	Heteropogon contortus
	Iseilema vaginiflorum
	Leptochloa neesii
	Ophiurus exaltatus
	Oryza australiensis
	Panicum decompositum
	Panicum effusum
	Panicum mindanaense
	Paspalum scrobiculatum
	Perotis rara
	Pseudochaetochloa australiensis
	Pseudopogonatherum irritans
	Schizachyrium fragile
	Sehima nervosum
	Setaria apiculata
	Sorghum plumosum
	Sorghum stipoideum
	Sporobolus australasicus
	* *Sporobolus jacquemontii*
	Sporobolus mitchellii
	Themeda triandra
	Triodia bitextura
	Urochloa pubigera

APPENDIX 7: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY FAMILY

* denotes introduced (weed) species

Family	**Taxon**
Polygalaceae	*Polygala* sp. Rhianthoides shoulders (M.H. Andrews 398) (P1)
	Polygala triflora
Portulacaceae	*Calandrinia* sp. *quadrivalvis* (papillose form)
Proteaceae	*Grevillea agrifolia*
	Grevillea decurrens
	Grevillea erythroclada
	Grevillea mimosoides
	Grevillea pteridifolia
	Grevillea refracta
	Hakea arborescens
	Persoonia falcata
Putrangivaceae	*Petalostigma pubescens*
Rubiaceae	* *Mitracarpus ?hirtus*
	Oldenlandia galioides
	Oldenlandia mitrasacmoides
	Spermacoce argillacea
	Spermacoce phaeosperma
	Spermacoce sp. aff. *leptoloba* (possible new species)
Santalaceae	*Exocarpos latifolius*
Sapindaceae	*Atalaya hemiglauca*
	Atalaya variifolia
	* *Cardiospermum halicacabum* var. *halicacabum*
	Dodonaea hispidula var. *phylloptera*
Solanaceae	*Solanum ?dioicum*
	Solanum lucani
Stylidiaceae	*Stylidium semipartitum*
Violaceae	*Hybanthus aurantiacus*
Vitaceae	*Cayratia trifolia*
Xyridaceae	*Xyris complanata*
Zygophyllaceae	* *Tribulus terrestris*

APPENDIX 8 – SUMMARY OF VASCULAR PLANT TAXA BY COMMUNITY, SITE AND PERCENT COVER

APPENDIX 8: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY QUADRATS AND PERCENT COVER

* denotes introduced (weed) species; + indicates a cover value of <1%.

	Vegetation Unit	F1				S1					W1				W2					W3				W4						W5										W6		
	Site number	29	30	31	32	6	14	15	16	18	17	36	40	43	24	25	26	27	28	20	33	34	35	21	22	23	37	38	39	1	2	3	4	5	7	8	9	10	11	12	13	19	41	42	oppo.
	Plant Taxon																																											
	Abelmoschus ficulneus					+	+	+		+																				+	+	+	+	+	+	+	+	+		+	+		+	+	
	Abutilon hannii	+									+								+																	+									
	Acacia colei var. *colei*			+	15								+	+						+																								
	Acacia cowleana																								+				+															
	Acacia elachantha								+								+	+	1																									
	Acacia platycarpa															+								+					+															
	Acacia tumida var. *tumida*			+								+	+								+	3	1																					
	Achyranthes aspera										+																						+			+				+				
	Adansonia gregorii																																											+
*	*Aerva javanica*																																										+	
	Aeschynomene indica							+		+																					+			+		+	+	+		+		+	5	
	Albizia lebbeck																																											+
	Alternanthera denticulata												+																															
	Alternanthera nodiflora																														+										+		+	
*	*Alysicarpus vaginalis*										+										+																						
	Alyxia spicata																				+																						
	Ammannia auriculata						+	+	+				+																					+			+		+	+	+			+	
	Ammannia baccifera	+		+	+	+	+		+																									+			+	+					+		
	Amyema sp.																																		+			+							
	Aristida holathera var. *holathera*											10		+							+							+	+															
	Aristida hygrometrica																								+																			
	Aristida latifolia																																	+			+				+		1		
	Aristida pruinosa	20	20	1								1																																	
	Arundinella nepalensis					3	10		1	+																									1									
	Asparagus racemosus									+																								+		+			+					
	Atalaya hemiglauca	1		+	+		+	+																											1	10		10		2	+		2		
	Atalaya variifolia					+		+			+						+	+	+											2	+	+	+	+		+	5								
	Bacopa floribunda						+						+	+						15	+	+	+																					
	Bauhinia cunninghamii	3		3	1	3	2	+	1	2	+						+	2	1		+						+			3	2	1	5	1	5	5		2	+	4	7		3		
	Bergia pedicellaris																																			+			+					
*	*Bidens bipinnata*																																			+								
	Blumea diffusa		+	+		+	+		+			+	+								+		+				+		+				+		+	+							
	Blumea saxatilis	+	+		+							+	+	+		+					+					+	+	+	+														
	Boerhavia burbidgeana	+																																										
	Boerhavia coccinea																	+																										
	Brachychiton diversifolius subsp. *diversifolius*				+						+																																	
	Bridelia tomentosa										+							1	+																	+	+							
	Buchanania oblongifolia	+			+						1	+	1	3	1	2	2	1	2		+	+		+			+	+	3	+														
	Buchnera asperata						+					+			+	+	+	+						+		+		+															
	Buchnera linearis																							+	+	+																		
	Byblis rorida																			+		+	+																					
	Cajanus marmoratus																											+																
	Calandrinia sp. *quadrivalvis* (papillose form)												+																															
*	*Calotropis procera*																																									10	10	
	Calytrix achaeta															+																												
	Calytrix exstipulata (s.l.)														10	+																												
	Capparis lasiantha																																	+		+				+		+		
	Capparis umbonata																+																											
*	*Cardiospermum halicacabum* var. *halicacabum*										+																			+														
	Carissa lanceolata	1								+								+																										
	Cathormion umbellatum subsp. *moniliforme*																														+			+				+			+			+	
	Cayratia trifolia					+	+	+	+		+																					+	+	+	+		+	+	+	+	+	+			
	Celtis philippensis	+									+							+	1																										
	Centipeda minima			+																																								
	Chamaecrista absus	+									+																	+																
	Chamaecrista mimosoides																				+	+	+																					
	Chionachne hubbardiana					5		1		+																				35	2	20	20	5	50	5	+	5	+	2	2				
	Chloris pumilio	1	10	2															1																										
	Christia australasica																		1																										
	Chrysopogon setifolius														2	1	10																											
	Chrysopogon sp.														30	25	15	40	60					55	60		60	70	50															
*	*Citrullus lanatus*																																											+

APPENDIX 8: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY QUADRATS AND PERCENT COVER

* denotes introduced (weed) species; + indicates a cover value of <1%.

	Vegetation Unit	F1				S1					W1				W2					W3				W4					W5												W6		
	Site number	29	30	31	32	6	14	15	16	18	17	36	40	43	24	25	26	27	28	20	33	34	35	21	22	23	37	38	39	1	2	3	4	5	7	8	9	10	11	12	13	19	41	42	oppo.
	Plant Taxon																																											
	Cleome tetrandra (s.l.)																										+																	
	Cleome viscosa																+																											
	Cochlospermum fraseri										+			1	+	+	+	2	2						2	+			+															
	Commelina ensifolia																													+		+												
	Commelina reticulata					+	+	+	+	+			+																	5	3	5	1	2	1	+	1	2	+	1	2	+		+	
	Corchorus fascicularis																																	+				+						
*	*Corchorus olitorius*																													+		+	+		+		+			+	+			
	Corchorus tridens										+																																	
	Corymbia bella								1	5	5									2					5																				
	Corymbia collina																			1	+	15	15																						
	Corymbia confertiflora	1		1	5						+	1		2	5	3	10			+	5																							
	Corymbia dichromophloia											+			5	10	15							1	3	+	+																
	Corymbia grandifolia subsp. *longa*			1																																								
	Corymbia greeniana (s.l.)			+	10						5																																	
	Corymbia polycarpa								+				2							3																								
	Crinum angustifolium					+	+	+		+																				+	+	+	+		+		+		+		+			
	Crosslandia setifolia																							1	+	1		+																
	Crotalaria crispata										+													+			2	2															
*	*Crotalaria juncea*									+																															+			
	Crotalaria medicaginea var. *neglecta*	+																	+					+																				
	Crotalaria montana var. *angustifolia*																		+																				+		+			
	Crotalaria novae-hollandiae subsp. *lasiophylla*																							+		+	+																
	Crotalaria novae-hollandiae subsp. *novae-hollandiae*										+																																	
	Croton arnhemicus (P1)													2													2																
	Cucumis maderaspatanus							+																							+	+		+		+			+				
*	*Cucumis melo*					+	+	+																									+	+							+			
	Cyanotis axillaris						+																							+	+	+	+			+			+	+	+			
	Cymbidium canaliculatum										+																																	
	Cynanchum puberulum																															+				+	+							
*	*Cynodon dactylon*								+		5	+																														2		
	Cyperus bifax						20																									+									20	1			
	Cyperus conicus																5				+	+	+						+																
	Cyperus difformis					+	1	+	+		+																						+		+					+			
	Cyperus iria													+																												+		
	Cyperus nervulosus					+	+	+	+													+																					
	Cyperus pulchellus		+								+	+	+																															
	Cyperus tenuispica		+			2		+	+				2																	+	+	1	1		2	+	+	+	+	+	+	1		
	Dactyloctenium radulans		+	+																																							
	Decaisnina angustata					+					+								+												+		+			+	+						
	Desmodium brownii																																											+
	Desmodium muelleri					+				+		+								+										+							+		+				
	Desmodium trichostachyum																																											+
	Dichanthium sericeum subsp. *humilius*		+	2																																							
	Dichanthium sericeum subsp. *sericeum*					10			+	5																				2			+	+		1	+	1		+			20		
	Dicliptera armata																5				+						+																	
*	*Digitaria ciliaris*										+									+																								
	Digitaria ctenantha			10	+		+						1								1	+																						
	Diospyros calycantha (P1)							+			+								+																						+			
	Dodonaea hispidula var. *phylloptera*																							+			3	2																
	Dolichandrone heterophylla			+					1		+	+									+	+			+																			
	Drosera indica (s.l.)																			5	+	2	+																					
*	*Echinochloa colona*										+																							+				+			60		
	Ectrosia leporina		+									+																																
	Ectrosia schultzii var. *schultzii*																					+	+																					
	Ehretia saligna							+			+										+												+										
	Eleocharis dulcis																																					+	+					
	Elytrophorus spicatus						+	+		+			+								+									+	2	1	1	+	2	+	+	+	+		1	+		
*	*Emilia sonchifolia*										+																																	
	Enneapogon polyphyllus	+																																										
	Enneapogon purpurascens																	2																										
	Eragrostis fallax	+									+										5								2														
*	*Eragrostis minor*						+	+	+																										+								

APPENDIX 8: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY QUADRATS AND PERCENT COVER

* denotes introduced (weed) species; + indicates a cover value of <1%.

	Vegetation Unit	F1				S1					W1				W2					W3				W4					W5												W6		
	Site number	29	30	31	32	6	14	15	16	18	17	36	40	43	24	25	26	27	28	20	33	34	35	21	22	23	37	38	39	1	2	3	4	5	7	8	9	10	11	12	13	19	41	42	oppo.
	Plant Taxon																																											
	Eragrostis potamophila										+		2																																
	Eragrostis schultzii (P3)	2	5	10	2						2	20	5	5	+					+							1	2	2															
	Eragrostis tenellula				10						+	+						+																							+	2		
	Eriachne avenacea											+			2	15																											+	
	Eriachne ciliata														+	+	+									+		+															
	Eriachne obtusa		+									1	1	2	+	5						50	30			1	1		10														
	Eriocaulon pusillum																					+																					
	Erythrina vespertilio										1																																
	Erythrophleum chlorostachys	1										15		1	5	1	10							2	2	2	1		5														
	Erythroxylum ellipticum															+	+																										
	Eucalyptus brevifolia										20	5	8			1								15	5	30	15	5															
	Eucalyptus microtheca	35			15							10									30																						
	Eucalyptus obconica																																								1			
	Eucalyptus pruinosa subsp. *pruinosa*		25	30	1																																						
	Eucalyptus tectifica																													2							10	3	2			5			
	Eucalyptus tetrodonta										25	10		10										15	+	2	12	30	35														
*	*Euphorbia hirta*										+										+																						
	Euphorbia kimberleyensis																	+																										
	Euphorbia maconochieana																																			+								
	Euphorbia mitchelliana (s.l.)																	+																	+								
	Euphorbia sp.																	+	+																								
	Evolvulus alsinoides var. *decumbens*	+																																									
	Evolvulus alsinoides var. *villosicalyx*																	+	+																								
	Excoecaria parvifolia			+																												3		25			3	5	10	+	5	24		2	
	Exocarpos latifolius	+		+							+								+																								
	Ficus aculeata var. *aculeata*	+				+	+		+		+						1	+			1																						
	Ficus aculeata var. *indecora*																																										+
	Ficus virens var. virens																		+																								
	Fimbristylis cardiocarpa										+																																
	Fimbristylis aff. *carolinii* (probably sp. nov.)																												+														
	Fimbristylis depauperata						+																							+			+		+					+			
	Fimbristylis cf. *dichotoma* (desert form)							+																													+							
	Fimbristylis laxiglumis (P2)						+	+	+																					+	+				+		+		+		+	+		
	Fimbristylis littoralis			+																10	+																	+						
	Fimbristylis microcarya																																+										
	Fimbristylis pachyptera (P1)														1	5																											
	Fimbristylis rara					+							+																			+										
	Fimbristylis squarrulosa																																										+	
	Fimbristylis tetragona																			2	1	10	15																					
	Flemingia pauciflora					+	2		+																							+		+	+	+				+	+		
	Flueggea virosa subsp. *melanthesoides*							+											+														+			+							
	Fuirena ciliaris												+							15	1	5	15						+														
	Galactia tenuiflora (s.l.)																	3						+		+	+																
	Glossostigma drummondii																																								1			
	Glycine arenaria										+													+				+															
	Glycine tomentella (s.l.)																							+																		
	Gomphrena affinis												+	+																													
	Gomphrena brachystylis subsp. *brachystylis*														+																												
*	*Gomphrena celosioides*											+													+	+		+															
	Goodenia armitiana											+			1	+								1	1	+	+		+														
	Goodenia sp. cf. *brachypoda* (P1)										1																																
	Goodenia byrnesii (P1)																																										+	
	Goodenia durackiana (P1)					+	+			+																				+	+	+	+				+				+			
	Goodenia heppleana										+																																
	Goodenia malvina (P1)							+																													+			+			+	
	Goodenia odonnellii	+	+									+																															
	Grevillea agrifolia				+								1										+					2	+														
	Grevillea decurrens											4		1									+						+														
	Grevillea erythroclada										+										+		+																				
	Grevillea mimosoides																	+								+																
	Grevillea pteridifolia																						+						+													
	Grevillea refracta														2	1								1	10	+																	

APPENDIX 8: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY QUADRATS AND PERCENT COVER

* denotes introduced (weed) species; + indicates a cover value of <1%.

	Vegetation Unit	F1				S1					W1				W2					W3				W4					W5												W6		
	Site number	29	30	31	32	6	14	15	16	18	17	36	40	43	24	25	26	27	28	20	33	34	35	21	22	23	37	38	39	1	2	3	4	5	7	8	9	10	11	12	13	19	41	42	oppo.
	Plant Taxon																																											
	Grewia breviflora	+		1	+													+	+																									
	Grewia retusifolia	+		+	5	+				+	3							+			+	+					+	+							+	2		+						
	Haemodorum ensifolium												+	+							+	+	+	+					+															
	Hakea arborescens				3						+						+	5	20																										
	Heliotropium tenuifolium		+															+	+																									
	Heteropogon contortus	10	5	2	15				+		2	3							5		20						+	+													+				
	Hibiscus austrinus var. *austrinus*					+		+	1	+										+										+	5	+	+	+	1		+	+	+	+	+		+		
	Hibiscus aff. calcicola																																							+					
	Hibiscus meraukensis																																												+
	Hybanthus aurantiacus																								1	+	+																		
	Hydrolea zeylanica (P1)																																							+					
	Hygrophila angustifolia			+	2					+	+									+		+								+	10	1	+	1	1	+	5	10	2	2	+	2		1	
*	*Hyptis suaveolens*		+	+	+								20	25	+					1																								
	Indigofera colutea																+		+																									
	Indigofera linifolia																							+		+																	
	Indigofera trita																		+															+									
	Ipomoea abrupta							+			+																																	
	Ipomoea diamantinensis																																											+
	Ipomoea eriocarpa	+									+	+							+						1	+	+	+					+											
	Iseilema vaginiflorum					20	2	5	5	45																				5	10	5	50	70	15	5	2	2	2	10	2	1	20		
	Jacksonia forrestii												+																															
	Jacquemontia paniculata																																											+
	Jacquemontia sp. Keep River (J.L. Egan 5051) (P1)																+	+																										
	Jasminum molle				+						+							2	+																	+								
	Leptochloa neesii	2	5	1																											+												2		
	Limnophila fragrans																					+	+																					
	Lindernia clausa																			+			+																					
	Lobelia dioica																					+																						
	Ludwigia perennis				+	+	15	+	1	+			1	+						15	15	1	10						3	1	50	30	2	5	1	+	2	5	5	45	35	2		1	
*	*Macroptilium lathyroides*																																										1	+	
*	*Malvastrum americanum*	+																			+																							
	Marsilea hirsuta																														+	+	1		+		+		+		+		+	
	Melaleuca minutifolia		5	1																																								
	Melaleuca viridiflora																				1	+																						
	Melhania oblongifolia																	1																										
	Melochia corchorifolia																																							+			3		
*	*Melochia pyramidata*					+		+	+		+																					+	+				+				+			
	Merremia hederacea																																		+								+		
	Microstachys chamaelea										+																+																
	Mimulus uvedaliae						+		+				+							+	+	+	+								+		+	+				+		+	+		
	Minuria macrorhiza (P2)											10												+		+	+																	
*	*Mitracarpus ?hirtus*			+	+																																								
	Mitrasacme connata											+				+									+	+																		
	Mitrasacme exserta																																											+
	Mitrasacme nudicaulis var. *nudicaulis*															+										+																	
	Mitrasacme nummularia										+																																	
?	*Myriophyllum* sp.																			+																								
	Nelsonia campestris							+			+									+		+									+		+						+	1	+			
	Neptunia dimorphantha			+																																								
	Neptunia monosperma						+	+		+																				+	+	+	+	+	+		+	+	+	2	+	+	+		
	Nesaea arnhemica		+		+																									+	+	+			+	+			+		+		+		
	Notoleptopus decaisnei																				+																							
	Oldenlandia galioides																																										+	
	Oldenlandia mitrasacmoides		+						+			+			+	+								+	+	+																	
	Operculina aequisepala																															+				+				+	+			
	Operculina brownii																																+		+	+								
	Ophiurus exaltatus					10		45	10	3																							2	+	10	30	65	+			+	2	+	
	Oryza australiensis									+	+	1			+	+	+		5						+		+	+		+	+	1		1		1	+	20	30		+		10	
	Owenia vernicosa																									+		+	+															
	Pandanus spiralis																																											+
	Panicum decompositum								1								5													10	+	10	5	3	5	10	3.5	20		6	15	8	15		
	Panicum effusum	+	+	+	1																																							

APPENDIX 8: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY QUADRATS AND PERCENT COVER

* denotes introduced (weed) species; + indicates a cover value of <1%.

	Vegetation Unit	F1				S1					W1				W2					W3				W4					W5												W6		
	Site number	29	30	31	32	6	14	15	16	18	17	36	40	43	24	25	26	27	28	20	33	34	35	21	22	23	37	38	39	1	2	3	4	5	7	8	9	10	11	12	13	19	41	42	oppo.
	Plant Taxon																																											
	Panicum mindanaense										5										1																								
	Paspalum scrobiculatum		+									+															+				+									+		1		
*	*Passiflora foetida*																10				+																							+		
	Perotis rara	+									+		+																																
	Persoonia falcata										+					+																													
	Petalostigma pubescens										1			5	+						+							1																	
	Phyllanthus maderaspatensis					+	+		+									+	+											+	+	+	+		+	+	+	+		+	+		+			
	Phyllanthus virgatus																						+			+																			
	Planchonia careya																					2						+	+																
	Polycarpaea corymbosa														+													+																	
	Polycarpaea longiflora																									+																			
	Polygala sp. Rhianthoides shoulders (M.H. Andrews 398) (P1)					+																																						
	Polygala triflora																							+			+																	
	Polymeria sp. A Kimberley Flora (T.E.H. Aplin et al. 418)					1	5.1	+	5	1																				10	1	2	2	2	1	+	1	+	+	+	2		+		
	Premna acuminata										+							1						+											+									
	Pseudochaetochloa australiensis																																											+
	Pseudopogonatherum irritans			+						+			+	+						35	20	20	5						+														
	Pterocaulon serrulatum	+			+																																							
	Pterocaulon sphacelatum											+																																
	Ptilotus corymbosus														+	+									+	+																		
	Ptilotus exaltatus																																											+
	Ptilotus spicatus																																+		+	+								
	Rhynchosia minima					+	+	+			+							+	1											+					+	1					+		+		
	Rhynchospora exserta										+				+																													
	Rostellularia adscendens																																+											
	Rotala diandra									+																					+							+	+			+		
	Rotala mexicana												5							1			2					+																
	Schizachyrium fragile																									+																		
	Schoenoplectus dissachanthus								+																						+												
	Scleria novae-hollandiae						+			+																					+	+								1		+		
	Sehima nervosum						1		2									5	1														+			1								
*	*Senna obtusifolia*							+																																				
	Senna oligoclada																							+																				
	Senna planitiicola			+																																								
	Sesbania simpliciuscula var. *simpliciuscula*																																	+										
	Setaria apiculata												+								+	+	+					+	+														
*	*Sida acuta*	5	10	25	+						3	+	1							+	+	+				+	+																	
*	*Sida cordifolia*	15	1	15	+							5	+	+				+			+	+					+																	
	Sida rohlenae subsp. *occidentalis*							+	1		1																																		
	Solanum ?dioicum																								+																			
	Solanum lucani																																											+
	Sorghum plumosum					10	1	15	1	5											+		30							1		5		1			+		10	+		10	40	
	Sorghum stipoideum																							+		35																	
	Spermacoce argillacea					+	+																							+	+	+			+		+						
	Spermacoce phaeosperma														5	+								+	1	1		+															
	Spermacoce sp. nov. aff. *leptoloba*										+																																	
	Sporobolus australasicus	+																																									
*	*Sporobolus jacquemontii*												5	+							5																							
	Sporobolus mitchellii	+	+	+								+																																
	Stackhousia intermedia (s.l.)											+												+			+	+															
	Stemodia debilis			+			+		+																								+			+					+		
	Stemodia lythrifolia											+	2	1	+	+				+					+	+	+		+														
	Streptoglossa odora		+																																								
	Strychnos lucida										+							+																		+						+		
	Stylidium semipartitum																																											+
*	*Stylosanthes hamata*	+	+	1	1						+	1						+	+	+	1	2		+		+	3	+													+		+		
	Tephrosia remotiflora																											+																
	Tephrosia simplicifolia														+										+																			
	Tephrosia spechtii																							+		+																		
	Tephrosia subpectinata (s.l.)																								+				+															
	Tephrosia virens (s.l.)																																+											
	Terminalia arostrata																						+																					

APPENDIX 8: SUMMARY OF VASCULAR PLANT TAXA RECORDED AT SORBY HILLS SURVEY AREA BY QUADRATS AND PERCENT COVER

* denotes introduced (weed) species; + indicates a cover value of <1%.

	Vegetation Unit	F1				S1					W1				W2					W3				W4					W5													W6		
	Site number	29	30	31	32	6	14	15	16	18	17	36	40	43	24	25	26	27	28	20	33	34	35	21	22	23	37	38	39	1	2	3	4	5	7	8	9	10	11	12	13	19	41	42	oppo.
	Plant Taxon																																											
	Terminalia canescens											+						+	1						5																			
	Terminalia microcarpa	+																																										
	Terminalia platyphylla				+							1			1	1	1	1	1		+			+		+		+																
	Terminalia volucris					+		+	+	3											+			+						8	10	1	20	1	24	15	10	20	1	4	2	1		+	
	Themeda triandra					30	30	45	65	45											15																							
	Tinospora smilacina			+							+								+																				+				
*	*Tribulus terrestris*																																											+
	Trichodesma zeylanicum var. *latisepalum*																																+	+		+				+			+	
*	*Tridax procumbens*										+																																	
	Triodia bitextura											1			5	10									1	10	+		+															
	Triumfetta clivorum subsp. *clivorum*																																												+
	Uraria lagopodioides																+																											
	Urochloa pubigera											+																																
	Utricularia chrysantha																			1	+	2																						
*	*Vachellia farnesiana*						+																																				1		
	Vachellia valida					1	+	+	+	+																				5	2	3	+	3	+	+	2	+	+	+	+	+	+	1	
	Vigna lanceolata (s.l.)	+				+		+		+	+																			+	+	+		+	+	+	+	+	+	+	+		+	+	
	Vigna radiata var. ?					+		+		+																														+				
	Waltheria indica											3		+										+			+	+	+															
	Wedelia asperrima					+	+		+	+																				+	+	+		+	+	+	+	+		+	+		+		
	Wrightia saligna													+			+	1						+	+		+	+	+															
	Xenostegia tridentata																2																											
	Xyris complanata																					+	+																					
	Zornia prostrata										+	+												+																				

APPENDIX 9 – LOCATIONS OF PLANTS OF CONSERVATION SIGNIFICANCE

APPENDIX 9: LOCATIONS OF PLANTS WITH ACTUAL OR POSSIBLE CONSERVATION SIGNIFICANCE (GDA94, MGA Zone 52L)

Species	Conservation Significance	Easting	Northing	Site	Notes
Croton arnhemicus	P1	495755	8291151	37	
Croton arnhemicus	P1	495503	8292997	43	
Diospyros calycantha	P1 & range extension	498126	8292996	15	
Diospyros calycantha	P1 & range extension	495549	8290299	17	
Diospyros calycantha	P1 & range extension	496904	8290739	19	
Diospyros calycantha	P1 & range extension	495900	8290400	28	
Fimbristylis pachyptera	P1	495631	8292785	24	
Fimbristylis pachyptera	P1	495500	8292500	25	
Goodenia sp. cf. *brachypoda*	P1 or ?new species	495549	8290299	17	Not in report
Goodenia byrnesii	P1	496235	8291240	opp	
Goodenia durackiana	P1	498000	8290750	1	
Goodenia durackiana	P1	496009	8293116	2	
Goodenia durackiana	P1	497995	8291781	3	
Goodenia durackiana	P1	496900	8293366	4	
Goodenia durackiana	P1	498500	8293510	6	
Goodenia durackiana	P1	498484	8290204	9	
Goodenia durackiana	P1	498357	8291215	13	
Goodenia durackiana	P1	498560	8292254	14	
Goodenia durackiana	P1	496160	8292030	18	
Goodenia malvina	P1	497354	8291314	8	
Goodenia malvina	P1	496645	8291508	11	
Goodenia malvina	P1	498126	8292996	15	
Goodenia malvina	P1	496727	8293239	41	
Hydrolea zeylanica	P1 & range extension	496377	8292592	12	
Jacquemontia sp. Keep River (J.L. Egan 5051)	P1	496175	8291247	26	
Jacquemontia sp. Keep River (J.L. Egan 5051)	P1	496550	8290788	27	
Polygala sp. Rhianthoides shoulders (M.H. Andrews 398)	P1	498500	8293510	6	
Fimbristylis laxiglumis	P2	498000	8290750	1	
Fimbristylis laxiglumis	P2	496009	8293116	2	
Fimbristylis laxiglumis	P2	497111	8292380	7	
Fimbristylis laxiglumis	P2	498484	8290204	9	
Fimbristylis laxiglumis	P2	496645	8291508	11	
Fimbristylis laxiglumis	P2	498357	8291215	13	
Fimbristylis laxiglumis	P2	498560	8292254	14	
Fimbristylis laxiglumis	P2	498126	8292996	15	
Fimbristylis laxiglumis	P2	497572	8293586	16	
Fimbristylis laxiglumis	P2	496904	8290739	19	
Minuria macrorhiza	P2	495600	8291503	21	
Minuria macrorhiza	P2	495552	8290976	23	
Minuria macrorhiza	P2	495755	8291151	31	
Minuria macrorhiza	P2	495558	8290636	36	
Eragrostis schultzii	P3	495549	8290299	17	
Eragrostis schultzii	P3	495563	8293133	20	
Eragrostis schultzii	P3	495631	8292785	24	
Eragrostis schultzii	P3	496447	8290449	29	
Eragrostis schultzii	P3	496219	8290714	30	
Eragrostis schultzii	P3	496435	8291278	31	
Eragrostis schultzii	P3	495978	8290894	32	
Eragrostis schultzii	P3	495558	8290636	36	
Eragrostis schultzii	P3	495755	8291151	37	
Eragrostis schultzii	P3	495827	8291540	38	
Eragrostis schultzii	P3	495722	8291903	39	
Eragrostis schultzii	P3	495808	8292728	40	
Eragrostis schultzii	P3	495503	8292997	43	
Fimbristylis aff. *carolinii*	?new species	495722	8291903	39	
Hibiscus aff. *calcicola*	?new species	496377	8292592	12	
Spermacoce aff. *leptoloba*	?new species	495549	8290299	17	
Polygala triflora	under taxonomic review	495600	8291503	21	
Polygala triflora	under taxonomic review	495755	8291151	37	
Fimbristylis cf. *dichotoma* (desert form)	Range extension	498484	8290204	9	
Fimbristylis cf. *dichotoma* (desert form)	Range extension	498126	8292996	15	

Appendix 2: Terrestrial Fauna Assessment describing Non-Volant Vertebrate Fauna

SORBY MANAGEMENT PTY LTD



SORBY HILLS PROPOSED SILVER LEAD ZINC MINE TERRESTRIAL FAUNA ASSESSMENT

SEPTEMBER 2011

Authors

Dr Mitchell Ladyman

ANIMAL PLANT MINERAL

This report was completed for Sorby Management Pty Ltd

KML11002 – Sorby Hills Biological Assessment Survey

Completed by: ***Animal Plant Mineral Pty Ltd***

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EXECUTIVE SUMMARY

APM was engaged by Sorby Management Proprietary Limited (SMPL) on 4 April 2011 to undertake the biological assessment surveys and environmental approvals for the Sorby Hills Silver Lead Zinc project. An extensive field fauna survey was carried out within Kimberley Metals mining tenements M80/286 and M80/197.

The field survey was designed in accordance with Guidance Statement 56 (EPA 2004) and Environmental Protection Authority (EPA) Position Statement No 3. (EPA 2002) and EPBC Act Policy Statement 3.25 (DSEWPAC, 2011b) and included:

The survey was undertaken over three phases to adequately sample the terrestrial vertebrate fauna over the changing seasons. The first survey occurred immediately after the cessation of wet season rainfall in early April when the majority of the project area was still flooded. The final survey was completed in early June when rainfall had ceased completely, the project area had become dry and the temperature and relative humidity had fallen significantly.

A total of 25 reptile, 15 amphibian and 8 non-volant mammal fauna were trapped or recorded during the survey. Based on distribution and known habitat preferences 18 ground dwelling mammals, 21 frogs, and 63 reptiles potentially occur within the study area (WA Museum, 2009).

Fauna Site 7 comprised an Open Woodland of *Bauhinia cunninghamii, Excoecaria parvifolia* and *Vachellia valida* over mixed Shrubland/Grassland/Forbland of *Sorghum plumosum, *Calotropis procera, Vigna lanceolata* etc and is very typical of the cracking clay plains that occur extensively in the area. The exclusion of cattle and the presence of permanent water resulted in a high number of fauna captures. Site 7 most accurately represents the fauna assemblages that the broad floodplains would have supported prior to anthropogenic disturbance.

Site 4 represents a very good example of the very valuable habitat that occurs at the interzone between the undulating plains and foothills of the sandstone ranges and the floodplains and is considered the most valuable of the fauna habitat in the project area. It is worth of conservation via the exclusion of development. The area is dominated by Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia dichromophloia* over Sparse Shrubland of *Erythrophleum chlorostachys, Grevillea refracta, Dodonaea hispidula* var. *phylloptera* and *Buchanania oblongifolia* over Grassland of *Chrysopogon* sp., *Sorghum stipoideum, Eriachne obtusa, Triodia bitextura* and *Eragrostis schultzii* (P3). The exclusion of cattle meant that the vegetation in Site 4 was in Excellent condition.

Of the seven species listed under the EPBC Act 1999 (cth), Wildlife Conservation Act 1950 (cth) or the DEC Priority or Northern Territory Near Threatened lists, only four have been recorded within any of the surveys undertaken in the area. These four species are the Northern Death Adder *Acanthophis praelongus* (NTNT), the Freshwater Crocodile *Crocodylus johnstoni* Short-tailed Mouse (S) *Leggadina lakedownensis* (P4) and the Sand Goanna *Varanus panoptes* subsp. *panoptes* (NTNT). All of these

species are known to occur and are expected to occur in close proximity or within the project area though none are under direct threat from the project.

Within the 1782 ha of the KML lease areas (M80/197 and M80/286), only 427.8 ha are going to be impacted and therefore 1354.47 ha or 76 % will be retained. As part of the Sorby Hills project SMPL will further enhance the value of the retained natural habitat by destocking and the management of wildfire.

Working within the constraints of engineering and economic feasibility, the areas targeted for clearing for construction of the mine infrastructure should be the areas that are already degraded and are of lower value for fauna. There is a very large area around the Sorby Hills camp that comprises the stock yards, drovers' camp, old core shed and a large quarry that has been used as a source for road base. As such it is an ideal location for mine processing infrastructure.

To preserve valuable fauna habitat the mine plan has been designed to exclude impact to the interzone and foot slopes of the Sorby Hills. This area is to remain fenced off to exclude cattle. In addition protection of these areas will contribute to the protection of habitats representative of the Monsoon vine thickets of limestone ranges which are listed as Priority Ecological Communities by the Department of Environment and Conservation. Most of the lowland country was quite heavily grazed; however the high productivity of the 'blacksoil' clays appeared to make the vegetation resilient to trampling, grazing and weed invasion. The vegetation across the project area remains structurally intact.

Overall, the Sorby Hills project will directly impact a relatively small area of fauna habitat that is well represented locally. Active management that will benefit native fauna occupying those areas that are to remain undisturbed will result in a net positive impact on the fauna assemblages of the project area.

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1. INTRODUCTION

1.1 INTRODUCTION AND SCOPE OF WORK

APM was engaged by Sorby Management Proprietary Limited (SMPL) on 4 April 2011 to undertake the biological assessment surveys and environmental approvals for the Sorby Hills Silver Lead Zinc project. The results of the terrestrial vertebrate survey undertaken in 2011 are reported herein (the project). The results of the ornithological survey and the bat survey are reported separately and should be considered in conjunction with this report.

An extensive field fauna survey was carried out within Kimberley Metals mining tenements M80/286 and M80/197 (the project area)(Figure 1). Specifically, the target areas over which the surveys were focussed were:

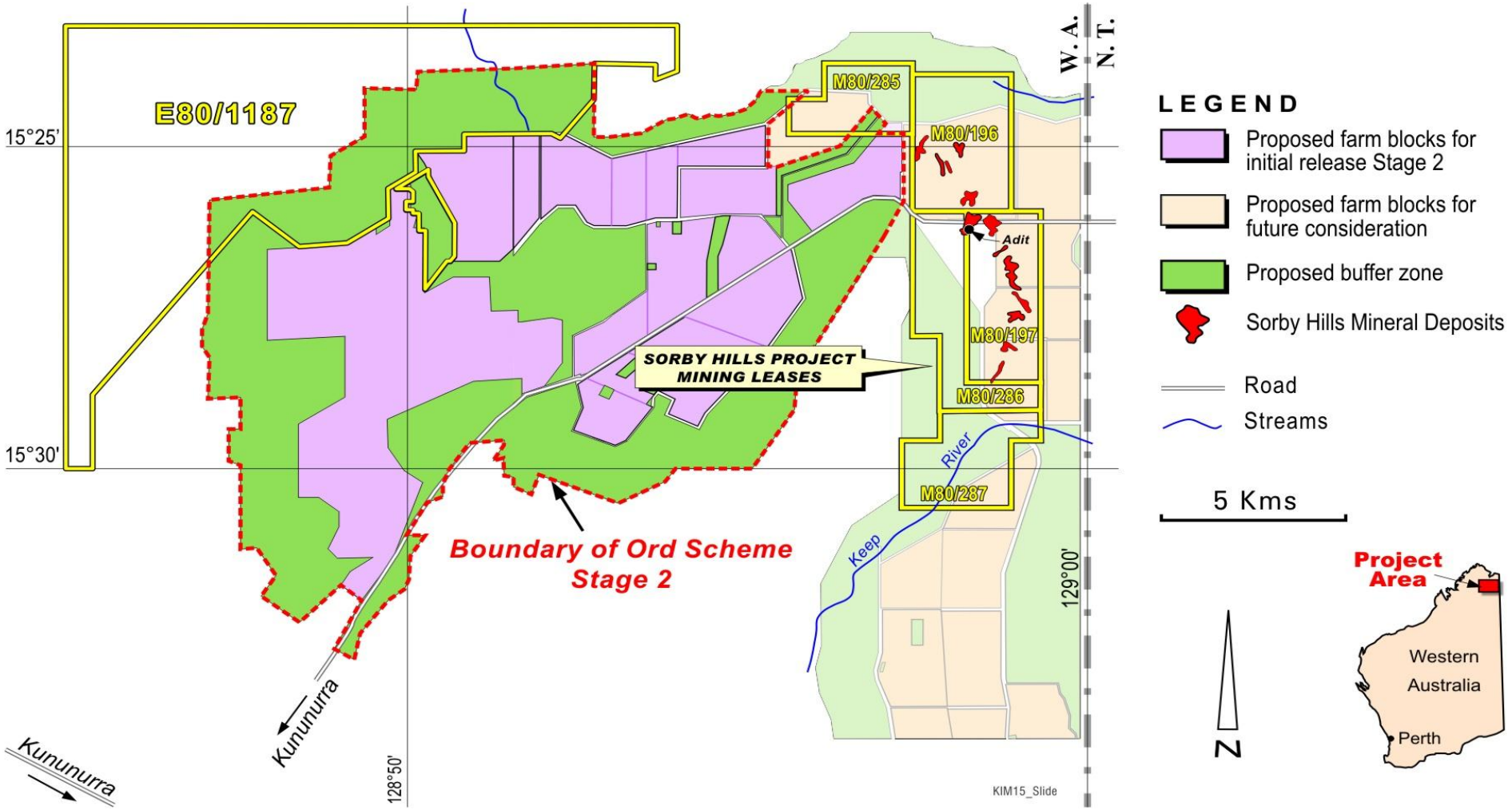
- Pods C, D, E and F on M80/197; and
- Site infrastructure on M80/286 which comprised;
    - Site office;
    - Run of Mine;
    - Processing Plant;
    - Workshop; and
    - Tailings facility.

The field assessment was designed in accordance with Guidance Statement 56 (EPA 2004) and Environmental Protection Authority (EPA) Position Statement No 3. (EPA 2002) and EPBC Act Policy Statement 3.25 (DSEWPAC, 2011b) and included:

- a desk-top investigation of the project area, including a review of on-line databases and reports available in the public domain;
- Assimilation and analysis of all available data collected locally and regionally by APM;
- a review of matters of national environmental significance that are protected under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* that potentially occur within the vicinity of the project area;
- discussion of the likely occurrence of conservation significant species listed under the *Wildlife Conservation Act 1950* in the project area;
- a review of the currently listed Priority Ecological and Threatened Ecological Communities of the Kimberley region to determine if these communities are present in the project area;
- consideration of the potential risks to the fauna and fauna habitat associated with clearing of native vegetation to accommodate the proposed project; and
- the identification of any environmental issues relating to fauna and fauna habitat that may require the current proposed mine impact footprint to be altered.

The fauna component of the field survey was undertaken over three phases to adequately sample the terrestrial vertebrate fauna over the changing seasons. The first survey occurred immediately after the cessation of wet season rainfall in early April when the majority of the project area was still flooded. The final survey was completed in early June when rainfall had ceased completely, the project area had become dry and the temperature and relative humidity had fallen significantly.

The outcomes of the field survey were assessed in the context of the environmental assessment process. All biological issues that relate to the development are reported herein and measures to mitigate and manage impacts is proposed and discussed.



Auth: M Ladyman	Project: SMPL Sorby Hills	NORTH	**Figure 1: General Location Map**
Date: October 2011	Datum: GDA94 MGA Zone 52		

1.2 BACKGROUND AND SUPPORTING INFORMATION

The project area is located in the Victoria Bonaparte 1 sub-region of Western Australia, defined by Thackway and Cresswell (1995) as:

> "The Phanerozoic strata of the Bonaparte Basin in the north-western part are mantled by Quaternary marine sediments supporting Samphire – Sporobolus grasslands and mangal, and by red earth plains and black soil plains with an open savanna of high grasses. Plateau and abrupt ranges of Proterozoic sandstone, known as the Victoria Plateau, occur in the south and east, and are partially mantled by skeletal sandy soils with low tree savannas and hummock grasslands. In the south-east are limited areas of gently undulating terrain on a variety of sedimentary rocks supporting low snappy gum over hummock grasslands and also of gently sloping floodplains supporting Melaleuca minutifolia low woodland over annual sorghums. The climate is dry hot tropical, semi-arid summer rainfall. In the south (of the sub-region within Western Australia), red and black-soil plains with savanna woodlands, emergent quartz-sandstone ranges with tree-steppe over hummock grassland and limestone ranges with open-savanna vine thickets. The area of the Victoria Bonaparte 1 sub-region (the part of the sub-region is represented in Western Australia) is 1, 932, 467 ha."

The Biodiversity Audit of Western Australia (Dept. of CALM 2003) identifies a number of rare features of the Victoria Bonaparte regions. Only two are relevant to the Sorby Hills project and these are the alluvial plain system of the Ord and Weaber Plains and the potential for areas to support populations of Wild Rice.

The project area lies in the Gardner Botanical District within the Northern Botanical Province of Western Australia (Beard 1975). The vegetation of the Kimberley has been mapped and is readily accessible at http://savanna.cdu.edu.au/information/map_maker.html. The landscape supports hummock, tussock and bunch grasslands, shrublands, woodlands, riverine forest, rainforest patches and paperbark thickets along the margins of some water ways. The tropical savanna is diverse across the Kimberley, however insufficient comprehensive mapping has been carried out to discriminate savanna vegetation types on a fine scale across broad areas (McKenzie et al. 2009).

Many biodiversity and taxon specific surveys have been undertaken which either focus on a particular biotope (e.g. rainforests) or particular areas, such as conservation reserves. These surveys have been assimilated and reported by Waples (2007).

There has been a lack of systematic broad survey work across the Kimberley. This is very apparent when considering the spatial representation of collections or observations of fauna of conservation significance. Collection records are very closely aligned with roads, areas of human habitat or conservation areas, leaving large tracts of land with few if any records (Handasyde, 2005).

The recently published Ord Stage II EIS encapsulates a significant amount of work on the biological and non-biological attributes of the area and this information is available in the public domain. However, the biological components of these surveys are still dependent upon flora and fauna surveys undertaken more than 15 years ago.

Previous surveys of areas targeted for the Ord Stage 2 M2 development (mid-1990 development proposal) have been undertaken. These include baseline flora and fauna surveys executed by ecologia Environmental Consultants Pty Ltd (hereafter referred to as ecologia) in October 1996 and February 1997 (ecologia 1997) and reptile and amphibian surveys conducted by HLA in March and June 2004 (HLA 2005). These surveys focussed on the Knox Creek, Keep River, Carlton and Weaber Plains areas.

There has been some fauna work undertaken in the Keep River National Park (McKean 1986 Page 4 of ecologia). The Department of Agriculture has produced a reptile and amphibian list for the north-east Kimberley (Gowland and Sonnemann 1980) and bird and mammal lists for the Ord River Irrigation area (Gowland and Brennan, 1980: Gowland 1980). Tidemann et al. (1987) focuses on the upland sandstone areas around Spirit Hill Station.

The Kimberley is more frequently becoming a target for resource exploration and development. Similar to the Pilbara, biological surveys undertaken for the Environmental Impact Assessment process will contribute significantly to the body of knowledge on the flora and fauna of the area. However, the gain in knowledge is offset by the increase in disturbance. The Kimberley mammal fauna is broadly regarded as being intact, with no known extinctions. Many authors suggest that this may be an overly conservative assumption with a great number of mammals showing severe range restrictions and declines in abundance (Kitchener 1978, McKenzie 1981 in Protecting the Kimberley).

2. METHODS

2.1 CONTRIBUTING AUTHORS

The strategy for the biological assessment of the Sorby Hills project was developed and managed by APM Principal Biologist Dr Mitch Ladyman.

The field fauna component of this survey was undertaken by Dr Mitch Ladyman, with assistance from Ms Anna Price and Mr Tony Smith. Ornithological surveys were executed by Dr Steven Reynolds and the analysis and reporting on bat fauna was done by Mr Bob Bullen of Bat Call W.A. Additional assistance was provided by Mr Shane McAdam.

2.2 SURVEY CONDITIONS

Conditions were ideal for the fauna surveys. Phase I of the survey was undertaken at the end of one of the wettest summer rainfall seasons on record.

The total average accumulated rainfall for February, March and April is 370.4 (Table 1). However, 854 mm had fallen in the three months prior to the current survey.

Table 1 Average Temperature and Rainfall Data for Kununurra (Bureau of Meteorology)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	36.4	35.5	35.4	35.5	32.9	30.5	30.3	33.6	36.4	38.3	38.8	38.0	35.1	21	1965 1986
Mean minimum temperature (°C)	25.2	24.9	24.1	21.4	19.1	15.9	15.0	17.4	20.8	23.7	25.4	25.7	21.6	21	1965 1986
Rainfall															
Mean rainfall (mm)	196.6	213.0	136.2	21.2	10.0	1.3	3.9	0.1	2.8	25.5	70.9	105.3	796.8	30	1962 1997
Decile 5 (median) rainfall (mm)	181.1	210.9	102.9	8.8	0.0	0.0	0.0	0.0	0.0	13.1	57.6	101.6	778.7	27	1962 1997
Mean number of days of rain ≥ 1 mm	10.4	10.6	7.2	1.8	0.7	0.2	0.2	0.1	0.3	1.9	4.1	6.9	44.4	27	1962 1997

2.3 SURVEY METHODOLOGY

2.3.1 LEGISLATION

A range of legislation and agreements relevant to biodiversity conservation in Western Australia were considered in the planning and reporting of this survey, including:

- Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act);
- Wildlife Conservation Act 1950;
- Conservation and Land Management Act 1984;
- Environmental Protection Act 1986 (EP Act);
- Animal Welfare Act 2002; and
- Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention, 1979) published October 2003.

In Western Australia, all native fauna species are protected under the Wildlife Conservation Act 1950-1979. Fauna species that are considered rare, threatened with extinction or have high conservation value are specially protected by four schedules (Appendix 1) in this Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). In addition to the above classification, the Department of Environment and Conservation (DEC) also classify some other fauna under five different Priority codes (Appendix 1). Species considered to be of national conservation significance are protected under the EPBC Act 1999. Under this Act, activities that may have a significant impact on a species of national conservation significance must be referred to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) for assessment.

2.3.2 GUIDELINES FOR SURVEY PROTOCOL

The survey was designed to meet the criteria of a Level 2 survey (Detailed survey), as defined in the according to the EPA Guidance Statement No. 56 on terrestrial fauna surveys for environmental impact assessment (Environmental Protection Authority 2004) and the associated technical appendices (Environmental Protection Authority 2010).

A Detailed survey, rather than a Comprehensive survey (Environmental Protection Authority 2004), was deemed sufficient in this instance for a number of reasons:

1. The survey outcome would enhance the level of knowledge of fauna at the locality scale;

2. The general knowledge of terrestrial vertebrate fauna in the area has been established by a previous fauna survey of the area and areas immediately adjacent, which will contribute to the efficiency of the proposed Level 2 survey; and

3. The survey was undertaken from April to June, following the wet season which is the ideal sampling period for this region.

The survey design also gave due consideration to the Draft Northern Quoll Policy Statement (Commonwealth of Australia 2009). The survey effort for Northern Quoll is based on an approximated disturbance area of 250 ha of potential quoll habitat (See Table 1 of the Draft NQ Policy Statement extract at the end of this document).

An ornithological assessment and an assessment of bat fauna occupying the area were also undertaken. The results of these surveys are documented in separate stand-alone reports.

2.3.2.1 DESKTOP ASSESSMENT

Lists of fauna expected to occur in the study area were produced using information from a number of sources and are presented in Appendix 4. As far as possible, expected species are those that are likely to utilise the study area, or be affected by changes to the study area. The lists exclude species that have been recorded in the general region as vagrants or for which suitable habitat is absent. The sources of information included publications that provide information on general patterns of distribution of frogs (Tyler and Doughty, 2009), reptiles (Storr et al. 1983, 1990, 1999 and 2002), birds (Barrett et al. 2003; Johnstone and Storr, 1998; Johnstone and Storr, 2004), and mammals (Menkhorst and Knight, 2001; Van Dyck and Strahan, 2008).

The databases listed below in Table 2 were searched for specimen or observational records and the search results are included as Appendix 2 and 3.

Table 2 Databases searched to generate the expected species list presented in Appendix 2 and 3.

Database	Type of records held on database	Area searched
NatureMap (DEC, 20011b)	Records of specimens held in the WA Museum, WA Herbarium and DEC Fauna Database. Includes historical data.	Radial search for 40 km from 128° 58' 18'' E, 15° 27' 25'' S
EPBC Protected Matters Search Tool (DSEWPC, 2011c)	Records on matters protected under the EPBC Act, including threatened species.	Radial search for 10 km from 128° 58' 18'' E, 15° 27' 25'' S

In addition, APM Pty Ltd and other consulting groups have undertaken a substantiative amount of baseline trapping work around the project area and the results of these surveys have been included in the present study. These surveys include the following:

- Animal Plant Mineral Pty Ltd (2009). Ord Stage 2 West Bank, East Bank, Mantinea and Packsaddle biological assessment survey. Unpublished report undertaken for Landcorp and RDL;
- Animal Plant Mineral Pty Ltd (2009). Main Roads Western Australia Material Investigation Areas Supplement to an Application to Clear Native Vegetation. July 2009.
- Animal Plant Mineral Pty Ltd (2010) Weaber Plain Development Project Threatened and Migratory Bird Species Inventory. March and August 2010.
- Ecologia Environmental Consultants (Ecologia) (1997). Ord Irrigation Area – Stage 2 M2 development area terrestrial biological assessment. Prepared for the Department of Industry and Resources;
- Hale, J 2008, Ecological Character Description of the Ord River Floodplain Ramsar Site, Report to the Department of Environment and Conservation, Perth, Western Australia;
- Hart, R. (1999). A fauna survey of the M2 development area and the Ord River IrrigationScheme. Prepared for Kinhill Pty Ltd, October 1999;
- HLA Envirosciences Pty Ltd (HLA) (2005a). An assessment of introduced cane toads impacts to the native Australian Fauna, with particular reference to the east Kimberley region. Prepared for the Department of Industry and Resources, April 2005;
- HLA Envirosciences Pty Ltd (HLA) (2005b) Assessment of Chytrid in Frogs – Ord RiverIrrigation Area, Stage 2 M2. Prepared for the Department of Industry and Resources, May 2005; and

- HLA Envirosciences Pty Ltd (HLA) (2005c). Herpetofauna Survey Ord River Irrigation Area, Stage 2, M2. Prepared for the Department of Industry and Resources, April 2005.

Taxonomy and nomenclature for fauna species used in this report generally follow the WA Museum list on the NatureMap website (DEC, 2011b) with alternative bird taxonomy from Christidis and Boles (2008) given in parentheses. This is because the WA Museum utilises different bird taxonomy to that which is nationally accepted (Christidis and Boles, 2008).

Three levels of conservation significance are recognised in this report and these are based on how fauna conservation status is determined by the DEC and the DSEWPAC (Appendix 1):

Conservation Significance 1:

- Species listed under State or Commonwealth Acts.

Conservation Significance 2:

- Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by DEC.

Conservation Significance 3:

- Species not listed under State or Commonwealth Acts or in publications on threatened fauna or as Priority species by DEC, but considered of local significance because of their pattern of distribution or habitat preferences.

At the highest level of conservation significance (Conservation Significance 1) are those species that are protected under State or Commonwealth legislation.

The EPBC Act 1999 is the Commonwealth Government's primary piece of environmental legislation. Listed under Part 3 of the EPBC Act 1999 are 'matters of National Environmental Significance' that include threatened species and ecological communities and migratory species, among others. International Union for the Conservation of Nature (IUCN) categories are used to categorise threatened species as 'extinct', 'extinct in the wild', 'critically endangered', 'endangered', 'vulnerable' and 'conservation dependent', with all categories except 'extinct' and 'conservation dependent' listed as matters of National Environmental Significance. A list of migratory species is also maintained, containing mostly bird and marine species. The migratory species listed are those recognised under CAMBA, JAMBA or species listed under the Bonn Convention for which Australia is a range state. Species listed in JAMBA are also protected under Schedule 3 of the Western Australian Wildlife Conservation Act 1950 (WA Wildlife Conservation Act).

The WA Wildlife Conservation Act is State legislation for fauna protection administered by the DEC. The WA Wildlife Conservation Act lists species under a set of Schedules, where threatened species are listed as Schedule 1. Schedule 1 species are further categorised by DEC into the IUCN categories 'extinct', 'extinct in the wild', 'critically endangered',

'endangered', 'vulnerable' and 'conservation dependent' species (DEC 2011a). The schedules and categories are further described in Appendix 1.

The second-highest level of conservation significance (Conservation Significance 2) are species that are listed under publications on threatened species, or are listed as Priority species by DEC.

Reports on the conservation status of most vertebrate fauna species have been produced by DSEWPAC in the form of Action Plans. An Action Plan is a review of the conservation status of a taxonomic group against IUCN categories. Action Plans have been prepared for amphibians (Tyler, 1998), 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). These publications also use categories similar to those used by the EPBC Act 1999. The information presented in some of the earlier Action Plans may be out of date due to changes since publication.

At the third-highest level of conservation significance (Conservation Significance 3) are species that are not recognised under Commonwealth or State legislation, listed in publications by DSEWPAC or listed as Priority species by DEC. These are species considered to be of local significance in the study area because they are at the limit of their distribution in the area, they have a very restricted range or they occur in breeding colonies (e.g. some waterbirds). This level of significance has no legislative or published recognition and is based on interpretation of information on the species patterns of distribution. Recognition of such species is consistent with the aim of preserving regional biodiversity.

The conservation value of the area, and therefore the potential future impacts, were also assessed in the context of the biogeographical regionalisation of Australia (Thackway and Cresswell, 1995). Bioregions are large, geographically distinct areas of land with common characteristics such as physiography, climate, vegetation and animal communities. They represent lowest order of resolution between different flora and fauna habitats. There are 85 bioregions and 403 sub-regions in Australia, and they are described in the Australian Natural Resources Atlas (Australian Government, 2011) and the Biodiversity Audit of Western Australia (DEC, 2003). A description of the relevant bioregion (Victoria Bonaparte) was read in order to identify regional and local issues of conservation significance.

The study area was also assessed in the context of vegetation mapping programs carried out by Beard (1979) and Fox et al. (2001), as well as the Rangeland Land System Mapping for Western Australia dataset (Department of Agriculture and Food 2009).

2.3.2.2 FIELDWORK

A total of 23 systematic fauna survey sites were established, with their locations selected based on available habitat, soil and vegetation types, accessibility and the species likely to be present (Table 3). Some sites were sampled on more than one occasion with the method

of sampling differing over the different phases of the survey. Sampling sites are shown over the Tropical Savanna CRC mapping (further detailed below) (Figure 2) and also over aerial photography in relation to the mine infrastructure, pit and tailings layout (Figure 3)

Table 4 presents the total fauna trapping survey effort from April to June, 2011. Where a habitat contains 35 species, then 100-280 individuals will need to be caught to record 80% of the species, and 200-600 individuals will need to be caught to record 90% of the species. Where there is a high proportion of singletons and doubletons in the dataset, then the sample size will need to be toward the higher end of the recommended number of individuals to be caught (Thompson and Thompson, 2007).

The current survey targeted two major habitat types with a total expected 138 trappable (ground dwelling) species. Post hoc analysis of results revealed that the two habitats contained an average of 26. species each. During the current survey 544individuals were trapped.

Table 3 Location of trapping sites and relevant habitat description

Standard Trapping Array Location (Zone 52)	Centre or Start		Finish		Habitat
Sorby Camp	495717	8292873			
KML Core Shed	495568	8292838			
KML Site 1 (Phase I)	496013	8293195			
KML Site 2 (Phase I)	495856	8293082			
KML Site 3 (Phase I)	495844	8292922			
KML Site 4 (Phase I)	495861	8292364			
KML Site 5 (Phase I)	495499	8292238			Darwin stringybark, Darwin woollybutt and mixed Corymbia spp. Over fan palms, tussock grasses and Triodia bitextura (curly spinifex). Gravel and rocky surface substrate with a highly compacted soil profile. Sorghum spp. present in abundance.
KML Site 6 (Phase I)	495639	8292282			Darwin stringybark, Darwin woollybutt and mixed Corymbia spp. Over fan palms, tussock grasses and Triodia bitextura (curly spinifex). Soil profile was deep sands highly suitable for burrowing species. Sorghum spp. present in abundance.
KML Site 7 (Phase I)	496774	8293176			
KML Site 8 (Phase II)	497942	8291415			
KML Site 9 (Phase II)	495596	8290705			
KML Site 10 (Phase II)	495418	8290465			
KML Site 11 (Phase II)	497625	8291812			
KML Site 12 (Phase II)	495769	8293638			
KML Site 13 (Phase II)	496578	8291203			
KML Site 14 (Phase III)	496185	8291235	496148	8291239	
KML Site 15 (Phase III)	495971	8290357	495991	8290403	
KML Site 16 (Phase III)	495203	8291415	494863	8291292	Bloodwood and Darwin woollybutt and Darwin stringybark open woodland with *Triodia bitextura* (curly spinifex) and Sorghum spp. Grasses. Substrate graduated from round pebbles, rocks and boulders on rolling foothills and valley minor drainage channels to high vertical sandstone cliffs with little or no soil present at the base.
KML Site 17 (Phase III)	495566	8291589	495688	8291565	
KML Site 18 (Phase I)	495913	8293140			
KML Site 19 (Phase I)	495863	8293098			
KML Site 20 (Phase II)	496641	8291388			
KML Site 21 (Phase III)	496678	8293179			
KML Site 22 (Phase III)	496075	8292807			
KML Site 23 (Phase III)	496578	8291393			

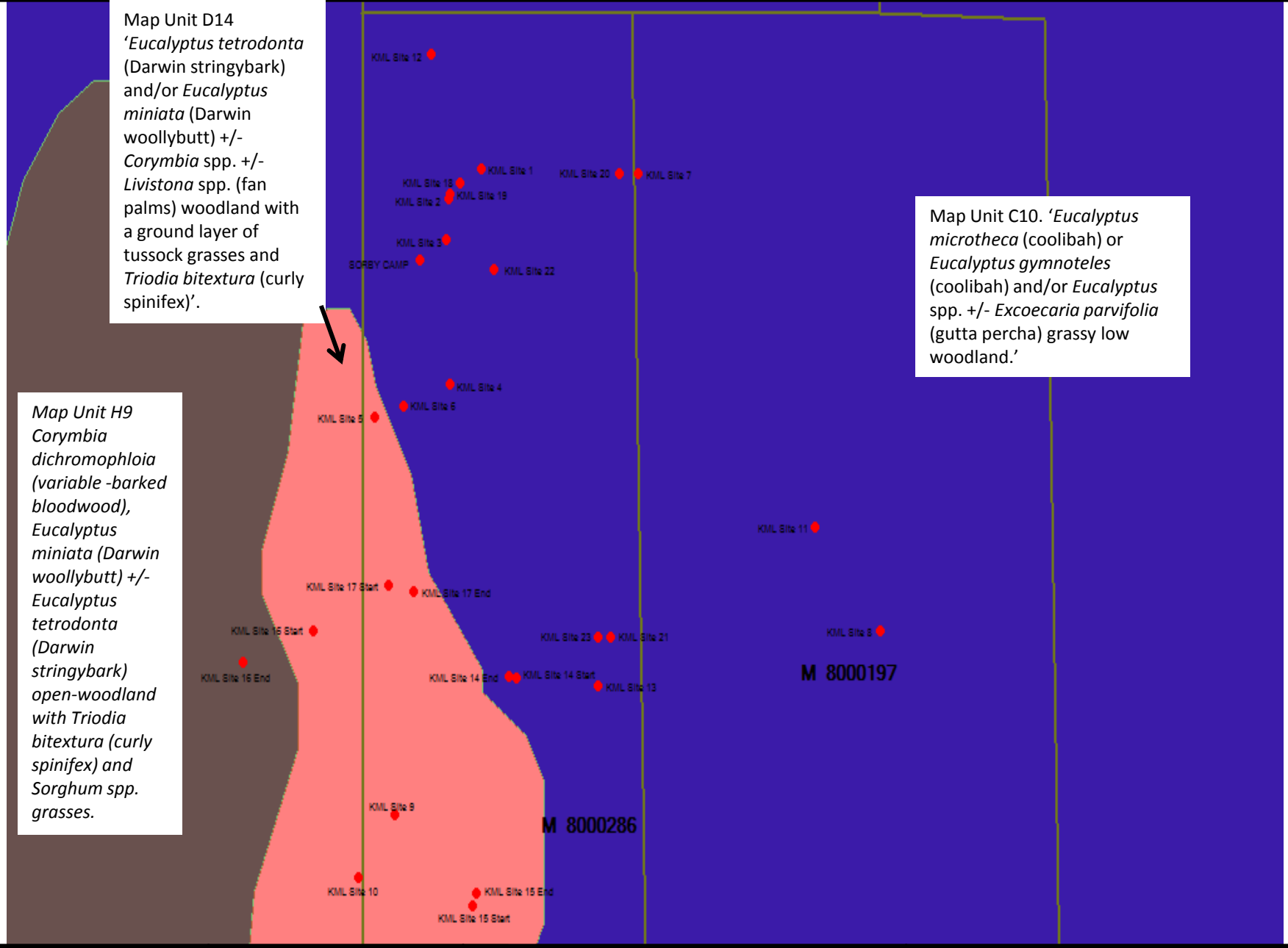
Table 4 Fauna survey effort.

Standard Trapping Array	Start	Finish	# of Nights	Cage	Box	Pit	Turtle	Funnel	Total Trap Nights
KML Site 1 (Phase I)	17-Apr	21-Apr	4					16	64
KML Site 2 (Phase I)	17-Apr	21-Apr	4					16	64
KML Site 3 (Phase I)	17-Apr	21-Apr	4					9	36
KML Site 4 (Phase I)	18-Apr	21-Apr	3					16	48
KML Site 5 (Phase I)	18-Apr	21-Apr	3					16	48
KML Site 6 (Phase I)	18-Apr	21-Apr	3					16	48
KML Site 7 (Phase I)	19-Apr	21-Apr	2					16	32
KML Site 2 (Phase II)	10-May	18-May	8			7		16	184
KML Site 3 (Phase II)	10-May	18-May	8			7		16	184
KML Site 4 (Phase II)	10-May	17-May	7			7		16	161
KML Site 6 (Phase II)	10-May	17-May	7			7		16	161
KML Site 7 (Phase II)	10-May	18-May	8			7		16	184
KML Site 8 (Phase II)	10-May	18-May	8			6		16	176
KML Site 8 (Phase II - additional traps)	15-May	18-May	3		20				60
KML Site 9 (Phase II)	10-May	17-May	7			7		14	147
KML Site 10 (Phase II)	10-May	17-May	7			7		16	161
KML Site 11 (Phase II)	11-May	18-May	7					14	98
KML Site 11 (Phase II - additional traps)	15-May	18-May	3		20				60
KML Site 12 (Phase II)	14-May	18-May	4		20				80
KML Site 12 (Phase III)	30-May	3-Jun	4		20				80
KML Site 13 (Phase II)	14-May	18-May	4		40				160
KML Site 13 (Phase III)	30-May	3-Jun	4		40				160
KML Site 14 (Phase III)	30-May	3-Jun	4	30					120
KML Site 15 (Phase III)	30-May	3-Jun	4	20					80
KML Site 16 (Phase III)	30-May	3-Jun	4	30					120
KML Site 17 (Phase III)	30-May	3-Jun	4	8					32
KML Site 18 (Phase I)	17-Apr	21-Apr	4				5		20
KML Site 19 (Phase I)	17-Apr	21-Apr	4				2		8
KML Site 18 (Phase II)	14-May	18-May	4				2		8
KML Site 19 (Phase II)	14-May	18-May	4				2		8
KML Site 18 (Phase III)	30-May	3-Jun	4				2		8
KML Site 19 (Phase III)	30-May	3-Jun	4				2		8
KML Site 20 (Phase II)	14-May	18-May	4				5		20
KML Site 20 (Phase III)	30-May	1-Jun	2				5		10
KML Site 21 (Phase III)	1-Jun	3-Jun	2				5		10
KML Site 22 (Phase III)	1-Jun	3-Jun	2				5		10
KML Site 23 (Phase III)	30-May	3-Jun	4		20				80
Total									**2938**

2.3.2.2 ANALYSIS OF DATA

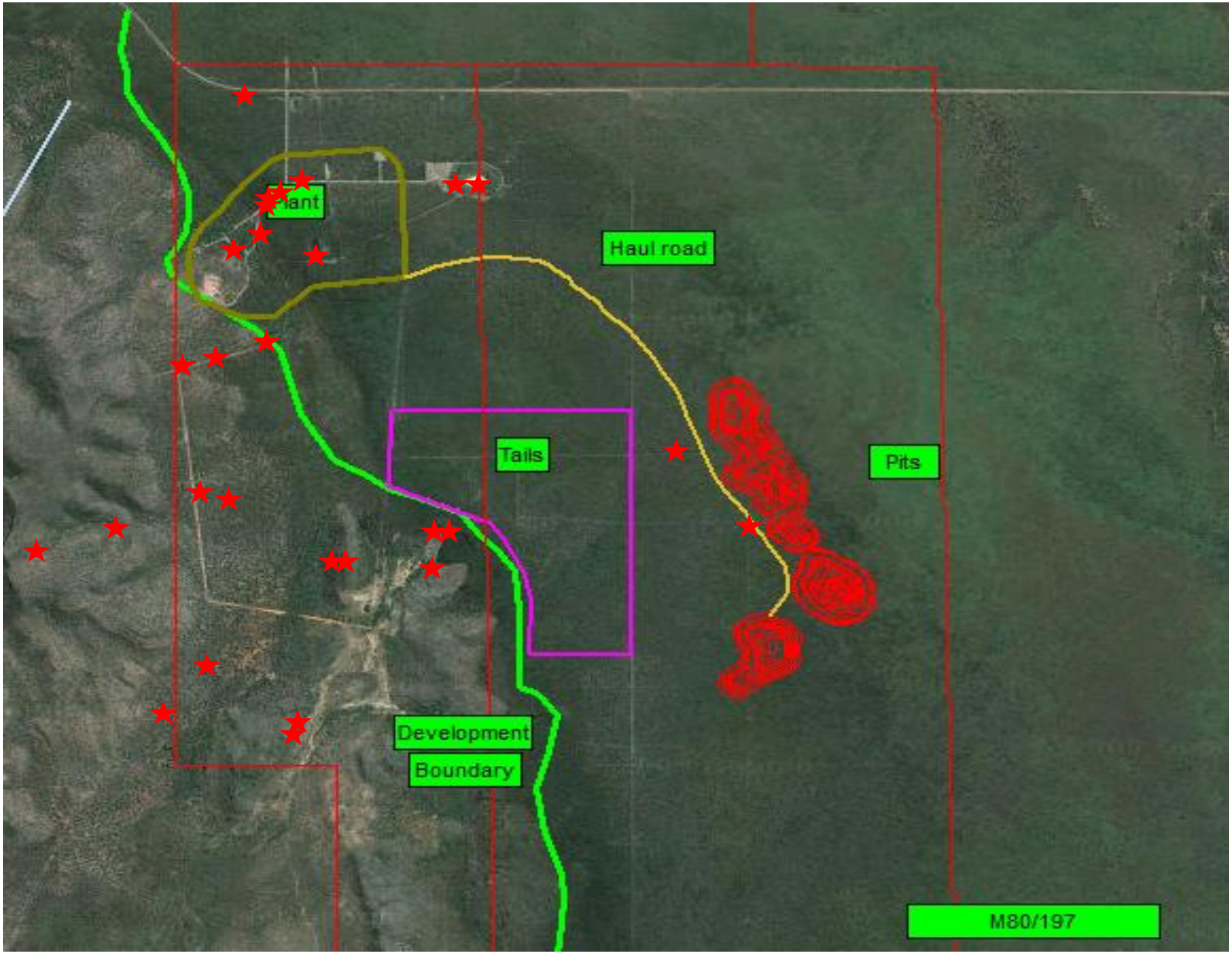
Determining the abundance and diversity of species in the study area can only be achieved for species that are easy to be detected or captured. This is because the calculation of these indices requires the capture of many individuals of the same species within defined areas. Often the capture rates of terrestrial vertebrate fauna are low and sporadic, preventing any worthwhile statistical analysis. Species groups that are typically caught in significant numbers in the Kimberley are reptiles, amphibians and small mammals. Estimates of diversity and abundance of these fauna groups provide a suitable proxy for determining the overall health of the fauna assemblages.

Fauna values (assemblages and habitat) were described based on the outcome of the field survey work, in a local and regional setting, which meant the consideration of fauna beyond the project area boundaries using the ecologia and HLA surveys as a basis for comparison (ecologia, 1997; HLA 2005).



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral	NORTH
Date: October 2011	Datum: GDA94 MGA Zone 52		

Figure 2: CRC Tropical Vegetation Maps with Fauna Locations.



Auth: M Ladyman	Project: SMPL Sorby Hills	aPM animal plant mineral	NORTH
Date: October 2011	Datum: GDA94 MGA Zone 52		

Figure 3: Fauna survey sites over SMPL mine site layout and lease boundaries.

3. RESULTS

3.1 DESKTOP ASSESSMENT

3.1.1 REGIONAL FAUNA HABITAT

Fauna assemblages are intrinsically linked to available habitat. Physiography, soils and vegetation are the primary elements of fauna habitat. Hence, vegetation descriptions are valuable for understanding and interpreting faunal assemblages.

3.1.1.1 IBRA BIOREGIONS

Mapping for the Interim Biogeographic Regionalisation for Australia (IBRA version 6.1) programme placed the Sorby Hills project area in the Victoria Bonaparte Bioregion (DSEWPAC undated). This bioregion comes under the Tropical and Subtropical Grasslands, Savannas and Shrublands Ecoregion which stretches across northern Australia into northern NSW. The Victoria Bonaparte Bioregion continues into the Northern Territory as far as Bradshaw (Department of Sustainability, Environment, Water, Population and Communities 2011a). Within the Victoria Bonaparte Bioregion the vegetation over lowland parts of the survey area has been mapped as 'Tussock grasslands' while upland areas come under 'Tropical Eucalyptus woodland/grasslands'. Tussock grasslands covered an estimated 631,088ha (8.7%) of the bioregion prior to European settlement. By about 1997 this area was little changed at 631,032 ha (8.7%). Tropical Eucalyptus woodland/grasslands covered an estimated 4,696,792 (64.6%) of the bioregion prior to European settlement. By about 1997 this area had been slightly reduced to 4,678,368 (64.4%) (Australian Government, 2011).

Rare features of the Victoria Bonaparte Bioregion that are relevant to the project area include:

- Ramsar listed wetlands of the Ord Floodplain and Lake Kununurra;
- Cambridge Gulf and associated river systems;
- Alluvial plain systems of the Ord and Weaber Plains;
- The Devonian reef system of Ningbing Range with its particular vegetation associations (rainforest patches) and extensive cave systems; and
- Fox and rabbit free and essentially uninhabited.

Permanent water bodies in the project area are known to support EPBC 1999 (cth) listed Threatened and Migratory bird species that are drawn to the area because of the size and

stability of the Ramsar listed wetlands of the Ord Floodplain and Lake Kununurra. These species are discussed in more detail in the associated APM (2011a) ornithological report.

The Keep River receives water from the Sorby Hills catchment basin and therefore has the potential to be impacted by the project. The Keep River is influenced by the dynamics of the the Joseph Bonaparte Gulf, creating river systems very similar to those influenced by the Cambridge Gulf to the west.

The low lying portion of the Sorby Hills survey area would be included under the alluvial plain systems of the Ord and Weaber Plains.

In addition, there are geological elements in the project area that are very similar to the Ningbing Range. Small pockets of tropical vine thicket were located in the project area and there is evidence of cavernous networks with the rock outcrops.

3.1.1.2 BEARD'S VEGETATION SURVEY OF WESTERN AUSTRALIA

Earlier mapping by Beard (1979) included the survey area in the Cambridge Gulf Lowlands Physiographic Province within the larger Ordland Physiographic Division. Ordland includes much of the east Kimberley from Joseph Bonaparte Gulf south to the Tanami Desert. The Cambridge Gulf Lowlands comprise the northern part of Ordland, stretching from the West Arm of Admiralty Gulf to the Northern Territory border. Beard included the Cambridge Gulf Lowlands in his Gardner Botanical District, a large area between Collier Bay and the Northern Territory encompassing both the Northern Kimberley and Victoria Bonaparte bioregions. Within the Sorby Hills survey area he recognized two vegetation types:

1. High grass savanna of scattered low *Bauhinia cunninghamii* and *Eucalyptus microtheca* over a mid-dense (30-70%) cover of bunch grasses esp. *Dichanthium fecundum, Sorghum* spp. and *Chrysopogon* spp. on cracking clay soils. This vegetation was restricted to a few hundred square kilometres of country north of the Ord River irrigated area and continuing eastwards across the Northern Territory border.

2. Upland high grass savanna of open (10-30%) *Corymbia dichromophloia* and *Eucalyptus miniata* over a mid-dense (30-70%) cover of bunch/hummock grasses esp. *Triodia* spp. and *Sorghum* spp. Beard found this general vegetation type to be very widespread across the north Kimberley, and mapped most of the Gardner Botanical District under it.

3.1.1.3 THE VEGETATION OF THE AUSTRALIAN TROPICAL SAVANNAS

In 2001 the Queensland Environmental Protection Agency published a map and technical report bringing together vegetation mapping programs from Queensland, the Northern Territory and Western Australia to produce a consistent map for all of northern Australia (Fox *et al*. 2001). The report grouped and arranged northern Australian vegetation types into a three tiered hierarchy. The 439 vegetation associations (units) from the various state and territory surveys were compared and collated to produce 249 generalised units applicable across state and territory borders. These units were sorted into 125 alliances and sub-alliances, which were in turn grouped into 26 'broad vegetation groups'.

Under the Fox *et al*. (2001) system the vegetation of the Sorby Hills survey area was divided into the two alliances (or map units) described below:

1. Map Unit C10. '*Eucalyptus microtheca* (coolibah) or *Eucalyptus gymnoteles* (coolibah) and/or *Eucalyptus* spp. +/- *Excoecaria parvifolia* (gutta percha) grassy low woodland.' This alliance occurs on gently sloping floodplains and backplains, often with braided channels. Soils are generally light to heavy grey and brown clays and cracking clays, gradational mottled yellow structured clay soils and some loams. Fox *et al*. (2001) included under Unit C10 patches of land from the mouth of the Fitzroy River south of Derby east to the Normanby River in northern Queensland. The unit accounts for a total of 18,551 km^2 and incorporates twelve vegetation types from previous mapping projects including eight from Beard (1979).

   The alliance represented by Map Unit C10 was further broken down into associations. In the survey area the association was recorded as Map Unit C21, though this association was not described in the report.

   The area of land mapped as primarily Map Unit C21 within Map Unit C10 across the tropics totalled 1,085,228 Ha. The portion of the Sorby Hills study area mapped as Map Unit C21 totalled about 1045 Ha.

2. Map Unit D14 '*Eucalyptus tetrodonta* (Darwin stringybark) and/or *Eucalyptus miniata* (Darwin woollybutt) +/- *Corymbia* spp. +/- *Livistona* spp. (fan palms) woodland with a ground layer of tussock grasses and *Triodia bitextura* (curly spinifex)'. This alliance occurs on undulating plains with deep soils on dissected and remnant plateaus over Mesozoic sandstone and laterite. In some parts the soils are shallower and the laterite becomes exposed, and there are some occurrences on broken sandstone plateaus with shallow sandy soil. The soils include red earthy sands with ironstone gravel, red clay-loam and sandy red earths that may have ironstone gravel. Fox *et al*. (2001) included under Unit D14 patches of land from Cape Leveque at the entrance to King Sound north of Broome east to the Wilton River in Arnhem Land. The unit accounts for a total of 20,006 km^2 and incorporates six vegetation types from previous mapping projects, including three from Beard (1979).

   The alliance represented by Map Unit D14 was further broken down into associations. In the survey area the association was recorded as Map Unit D26 -

'Eucalyptus brevifolia (snappy gum) low open- woodland with *Triodia* spp. (spinifex) hummock grass or sometimes a hummock grassland without trees'.

The area of land mapped as Map Unit D26 within Map Unit D14 across the tropics totalled 1,528,117 Ha. The portion of the Sorby Hills study area mapped as Map Unit D26 totalled about 120 Ha.

Figure 2 plots the sampling locations over the Tropical Savanna CRC mapping to show how the trapping sites fall over the two major habitat units.

3.1.1.4 RANGELAND LAND SYSTEM MAPPING

The Rangeland Land System Mapping for Western Australia dataset (Department of Agriculture and Food 2009) was consulted to further facilitate a broad assessment of the regional representation of vegetation that occurs in the study area. A land system is defined as 'an area or group of areas, throughout which there is a recurring pattern of topography, soils and vegetation' (Christian and Stewart 1953). The two land systems included in the study area are:

1. **Pinkerton – Hills, ranges and plateaux with eucalypt woodlands and tall grasses.** Rugged plateaux, hills and ridges on sedimentary rock supporting stringybark-bloodwood woodland over upland tall grass. This land system covers 1,537,195 ha of land in Western Australia. The vegetation alliance Unit D14 (Fox *et al*. 2001) was found on this land system.

2. **Ivanhoe – Alluvial plains with tussock grasslands.** Many small to medium areas of gently sloping alluvial "black soil" plains with some timbered "red" soil in the central and northern parts of the area. This land system covers 125,825 ha of land in Western Australia. The vegetation alliance Unit C10 (Fox *et al*. 2001) was found on this land system.

3.1.2 *FAUNA OF THE ORD FLOODPLAINS*

The greater Ord Floodplains and the surrounding ranges are a diverse and dynamic ecosystem where fauna diversity is driven by strong 'wet season' and 'dry season' influences, including high seasonal rainfall, rapid and short duration surface water flows, broad-scale flooding contracting to small remnant water bodies supporting a high density of fauna in the dry season. Seepage from surrounding ranges and plains maintain freshwater tributaries and sumps long into the dry season.

Much of the project area comprises black soil plains or cracking clays that have been recognised as a unique fauna habitat, well represented within the Ord Floodplains area, but poorly represented elsewhere and also poorly represented in conservation estates (DEC 2003).

A standard area search of Naturemap (a database produced by the Department of Environment and Conservation and the Western Australian Museum) reveals that 310 terrestrial vertebrate species have been lodged with the Western Australian Museum within a collection area 80 km with the central point located north-east of Kununurra (Appendix 2). This database reveals 509 species if the centre point is Kununurra. This provides a very clear indication of the lack of survey work undertaken in the far north-eastern Kimberley, on the boarder of Western Australia and the Northern Territory.

A total of 11 of these species are listed as species of conservation significance by the *Environmental Protection and Biodiversity Act 1999* (cth), *Wildlife Conservation Act 1950* (cth), DEC Priority Fauna list or Northern Territory Threatened Fauna list (Appendix B). The Kimberley is regarded as being a National Biodiversity Hotspot with 230 plant, 16 fish, 10 frog, 31 reptile, 2 bird and 6 mammal species known to be endemic to the region (McKenzie *et al.* 2009).

Approximately 102 species of reptile, amphibian and non-volant (non-flying) mammals are expected to occur in the project area based on known habitat requirements. This represents half of the known reptiles, amphibians and mammals known to occur across the broader Kimberley (McKenzie *et al.* 2009), and is a reasonable estimate of expected occurrence given that the project area does not include large areas of rugged and heavily dissected ranges.

Tributaries associated with Keep River and Knox Creek would support at least 15 species of freshwater fishes (mainly catfishes, grunters and gudgeons). However, the Naturemap search did not reveal any species that have been previously collected in the Sorby Hills area. The Archerfish *Toxotes chatareus* is abundant, while four fishes (two catfish *Arius* spp., Strawman *Quirichthys stramineus*, Giant Glassfish *Parambassis gulliveri*) are known in Western Australia only from sites around the Ord River System. The widespread freshwater crayfish *Macrobrachium rosenbergii* ('Cherrabun') also occurs here. Three species of freshwater turtle are known from the area and one of these, *Emydura australis*, is restricted to the Kimberley – Victoria River region. The native Water Rat *Hydromys chrysogaster* also

occurs around Lake Kununurra. The site is also a major breeding area for Freshwater Crocodile.

3.1.3 PRIORITY ECOLOGICAL COMMUNITIES

There are sixteen Priority Ecological Communities (PECs) listed for the Kimberley region. Three of these have some relevance to the Sorby Hills project:

- Monsoon vine thickets of limestone ranges
- *Oryza australiensis* (wild rice) grasslands on alluvial flats of the Ord River
- Camaenid land snails of limestone hills of the Jeremiah and Ningbing Ranges

The project area supports a number of small pockets of vegetation that could be classified as the PEC 'Monsoon vine thickets of limestone ranges'. This occupies about 2 hectares of country centred around the point 496623mE; 8291249mN and 496536mE; 8290950mN (MGA94 Zone 52L) and has been identified as occurring adjacent a small limestone outcrop (Figure 4).

3.2.4 PROTECTED MATTERS SEARCH TOOL

The Protected Matters Search Tool identified five non-volant terrestrial vertebrate species listed under the act. These were:

- *Conilurus penicillatus*, Brush-tailed Rabbit-rat or Brush-tailed Tree-rat - Vulnerable
- *Dasyurus hallucatus*, Northern Quoll - Endangered
- *Xeromys myoides* - Water Mouse, False Water Rat - Vulnerable
- *Crocodylus johnstoni*, Freshwater Crocodile, Johnston's Crocodile
- *Crocodylus porosus*, Salt-water Crocodile, Estuarine Crocodile

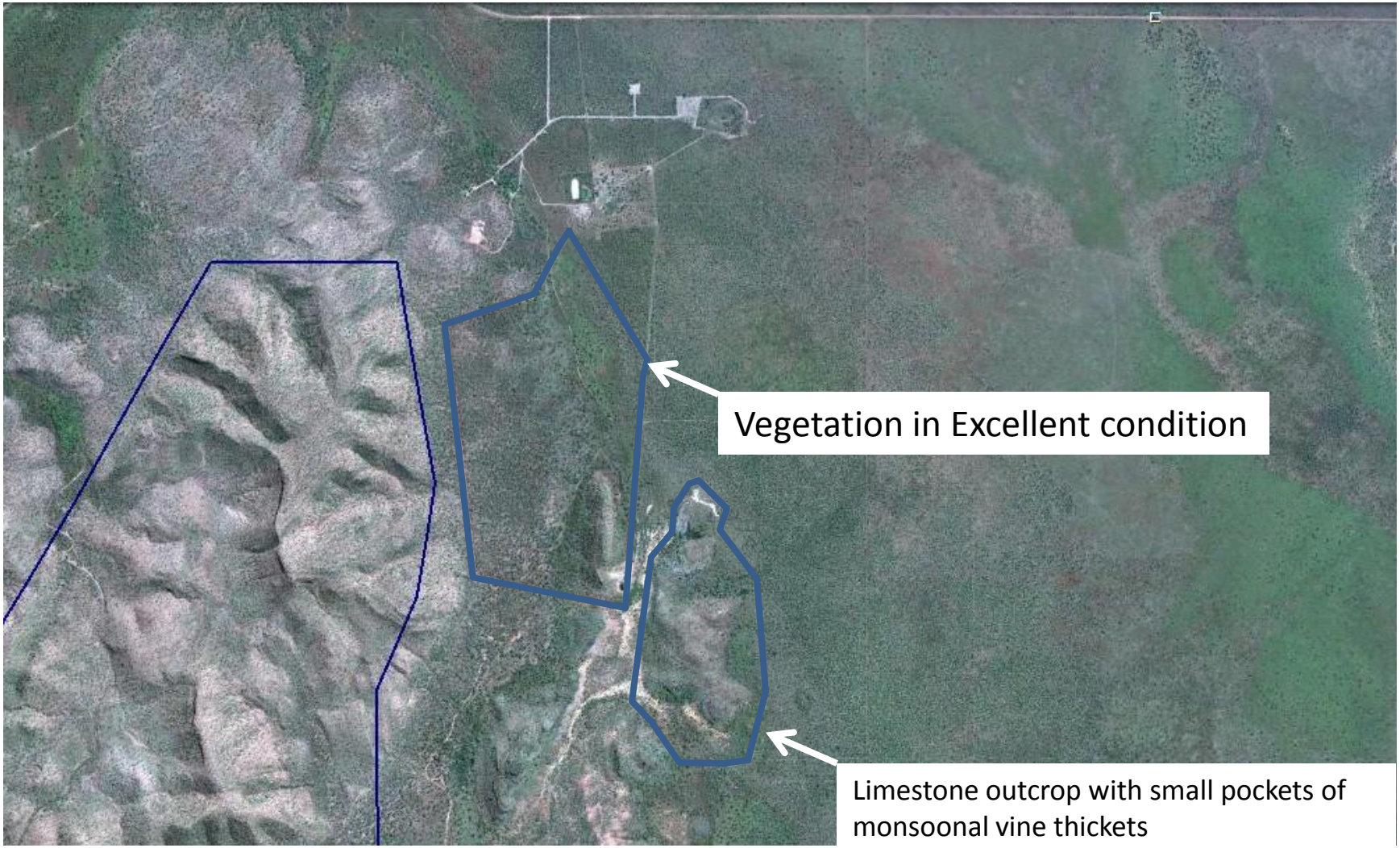
The Brush-tailed Rabbit-rat is extremely unlikely to occur due to lack of available habitat in the project area. Van Dyck and Strahan (2008) indicate that the project area sits in the middle of two disjuct areas of the species distribution.

It is unlikely that the Northern Quoll exists in or near the project area, based on the lack of records in the region. However, intensive trapping was still undertaken to determine if this species was present in the survey area.

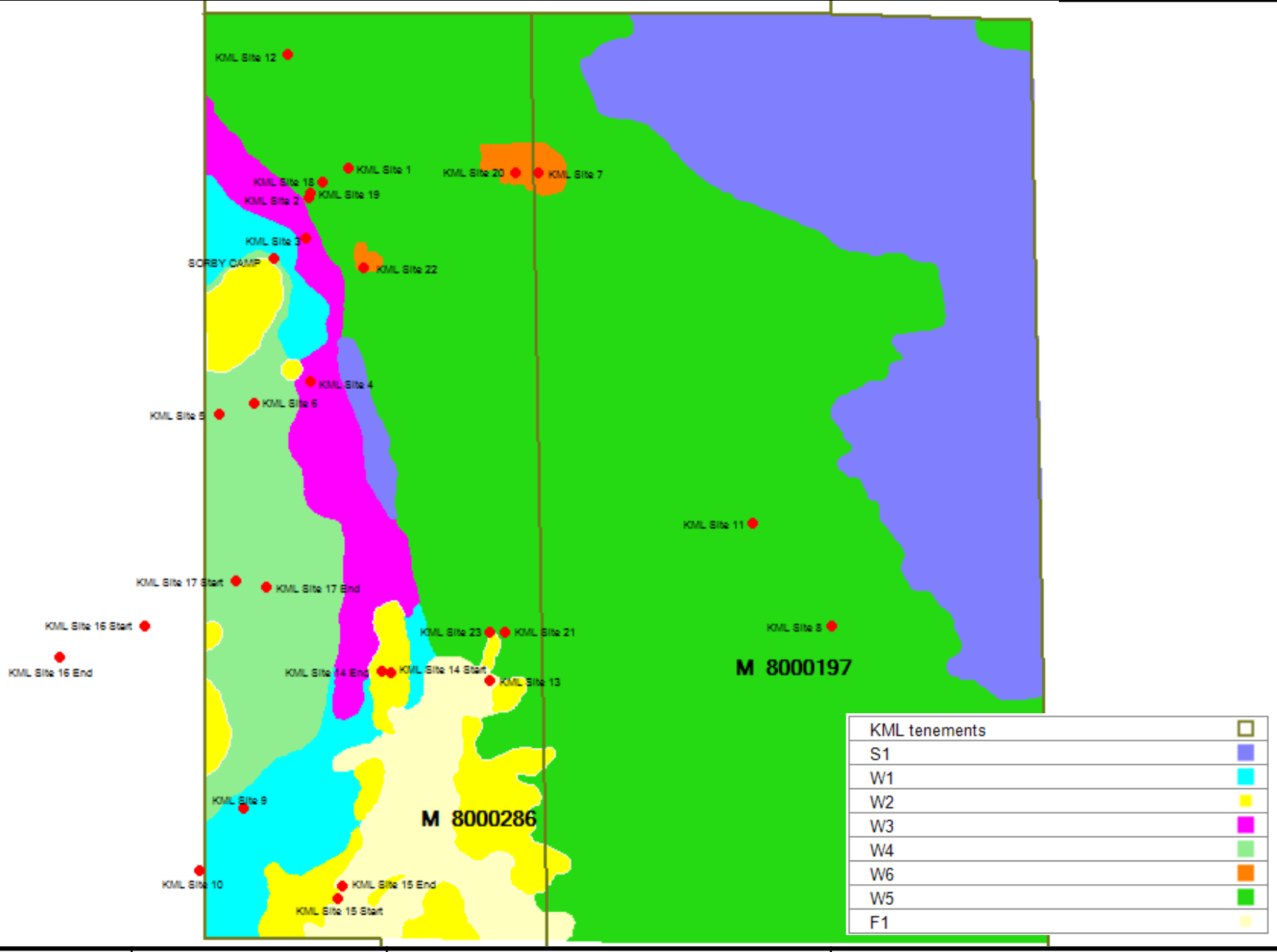
The Sorby Hills project area is located outside of the range of the Water Mouse, and does not support any suitable habitat for this species.

The Salt-water and Fresh-water crocodiles both have the potential to occupy the project area.

The search also produced two state and territory reserves close to the project area. These were the Point Spring Nature Reserve about 8km north-west of the survey area, and some proposed extensions to the Northern Territory's Keep River National Park which would extend it up to the Western Australian border (DSEWPC, 2011).



Auth: M Ladyman	Project: SMPL Sorby Hills	NORTH	**Figure 4: Areas to be considered for conservation purposes.**
Date: October 2011	Datum: GDA94 MGA Zone 52		



Auth: M Ladyman	Project: SMPL Sorby Hills		
Date: October 2011	Datum: GDA94 MGA Zone 52		

NORTH

Figure 5: Fauna survey sites over vegetation units

3.2 FIELD SURVEY ASSESSMENT

3.2.1 FAUNA SPECIES ASSEMBLAGES

A total of 25 reptile, 15 amphibian and 8 non-volant mammal fauna were trapped or recorded during the survey. This comprises species identifiable with a high level of confidence. The complete list of individuals captured is shown in Appendix 5 for all sites sampled in the local area. Based on distribution and known habitat preferences 18 ground dwelling mammals, 21 frogs, and 63 reptiles potentially occur within the study area (WA Museum, 2009). Table 5 shows richness and abundance of fauna collected over a number of surveys in the local area (see references herein).

The abundance of frog fauna captured at Sorby Hills was relatively high compared to the other sites sampled, with the 370 records surpassed only by the number of individuals captured at Packsaddle by APM in 2009. The trapping effort was 2938 compared with 2310. The number of reptiles captured was relatively low compared to other sites, in particular HLA and Ecologia. The comparison with HLA is not specifically relevant as the results from this survey obviously came from opportunistic sampling as only 192 traps were deployed.

Table 5 Richness and abundance for fauna trapped in the local area.

	Naturemap	Sorby	Packsaddle	Mantinea	Westbank	HLA	Ecologia
Abundance							
Mammal		14	37	18	14	0	0
Amphibians		370	386	164	49	266	118
Reptiles		160	119	124	102	407	206
Richness							
Mammal	18	7	7	4	5	0	0
Amphibians	21	15	12	8	6	15	16
Reptiles	63	25	22	17	21	43	29

The surveys undertaken in the vicinity have contributed two species to the number of fauna species previously recorded in the area. *Litoria tornieri* was captured around the camp site at Sorby Hills and *Uperoleia lithomoda* was collected by HLA. These species did not appear as potentially likely to occur based on the data base searches.

No surprisingly a large number of mammal species that were expected to occur based on historical records were not captured. This includes P4 Water-rat *Hydromys chrysogaster* Short-eared Rock-wallaby *Petrogale brachyotis,* Common Planigale *Planigale maculata,* Ningbing Pseudantechinus *Pseudantechinus ningbing*, Black Rat *Rattus rattus*, Pale Field-rat *Rattus tunneyi*, Long-haired Rat Rattus villosissimus. This is most likely due to the limited amount of trapping deployed at critical times of the year when these species are most active. The data incorportated from HLA and Ecologia does not include mammal records, thus comparisons can only be made with Packsaddle Mantinea and Westbank surveys. The richness recorded at Sorby Hills exceeded these three other site.

The results of the surveys listed above have contributed significantly to the records of reptiles around the project area giving some indication of the lack of previous collection work. Summing the total species richness of the six surveys has resulted in the collection of 18 new species of reptile for the area. Seven of these new species have only been recorded in the Sorby Hills area. This represents 1/3 of the reptiles captured which is a very large proportion.

3.2.2 FAUNA SPECIES ASSEMBLAGES

In the following tables, the fauna species trapped in the project area have been grouped together based on their habitat preferences or requirements as detailed in the literature. Each of the 23 fauna trapping sites has then been classified into either of the two vegetation units described by Fox *et al*. (2001) that comprehensively describe the available major fauna habitats available in the project area. These units are:

1. Map Unit C10 (yellow). '*Eucalyptus microtheca* (coolibah) or *Eucalyptus gymnoteles* (coolibah) and/or *Eucalyptus* spp. +/- *Excoecaria parvifolia* (gutta percha) grassy low woodland.' This alliance occurs on gently sloping floodplains and backplains, often with braided channels. Soils are generally light to heavy grey and brown clays and cracking clays, gradational mottled yellow structured clay soils and some loams.

2. Map Unit D14 (orange) '*Eucalyptus tetrodonta* (Darwin stringybark) and/or *Eucalyptus miniata* (Darwin woollybutt) +/- *Corymbia* spp. +/- *Livistona* spp. (fan palms) woodland with a ground layer of tussock grasses and *Triodia bitextura* (curly spinifex)'. This alliance occurs on undulating plains with deep soils on dissected and remnant plateaus over Mesozoic sandstone and laterite. In some parts the soils are shallower and the laterite becomes exposed, and there are some occurrences on broken sandstone plateaus with shallow sandy soil. The soils include red earthy sands with ironstone gravel, red clay-loam and sandy red earths that may have ironstone gravel.

The fauna sites have been plotted over the vegetation mapping produced specifically for the project area and reported in APM (2011b).

3.2.2.1 GENERALIST FAUNA SPECIES

The cane toad *Bufo marinus* was ubiquitous across the site and was captured frequently in all habitats and microhabitats. During nocturnal surveys they were in high abundance along the roads where they appeared to congregate. They were frequently observed sitting on cow pats feeding on insects drawn to the faecal matter. Cane toads are known to radiate along roads where as there is not vegetation to impede their progress. . Their presence dropped off dramatically with the onset of the dry season. In the later phases of the surveys

large individuals were observed during the day taking refuge in deep and inundated cow puds on the margins of the remaining wetlands.

The large and robust northern blue-tongue is expected to occupy all habitats. However, individuals were only captured or recorded in floodplain habitats. The spiny-tailed monitor *Varanus acanthurus* was recorded where it was expected to occur in a fractured rocky area. The single individual was captured on the very low limestone rise (Site 13) protruding from the clay pan soils near the lagoon. This habitat may be very valuable to the local faunal assemblages as it provides a very heterogeneous mix of microhabits and refuge in the deep cracks and fissure of the limestone located immediately adjacent a permanent or near permanent wetland area that would be highly productive environment supporting prey for a range of fauna.

The species assemblage listed in Table 6 gives an indication of the broad range of habitat generalists captured across the project area with many of the major reptile groups represented.

6 Generalist terrestrial vertebrate fauna

Genus and Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 21
Bufo marinus	0	5	9	4		7	7	1	3					1
Tiliqua scincoides subsp. intermedia	0						1					4		
Varanus acanthurus	0												3	
Litoria nasuta	2		9	2	1		4	5			1			
Antaresia childreni	0		1											
Litoria caerulea	0	1	2	1		1	1							
Litoria rubella	0						2							
Morethia ruficauda subsp. ruficauda	0					3				1				

3.2.2.2 FAUNA OF THE ELEVATED LANDS AND UNDULATING PLAINS (D14)

The elevated sandy foot-slopes provide a very unique and valuable habitat for a number of fauna species (Table 7). The soil profile comprises deeply weathered sandstone sands with very little clay content and a high loam content. The underlying sandstone bedrock abuts the heavy clay soils of the plains, creating an interzone between the foothills and the floodplains that becomes very inundated, to the point where there is gentle sheet flow across the surface from the foothills to the plains after sufficient rain. This type of sodden soils promotes very lush herb ground cover and excellent breeding platforms for specialist frog species such as the northern toadlet *Uperoleia borealis*. The hidden-ear frog *Cyclorana cryptotis* is another species that specifically occupies this type of habitat. The males call from the base of tall grasses around the edge of temporary pools of water. The sandy substrates are also particularly valuable for burrowing skink species such as *Lerista griffini*. A diverse woodland over-story provides habitat for arboreal skinks and varanids, and also produces

abundant litter and detrital material for fossorial skinks, such as the rainbow skink, *Carlia tricantha* and the snakes that feed upon them (e.g. little spotted snake, *Suta punctata*).

The fact that this habitat represents an interzone of the foothills and plains is evident when considering the presence of species such as the northern spadefoot, *Notaden melanoscaphus*. This species is typically only associated with impervious clay soils. These clay soils are present immediately adjacent fauna trapping Site 4. The transition from the sandy loams of Site 4 to the clay soils of the floodplain is very abrupt. Interzones or fringe habitats are generally considered very valuable to fauna species as greater habitat heterogeneity supports a greater species richness per unit area.

Table 7 Fauna of the elevated lands and undulating plains.

Species	Site 1	Site 3	Site 4	Site 6	Site 9
Cyclorana cryptotis			2	1	
Lerista griffini				8	4
Suta punctata					1
Uperoleia borealis	13		24	13	
Carlia tricantha		1		5	
Notaden melanoscarphus			1		
Varanus scalaris				3	1

Moving up the footslopes away from the interzone (the interface between the foothills and the clay floodplains) the overstory is remains relatively unchanged with a mixed woodland of Eucalyptus and Corymbia species. However, the herbs and tussock grasses of the interzone give way to high Sorghum spp. grasses growing on heavy stony soils. This change in vegetation and substrate also marks a change in fauna assemblages.

Further upslope the physiography changes from low rolling hills to steeper hills with some abrupt outcrops. In these outcropping environments mammal specialists, such as the common rock-rat. *Zyzomys argurus* and the northern shovel-nosed snake *Brachyurophis roperi*, are commonly captured (Table 8).

Table 8 Fauna of the footslopes and outcrops.

Genus and Species	Site 1	Site 2	Site 4	Site 6	Site 7	Site 10	Site 13	Site 14
Zyzomys argurus								2
Brachyurophis roperi						1		
Sminthopsis macroura							1	5
Carlia munda	1	4		1	14			
Diporiphora magna						1		

3.2.2.3 FAUNA OF THE GENTLYSLOPING FLOODPLAINS AND BACKPLAINS (C10)

The floodplain woodlands comprise the habitat most represented across the project area, and the habitat that supports the most diverse fauna assemblage (Table 9). The frog fauna were particularly diverse with a range of hylid (tree dwelling species) and myobatrachid (ground-dwelling) frogs captured. The flat-headed frog *Limnodynastes depressus* is morphological adapted to the cracking clay environment of the flood plain with a dorsolaterally flattened head enabling it to penetrate small cracks to take refuge from predators and the dessicating conditions of the dry season. The closely related marbled Frog *Limnodynastes convexiusculus* is often captured in abundance when trapping is undertaken on cracking clay soils during the wet season. In previous surveys around the Ord River flood plains, this species has proven to be the most abundant species captured. The ornate burrowing frog *Opisthodon ornatus* is another ground dwelling frog species particularly common in the flooded woodlands. The ta – ta dragons, *Amphibolurus gilberti* and *A. temporalis*, are commonly associated with woodlands in close association with water. The keelback snake, *Tropidonophis mainii* was particularly abundant around remnant water bodies on the floodplains with 25 individuals captured at the incline dam at Site 7. This was the second most abundant species captured from a single site during the survey. Feeding on frogs, tadpoles, lizards and fish this species would have access to an unlimited food supply at this time of the year in this environment. The vast majority of individuals captured were hatchlings, with up to three individuals captured in one trap at one time.

Table 9 Fauna of the gently sloping floodplains and back plains.

Genus and Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 10	Site 11	Site 13	Site 20
Amphibolurus gilberti	20	1					1			3		
Amphibolurus temporalis	1											
Limnodynastes convexiusculus	1	2	3		1		9	5		3		
Limnodynastes depressus		9	10	1			7	3		7		
Cryptoblepharus plagiocephalus							1					
Ctenotus inornatus								8				
Ctenotus rimacola subsp. Camptris										1		
Ctenotus robustus									1	4		
Demansia papuensis	1	8	4	2		2	2			4	2	
Demansia vestigiata							1	1				
Litoria rothii	1	1		1					1			
Litoria tornieri	1	1		2			1					
Opisthodon ornatus	1	1	1	1		2						
Planigale ingrami			1	3				1				
Pseudomys delicatulus				1								
Tropidonophis mairii	1	2					24					
Varanus mertensi												1
Cyclorana australis	9	2	2	25		1	5	1		1		

The trapping data showed very clear demarcation between the uplands habitat and the floodplains in terms of the animals the two major habitat support. Of the 38 species trapped at Sorby Hill, 12 species were only trapped in the upland areas and 11 species were trapped on the floodplain. Fifteen species were trapped in both habitats.

The species trapped only in the floodplain cracking clays included *Antaresia stimsoni*, *Cryptophis pallidiceps, Legggadinna lakedownensis, Limnodynastes depressus, Pseudomys nanus Tiliqua scincoides* subsp. *intermedia, Litoria rubella, Amphibolurus gilberti, Cryptoblepharus plagiocephalus Ctenotus inornatus, Ctenotus rimacola* subsp. *camptris, Amphibolurus temporalis, Demansia vestigiata, Tropidonophis mairii and Varanus mertensi.* None of these species are regarded as species especially dependant on cracking clay soils of the Ord River floodplain, despite the fact that a number of species, such as *L. depressus*, are limited to swamps and flooded plains.

The Long-tailed Planigale *Planigale ingrami* is reported as being common in seasonally flooded grasslands and savanna woodlands with cracking clay soils, riparian areas and black soil plains across northern Australia (Menkhorst and Knight 2004). The present survey recorded *P. ingrami* predominantly on the floodplains but also in the interzone between the two habitats. During previous surveys by APM this species has been collected in rocky outcrops.

Notably absent from the flooded wetlands were species such as Northern Long-necked Turtle *Chelodina rugosa*, North-west Red-faced Turtle *Emydura australis*, Freshwater Crocodile *Crocodylus johnstonei* and the frogs *Cyclorana cultripes* and *Litoria inermis*. A significant trapping effort was invested in attempting to capture turtles and freshwater crocodiles, but none were collected.

The Northern Brown Bandicoot *Isoodon macrurous* and the small varanid *Varanus mitchelli* were expected to occur in the vegetation around the lagoon near Site 13. Other species not recorded include *Glaphyromorphus isolepis*, *Furina ornata* and *Carlia amax* would normally be considered common to other habitats to general savanna woodland habitats in the floodplains and back plains.

Other species likely to occupy the woodland habitat include *Strophurus ciliaris*, *Rhyncoedura ornata*, *Pseudomys delicatulus*, *Pseudonaja ingrami*, *Pseudonaja nuchalis*, *Ramphotyphlops ligatus*, *Lucasium stenodactylum, Gehyra australis, Ctenotus piankii, Ctenotus militaris*. All of these species represent typical woodland taxa. The savanna woodlands are well represented both locally and regionally.

3.2.3 SITE SPECIES RICHNESS, ABUNDANCE AND DIVERSITY

True comparisons of fauna habitat species richness and diversity can only be made for survey sites where similar systematic survey effort was invested. Due to the limitations on access to sites on the floodplain during the April (Phase I) survey and the establishment of more trapping sites on the

floodplain during the May (Phase II) survey the trapping data are not precisely replicated across the 11 main trapping sites. However, the difference in trapping regimes is unlikely to influence the results as the primary trapping methods (funnel and pit traps) captured the same species throughout the survey. Table 10 lists ranks the 11 sites in relation to the three main indices used to assess fauna the value of the sites for terrestrial vertebrate fauna.

Table 10 Site rankings based on ecological indices.

Rank	Site	Richness	Site	Abundance	Site	Diversity
1	Site 7	15	Site 7	80	Site 7	2.174491
2	Site 4	14	Site 4	70	Site 2	2.147085
3	Site 1	12	Site 1	52	Site 6	2.126473
4	Site 2	12	Site 6	47	Site 3	2.035863
5	Site 6	12	Site 3	43	Site 11	1.873746
6	Site 3	11	Site 2	37	Site 4	1.803761
7	Site 8	8	Site 8	25	Site 8	1.777846
8	Site 11	8	Site 11	24	Site 1	1.750853
9	Site 10	5	Site 9	9	Site 10	1.609438
10	Site 9	4	Site 10	5	Site 9	1.21489
11	Site 5	2	Site 5	2	Site 5	0.693147

A rudimentary approach was used to rank habitat values based on the trapping results. The top 5 sites were scored 5 to 1 for each of the three attributes of diversity, richness and abundance. Sites not in the top 5 were scored zero. The overall score for habitat value was the sum of the three scores with the maximum potential score for a site being 15 (Table 11).

Table 11 Habitat value.

Site Number	**Rank**
Site 7	15
Site 4	8
Site 1	6
Site 2	6
Site 6	6

Site 7 comprised an Open Woodland of *Bauhinia cunninghamii, Excoecaria parvifolia* and *Vachellia valida* over mixed Shrubland/Grassland/Forbland of *Sorghum plumosum, *Calotropis procera, Vigna lanceolata* etc. The area, despite being representative of the floodplain habitat, had been subject to earthworks for dam construction and pit excavation in the past. As such the flora was a mix of exotics, native disturbance opportunists the typical cracking clay woodland species.

Cattle had been excluded from the area resulting in a notable increase in tussock grasses when compared to the surrounding area. The presence of a permanent water body adds to the habitat value of the site and contributes to the overall species richness. The fact that the site supports many species in high numbers contributes to its overall diversity, with large numbers of frog species (*Limnodynastes convexiusculus*, *L. depressus*, *Litoria nasuta*, *Cyclorana australis*), skinks (*Carlia munda*), and snakes (*Tropidonophis mairii*).

The results from Site 7 are strongly augmented by opportunistic species records that were not included in the analysis of diversity indices but do further highlight the broad assemblage that this site supports.

Site 7 most accurately represents the fauna assemblages that the broad floodplains would be shown to support if trapping was undertaken over a longer period of time.



Plate A Vegetation Unit W6 and Fauna Site 7

Site 4 had a very similar species richness and similar abundance to Site 7. However, it had a lower species diversity. Diversity is reduced when one particular species represents a large number of captures from within the total captures of the species assemblage. In this case 24 of the 70 individuals captured were of the small ground dwelling northern toadlet, *Uperoleia borealis*. Another 25 indivuals of the Giant Frog *Cyclorana australis* also influenced the overall diversity.

Site 4 represents a very good example of the very valuable habitat that occurs at the interzone between the undulating plains and foothills of the sandstone ranges and the floodplains. The area is dominated by Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia dichromophloia* over Sparse Shrubland of *Erythrophleum chlorostachys, Grevillea refracta, Dodonaea hispidula* var*. phylloptera* and *Buchanania oblongifolia* over Grassland of *Chrysopogon* sp*., Sorghum stipoideum, Eriachne obtusa, Triodia bitextura* and *Eragrostis schultzii* (P3).

As with Site 7 the outcomes of the trapping survey were possibly greatly influenced by the exclusion of cattle from this area, albeit on only one side. The trapping site was located on a fence line on one side of which cattle were excluded. On the other side of the trapping line that habitat comprised heavily inundated sandy loamy soils with tight tussock grasses and small pockets of clean flowing water favoured by frog species such as *Cyclorana australias* and *U. borealis*.

The botanist undertaking the flora survey of the project area described the habitat around Site 4 was in Excellent condition.



Plate B Vegetation Unit W4

Sites 9 and 10 were located in complex and hetrogenous fauna habitats that were expected to support a high diversity and species richness. The Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia confertiflora* over Open to Sparse Shrubland of **Hyptis suaveolens, Buchanania oblongifolia, Grevillea* spp. and *Acacia* spp. over mixed Grassland/Forbland of *Eragrostis schultzii* (P3)*, *Cynodon dactylon, Eriachne obtusa, Heteropogon contortus*, *Stemodia lythrifolia, Blumea saxatilis* and *Cyperus pulchellus* provided and abundance of fauna microhabitats. The soil profile comprised brown and grey loamy sands, sandy loams and clay loams on flat or gently sloping country ideal for burrowing species, and the abundant overstory vegetation contributed to very well developed detrital and litter piles around the base of large trees. The area was described as being in excellent condition.

Despite the diversity of habitats, and utility of the sandy loamy soil profile these two habitats returned the lowest species richness and diversity. However, trapping at these two sites revealed a number of highly cryptic species that are not frequently recorded and were not recorded at any other sites. These included the little spotted snake *Suta punctata* and the northern shovel-nosed snake *Brachyurophis roperi*.



Plate C Vegetation Unit W1

3.3.1.1.1 FAUNA OF CONSERVATION SIGNIFICANCE

Database searches and previous surveys reveal that approximately 43 ground dwelling fauna species of conservation significance listed under the following four ranks of conservation significance:

1. EPBC, Wildlife Conservation Act or DEC Priority, NT Near Threatened;
2. Species of Concern as Described by HLA;
3. NT DIPE;
4. Locally or Regional Significant

Though not all of the above categories provide statutory protection to the fauna listed, all fauna listed under these categories are included in the table as they represent poorly understood fauna known to occur in the region. Collection records from previous surveys (ecologia, Kinhill and HLA) are also included in Table 12 to highlight the relevant occurrence of each of the fauna in the region. Rare or specially protected fauna are not often recorded during single survey events, so their presence and significance can usually only be appreciated in a regional context.

Table 12 Fauna of Conservation Significance

Level of Conservation Significance	Sorby Hills	Ecologia	Kinhill	HLA	APM
EPBC, Wildlife Conservation Act or DEC Priority, NT Near Threatened.					
Acanthophis praelongus Northern Death Adder NTNT				√	
Chelosania brunnea Chameleon Dragon NTNT					
Crocodylus johnstoni Freshwater Crocodile S		√			√
Hydromys chrysogaster Water-rat P4					
Leggadina lakedownensis Short-tailed Mouse P4					√
Ramphotyphlops troglodytes P1					
Varanus panoptes subsp. *panoptes* NTNT		√		√	√
Species of Concern as Described by HLA					
Uperoleia trachyderma (poorly collected; not resolved)					

Level of Conservation Significance	Sorby Hills	Ecologia	Kinhill	HLA	APM
Chelodina sp. (not represented in museum collections)		√			
Tympanocryptis uniformis		√			
Ctenotus joanae (not represented in museum collection)		√			
Menetia spp.					
Menetia alanae (poorly collected from the region)		√			
Proablepharus (tenuis?)(poorly collected; recently described)		√		√	
Ramphotyphlops spp. (not represented in museum collection)		√			
NT DIPE					
Uperoleia trachyderma					
Uperoleia borealis	√	√			√
Uperoleia inundata					
Uperoleia lithomoda				√	
Limnodynastes depressus	√	√	√		√
Limnodynastes tasmaniensis					
Cyclorana australis	√	√		√	√
Cyclorana cryptotis	√				
Cyclorana vagitus		√			

Level of Conservation Significance	Sorby Hills	Ecologia	Kinhill	HLA	APM
Chelodina sp.		√			
Tympanocryptis uniformis		√			
Ctenotus rimacola camptris	√			√	
Ctenotus inornatus	√	√		√	√
Ctenotus joanae		√			
Menetia sp.					
Morethia nov. sp		√			
Ramphotyphlops sp.		√			
Ramphotyphlops sp. 2					
Locally or Regional Significant					
Pseudantechinus ningbing		√			
Planigale ingrami	√				√
Rattus colletti		√			
Ctenotus tantillus		√		√	√
Suta ordensis					
Notaden melanoscaphus	√	√		√	√
Uperoleia borealis	√	√			√
Uperoleia trachyderma					

Of those seven species listed under the EPBC Act 1999 (cth), Wildlife Conservation Act 1950 (cth) or the DEC Priority or Northern Territory Near Threatened lists, only four have been recorded within any of the surveys undertaken in the area. These four species are the Northern Death Adder *Acanthophis praelongus* (NTNT), the Freshwater Crocodile *Crocodylus johnstoni* Short-tailed Mouse (S) *Leggadina lakedownensis* (P4) and the Sand Goanna *Varanus panoptes* subsp. *panoptes* (NTNT). All of these species are known to occur and are expected to occur in close proximity or within the project area.

The Northern Death Adder *Acanthophis praelongus* inhabits grasslands, woodlands, rocky ranges and outcrops and would be expected to occur broadly, but in low densities across the project area. Threatening processes from the proposed Sorby Hills project would relate to loss of individuals during clearing. However populations are more immediately under threat from the Cane Toad *Bufo marinus*.

The Sand Goanna *Varanus panoptes* subsp. *panoptes* is a remarkably resilient species that is not likely to be impacted significantly by the development of the Sorby Hills project. Individuals are typically recorded in close association with roads or settlements. This species occurs as a transient in many habitats and will very likely forage within the development area once it has become established. Like the death adder, this is species is more likely to be threatened by the introduction of the Cane Toad *Bufo marinus*.

Within the project areas, and more specifically, the areas likely to be impacted, there were very few locations where the Freshwater Crocodile *Crocodylus johnstoni* may potentially occur. However, individuals occur ubiquitously throughout the area and will most certainly occur within Knox Creek. Individuals may be attracted to large standing water sources once the project is established.

The Short-tailed Mouse *Leggadina lakedownensis* is listed as Priority 4 by the DEC, in Western Australia. A total of 179 individuals have been lodged with the WA Museum but none of these have been lodged from the Kimberley in the last 10 years. However, this may only reflect the lack of collection through lack of survey work in the area. The Short-tailed mouse is generally regarded as occurring in low population densities when compared with other rodents. This makes it vulnerable to disturbance and predation. Moro (2001) also details that this species suffers impact arising from competition with the House Mouse *Mus musculus*. The single capture of this species during the survey of Mantinea Plain in 2009 gives little indication of the distribution of this species across the Ord River flood plains. The habitat from which it was recorded was a badly degraded cracking clay with a sparse Bauhinia woodland. It is not described as a habitat specialist and therefore the potential threat of the irrigation expansion will be to the few individuals that occur broadly across the project area.

No suitable habitat is present for the water rat Hydromys chryogaster (P4) as there are no heavily vegetated water ways. Insufficient information exists to determine if the blind snake Ramphotyphlops troglodytes may potentially occur in the project area. Records are so scant that the species was not included on the expected species list following the database search.

The semi arboreal and very cryptic chameleon dragon Chelosania brunnea has not been recorded in the area but is may potentially occur. It is very infrequently recorded due to its cryptic habit of perching on trees, similar to the frilled lizard *Chlamydosaurus kingii*. However, it is a significantly smaller species and thus not as easily spotted during surveys.

All of the remaining fauna species of conservation significance are listed primarily because of poor taxonomic resolution or local/regional significance. HLA lists a total of eight species collected that are poorly described in the literature. This is a direct result of lack of collection and vouchering in the region. Vouchering done during earlier surveys have been lost within the W.A. and N.T museum system. None of these species listed by HLA were recorded during the Sorby Hills survey.

The highest number of conservation significant fauna recorded during the Sorby Hills survey fall within the group of NT DIPE listed species. The northern toadlet *Uperoleia borealis* was regarded as being locally or regionally significant. Tyler *et al.* (1998) reports that this species is confined to the east Kimberley, though populations probably spread more broadly into the Northern Territory. This species was one of the most locally abundant species in the Sorby Hills area, and was similarly common in the Packsaddle project area. This species is obviously well represented in the project area. Similarly, *Limnodynastes depresses* was reported in the 2005 HLA survey as being captured readily on the Ord River floodplain but incorrectly described as *L. tasmaniensis*. This species was captured in abundance on the floodplain habitats in the Sorby Hills project area and is very likely more common historically that was originally thought. The Giant Frog *Cyclorana australis* is also listed by the NT DIPE. With the exception of the Cane Toad *Bufo marinus*, *C. australis* was the most common frog captured across the project area and the species captured in the highest abundance.

Cyclorana cryptotis was one species listed by the NT DIPE which was a significant record for the the Sorby Hills site as this species was not collected during any other surveys. During the Sorby Hills field survey work only three individuals were collected and all of these occurred at Sites 4 and 6, which were located immediately adjacent each other at the interzone of the floodplains and the uplands.

Another significant record was of the skinks speicies Ctenotus rimacola camptris which is listed as vulnerable in the NT. This species specifically inhabitat deep cracking clay soils and a single individual was captured in a funnel trap at Site 11. Only twenty individuals of this species have been collected in the state and a number of these have been collected on the Savanna Highway east of Kununurra which is directly south of the project area.

Table 12 shows that many of the species listed by the Northern Territory DPI were recorded by at least one of the four consulting biological surveys. Again, this provides evidence that more frequent baseline surveys across the Kimberley would provide better information about fauna species of conservation significance.

4. DISCUSSION

4.2 FAUNA HABITATS OF CONSERVATION SIGNIFICANCE

There are sixteen Priority Ecological Communities (PECs) listed for the Kimberley region. Three of these have some relevance to the Sorby Hills project:

- Monsoon vine thickets of limestone ranges
- *Oryza australiensis* (wild rice) grasslands on alluvial flats of the Ord River
- Camaenid land snails of limestone hills of the Jeremiah and Ningbing Ranges

Figure 4 identifies areas proposed for consideration as conservation areas that should remain fenced off to exclude cattle. Protection of these areas will contribute to the protection of habitats representative of the Monsoon vine thickets of limestone ranges.

Botanical survey work specific to the project area did not record occurrences of wild rice (Oryza australiensis).

During the field survey many collections of Camaenid land snakes were collected from around the limestone hills near Sites 13 and 15. These snails have been lodged with the Western Australian Museum as a record for the area.

4.2 MAINTENANCE OF REGIONAL FAUNA HABITATS

Conservation to maintain diversity in the Sorby Hills project area must focus on the retention of comprehensive, adequate and representative habitats as per the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia, 1996). Conservation of these areas should be aligned with the Western Australian and Northern Territory government conservation reserve initiatives and those proposed in the Ord Final Agreement.

As part of the Ord River Irrigation Area – Weaber Plain Development Project the Weaber Plain area will have 10 805 ha set aside as a buffer zone and conservation area. This area will be destocked to improve its habitat integrity. The Environmental Impact Statement identifies that more than 75% of habitat suitable for EPBC listed wetland species will be preserved and that approximately 30% of habitat for remaining non-wetland specific birds (mainly small passerines) will be preserved. The buffer area represents almost exactly 50% of the total area outlined in the Weaber Plain Development Project.

Thus it is reasonable to suggest that as the Ord Irrigation Expansion program continues across the remaining stages, a similar percentage of plains habitat (50%) will be preserved. This would include the Knox Creek area.

In addition to the 10805 ha buffer area managed by the OIEP, and the area to remain undisturbed in the project tenement boundaries, the signing of the Ord final agreement has resulted in the establishment of six reserves in the surrounding ranges and the Packsaddle Swamp conservation area. In total this area covers some 188 200 ha. Within these reserves, habitat identical to that which exists within the Sorby Hills project will be preserved.

Cracking clay habitat specialist would be lost if entire habitats are impacted in a local area. However, this is not to be the case for the Sorby Hills project. Within the 1782 ha of the KML lease areas (M80/197 and M80/286), only 427.8 ha are going to be impacted and therefore 1354.47 ha or 76 % will be retained. Similar to the OIEP development, the Sorby Hills project area will be destocked and burning will be managed. The development boundaries have been designed specifically to enhance and maintain the value of fauna habitat around the base of Sorby Hills, the interzone with Knox Creek Plain and the densely vegetated grassland around KML Census Site 001 (Figure 4). It is proposed that the lowland area from which cattle have historically been excluded (See Figure 4) should remain undisturbed and fenced to deter cattle. Botanists deemed this are to be in 'Excellent' condition and this is reflected in the diversity for fauna recorded, in particular from Site 004 and 006.

Working within the constraints of engineering and economic feasibility, the areas targeted for clearing should be the areas that are already degraded and are of lower value for fauna. There is a very large area around the Sorby Hills camp that comprises the stock yards, drovers' camp, old core shed and a large quarry that has been used as a source for road base. Much of this area is located on the intezone habitat between the plains and the undulating slopes. However, the historical disturbance is so significance that there is little chance for restoration of this area. As such it is an ideal location for mine processing infrastructure.

Most of the lowland country was quite heavily grazed; however the high productivity of the 'blacksoil' clays appeared to make the vegetation resilient to trampling, grazing and weed invasion. The vegetation across the project area remains structurally intact.

4.2 SURVEY OUTCOMES AND CONSTRAINTS

This survey represents a baseline biological assessment survey for terrestrial vertebrate fauna active at the end of the wet season and progressing into the dry season. Access across the flood plains was limited in the April survey, however the opportunity to place traps in the flooded woodlands on roads that were elevated above the flooded clay pans resulted in the capture of a diverse array of amphibians and a number of reptiles. No mammals were captured during the initial phase of the survey and this may be due to a low period of activity for these species. Certainly the funnel traps used in Phase I are sufficiently capable of capturing a diverse array of rats, mice and dasyurids.

Trapping effort at each site was limited by access, but improved as the survey progressed into the dry season. Nevertheless, the survey achieved nearly 3,000 trap nights and resulted

in the capture of 544 individuals. This coupled with the hundreds of records from the 2009 APM surveys, the 2005 HLA survey and the 1996 ecologia surveys has provided adequate data to not only report on the fauna assmblages but also contribute to what is known in the region.

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APPENDIX 1 – FAUNA CONSERVATION CODE DEFINITIONS

Definitions of Fauna Conservation Codes

Three levels of conservation significance are recognised in this report and these are based on how fauna conservation status is determined by the DEC and the Department of SEWPAC.

Conservation Significance 1:

- Species listed under State or Commonwealth Acts.

Conservation Significance 2:

- Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by DEC.

Conservation Significance 3:

- Species not listed under State or Commonwealth Acts or in publications on threatened fauna or as Priority species by DEC, but considered of local significance because of their pattern of distribution or habitat preferences.

DEC and the Department of SEWPAC Classify fauna according to the following Schedules:

Schedule 1: Fauna that are rare or likely to become extinct.

Schedule 2: Fauna presumed to be extinct.

Schedule 3: Migratory birds that are listed under JAMBA.

Schedule 4: Other specially protected fauna.

DEC and the Department of SEWPAC Definitions:

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 very 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: 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.

DEC and the Department of SEWPAC recognise five levels of priority fauna:

Priority 1: Taxa with few, poorly known populations on threatened lands.
Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 2: Taxa with few, poorly known populations on conservation lands.
Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 3: Taxa with several, poorly known populations, some on conservation lands.
Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

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. These taxa are usually represented on conservation lands.

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 2 – NATUREMAP DATABASE SEARCH RESULTS

NatureMap Database Search Results

AMPHIBIANS
Bufo marinus Cane Toad
Crinia bilingua Bilingual Froglet
Cyclorana australis Giant Frog
Cyclorana cryptotis Hidden-ear Frog
Cyclorana cultripes Knife-footed Frog
Cyclorana longipes Long-footed Frog
Cyclorana vagitus Wailing Frog
Limnodynastes convexiusculus Marbled Frog
Limnodynastes depressus Flat-headed Frog
Litoria caerulea Green Tree Frog
Litoria coplandi Rock Frog
Litoria inermis Bumpy Rocket Frog
Litoria meiriana Rockhole Frog
Litoria nasuta Striped Rocket Frog
Litoria pallida Pale Rocket Frog
Litoria rothii Northern Laughing Tree Frog
Litoria rubella Little Red Tree Frog
Litoria splendida Splendid Tree Frog
Opisthodon ornatus Ornate Burrowing Frog
Uperoleia borealis Northern Taodlet
Uperoleia trachyderma Blacksoil Toadlet

MAMMALS
Hydromys chrysogaster Water-rat P4
Isoodon macrourus Northern Brown Bandicoot
Macropus agilis Agile Wallaby
Macropus robustus subsp. erubescens Euro
Melomys burtoni Grassland Melomys
Mus musculus House Mouse
Onychogalea unguifera Northern Nailtail Wallaby
Petrogale brachyotis Short-eared Rock-wallaby
Planigale ingrami Long-tailed Planigale
Planigale maculata Common Planigale
Pseudantechinus ningbing Ningbing Pseudantechinus
Pseudomys delicatulus Delicate Mouse
Pseudomys nanus Western Chestnut Mouse
Rattus rattus Black Rat
Rattus tunneyi Pale Field-rat
Rattus villosissimus Long-haired Rat
Tachyglossus aculeatus Echidna
Zyzomys argurus Common Rock-rat

REPTILES
Amphibolurus gilberti subsp. gilberti
Amphibolurus gilberti Ta-Ta
Antaresia childreni Children's Python
Aspidites melanocephalus Black-headed Python
Boiga irregularis Brown Tree Snake
Brachyurophis roperi
Carlia amax
Carlia munda
Chelodina rugosa Northern Long-necked Turtle
Chlamydosaurus kingii Frill-necked Lizard
Crocodylus johnstoni Freshwater Crocodile S
Cryptoblepharus exochus
Cryptoblepharus ruber
Cryptophis pallidiceps Northern Small-eyed Snake
Ctenotus inornatus
Ctenotus militaris
Ctenotus pantherinus subsp. calx
Ctenotus piankai (name not current)
Ctenotus rimacola subsp. camptris
Ctenotus robustus
Ctenotus tantillus
Delma tincta
Demansia papuensis Great Black Whipsnake
Demansia vestigiata Lesser Black Whipsnake
Dendrelaphis punctulata Green Tree Snake
Diporiphora arnhemica
Diporiphora bennettii
Diporiphora lalliae
Diporiphora magna
Emydura australis
Furina ornata Moon Snake
Gehyra australis
Gehyra nana
Glaphyromorphus isolepis
Heteronotia binoei Bynoe's Gecko
Heteronotia planiceps
Lerista borealis
Lerista griffini
Lialis burtonis
Liasis mackloti subsp. fuscus
Liasis olivaceus subsp. olivaceus
Menetia greyii
Menetia maini
Morethia ruficauda subsp. ruficauda
Notoscincus ornatus subsp. wotjulum
Proablepharus tenuis
Pseudechis australis Mulga Snake
Pseudonaja ingrami Ingram's Brown Snake
Pygopus steelescotti

Ramphotyphlops diversus
Ramphotyphlops guentheri
Ramphotyphlops ligatus
Ramphotyphlops unguirostris
Strophurus ciliaris subsp. ciliaris
Suta ordensis Ord Snake
Tiliqua multifasciata Central Blue-tongue
Tiliqua scincoides subsp. intermedia
Varanus acanthurus Spiny-tailed Monitor
Varanus mitchelli Mitchell's Water Monitor
Varanus panoptes subsp. panoptes
Varanus scalaris Spotted Tree Monitor
Vermicella intermedia
Vermicella multifasciata

APPENDIX 3 – EPBC PROTECTED MATTERS SEARCH

Australian Government
Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report: Coordinates

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

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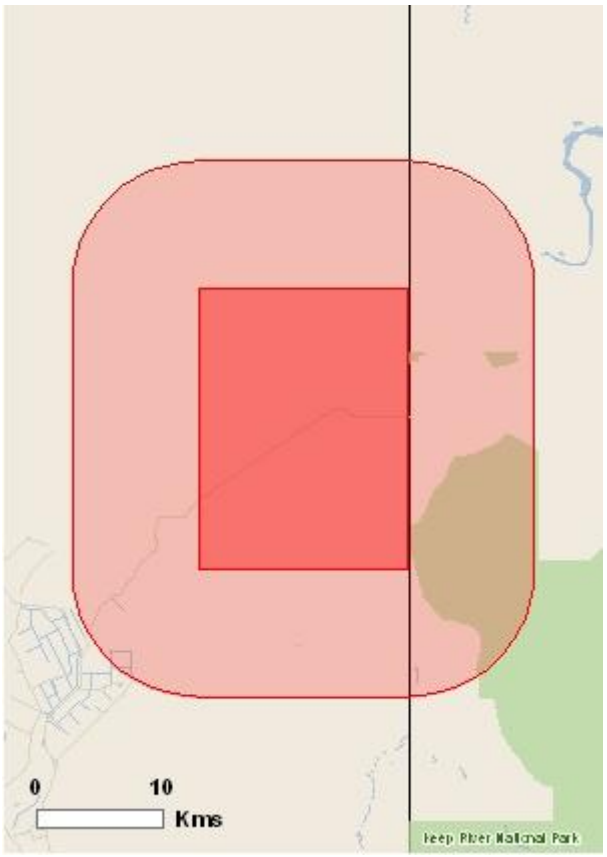
Summary

Details

Matters of NES
Other matters protected by the EPBC Act
Extra Information

Caveat

Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 10.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance (Ramsar Wetlands):	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	None
Threatened Species:	9
Migratory Species:	17

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	13
Whales and Other Cetaceans:	None

Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	2
State and Territory Reserves:	2
Regional Forest Agreements:	None
Invasive Species:	10
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Wetlands of International Significance (RAMSAR Sites)		**[Resource Information]**
Name	Proximity	
Ord river floodplain	Upstream from Ramsar site	

Threatened Species		**[Resource Information]**
Name	Status	Type of Presence
BIRDS		
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Malurus coronatus coronatus Purple-crowned Fairy-wren (western) [64442]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
MAMMALS		
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat [132]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll [331]	Endangered	Species or species habitat likely to occur within area
Xeromys myoides Water Mouse, False Water Rat [66]	Vulnerable	Species or species habitat may occur within area

SHARKS		
Pristis microdon		
Freshwater Sawfish [66182]	Vulnerable	Species or species habitat likely to occur within area

Migratory Species [Resource Information]

Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Marine Species		
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Coracina tenuirostris melvillensis		
Melville Cicadabird [26187]		Species or species habitat may occur within area
Erythrura gouldiae		
Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei		
Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Poecilodryas superciliosa cerviniventris		
Derby White-browed Robin [26190]		Species or species habitat likely to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Rostratula benghalensis s. lat.		

Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Rostratula benghalensis s. lat.		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area
Reptiles		
Crocodylus johnstoni		
Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	Status
Natural	
Parts of the Kimberley WA	Indicative Place
Indigenous	
Weaber Range Sites Complex NT	Registered

State and Territory Reserves [Resource Information]

Point Spring, WA

Keep River Extension (proposed), NT

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Frogs		
Bufo marinus		
Cane Toad [1772]		Species or species habitat likely to occur within area
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Plants		
Brachiaria mutica		
Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Hymenachne amplexicaulis		
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Mimosa pigra		
Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Parkinsonia aculeata		
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat may occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at

the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:
- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:
- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:
- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-15.34214 128.84934,-15.34214 128.99925,-15.5444 128.99925,-15.5444 128.84934,-15.34214 128.84934

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts

-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 4 – FAUNA SPECIES POTENTIALLY OCCURRING IN THE PROJECT AREA

Fauna Species Potentially Occurring in the Project Area

REPTILES	AMPHIBIANS	MAMMALS
Acanthophis praelongus	Bufo marinus	Hydromys chrysogaster
Amphibolurus gilberti subsp. gilberti	Crinia bilingua	Isoodon macrourus
Amphibolurus gilberti	Cyclorana australis	Leggadinna lakedownensi
Amphibolurus temporalis	Cyclorana cryptotis	Macropus agilis
Antaresia childreni	Cyclorana cultripes	Macropus robustus subsp. erubescens
Aspidites melanocephalus	Cyclorana longipes	Melomys burtoni
Boiga irregularis	Cyclorana vagitus	Mus musculus
Brachyurophis roperi	Limnodynastes convexiusculus	Onychogalea unguifera
Carlia amax	Limnodynastes depressus	Petrogale brachyotis
Carlia munda	Litoria bicolor	Planigale ingrami
Carlia tricantha	Litoria caerulea	Planigale maculata
Carlia rufilatus	Litoria coplandi	Pseudantechinus ningbing
Chelodina rugosa	Litoria inermis	Pseudomys delicatulus
Chlamydosaurus kingii	Litoria meiriana	Pseudomys nanus
Crocodylus johnstoni	Litoria nasuta	Rattus rattus
Crocodylus porosus	Litoria pallida	Rattus tunneyi
Cryptoblepharus exochus	Litoria rothii	Rattus villosissimus
Cryptoblepharus carnabyi	Litoria rubella	Sminthopsis macroura
Cryptoblepharus metallicus	Litoria splendida	Tachyglossus aculeatus
Cryptoblepharus plagiocephalus	Litoria tornieri	Zyzomys argurus
Cryptoblepharus ruber	Litoria wotjulmensis	Hydromys chrysogaster
Cryptophis pallidiceps	Notaden melanoscarphus	Isoodon macrourus
Ctenotus inornatus	Opisthodon ornatus	Leggadinna lakedownensi
Ctenotus militaris	Uperoleia borealis	Macropus agilis
Ctenotus pantherinus	Uperoleia trachyderma	Macropus robustus subsp. erubescens
Ctenotus pantherinus subsp. calx	Uperoleia lithomoda	Melomys burtoni
Ctenotus piankai	Bufo marinus	Mus musculus
Ctenotus rimacola subsp. camptris	Crinia bilingua	Onychogalea unguifera
Ctenotus robustus	Cyclorana australis	Petrogale brachyotis
Ctenotus tantillus	Cyclorana cryptotis	Planigale ingrami
Delma sp.	Cyclorana cultripes	Planigale maculata
Delma tincta	Cyclorana longipes	Pseudantechinus ningbing
Demansia sp.	Cyclorana vagitus	Pseudomys delicatulus
Demansia papuensis	Limnodynastes convexiusculus	Pseudomys nanus
Demansia vestigiata	Limnodynastes depressus	Rattus rattus
Dendrelaphis punctulata	Litoria bicolor	Rattus tunneyi
Diplodactylus ciliaris ciliaris	Litoria caerulea	Rattus villosissimus

Diplodactylus stenodactylus	Litoria coplandi	Sminthopsis macroura
Diporiphora arnhemica	Litoria inermis	Tachyglossus aculeatus
Diporiphora bennettii	Litoria meiriana	Zyzomys argurus
Diporiphora bilineata	Litoria nasuta	
Diporiphora lalliae	Litoria pallida	
Diporiphora magna	Litoria rothii	
Emydura australis	Litoria rubella	
Eremiascincus fasciolatus	Litoria splendida	
Furina ornata	Litoria tornieri	
Gehyra australis	Litoria wotjulmensis	
Gehyra koira	Notaden melanoscarphus	
Gehyra nana	Opisthodon ornatus	
Gehyra punctata	Uperoleia borealis	
Glaphyromorphus isolepis	Uperoleia trachyderma	
Heteronotia binoei	Uperoleia lithomoda	
Heteronotia planiceps		
Lerista borealis		
Lerista greeri		
Lerista griffini		
Lialis burtonis		
Liasis mackloti subsp. fuscus		
Liasis olivaceus subsp. olivaceus		
Lucasium stenodactylus		
Menetia alanae		
Menetia greyii		
Menetia maini		
Morethia ruficauda subsp. ruficauda		
Morethia storri		
Notoscincus ornatus subsp. wotjulum		
Oedura rhombifera		
Proablepharus tenuis		
Pseudechis australis		
Pseudonaja ingrami		
Pseudonaja nachalis		
Pygopus steelescotti		
Ramphotyphlops diversus		
Ramphotyphlops guentheri		
Ramphotyphlops ligatus		
Ramphotyphlops unguirostris		
Strophurus ciliaris subsp. ciliaris		
Suta ordensis		
Suta punctata		

Tiliqua multifasciata		
Tiliqua scincoides subsp. intermedia		
Tropidonophis mairii		
Tympanocryptis lineata		
Varanus acanthurus		
Varanus gouldii		
Varanus mertensi		
Varanus mitchelli		
Varanus panoptes subsp. panoptes		
Varanus scalaris		
Varanus tristis		
Vermicella intermedia		
Vermicella multifasciata		

APPENDIX 5 – FAUNA CAPTURED IN THE REGION

Fauna Species Occurring in the Project Area

MAMMALS

	Naturemap	Sorby	Packsaddle	Mantinea	Westbank	HLA	Ecologia
Hydromys chrysogaster	1						
Isoodon macrourus	1		8		2		
Leggadinna lakedownensi				1			
Macropus agilis	1						
Macropus robustus subsp. erubescens	1						
Melomys burtoni	1		11	1	7		
Mus musculus	1		1	14	1		
Onychogalea unguifera	1						
Petrogale brachyotis	1						
Planigale ingrami	1	5	3	2			
Planigale maculata	1						
Pseudantechinus ningbing	1						
Pseudomys delicatulus	1	1	2		2		
Pseudomys nanus	1		3		2		
Rattus rattus	1						
Rattus tunneyi	1						
Rattus villosissimus	1						
Sminthopsis macroura		6					
Tachyglossus aculeatus	1						
Zyzomys argurus	1	2	9				
TOTAL		**14**	**37**	**18**	**14**	**0**	**0**

AMPHIBIANS

	Naturemap	Sorby	Packsaddle	Mantinea	Westbank	HLA	Ecologia
Bufo marinus	1	106					
Crinia bilingua	1		160			5	1
Cyclorana australis	1	67	9			14	24
Cyclorana cryptotis	1	3					
Cyclorana cultripes	1			12		3	
Cyclorana longipes	1			2	1	1	
Cyclorana vagitus	1						8
Limnodynastes convexiusculus	1	25	10	118	34	6	12
Limnodynastes depressus	1	58		2	1		10
Litoria bicolor							7
Litoria caerulea	1	9	5	5		10	13
Litoria coplandi	1	1					3
Litoria inermis	1	3	3		3	32	2
Litoria meiriana	1						
Litoria nasuta	1	27	65	19	1	11	9
Litoria pallida	1		21			53	7
Litoria rothii	1	5				90	5
Litoria rubella	1	5	2	4		11	2
Litoria splendida	1						

Litoria tornieri		7					
Litoria wotjulmensis			8			2	
Notaden melanoscarphus		1	3	2		3	1
Opisthodon ornatus	1	2	23		9	4	12
Uperoleia borealis	1	51	77				2
Uperoleia trachyderma	1						
Uperoleia lithomoda						21	
TOTAL		**370**	**386**	**164**	**49**	**266**	**118**

REPTILES

	Naturemap	Sorby	Packsaddle	Mantinea	Westbank	HLA	Ecologia
Acanthophis praelongus							1
Amphibolurus gilberti subsp. gilberti	1	6	15	5	17		22
Amphibolurus gilberti	1						2
Amphibolurus temporalis		1					
Antaresia childreni	1	3	1				2
Aspidites melanocephalus	1						1
Boiga irregularis	1						
Brachyurophis roperi	1	1					
Carlia amax	1					1	
Carlia munda	1	20	28	50	1	31	15
Carlia tricantha		6					1
Carlia rufilatus						12	2
Chelodina rugosa	1		3				
Chlamydosaurus kingii	1					3	4
Crocodylus johnstoni	1		1				6
Crocodylus porosus							2
Cryptoblepharus exochus	1						
Cryptoblepharus carnabyi						2	6
Cryptoblepharus metallicus				2	1		
Cryptoblepharus plagiocephalus		1				66	13
Cryptoblepharus ruber	1			5			
Cryptophis pallidiceps	1			1			
Ctenotus inornatus	1	8	6	19	1	1	6
Ctenotus militaris	1				7		
Ctenotus pantherinus			5		2		
Ctenotus pantherinus subsp. calx	1					2	
Ctenotus piankai	1						
Ctenotus rimacola subsp. camptris	1	1	1			1	

Ctenotus robustus	1	5	5	1	9	34	6
Ctenotus tantillus	1		2		1	13	2
Delma sp.						2	
Delma tincta	1	1		2	1		3
Demansia sp.						1	1
Demansia papuensis	1	30	1		2		
Demansia vestigiata	1	2		3		4	
Dendrelaphis punctulata	1					1	
Diplodactylus ciliaris ciliaris						11	2
Diplodactylus stenodactylus							1
Diporiphora arnhemica	1						
Diporiphora bennettii	1					1	
Diporiphora bilineata						5	
Diporiphora lalliae	1		5		3		1
Diporiphora magna	1	1			2	83	7
Emydura australis	1		9				
Eremiascincus fasciolatus						2	
Furina ornata	1			1			1
Gehyra australis	1			1		42	4
Gehyra koira		2					
Gehyra nana	1					15	4
Gehyra punctata							1
Glaphyromorphus isolepis	1		2	1		4	6
Heteronotia binoei	1	2	10	16	38	19	24
Heteronotia planiceps	1						
Lerista borealis	1						1
Lerista greeri						3	
Lerista griffini	1	12	15	3	3	6	4
Lialis burtonis	1						1
Liasis mackloti subsp. fuscus	1					1	
Liasis olivaceus subsp. olivaceus	1						
Lucasium stenodactylus					3		
Menetia alanae							1
Menetia greyii	1			8	1	5	15
Menetia maini	1					1	
Morethia ruficauda subsp. ruficauda	1	5	1		2	8	3
Morethia storri						2	
Notoscincus ornatus subsp. wotjulum	1					2	
Oedura rhombifera						2	1

Proablepharus tenuis	1					2	3
Pseudechis australis	1	2		1		3	3
Pseudonaja ingrami	1		1				
Pseudonaja nachalis					1		1
Pygopus steelescotti	1						
Ramphotyphlops diversus	1					1	
Ramphotyphlops guentheri	1						
Ramphotyphlops ligatus	1				2	2	4
Ramphotyphlops unguirostris	1						1
Strophurus ciliaris subsp. ciliaris	1				3		
Suta ordensis	1						
Suta punctata		1					
Tiliqua multifasciata	1						
Tiliqua scincoides subsp. intermedia	1	7					2
Tropidonophis mairii		32	1	5		2	1
Tympanocryptis lineata							1
Varanus acanthurus	1	4			2	1	3
Varanus gouldii			1				4
Varanus mertensi		1	2			1	2
Varanus mitchelli	1		4				
Varanus panoptes subsp. panoptes	1					4	3
Varanus scalaris	1	6				4	4
Varanus tristis							2
Vermicella intermedia	1					1	
Vermicella multifasciata	1						
	TOTAL	**160**	**119**	**124**	**102**	**407**	**206**

Appendix 3: Ornithological Assessment describing all Avifauna Species

SORBY MANAGEMENT PTY LTD



BIRD SPECIES RICHNESS AND DIVERSITY IN SORBY MANAGEMENT PROPRIETY LIMITED (SMPL) SORBY HILLS SILVER LEAD ZINC PROJECT (SORBY HILLS).

OCTOBER 2011

Author

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This report was completed for Sorby Management Pty Ltd

KML11002 – Sorby Hills Biological Assessment Survey

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ABSTRACT

A total of 95 species were actually recorded in the five day field survey of the Sorby Management Propriety Limited (SMPL) Sorby Hills Silver Lead Zinc Project (Sorby Hills). Based on records collected by Animal Plant Mineral (APM) from 23 collection events in the local area over the period from May 2009 to May 2011, and comparing the size and structure of the project area with other similar areas that were surveyed over longer periods, the Sorby Hills project area potentially supports 144 species of birds. Most of the species recorded are common to the surrounding areas. Previous surveys have revealed that up to 239 species of birds, including 90 passerines and 149 non-passerines are expected to occur in the Ord River floodplains and surrounding ranges.

The bird assemblages recorded in the Sorby Hills project area are representative of those communities that would inhabit similar habitats elsewhere. There are no habitats or microhabitats in the proposed impact area that are not well represented elsewhere in the East Kimberley region.

However, the standing fresh water bodies at Sorby Hills are an important component of the habitat within the Sorby Hills project area, despite the fact that three (i.e. the cattle yards, the old incline, the Sorby Hills dams) of the four water bodies are not naturally occurring.

Many species recorded during the survey would utilise many of the habitats described on various occasions throughout the project area over the different seasons. The low relative area of impact of the project ensures that the majority of these habitats will remain and sustain viable populations of these species. Volant fauna (bats and birds) can be resilient to broad-scale clearing, provided that habitat resources required for breeding or refuge are retained to some degree. Highly mobile volant fauna can move beyond disturbed areas to feed. However, damage to nesting or refuge sites can lead to demise in local populations. In some cases this can persist to an extent where the species is unable to recolonise.

A total of 40 species were recorded during the systematic census. KML Census Site 001 had the highest species richness and the greatest number of species unique to the site. KML Census Site 005 had the second highest species richness but only one species unique to the site. KML Census Site 003 and Site 004 were located in similar woodland habitat and had similar species richness and composition.

Richness, Abundance and Diversity data were also calculated for the Weaber Plains Ord Stage 2 project. Based on a total of 50 census there was an average of 12 species and 47 individuals located, and the average diversity was 1.936. All of the calculated indices are lower for Sorby Hills than for Weaber Plain. Only KML Census Site 1 had a diversity indices within the 95% confidence interval of Weaber Plains. All sites with the exception of KML Census Site 2 were within one standard deviation of the Weaber Plains diversity index.

Despite the minor variations in the avifauna habitats across the five Sorby Hills sites chosen for sampling there was no significant difference in richness, abundance or diversity between any of the five survey areas.

When the data are compared with the Parry Lagoon wetland area Parry Lagoon is shown to have a significantly greater diversity than both Weaber Plains and Sorby Hills using the census data for morning census only (Parry Lagoon was not surveyed in the afternoon thus reducing the power of the test.

A total of eight species listed under the EPBC Act (1999) as Threatened or Migratory or Other Matters have been recorded in recent surveys undertaken by APM in the region. Five of these species were recorded during the survey at Sorby Hills and one additional species, White-bellied Sea-eagle, has been recorded occupying the Keep River nearby. Though not recorded during the Sorby Hills survey, the Common Cicadabird and Rufous Fantail have a preference for dry rainforest, vine scrub or tall riverine forest of Melaleuca leucadendra, and vine covered slopes. There are some suitable habitats in the project area. The Cattle Egret, Eastern Great Egret and the Rainbow Bee-eater were listed species common to all three survey areas (Parry Lagoon, Weaber Plain and Keep River/Border Creek). Rainbow Bee-eaters were very common in each of the areas and in much of northern Australia may include both sedentary and migratory animals, depending on the time of year. Cattle Egret were observed in much greater numbers at Parry Lagoon (100 individuals) and Keep River/Border Creek (71 individuals) than at Weaber Plain (3 individuals) and Sorby Hills (16 individuals). Fifteen Eastern Great Egrets were recorded at Parry Lagoon and 18 were recorded at Keep River/Border Creek. This compares with only two recorded on the Weaber Plain project area and a single individual recorded at Sorby Hills.

The record of Gouldian Finch was made at the base of the Sorby Hills at KML003, exactly where the species would be expected to occur at this time of the year.

The entire design and layout of the SMPL Sorby Hills mine has been structured around maintaining the required habitat for the Gouldian Finch, with the development exclusion zone allowing quality breeding habitat in the foot hills of the Sorby Hills to remain undisturbed. A number of the existing permanent freshwater sources are also forecast to remain undisturbed.

Leading up to the commencement of the development SMPL are committed to undertaking further survey work for the Gouldian Finch.

Although disturbance to the Sorby Hills project area will have localised impact on the bird species that utilise the area, the regional impact will be made less significant if other areas providing a greater array of critical habitats, such as Parry Lagoons, are actively maintained and managed as conservation reserves.

As part of the of the Ord River Irrigation Area – Weaber Plain Development Project the Weaber Plain area will have 10 805 ha set aside as a buffer zone and conservation area. This area will be destocked to improve its habitat integrity. The Environmental Impact Statement

identifies that more than 75% of habitat suitable for EPBC listed wetland species will be preserved and that approximately 30% of habitat for remaining non-wetland specific birds (mainly small passerines) will be preserved. The buffer area represents almost exactly 50% of the total area outlined in the Weaber Plain Development Project.

Within the 1782 ha of the SMPL lease areas (M80/197 and M80/286), only 427.8 are going to be impacted and therefore 1354.47 ha or 76 % will be retained. These areas will be destocked and burning will be managed to stimulate Gouldian Finch retention.

In addition to the 10805 ha buffer area managed by the Ord Irrigation Expansion, a total of approximately 188 200 ha of rangelands will be conserved under the Ord final agreement Within these reserves, habitat identical to that which occurs at Sorby Hills will be preserved.

The development boundaries of the Sorby Hills project have been designed specifically to enhance and maintain the value of avifauna habitat around the base of Sorby Hills, the interzone with Knox Creek Plain and the densely vegetated grassland around KML Census Site 001.

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1. INTRODUCTION

1.1 INTRODUCTION AND SCOPE OF WORK

Sorby Management Propriety Limited (SMPL) proposes to develop the Sorby Hills Silver Lead Zinc Project (Sorby Hills), 50km north north-east of Kununurra, Western Australia. SMPL intend to mine four ore pods out of three open pits located on the Knox Creek Plain, with a small number of the infrastructure components located on the slightly elevated foothills of the adjacent Sorby Hills. The project is proposed to mine below the water table and water may be dispensed into the Keep River or used to irrigate crops as part of the Ord Irrigation Expansion Project (OIEP).

Adjacent to the proposed Sorby Hills project area is the now approved development of 10 300 hectares associated with the OIEP, and an associated buffer zone of 10 480 ha surrounding the irrigated farm lots that are still to be constructed. The buffer zone was proposed as part of the development to ensure the preservation of cracking clay habitat and the protection of the proposed Pincombe Range and Weaber Range conservation areas adjacent to Weaber Plain.

The Sorby Hills project area is shown in proximity to the OIEP development in Figure 1. Figure 2 shows the location of the pits and infrastructure in relation to the Knox Creek Plains and uplands of Sorby Hills.

The proposed development of the Sorby Hills area will be referred under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to the Minister for Sustainability, Environment, Water, Populations, Arts and Community (SEWPAC). The development of the Sorby Hills project has the potential to have a significant impact on listed threatened species and communities (sections 18 and 18A) and listed migratory species (sections 20 and 20A) protected under Part 3 of the *EPBC Act 1999* (Commonwealth).

The *EPBC Act 1999* listed species of interest for the current survey included:

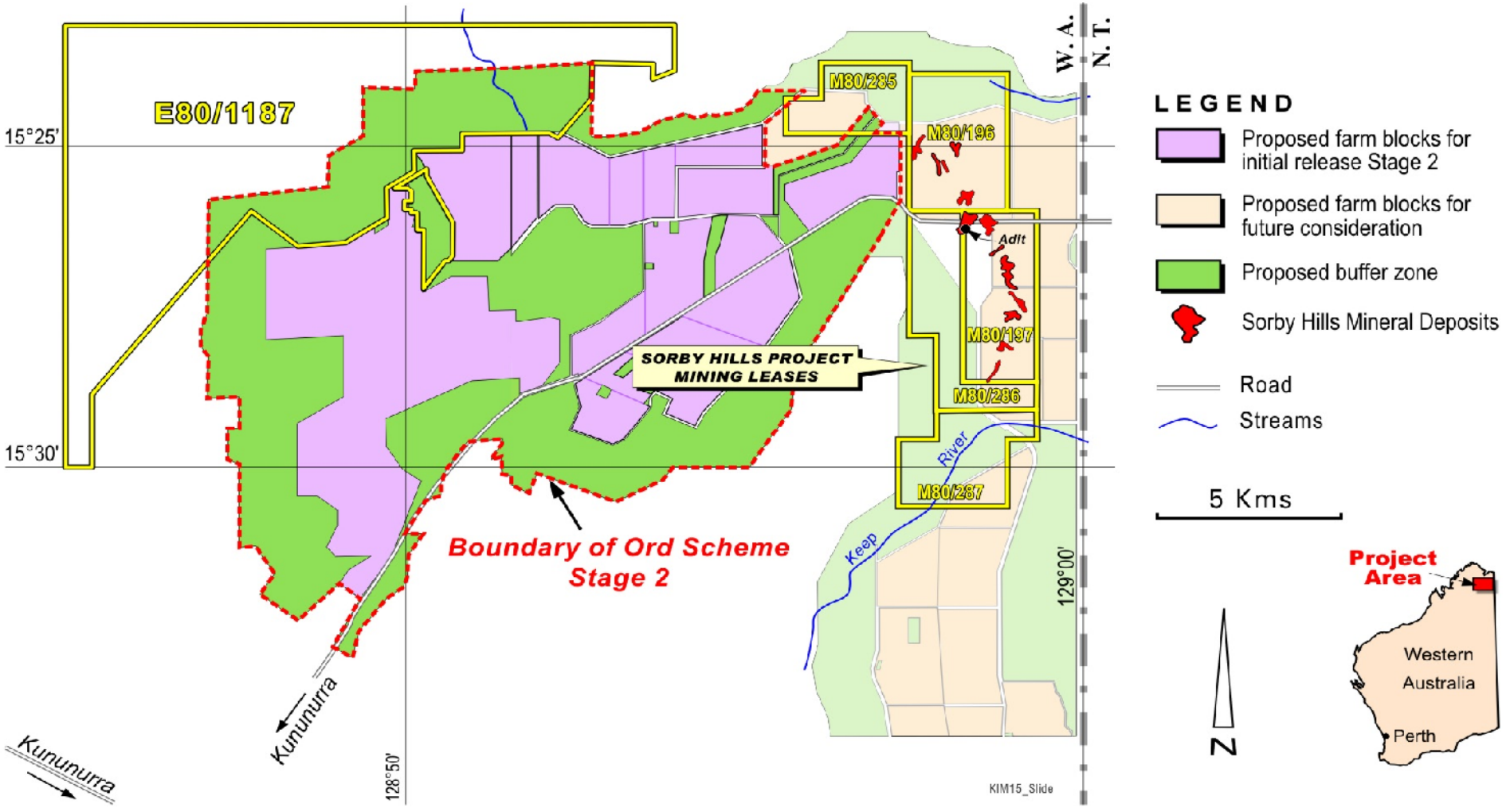
1. **Red Goshawk** *Erythrotriorchis radiatus* Threatened (Vulnerable)
2. **Gouldian Finch** *Erythrura gouldiae* Threatened (Endangered). Migratory (terrestrial)
3. **Northern Shrike-tit** *Falcunculus frontatus whitei* Threatened (Vulnerable). Migratory (terrestrial)
4. **Purple-crowned Fairy-wren (western]** *Malurus coronatus coronatus* Threatened (Vulnerable)
5. **Australian Painted Snipe** *Rostratula australis* Threatened (Vulnerable)
6. **Melville Cicadabird** *Coracina tenuirostris melvillensis* Migratory (terrestrial)
7. **White-bellied Sea-Eagle** *Haliaeetus leucogaster* Migratory (terrestrial)

8. **Barn Swallow** *Hirundo rustica* Migratory (terrestrial)
9. **Rainbow Bee-eater** *Merops ornatus* Migratory (terrestrial)
10. **Derby White-browed Robin** *Poecilodryas superciliosa cerviniventris* Migratory (terrestrial)
11. **Rufous Fantail** *Rhipidura rufifrons* Migratory (terrestrial)
12. **Great Egret** *Ardea alba* Migratory (wetland/marine)
13. **Cattle Egret** *Ardea ibis* Migratory (wetland/marine)
14. **Oriental Plover** *Charadrius veredus* Migratory (wetland)
15. **Oriental Pratincole** *Glareola maldivarum* Migratory (wetland)
16. **Painted Snipe** *Rostratula benghalensis s. lat.* Migratory (wetland)
17. **Fork-tailed Swift** *Apus pacificus* Migratory (marine)

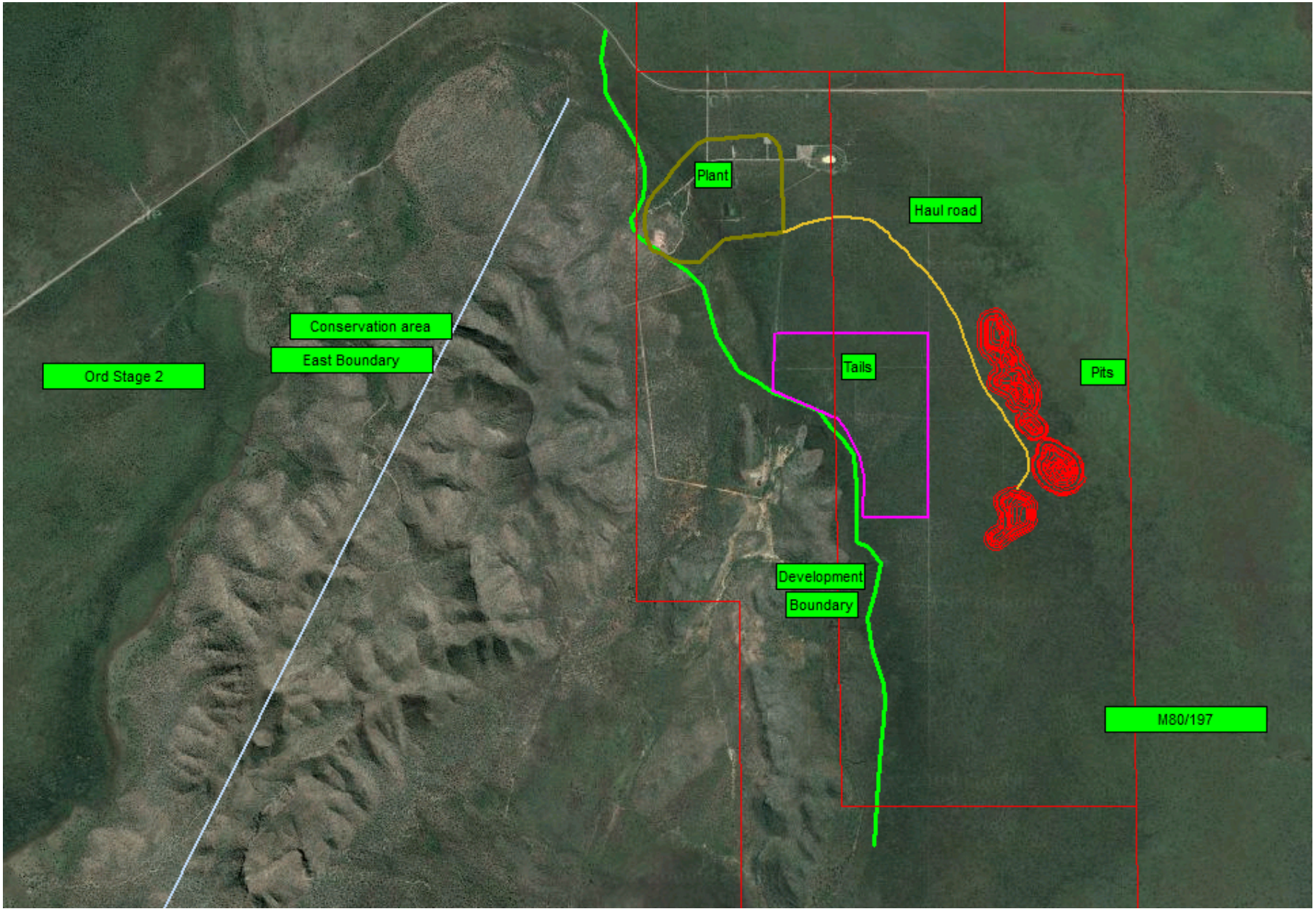
To determine the extent of the potential impact from the proposal on general avifauna assemblages and EPBC 1999 Act (Cth) threatened and migratory bird species that utilise the Sorby Hills area, Animal Plant Mineral Pty Ltd undertook a systematic survey of birds occupying the project area and compared the data with similarly acquired data from the Weaber Plains OIEP project area and Parry Lagoons, which is an area currently designated as a conservation reserve (Parry Lagoons Nature Reserve). Similarities or differences in avifauna assemblages between these three areas could then be extrapolated to determine the general avifauna assemblages in areas not proposed for disturbance.

A secondary objective was to determine whether or not the Knox Creek plains areas of the Sorby Hills project, which are comprised mainly of cracking clay floodplains, provided any avifauna habitat that was significantly better flood plain habitat than that already designated as conservation reserve elsewhere or that designated as 'buffer' in the OEIP. To achieve this secondary objective, ornithologists replicated the comprehensive and systematic census surveys at Weaber Plain and Parry Lagoons Nature Reserve and the data were compared with all other sites (i.e. project total 20 sites).

Opportunistic surveys were also undertaken along the Keep River to determine the species assemblages along these riverine habitats that may be adversely impacted by tail water flowing out of the irrigation area and along these watercourses.



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral NORTH	**Figure 1: General Location Map**
Date: October 2011	Datum: GDA94 MGA Zone 52		



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral NORTH	**Figure 2: Locations of Proposed Disturbance Areas Relative to the Topographic Features of Sorby Hills and the Knox Creek Plain**
Date: October 2011	Datum: GDA94 MGA Zone 52		

1.2 BACKGROUND AND EXISTING ENVIRONMENT

Based on the mapping of Fox et al (2001) the vast majority of the project area has been categorised as *Eucalyptus tectifica* (Darwin box) and/or *Corymbia* spp. Woodland with *Sorghum* spp.(sorghum) and *Sehima nervosum* (white grass) tussock grasses. This vegetation overlies Cainozoic alluvial plains and piedmont fans. The Cainozoic clay deposits form gently undulating plains with poorly developed drainage systems. There are deep cracking clays of moderate to high fertility and a gilgai microrelief.

Where the project area is interspersed with sandstone outcrops or is adjacent to sandstone ranges the vegetation shifts to *Eucalyptus microtheca* (coolibah) or *Eucalyptus gymnoteles* (coolibah) and/or *Eucalyptus* spp. +/- *Excoecaria parvifolia* (gutta percha) grassy low woodland. The Cainozoic sands are uniform and generally very level. The sands, earths or texture contrasts often overlie laterite profiles or weathered or unweathered bedrock.

The survey was undertaken at the end of one of the wettest summer rainfall seasons on record, associated with a widespread La Nina event that affected much of northern Australia. The total average accumulated rainfall at Kununurra for February, March and April is 370.4 mm (Table 1). However, 854 mm had fallen in the three months prior to the current survey (Appendix 1). In the previous year, when the comparative data for Weaber Plain and Parry's Lagoon were collected, the region was experiencing a very dry wet season. February rainfall was lower than average, with 172mm falling; 41mm less than the average. March 2010 was very dry with only 84mm falling compared with the average of 136mm. This is a total of 256mm for the two months, as compared with the average of 349.2 mm, and the 2011 total of 745 mm. During the Sorby Hills survey (April 2011), the majority of the Knox Creek plains area was flooded. On the foothills of the Sorby Hills little surface water was apparent and the Sorghum grasses were dry and setting seed.

Table 1: Average Temperature and Rainfall Data for Kununurra (Bureau of Meteorology)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	36.4	35.5	35.4	35.5	32.9	30.5	30.3	33.6	36.4	38.3	38.8	38.0	35.1	21	1965 1986
Mean minimum temperature (°C)	25.2	24.9	24.1	21.4	19.1	15.9	15.0	17.4	20.8	23.7	25.4	25.7	21.6	21	1965 1986
Rainfall															
Mean rainfall (mm)	196.6	213.0	136.2	21.2	10.0	1.3	3.9	0.1	2.8	25.5	70.9	105.3	796.8	30	1962 1997
Decile 5 (median) rainfall (mm)	181.1	210.9	102.9	8.8	0.0	0.0	0.0	0.0	0.0	13.1	57.6	101.6	778.7	27	1962 1997
Mean number of days of rain ≥ 1 mm	10.4	10.6	7.2	1.8	0.7	0.2	0.2	0.1	0.3	1.9	4.1	6.9	44.4	27	1962 1997

2. METHODS

The field survey was undertaken from 16 – 21 April, 2011. The total number of hours spent recording data was 25 hours.

To determine the similarity and differences between the areas as habitat for avifauna, ornithologists undertook a comprehensive and systematic series of bird census for replicated sites. Replicated sites included one site within the Sorby Hills project impact footprint, one site within the Weaber Plain development area and a comparison site selected in close proximity, but within the buffer zone. A total of five replicated sites were selected for assessment giving a total of 15 sites for analysis.

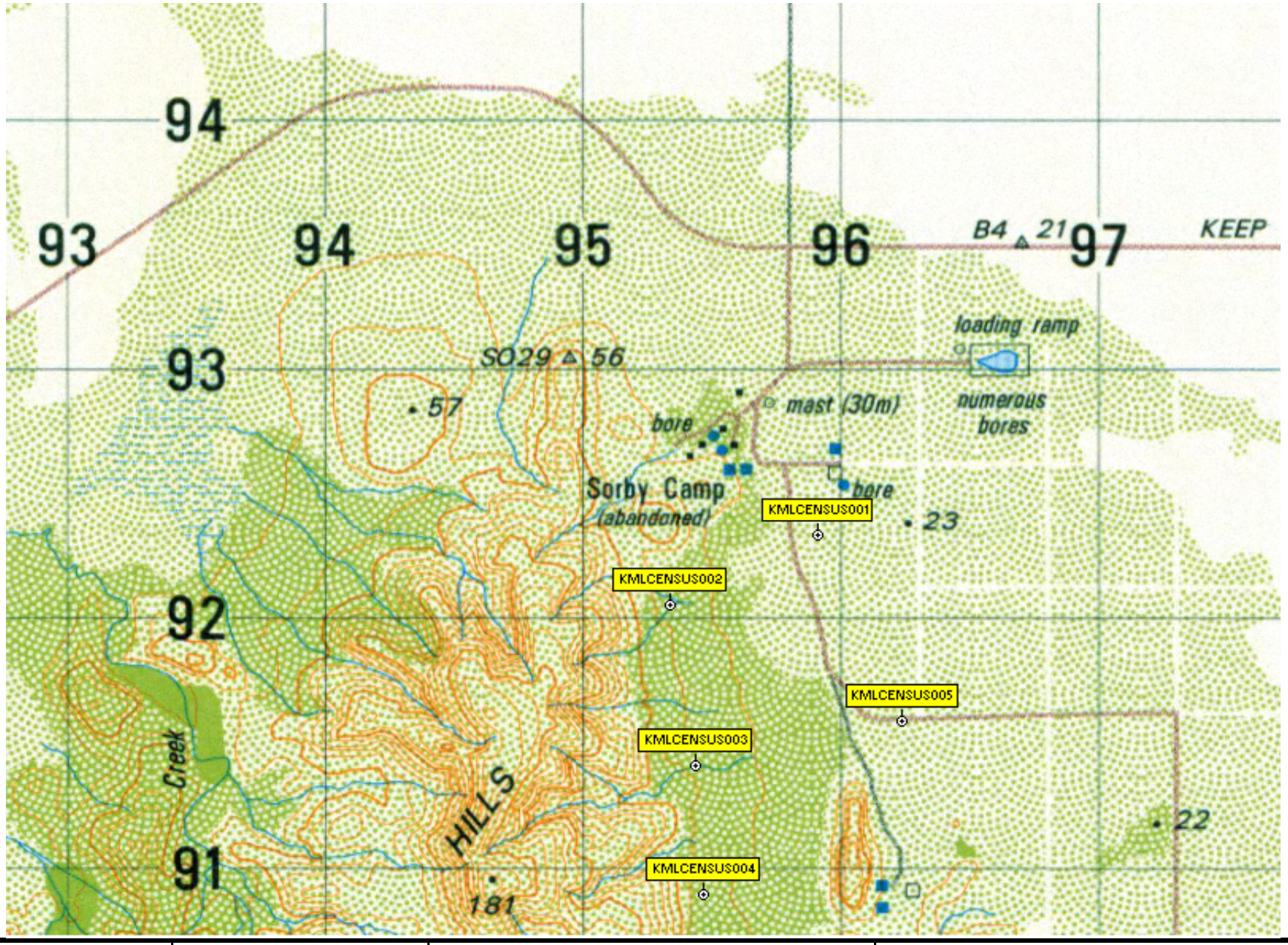
Systematic surveys were undertaken to replicate survey methodology of Birds Australia Atlas and Bird Monitoring data collection protocols (see http://www.birdsaustralia.com.au/our-projects/atlas-birdata.html). Surveys were undertaken for 20 minutes and commenced on the hour at 0600 hrs, 0700 hrs, 0800 hrs, 1600 hrs and 1700 hrs.

Ornithologists were restricted to moving within a 2.5 ha area and had to stay within the same core habitat. Hence, surveys undertaken along drainage lines were longer than they were wide. However, in most cases census areas radiated out from a centre point to cover the appropriate area.

During the set time census ornithologists were not to record any bird species or activity outside of the survey area or outside of the survey duration. Any data that were collected outside the census parameters were recorded separately and were not included in the analysis of systematic data.

Five sites were chosen in the project area (Figure 3). Each of the sites was selected to represent slight variation in the typical tropical savanna common to the region. Site photos are presented in Appendix 2 and each site photo has a brief description of the dominant vegetation type. The time of day that each site was sampled shifted daily so all sites were sampled at all times (Table 2)

The methodology described above was structured to minimise all variables such that the species richness and diversity recorded during the censuses could be compared between sites statistically. It is not appropriate to compare data quantitatively where those data are not collected systematically. Controlling variable such as time of day, duration, area surveyed and date enabled species richness and diversity of sites to be analysed and compared.



Auth: M Ladyman	Project: SMPL Sorby Hills	apm animal plant mineral	**Figure 3: Locations of the Avifauna Systematic Census Sites**
Date: October 2011	Datum: GDA94 MGA Zone 52	NORTH	

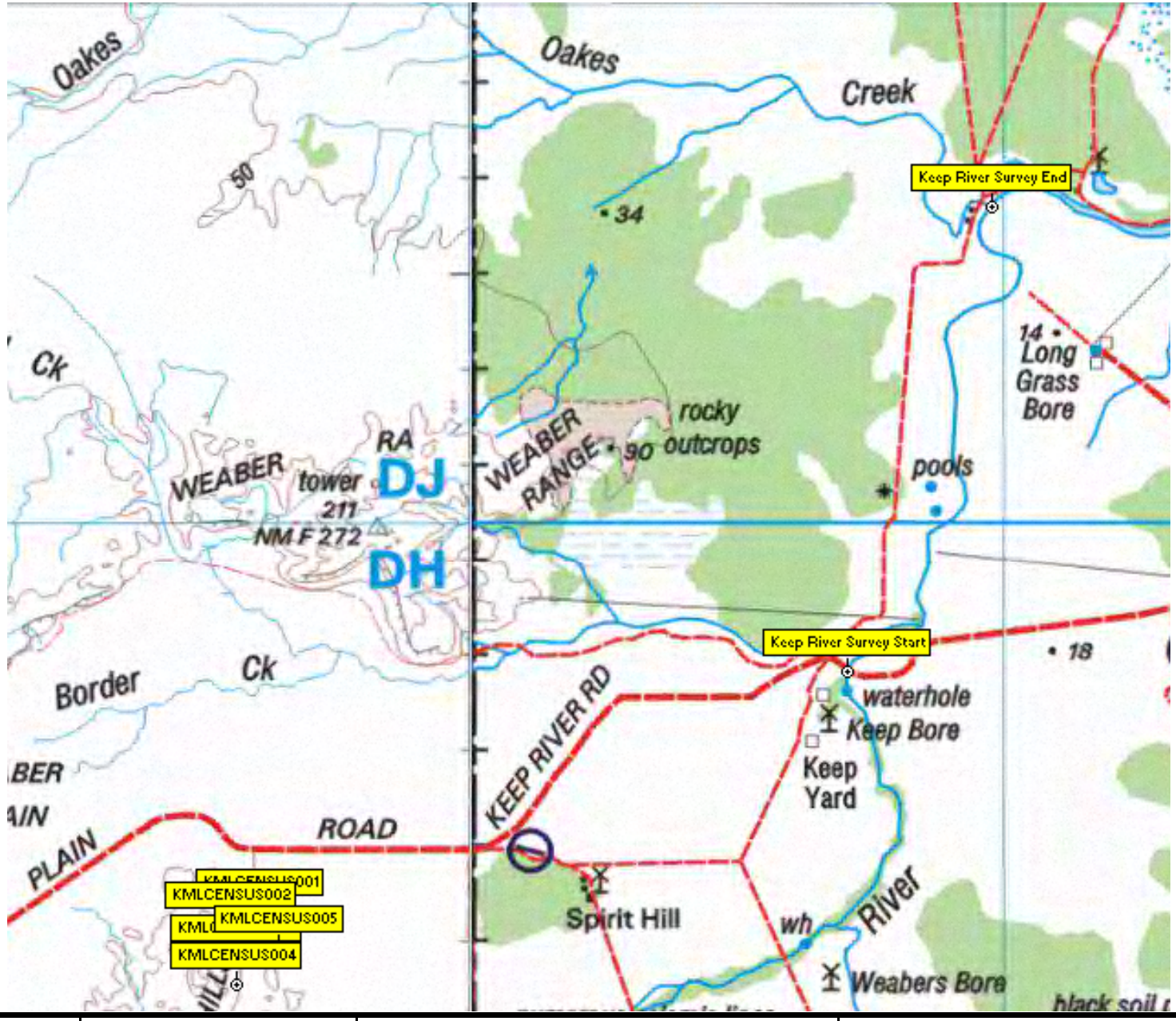
Table 2: Example Table to show Variation in Site Sampling over Time (Rows), Days (Columns) and Ornithologists (Cells)

	0600		0700		0800		1600		1700	
17/4/2011	Steve Reynolds	KML001	Steve Reynolds	KML002	Steve Reynolds	KML003	Steve Reynolds	KML004	Steve Reynolds	KML005
18/4/2011	Steve Reynolds	KML002	Steve Reynolds	KML003	Steve Reynolds	KML004	Steve Reynolds	KML005	Steve Reynolds	KML001
19/4/2011	Steve Reynolds	KML003	Steve Reynolds	KML004	Steve Reynolds	KML005	Steve Reynolds	KML001	KML002	Steve Reynolds
20/4/2011	Steve Reynolds	KML004	Steve Reynolds	KML005	Steve Reynolds	KML001	Steve Reynolds	KML002	Steve Reynolds	KML003
21/4/2011	Steve Reynolds	KML005	Steve Reynolds	KML001	Steve Reynolds	KML002	Steve Reynolds	KML003	Steve Reynolds	KML004

The slightly elevated areas of the Sorby Hills and the fringes of the Knox Creek floodplain were all subjected to intensive opportunistic sampling. Considerably more effort would have been expended on the floodplain areas if these areas had been accessible in April. These areas are proposed for further sampling in November 2011. This was the most appropriate method to reveal the presence of EPBC Act 1999 (cth) listed threatened and migratory bird species. It was also the most appropriate method to increase the general species count and obtain a reasonable assessment of the total species richness of the areas.

Opportunistic sampling commenced half an hour before sunrise on most days (0515 hrs) and proceeded throughout the day. Where possible, and appropriate, diurnal sampling was augmented with nocturnal sampling in an effort to record species such as owls and night jars. During opportunistic sampling ornithologists start at a set point and wander freely in pursuit of species of interest. For instance, an ornithologist may pursue feeding flocks of finches in an effort to discover individual Gouldian Finches foraging in mixed flocks. As stated, these surveys are opportunistic and it is difficult to approximate the area and locations covered. As a general rule, ornithologists rarely move more than 1 – 1.5 km in a one hour census, and remain within a particular habitat type for the duration of the census. The level of intensity, coverage and success of opportunistic sampling is usually measured by the number of species recorded and the number of species of conservation significance located. A total of 18 hours were spent during opportunistic surveys of the key areas of interest.

With regard to the opportunistic surveys of Keep River the ornithologist restricted their sampling attention to the riverine habitats that may be adversely impacted by tail water flowing out of the project area and along these water courses. Sampling occurred along the Keep River from the intersection of Keep River Road and Keep River north to the further most point that was accessible, marked as Far North Keep on Figure 4. This work was undertaken in 2010.



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral NORTH	**Figure 4: Relative Location of Sites Sampled along the Keep River**
Date: October 2011	Datum: GDA94 MGA Zone 52		

3. RESULTS

A total of 95 species were recorded in the KML project area during the April census period (Table 3). An additional 30 species were recorded from the Weaber Plains clay pan habitats and a further 31 species were recorded from the surrounding rangelands. Twelve species were common to both these adjacent areas.

Table 3: Records of Bird Species Richness in the Project Area and Adjacent Areas

	Recorded at KML	Recorded in Adjacent Plains	Recorded in Adjacent Rangelands	Recorded in Adjacent Ranges and Plains
Bird Species Richness	95	18	19	12

Approximately 72% of the total bird species (n=107) recorded in the adjacent plains habitat and 63% of total species (n=85) recorded in the adjacent ranges were recorded at KML. Therefore it is reasonable to expect that the avifauna species richness for the project area is 144 species. A total of forty-one species not recorded at KML were recorded in rivers and creeks in the region.

Table 4 identifies bird species that were expected to occur at Sorby Hills that had only been recorded at one other survey site. There were a number of bird species that were recorded at Sorby Hills that have been recorded infrequently elsewhere. These species are identified in Table 5

Five species listed under the EPBC Act (1999) as Threatened or Migratory or Other Matters were recorded during the Sorby Hills survey. A total of eight EPBC listed species have been recorded in recent surveys undertaken by APM in the region (Table 6). The three additional species not recorded at KML include the Common Cicadabird, the Rufous Fantail and the White-bellied Sea-eagle. A White-bellied Sea-eagle has been recorded close by on the Keep River Road crossing of Keep River with another individual recorded on the river up-stream with both sites shown on Figure 4.

Table 4: Species Expected to Occur at Sorby Hills that have only previously been recorded at one Other Location in the Kununurra Region

Species	Comment
Eurasian Coot	common and widespread, but less common in monsoonal northern Australia
Australasian Figbird	This species requires dense rain forest patches. Has the potential to occur, though unlikely.
Little Crow	May potentially occur. However, it is a seasonal visitor recorded in the dry season only.
Yellow Chat	Generally uncommon and very patchily distributed in suitable habitat
Eastern Barn Owl	Nocturnal so not often encountered.
Rufous Fantail	May potentially occur in the dense dry rainforest patches.
Common Cicadabird	Uncommon in the Kimberley and elsewhere. EPBC listed species.
Variegated Fairy-wren	Restricted to rocky or rangeland habitats and has been recorded at Pinncombe Range.
Black Falcon	Vagrant and transitory bird of prey, so recorded infrequently.
Common Bronzewing	Usually distributed inland, however, may extend to the southern Kimberley.
Eastern Grass Owl	Nocturnal and uncommon, but may potentially occur.
Grey Falcon	Vagrant and transitory bird of prey, so recorded infrequently. DEC Priority listed species.
Grey-fronted Honeyeater	Usually distributed inland, however, the distribution can extend to the southern Kimberley.
Long-toed Stint	Regarded as an uncommon migratory freshwater shore bird.
Square-tailed Kite	Vagrant and transitory bird of prey, generally regarded as rare or uncommon.

Table 5: Species Recorded at Sorby Hills and only Recorded at Four or Fewer other Locations

Species	# previous locations	Comment
Green Pygmy-goose	4	Not regarded as common in the Kimberley and requires permanent water.
Red-chested Button-quail	4	Not regarded as common and also difficult to identify when flushed.
Tawny Grassbird	4	Moderately common, but usually only recorded during the wet season.
Wandering Whistling-Duck	4	Populations can be highly localised in the Kimberley; requires freshwater.
Australian Owlet-nightjar	3	Nocturnal so not often encountered.
Spotless Crake	3	Not regarded as being common and also particularly difficult to locate in the field; occupies dense vegetation near water.
Red-kneed Dotterel	2	Common where suitable habitat occurs, and perhaps shows the limitations of available habitat.
Zitting Cisticola	2	Recorded very occasionally but usually only on short grassy estuarine plains in the East Kimberley. An unusual record.

Table 6: EPBC Listed Avifauna Species Recorded in the Kununurra Region

	Apr-10	Aug-10	Aug-10	Mar-10	Mar-10	Mar-10	Mar-10	Mar-10	Mar-10	Mar-10	Mar-10	Jun-10	May-10	Jun-10	May-10	May-10		
EPBC Listed Species	KML Sorby Hills	Weaber Plain	Border Cr/Keep River	Weaber Plain Development Area	Westbank	Packsaddle	Pincombe Range Conservation Area	Livistona Range Conservation Area	Ningbing Range Conservation Area	Point Springs	Keep River	Oakes Creek	Packsaddle	Mantinea	West Bank	East Bank	Total Number of Individuals Recorded	Number of Locations Recorded
Cattle Egret	26	3	71		15								3	20	5		**143**	**7**
Common Cicadabird									3								**3**	**1**
Eastern Great Egret	3	2	18	4									10	14	8		**59**	**7**
Gouldian Finch	3	35				8									5		**51**	**4**
Rainbow Bee-eater	45	132	150				8	3		2		4	113	514	124	15	**1110**	**11**
Rufous Fantail																	**0**	**0**
White-bellied Sea-Eagle			15								2	1	2	3	2		**25**	**6**
Magpie Goose	3	1												25			**29**	**3**

Single record of Rufous Fantail cannot be attributed to a single project area listed above.

A total of 40 species were recorded during the systematic census. The limitations imposed on the set time systematic censusing obviously significantly reduced the number of species recorded. During the systematic census periods the Peaceful Dove, Red-backed Fairy-wren and Weebill were the three most common species recorded. Other common and widepsread species included Bar-shouldered Dove, Rainbow Bee-eater, Rufous Whistler and White-throated Honeyeater.

KML Census Site 001 was noted as having the highest species richness and the highest number of species unique to the site, with 12 species only found at Site 1. Site 5 had the second highest species richness but only one species unique to the site. Site 3 had 16 species of which 5 were unique while Site 4 had 14 species of which 3 were unique. Site 2 had 10 species, none of which were unique to the site.

Richness, Abundance and Diversity data were also calculated for the Weaber Plains Ord Stage 2 project. Based on a total of 50 census there was an average of 12 species and 47 individuals located, and the average diversity was 1.936. All of the calculated indices are lower for Sorby Hills than for Weaber Plain. Only KML Census Site 1 had a diversity indices within the 95% confidence interval of Weaber Plains. All sites with the exception of Site 2 were within one standard deviation of the Weaber Plains diversity index.

Despite the minor variations in the avifauna habitats across the five Sorby Hills sites chosen for sampling (see Appendix 2 for site photos and brief descriptions) there was no significant difference in richness, abundance or diversity between any of the five survey areas. When all of the Weaber Plains sites are compared with the Sorby Hills sites, Weaber Plains is shown to have a higher diversity than Sorby Hills ($P= 0.01$, $T_{(73)} = 2.637$).

When the data are compared with the Parry Lagoon wetland area (Table 7), Parry Lagoon is shown to have a significantly greater diversity than both Weaber Plains and Sorby Hills using the census data for morning census only (Parry Lagoon was not surveyed in the afternoon thus reducing the power of the test).

Table 7: Summary Statistics of Comparison of Systematic Census Results

Comparison	Difference	q	P Value
Parry vs Weaber	0.6134	5.223	** P<0.01
Parry vs Sorby	0.8325	6.759	*** P<0.001
Weaber vs Sorby	0.2191	1.779	ns P>0.05

The record of Gouldian Finch was made at the base of the Sorby Hills at KMLCensus Site 002. This sighting consisted of several birds that appeared to be moving through the woodland area.

4. DISCUSSION

4.1 SPECIES RICHNESS

A total of 95 species were actually recorded in the five day field survey of the Sorby Management Propriety Limited (SMPL) Sorby Hills Silver Lead Zinc Project (Sorby Hills). These species were recorded over 25 periods of set time censusing, with additional time spent recording opportunistic sightings.

Based on records collected by Animal Plant Mineral (APM) from 23 collection events in the local area over the period from May 2009 to May 2011, and comparing the size and structure of the project area with other similar areas that were surveyed over longer periods, the Sorby Hills project area potentially supports 144 species of birds. A total of 1360 bird records were made during the Sorby Hills field survey. However the analysis of ornithological data reported herein is based on the collection of an approximate 57 000 bird records. This is an estimate, as large numbers of birds in flocks are often not counted individually but approximated. Censusing, using similar techniques in adjacent areas around the Ord River region show that there is a very significant positive correlation between the time spent searching and the number of species recorded ($y = 1.4356x + 51.356$, $R^2 = 0.8569$), up to the expected or potential total species richness. Therefore, it can be concluded that a similar survey effort would have revealed a similar number of the same species.

Most of the species recorded are common to the surrounding areas. For instance, of the 95 species recorded at Sorby Hills, 80 were recorded on the Mantinea Flats. Analysis of records from the adjacent 23 other surveys reveals that 81 (85%) species have been recorded at 5 or more other locations. Approximately 46 (48%) of the species recorded have been located at 10 locations.

The greatest species richness recorded in a single survey within the same region by APM is 139 species recorded at Mantinea Flats following 69 hours of censusing.

There are many avifauna habitats that are common to these two areas including red earth plains and black soil plains, with some fresh water lagoons, and an open savanna of high grasses surrounded by abrupt ranges of Proterozoic sandstone.

Previous surveys have revealed that up to 239 species of birds, including 90 passerines and 149 non-passerines are expected to occur in the Ord River floodplains and surrounding ranges. Ecologia (1996) recorded a total of 156 species of birds over 64 hours of sampling in the Weaber Plain, Keep River and Knox Creek areas during October 1996 and February 1997 (ecologia 1997). George Swann recorded 162 species of birds in 150 hours of sampling the Packsaddle, West Bank and Mantinea flood plain areas in 2009 (APM, 2009). Robinson

(1961) noted 121 species based on surveys in the Ord River area in the vicinity of the Kimberley Research Station and other locations (including lagoons) during two weeks in June 1960. With the effect of fire, human disturbance and feral predation the avifauna species assemblages may now be greatly simplified when compared to their historical presence and it is unlikely that the full complement of 239 species could be recorded, even if several surveys were undertaken throughout a single year or over multiple years.

4.2 AVIFAUNA ASSEMBLAGES AND HABITAT USE

The bird assemblages recorded in the Sorby Hills project area are representative of those communities that would inhabit similar habitats elsewhere. There are no habitats or microhabitats in the proposed impact area that are not well represented elsewhere in the East Kimberley region.

The standing fresh water bodies at Sorby Hills are an important component of the habitat within the Sorby Hills project area, despite the fact that three (i.e. the cattle yards, the old incline, the Sorby Hills dams) of the four water bodies are not naturally occurring. A total of eight species of Anseriformes (ducks and geese) have been recorded in the region and four of these species were located at Sorby Hills, including Radjah Shelduck, Green Pygmy-goose and Wandering Whistling-Duck. The only other surveys to record a similar number of species from this group were the Mantinea and Parry Lagoon surveys. Both of these sites support very large fresh water lagoons, such as Marlgu Billabong in the Parry Lagoons Nature Reserve. Permanent wetlands in the monsoonal tropics of Australia are important as dry season refuge areas for waterbirds, with many birds congregating at these sites as surrounding areas dry out (Crawford, 1979). Despite the extensive work undertaken at Weaber Plain, immediately adjacent to Sorby Hills, only two species of ducks were recorded, reflecting the limited availability of suitable freshwater habitats in the area.

Sorby Hills also provides important watering points for large numbers of finch species, including the Yellow-rumped Mannikin, Chestnut-breasted Mannikin, Star Finch, Masked Finch, and Double-barred Finch, with many finches congregating in the long grass surrounding the cattle yard dam. Most importantly, the area provides water for Gouldian Finch. The dense shrubs around the incline dam make this location ideal for drinking birds including finches, doves and honeyeaters.

The Sorby Hills project area is located no less than 55 km from the coast and does not support any mangal, estuarine or samphire communities. Therefore, Sorby Hills supports very few species of Charadriiforms (predominantly coastal waders, gulls and terns). Although many of these species will occupy inland water bodies, only three species were recorded near water in the project area; Black-fronted Dotterel, Red-kneed Dotterel and Masked

Lapwing. The Black-fronted Dotterel is generally more common than the Red-kneed Dotterel but both species live around lagoons where they feed along the muddy fringes (Blakers et al., 1984). The Bush Stone-curlew is a slightly aberrant, nocturnal species of wader that is fully terrestrial. Thirty eight species of charadriiformes are known to occur in the region, based on APM records. However, the majority were recorded in near coastal areas such as around the mouth of the Ord River, the false mouths of the Ord River and Parry's Lagoons. A very large number of these species were also located during the Border Creek surveys, where the confluence of Border Creek and the Keep River is more representative of an estuarine environment.

The value of the freshwater bodies at Sorby Hills is reflected in the number of Ciconiiformes (herons, bitterns, ibises and spoonbills) species that the project area supports. Sorby Hills, the nearby Border Creek and Packsaddle each recorded 12 species from this group, while other areas, such as Mantinea Flat and Westbank, recorded 13 and 9 species respectively. Most of the herons and egrets in the project area were recorded near the partially inundated cattle yards area, including four species of white egret, Pied Heron and White-faced Heron. However, the Black Bittern, a rarely encountered, largely nocturnal species, was observed in seasonally inundated woodland habitat at KML Census Site 005. A total of three surveys on the Weaber Plains only recorded 8 species. All of these survey areas recorded the two EPBC listed Ciconiiforme species; the Eastern Great Egret and the Cattle Egret. All of these survey areas encompass at least one open fresh water body with associated seasonal shallow inundated grassland.

The nocturnal bird assemblage at Sorby Hills was well represented with all three of the Caprimulgiformes (frogmouths and nightjars) species known from the region (Tawny Frogmouth, Spotted Nightjar and Australian Owlet-nightjar) recorded opportunistically at night. This was most likely attributed to the amount of time spent surveying at night. All of these species were also recorded nearby at Border Creek, where significant time was spent searching at night. Common owls, such as the Boobook Owl and Barking Owl were not recorded at Sorby Hills and Mantinea Flats was the only project area, of the 24 surveys, to record the Eastern Barn Owl and Eastern Grass Owl.

The Sorby Hills survey was one of only two sites across the 24 sites surveyed where all three species of Turniciformes (button quails) were located. This may have been due to the levels of inundation pushing individuals off the flats and into the slightly elevated foothills. Alternatively, it may be due to the quality of the grasslands that occur at Sorby Hills and the timing of the survey at a time of the year when these birds are active.

Of the eight species of Columbiformes the four most common species were recorded at KML. The Diamond Dove and Common Bronzewing were not recorded at KML, despite being commonly recorded locally and regionally. This may be because the species is typically recorded in woodlands near drinkable water and, during the survey, the woodlands were

mostly inundated. Diamond Doves are more likely to occur in the Kimberley in the dry season, when they move from drier inland areas to subcoastal sites (Crawford, 1972). The Spinifex Pigeon was not recorded despite the amount of survey time spent in it's preferred habitat of hills or stony flats near water; it is likely to occur in nearby more elevated habitat in the Pincombe Range. The Emerald Dove occupies monsoon forests and acacia thickets, and this species was not likely to utilise the project area, except in the small patches of dry tropical vine thicket. Records of the Emerald Dove and Spinifex Pigeon were sparse across all survey areas in the region.

Several parrot species were observed in the area, including small flocks of Red-tailed Black Cockatoos on most days, and a group of Little Corella near the cattle yards. Good numbers of Red-winged Parrot were also evident in the area.

Only one species of Cuculiformes (Cuckoos) was located at Sorby Hills. In most other areas at least five of the recorded eight species were located. It may be that the timing was in between seasons where birds are migrating or moving south. Species such as Brush Cuckoo and Koel are more prominent in the wet season, whereas Pallid Cuckoo is generally a dry season visitor to the East Kimberley. Looking at the records of other surveys during the same time period, it appears that this group is sparse in the area around March.

Eleven to 16 species of Falconiformes (birds of prey) were recorded in each of the separate surveys of the Mantinea, Packsaddle and West Bank areas in the dry season of 2009. Five species were recorded at Sorby Hills which is the average number of species recorded from this group across the 24 individual surveys. Most were common species including Brown Falcon and Whistling Kite, but the less common species Brown Goshawk and Little Eagle were also observed. Other species are likely to occur in the project area, however raptors invariably occur at low densities and can be difficult to detect.

Gruiformes (cranes, rails, crakes, waterhens, coots and bustards) occurred sporadically across all of the 24 surveys with a total of seven species recorded. However, few surveys recorded more than three species from this group, with Sorby Hill recording three species. The Brolga and the Australian Bustard have been recorded at a number of the sites, but the Spotless Crake was only recorded at three sites, all of which provide the dense water side vegetation this species requires.

The records for the Pelecaniformes give some indication of the type of fresh water habitat available on site. Only the Little Pied Cormorant and the Pelican were recorded of the five species from this group known to occur in the region. Other sites such as Border Creek and Mantinea recorded four of the five species and all five species were recorded at West Bank. These three sites all have very deep water bodies that probably supporter a greater diversity of fish fauna than the water bodies at Sorby Hills. For instance Johnson and Storr (1998) notes that the Pied Comorant only occupies the deeper fresh water of Lake Argyle, and the

Little Black Comorant, not found at Sorby Hills, is described as rarely occupying reservoirs and farm dams.

Sorby Hills supports a very typical assemblage of Passerine species. Half of the passerines recorded in the region over the 24 surveys were recorded at Sorby Hills. In other similar surveys, where a similar amount of set time censusing was undertaken, between 58 and 69% of the passerine species were recorded. Eight species of honeyeater (Meliphagidae), six species of finch (Estrildidae) and three species of cuckoo-shrikes (Campephagidae) were recorded in the area. Many passerine species were located around the base of Sorby Hills. This area provides suitable breeding habitat for the Gouldian Finch, which would then feed in the open plains during the remainder of the year.

Gouldian Finches are commonly found in association with Long-tailed Finches, although not exclusively. More than 200 Long-tailed Finches were located in 13 areas along Border Creek and the Keep River. One hundred individuals were found across 13 areas in the Weaber Plain project area, however none were recorded in the Sorby Hills area during the April survey.

Other passerine species recorded in the project area that tend to be infrequently observed included Black-tailed Treecreeper (resident at KML Census Site 003 in Eucalypt woodland habitat), Masked Finch, Yellow-rumped Mannikin (moderately abundant in long grass), Zitting Cisticola and Varied Sittella (recorded opportunistically on the lower slopes of the hills).

4.3 GENERAL HABITAT USE

The extensive pastures of sorghum and other grasses are very important feeding areas supporting large numbers of finches, the two button-quail species, Black-faced Woodswallow and Varied Sitella. Most importantly, these are the feeding areas of the Gouldian Finch. Often significant volumes of seed drops to the ground after fire, creating opportunities for feeding flocks of finches, such as were observed in this area.

The Tawny Grassbird was recorded on a number of occasions in very tall grass growing through heavily inundated soil where the foot hills meet the plain. This species has a scattered distribution in suitable habitats and is more widespread in the wet season, found among rank vegetation where it breeds. Other species located around this habitat include Red-backed Fairy Wren, Golden-headed Cisticola and Yellow-rumped Mannikin.

There were no large water courses supporting large Eucalypts likely to support the Red Goshawk. However, the Barking Owl and Masked Owl would be expected to occur in the Eucalypt woodlands that sit in the small valley between the base of the Sorby Hills, before the plains commence. In areas of well-developed *Eucalyptus tectifica* woodland typical

species were present, including Black-faced Woodswallow, Black-tailed Treecreeper, Jacky Winter, Brown Honeyeater and Rufous-throated Honeyeater.

Observations of birds of prey indicated that the interface between the foothills and the plains were heavily favoured by this group, with all five species recorded only along the fringe of the foothills. This habitat provides roosting trees, grass plains over which to forage and possible up drafts for soaring.

A total of forty-one species not recorded at KML were recorded in rivers and creeks in the region. There are no significant rivers or creeks in the project area, however, there is potential for secondary downstream impacts from changes in flow regime arising from modifications of the landscape within the project impact footprint.

Many species recorded during the survey, such as the very conspicuous Red-tailed Black Cockatoo, would utilise many of the habitats described on various occasions throughout the project area over the different seasons. The low relative area of impact of the project ensures that the majority of these habitats will remain and sustain viable populations of these species. Volant fauna (bats and birds) can be resilient to broad-scale clearing, provided that habitat resources required for breeding or refuge are retained to some degree. Highly mobile volant fauna can move beyond disturbed areas to feed. However, damage to nesting or refuge sites can lead to demise in local populations. In some cases this can persist to an extent where the species is unable to recolonise. The Purple-crowned Fairy-wren is a good example. This species was once distributed along the entire length of the Ord River. It is now only present in the upper reaches of Lake Argyle. Habitat destruction from grazing and fire compromised populations on the lower Ord River and they have since never recovered.

However, for the most part this impact is unlikely to significantly impact local populations of species that will move to neighbouring undisturbed sites.

4.4 SYSTEMATIC CENSUS

A total of 40 species were recorded during the systematic census. The limitations of recording birds in a set area during replicated cenuses reduced the number of species recorded during systematic censuses, but facilitate comparisons with other surveys conducted using identical procedures.

The common and widespread species Peaceful Dove, Red-backed Fairy-wren and Weebill were the three most common species recorded during systematic surveys. Bird species recorded at four or more systematic sites included Peaceful Dove, Rainbow Bee-eater, Red-backed Fairy-wren, Rufous Whistler, Striated Pardalote and White-throated Honeyeater.

KML Census Site 001 had the highest species richness and the greatest number of species unique to the site. A total of 12 species were only found at Site 001 during systematic censuses, including Chestnut-breasted Mannikin, Yellow-rumped Mannikin, Star Finch, Tawny Grassbird, Golden-headed Cisticola and Zitting Cisticola. The tall, dense grassland understorey at this site was particularly suited to flocks of granivorous finches. Species of Cisticola occupy rank grass and are more conspicuous during the wet season when they are calling, and were observed regularly at Site 001. KML Census Site 005 had the second highest species richness but only one species unique to the site. KML Census Site 003 and Site 004 were located in similar woodland habitat and had similar species richness and composition.

Richness, Abundance and Diversity data were also calculated for the Weaber Plains Ord Stage 2 project. Based on a total of 50 census there was an average of 12 species and 47 individuals located, and the average diversity was 1.936. All of the calculated indices are lower for Sorby Hills than for Weaber Plain. Only KML Census Site 1 had a diversity index within the 95% confidence interval of Weaber Plains. All sites with the exception of KML Census Site 2 were within one standard deviation of the Weaber Plains diversity index.

Despite the minor variations in the avifauna habitats across the five Sorby Hills sites chosen for sampling (see Appendix 2 for site photos and brief descriptions) there was no significant difference in richness, abundance or diversity between any of the five survey areas.

When the data are compared with the Parry Lagoon wetland area Parry Lagoon is shown to have a significantly greater diversity than both Weaber Plains and Sorby Hills using the census data for morning census only (Parry Lagoon was not surveyed in the afternoon thus reducing the power of the test.

4.4 EPBC LISTED SPECIES

A total of eight species listed under the EPBC Act (1999) as Threatened or Migratory or Other Matters have been recorded in recent surveys undertaken by APM in the region. Five of these species were recorded during the survey at Sorby Hills and one additional species, White-bellied Sea-eagle, has been recorded occupying the Keep River nearby.

Though not recorded during the Sorby Hills survey, the Common Cicadabird was recorded during ground survey work in Ningbing Range, approximately 50km north of the Sorby Hills site. The species has a preference for dry rainforest, vine scrub or tall riverine forest of Melaleuca leucadendra. There are very few patches of suitable habitat for this species other than those marked on Figure 5.

The Rufous Fantail also occupies habitats similar to those of the Common Cicadabird. In addition it also inhabits vine covered slopes. Such habitat was noted as occurring on the KML site and also shown in Figure 5 (purple polygons in addition to white polygons).

Though it is not possible to make statistical comparisons of the number of listed species each area supports, the data show that the Cattle Egret, Eastern Great Egret and the Rainbow Bee-eater were listed species common to all three survey areas (Parry Lagoon, Weaber Plain and Keep River/Border Creek). Rainbow Bee-eaters were very common in each of the areas and in much of northern Australia may include both sedentary and migratory animals, depending on the time of year. Cattle Egret were observed in much greater numbers at Parry Lagoon (100 individuals) and Keep River/Border Creek (71 individuals) than at Weaber Plain (3 individuals) and Sorby Hills (16 individuals). Fifteen Eastern Great Egrets were recorded at Parry Lagoon and 18 were recorded at Keep River/Border Creek. This compares with only two recorded on the Weaber Plain project area and a single individual recorded at Sorby Hills.

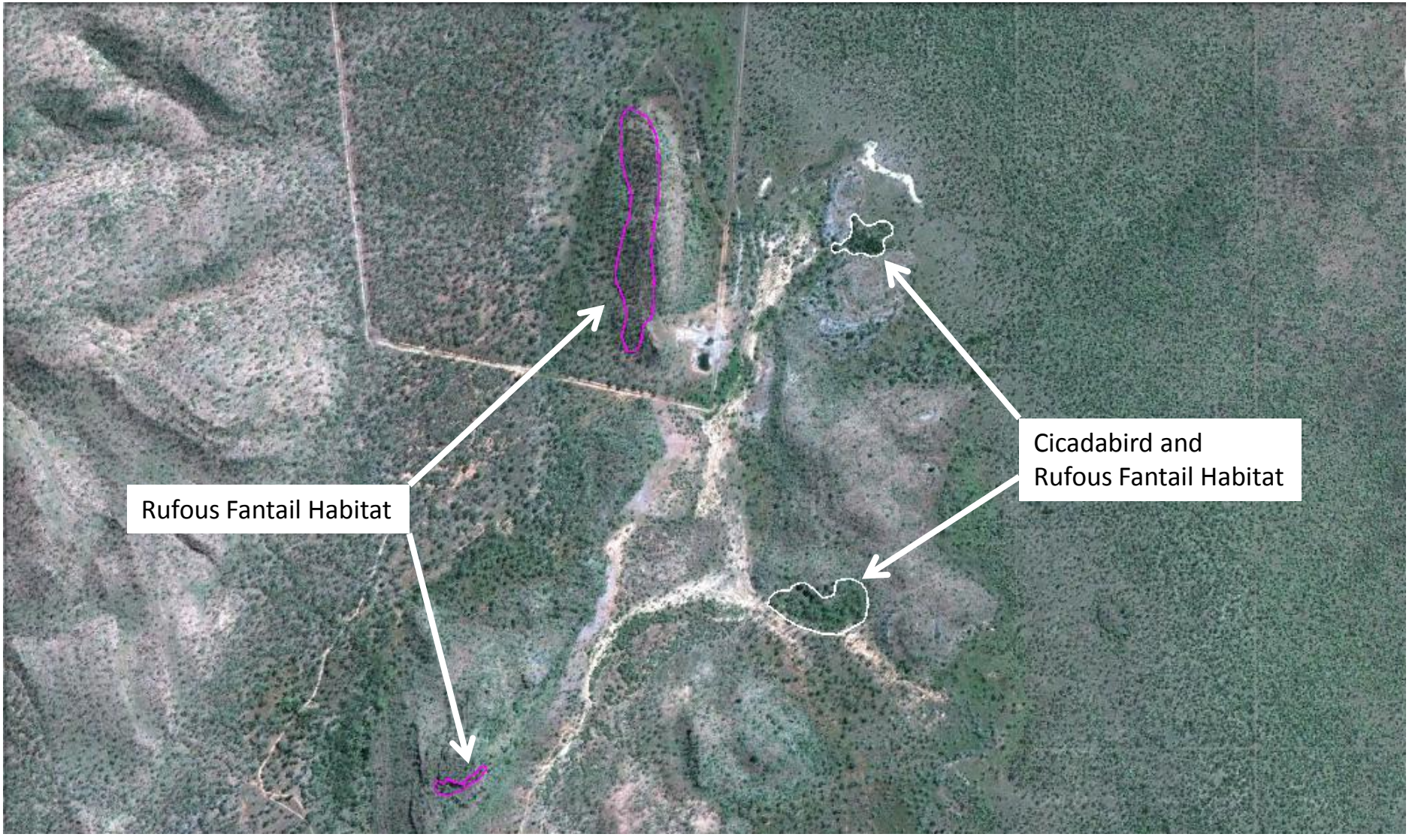
The great majority of the 17 EPBC Act 1999 (cth) target species potentially occurring in the survey areas were not located during the surveys. Nevertheless, a sub-set of these species may occur and consideration should be given to where they potentially occur.

It is possible that the Northern Shrike-tit *Falcunculus frontatus whitei* may occur in the foothills of Sorby Hills. Several key plant species were noted as occurring along the western boundary of M80/286.

No habitat appeared suitable for Purple-crowned Fairy-wren (western) *Malurus coronatus coronatus*. Some small pockets of tropical vine thicket were located to the south east of the 'Lagoon' area shown on Figure 5. Melville Cicadabird *Coracina tenuirostris melvillensis* may utilise this habitat and the area looked particularly suitable for Derby White-browed (Buff-sided) Robin *Poecilodryas superciliosa cerviniventris* and Rufous (Arafura) Fantail *Rhipidura rufifrons*. The fact that this suite of species was absent is most likely due to the historical impact from cattle grazing in the area, and in particular, along the creeks.

No habitat was present for the Australian Painted Snipe *Rostratula australis* due to the lack of permanent wet areas and Typha spp. sedge due to the impact from cattle. This species is hard to locate as it feeds at night sheltering in shade, sometimes away from water, during the day.

The Barn Swallow *Hirundo rustica*, Fork-tailed Swift *Apus pacificus*, Oriental Pratincole *Glareola maldivarum* and the Oriental Plover *Charadrius veredus* are all migratory species that could potentially use the project area. The Barn Swallow and Fork-tailed Swift are aerial species that may pass over the project area, whereas Oriental Plover are most likely in areas of dry ground such as near the cattle yards.



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral NORTH	**Figure 5: Cicadabird and Rufous Fantail Habitat**
Date: October 2011	Datum: GDA94 MGA Zone 52		

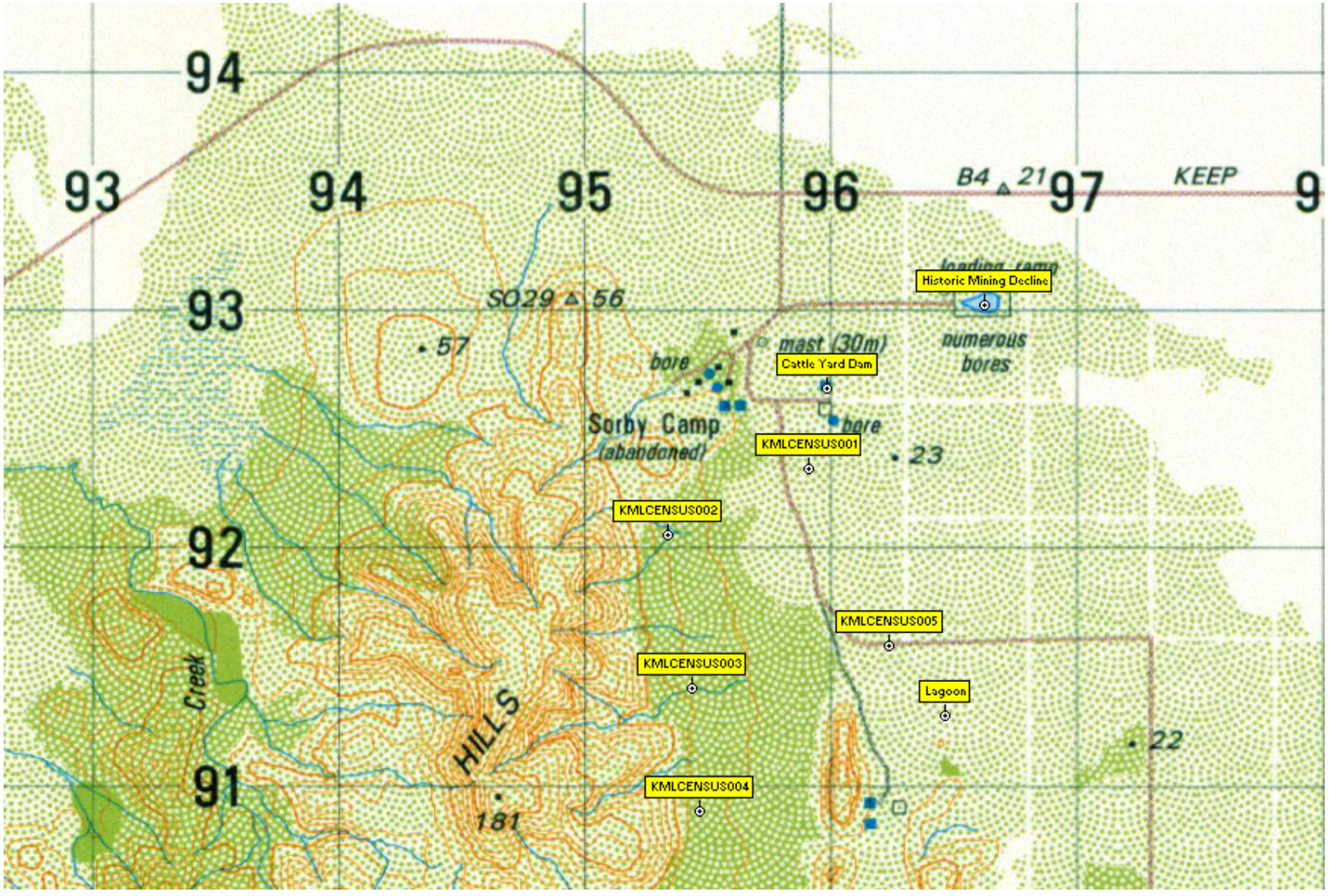
4.4.1 GOULDIAN FINCH

The record of Gouldian Finch was made at the base of the Sorby Hills at KML003, exactly where the species would be expected to occur at this time of the year.

This record suggests that similar flocks of Gouldian Finches could occupy other foothills in the local area. The species is strongly dependant on *Sorghum* spp. grasslands for food and individuals are usually found foraging in close proximity to fresh water. Their ecology is very well documented through studies in suitable areas of the Northern Territory (Tidemann and Woinarski, 1994). The potential impact of the development of the Sorby Hills has been considered in the context of loss of grasslands, increased fire risk, and loss of habitat to dust and feral fauna and contamination of local water sources.

The entire design and layout of the SMPL Sorby Hills mine has been structured around maintaining the required habitat for the Gouldian Finch, with the development exclusion zone allowing quality breeding habitat in the foot hills of the Sorby Hills to remain undisturbed. A number of the existing permanent freshwater sources are also forecast to remain undisturbed. Potential water sources for the Gouldian Finch are shown in Figure 6.

Leading up to the commencement of the development SMPL are committed to undertaking further survey work for the Gouldian Finch. An assessment of local populations of Gouldian Finch, comprising the monitoring of any and all remnant water bodies in the Weaber Plains area for two hours after sunrise for no less than five consecutive mornings (as per the methodology of the Save the Gouldian Fund's annual water hole counts) was proposed for October, 2011. However, this 2011 survey was abandoned by APM/SMPL and the Save the Gouldian Fund. Due to the unusual amount of rainfall in the Kimberley earlier in 2011, too much water was still present on the plains. This makes populations counts impossible to undertake with any degree of accuracy. It is anticipated that this work will continue in 2012.



Auth: M Ladyman	Project: SMPL Sorby Hills	animal plant mineral NORTH	**Figure 6: Potential Water Sources for the Gouldian Finch**
Date: October 2011	Datum: GDA94 MGA Zone 52		

4.5 IMPACT MITIGATION

Although disturbance to the Sorby Hills project area will have localised impact on the bird species that utilise the area, the regional impact will be made less significant if other areas providing a greater array of critical habitats, such as Parry Lagoons, are actively maintained and managed as conservation reserves.

As part of the Ord River Irrigation Area – Weaber Plain Development Project the Weaber Plain area will have 10 805 ha set aside as a buffer zone and conservation area. This area will be destocked to improve its habitat integrity. The Environmental Impact Statement identifies that more than 75% of habitat suitable for EPBC listed wetland species will be preserved and that approximately 30% of habitat for remaining non-wetland specific birds (mainly small passerines) will be preserved. The buffer area represents almost exactly 50% of the total area outlined in the Weaber Plain Development Project.

Thus it is reasonable to suggest that as the Ord Irrigation Expansion program continues across the remaining stages, a similar percentage of plains habitat will be preserved. This would include the Knox Creek area.

However, within the 1782 ha of the KML lease areas (M80/197 and M80/286), only 427.8 ha are going to be impacted and therefore 1354.47 ha or 76 % will be retained. Similar to the OIEP development, the Sorby Hills project area will be destocked and burning will be managed to stimulate Gouldian Finch retention.

In addition to the 10805 ha buffer area managed by the OIEP, and the area to remain undisturbed in the project tenement boundaries, the signing of the Ord final agreement has resulted in the establishment of six reserves in the surrounding ranges and the Packsaddle Swamp conservation area. In total this area covers some 188 200 ha. Within these reserves, habitat identical to that which exists within the Sorby Hills project will be preserved.

As previously stated the development boundaries have been designed specifically to enhance and maintain the value of avifauna habitat around the base of Sorby Hills, the interzone with Knox Creek Plain and the densely vegetated grassland around KML Census Site 001.

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APPENDIX 1 – SUMMARY CLIMATE DATA

APPENDIX 1: SUMMARY CLIMATE DATA

Date	Day	Temps		Rain
		Min	Max	
		°C	°C	mm
1	Tu	23.8	34.4	0
2	We	24.6	34.4	2.6
3	Th	25.1	37.5	0
4	Fr	22.8	34.3	19.8
5	Sa	26.5	33	0
6	Su	23.8	31	32.6
7	Mo	24.3	28.1	28
8	Tu	23.2	29.9	79.4
9	We	23.5	33.3	37.8
10	Th	24	34.9	0
11	Fr	25.3	30	0
12	Sa	22.5	33.1	0.2
13	Su	22.8	32.4	23
14	Mo	22.5	32.2	13
15	Tu	22.8	34	17.6
16	We	25.4	35	0
17	Th	26	33.3	0
18	Fr	24.2	32.2	1.2
19	Sa	23.4	27	30.4
20	Su	23.7	29.6	34
21	Mo	24.5	31.2	0.4
22	Tu	24.6	33	2.2
23	We	25.3	33.5	6.2
24	Th	22.7	32.2	9.8
25	Fr	23.8	29.7	18
26	Sa	24.1	31.2	21.8
27	Su	24.5	30.5	41.4
28	Mo	24.9	31.4	6
Statistics for February 2011				
	Mean	24.1	32.2	
	Lowest	22.5	27	0
	Highest	26.5	37.5	79.4
	Total			425.4

Date	Day	Temps		Rain
		Min	Max	
		°C	°C	mm
1	Tu	24.6	31	0.2
2	We	25.2	32.6	0.2
3	Th	24.6	33.8	1.6
4	Fr	25	32.9	13
5	Sa	24.5	29.7	9.6
6	Su	24.7	32.3	21
7	Mo	24.5	32	0.4
8	Tu	24.7	32.9	0.4
9	We	23.8	29.6	40.4
10	Th	22.6	28.9	24.8
11	Fr	23.6	28.7	28.2
12	Sa	24	27.8	20.2
13	Su	23.3	29.8	40.8
14	Mo	23.8	34.1	3.6
15	Tu	24.9	32.8	0.2
16	We	24.6	32.5	0
17	Th	24.4	34.6	0
18	Fr	23.9	32.1	18.4
19	Sa	23.7	33.5	4.6
20	Su	25.5	34.1	0
21	Mo	24	32.9	20.8
22	Tu	23.5	33.1	3.8
23	We	23.5	32.9	50.8
24	Th	24.5	30.7	7.2
25	Fr	23.6	32.3	9.6
26	Sa	25.3	32.2	0
27	Su	25.5	32.2	0
28	Mo	26.1	33.4	0
29	Tu	23.9	34.5	0
30	We	24.3	34.9	0.4
31	Th	26.3	32.8	0
Statistics for March 2011				
	Mean	24.4	32.2	
	Lowest	22.6	27.8	0
	Highest	26.3	34.9	50.8
	Total			320.2

Date	Day	Temps		Rain
		Min	Max	
		°C	°C	mm
1	Fr	23	26.4	1.6
2	Sa	22.9	25.3	
3	Su	23	25.7	
4	Mo	23.5	25.3	98.2
5	Tu	21.5	28.6	9.2
6	We	23.9	31.3	0
7	Th	24.2	32.6	0
8	Fr	24.8	34.4	0
9	Sa	24.8	34.1	0
10	Su	24.2	33.8	0
11	Mo	23.4	33	0
12	Tu	20.2	32.5	0
13	We	19.9	32.6	0
14	Th	21.3	33.1	0
15	Fr	23.7	31.4	0
16	Sa	21.7	31.9	0
17	Su	22.8	30.6	0
18	Mo	16.5	29.6	0
19	Tu	14.7	30.1	0
20	We	15	31.9	0
21	Th	15.9	32.3	0
22	Fr	18.4	33.2	0
23	Sa	20.1	33.3	0
24	Su	17.7	32.2	0
25	Mo	19	33	0
26	Tu	17.7	33.6	0
27	We	18.5	33.1	0
28	Th	18.9	32.3	0
29	Fr	17.1	32.1	0
30	Sa	17.8	32	0
Statistics for April 2011				
	Mean	20.5	31.4	
	Lowest	14.7	25.3	0
	Highest	24.8	34.4	98.2
	Total			109

APPENDIX 2 – SITE PHOTOS

Appendix 2 – Site photos for the Sorby Hills Project Area and comparison areas on Weaber Plains and Parrys Lagoon.



Plate 1: KML Census Site 001



Plate 2: KML Census Site 002

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Plate 3: KML Census Site 003



Plate 4: KML Census Site 004

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Plate 5: KML Census Site 005



Plate 6: WPD1 - *Terminalia* sp. over sparse grassland on seasonally waterlogged black clay-loam.

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Plate 7: WPB1 - ?*Excoecaria ovalifolia* over ?*Chrysopogon latifolia* and other grasses.



Plate 8: WDP2- *Typha* ?*domingensis* swamp.

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Plate 9: WPB- *Typha* ?*domingensis* swamp.



Plate 10: WPD3 - *Lysiphyllum* (Bauhinia) *cunninghamii* and *Terminalia* sp. with ?*Codonocarpus cotinifolius* over tall grassland.

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Plate 11: WPB3 - *Lysiphyllum* (Bauhinia) *cunninghamii* and *Eucalyptus tectifica* over tall grassland (?*Chrysopogon* or annual *Sorghum* sp.)



Plate 12: WPB4 - ?*Excoecaria ovalifolia* with *Eucalyptus tectifica* and *Melaleuca* sp. along drainage line.

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Plate 13 WPB4 - ?*Excoecaria ovalifolia* with *Eucalyptus tectifica* and *Melaleuca* sp. along drainage line.



Plate 14: WPD5 - *Vachellia* ?*ditricha* over tall grassland.

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Plate 15: WPB5 - *Lysiphyllum* (Bauhinia) *cunninghamii* over tall grassland.

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Plate 16: PC1A- Lagoon with *Nymphaea* ?*immutabilis* subsp. *immutabilis* bordered by riverine vegetation.



Plate 17: PC1G - Lagoon with *Nymphaea ?violacea*.

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Plate 18: PC2A - Open grassland of *Heteropogon contortus* and C*hrysopogon* sp. with *Passiflora foetida* and scattered *Hakea arborescens*.



Plate 19: PC2G - Open grassland of *Heteropogon contortus* with sparse *Chrysopogon* sp. and scattered *Adansonia gregori*.

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Plate 20: PC3A - Open woodland with *Corymbia polycarpa*, *Acacia tumida* and *Planchona careya* over tall grassland (?*Chrysopogon* or annual *Sorghum* sp.)



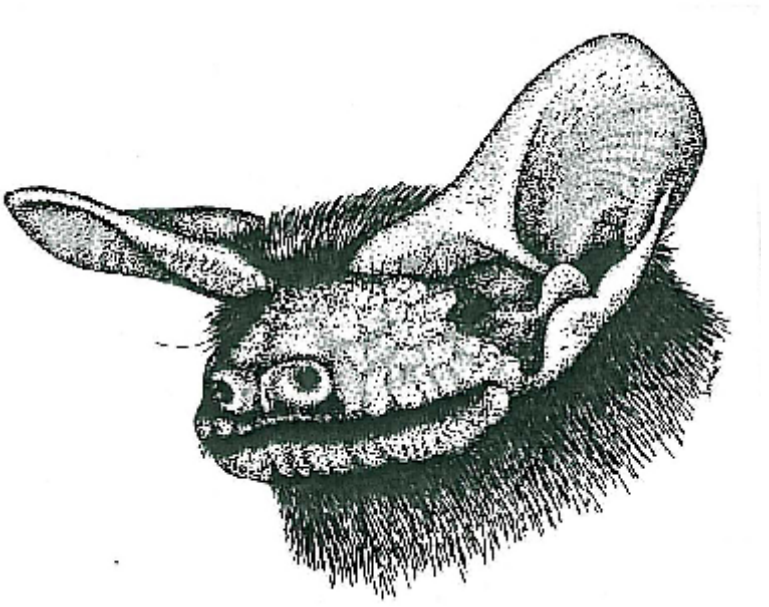
Plate 21: PC3G - Open woodland with *Eucalyptus tectifica* and *Acacia tumida* over tall grassland (?*Chrysopogon* or annual *Sorghum* sp.)

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Appendix 4: Echolocation Survey to describe Bat Species Present

Sorby Hills Fauna Survey

Echolocation Survey of Bat Activity in the Sorby Hills of the East Kimberley, WA
April – May 2011.
22 May 2011



Prepared for Animal Plant Mineral Pty Ltd

Prepared by BAT CALL WA

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Summary

Chiroptera species presence, with an estimate of activity level, is presented for several sites at the Sorby Hills project area of the eastern Kimberley. Animal Plant Mineral Pty Ltd (APM) carried out an echolocation based survey of the study area between the 17th of April and the 16th May 2011. Bat Call WA has reviewed the recordings made and provided species lists for the bats present.

Ten species were detected in total. These include two species that are not commonly detected, being the dusky leaf-nosed bat (*Hipposideros ater*) and the pygmy long-eared bat (*Nyctophilus walkeri*).

Habitats

The sites for this survey cover a series of locations on the Sorby Hills and adjacent Knox Creek plain, approximately 50 km northeast of Kununurra. Recordings were made in a number of habitats including:

Sorby Hills Foothills (Core Shed)
Low rounded hills with a relatively deep soil profile and abundant exposed sandstone boulders. Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia confertiflora* over Open to Sparse Shrubland of **Hyptis suaveolens, Buchanania oblongifolia, Grevillea* spp. and *Acacia* spp. over mixed Grassland/Forbland of *Eragrostis schultzii* (P3)*, *Cynodon dactylon, Eriachne obtusa, Heteropogon contortus*, *Stemodia lythrifolia, Blumea saxatilis* and *Cyperus pulchellus.*

Sorby Hills Foothills (Camp Site)
Transition zone at the base of the low rounded foothills at the intercept of the cracking clay flood plains. Woodland or Open Forest of *Eucalyptus tetrodonta, Eucalyptus brevifolia* and *Corymbia dichromophloia* over Sparse Shrubland of *Erythrophleum chlorostachys, Grevillea refracta, Dodonaea hispidula* var. *phylloptera* and *Buchanania oblongifolia* over Grassland of *Chrysopogon* sp.*, Sorghum stipoideum, Eriachne obtusa, Triodia bitextura* and *Eragrostis schultzii* (P3) .

Ridge Top, Creek Line (KML Site 16) and low rounded Devonian Limestone extrusion (KML Site 14)
Very high and abrupt sandstone cliffs with very deep fissures running vertically to varying depths. Little to no vegetation on the cliff face. Along the cliff top and back into the adjacent ranges occurs a Woodland

or Open Forest of *Corymbia dichromophloia, Corymbia confertiflora, Erythrophleum chlorostachys, Buchanania oblongifolia, Owenia vernicosa* and *Terminalia platyphylla* over Grassland/Hummock Grassland of *Chrysopogon* sp.*, Triodia bitextura, Chrysopogon setifolius, Sehima nervosum* and *Eriachne avenacea.* The creekline habitat sampled comprised a deeply dissected intermittent drainage line.

Cracking Clay (KML Site 20)
Heavy clay soils subject to long periods of inundation. When dry, the habitat comprises very deep cracking clay soils. Woodland and Open Woodland of *Bauhinia cunninghamii, Excoecaria parvifolia and Eucalyptus tectifica* over Open to Sparse Shrubland of *Terminalia volucris, Atalaya hemiglauca Vachellia valida* over mixed Grassland/Forbland and Closed Grassland/Forbland of *Ludwigia perennis, Iseilema vaginiflorum, Chionachne hubbardiana, Ophiurus exaltatus, Panicum decompositum* and *Oryza australiensis*.

Details of these are presented in Table 1. Figure 1 presents the Anabat sampling sites in relation to local features.

Bat Fauna

A microbat assemblage of 10 insectivorous species was confirmed as present in the study area at the end of the wet season. Nine of the species are relatively common in the east Kimberley. The tenth, the pygmy long-eared bat is at the edge of its range and is not often recorded.

Chaerephon jobensis (Northern free-tailed bat) is a mid size (20 g) insectivore. It is common along the riparian lines of the tropical north of Western Australia (WA). Its conservation status is not listed (EPBC Act 1999). The activity level of this species observed during this study can be characterised as medium to low. This activity level is typical of this species in Kimberley regions away from the larger river systems.

Chalinolobus gouldii (Gould's wattled bat) is ubiquitous throughout temperate and tropical WA. It is a medium size (13g) insectivore and commonly roosts in tree hollows (Churchill 1988). Its conservation status is not listed (EPBC Act 1999). The activity level of this species observed during this study can be characterised as low. This behaviour and prevalence is typical of this species in inland Kimberley regions; this species is more commonly found in areas to the south.

Chalinolobus nigrogriseus (Hoary wattled bat) is a small (6g in the Kimberley) insectivore common across tropical Australia. Its conservation status is not listed (EPBC Act 1999). This species was found across the study area; its observed activity level can be characterised as low to medium. It was the species most commonly recorded in this study. It is a tree roosting bat that may show some impact from the loss of woodland habitat.

Hipposideros ater (Dusky leaf-nosed bat) is a small (4g) insectivore present across the Kimberley and the Top End of the Northern Territory (NT). Its conservation status is not listed (EPBC Act 1999). This species is found in the warm and humid areas of shallow caves and abandoned mines and is usually sensitive to the approach of an observer. It forages in forest, woodlands and grasslands in close proximity to the ground (Churchill 2008). The presence of this species in the study area was detected by a single call.

Miniopterus schreibersii orianae (Northern bent winged bat) is a mid size (10g) insectivore. It commonly roosts in caves and man-made structures. Its conservation status is not listed (EPBC Act 1999). The activity level of this species observed during this study can be characterised as low. This is typical of this species in such Kimberley regions away from specific roost caves that harbour large colonies.

Nyctophilus walkeri (Pygmy long-eared bat) is a small (5g) insectivore present across the North Kimberley and the Top End of the NT. Its conservation status is not listed (EPBC Act 1999). It often roosts in foliage and forages in dense thickets and woodlands associated with watercourses (Churchill 2008). The presence of this species in the study area was detected by a single call.

Saccolaimus flaviventris (Yellow-bellied sheath-tailed bat) is a large (45g) insectivore. It is common throughout tropical north-western WA. Its conservation status is not listed (EPBC Act 1999). The activity level of this species observed during this study can be characterised as low; this is typical of this species in the Kimberley region in general.

Scotorepens greyii (Little broad-nosed bat) is ubiquitous throughout tropical WA. It is a small (8g) insectivore and commonly roosts in tree hollows (Churchill 1988). Its conservation status is not listed (EPBC Act 1999). The activity level of this species observed during this study can be characterised as low, despite being recorded at the majority of sites. This

observation concurs with the expected prevalence and behaviour of this species throughout the Kimberley region in general.

Taphozous georgianus (Common sheath-tailed bat) is a mid size (25 g) insectivore. It is common in the Pilbara and Kimberley regions of the tropical north of WA. Its conservation status is not listed (EPBC Act 1999). It roosts in caves, hollows and mines throughout the region. The activity level of this species observed during this study can be characterised as low. This observation is expected given the availability of suitable roost locations along the gullies and ridges of the study region.

Vespadelus caurinus (Northern cave bat) is one of the smallest (~5g) insectivores found across the more rugged shrubland and ridges of the Kimberley. They forage close to the vegetation of the lower canopy and the understorey and commonly roost in caves and mines but also use other locations such as man-made structures. Its conservation status is not listed (EPBC Act 1999). It is considered to be extant albeit not common across the ridges and plains of the study region.

Characteristics of the calls recorded are presented in Table 2 and the species occurrence by site is presented in Table 3.

Survey Timing, Moon Phase and Weather

The systematic echolocation survey was conducted between the 17th to 20th April and 14th to 16th May 2011. The survey was conducted in a warm and dry period. All sampling evenings had minimum temperatures between 15^{O}C and 20 ^{O}C overnight. The moon in both periods was full.

Survey Team

The bat sampling work was conducted by Dr Mitchell Ladyman of APM. No activities were conducted that directly impacted upon the bat fauna present.

R. D. Bullen of Bat Call WA completed analysis of echolocation recordings.

Systematic Sampling

The survey consisted of completing ten bat sound recordings of varying lengths, beginning at dusk, at the selected locations. The recordings were

"continuous" made using Anabat II (Titley Electronics, Ballina, NSW) detectors, set to divide by 16, in conjunction with Olympus LS series linear PCM recorders (Olympus, Japan).

COOL EDIT 2000 (Now available as AUDITION from Adobe Systems Inc.) was used to display each "continuous call" (Hyder 2010) sequence for identification. Only good quality call sequences were used. Details of calls analysed are provided in Table 2 as recommended by Australasian Bat Society (ABS 2006). Results are presented in table 3 below and are shown according to recording night and site. Reference data for the species identified are available in Bullen and McKenzie 2002 and McKenzie and Bullen 2009.

Bat activity was then characterised as "Low", "Medium" or "High" based on the rate of call sequences recorded.

- Low species activity is referred when a species is recorded with call spacing less often than ten minutes,
- Medium species activity refers to call recordings more often than 10 minutes but less often than two minutes apart for a significant time period followed by sporadic records for the remainder of the session.
- High species activity refers to call recording more often than two minutes apart for significant periods followed by reasonably regular records for the remainder of the session.

Further details of the calls analysed including graphical presentations are available from Bat Call WA on request.

Survey Limitations

The sites surveyed vary in their nature and accessibility. The recorders were set at ground level with the microphone pointing approximately 45 degrees upward at the sites. The survey method applied is biased against species that are known to forage close to the ground in shrubland and woodland environments. Species that may be under-represented as a result may include *Nyctophilus spp.* and others that are known to forage in the vegetation.

Bat species density is impossible to estimate from echolocation records. Bat activity is therefore substituted as an approximate guide to the relative numbers of each species using the study area.

References

ABS (2006). Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. *The Australasian Bat Society Newsletter* 27: 6-9.

Bullen R.D. and McKenzie N.L. (2002). Differentiating Western Australian Nyctophilus (Chiroptera: Vespertilionidae) echolocation calls. *Australian Mammalogy*. 23: 89-93

Hyder, B.M., Dell, J. and Cowan, M.A. (eds) (2010). *Technical guide – Terrestrial vertebrate fauna surveys for environmental impact assessment.* Technical report of the Environmental Protection Authority and the Department of Environment and Conservation.

McKenzie, N.L. and Bullen R.D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum* Supplement **78**, 123-155.

Table 1: Summary of Site Specific details.

Date	Site	Recording Time	Habitat	Latitude	Longitude
17 April	Camp site	150 minute continuous recording.	Flyway over pool.	15° 26.488’	128° 57.604’
17 April	Core Shed	140 minute continuous recording	On a creek line adjacent to the core shed.	15° 26.492’	128° 57.521’
18 April	Core Shed	560 minute continuous recording	On a creek line adjacent to the core shed.	15° 26.492’	128° 57.521’
18 April	Core Shed	640 minute continuous recording	On a creek line adjacent to the core shed.	15° 26.492’	128° 57.521’
20 April	KML Site 16 (Anabat 20/4b)	720 minute continuous recording	On top of a sandstone ridge above Site 16	15° 27.296’	128° 57.182’
20 April	KML Site 16 (Anabat 20/4a)	720 minute continuous recording	On a creekline between hills (behind Site 16)	15° 27.378’	128° 57.418’
14 May	KML Site 13 (Anabat 14/5a)	420 minute continuous recording	Low rounded Devonian limestone outcrop	15° 27.399’	128° 58.094’
15 May	KML Site 20 (Anabat 14/5b)	720 minute continuous recording	Adjacent lagoon cracking clay soils	15° 27.350’	128° 58.135’
16 May	Camp site	210 minute continuous recording	Euc woodland.	15° 26.4878’	128° 57.6038’
16 May	Camp site	600 minute continuous recording	Euc woodland.	15° 26.4878’	128° 57.6038’

Table 2: Summary of Echolocation call characteristics for microbat species present.

Genus species Authority	Common name	Ave. F_{peakC} kHz	Ave. Q	Typical Duration msec	Typical Call Shape
Chaerephon jobensis (Miller 1902)	Northern free-tailed bat	20	5	8 - 15	Shallow FM
Chalinolobus gouldii (Grey 1841)	Gould's wattled bat	32	10	7 - 11	FM
Chalinolobus nigrogriseus (Gould 1856)	Hoary wattled bat	38	14	5 - 8	FM
Hipposideros ater	Northern leaf-nosed bat	103	30	12 - 18	CF
Miniopterus schreibersii orianae Thomas 1922	Northern bent-winged bat	50	8	5 - 8	FM
Nyctophilus walkeri	Pygmy long-eared bat	53	5	5	Steep FM
Saccolaimus flaviventris (Peters 1867)	Yellow-bellied sheath-tailed bat	18	9	12 - 21	CF - FM
Scotorepens greyii (Gray 1843)	Little broad-nosed bat	38	9	7 - 13	FM
Taphozous georgianus Thomas 1915	Common sheath-tailed bat	24.5	14	9 - 18	Cf – Shallow FM
Vespadelus caurinus (Thomas 1914)	Northern cave bat	60	10	4 - 8	FM

Note: FpeakC and Q are defined in McKenzie and Bullen 2003.

Table 3: Microbat lists obtained presented by site.

Date	Site	*Chaerephon jobensis*	*Chalinolobus gouldii*	*Chalinolobus nigrogriseus*	*Hipposideros ater*	*Miniopterus schreibersii*	*Nyctophilus walkeri*	*Saccolaimus flaviventris*	*Scotorepens greyii*	*Taphozous georgianus*	*Vespadelus caurinus*
17 April	Camp site			Low							
17 April	Core Shed	Med		Low							
18 April	Core Shed	Med	Low	Low		Low		Low	Low		
18 April	Core Shed			Low					Low		
20 April	KML Site 16 (Anabat 20/4b)			Low	Low (1 call)	Low			Low	Low	
20 April	KML Site 16 (Anabat 20/4a)			High					Low		Low
14 May	KML Site 13 (Anabat 14/5a)	Low	Low	Med			1 weak call		Low		
15 May	KML Site 20 (Anabat 14/5b)	Low		Low		Low		Low	Low		
16 May	Camp site			Low							
16 May	Camp site	Low		Low							

Low activity refers to single calls or sporadic calls with spacing greater than 10 minutes apart.
Med activity refers to call records more often than 10 minutes but less often than 2 minutes apart for significant periods of time
High activity refers to call records more often than 2 minutes for significant periods of time

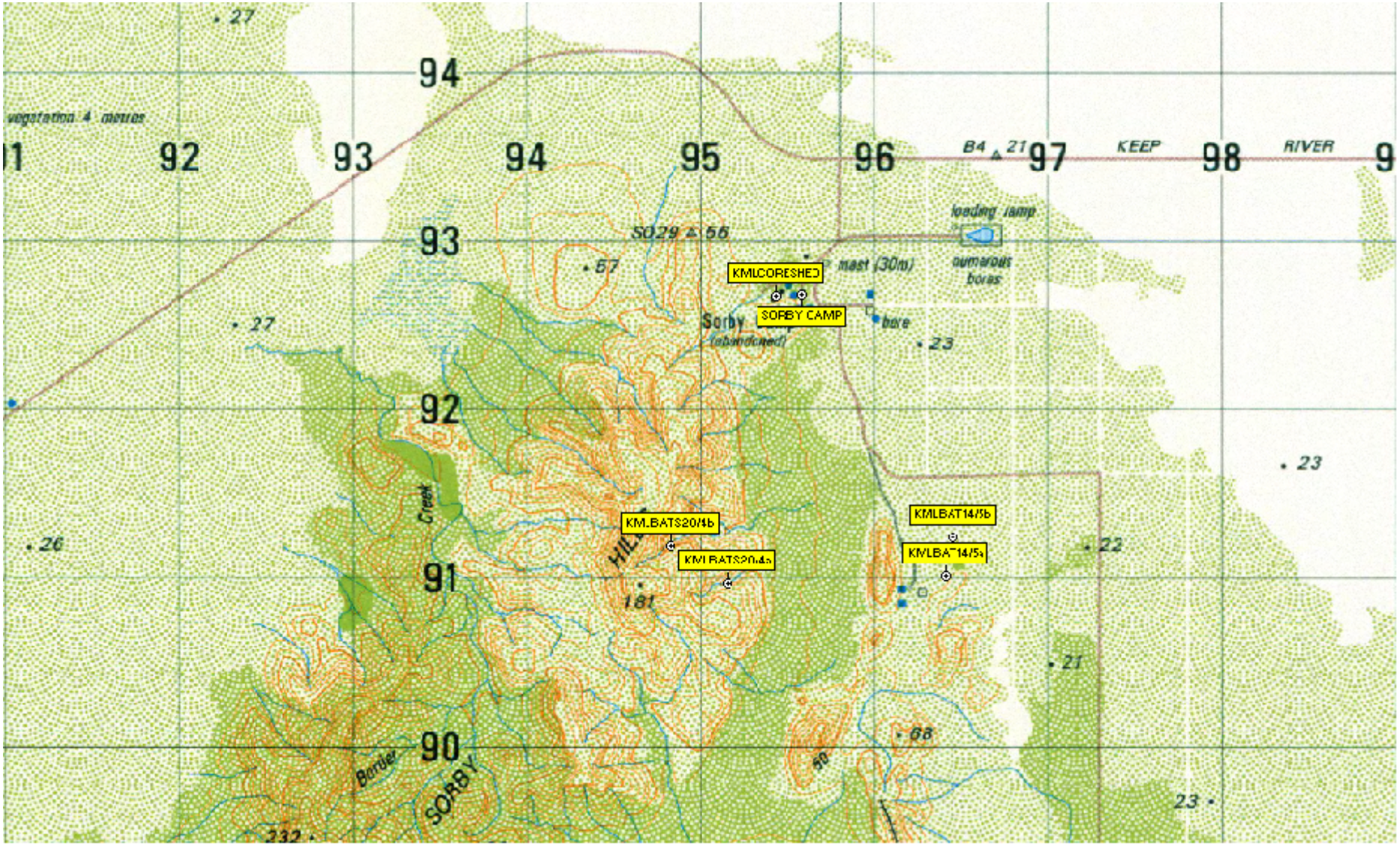


Figure 1 Locations of echolocation recording points

Appendix 5: Subterranean Fauna Assessment Data

SMPL Sorby Hills Raw Stygofauna Data

fldBrieflocatio	fldFieldBore	fldSiteCod	tblSitetyp	Latitude	Longitude	fldVisitDate	fldSampleDa	fldSampleCo	fldClass	fldOrder
Sorby Hills	WP24	APM003	Control	-15.4934	128.9979	23-Aug-11	23-Aug-11	23-Aug-11	Crustacea	Copepoda
Sorby Hills	WP24	APM003	Control	-15.4934	128.9979	23-Aug-11	23-Aug-11	23-Aug-11	Oligochaeta	-
Sorby Hills	ORD17	APM005	Control	-15.5183	128.9825	23-Aug-11	23-Aug-11	23-Aug-11	Oligochaeta	-
Sorby Hills	KC2	APM006	Control	-15.4943	128.9808	23-Aug-11	23-Aug-11	23-Aug-11	Crustacea	Isopoda
Sorby Hills	WBS1112	APM019	Control	-15.4338	128.9725	24-Aug-11	24-Aug-11	24-Aug-11	Crustacea	Copepoda
Sorby Hills	WBS1112	APM019	Control	-15.4338	128.9725	24-Aug-11	24-Aug-11	24-Aug-11	Crustacea	Syncarida
Sorby Hills	WBS1112	APM019	Control	-15.4338	128.9725	24-Aug-11	24-Aug-11	24-Aug-11	Crustacea	Copepoda
Sorby Hills	WBS7005	APM032	Impact	-15.4563	128.9808	25-Aug-11	25-Aug-11	25-Aug-11	Crustacea	Ostracoda
Sorby Hills	WBS6040	APM022	Impact	-15.4541	128.9821	08-Nov-11	08-Nov-11	08-Nov-11	Crustacea	Ostracoda
Sorby Hills	WBS7008	APM023	Impact	-15.4540	128.9833	08-Nov-11	08-Nov-11	08-Nov-11	Crustacea	Ostracoda
Sorby Hills	WBS7027	APM034	Impact	-15.4595	128.9873	08-Nov-11	08-Nov-11	08-Nov-11	Arachnida	Acariformes
Sorby Hills	WBS7027	APM034	Impact	-15.4595	128.9873	08-Nov-11	08-Nov-11	08-Nov-11	Crustacea	Ostracoda
Sorby Hills	WBS7029	APM016	Control	-15.4366	128.9714	09-Nov-11	09-Nov-11	09-Nov-11	Crustacea	Ostracoda
Sorby Hills	WBS1112	APM019	Control	-15.4338	128.9725	09-Nov-11	09-Nov-11	09-Nov-11	Crustacea	Syncarida
Sorby Hills	WBS1112	APM019	Control	-15.4338	128.9725	09-Nov-11	09-Nov-11	09-Nov-11	Crustacea	Copepoda
Sorby Hills	WBS1112	APM019	Control	-15.4338	128.9725	09-Nov-11	09-Nov-11	09-Nov-11	Crustacea	Ostracoda
Sorby Hills	WBS1112	APM019	Control	-15.4338	128.9725	09-Nov-11	09-Nov-11	09-Nov-11	Crustacea	Copepoda
Sorby Hills	WBS5083	APM012	Control	-15.4338	128.9761	09-Nov-11	09-Nov-11	09-Nov-11	Crustacea	Copepoda
Sorby Hills	WBS5090	APM042	Control	-15.4356	128.9744	10-Nov-11	10-Nov-11	10-Nov-11	Crustacea	Ostracoda
Sorby Hills	WBS6044	APM044	Control	-25.4356	128.9717	10-Nov-11	10-Nov-11	10-Nov-11	Crustacea	Copepoda
Sorby Hills	WBS6044	APM044	Control	-25.4356	128.9717	10-Nov-11	10-Nov-11	10-Nov-11	Crustacea	Copepoda
Sorby Hills	WBS1106	APM046	Control	-15.4356	128.9706	10-Nov-11	10-Nov-11	10-Nov-11	Nematoda	-
Sorby Hills	WBS5078	APM028	Impact	-15.4473	128.9817	10-Nov-11	10-Nov-11	10-Nov-11	Crustacea	Ostracoda

SMPL Sorby Hills Raw Stygofauna Data

fldFieldBoreC	fldClass	fldOrder	fldFamily	fldGenus	fldLowestID	fldTrueStyg	fldTrueTrog	fldLowestIDN	fldTaxonStatus	fldNumberIde
WP24	Crustacea	Copepoda	Parastenc	Parastenoc	Parastenoc	-1	0	OJ660199	Species Final	4
WP24	Oligochaeta	-	-	-	Oligochaeta	-1	0	1F9999999	Preliminary	1
ORD17	Oligochaeta	-	-	-	Oligochaeta	-1	0	1F9999999	Preliminary	1
KC2	Crustacea	Isopoda	Tainisopic	Tainisopus	Tainisopus	-1	0	OR3102A1	Species Final	1
WBS1112	Crustacea	Copepoda	Ameirida	-	Ameiridae	-1	0	OJ6499A3	Species Final	13
WBS1112	Crustacea	Syncarida	Bathynelli	Bathynella	Bathynella	-1	0	ON070199	Higher Order	1
WBS1112	Crustacea	Copepoda	Cyclopida	Australocy	Australocyc	-1	0	OJ3103A0	Species Final	3
WBS7005	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	1
WBS6040	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	1
WBS7008	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	14
WBS7027	Arachnida	Acariforme	-	-	Acariforme	-1	0	1IL999999	Preliminary	1
WBS7027	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	1
WBS7029	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	2
WBS1112	Crustacea	Syncarida	Bathynelli	Bathynella	Bathynella	-1	0	ON070199	Preliminary	4
WBS1112	Crustacea	Copepoda	-	-	Harpacticoi	-1	0	OJ699999	Preliminary	14
WBS1112	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	1
WBS1112	Crustacea	Copepoda	-	-	Cyclopoida	-1	0	OJ399999	Preliminary	4
WBS5083	Crustacea	Copepoda	-	-	Harpacticoi	-1	0	OJ699999	Preliminary	1
WBS5090	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	1
WBS6044	Crustacea	Copepoda	-	-	Harpacticoi	-1	0	OJ699999	Preliminary	1
WBS6044	Crustacea	Copepoda	-	-	Cyclopoida	-1	0	OJ399999	Preliminary	9
WBS1106	Nematoda	-	-	-	Nematoda	-1	0	IJ999999	Higher Order	2
WBS5078	Crustacea	Ostracoda	-	-	Ostracoda	-1	0	OH999999	Preliminary	1

SMPL Sorby Hills Raw Stygofauna Data

fldFieldBoreC	fldNumberId	fldDepthto	fldDeptht	fldComme
WP24	4	10	50	male on
WP24	1	10	50	
ORD17	1	10	24	
KC2	1	7	17	male, nr
WBS1112	13	10	56	
WBS1112	1	10	56	large
WBS1112	3	10	56	
WBS7005	1	9	55	single
WBS6040	1	11	15	
WBS7008	14	10	45	Valves
WBS7027	1	9	36	
WBS7027	1	9	36	Valve
WBS7029	2	9	11	
WBS1112	4	10	56	
WBS1112	14	10	56	
WBS1112	1	10	56	Valve
WBS1112	4	10	56	
WBS5083	1	10	100	
WBS5090	1	13	102	Valve only
WBS6044	1	13	26	
WBS6044	9	13	26	
WBS1106	2	13	60	
WBS5078	1	10	29	Valve only

Lowest ID	Order	Class	Control	Impact	
(nr	Copepoda	Crustacea	13		
ops nr	Copepoda	Crustacea	3		
sp.	Syncarida	Crustacea	5		
Cyclopoida	Copepoda	Crustacea	13		
da sp	Copepoda	Crustacea	16		
Nematoda	-	Nematoda	2		
Oligochaeta	-	Oligochaeta	2		
(Unident.)	Ostracoda	Crustacea	4	18	
aris sp.	Copepoda	Crustacea	4		
sp. B2	Isopoda	Crustacea	1		

Appendix 6: Surface Water and Flood Assessment

S O I L W A T E R C O N S U L T A N T S

SORBY HILLS DEPOSIT SURFACE FLOW ANALYSIS

Prepared for: **SORBY MANAGEMENT PTY LTD**

Date of Issue: 9 December 2011

Project No.: PN0219-1-1-SML-003

soilwater

A member of the SOIL WATER GROUP

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			Originator	Reviewer	Approved
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C	09/12/11	Final report submitted to client	SC	ASP	ASP

Revision Code*	
A - Report issued for internal SWC review	1 - First Revision
B - Draft report issued for client for review	2 - Second Revision
C - Final report issued to	3 - Third Revision

LIMITATIONS

The sole purpose of this report and the associated services performed by Soil Water Consultants (SWC) was to undertake a surface water assessment for the proposed Sorby Hills Project (SHP). This work was conducted in accordance with the Scope of Work discussed with Sorby Management Pty Ltd ('the Client').

SWC performed the services in a manner consistent with the normal level of care and expertise exercised by members of the earth sciences profession. Subject to the Scope of Work, the surface water analysis was confined solely to the infrastructure area within the SHP. No extrapolation of the results and recommendations reported in this study should be made to areas external to this project area. In preparing this study, SWC has relied on published soil reports from various soil researchers and information provided by the Client. All information is presumed accurate and SWC has not attempted to verify the accuracy or completeness of such information. While normal assessments of data reliability have been made, SWC assumes no responsibility or liability for errors in this information. All conclusions and recommendations are the professional opinions of SWC personnel.

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1. INTRODUCTION

Soil Water Consultants (SWC) were engaged by Sorby Management Pty Ltd (SMPL) to undertake a surface water assessment for the proposed Sorby Hills Silver Lead Zinc Project (Sorby Hills Project - SHP). The objectives of this work were to:

- Identify surface water flows within the SHP.
- Quantify peak stream flow rates entering the SHP.
- Determine the spatial extent of potential flooding following high rainfall events.

The SHP will consist of three discrete open mine pits (to a maximum depth of 70 m), a tailings storage facility (TSF), processing plant and crusher, offices, workshops and supporting infrastructure (i.e. roads, laydown areas and a ROM pad) (Figure 1.1). Al components of the mine operation will be located on the flat clayey alluvial floodplain (Plate 1.1), east of the Sorby Hills Development Exclusion Zone (SHDEZ; Figure 1.1).

Plate 1.1: Flat clayey alluvial floodplain where all mine operations for the SHP will be located.



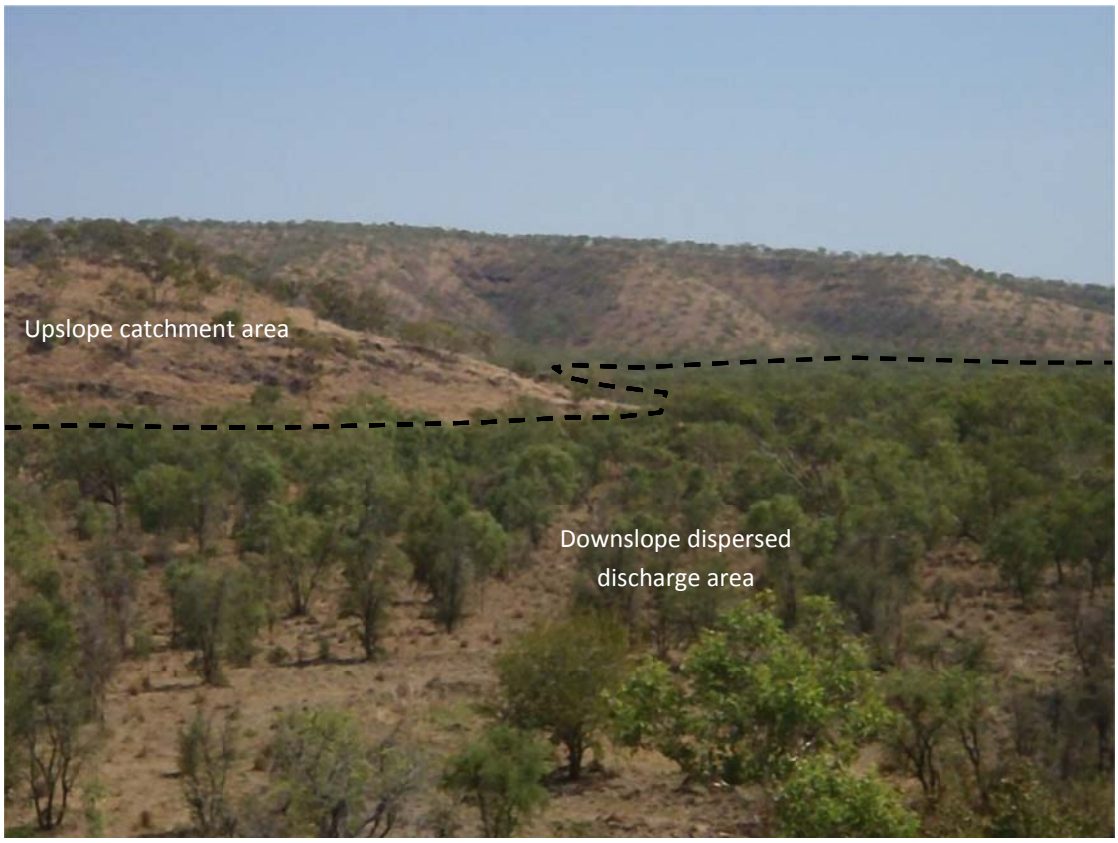
2. SURFACE WATER FLOWS

The surface hydrology within the SHP area is dominated by sluggish surface water flows within the alluvial floodplain. Observations by site personnel during the wet season identifies that the entire floodplain saturates and becomes waterlogged, with 20 – 30 cm of ponded water across the landsurface. No defined drainage systems occur within the Project Area, with the Border and Knox Creeks located 3.5 km to the north and south, respectively, and the Keep River (which the Knox Creek flows into) situated 4.6 km to the south-east. Water

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draining the eastern margins of the Pincombe Range and northern Sorby Hills is dispersed rapidly across the floodplain at the break of slope (Plate 2.1), with no continuation of converging flows along a drainage channel extending onto the alluvial.

Plate 2.1: Break of slope separating the upslope catchment areas and the downstream dispersed discharge areas.



To establish the surface water flows and catchment areas within the SHP and surrounding regions a digital elevation model (DEM) was constructed using 1 m contour data obtained from the Department of Land Administration (DOLA). The constructed DEM is shown Figure 2.1 and consists of a grid cell size of 20 × 20 m covering a total area of 86,773 ha (resulting in 2,169,325 cells). Surface flows were identified using TOPAZ (TOpographical PArameteriZation; Garbrecht *et al*., 2004), with a maximum flow accumulation size (i.e. catchment area) of 10 ha. Flow outlets were located on the Northern Territory side of Border Creek and Keep River. All modelled surface flows and identified catchment boundaries are show in Figure 2.2.

The SHP is located in the upper portions of the Knox Creek and Keep River catchments. All surface flows within the floodplain of the SHP are towards the south-east, and although the modelled surface flows (Figure 2.2) show defined flow accumulation/stream flows, it is more likely to be sluggish uniform surface flows to the south-east. Water draining the eastern side of Sorby Hills and entering the SHP occurs in two defined regions, located north-west of the Plant Area and west of the TSF (Figure 2.3). All surface flows north of Weaber Plain Road and draining the western side of the Pincombe Ranges and Sorby Hills flows into Border Creek and does not enter into the SHP. The catchment areas of surface flows into the SHP are therefore relatively small with the Northwest and West Catchments having a total area of 226 and 381 ha, respectively.

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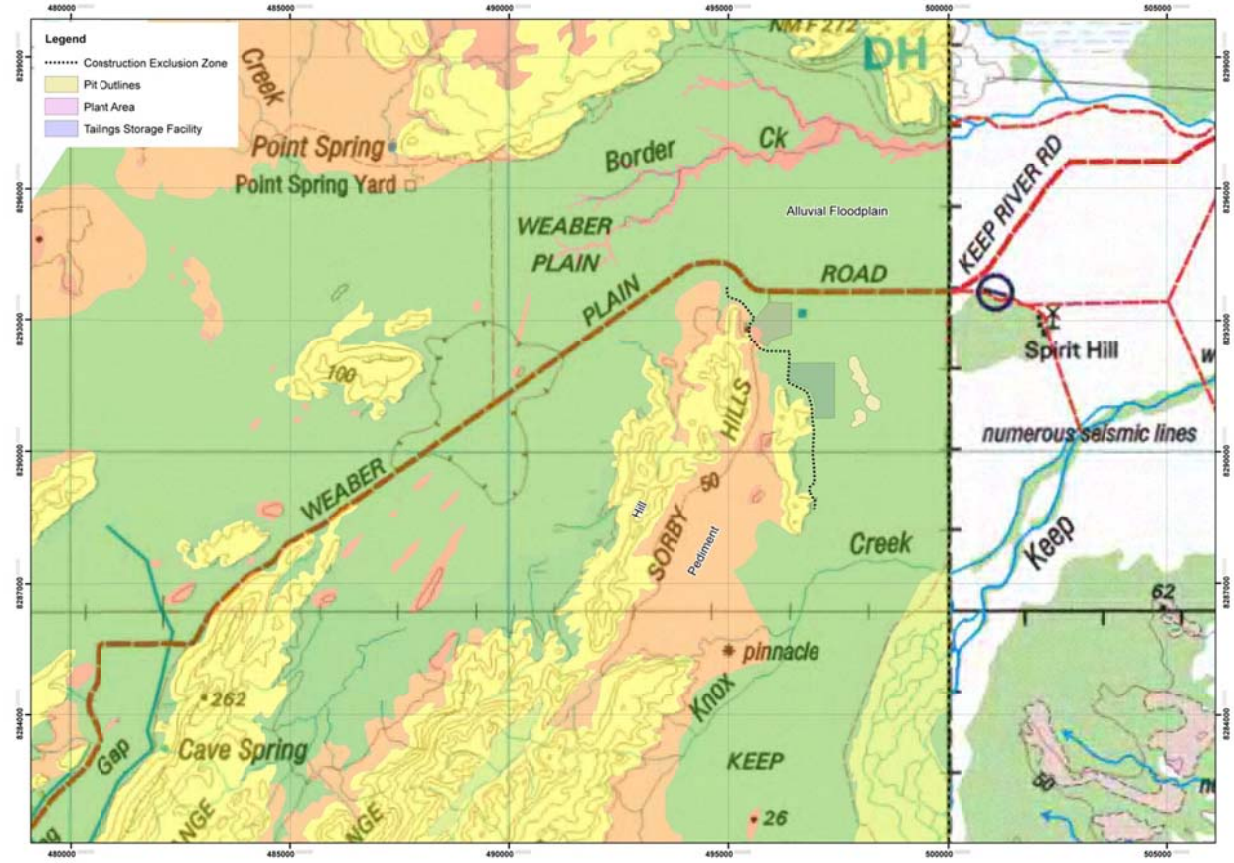


Figure 1.1: Geomorphic location of the SHP.

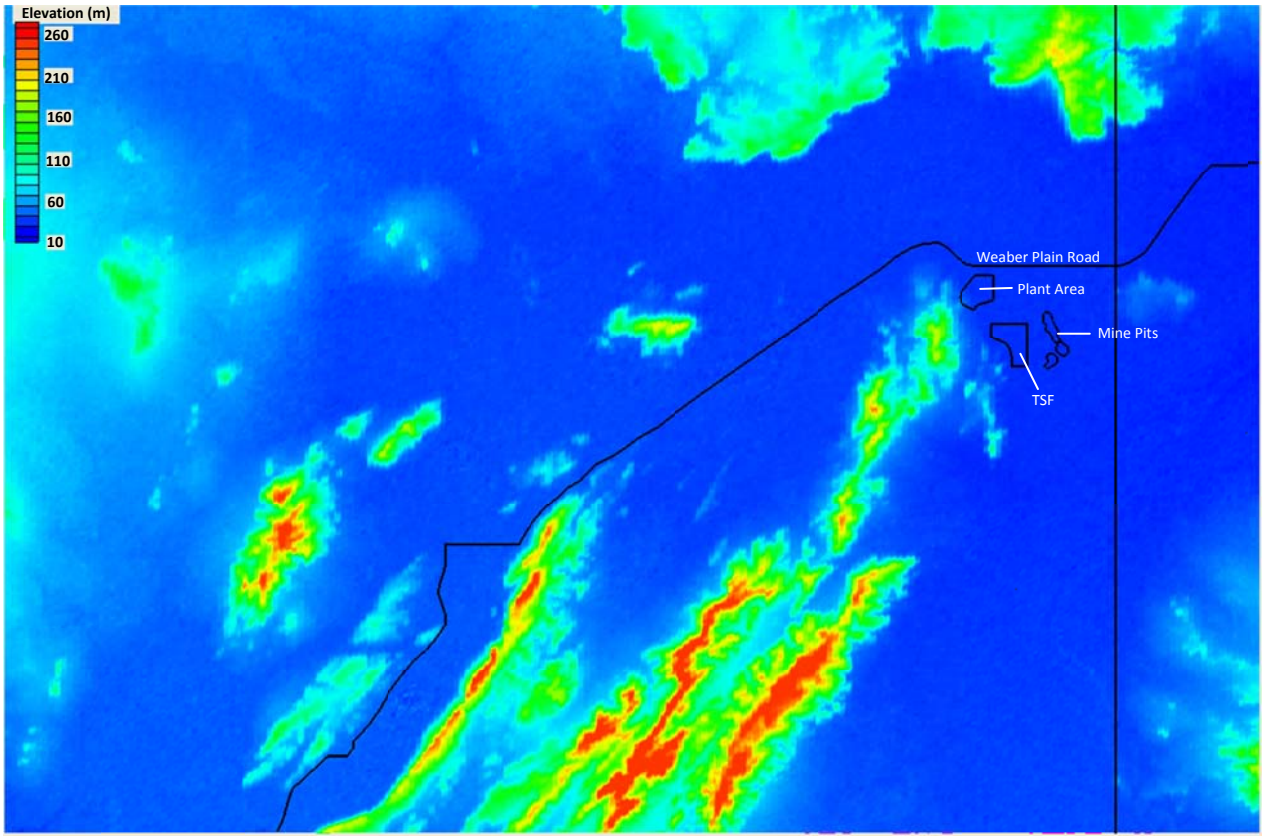


Figure 2.1: Constructed DEM for the SHP and surrounding region.

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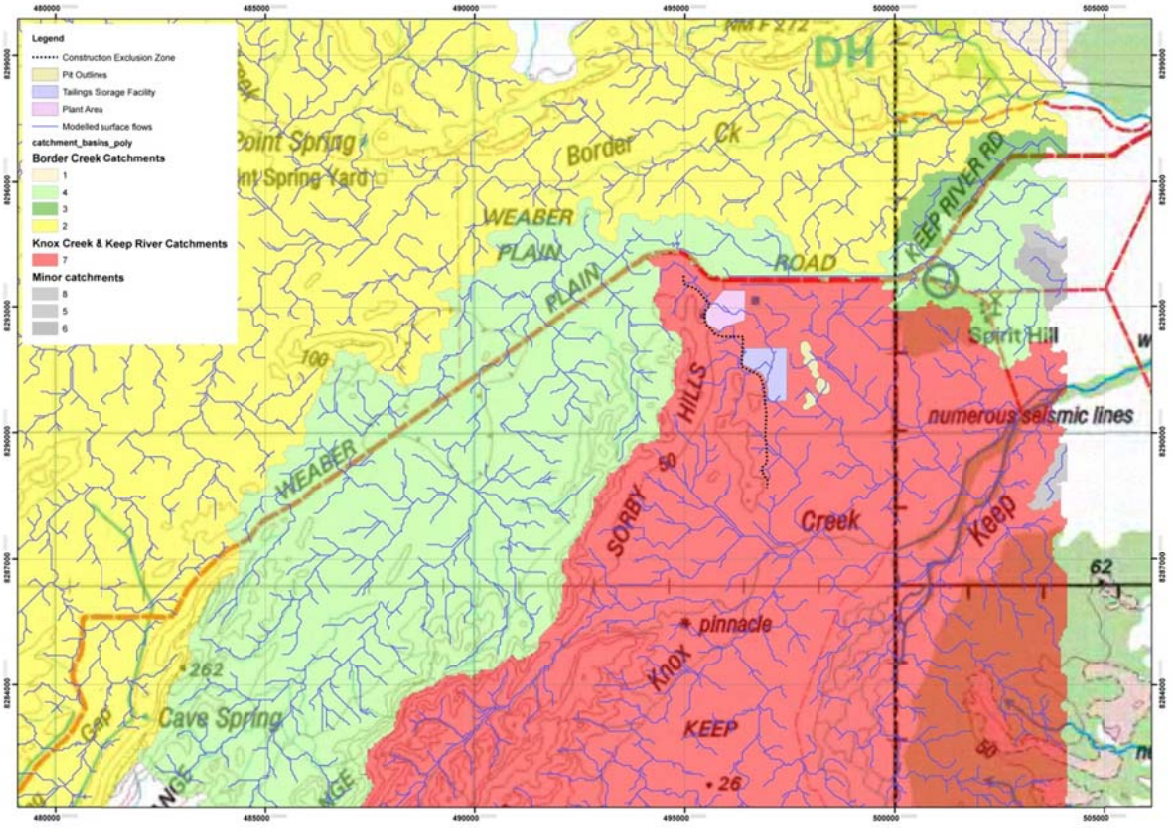


Figure 2.2: Modelled surface flows and catchment boundaries.

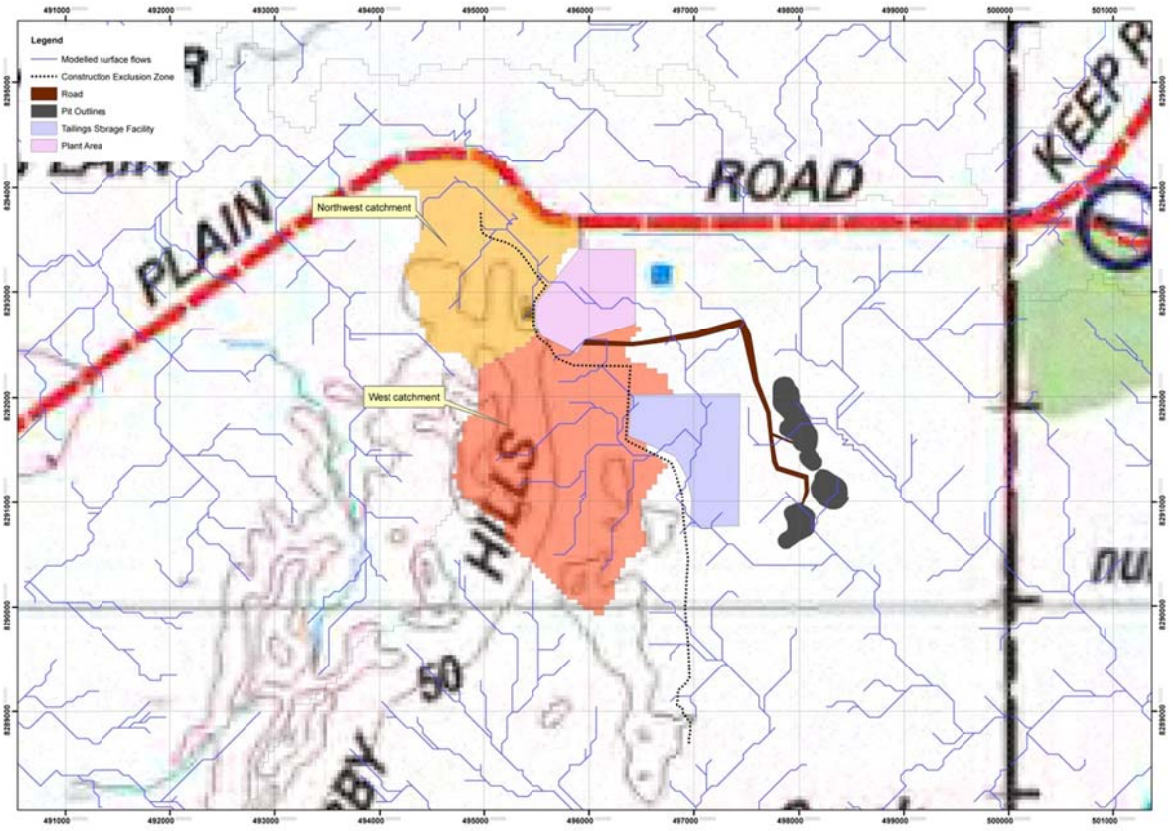


Figure 2.3: Modelled surface flows and catchment boundaries for water entering the SHP.

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3. PEAK FLOW ESTIMATION

Estimates of peak flood flows for the two catchments draining into the SHP have been derived to establish the magnitude of surface water management structures required at this site. As there are no flow records available for any of the watercourses that drain into the site, a 'design event approach' was adopted and rainfall-runoff models developed to generate flood hydrographs for these catchments. A design rainfall event is specified by rainfall duration, average rainfall intensity of a particular Average Recurrence Interval, ARI, and its temporal pattern. The design rainfall totals and intensities were determined using the techniques recommended in Australian Rainfall and Runoff, (2003) (ARR). Rainfall-runoff modelling was carried out using RORBWin Version 6.14 modelling software to establish peak flow estimates. The resulting peak flows were compared to those calculated using Index Flood and Rational methods.

3.1 DESIGN RAINFALL

In the absence of a long-term rainfall record at the mine site, design rainfall totals and intensities were determined using the techniques recommended in ARR. A design rainfall intensity chart was issued by the Hydrometeorological Advisory Service of the Bureau of Meteorology (BOM) for the location 497,902 mE and 8,291,937 mN (Zone 52).
The design rainfall intensities and depths for a range of ARIs from 1 to 100 years and durations from 5 minutes to 72 hours are tabulated in table 3.1 and 3.2 respectively. The average design rainfall depths are also depicted in figure 3.1.

Table 3.1: Average design rainfall intensities.

Duration	Intensity [mm/h] for ARI [a]						
	1	2	5	10	20	50	100
5Mins	120	155	200	228	266	319	361
6Mins	112	145	187	213	249	299	338
10Mins	92.7	120	155	178	208	249	282
20Mins	71	92.3	119	136	159	191	217
30Mins	58.9	76.6	99.1	113	133	159	181
1Hr	39.6	51.5	67	76.9	90.1	109	123
2Hrs	24.1	31.4	41.1	47.3	55.6	67.2	76.5
3Hrs	17.4	22.7	29.8	34.4	40.6	49.1	56
6Hrs	9.82	12.9	17	19.7	23.3	28.4	32.4
12Hrs	5.73	7.54	10.1	11.7	13.9	17	19.5
24Hrs	3.58	4.73	6.4	7.51	8.97	11	12.7
48Hrs	2.29	3.04	4.18	4.95	5.97	7.4	8.59
72Hrs	1.65	2.21	3.07	3.65	4.42	5.52	6.43

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Table 3.2: Average design rainfall totals.

Duration	Total rainfall depth [mm] for ARI [a]						
	1	2	5	10	20	50	100
5 min	10.0	12.9	16.7	19.0	22.2	26.6	30.1
6 min	11.2	14.5	18.7	21.3	24.9	29.9	33.8
10 min	15.5	20.0	25.8	29.7	34.7	41.5	47.0
20 min	23.7	30.8	39.7	45.3	53.0	63.7	72.3
30 min	29.5	38.3	49.6	56.5	66.5	79.5	90.5
1 h	39.6	51.5	67.0	76.9	90.1	109.0	123.0
2 h	48.2	62.8	82.2	94.6	111.2	134	153
3 h	52.2	68.1	89.4	103.2	121.8	147	168
6 h	58.9	77.4	102.0	118.2	140	170	194
12 h	68.8	90.5	121.2	140	167	204	234
24 h	85.9	113.5	154	180	215	264	305
48 h	109.9	146	201	238	287	355	412
72 h	118.8	159	221	263	318	397	463

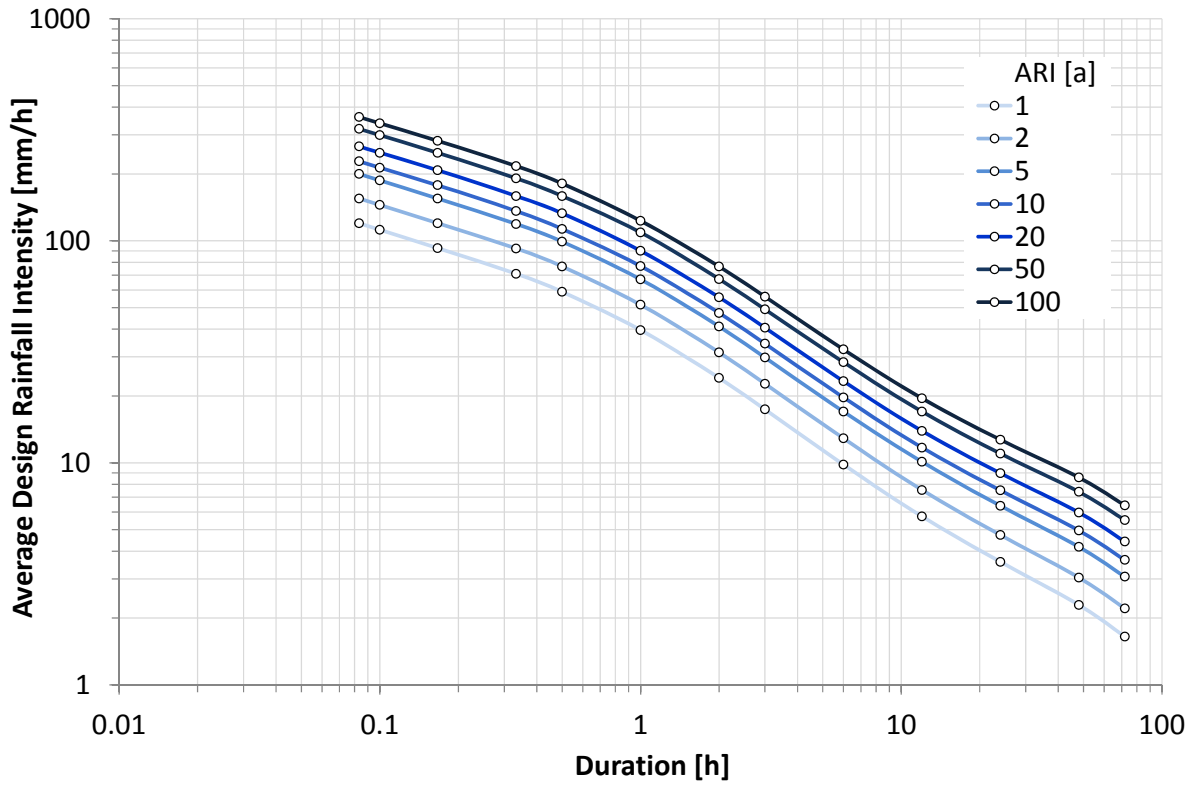


Figure 3.1: Design rainfall intensity-duration chart.

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Besides intensity and duration the temporal pattern of a storm is of significant importance for rainfall-runoff routing calculations. Temporal patterns for the design rainfall totals were determined in accordance with the methods described in ARR (ARR Vol 2, Book II, Section 2). There are different patterns for many durations and patterns also vary with in relation to the design frequency (ARI). The appropriate temporal patterns were assigned to design rainfall totals and the resulting data used as an input to the rainfall-runoff modelling process. Temporal patterns for the 1-hour duration rainfall event for 5, 20 and 100-year ARI are shown in Figure 3.2.

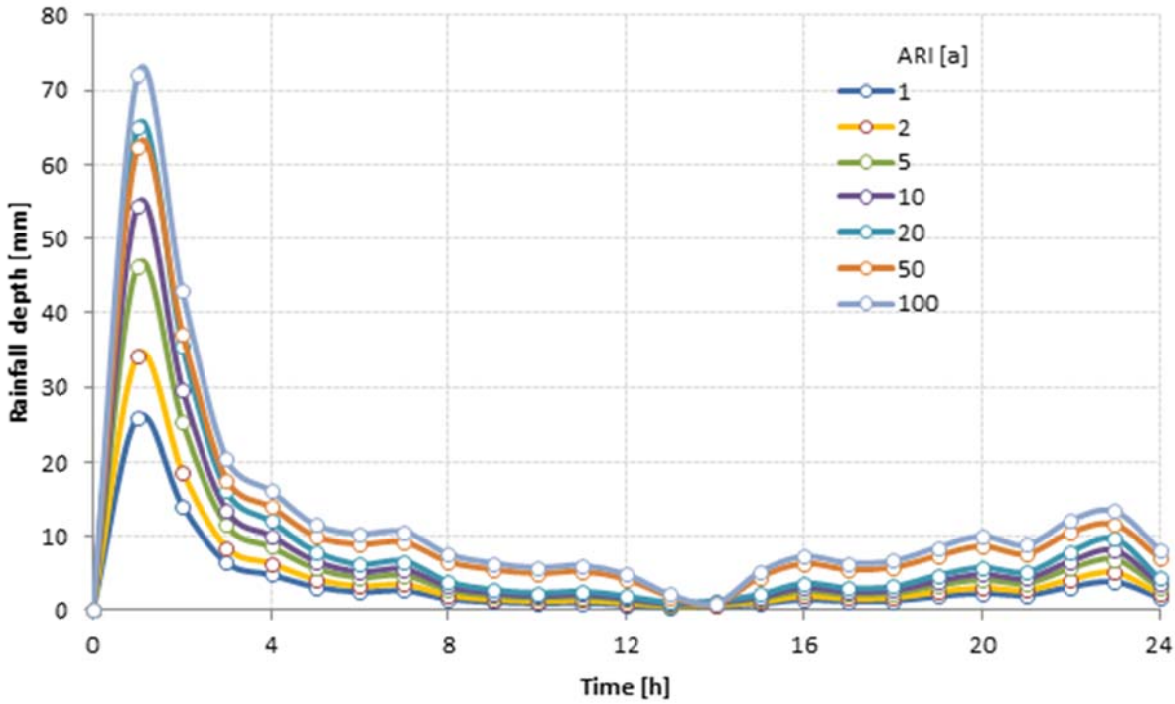


Figure 3.2: Design rainfall temporal pattern for a 24 h duration and recurrence intervals of 1 to 100 years.

3.2 DESIGN PEAK FLOWS

An initial loss-continuing loss rainfall-runoff model was developed in order to determine design event peak flows and hydrograph shapes for the two catchments entering the SHP. The model was constructed using RORBWin Version 6.14 modelling software. RORB model and RORB parameters are recommended by ARR for Australia. The rainfall-runoff modelling process requires estimation of the initial losses and continuing losses as well as well as RORB parameters k_c and m. Values for the initial loss and continuing losses expected in the two catchments were determined from ARR for the Kimberley Region of Western Australia (shallow sand over rock). The initial loss values vary with rainfall ARI, and parameter k_c differs between the subcatchments. The adopted values and the catchment properties used for the calculations are shown in Table 3.3 and 3.4, respectively.

Table 3.3: Rainfall runoff parameters and references.

Parameter	ARI [a]						ARR Reference
	2	5	10	20	50	100	
Initial loss [mm]	30	50	60	47	47	47*	Table 3.3 (Kimberleys), ARR Vol.1, Book II, Section 3
Continuing loss	5 [mm/h]						

* Extrapolated

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Table 3.4: Catchment properties and derived RORB parameters.

Catchment ID (Figure 2.3)	k_c [-] (RORB)	m (RORB	Basin area [km^2]	Max flow distance [km]	Equal area slope [m/km]
West Catchment	6	0.8 [-]	3.81	3.547	22.31
Northwest catchment	0.92	0.8 [-]	2.26	1.958	4.87

Non-linear channel routing was used to route the runoff down the drainage paths to the catchment outlet. Model runs for design events from 2-year to 100-year ARI were completed. Rainfall event durations ranging from 10 min to 72 hours were used as the input. The event which produces the highest peak flow (critical duration) was determined through the modelling process for each potential culvert location and ranged from 1 hour to 4.5 hours. Table 3.5 details the peak design flood flows at each outlet node for the given critical duration.

Table 3.5: Peak design flood flows at each outlet.

Catchment ID	Peak discharge [m^3/s] for ARI [a]						Critical duration [h] for ARI [a]					
	2	5	10	20	50	100	2	5	10	20	50	100
West catchment	13.30	10.67	11.08	29.54	42.38	54.99	1.5	3	4.5	4.5	1	1
Northwest catchment	3.89	3.10	3.31	8.93	12.85	16.15	2	3	4.5	4.5	2	1.5

The estimated peak flood flow for a 100-year ARI event and the critical duration of 1 hour at the outlet of the largest catchment (West Catchment) is 54.99 m^3/s. The 100 year design hydrographs for the critical duration are shown in Figure 3.3 for the two catchments.

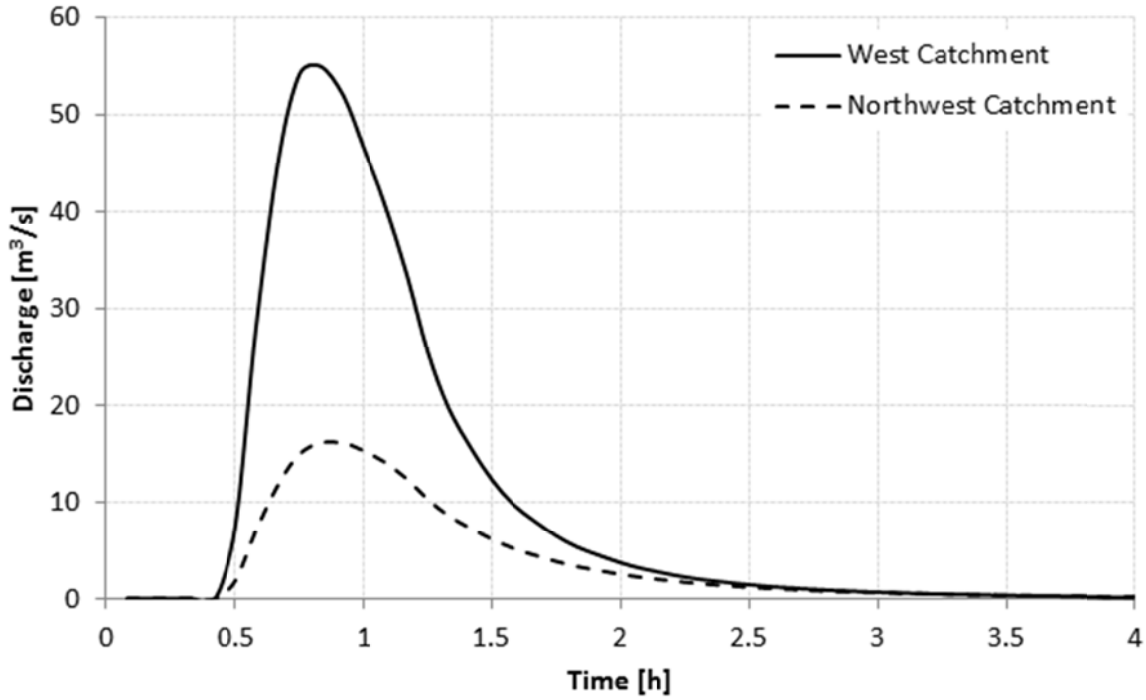


Figure 3.3: Design rainfall temporal pattern for a 24 h duration and recurrence intervals of 1 to100 years.

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Peak flows were also estimated using the Index Flood and Rational methods applicable to the Kimberley Region of Western Australia (ARR Vol 1, Book IV, Section 1). For the Index Flood Method the parameters used for calculations are catchment area and a frequency factor, Q_y/Q_5. The resulting Index Flood method estimated peak flows entering the SHP, for the 2-year to 100-year ARI events, are detailed in Table 3.6. For the Rational Method, the parameters used for the calculations are catchment area, maximum flow distance, time of concentration (t_c) and a frequency factor (C_y/Q_{10}). The design peak flood flows entering the SHP, calculated using the Rational Method, are provided in Table 3.7.

Table 3.6: Peak design flood flows for each catchment entering the SHP, calculated using the Index Flood method.

Catchment ID	Peak discharge [m^3/s] for ARI [a]					
	2	5	10	20	50	100
West catchment	19.27	28.68	37.24	48.56	64.66	75.74
Northwest catchment	10.20	15.16	19.67	25.65	34.14	39.98

Table 3.7: Peak design flood flows at each outlet calculated using the Rational method.

Catchment ID	Peak discharge [m^3/s] for ARI [a]					
	2	5	10	20	50	100
West catchment	19.29	28.36	36.08	44.57	56.92	67.53
Northwest catchment	11.05	16.24	20.66	25.52	32.59	38.67

A summary of all peak flow estimations are provided in Table 3.8. The results obtained using the Rainfall-Runoff Method are considered more accurate as actual site specific information, including routing, is used in the calculation.

Table 3.8: Summary of Peak design flood flows calculated using the various methods.

ARI	Catchment ID	Rainfall Runoff	Rational	Index Flood
100 years	West catchment	54.99	75.74	67.53
	Northwest catchment	16.15	39.98	38.67
50 years	West catchment	42.38	64.66	56.92
	Northwest catchment	12.85	34.14	32.59
20 years	West catchment	29.54	48.56	44.57
	Northwest catchment	8.93	25.65	25.52
10 years	West catchment	1	11.08	37.24
	Northwest catchment	15	3.31	19.67
5 years	West catchment	1	10.67	28.68
	Northwest catchment	15	3.10	15.16
2 years	West catchment	1	13.30	19.27
	Northwest catchment	15	3.89	10.20

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4. FLOOD EXTENT MAPPING

As discussed in Section 2 the SHP is situated with the large alluvial floodplain on the eastern side of the Pincombe Ranges and Sorby Hills. Given the geomorphology of the floodplain (i.e. extensive flat plain with no defined drainage channels) it is difficult to model and map flooding using typical approaches (i.e. HEC-RAS hydraulic modelling). Instead a volume balance approach was taken to estimate the extent to which water ponds on the alluvial surface and to determine the maximum likely flooding that is expected under intense rainfall events.

The alluvial floodplain saturates during the wet season, with water typically ponding to 20 – 30 cm of depth. The clayey soils, which exhibit defined shrink – swell properties (SWC, 2011), are likely to become saturated to 0.5 m following the onset of the wet season, and swell such that they form an effective 'clay-liner' across the floodplain (i.e. negligible infiltration after swelling). Any additional water landing on the floodplain (i.e. rainfall) ponds on the surface, and then either slowly flows to Knox Creek and Keep River, to the southeast, or evaporates. Based on the water retention properties listed in the Soil Characterisation Report (SWC, 2011), the clayey alluvial soils have a total storage capacity of 0.7 m^3/m^3 (i.e. 700 mm/m). If it is assumed that the surface 0.5 m of clay becomes saturated then 350 mm of water is consumed during the saturation process. Using the long-term (since 1944) monthly rainfall data listed in Table 4.1, all of the December and January rainfall is likely to be consumed in saturating the clayey alluvial soils; leaving the remaining 339 mm (0.33 m) of rainfall to pond on the surface of the floodplain (this ponded water depth is similar to that observed in the field, minus evaporation and runoff).

Table 4.1: Long-term monthly rainfall data for the Sorby Hill region for the wet season (Dec – Mar).

	December	January	February	March
Rainfall (mm)	145	203	208	133

If a worst case scenario is taken, and all rainfall (i.e. 689 mm) landing on the upstream Northwest and West Catchments reports to the floodplain (i.e. no infiltration of loss of water), then an additional 4,182,230 m^3 of water will enter the floodplain in the vicinity of the SHP. This volume of water equates to an additional 1,394 mm of water entering the site, and when combined with the already ponded water will result in a total ponded water height of 1.72 m.

If it is assumed that the upstream catchments have a 50 % runoff coefficient (i.e. 50 % of all rainfall runs off the catchment; equates to 344.5 mm) then an additional 2,088,080 m^3 of water will enter into the floodplain area in the vicinity of the SHP. This will result in a ponding water depth of 1.03 m. In the more realistic scenario, whereby only 30 % of the total rainfall runs offs from the upstream catchments (equivalent to 1,256,490 m^3), then the ponded water depth will only be 0.75 m deep. It is important to note that in the above scenarios, the volume of water running-off the upstream catchments in the 50 % runoff coefficient (344.5 mm) is equivalent to approximately 80 % of all rainfall falling in a 100 year 72 hr rainfall event (~ 420 mm) running of the catchment surface. Given that appreciably less water will likely runoff, it is considered that the ponding (flood) level of 1.03 m represents a maximum value and therefore all infrastructure will be required to be raised 1 m above the floodplain level to prevent flooding during intense rainfall events.

5. CONCLUSIONS & RECOMMENDATIONS

This study investigated surface water flows within the proposed SHP and the potential for flooding during intense (i.e. 100 year 72 hr ARI events). The major findings from this work area:

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- The upstream catchment areas for the SHP are relatively small covering a total area of 607 ha. Surface runoff from these catchments enters the SHP at two defined locations – northwest of the proposed plant area and west of the proposed Tailings Storage Facility (TSF).

- Maximum peak flows entering the SHP are likely to be in the order of 16 – 55 m^3/s. Drainage structures to be constructed on site (i.e. culverts, diversion channel) must be able to withstand this flow velocity without significant erosion and 'banking-up' of water.

- Under typical rainfall conditions, the alluvial floodplain within the SHP saturates, with a 20 – 30 cm layer of ponded water across the surface. It is expected that this depth of water will increase to around 1 m under a 100 year 72 hr ARI event, and subsequently all onsite infrastructure must be raised at least 1 m, and possibly rock armoured, to prevent flooding.

- To facilitate the removal of upstream runoff entering the SHP a diversion channel should be constructed along the western side of the project area. A schematic diagram showing a proposed diversion drain channel is shown in Figure 5.1. The outlet of this channel should be constructed so that it seamlessly keys-into one of the natural southeastern drainage features.

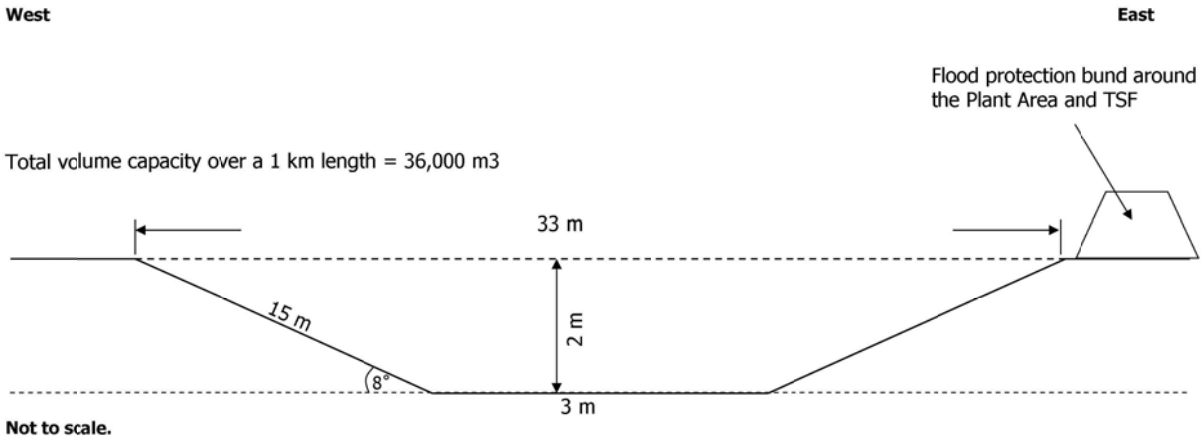


Figure 5.1: Proposed design for the diversion drain to be constructed on the western side of the SHP.

6. REFERENCES

ARR 2003, Pilgrim, DH, (ed), *Australian Rainfall & Runoff - A Guide to Flood Estimation*, Institution of Engineers, Australia, Barton, ACT.

Laurenson, E.M. R.G. Mein and R.J. Nathan, *RORB version 6 runoff routing program user manual*, Department of Civil Engineering, Monash University, 2010.

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Appendix 7: Hydrogeological Assessment for the Sorby Hills Project Ore Bodies













Australasian Groundwater & Environmental Consultants Pty Ltd

REPORT on

HYDROGEOLOGICAL ASSESSMENT (2011) FOR THE SORBY HILLS PROJECT

SILVER, LEAD, ZINC OREBODIES

prepared for
SORBY MANAGEMENT PTY LTD

Project No. G1489/A
November 2011

ABN:64 080 238 642

Australasian
Groundwater & Environmental
Consultants Pty Ltd

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DWI:ae(Sorby Hills)
Project No. G1489/A
November 2011

REPORT ON

HYDROGEOLOGICAL ASSESSMENT (2011) FOR THE SORBY HILLS PROJECT

SILVER, LEAD, ZINC OREBODIES

1.0 INTRODUCTION

Sorby Management Pty Ltd (Sorby Management), a joint venture company between Kimberley Metals Ltd and Henan Yuguang Gold and Lead Company Ltd (25%) are undertaking a pre-feasibility assessment for development of the Sorby Hills Project which is a lead-silver-zinc deposit in the East Kimberley region of Western Australia. The deposit was previously investigated in the late 1970's early 1980's by a joint venture between Aquitaine Australia Minerals Pty Ltd and Mimets Exploration following its discovery in 1971. A 179m long decline was developed to a depth of 35m but was terminated following large groundwater inflows. Subsequently a number of studies were undertaken and reports produced by various consultants in order to assess potential long-term inflow and options for a dewatering system. No further development of the project occurred after this event until Kimberley Metals acquired the mining lease in 2008.

In 2010, Kimberley Metals engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to undertake further assessment of the site hydrogeology to determine the dewatering requirements for the proposed mine development. This report presents the findings of the hydrogeological investigation undertaken in 2011, and has been prepared in accordance with the *Operational policy no. 5.12 – Hydrogeological reporting associated with a groundwater well licence* prepared by the Department of Water - Western Australia (DoW). This requires the extent of this investigation works being to an H2 level investigation which includes as a minimum, drilling and test pumping of the groundwater regime.

2.0 PROJECT DESCRIPTION

The Sorby Hills Project is located approximately 45km northeast of Kununurra from which it is accessed by road (refer Drawing No.1). The project consists of five granted mining leases (M80/196, M80/197, M80/285, M80/286, M80/287) and one exploration licence (E80/1187).

The deposit was discovered by Aquitaine Australia Minerals in 1971, and consists of a series of separate but adjacent carbonate hosted, near surface lead, silver, zinc deposits in the Burt Range Formation, which is within the Bonaparte Basin. The mineralisation is considered to be characteristic of a Mississippi Valley-type deposit.

Exploration and drilling programs provides for an estimate of inferred/indicated resource of 17.7 million tonnes grading 4.5% Pb, 54 g/t Ag and 0.7% Zn (using a 2.5% Pb or Zn cut-off). Sorby Management plans to commence a feasibility level study of the Sorby Hill Project in 2012, which will assess mining the orebodies via a series of shallow open pits.

2.1 Site Description and Topography

The site is located within the generally flat Knox Creek Plain which is around 20m AHD (Australian Height Datum) within the study area and comprises brown cracking alluvial clays that slope gently towards the east/northeast. The dominant topographic features proximal to the site include the Pincombe Range of hills (to 200m AHD) to the west and Spirit Hill to the northeast (to 40m AHD). Drainage is dominated by the Keep River which drains to the northeast some 4 – 5km to the east and Knox Creek, some 3km to the south, which is a tributary of the Keep River.

The site is contained within State (Crown) Land of which the landuse is exclusively for cattle ranching by Carlton Hill Station under a grazing agreement with Sate Government. The study area is generally underdeveloped and comprises predominantly grassland with emergent to dense low woodland (Kinhill, 2000).

2.2 Climate

Available rainfall and evaporation data has been sourced from the Bureau of Meteorology for Ivanhoe Station (002013) for rainfall and Kimberley Research Station (002014) for evaporation, recorded since 1907 and 1965 respectively, to the present. Where data was missing from Ivanhoe Station for rainfall, data was sourced from either Kimberley Research Station or Kununurra Aero (002056).

The climate is strongly seasonal with two distinct seasons controlled by the monsoon. Temperatures range from a mean winter minimum of 14.3°C in July, to a mean summer maximum of 39.0°C in November. The bulk of the average rainfall of 806mm falls during the summer months from December through to March, as shown on Table 1. The dry (winter) season is associated with milder temperatures and low to nil rainfall. Evaporation is high with the annual average pan evaporation exceeding the annual average rainfall by a factor of about 3.3, and exceeding rainfall for all months.

Table 1: MEAN RAINFALL/EVAPORATION DATA (mm)

Month	Rainfall	Evaporation
January	196.2	217.0
February	192.3	182.0
March	135.5	195.3
April	31.1	207.0
May	7.6	204.6
June	4.3	183.0
July	2.7	201.5
August	0.7	232.5
September	2.4	267.0
October	22.5	300.7
November	69.2	285.0
December	141.6	260.4
Total	**806.3**	**2736.0**

Note: Source – Bureau of Meteorology

In order to place recent rainfall years into an historical context, the Cumulative Rainfall Departure (CRD) which is a summation of the monthly departures of rainfall from the long-term average monthly rainfall, was calculated as follows:

$$CRD_n = CRD_{n-1} + (R_n - R_{av})$$

Where:	CRD_n	=	CRD for a given month
	CRD_{n-1}	=	CRD for a preceding month
	R_{av}	=	long term average rainfall for a given month
	R_n	=	actual rainfall for given month

A positive slope in the CRD plot indicates periods of above average rainfall which will also tend towards positive values, whilst a negative slope indicates periods when rainfall is below average. The calculated CRD between 1907 and 2011 for Ivanhoe Station is shown in Figure 1 below.

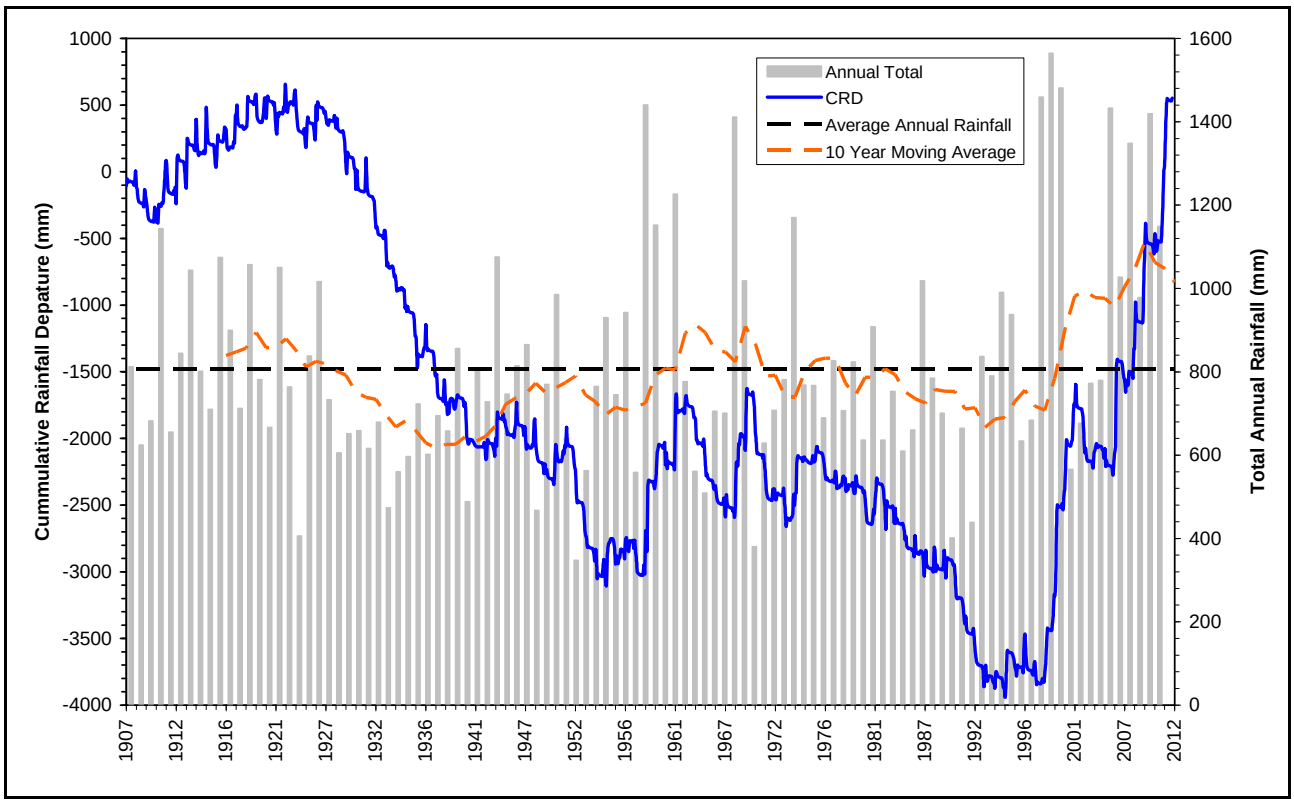


Figure 1: Cumulative Rainfall Departure – Ivanhoe Station (mm)

The CRD chart indicates that the Kimberley region northwest of Kununurra has been experiencing an extended period of above average rainfall from year 1999 onwards as observed by the overall positive slope during this period. This extended period is interspersed with short periods of below average rainfall as shown by declining to static CRD values, the most notable being between 2001 and 2005.

3.0 PREVIOUS STUDIES

A number of hydrogeological studies have been undertaken for the project area which include BRGM-Australia (Audibert and Jones, 1975), Australian Groundwater Consultants Pty Limited (AGC, 1979), Rockwater Proprietary Limited (Rockwater, 1980), Aquitaine-Mimets (1980) and University of NSW Water Research Laboratory (Dudgeon and Cox, 1981). These reports were reviewed by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE, 2009), and concluded that:

- *The early reports were quite broad in their description of the hydrogeological regime and the presence of recharge zones, particularly from the alluvial gravels and the need for confirmation of the extent and nature of the hydraulic barrier boundaries.*
- *High volumes of groundwater are likely to be produced as part of the overall dewatering requirements which could range from fresh to brackish / saline depending on the location within the site.*
- *Disposal options would need to be considered as the high groundwater volumes could present environmental issues.*
- *Further studies would be also required to assess the salinity from long-term dewatering and whether this will change over time.*
- *The number of bores, pumping rates and lead time to dewater a pit area would need to be assessed by 3D numerical modelling, and that further, more detailed data would be required on which to develop a conceptual groundwater model.*

4.0 GEOLOGY

The lead-zinc-silver deposits at Sorby Hills are located within the margin of the Bonaparte Basin adjacent to the north-eastern edge of the Kimberley Block. The western portion of the site is dominated by a Proterozoic (Pincombe Range) to Devonian aged basement complex. This basement geology outcrops along the western side of the study area forming the western edge of an easterly dipping basinal feature in which the stratigraphy hosting the Sorby Hills mineralisation has been deposited.

The site's geology is interpreted by CSA Global Pty Ltd (CSA, 2010) "*as a transgressive sequence of shelf carbonate-clastic rocks*". Based on this interpretation, the geology of the site is dominated by Carboniferous aged dolomitic formations which overlie the Devonian basement stratigraphy as summarised in Table 2.

Table 2: INITIAL ADOPTED AQUIFER PARAMETERS

Unit #	Unit Name	Lithology	Aquifer Type	Thickness
Tertiary Alluvium	Alluvium	Soils, Sands, Gravels	Unconfined Aquifer	10-30m
Black Shale	Milligans Formation	Shale	Aquiclude	0-300m
Upper Formation	Septimus Limestone	Argillaceous sediments	Aquiclude	0-50m
	Enga Sandstone	Dolomitic Siltstone		0-150m
	Gooseneck Member	Carbonates and Argillaceous Shaly Siltstone		0-100m

Table 2: INITIAL ADOPTED AQUIFER PARAMETERS				
Unit #	**Unit Name**	**Lithology**	**Aquifer Type**	**Thickness**
D3	Dolomite III	Dolomite	Confined Aquifer	0-15m
C1	Knox Siltstone	Interbedded Silty & Argillaceous Dolostone, Dolomitic Siltstone & Shale	Aquiclude	0-80m
D2	Dolomite II	Clastic Dolomite	Confined Aquifer	0-15m
D1	Dolomite I (Sorby Dolomite Member)	Dolomite	Confined Aquifer	0-100m

The mineralisation typically occurs as a series of discrete deposits referred to as A to I Pods within the D2 unit, the locations of which are shown in Drawing No. 2.

Structural mapping reported by CSA Global (CSA, 2010) identifies two dominant fault/fracture sets within the study area, these being a northeast orientated set considered to be continuous with the basement geology, and a second southeast orientated set which occurs on a roughly 200m to 400m spacing. The extent of this faulting in relation to the geological interpretation by Aquitaine in 1977 is presented in Drawing No. 2.

5.0 HYDROGEOLOGICAL REGIME CONCEPTUALISATION

Conceptualisation of the groundwater regime is that of a layered system of Carboniferous aged sediments contained within an easterly dipping basinal feature, which includes the stratigraphy hosting the Sorby Hills orebodies. These sediments are terminated by the Proterozoic (Pincombe Range) to Devonian aged basement complex which form the western edge of the basin and sub-crop beneath a surface veneer or covering of alluvial sediments. The basement geology complex is considered to be distinctly less permeable than the Carboniferous sediment aquifers.

Three aquifers occur within the site, these being:

- an upper alluvial aquifer within the surficial alluvial sediments which is considered unconfined;
- an intermediate confined aquifer within the D3 dolomite unit; and
- a deeper confined aquifer within the D2/D1 dolomite units.

Drilling to date has not intersected groundwater associated with the alluvial aquifer within the study area as this aquifer typically occurs within deeper sandy to gravelly alluvium that occurs further north (and presumably also to the east) of the current study area. However, the two deeper aquifers do occur with the study area, the D3 dolomite unit not always present, and the D2/D1 dolomites units forming the dominate aquifer within these Carboniferous sediments. The clastic C1 which is located stratigraphically between D2 and D3 is considered nearly impermeable as are the Upper Siltstone Carbonate Sequences and Black Shale which overlie D3.

The permeability and storativity of the dolomite units D1 and D3 are considered to be associated with fractures and solution channels/cavities which provide conduits for groundwater flow, with likely variability over short lateral distances. The permeability of the D2 unit is considered to be lower than D1 due to its more clastic composition and base metal mineralisation.

6.0 GROUNDWATER USE

The Department of Water (DoW) maintains a database of all registered groundwater bores in Western Australia and a search of the groundwater database covering an area that could potentially be impacted by the mine was undertaken. A search of the Water INformation (WIN) database has identified details for 196 registered bores within a 15km radius of the proposed mine, the majority of which were designated as a WBS series of bores and were the exploration boreholes drilled by Aquitaine when the ore bodies were originally investigated. Of these only 26 are observation bores that are reported to be currently operational and from which recent water level measurements was available, and two are assumed to be water supply bores and are reported to be currently operational. The location of these 26 observation bores and two water supply bores are summarised in Table 3 and shown in Drawing No. 7.

Table 3: REGISTERED BORE DETAILS

Name	Registered Number	Location	Easting	Northing	Ground Elevation
B6	8363	Weaber Plain	500,038	8,290,434	19.59
WBS1112	8378	Weaber Plain	497,039	8,293,702	20.78
W5S2R	8382	Weaber Plain	489,645	8,292,477	23.44
ORD19 (WP21)	11354518	Weaber Plain	497,132	8,293,688	20.85
ORD21 (WP15)	11354528	Weaber Plain	493,199	8,295,790	21.71
ORD22 (WP19)	11354531	Weaber Plain	494,916	8,298,221	20.62
WP10	13636796	Keep River Plain	488,503	8,290,291	24.68
WP11S	13636801	Keep River Plain	489,632	8,291,087	24.17
WP11D	13727062	Weaber Plain	489,632	8,291,087	24.17
WP12S	13724200	Weaber Plain	489,629	8,294,638	22.65
WP12M	13724204	Weaber Plain	489,629	8,294,638	22.65
WP12D	13724209	Weaber Plain	489,629	8,294,638	22.65
WP24	13636831	Keep River Plain	499,771	8,287,094	19.14
WP25	13636836	Keep River Plain	497,936	8,289,401	19.66
ORD17 (KC3)	11354495	Keep River Plain	498,123	8,284,349	21.21
ORD17A (KC3A)	11354505	Keep River Plain	498,123	8,284,350	21.35
ORD33 (KC6)	11354564	Keep River Plain	498,002	8,281,514	22.56
KC11	13633061	Keep River Plain	497,427	8,284,142	21.35
KC12	13636728	Keep River Plain	495,193	8,284,289	20.81
KC2	13636738	Keep River Plain	497,937	8,287,001	20.38
KC3PB	13636743	Keep River Plain	498,132	8,284,350	21.25
KC4	13636746	Keep River Plain	497,425	8,281,504	22.72
WBS 5081	23038557	Keep River Plain	497,132	8,293,499	20.63
WBS 1155	20082446	Keep River	497,344	8,285,298	20.59
W5S1	23025975	Weaber Plain	489,486	8,294,932	22.35
WBS5083	20083103	Keep River	497,447	8,293,701	20.96
Bore	20082442	Keep River	495,641	8,283,800	-
Ivanhoe No 3 Bore (Knox Creek)	20082428	Keep River	496,877	8,283,468	-

Hydrographs showing groundwater levels from nine of the monitoring bores which are located either within or adjacent to the study area are presented in Appendix A. The most recent round of water level measurements (November 2010) show groundwater levels are highest at the southern end of the mining tenement M8/287 where they range from 14.4m AHD (WBS1155) to 8.2m AHD

(WBS1112) adjacent to the Keep River Road. The longest continuous record is that for WBS1112 which shows groundwater levels measured between 1983 and 2010. This shows a notable rise in water levels during 1999, which corresponds with a similar rising trend in the CRD values post 1999, and hence a positive recharge potential resulting from the extended period of above average rainfall (refer Section 2.2).

7.0 FIELD INVESTIGATION PROGRAM

7.1 Overview

Previous studies have identified a number of risks and constraints with respect to the groundwater regime and project development. Review of these studies identified that further investigation of the site was warranted to better define and understand the groundwater regime. In part, this would require further assessment of the aquifer hosting and underlying the orebodies, that is the D2 and D1 Units respectively, and identifying to what extent these layers make up a single (main) aquifer.

One of the problems with previous pumping tests was the low pumping rates and minimal drawdown within the surrounding aquifer(s) not 'stressing' the aquifer and as such, resulting in the possibility that the aquifer properties determined might not be representative. Hence additional pumping tests were required to determine aquifer properties for transmissivity (hydraulic conductivity) and storativity which would allow verification of previous test pumping undertaken at the site.

With the above in mind, the objective of the field investigation program was to assess:

- the potential and feasibility of dewatering the pit;
- the potential and feasibility of obtaining a groundwater supply; and
- commencement of collection of a baseline groundwater quality dataset representative of the aquifer(s) to be dewatered.

This groundwater investigation program has focussed on the central to southern sections of the proposed open cut mining operations (C, D, E & F Pods) which is the focus of the initial (Stage 1) development for the project, and where the orebody is generally shallower being within around 70m below ground surface. The following scope of work was undertaken to address the objectives listed above:

- drilling of 13 monitoring bores within the D3, C1, D2 and D1 layers (OB1 to OB5, OB9 to OB11, OB13, OB14, OB15, OB15A, OB16);
- construction of 10 monitoring bores as open hole piezometers using 50mm diameter PVC (OB1 to OB4, OB9, OB11, OB14, OB15, OB15A, OB16);
- construction of three monitoring bores as vibrating wire piezometers fitted with sensors in different geological sequences (OB5, OB10, OB13);
- in-situ permeability testing by falling head test methodology of the 10 open hole monitoring bores;
- drilling and construction of three test production bores within the D2/D1 layers (TPB1, TPB3, TPB4);
- test pumping of the three test production bores and monitoring in all including the installed monitoring bores; and

- sampling of groundwater from both the open hole monitoring bores and test production bores to characterise the groundwater encountered within the site.

The drilling and bore construction works were supervised by a Class 2 Western Australia licensed water bore driller, in accordance with the Rights in Water and Irrigation Act 1914. Construction of the monitoring and test production bores complied with the *Minimum Construction Requirements for Water Bores in Australia, (2003, Ed. 2)*. Bore depths, screen settings etc were specified by a hydrogeologist from AGE based on the lithology intersected.

A brief description of the field investigation program is provided in the following sections.

7.2 Construction of Monitoring Bores

7.2.1 Objective

The objective of this part of the investigation was to establish a network of monitoring bores that intersected the D3, C1, D2 and D1 layers sufficient to provide data on the following:

- indicative location of high yielding groundwater zones, that is, highly fractured areas;
- groundwater levels within the D3, C1, D2 and D1 layers;
- groundwater quality;
- response of aquifer groundwater levels to groundwater extraction during the pumping tests.

7.2.2 Work Program

Drilling and construction of the monitoring bores was undertaken by Direct Drilling Australia Wide Pty Ltd (Direct Drilling) between 20 June and 7 July 2011. The boreholes were drilled using a 165mm (6 ½ inch) diameter percussion hammer bit to between 16m and 110m depth. The upper Tertiary Alluvial layer was sealed off using 200mm diameter Class 12 PVC casing, which was grout sealed into the top of the underlying weathered bedrock layer.

A generalised description of each unit intersected whilst drilling the monitoring bores is provided in Table 4. The drilling intersected varying thicknesses in the D3, C1, D2/D1 layers, which inturn were overlain by a relatively uniform thickness of Tertiary alluvial sediments, the depths of which are summarised below in Table 5. Composite logs of these monitoring bores are provided in Appendix B and the locations are shown on Drawing No. 3.

Table 4: GEOLOGICAL UNIT SUMMARY	
Geological Unit	**Description**
Tertiary Alluvium (TA)	SILTY CLAY, plastic, dark brown to red brown with some sand and gravel, moist
Upper Formation (UF)	CLAYSTONE / SILTSTONE, weathered to fresh, white to dark grey, hard
Dolomite III (D3)	DOLOMITE, weathered, white to orange brown, hard, wet in places (**AQUIFER**)
Knox Siltstone (C1)	INTERBEDDED SILTSTONE / Dolomite, weathered to fresh, brown to dark grey, hard with some pyrite and galena mineralisation, wet in places
Dolomite II (D2)	DOLOMITE, weathered to fresh, light to dark grey, hard, wet, generally with pyrite and galena mineralisation
Dolomite I (D1)	DOLOMITE, fresh, dark grey / grey brown to pinky grey, hard, wet, dissolution cavities sometimes present. (**AQUIFER**)

Table 5: MONITORING BORE GEOLOGY SUMMARY													
Geological Unit	OB1	OB2	OB3	OB4	OB5	OB9	OB10	OB11	OB13	OB14	OB15	OB15A	OB16
TA	0m – 15m	0m – 14m	0m – 14m	0m– 14m	0m – 13m	0m – 12m	0m – 13m	0m – 14m	0m – 10m	0m – 11m	0m – 6m	0m – 8m	0m – 12m
UF	–	–	–	–	–	–	–	–	10m – 19m	–	–	–	12m – 66m
D3	15m – 22m	14m – 22m	14m – 22m	–	13m – 27m	12m – 16m	13m – 71m	–	–	–	–	–	–
C1	22m – 103m	22m – 68m	22m – 68m	14m – EOH (19m)	27m – EOH (44m)	16m – 21m	71m – 90m	14m – 57m	19m – 29m	–	6m – 17m	8m – EOH (16m)	66m – 80m
D2	103m – EOH (110m)	68m – 91m	68m – 91m	–	–	21m – 33m	90m – EOH (97m)	57m – 86m	29m – 48m	11m – 53m	17m – 42m	–	80m – 93m
D1	–	91m – EOH (109m)	91m – EOH (109m)	–	–	33m – EOH (43m)	–	86m – EOH (102m)	48m – EOH (60m)	53m – EOH (67m)	42m – EOH (54m)	–	93m – EOH (109m)
Final Groundwater Yield (Initial Intersection)	0.15 L/sec (31m)	0.2 L/sec (24m)	15-25 L/sec (30m)	3L/sec (-)	5L/sec (21m)	5L/sec (30m)	4/sec (25m)	6L/sec (23m	4L/sec (25m)	8L/sec (32m)	10L/sec (12m)	2L/sec (12m)	3L/sec (30m)

The boreholes were constructed as monitoring bores using 50mm diameter, Class 18, uPVC casing with factory slotted screens positioned over the basal section. A gravel pack was placed around the screened sections and zones of groundwater inflow, and a monument style, 150mm diameter, Class 12, PVC borehead concreted around the protruding casing at ground surface. On completion, each monitoring bore was airlift developed to remove drilling fines and enhance hydraulic connection with the aquifer. Construction details for these monitoring bores are summarised in Table 6.

Table 6: PVC MONITORING BORE CONSTRUCTION DETAILS

Monitoring Bore	Eastings	Northings	Bore Elevation	Bore Depth (mbTOC)	Screened Section (mbGL)	Bentonite Seal (mbGL)	Gravel Pack (maGL)	Standing Water Level (mbTOC)	Top of PVC Casing (maGL)
OB1	497,891.19	8,292,444.73	20.64	109	103-109	90-92	92-109	12.04	0.62
OB2	497,886.43	8,292,251.54	20.66	109.3	97.2-109.3	88-91	91-109.3	11.84	0.63
OB3	497,880.08	8,292,097.65	20.65	61	55-61	45-47.3	47.3-58.5	11.79	0.71
OB4	497,979.27	8,291,677.11	20.40	19	15.3-18.3	12-13	13-17	11.41	0.56
OB9	498,123.78	8,291,407.70	20.39	42.7	33.7-36.7 39.7-42.7	28.7-29.7	29.7-42.7	11.08	0.58
OB11	498,254.17	8,291,055.63	20.32	102	69-75 81-87 93-99	63.7-65.3	65.3-102	11.09	0.50
OB14	498,029.10	8,290,775.58	20.28	67	40-43 46-49 52-58 61-67	29-31	31-67	10.10	0.55
OB15	497,954.30	8,290,593.10	20.32	54.3	30-36 42-54	19.8-21.2	21.2-54	9.38	0.46
OB15a	497,950.54	8,290,593.79	20.32	16	12-15	8-10	10-16	9.37	0.62
OB16	498,195.43	8,290,762.85	20.21	109	97-100 103-109	92-94	94-109	10.80	0.66

7.2.3 Vibrating Wire Piezometer Installation

Slope Indicator vibrating wire piezometer (VWP) sensors were installed in monitoring bores OB5, OB10 and OB13. The depth of each sensor was selected to monitor changes in pore water pressures or water levels associated with the D3, C1 and D2 layers in these boreholes, with the objective being to identify any changes in water pressures within these layers during pumping. That is, the sensors would provide an opportunity to identify any hydraulic interconnection or leakage from the geological units located stratigraphically above the D1 aquifer unit. This is achieved by grouting the sensors into place at their required depths in a bentonite-cement slurry. When the grout cures, each piezometer sensor is effectively isolated from the rest of the boreholes located above and below it, but becomes highly responsive to changes in pore-water pressures at its own elevation/depth (Slope Indicator, 2011).

These boreholes were drilled using a 165mm (6 ½ inch) diameter percussion hammer bit to between 44m and 97m depth. The upper Tertiary Alluvial layer was sealed off using 200mm diameter Class 12 PVC casing, which was grout sealed into the top of the underlying weathered bedrock layer.

The VWP sensors were taped onto a length of 32mm high pressure polypipe at their required depth, prior to being lowered into the borehole. The polypipe provided for a tremie pipe for pumping and placement of the bentonite-cement grout slurry into the borehole for the entire depth of the borehole below ground surface. The bentonite-cement grout slurry was prepared in accordance with the grout mixture ratios recommended by Slope Indicator. The grout was then left to set and harden over a two-week period.

Construction details for these monitoring bores are summarised in Table 7.

Table 7: VWP MONITORING BORE CONSTRUCTION DETAILS							
Monitoring Bore	**Eastings**	**Northings**	**Bore Elevation**	**Bore Depth (mbTOC)**	**VWP Sensor Depth (mbGL)**	**Standing Water Level (mbTOC)**	**Top of PVC Casing (maGL)**
OB5	497,913.15	8,292,099.08	20.64	44	23 & 40	10.76	0.20
OB10	498,295.18	8,291,202.91	20.29	97	30, 50 & 88	10.25	0.15
0B13	498,052.04	8,290,920.16	20.23	60	25, 35 & 55	9.96	0.20

7.3 Test Production Bore Drilling and Construction

7.3.1 Objectives

The location of the test production bores was selected by reviewing faulting/fractured geology intersected during CSA's 2010 resource drilling program, fault structures previously mapped by Aquitane Australia Minerals and the results of the observation bore drilling.

The objectives for establishing the test production bores were to enable long-term pumping tests to be undertaken from a number of locations across the site to:

- determine the hydraulic parameters and special variability of the D1 aquifer;
- identify the relationship, that is, degree of hydraulic connection between the groundwater contained within the D3, C1, D2 and D1 layers;
- assess the performance and the potential sustainable yield of the bore; and
- determine the water quality of the pumped groundwater.

7.3.2 Work Program

Drilling and construction of the test production bores (TPB1, TPB3 and TPB4) was undertaken by Direct Drilling. The drill holes were located adjacent to observation bores OB3, OB10 and OB14 respectively, and were drilled to between 65m and 85m depth as part of this drilling campaign. As for the observation bores, the drilling intersected varying thicknesses D3, C1, D2/D1 layers overlain by Tertiary alluvial sediments, the depths of which are summarised below in Table 5. Composite logs of these monitoring bores are provided in Appendix B and the locations are shown on Drawing No. 3.

A generalised description of the intersection depths for each geological unit is summarised in Table 8.

Table 8: TEST PRODUCTION BORE GEOLOGY SUMMARY			
Geological Unit	**TPB1**	**TPB3**	**TPB4**
TA	0m – 12m	0m – 13m	0m – 12m
UF	–	–	–
D3	12m – 26m	–	–
C1	26m – 48m	13m – 36m	–
D2	48m – 58m	36m – 62m	12m – 49m
D1	58M – EOH (65m)	62m – EOH (84m)	49m – EOH (78m)
Final Groundwater Yield (Initial Intersection)	2-5 L/sec (23m)	15-20 L/sec (63m)	0.5 L/sec (37m)

Construction of these bores required initially drilling sealing and casing off the upper Tertiary Alluvium, D3 and C1 layers with 200mm nominal diameter Class 12 PVC, which was pressure grouted into place. A 190mm diameter drill hole was then drilled into the D2 ad D1 layers which were subsequently left open in bores TPB3 and TPB4. In bore TPB1, a 17m length of 152mm ID, Class 12, 0.4mm machine slotted PVC casing was telescoped to the base of the borehole, with a "K" packer sealing off the base of the 200mm PVC casing. Construction details are summarised in Table 9.

Table 9: TEST PRODUCTION BORE CONSTRUCTION DETAILS

Monitoring Bore	Eastings	Northings	Bore Elevation	Bore Depth (mbTOC)	200mm Diameter Casing (mbGL)	Open Hole/Screened Section (mbGL)	Standing Water Level (mbTOC)	Top of PVC Casing (maGL)
TPB1	497,893.67	8,292,098.56	20.66	65	0-47.3	47.3-65 (screen)	11.23	0.14
TPB3	498,263.64	8,291,186.97	20.25	84	0-60	60-84	11.75	0.28
TPB4	498,013.74	8,290,790.65	20.27	78	0-48	48-78	10.24	0.44

7.4 In-Situ Permeability Testing

As a part of the investigation, falling head permeability tests were conducted in each open hole monitoring bore. The testing was designed to evaluate the hydraulic conductivity of aquifer material surrounding the bore screen. A falling head test requires a "slug" of water being poured into the bore and the rate of decline in water level being monitored. Water was sourced from a bore intersecting the same D1/D2 aquifer, thereby minimising potential for groundwater quality interferences when sampling these bores.

The falling head data sheets and graphical analysis for each monitoring bore tested are presented in Appendix C. The data was analysed using the Hvorslev Method (1951) for confined aquifers using *Aquifer Test 2011.1* software. The results of the analyses are summarised in Table 10.

Table 10: FALLING HEAD TEST RESULTS

Bore ID	Hydraulic Conductivity	
	m/sec	m/day
OB1	2.4×10^{-8}	2.2×10^{-3}
OB2	3.3×10^{-8}	2.9×10^{-3}
OB3	1.9×10^{-5}	1.7
OB4	1.2×10^{-6}	0.1
OB9	1.6×10^{-5}	1.4
OB11	2.0×10^{-6}	0.2
0B14	1.7×10^{-6}	0.2
OB15	2.3×10^{-6}	0.2
0B15A	8.3×10^{-6}	0.7
OB16	8.9×10^{-6}	0.8

The analyses indicate the variable range in hydraulic conductivity values for the dolomite geology across the study area, ranging from low to very low within the northern portion of the site (OB1 and OB2), to moderate in the central to southern portions of the study.

7.5 Aquifer Pumping Tests and Monitoring

The pumping tests for each test bore comprised three parts, viz:

- a multi-rate step test comprising up to six steps;
- a five-day constant rate test; and
- monitoring of aquifer recovery following cessation of pumping.

The pumping tests were conducted in accordance with Australian Standard AS 2368-1990 and were undertaken between 28 August and 12 September 2011.

7.5.1 Step Drawdown Test and Analysis

Overview

A step drawdown test was undertaken for each test bore to determine the optimal pumping rate for the constant rate test for each bore. This included running the pump between three and six, ninety-minute to two-hour duration steps at increasing rates of pumping, and recording the water level in the test bore at regular intervals for the duration of the test. A second step test was run for TPB3 as the results of the initial step test were inconclusive for selecting an optimal pumping rate for the constant rate test.

Prior to commencing the test, the initial standing water level was measured. The maximum drawdown of the water level at the end of each step for each test is summarised in Table 11.

Table 11: SUMMARY OF PUMPING RATES AND DRAWDOWN – STEP DRAWDOWN TEST

Step Test	Multi-Rate Step	Pumping Rate (L/s)	Maximum Drawdown (m)
TPB1	1	1.5	4.9
	2	1.9	9.5
	3	3.0	17.7
	4	3.9	23.4
	5	4.3	30.0
TPB3_A	1	5.2	3.8
	2	9.9	4.5
	3	15.1	6.2
	4	20.3	9.3
	5	24.3	11.6
	6	33.5	16.2

Table 11: SUMMARY OF PUMPING RATES AND DRAWDOWN – STEP DRAWDOWN TEST			
Step Test	**Multi-Rate Step**	**Pumping Rate (L/s)**	**Maximum Drawdown (m)**
TPB3_B	1	24.3	9.4
	2	30.6	13.6
	3	32.8	16.3
TPB4	1	1.2	11.3
	2	2.0	23.1
	3	2.8	36.7
	4	3.1	49.8

Based on the extent of water level drawdown and the available drawdown at the end of each step, the following pumping rates were determined for each constant rate test:

- TPB1 – 4L/sec;
- TPB3 – 31L/sec; and
- TPB4 – 3L/sec.

The drawdown and recovery plots for each step test are presented in Appendix D.

7.5.2 Constant Rate Pumping Test and Analysis

Overview

Constant rate pumping tests were undertaken over the period 122 hours and 124 hours (five days). During this period, the bores were pumped at the following constant rates:

- TPB1 – 4L/sec;
- TPB3 – 31L/sec; and
- TPB4 – 3L/sec.

The groundwater was pumped from the test bore via a 200m length discharge line located to direct this discharge water away from the pumping bore or observations bore, thereby reducing the potential for interference from localised recharge during the test. Pressure sensor data loggers were used to electronically record water levels in the pumping bore and observation bores during each pumping test. Spot water levels were also recorded with an electronic dipper in the monitoring bores. The monitoring network for each pumping test is summarised in Table 12, Table 13 and Table 14, and their locations are shown in Drawing No. 3.

During the period of each test, there was no rainfall recorded at the site or within the nearby region.

Following cessation of each constant rate pumping test, the water level recovery in the test bore and observation bores was monitored for a period up to three days.

Analysis of Data

The constant rate drawdown and water level recovery data were analysed using the "Aquifer Test Version 2011.1" software package. Drawdown data was analysed using the Theis Curve and the Cooper-Jacob straight line analysis, both methods of which are for confined aquifer conditions. The recovery data was analysed using the Theis recovery method.

Analyses of the drawdown and recovery data provide an estimate of the aquifer hydraulic parameters of transmissivity and storativity. Transmissivity is the product of hydraulic conductivity (permeability) by the aquifer thickness. Storativity, which can only be determined from analyses of data from observation bores, is a measure of the volume of water released from storage per unit surface area of the aquifer per unit decline in hydraulic head.

The drawdown and recovery plots and analyses sheets for each pumping test are given in Appendix D, and a summary of the test results are provided in Table 12, Table 13 and Table 14.

Table 12: ASSESSMENT OF CONSTANT RATE PUMPING TEST FOR TPB1

Test Production / Observation Bores	Distance from Bore Test (m)	Pre-pumping SWL (mBGL)	Maximum Drawdown (m)	Transmissivity (m^2/d)	Hydraulic Conductivity (m/d)	Storativity	Analysis
TPB1	0.00	11.23	28.87	18.2	0.4	-	Theis
				63.9	1.6	-	Cooper-Jacob
				1.8	0.0	-	Theis Recovery
OB02	152.64	11.75	0.23	742.0	18.1	8.05E-04	Theis
				729.0	17.8	6.35E-04	Cooper-Jacob
				954.0	23.3	-	Theis Recovery
OB03	10.00	11.78	0.21	1590.0	38.8	9.32E-02	Theis
				356.0	8.7	5.00E-01	Cooper-Jacob
				1670.0	40.7	-	Theis Recovery

Table 13: ASSESSMENT OF CONSTANT RATE PUMPING TEST FOR TPB3

Test Production / Observation Bores	Distance from Bore Test (m)	Pre-pumping SWL (mBGL)	Maximum Drawdown (m)	Transmissivity (m^2/d)	Hydraulic Conductivity (m/d)	Storativity	Analysis
TPB3	0.00	10.78	17.79	181.0	2.3	-	Theis
				251.0	3.2	-	Cooper-Jacob
				52.8	0.7	-	Theis Recovery
OB04	561.39	11.40	0.13	1620.0	20.8	2.16E-03	Theis
				1840.0	23.6	1.72E-03	Cooper-Jacob
				3440.0	44.1	-	Theis Recovery
OB09	257.70	11.05	0.13	217.0	2.8	ND	Theis
				267.0	3.4	ND	Cooper-Jacob
				117.0	1.5	-	Theis Recovery
OB10C	34.54	10.93	0.15	248.0	3.2	3.08E-04	Theis
				246.0	3.2	4.17E-04	Cooper-Jacob
				105.0	1.3	-	Theis Recovery
OB11	135.30	11.00	0.14	193.0	2.5	ND	Theis
				275.0	3.5	ND	Cooper-Jacob
				94.9	1.2	-	Theis Recovery
OB13C	342.50	10.65	0.11	627.0	8.0	1.06E-03	Theis
				628.0	8.1	1.01E-03	Cooper-Jacob
				765.0	9.8	-	Theis Recovery
OB14	473.81	10.07	0.13	722.0	9.3	1.11E-03	Theis
				758.0	9.7	9.88E-04	Cooper-Jacob
				1180.0	15.1	-	Theis Recovery

Table 14: ASSESSMENT OF CONSTANT RATE PUMPING TEST FOR TPB4							
Test Production / Observation Bores	**Distance from Bore Test (m)**	**Pre-pumping SWL (mBGL)**	**Maximum Drawdown (m)**	**Transmissivity (m^2/d)**	**Hydraulic Conductivity (m/d)**	**Storativity**	**Analysis**
TPB4	0.00	10.18	45.82	-	-	-	Theis
				249.0	3.8	-	Cooper-Jacob
				NA	NA	-	Theis Recovery
OB13C	136.97	10.65	0.11	169.0	2.6	ND	Theis
				490.0	7.4	ND	Cooper-Jacob
				119.0	1.8	-	Theis Recovery
OB14	21.63	10.07	0.13	115.0	1.7	ND	Theis
				115.0	1.7	ND	Cooper-Jacob
				55.8	0.8	-	Theis Recovery
OB15	203.07	9.49	0.02	227.0	3.4	3.05E-03	Theis
				323.0	4.9	1.48E-03	Cooper-Jacob
				-	-	-	Theis Recovery
OB16	184.70	10.46	0.08	-	-	-	Theis
				124.0	1.9	ND	Cooper-Jacob
				57.1	0.7	-	Theis Recovery

The drawdown curves for TPB4 and OB16 were not able to be fitted against a Theis curve and as such have not been reported. Similarly, analyses for storativity in OB9, OB11, OB13C, OB14 and OB16 were less than $1x10^{-6}$ which is unrealistic for a confined aquifer, and as such were not able to be determined (ND) for these bores.

As for the step test analyses, the constant rate pumping test for each test bore indicated variable aquifer parameters across the study area. The transmissivity values calculated from the test pumping bores in the D1/D2 aquifer ranged between $18m^2$/day and $250m^2$/day, indicating spatial variability in the hydraulic conductivity of the aquifer. It is noticed that the transmissivity values calculated from the monitoring pumping bores in the D1/D2 aquifer varied depending on their distance from the pumping bore with values increasing in excess of $1,000m^2$/day for those located distant from the pumping bore. Conversely the transmissivity values calculated from the monitoring pumping bores located closer to the pumping bores where the drawdown zone was greater, ranging between $95m^2$/day and $740m^2$/day. Depending on the aquifer thickness, this transmissivity range equates to moderate to high hydraulic conductivity range of the rock mass of between 1m/day (1.1×10^{-5}m/s) and 20m/day (2.3×10^{-4}m/s). Such variability in aquifer hydraulic conductivity is typical of a faulted/fractured rock aquifer and is due to the heterogeneous nature that results from fault/fracture geometry, orientation, spacing, aperture, roughness, matrix porosity and interconnection. Such faulting can form barrier boundaries that effectively compartmentalise groundwater flow, resulting in zones of higher permeability and hence higher groundwater inflows when intersected. It is possible that this type of faulted flow boundaries can impact on the groundwater flow regime by:

- compartmentalising groundwater flow and preventing uniform drawdown (dewatering) of the aquifer;
- indicating an initial high sustainable yield from the bore which then rapidly dewaters at some later time;
- indicating high groundwater inflows when initially intersected. Such inflows can be relatively short lived; with a duration of hours or days, but can present a risk to mine safety during the mine development phase and productivity in the short term.

Storativity values ranged from 0.05 to 6 x 10^{-4}, but with an average value around 2 x 10^{-3} which is considered typical for a confined aquifer hosted within a dolomite rocktype.

As expected, the drawdown response within the D1/D2 aquifer for each pumping test showed a greater aquifer drawdown proximal to the respective pumping bore. The extent of this drawdown varied across the site, with only the closest monitoring bores affected when pumping from TPB1 to a response across the entire monitoring borefield when pumping from TPB3. It is likely this variability in extent of drawdown is dependent on the hydraulic interconnection of the major fault structures intersected by each test bore. That is, a greater drawdown response would be expected for more permeable aquifer zones due to the aquifer's increased capacity for groundwater flow/movement. The extent of the maximum drawdown inferred from the groundwater level data for the D1/D2 aquifer is shown in Drawing Nos. 4 to 6.

The drawdown response in the VWP monitoring bores located variably within the D3, C1 and D2 layers was observed in each of the monitoring bores OB5A/5B, OB10A/10B/10C and OB13A/13B/13C, and is summarised in Table 15.

Table 15: PUMPING TEST RESULTS – VWP MONITORING BORES

Bore	Geological Unit	Distance from (Test Bore)	Pre-pumping SWL (mbGL)	Maximum Drawdown (m)
OB5A	D3	20m (TPB1)	11.97	0.20
OB5B	C1	20m (TPB1)	12.27	0.30
OB10A	D3	64.5m (TPB3)	10.89	3.33
OB10B	C1	64.5m (TPB3)	6.96	4.29
OB10C	D1/D2	64.5m (TPB3)	11.69	15.19
OB13A	D3	136m (TPB4)	10.39	1.25
OB13B	C1	136m (TPB4)	10.48	1.52
OB13C	D1/D2	136m (TPB4)	10.81	1.49

Drawdown responses were measured in each sensor during the respective pumping tests, indicating hydraulic interconnection between groundwater hosted within the upper stratigraphic units and the D1/D2 aquifer unit. It is likely that this is due to faulting and resultant fracturing extending throughout the Carboniferous geological units that makeup the bedrock sequences below the alluvial sediments. The greatest drawdown was recorded in OB10 during the pumping TPB3 test, whilst the least was in OB5 despite its closer proximity to the pumping bore TPB1. It is likely this was due to localised compartmentalisation hydraulically separating the observation from the pumping bore. The extent of the drawdown inferred in these monitoring bores during the pumping tests is shown in Drawing Nos. 4 to 6.

Hydrographs for each test bore and monitoring bore are presented in Appendix E covering the period of pumping tests for each bore. These show the overall recovered aquifer water level after completion of all three pumping tests, is lower than before these tests commenced, indicating aquifer depletion in this area. On going aquifer water level monitoring will confirm if this is the case.

Water Quality Monitoring

The electrical conductivity (EC) and pH of the pumped water was analysed during the constant rate pumping test using a portable meter. The pH and electrical conductivity are presented in Table 16.

The data show the groundwater quality is generally neutral and brackish with EC at the end of pumping ranging between 1,100µS/cm and 2,700µS/cm.

Table 16: FIELD WATER QUALITY DATA				
Test Pumping Bore	**Date**	**Day**	**pH**	**EC (µS/cm)**
TPB1	29 August	1	7.1	890
	3 September	5	7.1	1,120
TPB3	15 September	1	7.1	2,570
	21 September	5	7.1	2,700
TPB4	5 September	1	7.0	1,620
	11 September	5	6.9	1,530

In addition, two groundwater samples were collected during each constant rate pumping test at the same times representing commencement of the pumping test and prior to completion. All water samples were submitted to the ChemCentre laboratory in Perth for analysis.

7.6 Water Sample Collection and Analysis

7.6.1 Sampling and Analysis Methodology

In order to characterise and assess spatial variability in the groundwater composition, representative groundwater samples were collected from the each of the observation and test production bores.

The monitoring bores were developed and purged between 17 August and 29 September 2011, by airlift pumping, and then sampled using a hand bailer. Each bore was purged by removing at least four bore volumes in accordance with the guidelines prepared by the Department of Environmental Protection (DEC, 2001) for groundwater sampling. This was carried out to ensure:

- removal of any drilling fluids;
- establishment of hydraulic connection between the monitoring bore and aquifer; and
- collection of a representative groundwater sample.

Electrical conductivity (EC) and pH was monitored during development using a MC-81 pH-conductivity-salinity meter manufactured by TPS Electronics Pty Ltd to ensure sampling of a representative water sample from the borehole. The instrument was calibrated prior to undertaking the work, using factory-supplied calibration standard solutions.

When the EC had stabilised and the bores were yielding generally clear water, samples were collected for analysis. The samples were stored in appropriate containers supplied by ChemCentre, which is NATA registered for the laboratory analytical work performed for this assessment. The groundwater samples were analysed for:

- pH, EC, total dissolved solids (TDS), total suspended solids (TSS) , alkalinity, hardness;
- Major anions – carbonate, bicarbonate, chloride, sulphate;
- Major cations – calcium, magnesium, sodium, potassium;

- Total dissolved metals – aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc;
- Nutrients – nitrite, nitrate, total nitrogen, total phosphorus;
- BTEX hydrocarbons – Benzene, Toluene, Ethylbenzene, Xylene; and
- Total petroleum hydrocarbon (TPH) chains – C_6-C_9, C_{10}-C_{14}, C_{15}-C_{28}, C_{29}-C_{36}.

Copies of the laboratory analysis certificates are given in Appendix F, and are discussed in detail the following section.

7.6.2 Groundwater Quality

The groundwater quality data obtained from laboratory analyses is summarised in Table 17 to Table 20. A comparison of the water quality data was undertaken to identify any variation in the water quality across the study area. A Piper Diagram of the water quality data from each monitoring bore is shown in Figure 2.

Figure 2 indicates that the water quality across the study area is generally similar with the cation/anion balance show no dominant water type other than an overall predominance associated with sodium, magnesium, calcium, sulphate and bicarbonate.

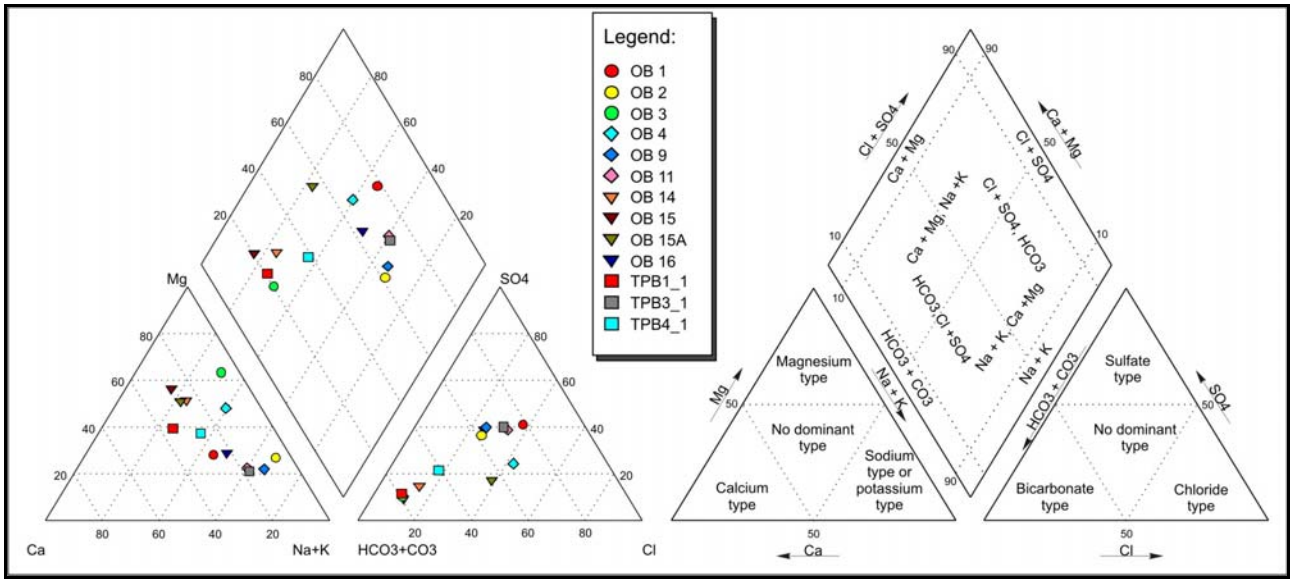


Figure 2: Piper Diagram of Sorby Hills Groundwater Quality

In addition, a comparison of pumping water quality from each test production bore was undertaken to identify any variation in water quality over the duration of the respective pumping test is shown in Figure 3. This shows no overall change in the water quality during the constant rate pumping tests, indicating the water abstracted during each pumping test was sourced from the same aquifer or aquifer type.

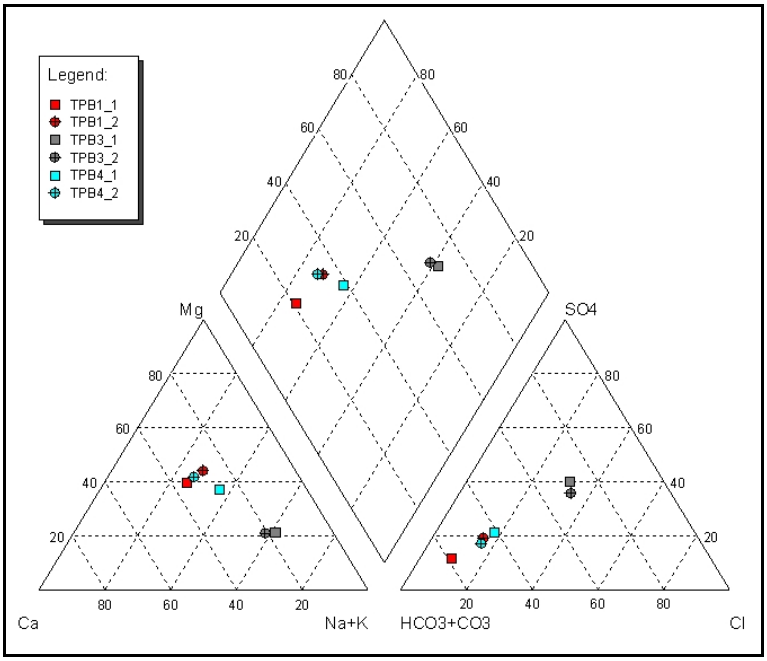


Figure 3: Piper Diagram of Pumping Water Quality

Water quality field determinations for pH and EC recorded during purging and sampling, indicate the groundwater to be slightly alkaline and brackish.

Ten groundwater samples were analysed from the observation bores prior to the constant rate pumping tests, and six from the test production bores over the duration of the pumping test. Comparison of this water quality data has been made against the following adopted water quality guidelines:

- Freshwater guidelines which are based on slightly to moderately disturbed systems on the basis the site is a cattle ranch and has been subject to previous mineral exploration. This adopts triggers levels calculated from a 95% protection level.
- Marine water guidelines which are based on high conservation/ecological value systems on the basis of potential groundwater and surface water drainage/discharge into the Keep River estuary, which could be considered to have a significant impact on the Matters of National Environmental Significance (Matters of NES), specifically in relation to Threatened and Migratory species. This adopts trigger levels calculated from a 99% protection level.

The results indicate the water quality was typically within the guideline levels for the majority of parameter analysed, with the exception of electrical conductivity (freshwater), lead, zinc, and to a lesser extent, total phosphorus and aluminium. Concentrations of nitrogen based nutrients and dissolved metals for silver, cadmium, cobalt, chromium, copper, mercury and selenium were all below laboratory detection limits.

Detectable levels of heavy end petroleum hydrocarbons (C_{15} to C_{36}) were reported in bores OB1 and OB2 which are considered to be from drilling process and probably hammer oil residue. It is noted these two bores were low yielding and of low permeability, in contrast to the higher yielding, more permeable central to southern monitoring bores. This being the case, it is possible any similar hydrocarbon contamination within the central to southern monitoring bores was removed during bore development and purging prior to sampling as a consequence of the more efficient and greater volumes of water pumped from these bores.

Table 17: LABORATORY ANALYSIS RESULTS – MONITORING BORES								
Analyte	**Units**	**LOR**	**OB1**	**OB2**	**OB3**	**OB4**	**Fresh-water**	**Marine Water**
pH		0.1	7.4	7.9	7.6	7.5	6-8	7-8.5
Electrical Conductivity	µS/cm		***2,580***	***1,530***	***866***	***2,130***	250	-
Total Dissolved Solids	mg/L	5	1,400	840	480	1,200	-	-
Total Suspended Solids	mg/L	1	380	1,400	140	130	-	-
Major Ions								
Calcium	mg/L	0.1	167	17.4	8.5	46.5	-	-
Potassium	mg/L	0.1	15	10.9	6.5	3.1	-	-
Magnesium	mg/L	0.1	107	51.8	51	109	-	-
Sodium	mg/L	0.1	311	237	41.7	167	-	-
Chloride	mg/L	***1***	***361***	***146***	***34***	***351***	0.003	-
Sulphate	mg/L	0.5	540	290	44	270	-	-
Alkalinity	mg/L	1	293	315	360	383	-	-
Carbonate	mg/L	1	<1	<1	<1	<1	-	-
Bicarbonate	mg/L	1	357	384	439	467	-	-
Hardness	mg/L	1	860	260	230	560	-	-
Trace Metals								
Silver	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00005	0.0008
Aluminium	mg/L	0.005	0.021	***0.087***	0.01	0.028	0.055	-
Arsenic	mg/L	0.001	0.007	0.007	0.002	<0.001	0.024	-
Boron	mg/L	0.02	0.04	0.05	0.04	0.04	0.37	-
Barium	mg/L	0.002	0.069	0.035	0.017	0.04	-	-
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0007
Cobalt	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	-	0.000005
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.00014
Copper	mg/L	0.002	<0.002	<0.002	<0.002	<0.002	0.0014	0.0003
Iron	mg/L	0.005	0.11	0.91	0.016	0.028	-	-
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	0.0001
Manganese	mg/L	0.001	0.34	0.12	0.063	0.006	1.9	-
Molybdenum	mg/L	0.001	0.002	0.01	<0.001	<0.001	-	-
Nickel	mg/L	0.001	0.002	<0.001	<0.001	<0.001	0.011	0.007
Lead	mg/L	0.0001	***0.0035***	***0.021***	***0.052***	***0.0088***	0.0034	0.0022
Selenium	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	0.011	-
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.011	-
Thallium	mg/L	0.0001	<0.0001	0.0001	0.0002	0.0003	-	-
Vanadium	mg/L	0.005	0.01	0.01	<0.005	<0.005	-	0.05
Zinc	mg/L	0.005	<0.005	0.005	0.006	0.007	0.008	0.007
Nutrients								
Nitrite	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	-	0.03
Nitrate	mg/L	0.05	<0.05	<0.05	<0.05	***0.13***	0.7	0.03
Total Nitrogen	mg/L	0.02	0.18	0.15	0.02	0.03	-	0.25
Total Phosphorous	mg/L	0.01	***0.03***	0.02	0.02	0.01	-	0.02
Petroleum Hydrocarbons								
Benzene	µg/L	1	<1.0	<1.0	<1.0	<1.0	0.95	0.5
Toluene	µg/L	1	<1.0	<1.0	<1.0	<1.0	-	-
Ethyl benzene	µg/L	1	<1.0	<1.0	<1.0	<1.0	-	-
Xylene	µg/L	2	<2.0	<2.0	<2.0	<2.0	0.35	-

Table 17: LABORATORY ANALYSIS RESULTS – MONITORING BORES								
Analyte	**Units**	**LOR**	**OB1**	**OB2**	**OB3**	**OB4**	**Fresh-water**	**Marine Water**
Total BTEX	µg/L	5	<5.0	<5.0	<5.0	<5.0	-	-
C_6-C_9	µg/L	25	<25	<25	<25	<25	-	-
C_{10}-C_{14}	µg/L	25	<25	<25	<25	<25	-	-
C_{15}-C_{28}	µg/L	100	***480***	***630***	<100	<100	-	-
C_{29}-C_{36}	µg/L	100	***1,500***	***1,200***	<100	<100	-	-
Total Petroleum Hydrocarbons	µg/L	250	***2,000***	***1,900***	<250	<250	-	-

Note: ***Bold/italic*** indicates exceedance of trigger value
- trigger value not determined

Table 18: LABORATORY ANALYSIS RESULTS – MONITORING BORES							
Analyte	**Units**	**LOR**	**OB9**	**OB11**	**OB14**	**Fresh-water**	**Marine Water**
pH		0.1	7.9	7.2	7.7	6-8	7-8.5
Electrical Conductivity	µS/cm		***1,810***	***2,900***	***1,310***	250	-
Total Dissolved Solids	mg/L	5	990	1,600	720	-	-
Total Suspended Solids	mg/L	1	3	20	1	-	-
Major Ions							
Calcium	mg/L	0.1	45.9	120	68.1	-	-
Potassium	mg/L	0.1	4.7	7.8	3.1	-	-
Magnesium	mg/L	0.1	50.8	91.2	86.1	-	-
Sodium	mg/L	0.1	288	459	74	-	-
Chloride	mg/L	***1***	***168***	***361***	***73***	0.003	-
Sulphate	mg/L	0.5	360	570	100	-	-
Alkalinity	mg/L	1	328	428	510	-	-
Carbonate	mg/L	1	<1	<1	<1	-	-
Bicarbonate	mg/L	1	400	522	622	-	-
Hardness	mg/L	1	320	670	520	-	-
Trace Metals							
Silver	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.00005	0.0008
Aluminium	mg/L	0.005	0.006	0.007	0.01	0.055	-
Arsenic	mg/L	0.001	0.015	0.004	0.003	0.024	-
Boron	mg/L	0.02	0.04	0.05	0.03	0.37	-
Barium	mg/L	0.002	0.011	0.044	0.024	-	-
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0007
Cobalt	mg/L	0.005	<0.005	<0.005	<0.005	-	0.000005
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	0.001	0.00014
Copper	mg/L	0.002	<0.002	<0.002	<0.002	0.0014	0.0003
Iron	mg/L	0.005	0.021	<0.005	0.013	-	-
Mercury	mg/L	0.0001	<0.0001	-	<0.0001	0.0006	0.0001
Manganese	mg/L	0.001	0.015	0.006	0.007	1.9	-
Molybdenum	mg/L	0.001	0.001	0.002	<0.001	-	-
Nickel	mg/L	0.001	<0.001	0.001	<0.001	0.011	0.007
Lead	mg/L	0.0001	***0.022***	0.0007	***0.016***	0.0034	0.0022
Selenium	mg/L	0.05	<0.05	<0.001	<0.05	0.011	-
Selenium	mg/L	0.001	<0.001	-	<0.001	0.011	-

Table 18: LABORATORY ANALYSIS RESULTS – MONITORING BORES							
Analyte	**Units**	**LOR**	**OB9**	**OB11**	**OB14**	**Fresh-water**	**Marine Water**
Thallium	mg/L	0.0001	0.0004	0.0006	0.0003	-	-
Vanadium	mg/L	0.005	<0.005	<0.005	<0.005	-	0.05
Zinc	mg/L	0.005	***0.042***	***0.075***	***0.029***	0.008	0.007
Nutrients							
Nitrite	mg/L	0.1	<0.1	<0.1	<0.1	-	0.03
Nitrate	mg/L	0.05	<0.05	<0.05	<0.05	0.7	0.03
Total Nitrogen	mg/L	0.02	<0.02	0.23	<0.02	-	0.25
Total Phosphorous	mg/L	0.01	0.01	0.01	0.01	-	0.02
Petroleum Hydrocarbons							
Benzene	µg/L	1	<1.0	<1.0	<1.0	0.95	0.5
Toluene	µg/L	1	<1.0	<1.0	<1.0	-	-
Ethyl benzene	µg/L	1	<1.0	<1.0	<1.0	-	-
Xylene	µg/L	2	<2.0	<2.0	<2.0	0.35	-
Total BTEX	µg/L	5	<5.0	<5.0	<5.0	-	-
C_6-C_9	µg/L	25	<25	<25	<25	-	-
C_{10}-C_{14}	µg/L	25	<25	<25	<25	-	-
C_{15}-C_{28}	µg/L	100	<100	<100	<100	-	-
C_{29}-C_{36}	µg/L	100	<100	<100	<100	-	-
Total Petroleum Hydrocarbons	µg/L	250	<250	<250	<250	-	-

Note: ***Bold/italic*** indicates exceedance of trigger value
- trigger value not determined

Table 19: LABORATORY ANALYSIS RESULTS – MONITORING BORES							
Analyte	**Units**	**LOR**	**OB15**	**OB15A**	**OB16**	**Fresh-water**	**Marine Water**
pH		0.1	7.4	7.4	7.4	6-8	7-8.5
Electrical Conductivity	µS/cm		***1,050***	***1,770***	***2,260***	250	-
Total Dissolved Solids	mg/L	5	580	970	1200	-	-
Total Suspended Solids	mg/L	1	160	240	9	-	-
Major Ions							
Calcium	mg/L	0.1	62.9	101	96.8	-	-
Potassium	mg/L	0.1	2.2	2	4.5	-	-
Magnesium	mg/L	0.1	78.4	116	76.9	-	-
Sodium	mg/L	0.1	41.5	94.7	249	-	-
Chloride	mg/L	***1***	***46***	***246***	***220***	0.003	-
Sulphate	mg/L	0.5	51	150	470	-	-
Alkalinity	mg/L	1	450	400	455	-	-
Carbonate	mg/L	1	<1	<1	<1	-	-
Bicarbonate	mg/L	1	549	488	555	-	-
Hardness	mg/L	1	480	730	560	-	-
Trace Metals							
Silver	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.00005	0.0008
Aluminium	mg/L	0.005	0.012	***0.058***	0.024	0.055	-
Arsenic	mg/L	0.001	0.001	<0.001	0.004	0.024	-
Boron	mg/L	0.02	0.04	<0.02	0.05	0.37	-

Table 19: LABORATORY ANALYSIS RESULTS – MONITORING BORES							
Analyte	**Units**	**LOR**	**OB15**	**OB15A**	**OB16**	**Fresh-water**	**Marine Water**
Barium	mg/L	0.002	0.013	0.007	0.057	-	-
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0007
Cobalt	mg/L	0.005	<0.005	<0.005	<0.005	-	0.000005
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	0.001	0.00014
Copper	mg/L	0.002	<0.002	<0.002	<0.002	0.0014	0.0003
Iron	mg/L	0.005	0.015	0.04	0.009	-	-
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.0006	0.0001
Manganese	mg/L	0.001	0.003	0.003	0.035	1.9	-
Molybdenum	mg/L	0.001	<0.001	<0.001	0.002	-	-
Nickel	mg/L	0.001	<0.001	<0.001	<0.001	0.011	0.007
Lead	mg/L	0.0001	0.0019	***0.014***	0.0014	0.0034	0.0022
Selenium	mg/L	0.05	<0.05	<0.05	<0.001	0.011	-
Selenium	mg/L	0.001	0.001	<0.001	-	0.011	-
Thallium	mg/L	0.0001	<0.0001	<0.0001	0.001	-	-
Vanadium	mg/L	0.005	<0.005	<0.005	<0.005	-	0.05
Zinc	mg/L	0.005	0.006	<0.005	***0.092***	0.008	0.007
Nutrients							
Nitrite	mg/L	0.1	<0.1	<0.1	<0.1	-	0.03
Nitrate	mg/L	***0.05***	***0.09***	***0.09***	***0.18***	0.7	0.03
Total Nitrogen	mg/L	0.02	0.06	<0.02	***0.35***	-	0.25
Total Phosphorous	mg/L	0.01	0.02	***0.03***	<0.01	-	0.02
Petroleum Hydrocarbons							
Benzene	µg/L	1	<1.0	<1.0	<1.0	0.95	0.5
Toluene	µg/L	1	<1.0	<1.0	<1.0	-	-
Ethyl benzene	µg/L	1	<1.0	<1.0	<1.0	-	-
Xylene	µg/L	2	<2.0	<2.0	<2.0	0.35	-
Total BTEX	µg/L	5	<5.0	<5.0	<5.0	-	-
C_6-C_9	µg/L	25	<25	<25	<25	-	-
C_{10}-C_{14}	µg/L	25	<25	<25	<25	-	-
C_{15}-C_{28}	µg/L	100	<100	<100	<100	-	-
C_{29}-C_{36}	µg/L	100	<100	<100	<100	-	-
Total Petroleum Hydrocarbons	µg/L	250	<250	<250	<250	-	-

Note: ***Bold/italic*** indicates exceedance of trigger value
- trigger value not determined

Table 20: LABORATORY ANALYSIS RESULTS – TEST PUMPING BORES										
Analyte	**Units**	**LOR**	**TPB1**	**TPB1**	**TPB3**	**TPB3**	**TPB4**	**TPB4**	**Fresh-water**	**Marine Water**
pH		0.1	7.3	7	7.2	7	6.9	6.8	6-8	7-8.5
Electrical Conductivity	µS/cm		***770***	***964***	***2,330***	***2,430***	***1,500***	***1,340***	250	-
Total Dissolved Solids	mg/L	5	420	530	1,300	1,300	820	740	-	-
Total Suspended Solids	mg/L	1	<1	24	<1	4	<1	17	-	-
Major Ions										
Calcium	mg/L	0.1	63.3	59	90.9	90.5	92.2	93.8	-	-
Potassium	mg/L	0.1	2.3	2.5	5.2	4	4.4	3.1	-	-
Magnesium	mg/L	0.1	43.1	56	66.8	55.2	78.3	74	-	-

Table 20: LABORATORY ANALYSIS RESULTS – TEST PUMPING BORES										
Analyte	**Units**	**LOR**	**TPB1**	**TPB1**	**TPB3**	**TPB3**	**TPB4**	**TPB4**	**Fresh-water**	**Marine Water**
Sodium	mg/L	0.1	50	65.6	359	289	140	86.1	-	-
Chloride	mg/L	1	***28***	***51***	***269***	***303***	***103***	***82***	0.003	-
Sulphate	mg/L	0.5	46	85	470	434	170	120	-	-
Alkalinity	mg/L	1	325	303	350	385	505	488	-	-
Carbonate	mg/L	1	<1	<1	<1	<1	<1	<1	-	-
Bicarbonate	mg/L	1	397	369	427	470	616	595	-	-
Hardness	mg/L	1	340	380	500	450	550	540	-	-
Trace Metals										
Silver	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00005	0.0008
Aluminium	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.055	-
Arsenic	mg/L	0.001	<0.001	<0.001	0.022	0.008	0.003	0.002	0.024	-
Boron	mg/L	0.02	0.03	0.04	0.06	0.06	0.05	0.035	0.37	-
Barium	mg/L	0.002	0.007	0.011	0.015	0.014	0.021	0.022	-	-
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0007
Cobalt	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.000005
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.00014
Copper	mg/L	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0014	0.0003
Iron	mg/L	0.005	<0.005	<0.005	0.063	0.05	0.042	0.032	-	-
Mercury	mg/L	0.0001	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	0.0001
Manganese	mg/L	0.001	0.015	0.001	0.014	0.021	0.005	0.004	1.9	-
Molybdenum	mg/L	0.001	<0.001	<0.001	0.002	0.002	0.001	<0.001	-	-
Nickel	mg/L	0.001	<0.001	***0.012***	0.004	<0.001	***0.009***	0.001	0.011	0.007
Lead	mg/L	0.0001	***0.011***	***0.017***	0.0014	0.0015	***0.0034***	0.0011	0.0034	0.0022
Selenium	mg/L	0.05	<0.001	<0.001	<0.001	<0.05	<0.001	<0.001	0.011	-
Selenium	mg/L	0.001	-	-	-	-	-	-	0.011	-
Thallium	mg/L	0.0001	0.0002	0.0001	0.0007	0.0007	0.0007	0.0006	-	-
Vanadium	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.05
Zinc	mg/L	0.005	0.006	***0.019***	***0.047***	***0.02***	***0.051***	***0.059***	0.008	0.007
Nutrients										
Nitrite	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	0.03
Nitrate	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.7	0.03
Total Nitrogen	mg/L	0.02	0.03	<0.02	0.04	0.14	<0.02	0.03	-	0.25
Total Phosphorous	mg/L	0.01	<0.01	0.02	<0.01	***0.05***	<0.01	<0.01	-	0.02
Petroleum Hydrocarbons										
Benzene	ug/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.95	0.5
Toluene	ug/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-
Ethyl benzene	ug/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-
Xylene	ug/L	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.35	-
Total BTEX	ug/L	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	-
C_6-C_9	ug/L	25	<25	<25	<25	<25	<25	<25	-	-
C_{10}-C_{14}	ug/L	25	<25	<25	<25	<25	<25	<25	-	-
C_{15}-C_{28}	ug/L	100	<100	<100	<100	<100	<100	<100	-	-
C_{29}-C_{36}	ug/L	100	<100	<100	<100	<100	<100	<100	-	-
Total Petroleum Hydrocarbons	ug/L	250	<250	<250	<250	<250	<250	<250	-	-

Note: ***Bold/italic*** indicates exceedance of trigger value
- trigger value not determined

8.0 GROUNDWATER ISSUES AND POTENTIAL MINING IMPACTS

No assessment for potential impacts, risks and constraints on the groundwater regime for the Sorby Hill Project have been undertaken as part of this initial hydrogeological investigation. It is proposed that this will be undertaken in 2012 following development of a predictive numerical groundwater model to simulate the dewatering requirements for the project. Output from this numerical modelling will be used to identify preferred options for dewatering the dolomite geology either by a borefield to enable pit development, or by in-pit dewatering. It will also provide input into the extent groundwater available for utilisation as a process water supply for the project. Taking the above into account, the following potential impacts, risks and constraints will be assessed:

- whether dewatering of dolomite geology orebody by borefield pumping and open pit groundwater inflows will provide sufficient water supply to satisfy the long-term process water demand of the mine;
- to what extent dewatering the dolomite geology aquifers will impact on the regional aquifer and hence existing landholder bores used for domestic supply and stock watering, springs and groundwater dependent ecosystems;
- to what extent the faults compartmentalises groundwater flow and/or whether these fault zones provide areas of higher transmissivity that should be targeted for dewatering options.

9.0 GROUNDWATER MONITORING PLAN

The proposed plan for future monitoring of the impact of mining on the groundwater resources in the area likely to be impacted by the Sorby Hills Project open pits is based on the recently installed monitoring bores OB1 to OB5, OB9 to OB11, OB13, OB14, OB15, OB15A, OB16.

These bores will form the initial monitoring bore network that will be used to establish a baseline groundwater monitoring dataset that will form the basis for monitoring the effects of mining activities on the groundwater resource, and on other users of the resource in terms of quality and quantity. This groundwater monitoring program will ultimately be developed to provide for both an on-going assessment of the impact of the proposed mine, and a timely warning of adverse impacts on the groundwater regime, so that remedial action can be taken, if necessary. The monitoring program is summarised in Table 21.

The data from the monitoring program should be reviewed annually and the results held on site. After three years of monitoring, a review should be undertaken to assess whether the frequency of monitoring should be changed to bi-annually or annually.

It is recommended that all groundwater monitoring, water level measurements and sample collection, storage and transportation be undertaken in accordance with the procedures outlined by the Department of Environmental Protection (DEC, 2001).

Table 21: PROPOSED GROUNDWATER MONITORING PROGRAM			
Location	**Parameters**	**Frequency**	**Comment**
Open Hole Piezometers			
OB1, OB2, OB3, OB4, OB9, OB11, OB14, OB15, OB15A, ON16	water level	Monthly	Monitor for and changes in water quality and water levels
OB1, OB3, OB4, OB11, OB15, OB15A	pH, EC, TDS cations/anions, metals, nutrients, BTEX and total hydrocarbons	Three-monthly	
Vibrating Wire Piezometers			
OB5A/5B, OB10A/10B/10C, OB13A/13B/13C	water level	Six-hourly	Monitor for and changes in water levels

It is proposed that the parameter suite for each groundwater sample over the next 12 months should remain the same as that analysed for this assessment. After this period, the suite of parameters can then be reviewed and amended where appropriate. This being the case, the parameter suite should include the following:

- pH, EC, total dissolved solids (TDS), total suspended solids (TSS) , alkalinity, hardness;
- Major anions – carbonate, bicarbonate, chloride, sulphate;
- Major cations – calcium, magnesium, sodium, potassium;
- Total dissolved metals – aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc;
- Nutrients – nitrite, nitrate, total nitrogen, total phosphorus;
- BTEX hydrocarbons – Benzene, Toluene, Ethyl benzene, Xylene; and
- Total petroleum hydrocarbon (TPH) chains – C_6-C_9, C_{10}-C_{14}, C_{15}-C_{28}, C_{29}-C_{36}.

The trigger levels adopted for this project for contaminants likely to result from project activities have been based on the ANZECC (2000) Freshwater and Marine Water Quality Guidelines and are outlined in Table 22.

Table 22: GROUNDWATER CONTAMINANT TRIGGER LEVEL			
Parameter	**Units**	**Freshwater**	**Marine Water**
pH		6-8	7-8.5
Electrical Conductivity	µS/cm	250	-
Chloride	mg/L	0.003	-
Silver	mg/L	0.00005	0.008
Aluminium	mg/L	0.055	-
Arsenic	mg/L	0.024	-
Boron	mg/L	-0.37	-

Table 22: GROUNDWATER CONTAMINANT TRIGGER LEVEL			
Parameter	**Units**	**Freshwater**	**Marine Water**
Cadmium	mg/L	0.0002	0.0007
Cobalt	mg/L	-	0.000005
Chromium	mg/L	0.001	0.00014
Copper	mg/L	0.0014	0.0003
Mercury	mg/L	0.0006	0.0001
Manganese	mg/L	1.9	-
Nickel	mg/L	0.011	0.007
Lead	mg/L	0.0034	0.0022
Selenium	mg/L	0.011	-
Vanadium	mg/L	-	0.05
Zinc	mg/L	0.008	0.007
Nitrite	mg/L	-	0.03
Nitrate	mg/L	0.7	0.03
Total Nitrogen	mg/L	-	0.25
Total Phosphorous	mg/L	-	0.02
Benzene	µg/L	0.95	0.5
Xylene	µg/L	0.35	-

These trigger levels are tentative only and should be reviewed following Sorby Management undertaking further rounds of groundwater sampling and laboratory analyses to establish a statistically representative baseline groundwater data set, prior to commencing mining.

10.0 REFERENCES

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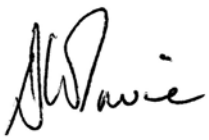
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13. Schlumberger Water Services (2011), "*Aquifer Test 2011.1*".

AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD



DUNCAN W. IRVINE
Principal Hydrogeologist

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Sorby Management Pty Ltd in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Memorandum G1489_A.M004.pdf dated 25 November 2010.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

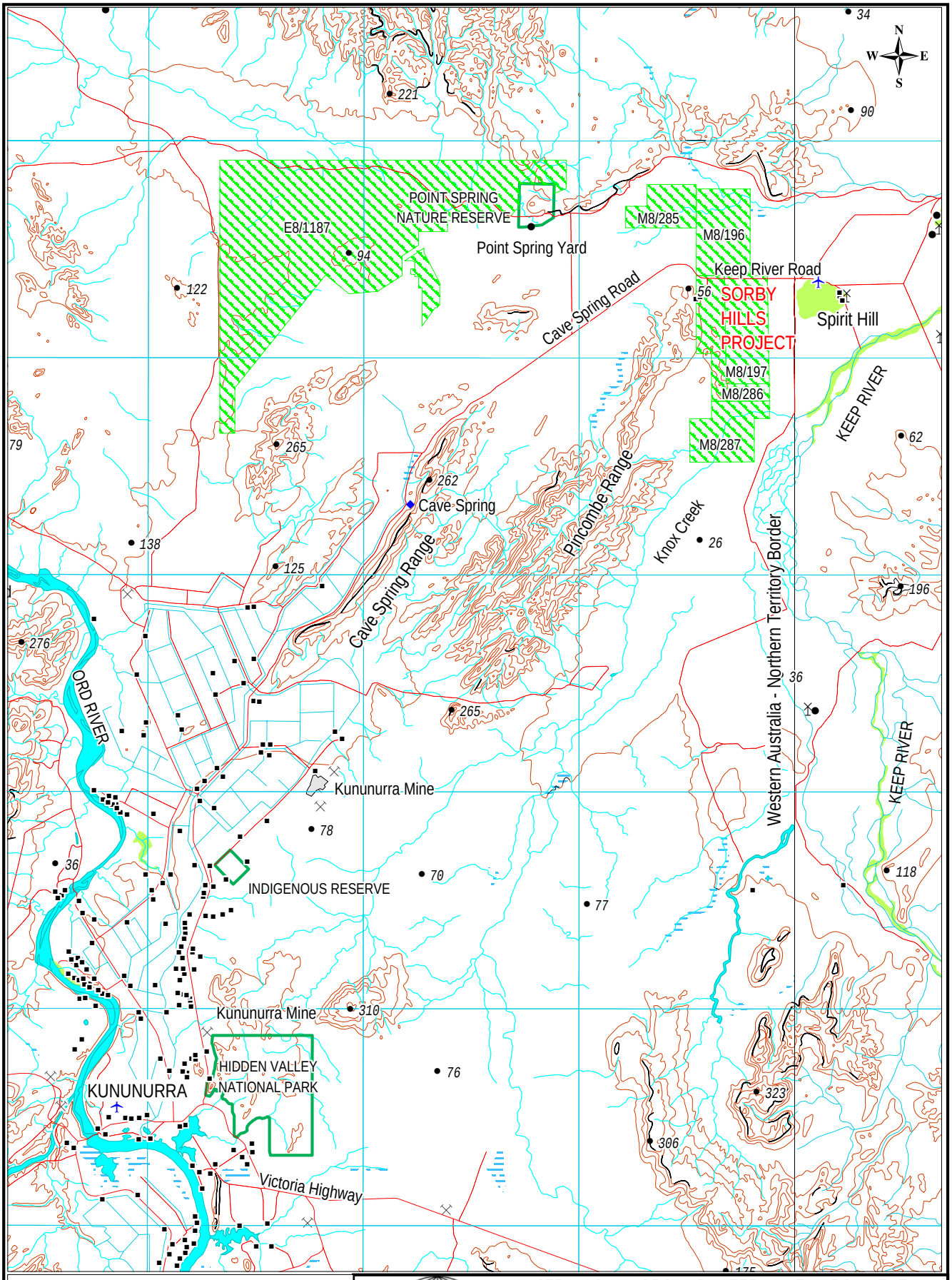
This study was undertaken between 21 April 2010 and 16 November 2011, and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

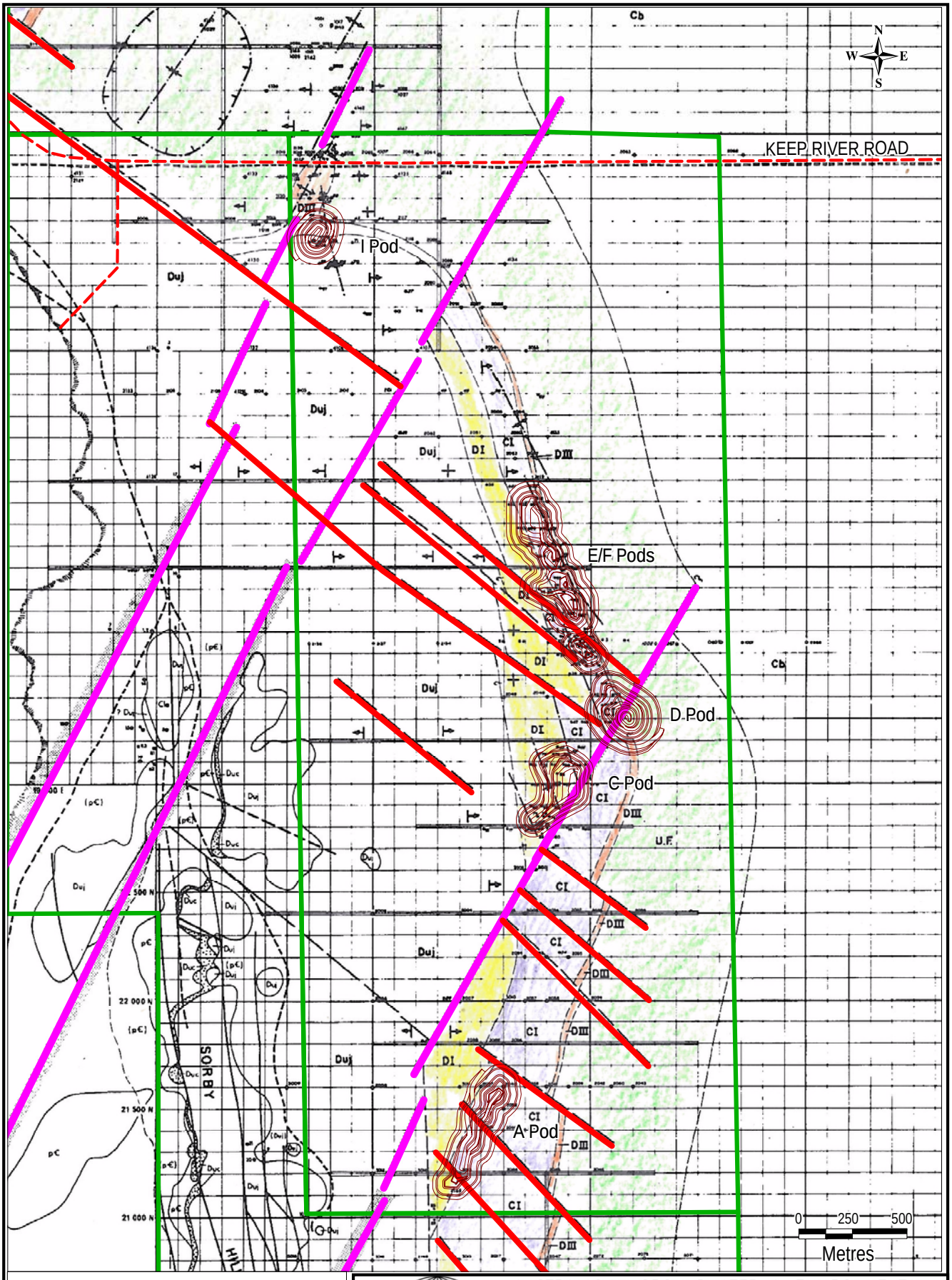


AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: SORBY HILLS PROJECT
HYDROGEOLOGICAL ASSESSMENT (2011)
LOCALITY PLAN SHOWING MINING AND EXPLORATION LEASES

CLIENT: Sorby Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1 : 250,000 (A4)	PROJECT No: Project G1489A	DRAWING No: 1
APPROVED BY:		DATE: November 2011	

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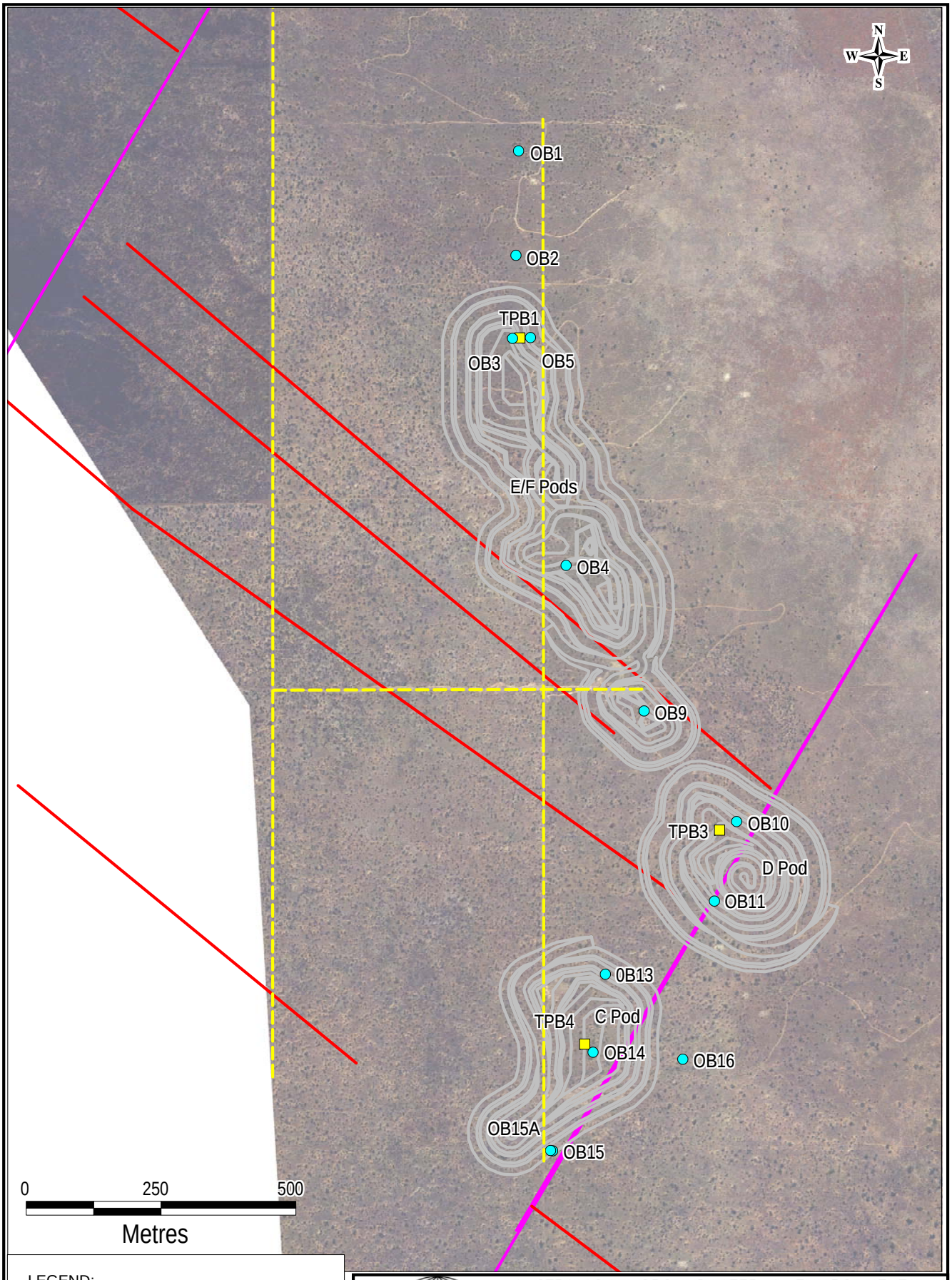
- Open Pit Outline
- SE Trending Faults
- NE Trending Basement Faults
- Mining Tenement Boundaries
- Road

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: SORBY HILLS PROJECT
HYDROGEOLOGICAL ASSESSMENT (2011)
SITE GEOLOGY AND STRUCTURE

CLIENT: Sorby Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1 : 25,000 (A4)	PROJECT No: G1489A	DRAWING No: 2
APPROVED BY:		DATE: November 2011	

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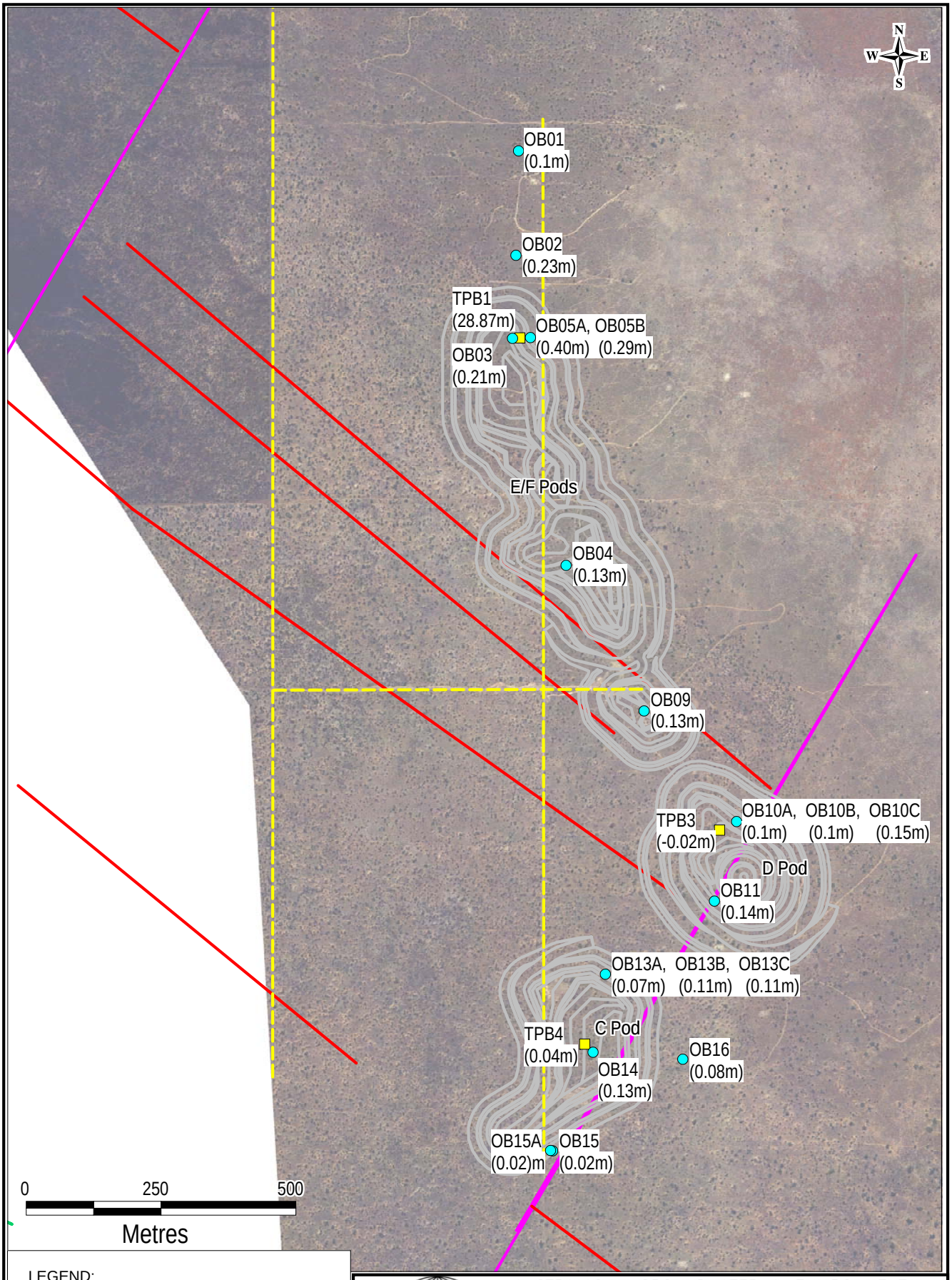
- Open Pit Outline
- SE Trending Faults
- NE Trending Basement Faults
- Monitoring Bores
- Test Pumping Bores
- Site Tracks

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: SORBY HILLS PROJECT
HYDROGEOLOGICAL ASSESSMENT (2011)
MONITORING BORE AND TEST PRODUCTION BORE LOCATIONS

CLIENT: Sorby Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1 : 25,000 (A4)	PROJECT No: G1489A	DRAWING No: 3
APPROVED BY:		DATE: November 2011	

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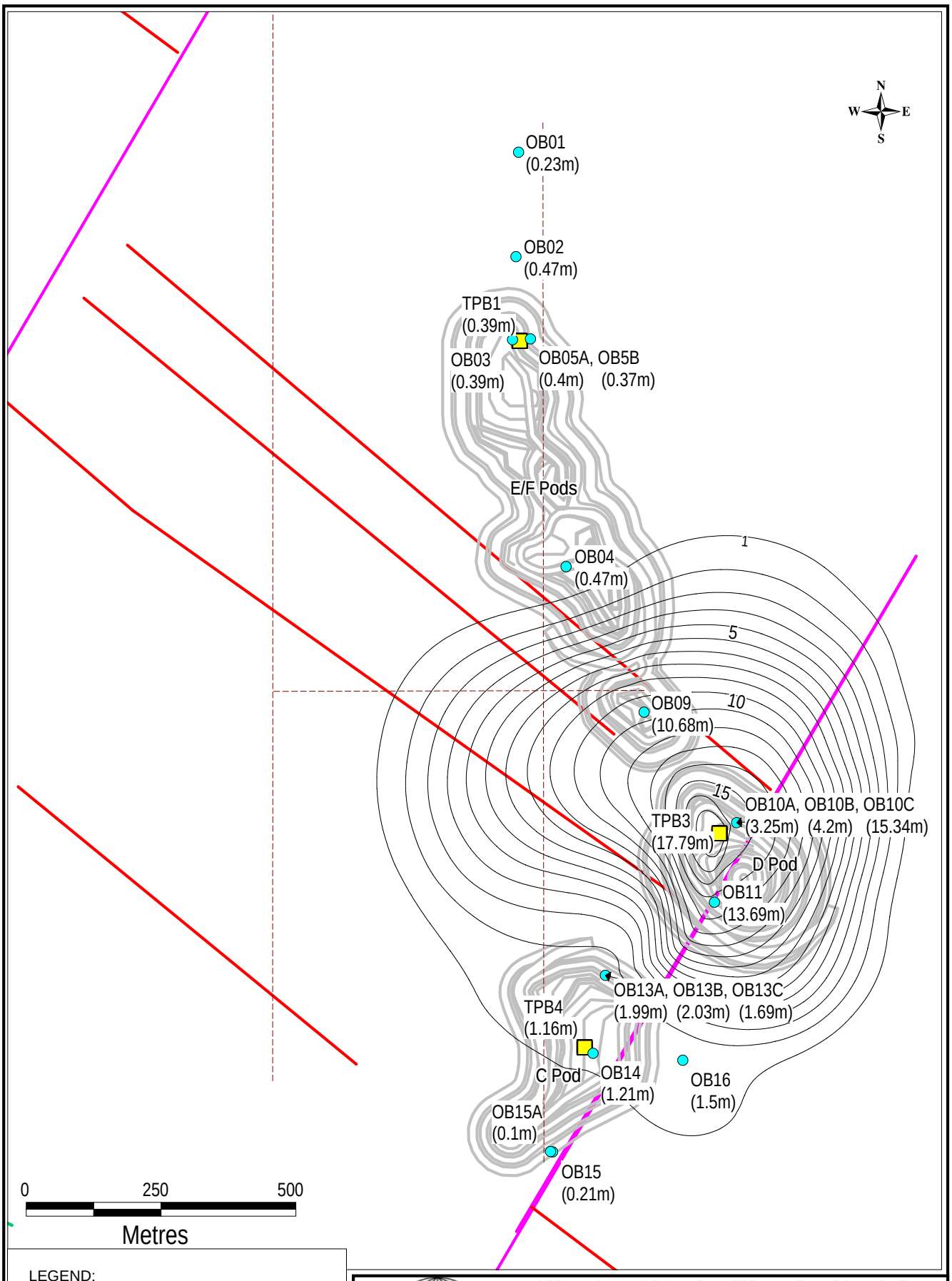
- Open Pit Outline
- Monitoring Bore (Drawdown)
- Pumping Bore (Drawdown)
- SE Trending Faults
- NE Trending Basement Faults
- Site_tracks

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AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: SORBY HILLS PROJECT
HYDROGEOLOGICAL ASSESSMENT (2011)
EXTENT OF DRAWDOWN - TPB1 CONSTANT RATE PUMPING TEST

CLIENT: Sorby Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1 : 10,000 (A4)	PROJECT No: G1489A	DRAWING No: 4
APPROVED BY:		DATE: November 2011	



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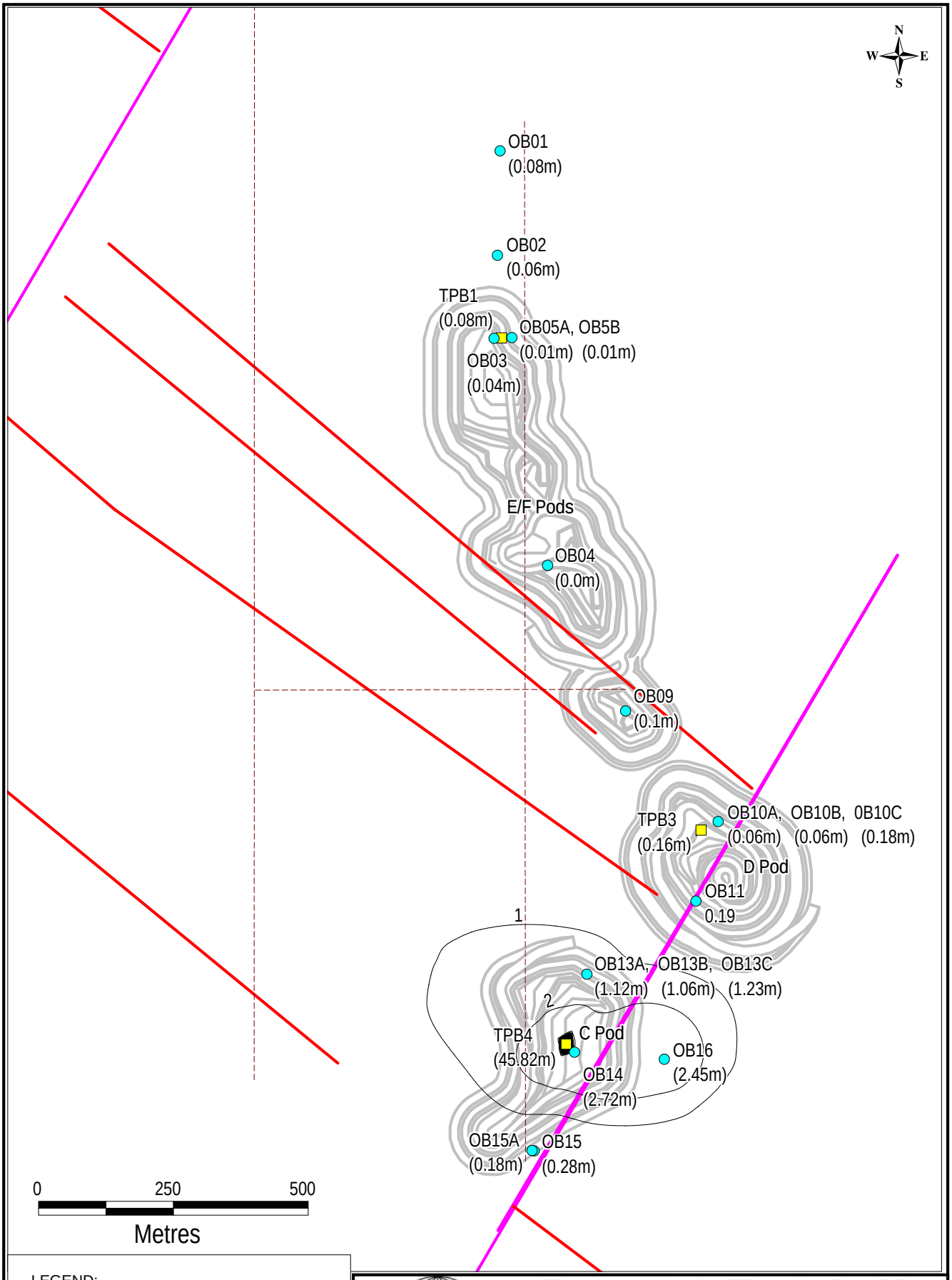
- Open Pit Outline
- Monitoring Bore (Drawdown)
- Pumping Bore (Drawdown)
- SE Trending Faults
- NE Trending Basement Faults
- Site Tracks

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: SORBY HILLS PROJECT
HYDROGEOLOGICAL ASSESSMENT (2011)
EXTENT OF DRAWDOWN - TPB3 CONSTANT RATE PUMPING TEST

CLIENT: Sorby Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1 : 10,000 (A4)	PROJECT No: G1489A	DRAWING No: 5
APPROVED BY:		DATE: November 2011	

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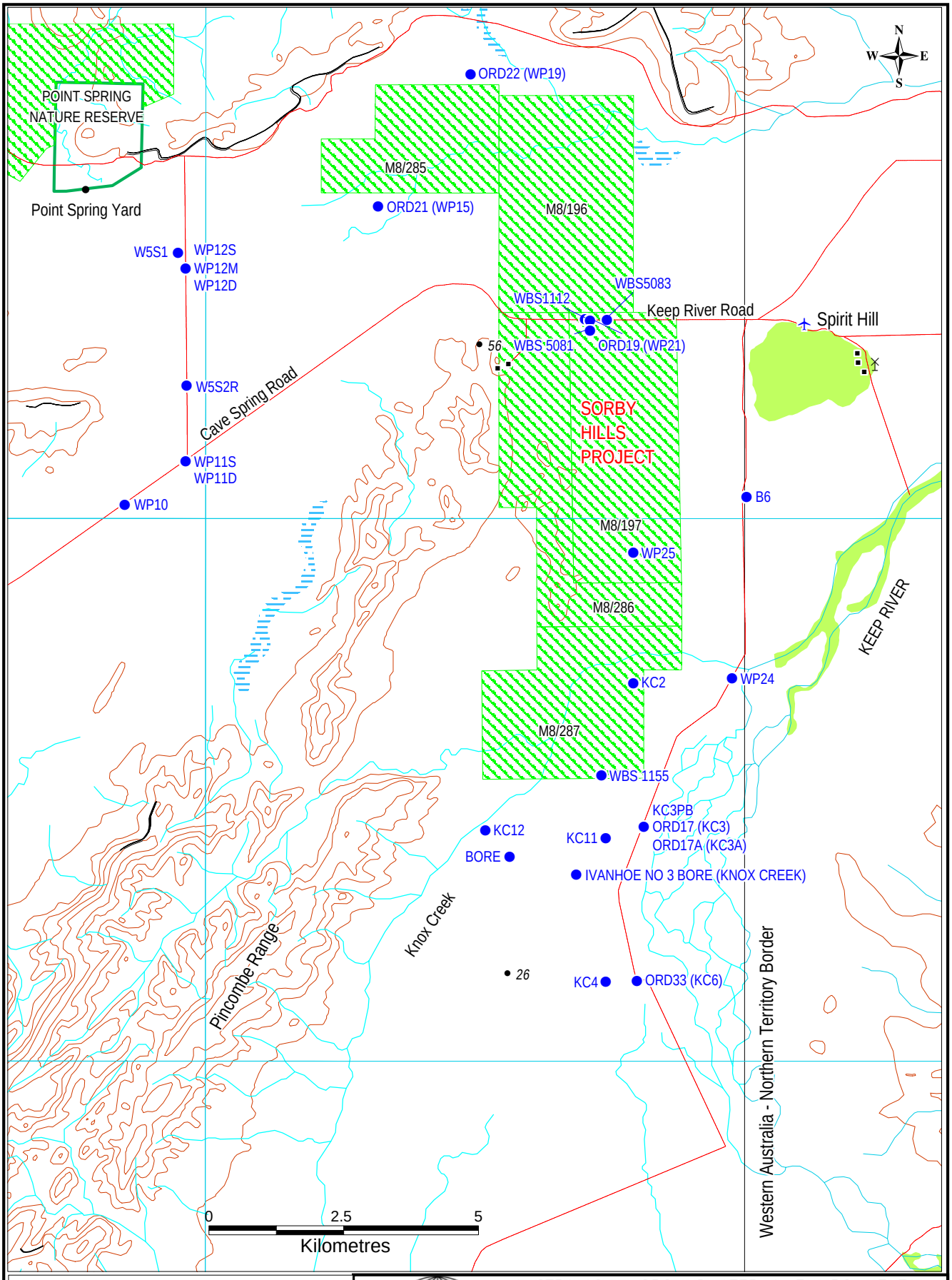


AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: SORBY HILLS LEAD-SILVER-ZINC DEPOSITS
HYDROGEOLOGICAL ASSESSMENT (2011)
EXTENT OF DRAWDOWN - TPB4 CONSTANT RATE PUMPING TEST

CLIENT: Sorby Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1 : 10,000 (A4)	PROJECT No: G1489A	DRAWING No: 6
APPROVED BY:		DATE: November 2011	

G:\Groundwater Jobs\G1489AGIS\Workspaces\G1489A D6_TPB4_Drawdown.wor



LEGEND:

- Registered Operational Bores
- Kimberly Metals Tenements

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: SORBY HILLS PROJECT
HYDROGEOLOGICAL ASSESSMENT (2011)
REGISTERED BORES

CLIENT: Sorby Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1 : 100,000 (A4)	PROJECT No: Project G1489A	DRAWING No: 7
APPROVED BY:		DATE: November 2011	

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APPENDIX A

Registered Bores Hydrographs

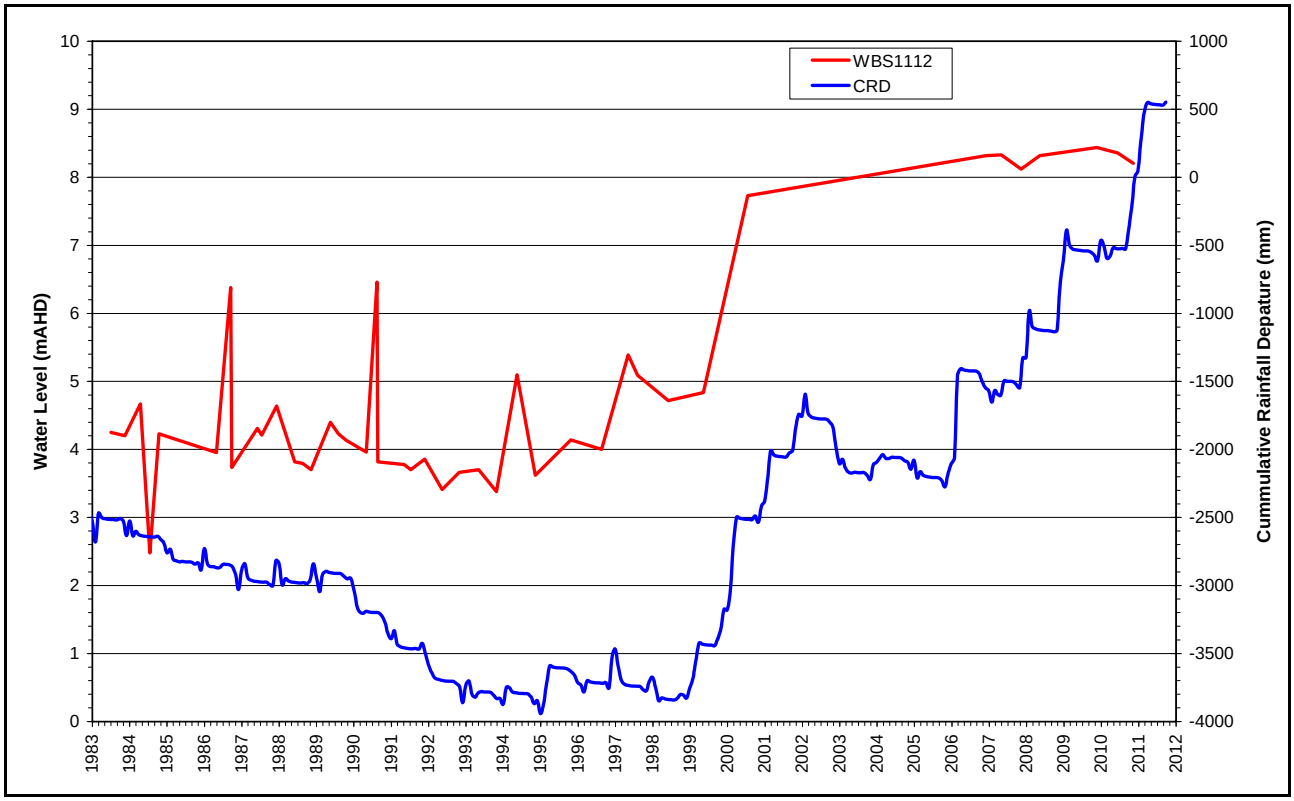


Figure A1: Hydrograph for Registered Monitoring Bore WBS1112

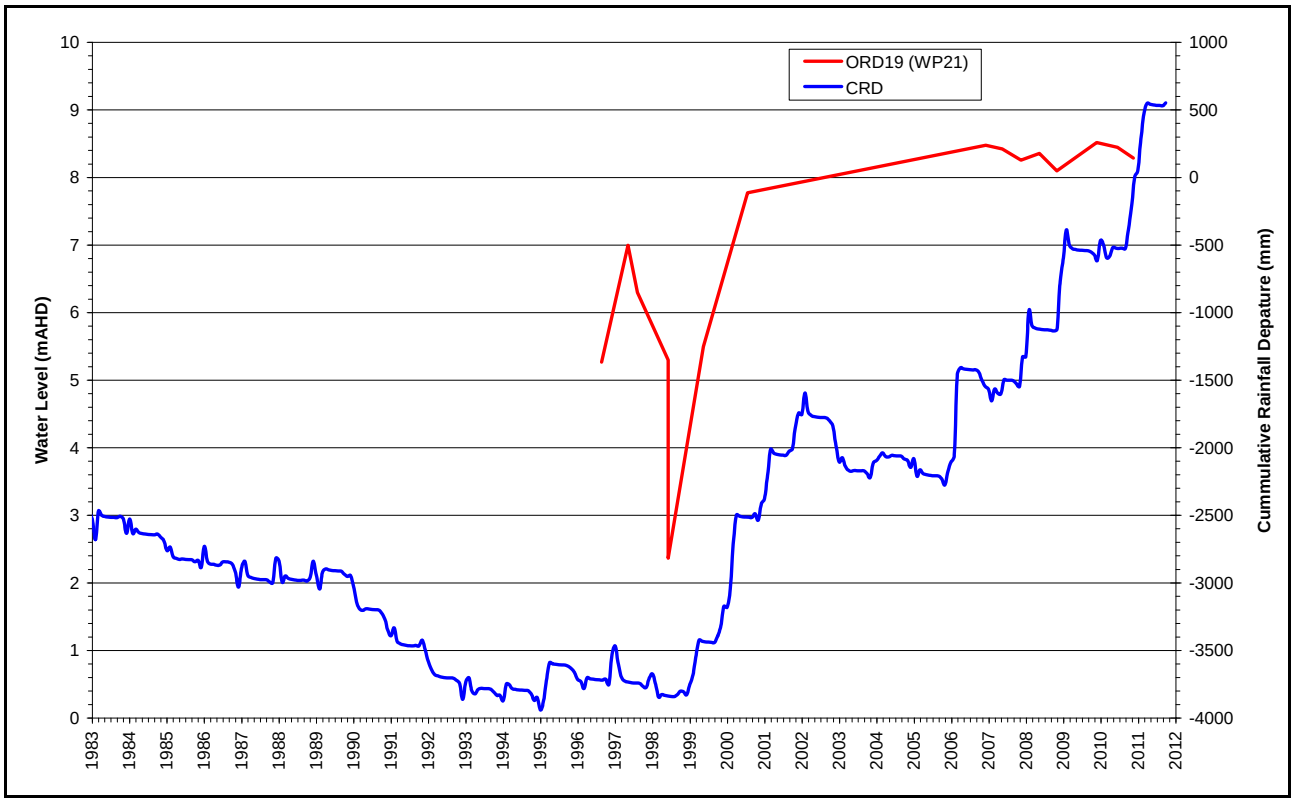


Figure A2: Hydrograph for Registered Monitoring Bore ORD19 (WP21)

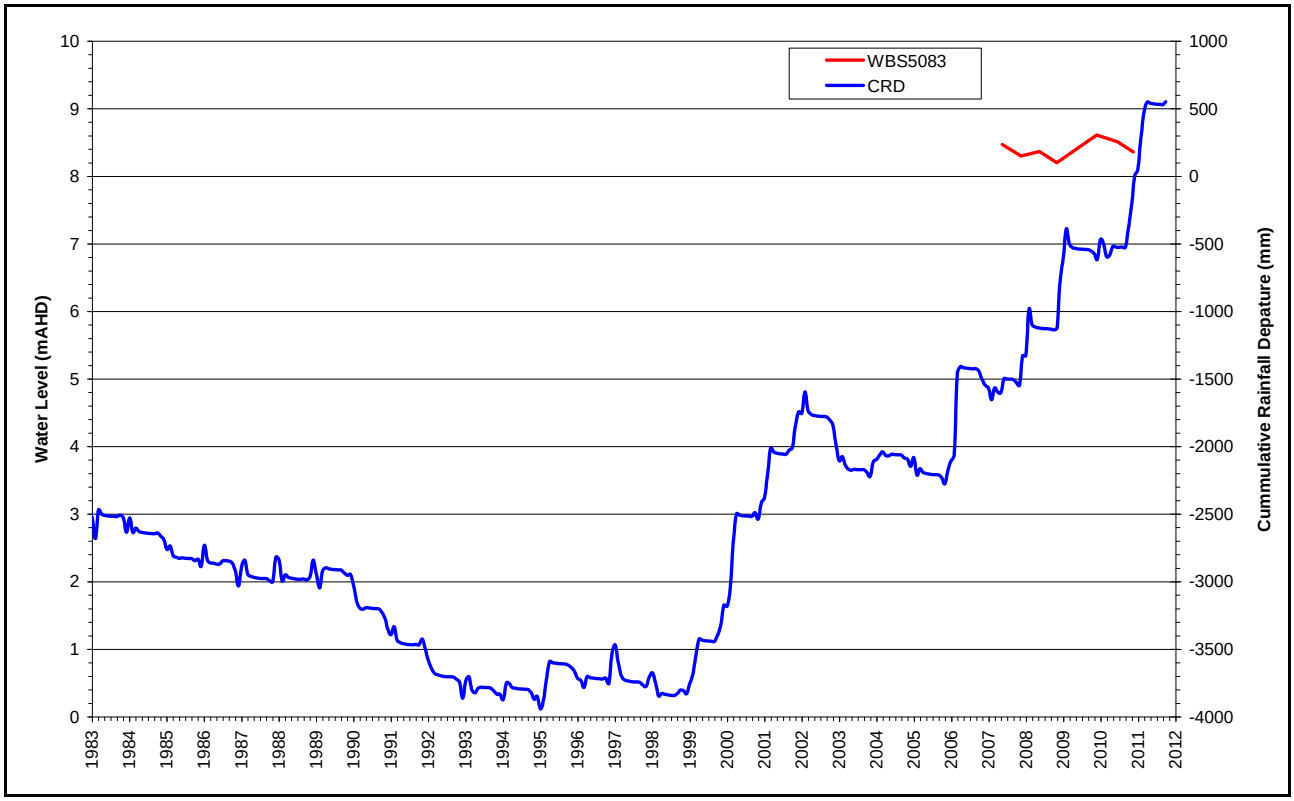


Figure A3: Hydrograph for Registered Monitoring Bore WBS5083

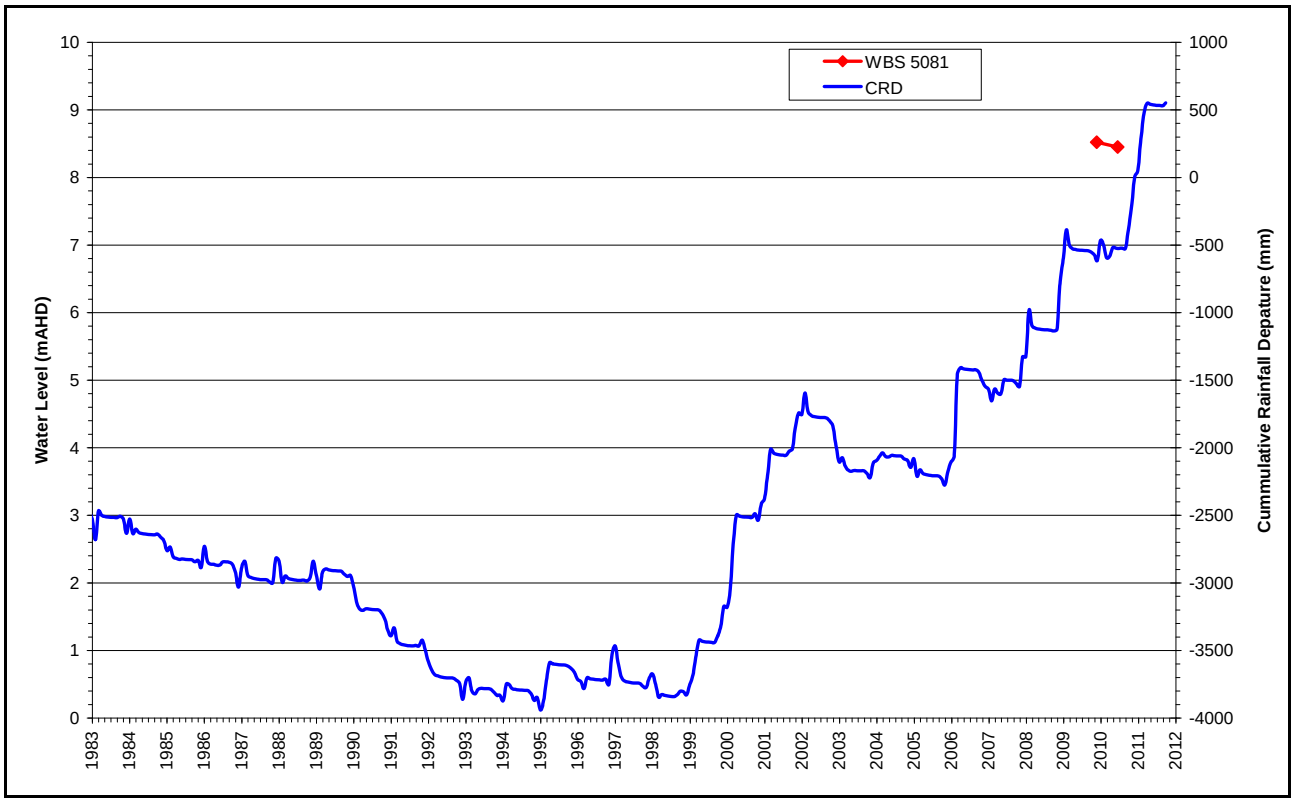


Figure A4: Hydrograph for Registered Monitoring Bore WBS5081

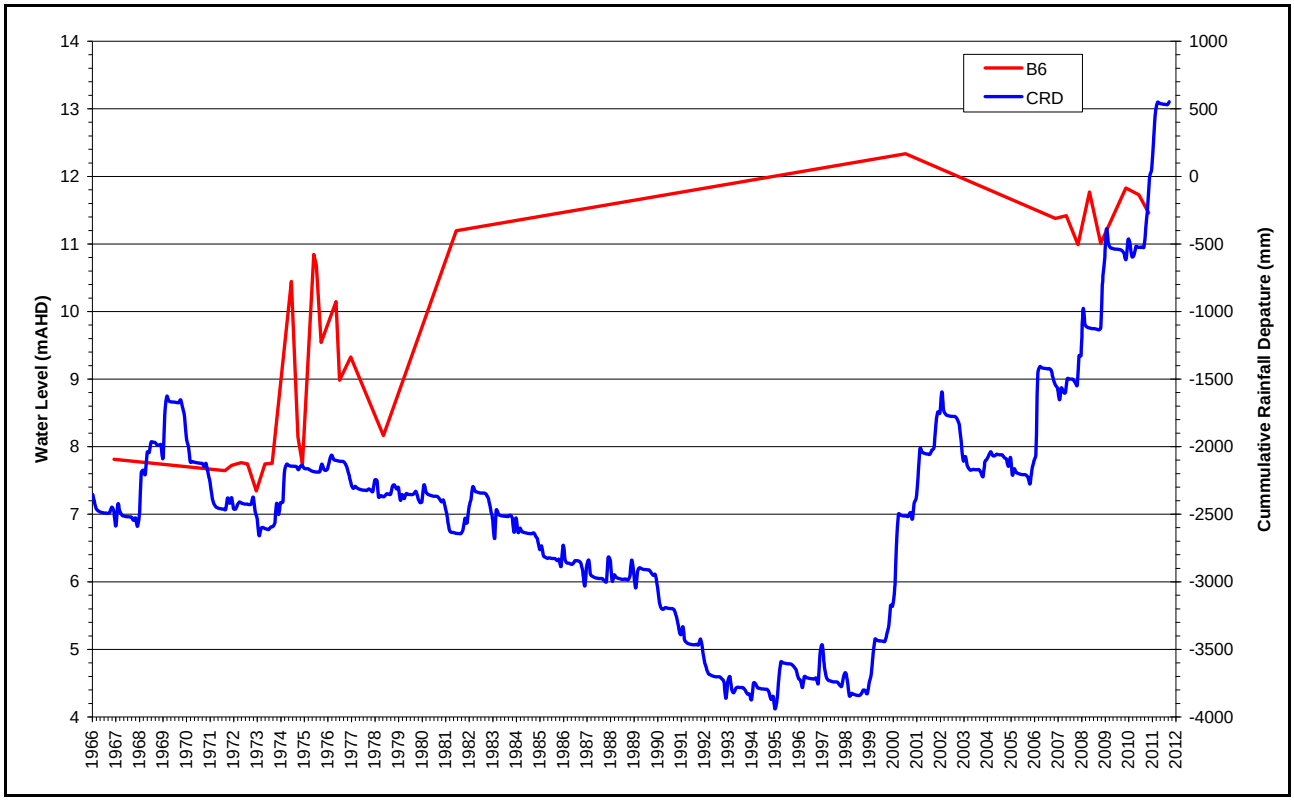


Figure A5: Hydrograph for Registered Monitoring Bore B6

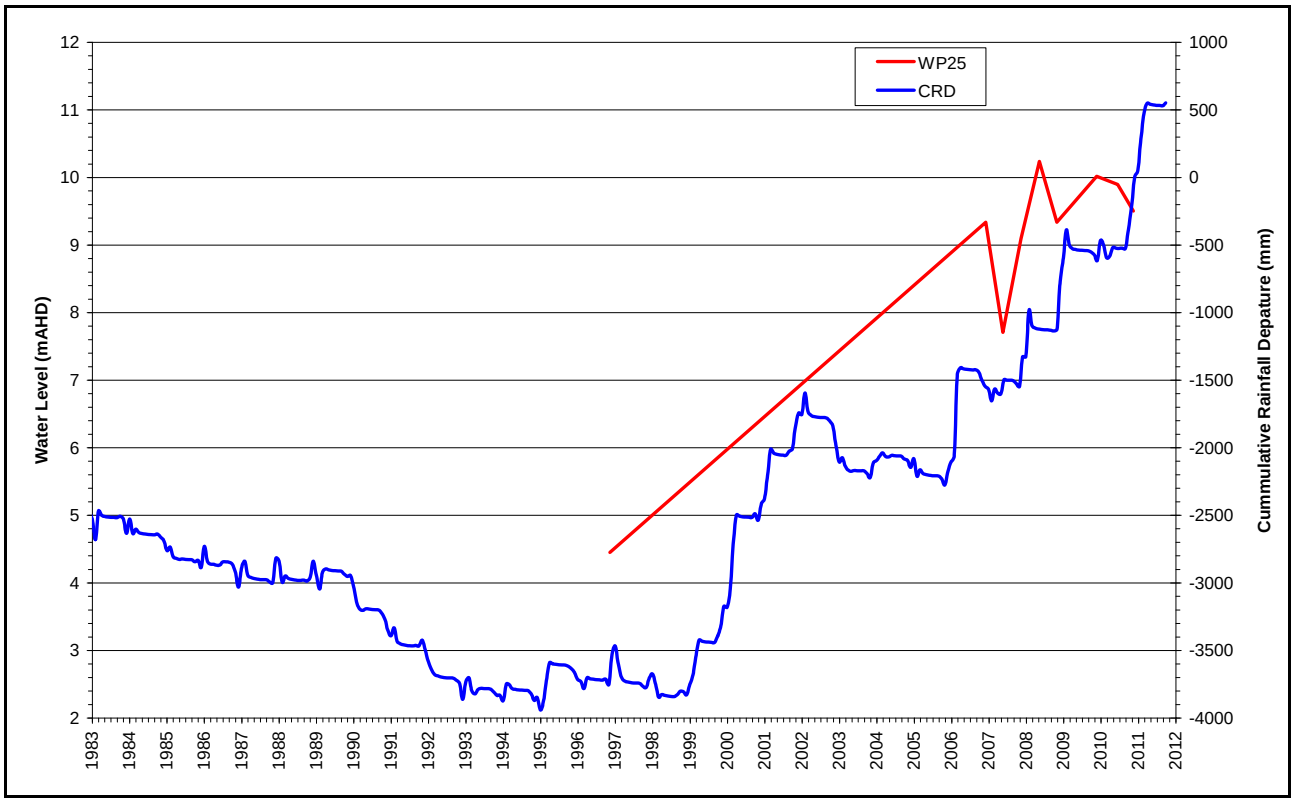


Figure A6: Hydrograph for Registered Monitoring Bore WP25

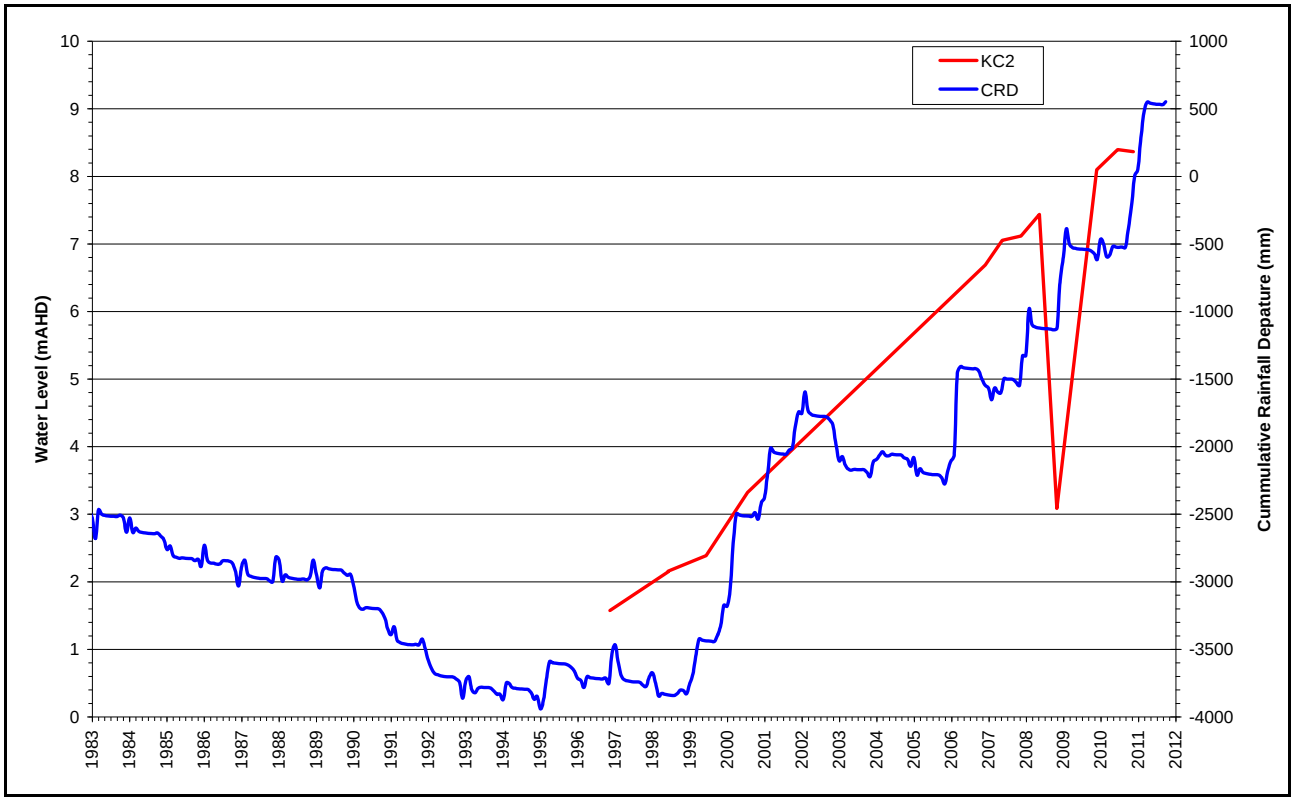


Figure A7: Hydrograph for Registered Monitoring Bore KC2

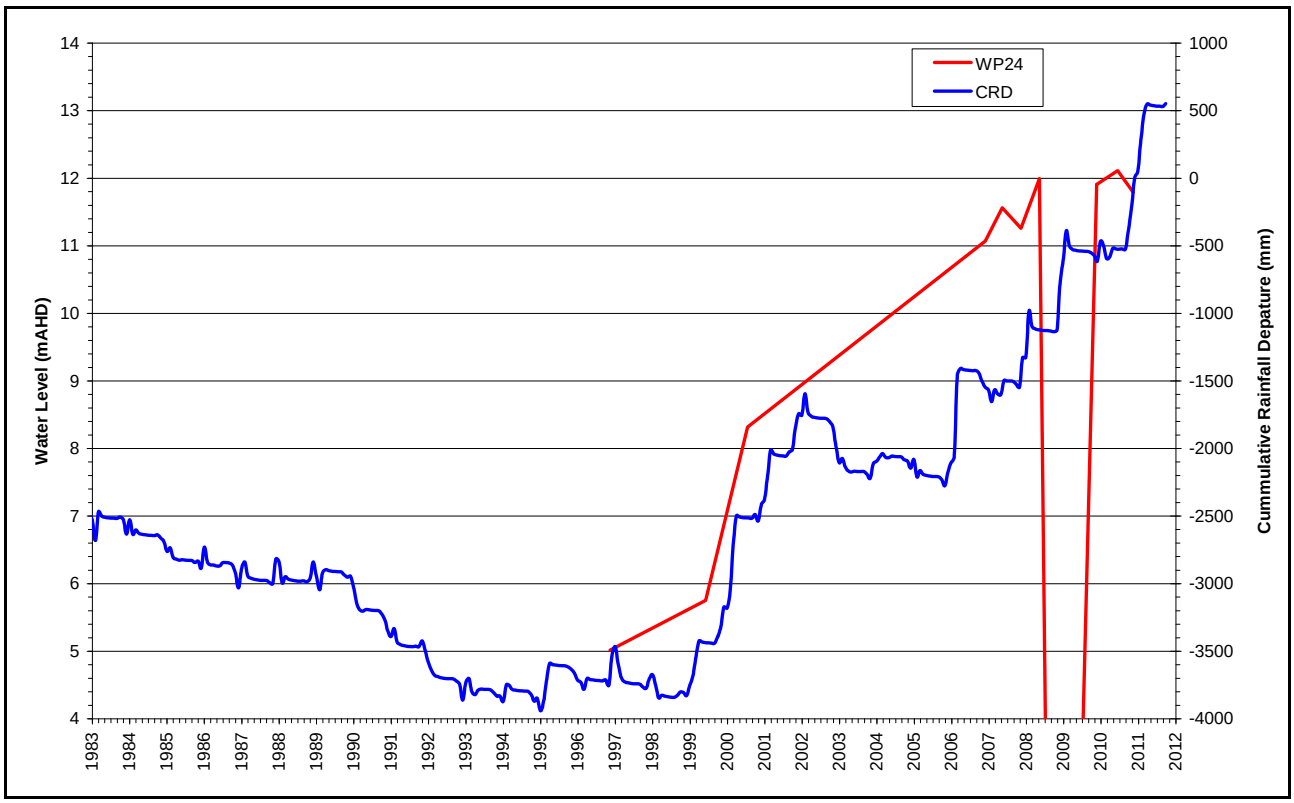


Figure A8: Hydrograph for Registered Monitoring Bore WP24

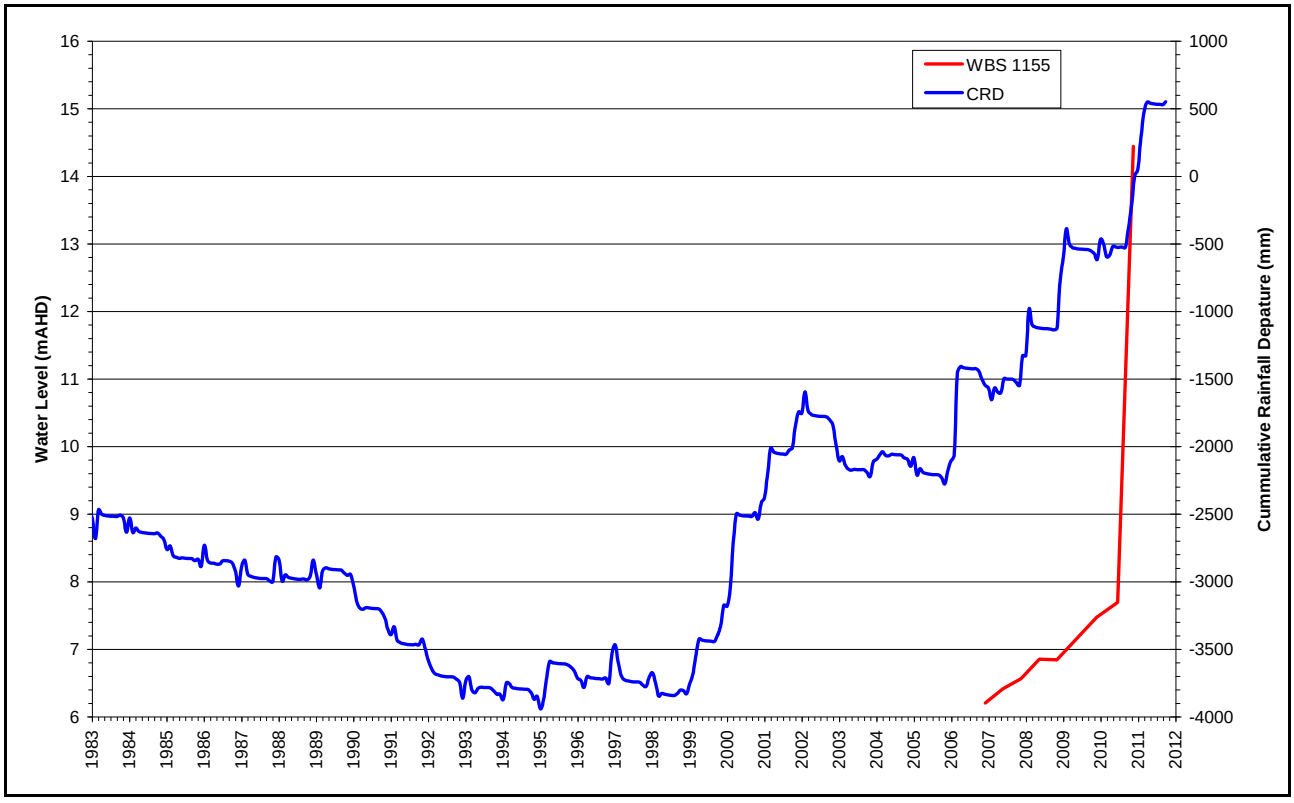


Figure A9: Hydrograph for Registered Monitoring Bore WBS1155

APPENDIX B

Observation Bore and Test Pumping Bore Logs

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB01**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	20/06/2011 - 23/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497889mE, 8292445mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		SILTY CLAY: (Cz) brown to dark brown with occasional red mottling, highly plastic, moist, sand with fine sub angular gravel component	SWL - 11.62m BGL - 25th July 11	+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
-5					Cemented, 0m to 90m
-10					
-15		DOLOMITE: (DIII) grey brown to light grey and white, highly weathered, approx 50% clay, moderately hard			311mm Tri-cone, 0m to 15.5m
-20		DOLOMITE: (DIII) grey brown and orange brown, moderately weathered, moderately hard		15.5m	165mm Hammer, 15.5m to 109m
-25		SILTSTONE: (Clbk) light brown to grey, moderately weathered, moderately hard			
		SILTSTONE: (Clbk) grey with minor discolouration, slightly weathered, moderately hard minor dolomite chips in sample (possible contamination)			
-30		SILTSTONE: (Clbk) grey, fresh, hard, dolomitised			50mm ID, PN18 uPVC, blank casing, 0m to 103m
		DOLOMITE: (Clbk) grey, fresh, hard, sugary texture and rare vug			Minor inflow (<0.1L/s) at 31m
-35		DOLOMITE: (Clbk) grey, fresh, hard			
		SILTSTONE: (Clbk) grey, fresh, hard, dolomitised			v notch 15mm (0.04L.s) at 35m
-40		DOLOMITE: (Clbk) grey, fresh, hard, with minor siltstone component			v notch 25mm (0.14L.s) at 36.5m
-45					
-50		SILTSTONE: (Clbk) grey, fresh, hard, laminated in horizons			v notch 25mm (0.14L.s) at 49m
-55					

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB01**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	20/06/2011 - 23/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497889mE, 8292445mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
56					
58					
60 / -60					
62					
64					
65					
66					
68					
70 / -70					
72					
74					
75					
76					
78					
80 / -80					
82					
84					
85					
86					
88					
90 / -90				--90m	Bentonite seal (1/4" pellets), 90m to 92m
92				--92m	
94					
95					
96		DOLOMITE: (Clbk) grey, fresh, hard, calcite and pyrite mineralisation present			
98					2-4mm washed, rounded, quartz, gravel pack, 92m to 109m
100 / -100		SILTSTONE: (Clbk) grey, fresh, hard, calcite, pyrite, and galena mineralisation present			
102					v notch 25mm (0.14L.s) at 101m
104		DOLOMITE: (Dll) grey, fresh, hard, calcite and pyrite mineralisation present		--103m	50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 103m to 109m
105					
106					
108					End Cap, 109
110 / -110				--109m	Total depth 109m

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB02**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	21/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497886mE, 8292250mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		SILTY CLAY: (Cz) red brown, plastic, moist, minor coarse sand component (<5%)		+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
-5					Cemented, 0m to 89m
-10					
-14m		DOLOMITE: (DIII) pale red brown and cream, extremely weathered to distinctly weathered, hard			311mm Tri-cone, 0m to 14m
-15					
-20					165mm Hammer, 14m to 109.3m
-25		DOLOMITE: (DIII) pale red brown and grey, extremely weathered to distinctly weathered, hard			samples damp at 24m
-30		SILTSTONE: (Clbk) grey, fresh to slightly weathered, hard	SWL - 10.83m BGL - 25 July 1		50mm ID, PN18 uPVC, blank casing, 0m to 97.3m
-35		SILTSTONE: (Clbk) orange brown, distinctly weathered, hard			
-40		SILTSTONE: (Clbk) grey, fresh, hard			
-45					
-50					
-55					

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB02**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	21/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497886mE, 8292250mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
56					
58		SILTSTONE: (Clbk) grey, fresh, hard, pyrite mineralisation			
60 -60					
62					
64					
-65 66					
68		DOLOMITE: (DII) grey brown, fresh, hard, galena and pyrite mineralisation			
70 -70					
72					
74					~0.03 L/s (bucket test) at 73m
-75 76					
78		SILTSTONE: (DII) light grey, fresh, hard, dolomitised, pyrite and galena mineralisation			
80 -80					
82		DOLOMITE: (DII) grey brown, fresh, hard, galena and pyrite mineralisation			
84					
-85 86					
88		DOLOMITE: (DII) dark brown, fresh, hard, galena and pyrite mineralisation, sugary texture		--88m	
90 -90				--91m	Bentonite seal (1/4" pellets), 89m to 91m
92		DOLOMITE: (DI) light brown, fresh, hard, pyrite mineralisation, sugary texture			
94					2-4mm washed, rounded, quartz, gravel pack, 91m to 109.3m
-95 96					
98				--97.3m	
100 -100					50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 97.3m to 109.3m
102					
104					
-105 106					
108					~0.2 L/s (bucket test) at 109m
110 -110				--109.3m	End Cap, 109.3 Total depth 109.3m

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BOREHOLE LOG

BOREHOLE ID: **OB03**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	19/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497882mE, 8292098mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 (0)		SILTY CLAY: (Cz) dark brown and red brown, slightly moist to dry, minor sand component (<5%)		+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
2					
4					
-5 (5)					Cemented, 0m to 45m
6					
8					
-10 (10)			▽		311mm Tri-cone, 0m to 14m
12		DOLOMITE: (DIII) red brown and black, extremely weathered, hard			
14		DOLOMITE: (DIII) pale brown and red brown, distinctly weathered, hard		~14m	165mm Hammer, 14m to 61m
-15 (15)					
16					
18					
-20 (20)					
22					
24					
-25 (25)					
26		SILTSTONE: (Clbk) grey and pale brown, slightly weathered, to fresh			
28					50mm ID, PN18 uPVC, blank casing, 0m to 52.5m
-30 (30)		DOLOMITE: (Clbk) pale red brown, distinctly weathered, hard, sugary texture			~1L/s (bucket test) at 30m
32					
34		SILTSTONE: (Clbk) grey, fresh, hard, dolomitised			
-35 (35)		DOLOMITE: (Clbk) dark grey, fresh hard, sugary texture			
36		SILTSTONE: (Clbk) grey and pale brown, fresh to slightly weathered, hard, dolomitised			
38					
-40 (40)					
42					
44					

SWL - 10.67m BGL - 25th July 11

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB03**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	19/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497882mE, 8292098mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
-45 (46)				--45m	Bentonite seal (1/4" pellets), 45m to 47.3m
(48)		DOLOMITE: (DII) grey and pale brown, fresh, hard, galena and pyrite mineralisation		--47.3m	2-4mm washed, rounded, quartz, gravel pack, 47.3m to 58.5m
-50 (52)				--52.5m	
(54)		DOLOMITE: (DII) grey and pale brown, fresh to slightly weathered, hard, pyrite mineralisation			50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 52.5m to 58.5m
-55 (56)		DOLOMITE: (DI) red brown, extremely weathered, minor dissolution cavities, highly fractured (significant hole collapse during drilling)		--58.5m	End Cap, 58.5
(58)					15-25 L/s (bucket test) at 61m
-60 (62)				--61m	Total depth 61m

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BOREHOLE LOG

BOREHOLE ID: **OB04**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	18/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497983mE, 8291676mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 (0)		SILTY CLAY: (Cz) brown to yellow brown, plastic, moist, sand with fine sub angular gravel component		+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
-5 (5)					Cemented, 0m to 12m
-10 (10)		DOLOMITE: (DII) red brown, extremely weathered, hard	▽		50mm ID, PN18 uPVC, blank casing, 0m to 15.3m 311mm Tri-cone, 0m to 12m Bentonite seal (1/4" pellets), 12m to 13m
		DOLOMITE: (DII) dark red brown, distinctly weathered, hard, fractured	SWL - 10.42m BGL - 25th July 2011	--12m	2-4mm washed, rounded, quartz, gravel pack, 13m to 17m
-15 (15)				--15.3m	165mm Hammer, 12m to 19m 50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 15.3m to 18.3m
		DOLOMITE: (DII) dark grey, distinctly weathered, hard, highly fractured, significant galena mineralisation		--17m	~3.1L/s (bucket test) at 18m
				--18.3m	End Cap, 18.3m
				--19m	Total depth 19m

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BOREHOLE LOG

BOREHOLE ID: **OB05**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	26/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497882mE, 8292098mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 (0)		SILTY CLAY: (Cz) dark brown and red brown, slightly moist, carbonate nodules		+0.6m	Cemented, 0m to 44m. Cement mix ratio: 1:2.5:0.3 (cement:water:bentonite)
14 (-15)		DOLOMITE: (DIII) white and orange, extremely weathered, hard		--14m	311mm Tri-cone, 0m to 14m 165mm Hammer, 15m to 44m
20 (-20)		DOLOMITE: (DIII) grey, fresh, hard, broken	SWL - 10.76m TOC - 11th August 2011		bucket flow test ~5 L/s at 21m
24 (-25)		DOLOMITE: (DIII) grey, fresh, hard, crystalline, fracture infill		--23m	Sensor A, set at 23m BGL
26		DOLOMITE: (DIII) grey, fresh, hard			
28		SILTSTONE: (Clbk) grey, fresh, hard, dolomitised			
30 (-30)		DOLOMITE: (Clbk) dark grey, fresh, hard			
32		DOLOMITE: (Clbk) dark grey, fresh, hard, minor pyrite mineralisation			
34 (-35)		SILTSTONE: (Clbk) Dark grey, fresh, hard, dolomitised			
36		DOLOMITE: (Clbk) dark grey, fresh, hard			
40 (-40)		DOLOMITE: (Clbk) dark grey, fresh, hard		--40m	Sensor B, set at 40m BGL
42					

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Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB05**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	26/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497882mE, 8292098mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
44 -45				--44m	Total depth 44m

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB09** Page 1 of 1

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	12/07/2011 - 13/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498125mE, 8291407mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0				+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
-5		SILTY CLAY: (Cz) brown, plastic, silty, coarse sand and gravel component <5%, moist			Cemented, 0m to 28.7m
-10			▽		
-15		DOLOMITE: (DIII) white and orange brown, extremely weathered, moderately hard			50mm ID, PN18 uPVC, blank casing, 0m to 33.7m, and 36.7m to 39.7m
-20		SILTSTONE: (Clbk) white and orange brown, extremely weathered, moderately hard			311mm Tri-cone, 0m to 22m
		DOLOMITE: (DII) light grey and orange brown, fresh to slightly weathered, moderately hard, significant galena mineralisation	SWL - 10.2m BGL - 25 July 2011	--22m	
-25		DOLOMITE: (DII) grey, fresh, hard, galena and pyrite mineralisation			165mm Hammer, 22m to 42.7m
-30				--28.7m --29.7m	Bentonite seal (1/4" pellets), 28.7m to 29.7m
					bucket flow test ~1L/s at 30m
		DOLOMITE: (DI) pale brown, fresh, hard, dissolution cavities, sugary texture		--33.7m	2-4mm washed, rounded, quartz, gravel pack, 29.7m to 42.7m
-35					bucket flow test ~5L/s at 35m
		DOLOMITE: (DI) dark grey, fresh, hard, pyrite mineralisation, sugary texture		--36.7m	50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 33.7m to 36.7m, and 39.7m to 42.7m
		DOLOMITE: (DI) pale brown and grey, fresh, hard, minor pyrite mineralisation, sugary texture		--39.7m	
-40					End Cap 42.7m
		DOLOMITE: (DI) grey, fresh, hard, minor pyrite mineralisation, sugary texture		--42.7m	Total depth 42.7m

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BOREHOLE LOG

BOREHOLE ID: **OB10**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	06/07/2011 - 07/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498296mE, 8291203mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 0		CLAY: (Cz) brown, plastic, silty, moist, coarse sand component <5%, gravel clasts in basal 3m			Cemented, 0m to 98m. Cement mix ratio: 1:2.5:0.3 (cement:water:bentonite)
-10 / 10			▽		
-15 / 15		DOLOMITE: (Clbk) light brown, extremely weathered, moderately hard, calcite		--15m	311mm Tri-cone, 0m to 15m 165mm Hammer, 15m to 98m
-20 / 20					
-25 / 25					moisture at 25m
-30 / 30		DOLOMITE: (Clbk) light brown and grey, extremely weathered to slightly weathered, minor siltstone SILTSTONE: (Clbk) grey and light brown, distinctly weathered to slightly weathered, hard	SWL - 9.99m BGL (open hole) - 25th July 2011	--30m	Sensor A, set at 30m BGL
-35 / 35		SILTSTONE: (Clbk?) light grey, fresh to slightly weathered (weathereing probably along fractures), dolomitised, hard. Poor sample return as insufficient flow to adequately clean hole			moisture at 32m
-40 / 40					

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BOREHOLE LOG

BOREHOLE ID: **OB10**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	06/07/2011 - 07/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498296mE, 8291203mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
44					
-45					
46					
48					
50				--50m	Sensor B, set at 50m BGL
-50					
52					
54					
-55					
56					
58					
60					
-60					
62					
64					
-65					
66					
68					
70					
-70					
72		DOLOMITE: (DII?) light grey, fresh, hard, minor galena and pyrite mineralisation			bucket flow test ~0.5 L/s at 71m
74					
-75					
76		DOLOMITE: (DII?) dark grey and light grey, fresh, hard, galena and pyrite mineralisation			
78					
80					
-80					
82		DOLOMITE: (DII?) light grey, fresh, hard, pyrite and galena mineralisation, calcite veins (<1mm)			
84					
-85					
86					

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Level 2, 15 Mallon St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **OB10**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	06/07/2011 - 07/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498296mE, 8291203mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
88		DOLOMITE: (DII?) dark grey to black, fresh, hard, pyrite mineralisation		--88m	Sensor C, set at 88m BGL bucket flow test ~4 L/s at 88m
90 -90		DOLOMITE: (DI) pale brown and grey, fresh, hard, pyrite mineralisation			
92					
94 -95					
96		DOLOMITE: (DI) grey, fresh, hard			

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BOREHOLE LOG

BOREHOLE ID: **OB11**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	04/07/2011 - 05/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498255mE, 8291055mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		SILTY CLAY: (Cz) brown, plastic, silty, coarse sand component <10%, moist	SWL - 9.99mBGL - 25th July 2011	+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
-5					Cemented, 0m to 63.7m
-10					
-15		SILTSTONE: (Clbk) orange brown and white, extremely weathered, moderately hard, significant calcite		-18m	311mm Tri-cone, 0m to 18m
-20					165mm Hammer, 18m to 102m
-25		SILTSTONE: (Clbk) grey to pale orange brown, distinctly weathered, moderately hard			bucket flow test ~0.4L/s at 23m
		SILTSTONE: (Clbk) grey, fresh, hard, dolomitised			
-30					bucket flow test ~0.5 L/s at 29m
-35					
-40					
-45		DOLOMITE: (Clbk) grey to brown, fresh, hard, sugary texture			
-50		SILTSTONE: (Clbk) grey, fresh, hard, dolomitised			

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BOREHOLE LOG

BOREHOLE ID: **OB11**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	04/07/2011 - 05/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498255mE, 8291055mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
52					
54					bucket flow test ~0.5L/s at 54m
-55					
56					
58		SILTSTONE: (DII) grey, fresh, hard, dolomitised, minor galena and pyrite mineralisation			
60					bucket flow test ~0.8 L/s at 60m
-60					50mm ID, PN18 uPVC, blank casing, 0m to 69m, 75m to 81m, and 87m to 93m
62					
64				--63.7m	
-65				--65.3m	Bentonite seal (1/4" pellets), 63.7m to 65.3m
66					
68		DOLOMITE: (DII) dark grey, fresh, hard, pyrite and galena mineralisation, calcite			
70				--69m	
-70					2-4mm washed, rounded, quartz, gravel pack, 65.3m to 102m
72		DOLOMITE: (DII) light grey and pale brown, fresh, hard, dissolution cavities			bucket flow test ~2.5L/s at 72m
74					
-75		DOLOMITE: (DII) grey and white, fresh, hard, calcite in veins, dissolution cavities		--75m	
76		DOLOMITE: (DII) light grey to light brown, fresh, hard, dissolution cavities			
78					bucket flow test ~5L/s at 78m
80					
-80				--81m	
82					50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 69m to 75m, 81m to 87m, and 93m to 99m
84		DOLOMITE: (DII) dark grey and white, fresh, hard			
-85					
86		DOLOMITE: (DI) pale brown, fresh, hard, dissolution cavities		--87m	
88		DOLOMITE: (DI) dark grey and white, fresh, hard, sugary texture, calcite			
90					
-90					
92		DOLOMITE: (DI) light grey to pale brown, fresh, hard, dissolution cavities		--93m	
94					
-95					
96					bucket flow test >6L/s at 96m
98		DOLOMITE: (DI) dark brown, fresh, hard, sugary texture		--99m	End Cap,99m
100					
-100					
102				--102m	Total depth 102m

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BOREHOLE LOG

BOREHOLE ID: **OB13** Page 1 of 1

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	13/07/2011 - 16/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498052mE, 8290921mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		SILTY CLAY: (Cz) brown and red, plastic, moist, coarse sand component <5%			
-5		SAND: (Cz) red brown, fine sand, loose, well sorted, qz and lithic grains, portion of sample indicates layer may be cemented in horizons			Cemented, 0m to 60m. Cement mix ratio: 1:2.5:0.3 (cement:water:bentonite)
-10		NO SAMPLE RETURN			
		SILTSTONE: (UF) red brown and white, extremely weathered, moderately hard			311mm Tri-cone, 0m to 18.5m (drilled on mud)
-15					
-18.5m					165mm Hammer, 18.5m to 60m
-20		DOLOMITE: (Clbk) reb brown and grey, distinctly weathered to slightly weathered, hard, minor siltstone in sample			
-25		SILTSTONE: (Clbk) grey, fresh to slightly weathered, hard		--25m	Sensor A, set at 25m BGL bucket flow test ~1 L/s at 25m
-30		DOLOMITE: (DII) pale brown to grey, fresh, hard, sugary texture, calcite and pyrite mineralisation			
		SILTSTONE: (DII) grey, fresh, hard, dolomitised			
-35		DOLOMITE: (DII) pale brown, fresh, hard, sugary texture, dissolution cavities		--35m	Sensor B, set at 35m BGL bucket flow test ~3 L/s at 35m
		DOLOMITE: (DII) grey to dark grey, fresh, hard, sugary texture			
-40		DOLOMITE: (DII) pale brown and grey, fresh, hard, pyrite mineralisation			
		NO SAMPLE RETURN			
-45		DOLOMITE: (DII) dark grey and grey, fresh, hard, pyrite and galena mineralisation			
-50		DOLOMITE: (DI) pale brown and grey, fresh, hard, sugary texture, dissolution cavities			
-55				--55m	bucket flow test ~4 L/s at 54m Sensor C, set at 55m BGL
		DOLOMITE: (DI) grey, fresh , hard			
-60		DOLOMITE: (DI) dark grey and grey, fresh, hard, sugary texture			Total depth 60m

SWL - 9.58m BGL (open hole) - 25th July 2011

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BOREHOLE LOG

BOREHOLE ID: **OB14**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	27/06/2011 - 28/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498030mE, 8290778mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 (0)				+0.6m	Protective lockable steel collar
					PVC Stick up, 0.6m
0 (0) – 11.5 (-10)		CLAY: (Cz) dark brown, plastic, silty, coarse sand component <5%, moist			Cemented, 0m to 29m
11.5 (-10) – 14 (-12)		DOLOMITE: (DII) dark red brown and white, extremely weathered, moderately hard, significant calcite			50mm ID, PN18 uPVC, blank casing, 0m to 40m, 49m to 52m, and 58m to 61m
14 (-12) – 18.5 (-15)		DOLOMITE: (DII) red brown, extremely weathered, moderately hard, ~50% calcite		-17.5m	311mm Tri-cone, 0m to 17.5m
18.5 (-15) – 20 (-20)		SILTSTONE: (DII) red brown, distinctly weathered, moderately hard			
20 (-20) – 29 (-25)		SILTSTONE: (DII) grey, slightly weathered to fresh, dolomitised	SWL - 9.28mBGL - 25th July 2011		165mm Hammer, 17.5m to 67m
29 (-25) – 31 (-30)		SILTSTONE: (DII) grey,slightly weathered to fresh, hard, dolomitised, minor pyrite and galena mineralisation		--29m	
31 (-30) – 40 (-35)		SILTSTONE: (DII) dark grey,slightly weathered to fresh, hard, dolomitised, pyrite and galena mineralisation		--31m	Bentonite seal (1/4" pellets), 29m to 31m
					bucket flow test ~0.5L/s at 32m
					2-4mm washed, rounded, quartz, gravel pack, 31m to 67m
40 (-40) – 44		DOLOMITE: (DII) dark grey and light grey, fresh, hard, dolomitised, pyrite and galena mineralisation, sugary texture		--40m	
				--43m	bucket flow test ~1L/s at 42m

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BOREHOLE LOG

BOREHOLE ID: **OB14**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	27/06/2011 - 28/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498030mE, 8290778mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
-45				--46m	bucket flow test ~1.5L/s at 45m
46					
48				--49m	bucket flow test ~4L/s at 49m
50 -50					50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 40m to 43m, 46m to 49m, 52m to 58m, and 61m to 67m
52				--52m	
54		DOLOMITE: (DI) Pale red brown, fresh, hard			
-55					
56		DOLOMITE: (DI) dark grey and light grey, fresh, hard			bucket flow test ~4L/s at 55m
58				--58m	
60 -60					
62				--61m	bucket flow test ~8.3L/s at 61m
64					
-65		DOLOMITE: (DI) light grey, fresh, hard			End Cap,67m
66				--67m	Total depth 67m

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BOREHOLE LOG

BOREHOLE ID: **OB15**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	24/06/2011 - 25/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497952mE, 8290596mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 (0)				+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
2		CLAY: (Cz) brown, highly plastic, moist, sand with fine sub angular gravel component			
4					
-5 (5)					Cemented, 0m to 19.8m
6		DOLOMITE: (Clbk) white to orange brown with black flecks, highly weathered, fractured, moderately hard, calcareous			
8					
-10 (10)					311mm Tri-cone, 0m to 11.5m
12				--11.5m	v notch 85mm (2.9 L/s) at 12m
-15 (14)					165mm Hammer, 11.5m to 30m
16					
18		DOLOMITE: (Clbk) brown, highly weathered to slightly weathered, moderately hard			
-20 (20)				--19.8m	50mm ID, PN18 uPVC, blank casing, 0m to 30m and 36m to 42m
22				--21.2m	Bentonite seal (1/4" pellets), 19.8m to 21.2m
24		DOLOMITE: (DII) Grey, fresh to slightly weathered, hard, pyrite and galena mineralisation	SWL - 8.36m - 27th July 2011		2-4mm washed, rounded, quartz, gravel pack, 21.2m to 54m
-25 (25)					
26					
28					
-30 (30)				--30m	
32					50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 30m to 36m and 42m to 54m
34					
-35 (35)					
36				--36m	bucket flow test ~2.9 L/s at 36m
38					
-40 (40)					
42				--42m	
44		DOLOMITE: (DI) pink grey, fresh, hard,			

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BOREHOLE LOG

BOREHOLE ID: **OB15**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	24/06/2011 - 25/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497952mE, 8290596mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
-45					bucket flow test >10 L/s at 46m
46		DOLOMITE: (DI) orange, weathered, hard,			
48					
50 -50		DOLOMITE: (DI) brown grey, fresh, hard,			
52		DOLOMITE: (DI) dark grey, fresh, hard			End Cap, 54
54				--54m	Total depth 54m

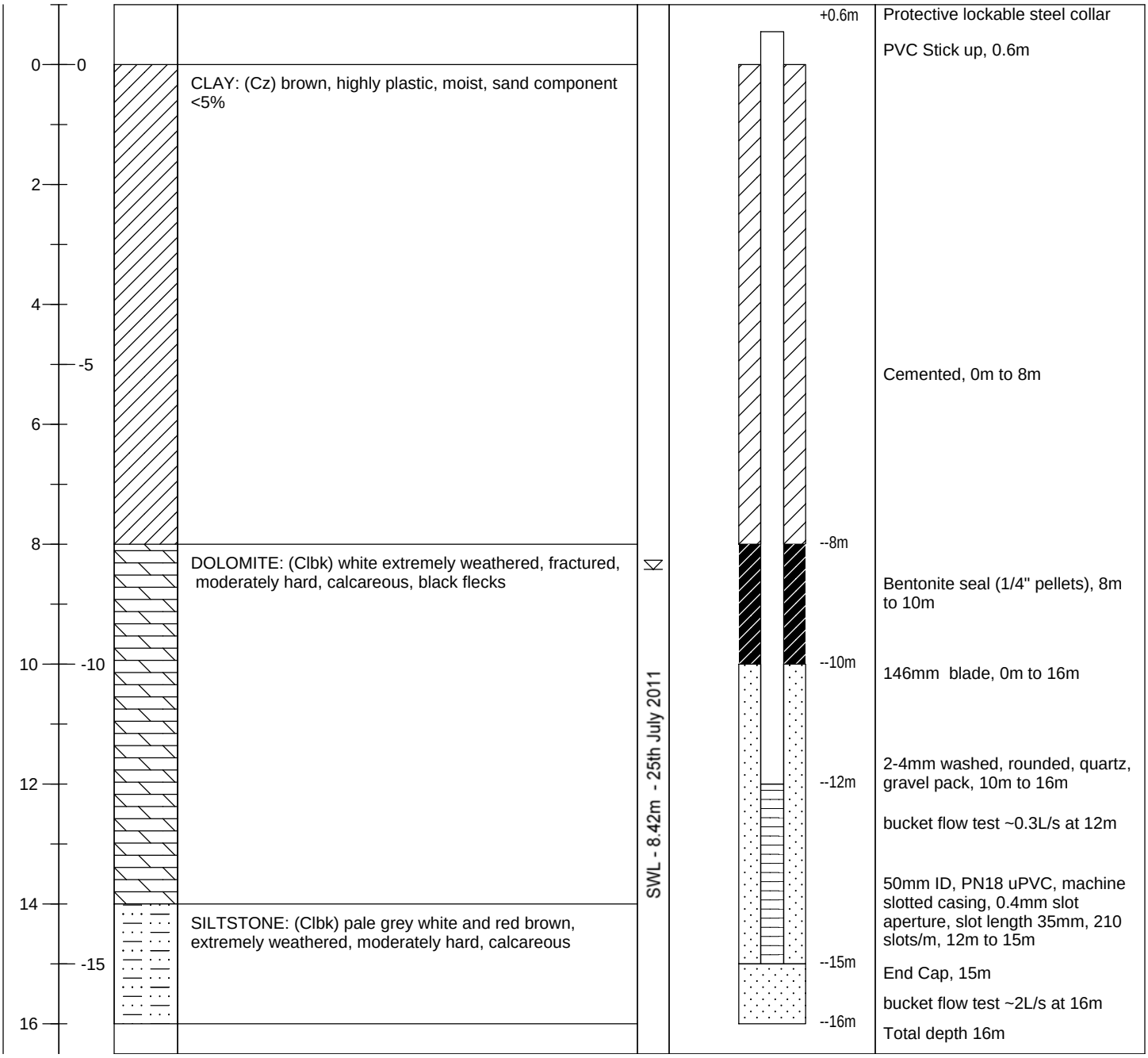
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BOREHOLE LOG

BOREHOLE ID: **OB15a**

PROJECT NO.	G1489a	DRILLER:	James	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	16/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497951mE, 8290595mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 — 0		CLAY: (Cz) brown, highly plastic, moist, sand component <5%		+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
-5					Cemented, 0m to 8m
8		DOLOMITE: (Clbk) white extremely weathered, fractured, moderately hard, calcareous, black flecks	SWL - 8.42m - 25th July 2011	--8m	Bentonite seal (1/4" pellets), 8m to 10m
-10				--10m	146mm blade, 0m to 16m
12				--12m	2-4mm washed, rounded, quartz, gravel pack, 10m to 16m bucket flow test ~0.3L/s at 12m
14		SILTSTONE: (Clbk) pale grey white and red brown, extremely weathered, moderately hard, calcareous			50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 12m to 15m
-15				--15m	End Cap, 15m
16				--16m	bucket flow test ~2L/s at 16m Total depth 16m



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BOREHOLE LOG

BOREHOLE ID: **OB16**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	25/06/2011 - 27/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498195mE, 8290765mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 0				+0.6m	Protective lockable steel collar
					PVC Stick up, 0.6m
0 / 0		CLAY: (Cz) dark brown to red brown, plastic, minor coarse sand (<5%), plastic, moist			
-5 / 5					Cemented, 0m to 92m
-10 / 10					
-10 / 12		CLAYSTONE: (UF) white and brown, extremely weathered, moderately hard, significant calcite (~40%)			50mm ID, PN18 uPVC, blank casing, 0m to 97m and 100m to 103m
-15 / 15		CLAYSTONE: (UF) brown and white, distinctly weathered, moderately hard, significant calcite (~30%)			311mm Tri-cone, 0m to 18m
-18m					
-20 / 20		SILTSTONE: (UF) dark grey and white,distinctly weathered, hard, dolomitised			165mm Hammer, 18m to 109m
-25 / 25		SILTSTONE: (UF) dark grey,slightly weathered to fresh, hard, dolomitised			
-30 / 30					v notch 35mm (0.3L/s) at 30m
-35 / 35					
-40 / 40					
42			SWL - 9.23m BGL - 6th July 2011		

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BOREHOLE LOG

BOREHOLE ID: **OB16**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	25/06/2011 - 27/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498195mE, 8290765mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
44 -45 46 48 50 -50 52					
54 -55 56		SILTSTONE: (UF) dark grey,slightly weathered to fresh, hard, dolomitised, minor pyrite mineralisation			
58 60 -60 62 64 -65		SILTSTONE: (UF) dark grey,slightly weathered to fresh, hard, dolomitised, minor pyrite and galena mineralisation			
66 68 70 -70 72 74 -75 76 78		SILTSTONE: (Clbk) dark grey, slightly weathered to fresh, hard, pyrite and galena mineralisation			v notch 35mm (0.3L/s) at 66m
80 -80 82 84 -85 86		DOLOMITE: (DII) dark grey and light grey, fresh to slightly weathered, hard, pyrite and galena mineralisation			

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BOREHOLE LOG

BOREHOLE ID: **OB16**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	25/06/2011 - 27/06/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498195mE, 8290765mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
88 90 -90 92 94 -95 96 98 100 -100 102 104 -105 106 108		DOLOMITE: (DI) brown grey and pink grey, fresh to slightly weathered, hard, no pyrite and galena mineralisation		--92m --94m --97m --100m --103m --109m	Bentonite seal (1/4" pellets), 92m to 94m v notch 35mm (0.3L/s) at 93m 2-4mm washed, rounded, quartz, gravel pack, 94m to 109m 50mm ID, PN18 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 97m to 100m and 103m to 109m v notch 45mm (0.6L/s) at 102m v notch 85mm (2.9L/s) at 106m End Cap,109m Total depth 109m

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BOREHOLE LOG

BOREHOLE ID: **TPB01** Page 1 of 1

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	22/07/2011 - 26/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0497882mE, 8292098mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0				+0.6m	Protective lockable steel collar PVC Stick up, 0.6m
-5		SILTY CLAY: (Cz) dark brown and red brown, slightly moist to dry, minor sand component (<5%)			Cemented, 0m to 47.8m
-10					375mm Tri-cone, 0m to 14m
-15		DOLOMITE: (DIII) red brown and black, extremely weathered, hard		--14m	311mm Hammer, 14m to 47.8m
-20		DOLOMITE: (DIII) pale brown and red brown, distinctly weathered, hard			~2 L/s (estimate) at 23m
-25					
-30		SILTSTONE: (Clbk) grey and pale brown, slightly weathered, to fresh			203mm ID, PN18 uPVC, blank casing, 0m to 47.5m
-35		DOLOMITE: (Clbk) pale red brown, distinctly weathered, hard, sugary texture			
-40		SILTSTONE: (Clbk) grey, fresh, hard, dolomitised			
-45		DOLOMITE: (Clbk) dark grey, fresh hard, sugary texture			
-50		SILTSTONE: (Clbk) grey and pale brown, fresh to slightly weathered, hard, dolomitised		--47.3m	K-packer at 46.3m to 47.8m 2-4mm washed, rounded, quartz, gravel pack, 47.3m to 58.5m
-55		SILTSTONE: (DII) dark grey, fresh to slightly weathered, hard, dolomitised			165mm Hammer, 47.8m to 65m
-60		DOLOMITE: (DII) orange brown, altered, hard, fractured			152mm ID, PN12 uPVC, machine slotted casing, 0.4mm slot aperture, slot length 35mm, 210 slots/m, 47.8m to 65m
-65		DOLOMITE: (DI?) dark grey, fresh, hard, sugary texture		--65m	2 - 5 L/s (bucket test) at 65m Total depth 65m

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BOREHOLE LOG

BOREHOLE ID: **TPB3**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	07/07/2011 - 11/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498264mE, 8291190mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 0		CLAY: (Cz) brown, plastic, silty, moist, coarse sand component <5%, gravel clasts in basal 3m	SWL - 10.13m - 25th July 2011	+0.6m	Protective lockable steel collar PVC Stick up, 0.4m Cemented, 0m to 60m
-5 / 5					
-10 / 10					
-15 / 15		DOLOMITE: (Clbk) dark brown and white, extremely weathered, moderately hard, calcite		-15m	375mm Tri-cone, 0m to 15m
-20 / 20		SILTSTONE: (Clbk) red brown and pale grey, extremely weathered to distinctly weathered, minor dolomite			311mm Hammer, 15m to 60m
-25 / 25		SILTSTONE: (Clbk) dark grey and red brown, slightly weathered to fresh, hard			
-30 / 30		SILTSTONE: (Clbk) grey, fresh, dolomitised, hard, minor sandstone			
-35 / 35		DOLOMITE: (Dll) light grey, fresh, hard, minor galena and pyrite mineralisation			
-40 / 40					

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BOREHOLE LOG

BOREHOLE ID: **TPB3**

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	07/07/2011 - 11/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498264mE, 8291190mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
44					
-45					
46					
48					
50					
-50		DOLOMITE: (DII) grey to dark grey, fresh, hard, galena and pyrite mineralisation, calcite veins			
52					
54					
-55					
56					
		DOLOMITE: (DII) grey to pale brown, fresh, hard, pyrite and galena mineralisation			
58					
60				-60m	
-60					
62		DOLOMITE: (DII) grey to pale brown, fresh, hard, pyrite and galena mineralisation, calcite veins (~1 mm thick)			
		DOLOMITE: (DI) light grey to light brown, fresh, hard, sugary texture			v-notch 42mm (0.5L/s) at 63m
64					
-65					190mm Hammer, 60 to 84m
66					
					bucket flow test ~0.3L/s at 66m
68		DOLOMITE: (DI) dark grey to black and white, fresh, hard, sugary texture, calcite veins (~1mm thick)			
		DOLOMITE: (DI) grey, fresh, hard			
70					
-70					Open Hole, 60m to 84m
72					
		DOLOMITE: (DI) pale brown, fresh, hard, minor pyrite, sugary texture			bucket flow test ~0.6L/s at 72m
74					
-75					
76					
		DOLOMITE: (DI) dark grey and pale brown, fresh, hard			
78					bucket flow test ~8L/s at 78m
		NO SAMPLE RETURN			
80					bucket flow test 15-20L/s at 84m
-80					
82					Total depth 84m
84				--84m	
-85					

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BOREHOLE LOG

BOREHOLE ID: **TPB4** Page 1 of 1

PROJECT NO.	G1489a	DRILLER:	James Coad	DATUM:	MGA94 Z52
PROJECT NAME:	Sorby Hills Project	DRILLING METHOD:	Rotary Air	GROUND LEVEL:	m AHD
DATE:	29/06/2011 - 04/07/2011	DRILL RIG:	HYDCO70	TOP OF CASING LEVEL:	m AHD
CONTRACTOR:	Direct Drilling	COORDINATES:	0498012mE, 8290790mN	LOGGED BY:	HM

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		SILTY CLAY: (Cz) red brown to light grey, plastic, silty, coarse sand component <10%, moist		+0.6m	Protective lockable steel collar PVC Stick up, 0.4m
-5					Cemented, 0m to 48m
-10					
-12		DOLOMITE: (DII) dark brown and white, extremely weathered, moderately hard, significant calcite		-12m	375mm Tri-cone, 0m to 12m
-15		NO SAMPLE RETURN			
-20		SILTSTONE: (DII) red brown, extremely weathered, moderately hard, significant calcite			
-22		NO SAMPLE RETURN			311mm Hammer, 12m to 48m
-25		SILTSTONE: (DII) grey and orange brown,slightly weathered to distinctly weathered, hard, dolomitised			
-30		SILTSTONE: (DII) grey, fresh to slightly weathered, hard, dolomitised			
-32		DOLOMITE: (DII) brown and grey, fresh to slightly weathered, hard, pyrite and galena mineralisation			
-35		DOLOMITE: (DII) grey, fresh to slightly weathered, hard, pyrite and galena mineralisation	SWL - 9.13m - 6th July 2011		bucket flow test ~0.5L/s at 37m (pre surface casing)
-40					
-45					
-48				-48m	bucket flow test ~0.5L/s at 47m (pre surface casing)
-50		DOLOMITE: (DI) grey and orange brown, fresh to slightly weathered, hard			bucket flow test ~1.5L/s at 50m (pre surface casing)
-52					190mm Hammer, 48 to 67m
-54		DOLOMITE: (DI) grey to light grey, fresh, hard, pyrite and galena mineralisation			bucket flow test ~0.6L/s at 54m
-55					
-58					
-60		DOLOMITE: (DI) light grey, fresh, hard, pyrite and galena mineralisation, dissolution cavities			bucket flow test ~0.6L/s at 60m
-65					
-68					
-70					
-72					
-74					
-75		DOLOMITE: (DI) dark grey, fresh, hard, pyrite mineralisation, dissolution cavities			Total depth 78m
-76					
-78		DOLOMITE: (DI) grey to light grey, fresh, hard		-78m	bucket flow test ~1.6L/s at 78m

APPENDIX C

In-Situ Permeability Test Analyses

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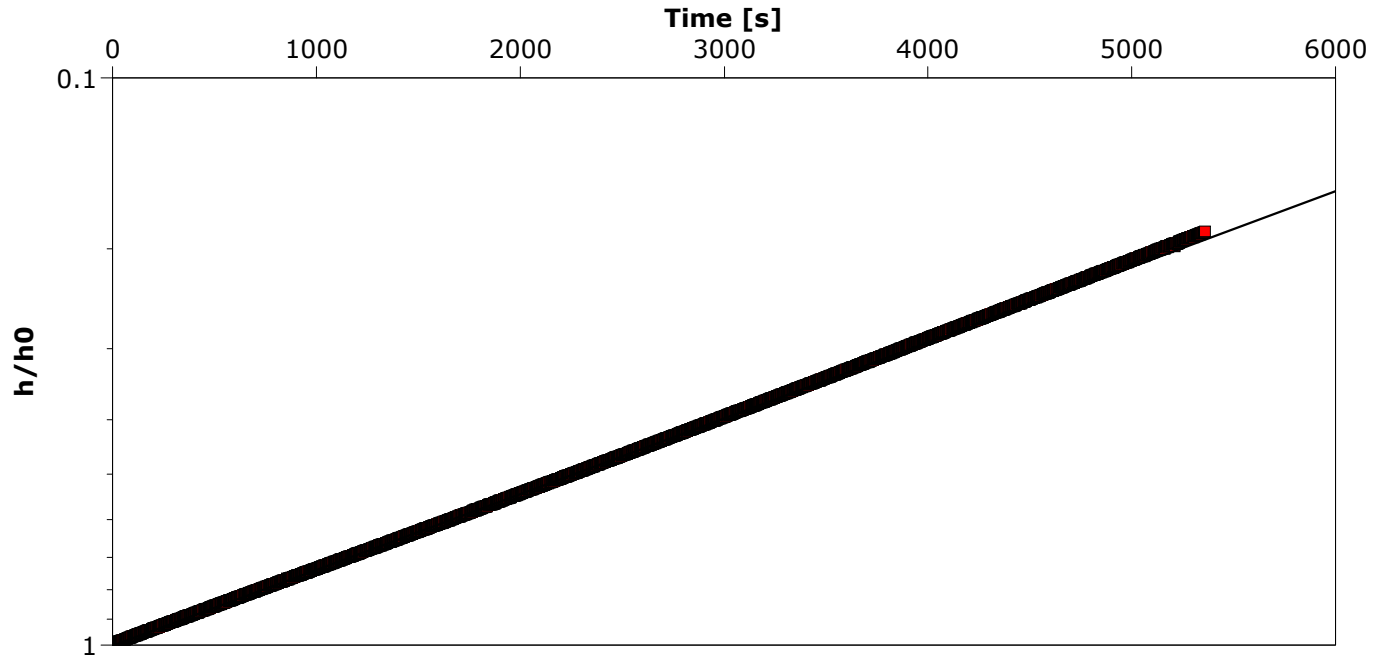
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB01
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 41.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB01	2.15×10^{-3}	

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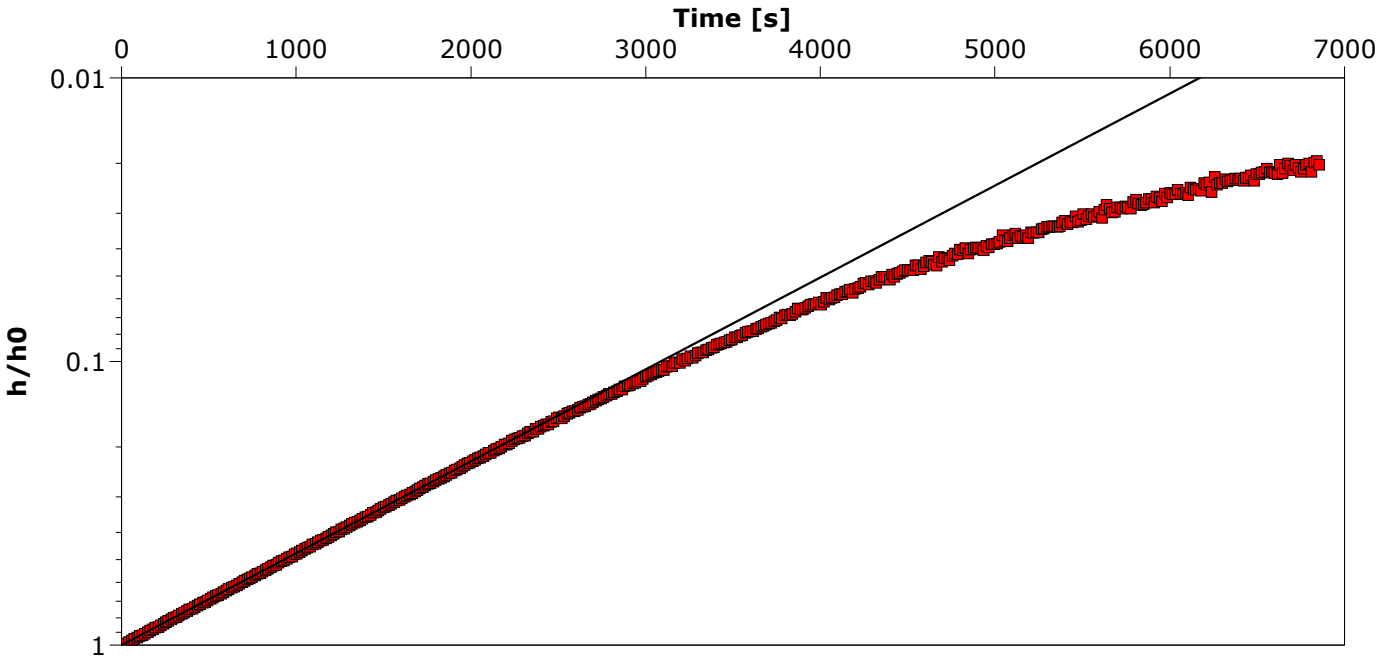
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB02
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 41.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB02	2.90×10^{-3}	

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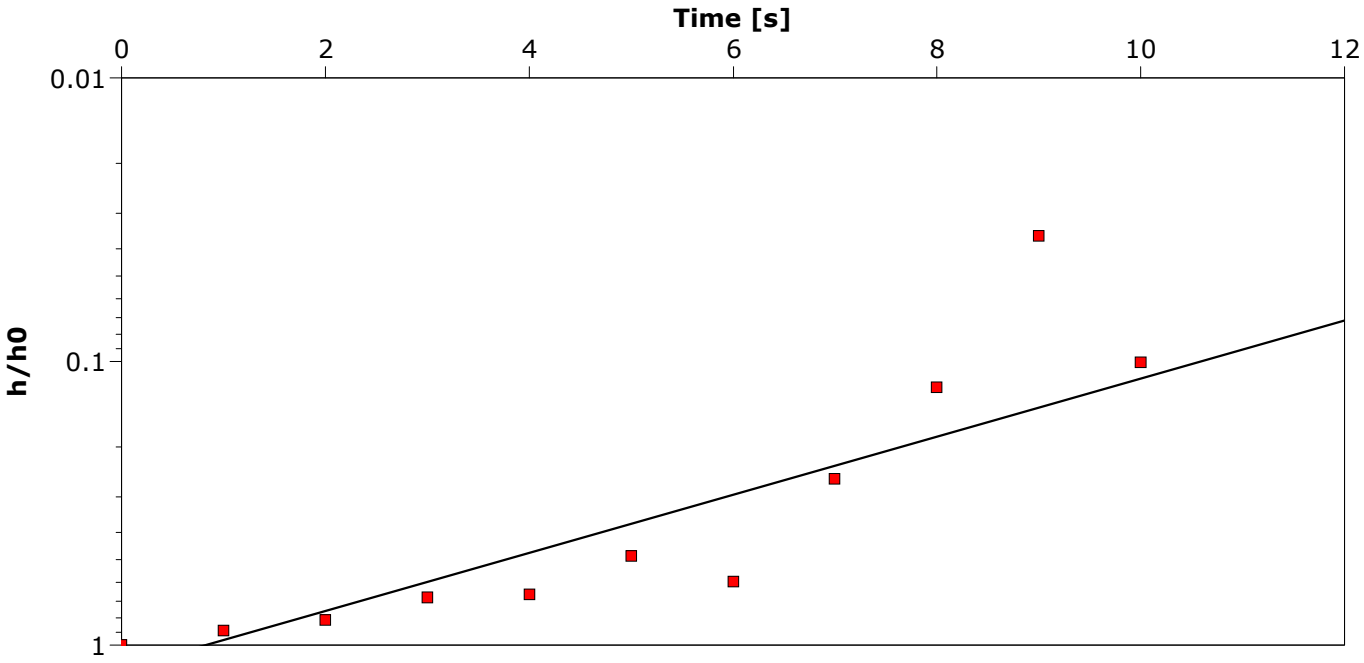
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB03
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 41.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB03	1.65×10^{0}	

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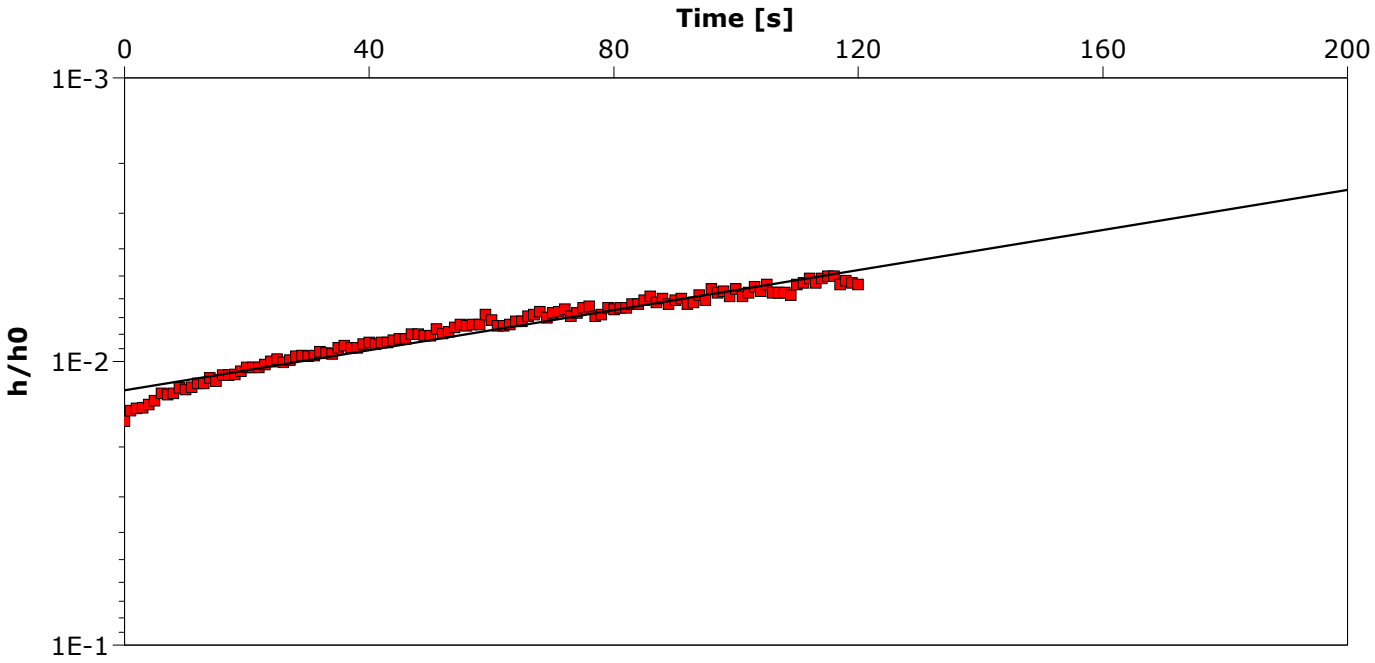
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB04
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 41.00 m		

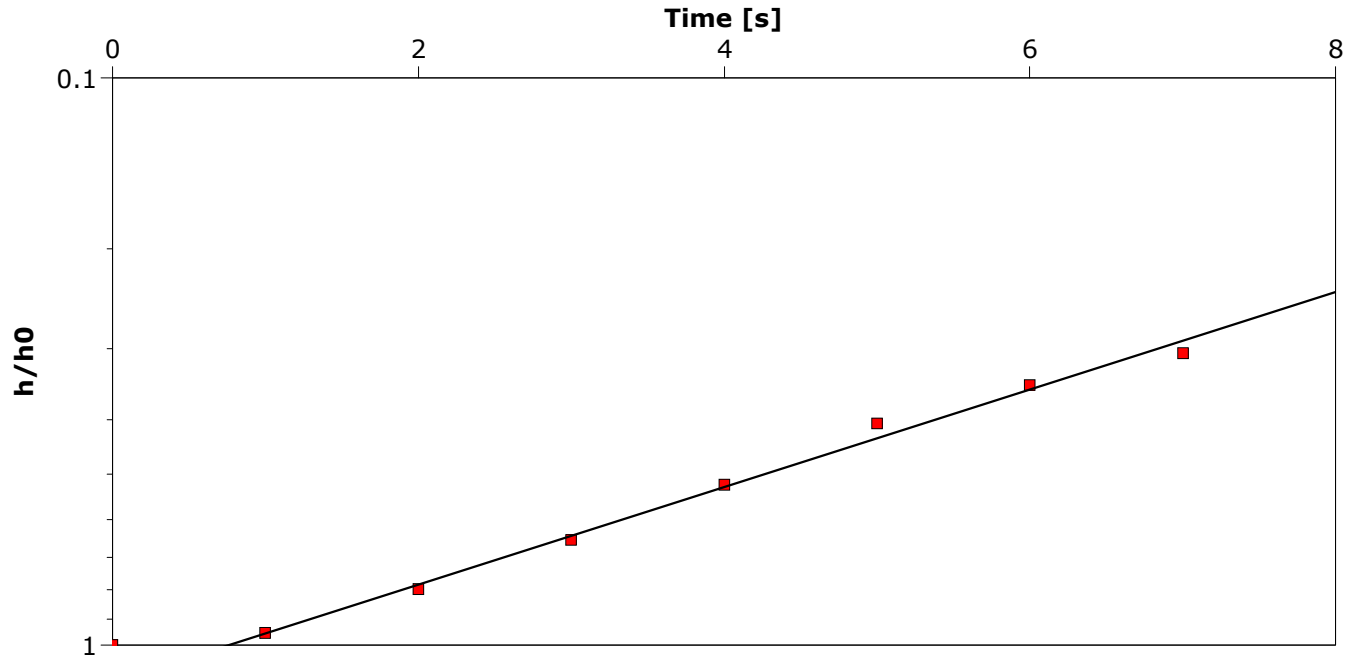


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB04	1.01×10^{-1}	

Australasian Groundwater and Environmental Consultants Pty Ltd **Level 2, 15 Mallon Street** **Bowen Hills** **Brisbane 4006**	**Slug Test Analysis Report** Project: Sorby Hills Number: G1489a Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB09
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 78.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB09	1.38×10^{0}	

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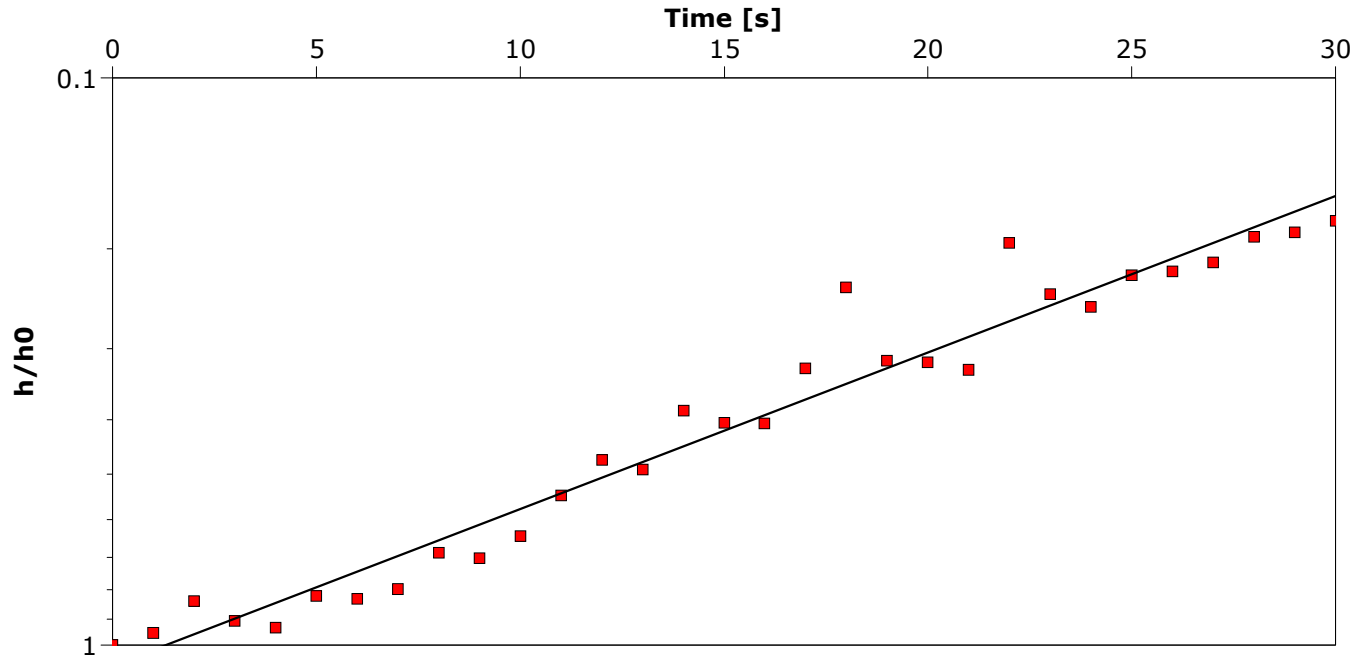
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB11
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 78.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB11	1.75×10^{-1}	

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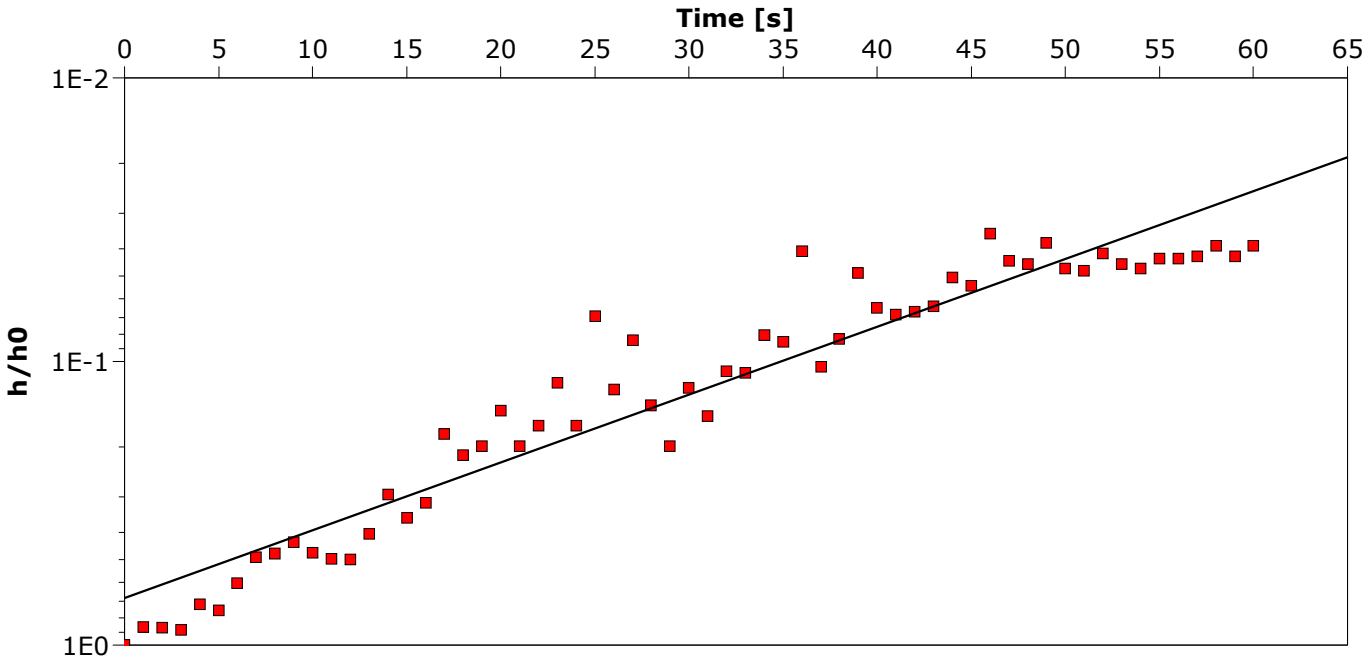
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB14
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 66.00 m		

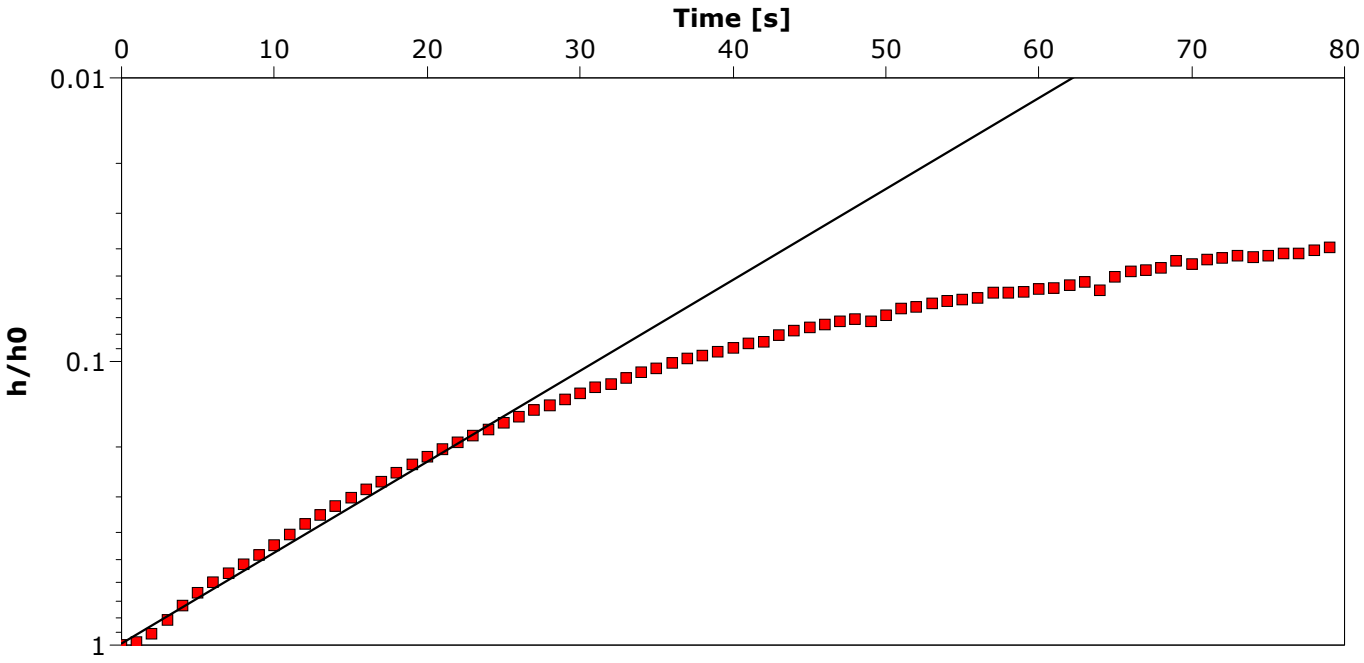


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB14	1.51×10^{-1}	

Australasian Groundwater and Environmental Consultants Pty Ltd **Level 2, 15 Mallon Street** **Bowen Hills** **Brisbane 4006**	**Slug Test Analysis Report** Project: Sorby Hills Number: G1489a Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB15
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 66.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB15	2.03×10^{-1}	

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Brisbane 4006

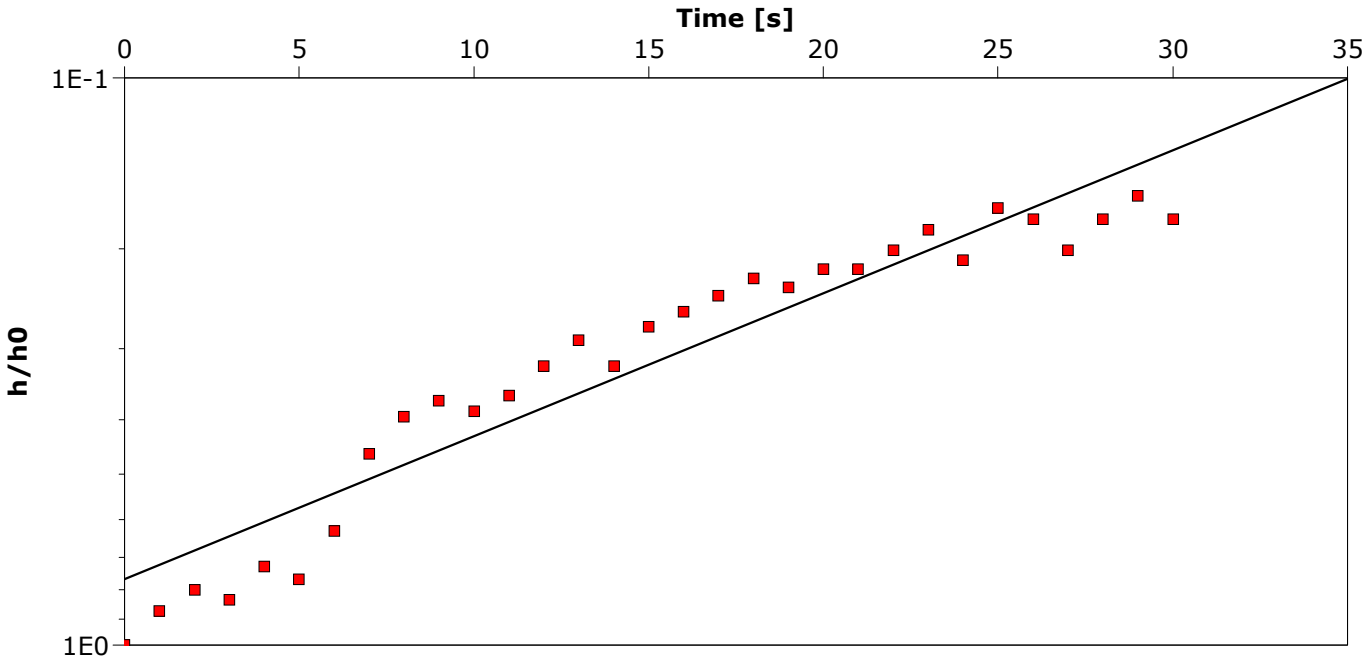
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB15A
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 66.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB15A	7.20×10^{-1}	

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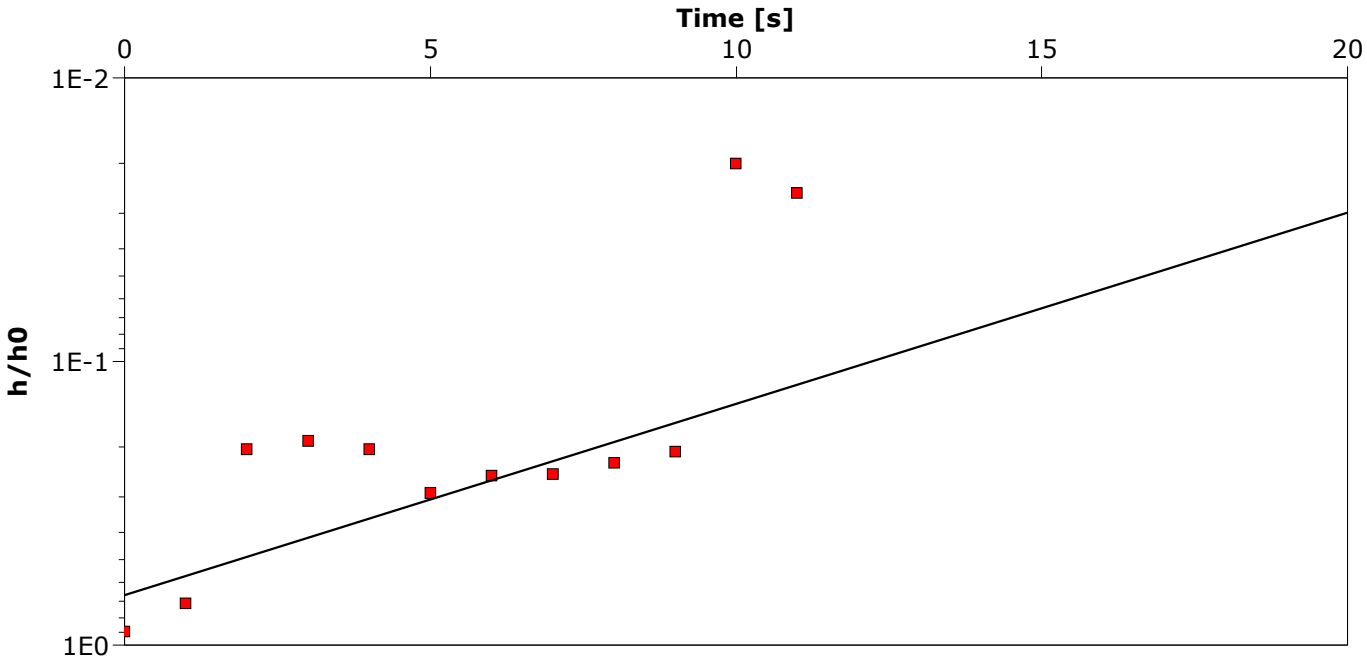
Slug Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Slug Test: Slug Test	Test Well: OB16
Test Conducted by: D. Irvine		Test Date: 11/08/2011
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/10/2011
Aquifer Thickness: 66.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
OB16	7.71×10^{-1}	

APPENDIX D

Pumping Test Plots and Analyses

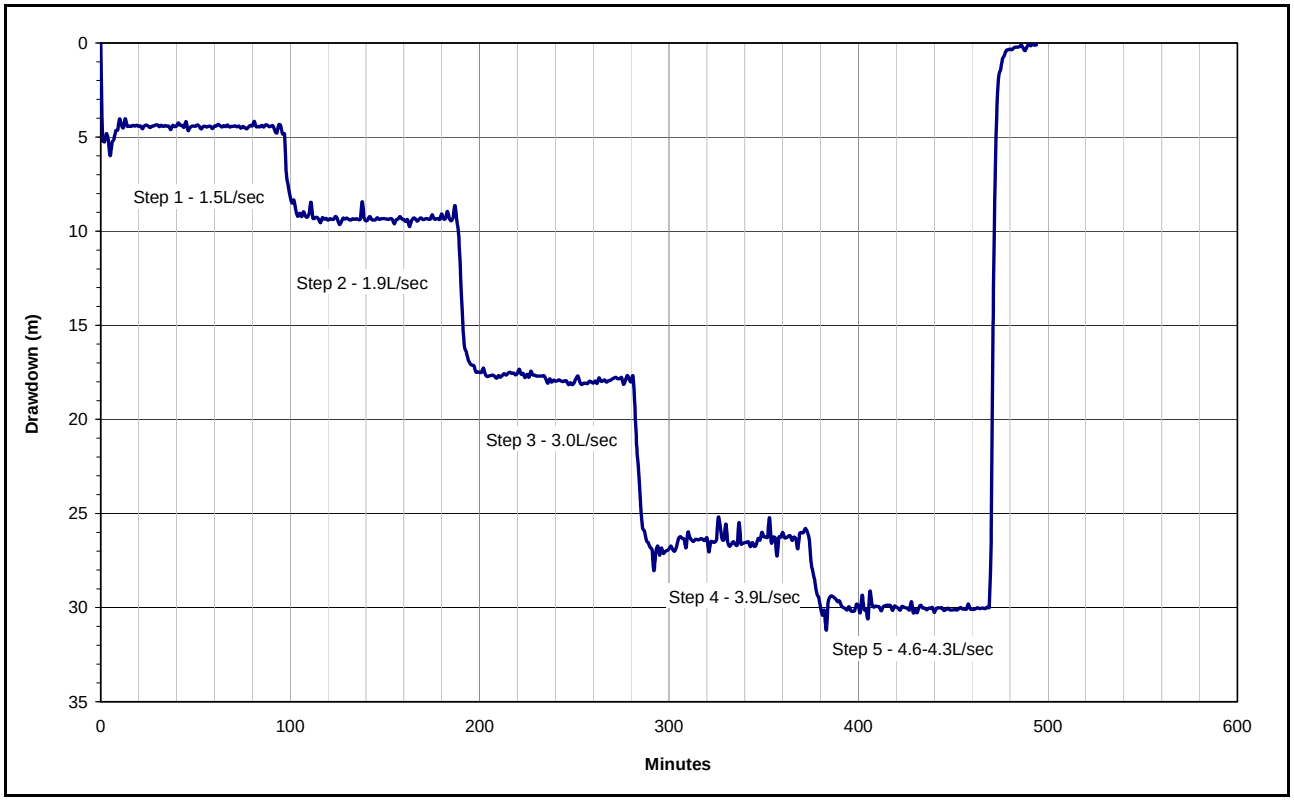


Figure D1: Step Rate Test for Test Pump Bore TPB1 (linear scale)

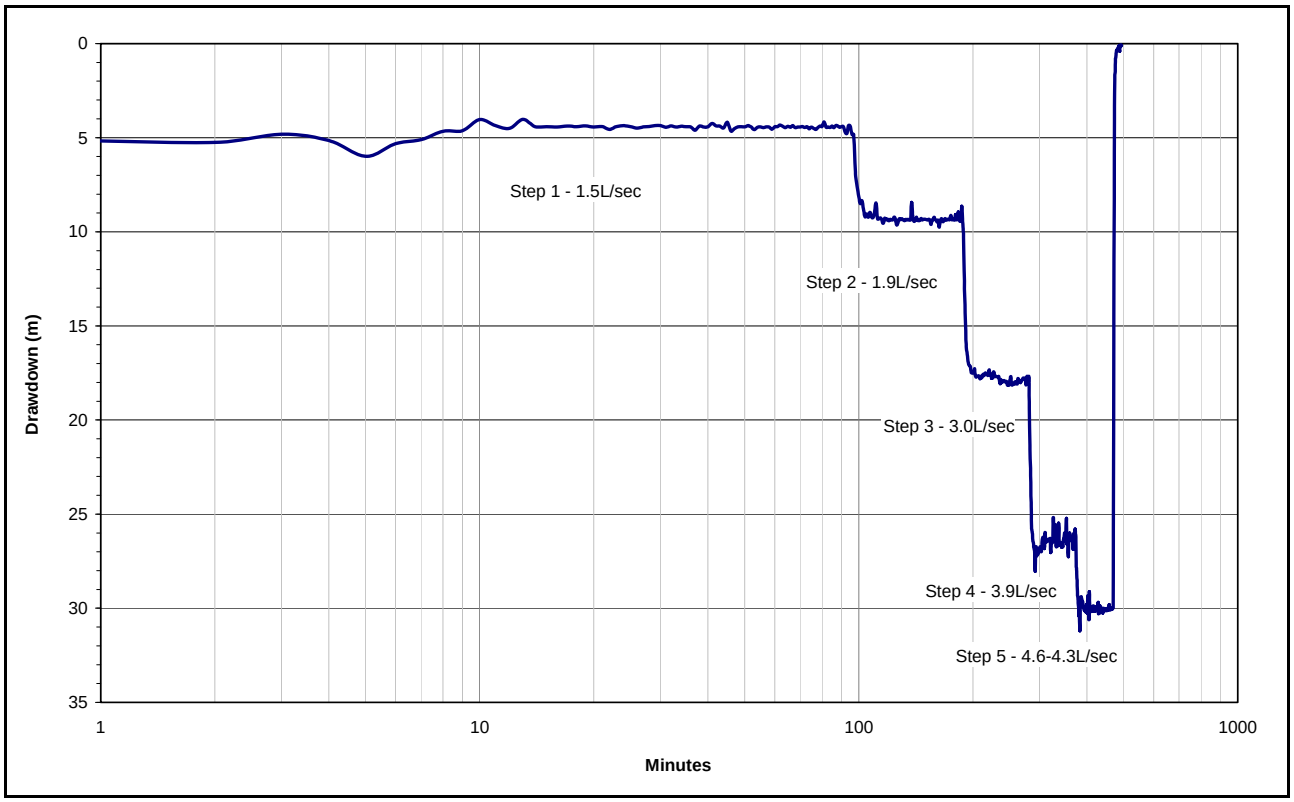


Figure D2: Step Rate Test for Test Pump Bore TPB1 (log-linear scale)

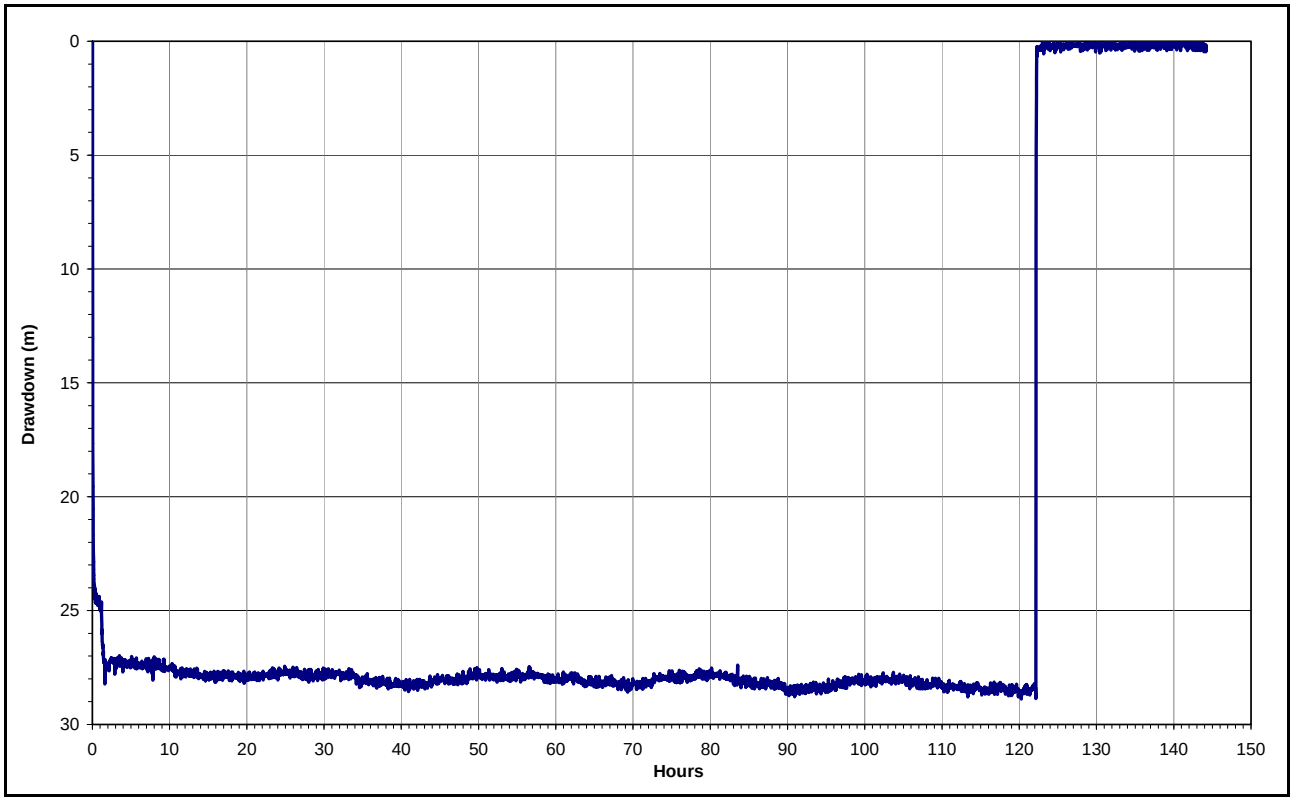


Figure D3: Constant Rate Test at 4L/sec for Test Pump Bore TPB1 (linear scale)

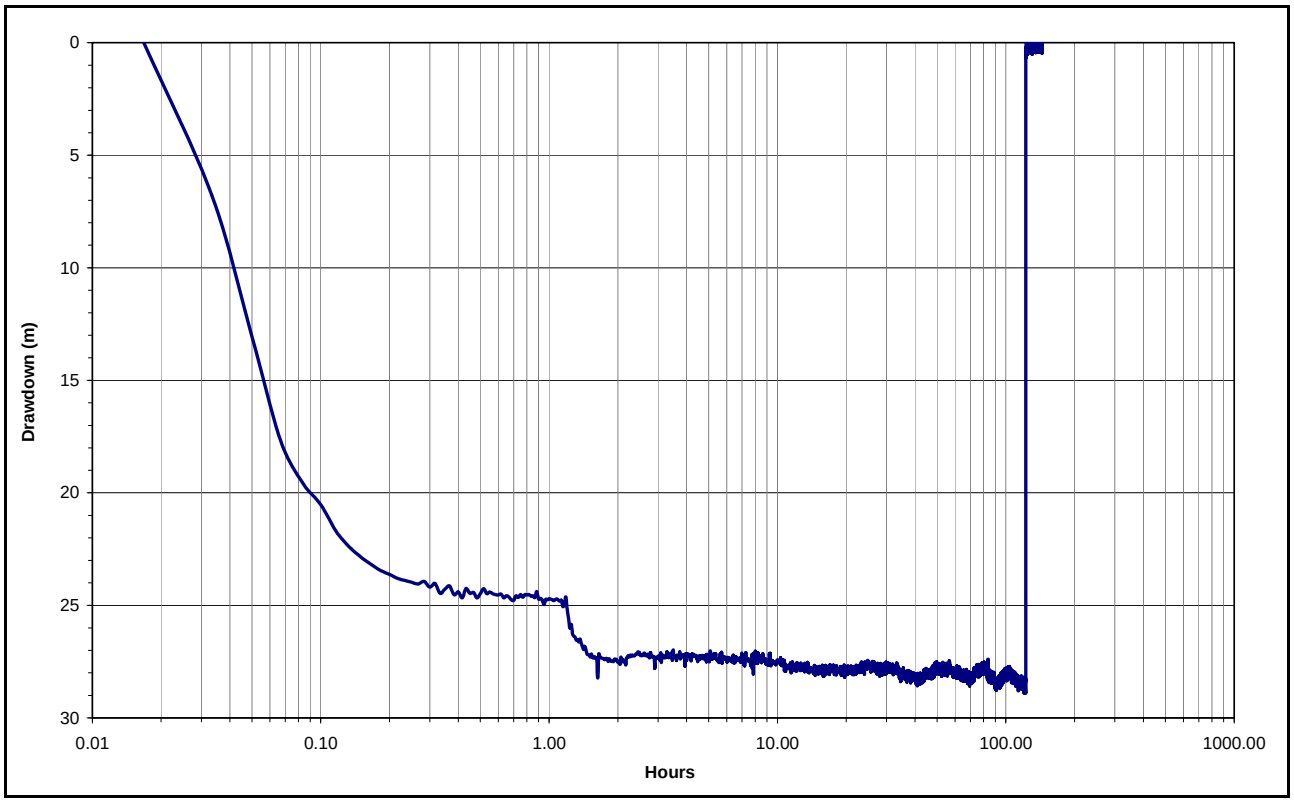


Figure D4: Constant Rate Test at 4L/sec for Test Pump Bore TPB1 (log-linear scale)

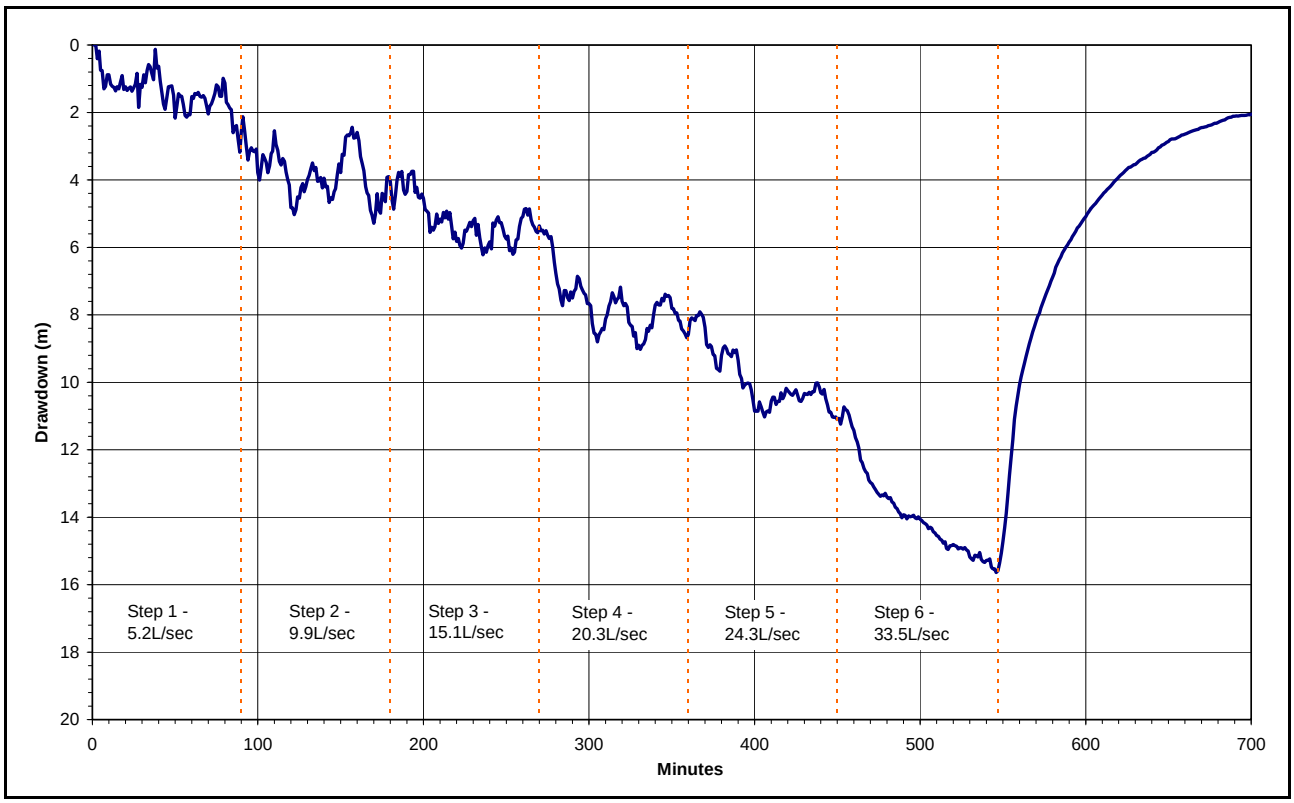


Figure D5: Step Rate Test 1 for Test Pump Bore TPB3 (linear scale)

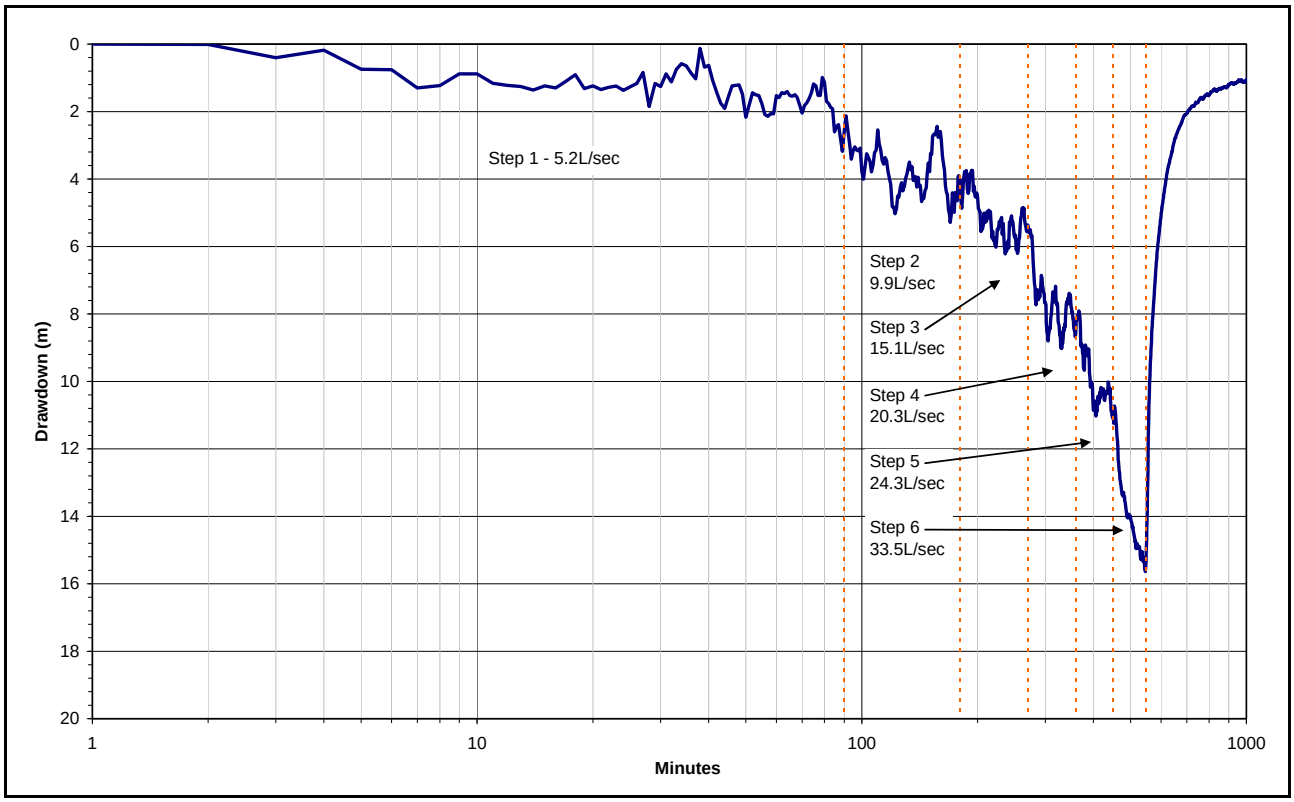


Figure D6: Step Rate Test 1 for Test Pump Bore TPB3 (log-linear scale)

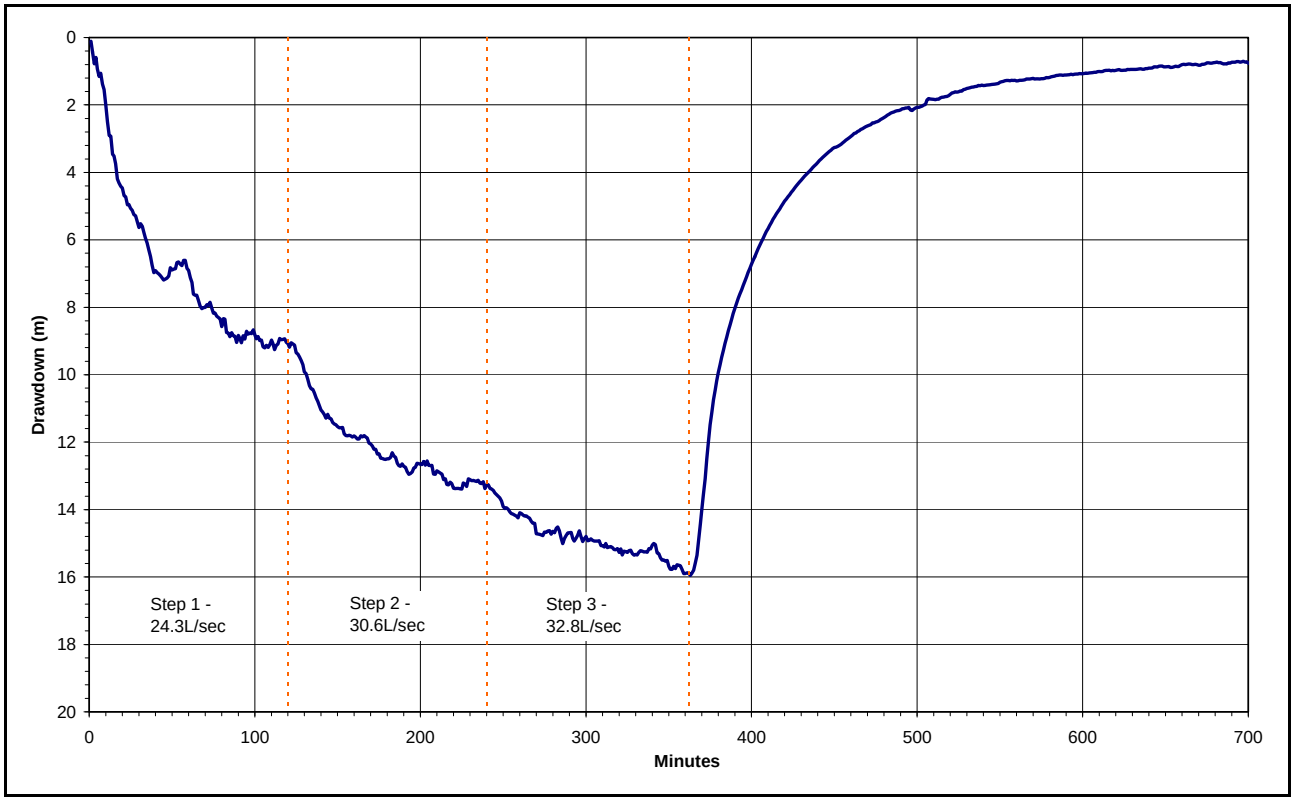


Figure D7: Step Rate Test 2 for Test Pump Bore TPB3 (linear scale)

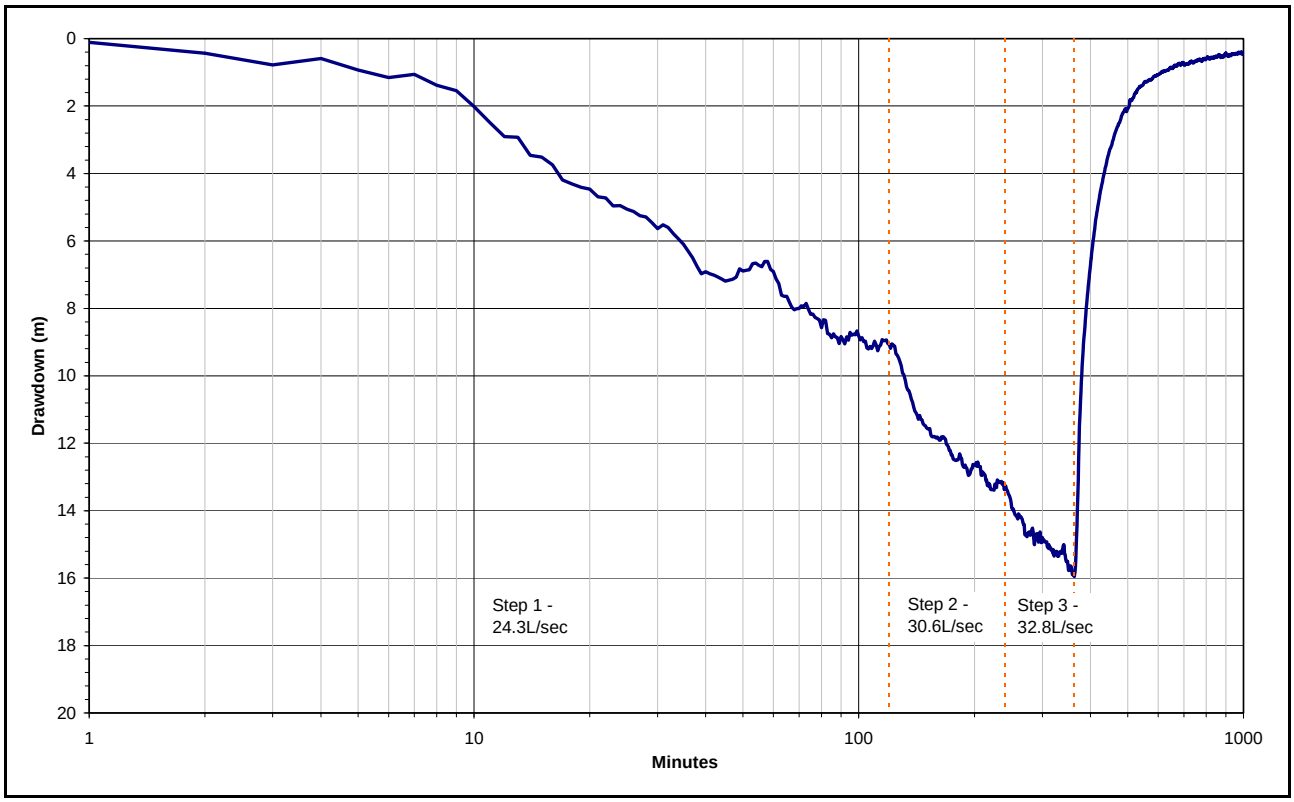


Figure D8: Step Rate Test 2 for Test Pump Bore TPB3 (log-linear scale)

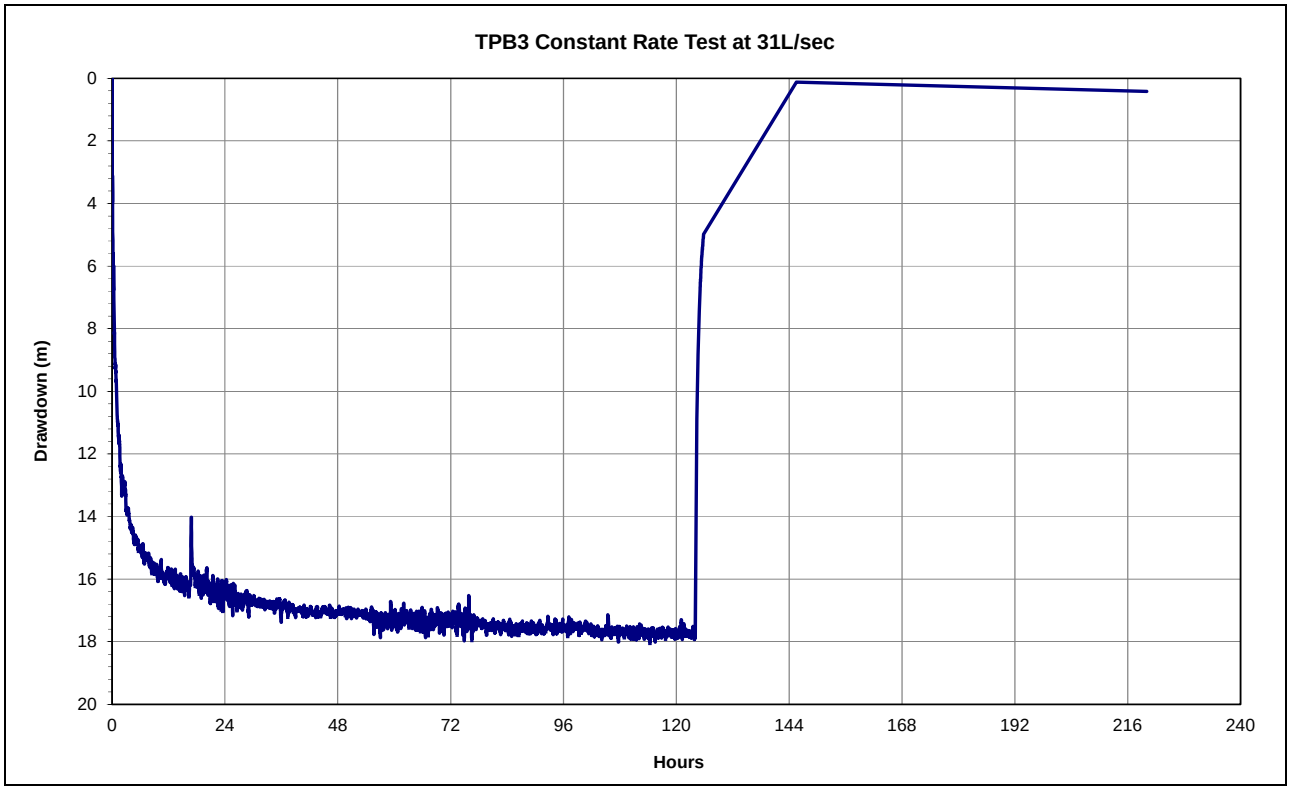


Figure D9: Constant Rate Test at 31L/sec for Test Pump Bore TPB3 (linear scale)

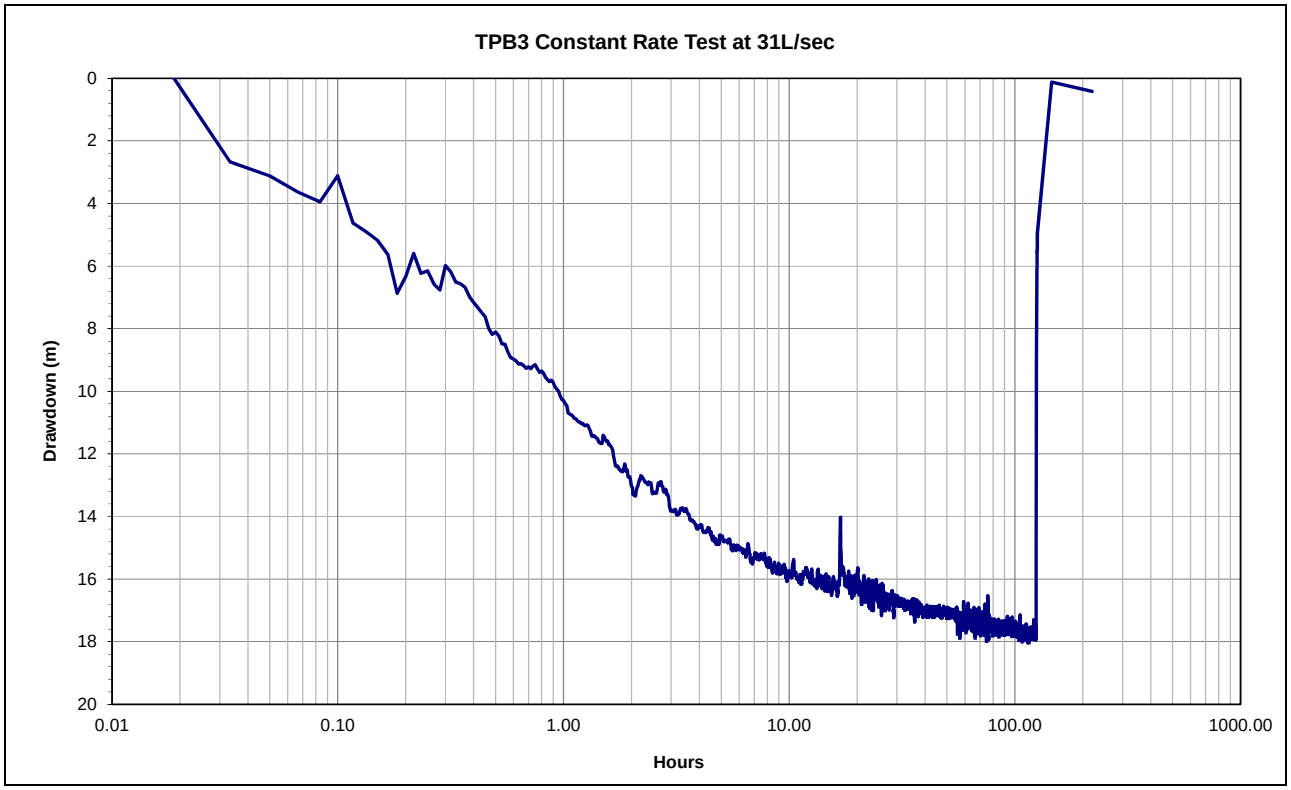


Figure D10: Constant Rate Test at 31L/sec for Test Pump Bore TPB3 (log-linear scale)

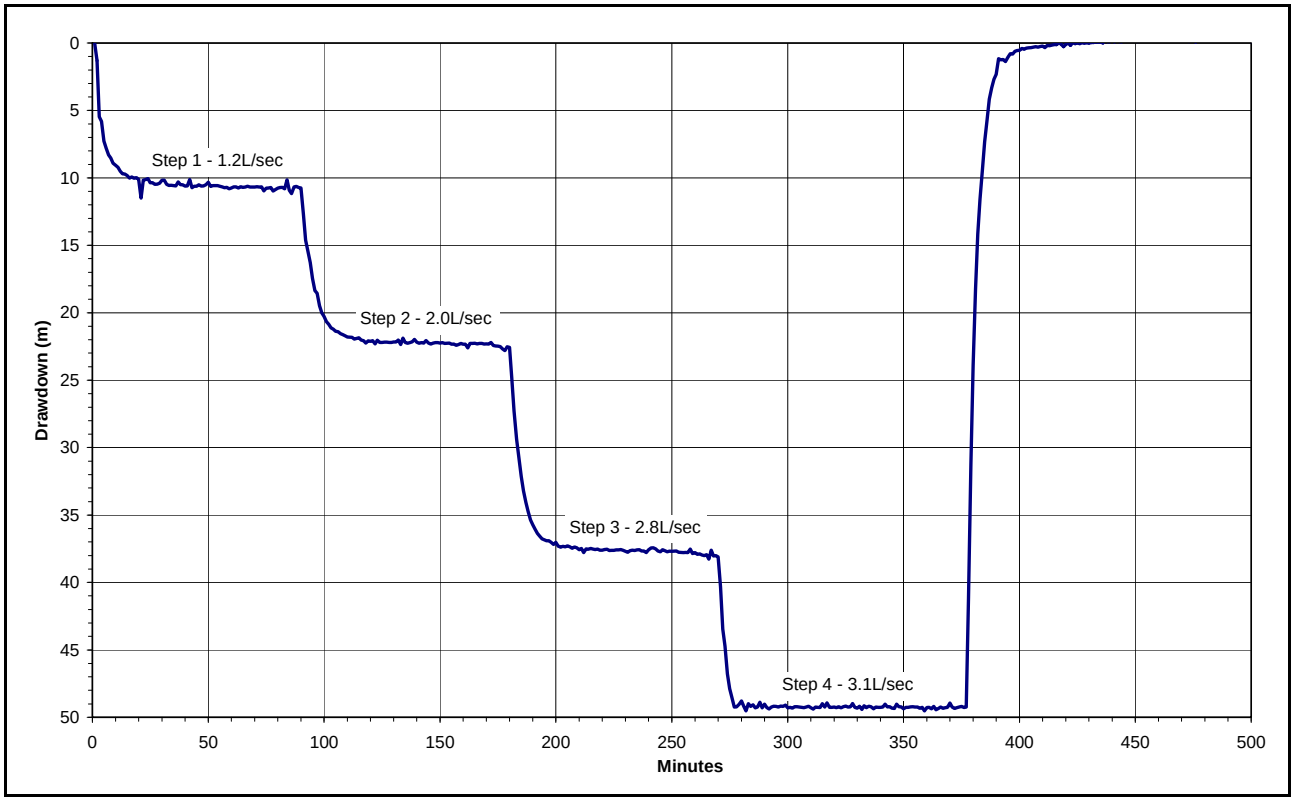


Figure D11: Step Rate Test for Test Pump Bore TPB4 (linear scale)

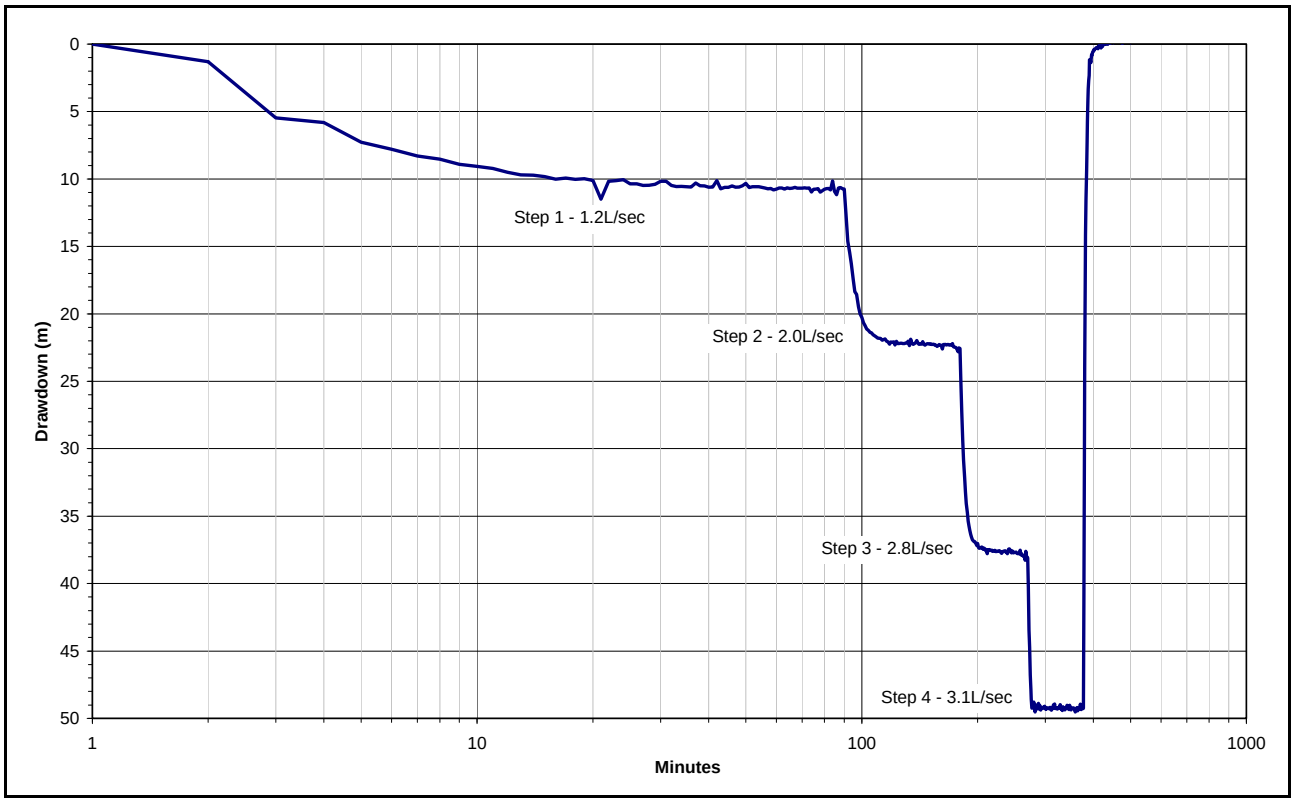


Figure D12: Step Rate Test for Test Pump Bore TPB4 (log-linear scale)

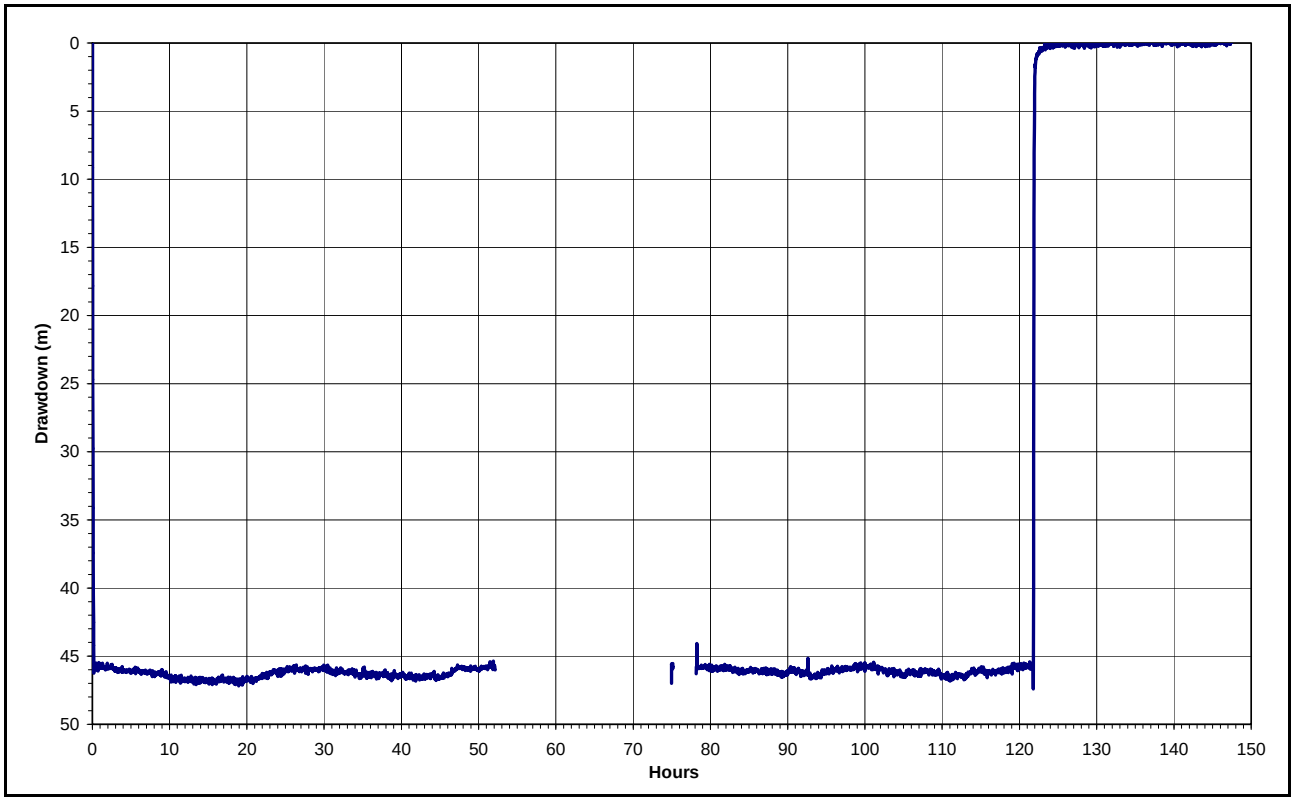


Figure D13: Constant Rate Test at 3L/sec for Test Pump Bore TPB4 (linear scale)

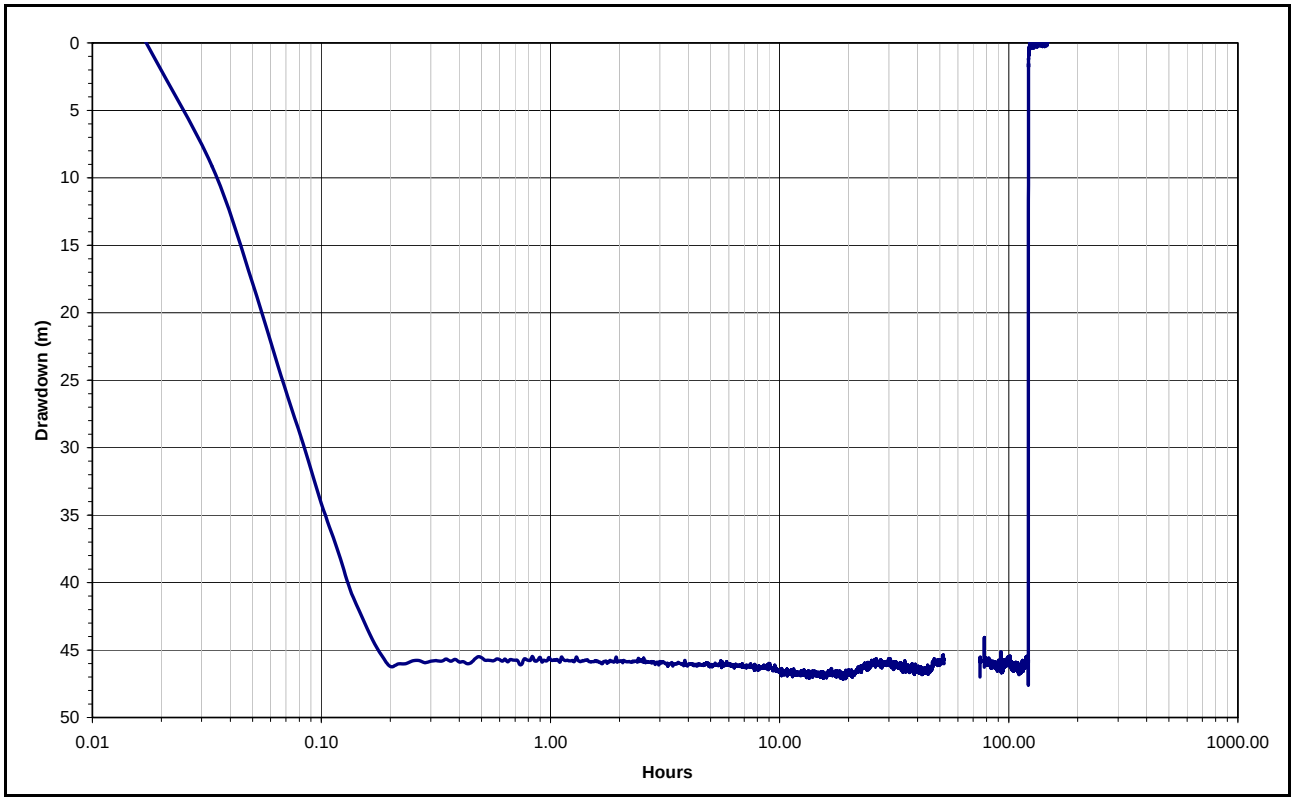


Figure D14: Constant Rate Test at 3L/sec for Test Pump Bore TPB4 (log-linear scale)

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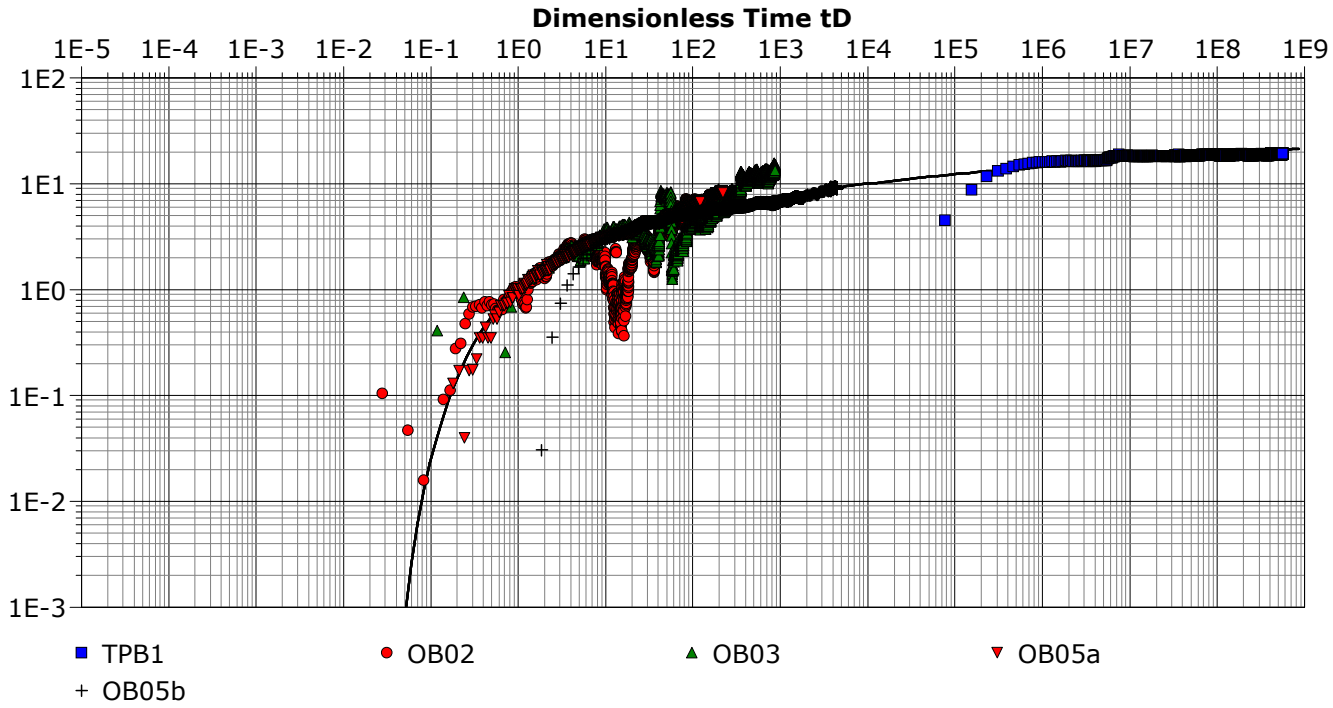
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB1 Pumping Test 1	Pumping Well: TPB1
Test Conducted by:		Test Date: 29/08/2011
Analysis Performed by: Henry McCarthy	Theis	Analysis Date: 10/10/2011
Aquifer Thickness: 41.00 m	Discharge Rate: 3.95 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
TPB1	1.82×10^{1}	4.44×10^{-1}		0.08	
OB02	7.42×10^{2}	1.81×10^{1}	8.05×10^{-4}	152.64	
OB03	1.59×10^{3}	3.88×10^{1}	9.36×10^{-2}	10.0	
OB05a	1.18×10^{3}	2.88×10^{1}	6.80×10^{-2}	20.0	
OB05b	8.59×10^{2}	2.10×10^{1}	2.44×10^{-3}	20.0	
Average	8.78×10^{2}	2.14×10^{1}	4.12×10^{-2}		

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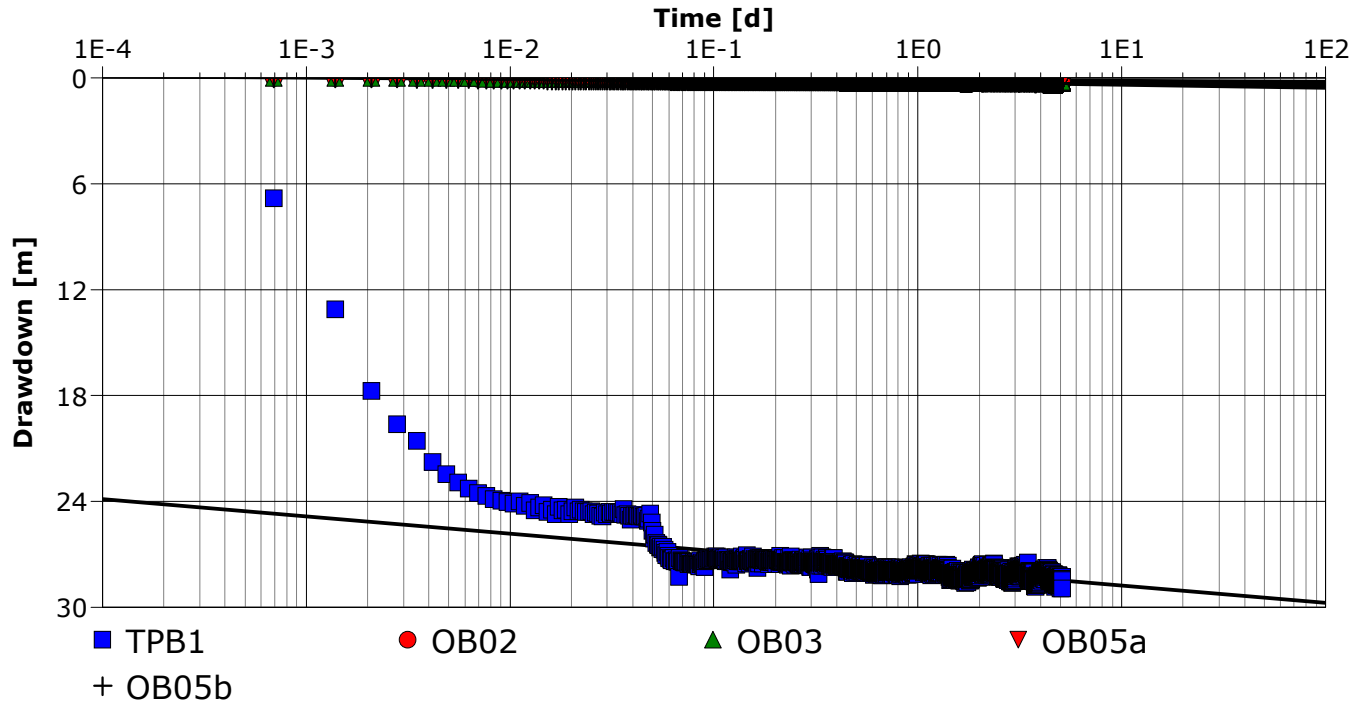
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB1 Pumping Test 1	Pumping Well: TPB1
Test Conducted by:		Test Date: 29/08/2011
Analysis Performed by:	Cooper & Jacob I	Analysis Date: 10/10/2011
Aquifer Thickness: 41.00 m	Discharge Rate: 3.95 [l/s]	



Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
TPB1	6.39×10^{1}	1.56×10^{0}		0.08	
OB02	7.29×10^{2}	1.78×10^{1}	6.35×10^{-4}	152.64	
OB03	3.56×10^{2}	8.68×10^{0}	5.00×10^{-1}	10.0	
OB05a	1.23×10^{3}	3.00×10^{1}	6.42×10^{-2}	20.0	
OB05b	7.79×10^{2}	1.90×10^{1}	6.89×10^{-3}	20.0	
Average	6.32×10^{2}	1.54×10^{1}	1.43×10^{-1}		

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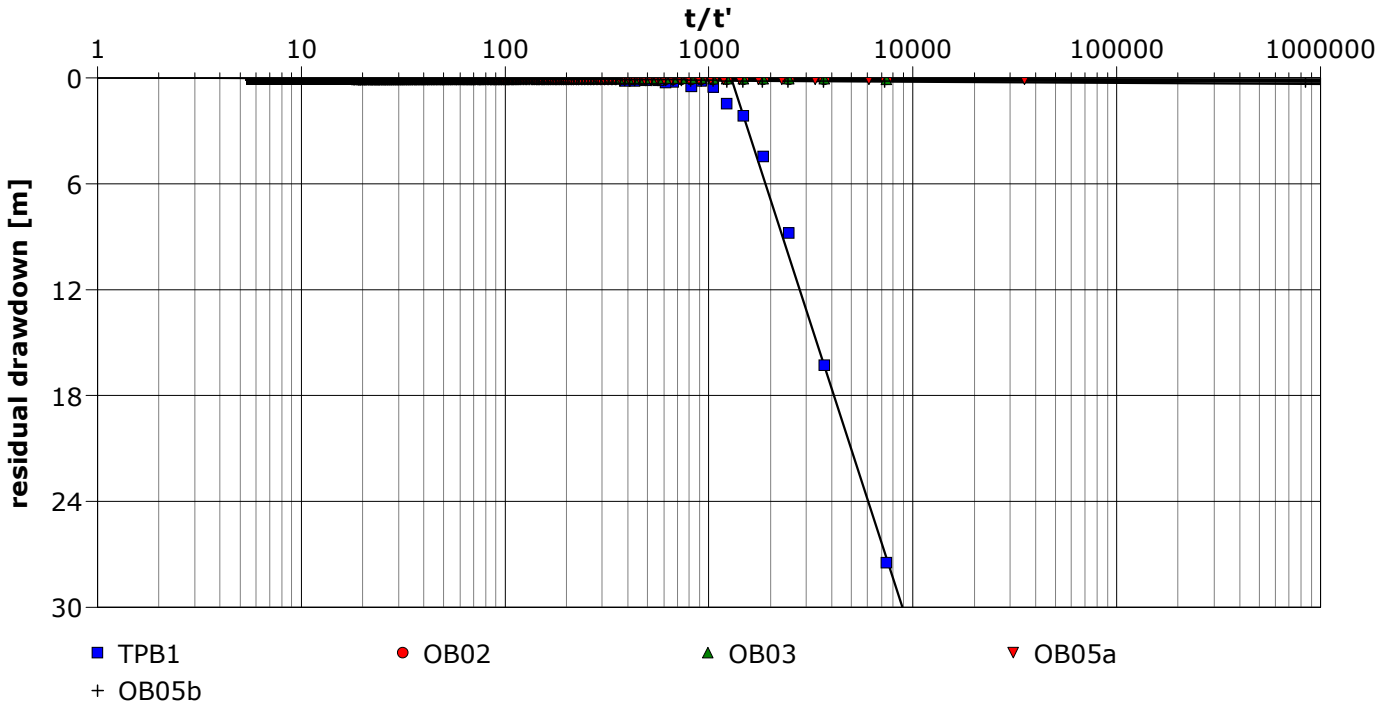
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1489a

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB1 Recovery	Pumping Well: TPB1
Test Conducted by:		Test Date: 10/10/2011
Analysis Performed by: Henry McCarthy	Theis Recovery	Analysis Date: 10/10/2011
Aquifer Thickness: 41.00 m	Discharge: variable, average rate 3.95 [l/s]	



Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
TPB1	1.75×10^{0}	4.27×10^{-2}	0.08	
OB02	9.54×10^{2}	2.33×10^{1}	152.64	
OB03	1.67×10^{3}	4.08×10^{1}	10.0	
OB05a	1.84×10^{3}	4.49×10^{1}	20.0	
OB05b	1.56×10^{3}	3.81×10^{1}	20.0	
Average	1.21×10^{3}	2.94×10^{1}		

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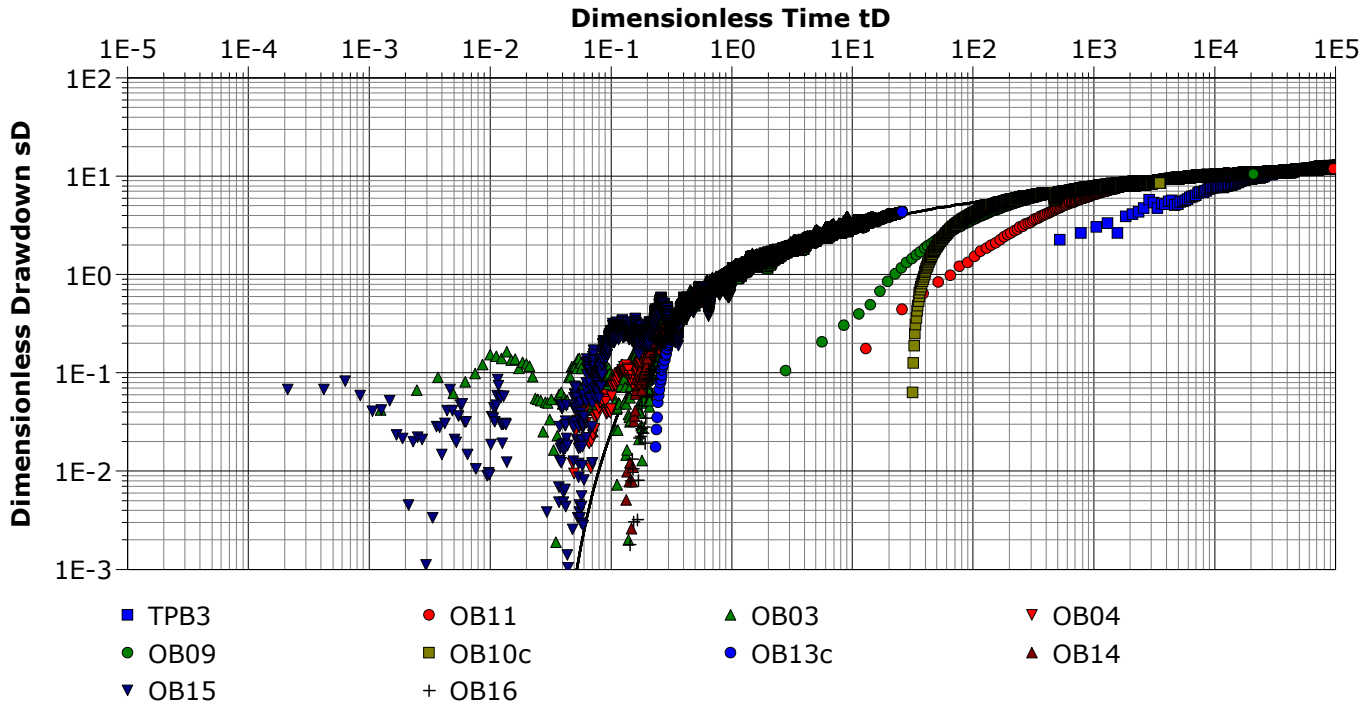
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1536

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB3 Pumping Test 2	Pumping Well: TPB3
Test Conducted by:		Test Date: 16/09/2011
Analysis Performed by: Henry McCarthy	TPB3 Theis	Analysis Date: 7/10/2011
Aquifer Thickness: 78.00 m	Discharge Rate: 31.21 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
TPB3	1.81×10^{2}	2.32×10^{0}		0.1	
OB11	1.93×10^{2}	2.47×10^{0}	5.68×10^{-7}	135.3	
OB03	1.76×10^{3}	2.25×10^{1}	1.01×10^{-3}	985.08	
OB04	1.62×10^{3}	2.08×10^{1}	2.16×10^{-3}	561.39	
OB09	2.17×10^{2}	2.78×10^{0}	8.06×10^{-7}	257.7	
OB10c	2.48×10^{2}	3.18×10^{0}	3.08×10^{-4}	34.54	
OB13c	6.27×10^{2}	8.04×10^{0}	1.06×10^{-3}	342.5	
OB14	7.22×10^{2}	9.25×10^{0}	1.11×10^{-3}	473.81	
OB15	1.39×10^{3}	1.78×10^{1}	1.01×10^{-2}	670.95	
OB16	6.13×10^{2}	7.86×10^{0}	8.12×10^{-4}	430.56	
Average	7.57×10^{2}	9.70×10^{0}	1.84×10^{-3}		

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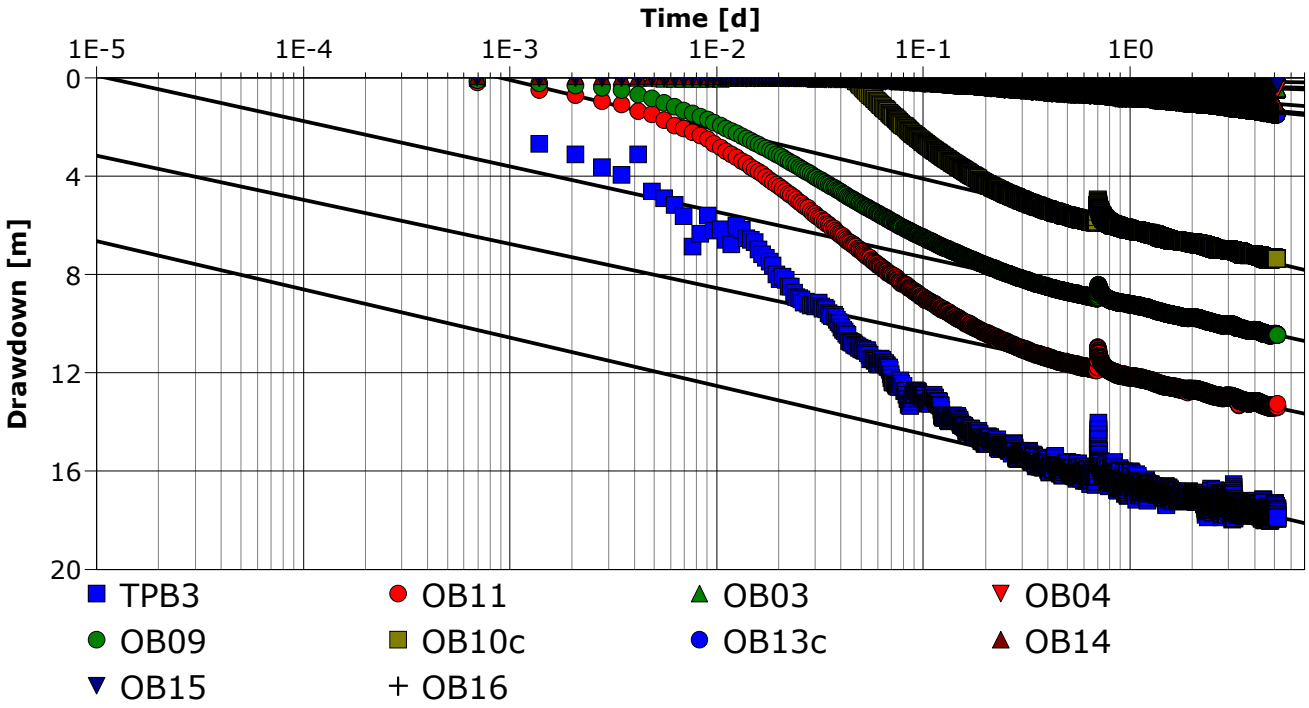
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1536

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB3 Pumping Test 2	Pumping Well: TPB3
Test Conducted by:		Test Date: 16/09/2011
Analysis Performed by: Henry McCarthy	Cooper & Jacob I	Analysis Date: 7/10/2011
Aquifer Thickness: 78.00 m	Discharge Rate: 31.21 [l/s]	



Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
TPB3	2.51×10^{2}	3.22×10^{0}		0.1	
OB11	2.75×10^{2}	3.53×10^{0}	5.73×10^{-9}	135.3	
OB03	2.11×10^{3}	2.71×10^{1}	6.38×10^{-4}	985.08	
OB04	1.84×10^{3}	2.36×10^{1}	1.72×10^{-3}	561.39	
OB09	2.67×10^{2}	3.42×10^{0}	1.00×10^{-7}	257.7	
OB10c	2.46×10^{2}	3.15×10^{0}	4.17×10^{-4}	34.54	
OB13c	6.28×10^{2}	8.05×10^{0}	1.01×10^{-3}	342.5	
OB14	7.58×10^{2}	9.72×10^{0}	9.88×10^{-4}	473.81	
OB15	3.82×10^{3}	4.90×10^{1}	4.75×10^{-3}	670.95	
OB16	6.58×10^{2}	8.44×10^{0}	6.89×10^{-4}	430.56	
Average	1.09×10^{3}	1.39×10^{1}	1.13×10^{-3}		

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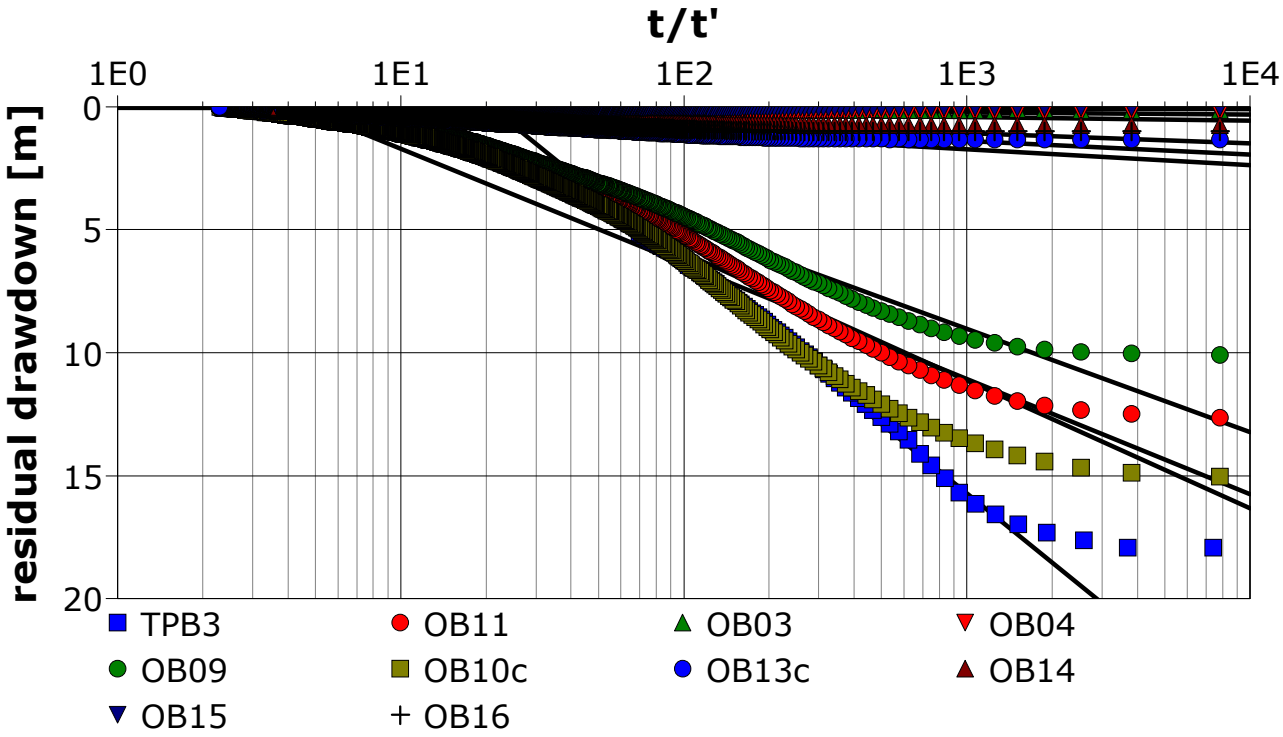
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1536

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB3_Recovery	Pumping Well: TPB3
Test Conducted by:		Test Date: 7/10/2011
Analysis Performed by: Henry McCarthy	Theis Recovery	Analysis Date: 7/10/2011
Aquifer Thickness: 78.00 m	Discharge: variable, average rate 31.21 [l/s]	



Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
TPB3	5.28×10^{1}	6.77×10^{-1}	0.1	
OB11	9.49×10^{1}	1.22×10^{0}	135.3	
OB03	5.62×10^{3}	7.20×10^{1}	985.08	
OB04	3.44×10^{3}	4.41×10^{1}	561.39	
OB09	1.17×10^{2}	1.51×10^{0}	257.7	
OB10c	1.05×10^{2}	1.35×10^{0}	34.54	
OB13c	7.65×10^{2}	9.81×10^{0}	342.5	
OB14	1.18×10^{3}	1.52×10^{1}	473.81	
OB15	2.94×10^{4}	3.77×10^{2}	670.95	
OB16	8.88×10^{2}	1.14×10^{1}	430.56	
Average	4.17×10^{3}	5.35×10^{1}		

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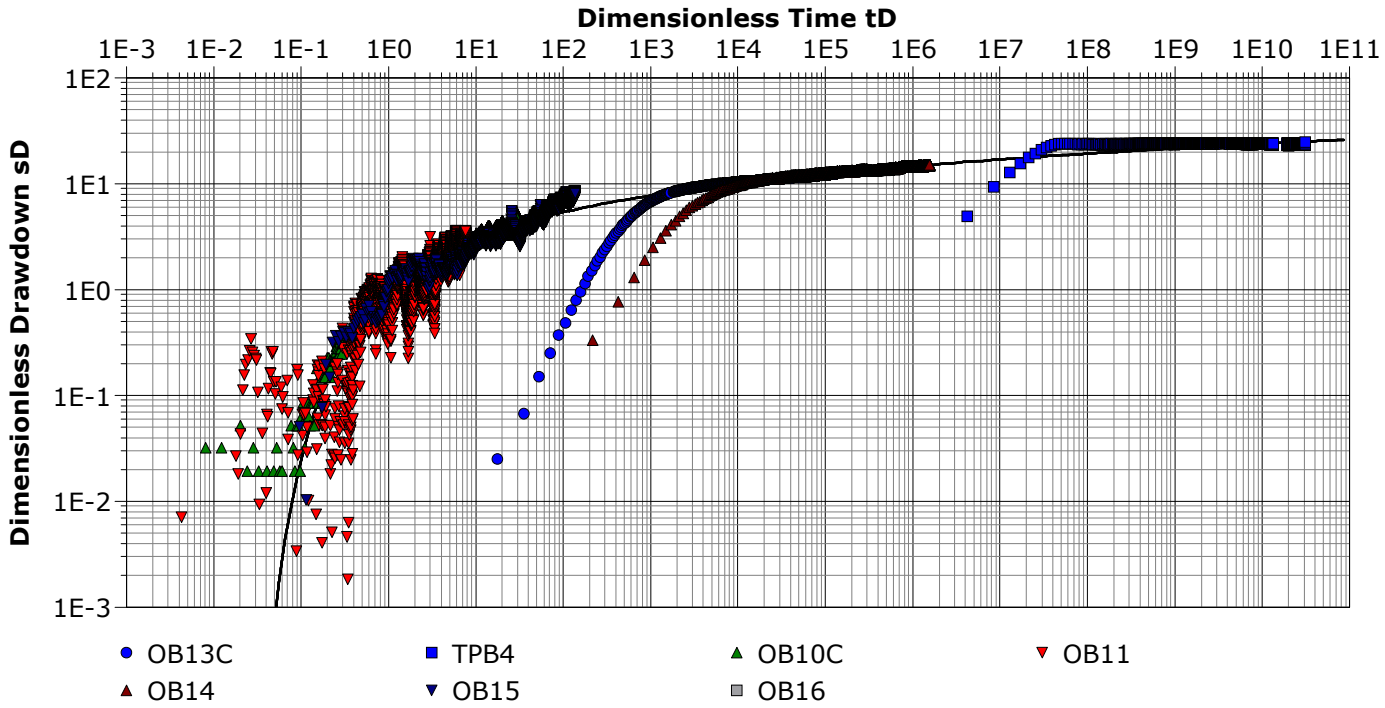
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1489A

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB4 Pumping Test 3	Pumping Well: TPB4
Test Conducted by:		Test Date: 6/09/2011
Analysis Performed by: Henry McCarthy	Theis	Analysis Date: 10/10/2011
Aquifer Thickness: 66.00 m	Discharge Rate: 2.95 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
OB13C	1.69×10^{2}	2.56×10^{0}	136.97	
TPB4	1.04×10^{1}	1.58×10^{-1}	0.1	
OB10C	7.47×10^{2}	1.13×10^{1}	501.22	
OB11	3.93×10^{2}	5.95×10^{0}	359.55	
OB14	1.15×10^{2}	1.74×10^{0}	21.63	
OB15	5.58×10^{2}	8.45×10^{0}	203.07	
OB16	9.02×10^{-8}	1.37×10^{-9}	184.7	
Average	2.85×10^{2}	4.31×10^{0}		

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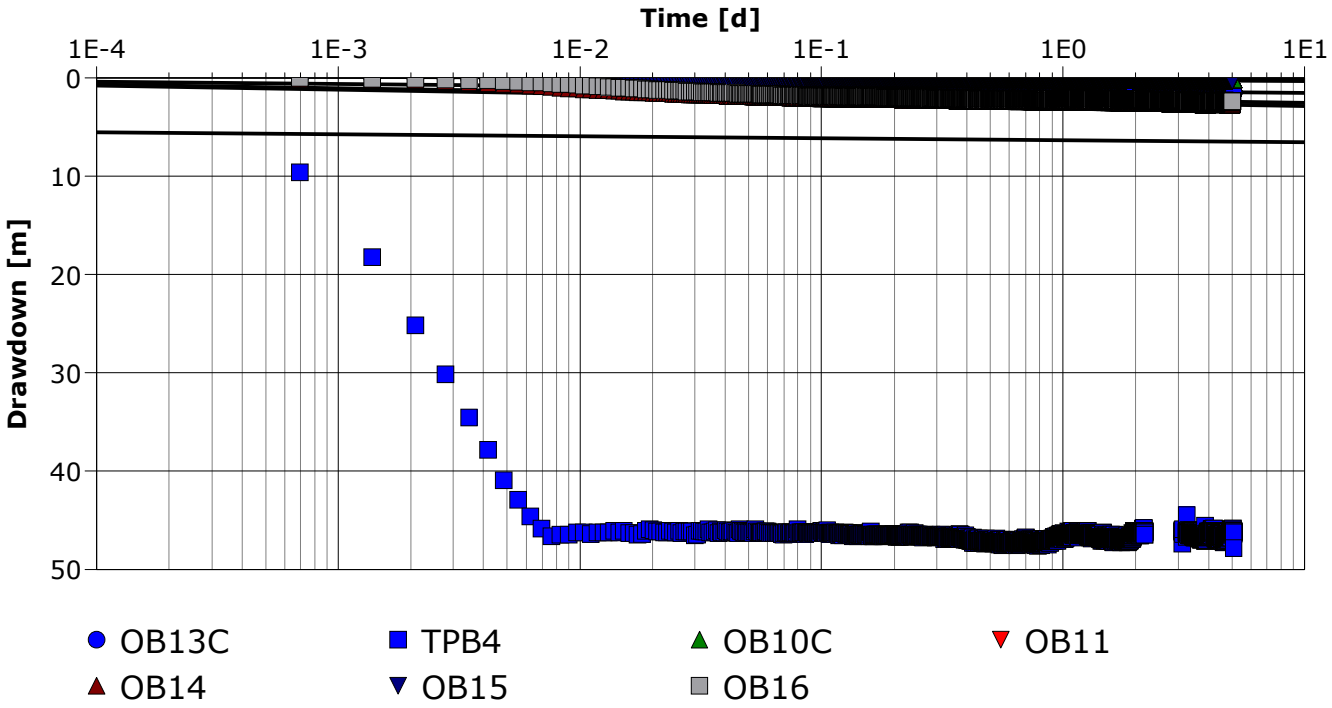
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1489A

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB4 Pumping Test 3	Pumping Well: TPB4
Test Conducted by:		Test Date: 6/09/2011
Analysis Performed by:	Cooper & Jacob I	Analysis Date: 12/10/2011
Aquifer Thickness: 66.00 m	Discharge Rate: 2.95 [l/s]	



Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
OB13C	2.03×10^{2}	3.08×10^{0}	3.87×10^{-8}	136.97	
TPB4	2.49×10^{2}	3.78×10^{0}		0.1	
OB10C	8.34×10^{2}	1.26×10^{1}	3.29×10^{-4}	501.22	
OB11	4.90×10^{2}	7.42×10^{0}	1.77×10^{-3}	359.55	
OB14	1.15×10^{2}	1.74×10^{0}	6.56×10^{-7}	21.63	
OB15	3.23×10^{2}	4.89×10^{0}	1.48×10^{-3}	203.07	
OB16	1.24×10^{2}	1.88×10^{0}	1.20×10^{-8}	184.7	
Average	3.34×10^{2}	5.06×10^{0}	5.97×10^{-4}		

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Bowen Hills
Brisbane 4006

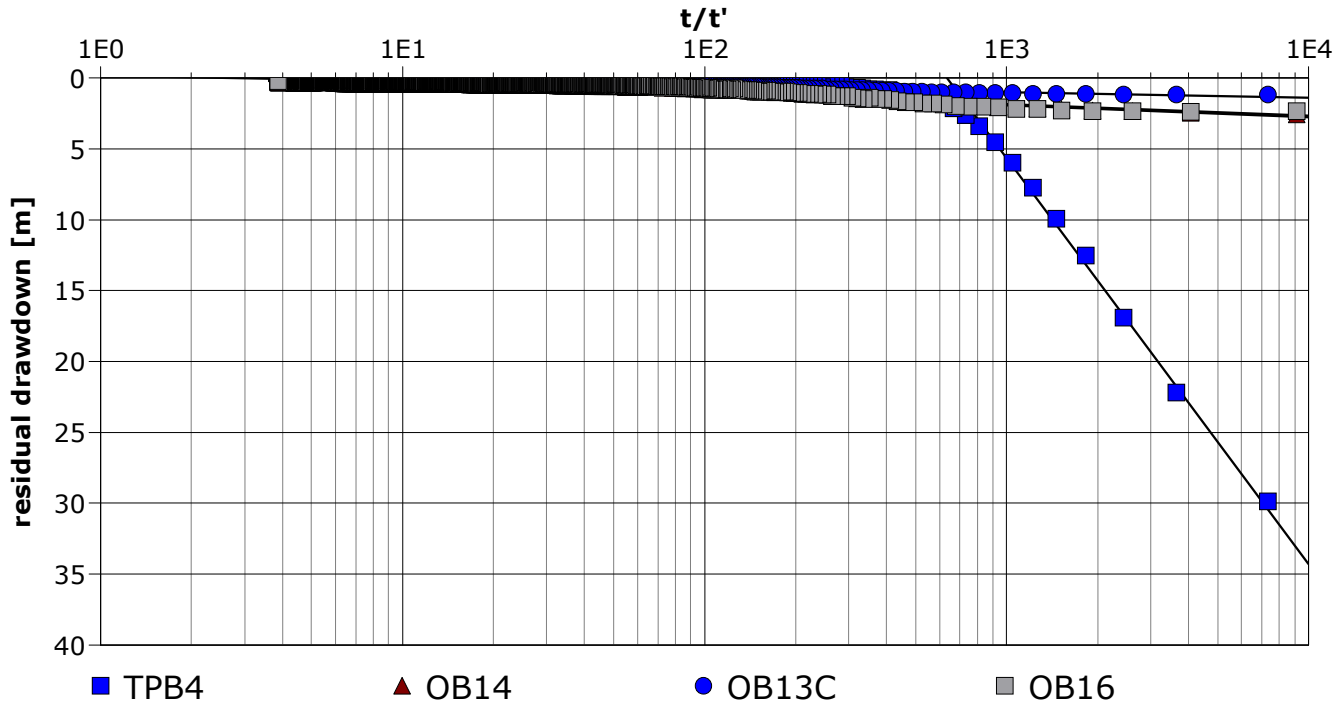
Pumping Test Analysis Report

Project: Sorby Hills

Number: G1489A

Client: Sorby Management Pty Ltd

Location:	Pumping Test: TPB4 Recovery	Pumping Well: TPB4
Test Conducted by:		Test Date: 12/10/2011
Analysis Performed by: Henry McCarthy	TPB4 Recovery	Analysis Date: 28/10/2011
Aquifer Thickness: 66.00 m	Discharge: variable, average rate 2.95 [l/s]	



Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
TPB4	1.63×10^{0}	2.47×10^{-2}	0.1	
OB14	5.58×10^{1}	8.45×10^{-1}	21.63	
OB13C	1.19×10^{2}	1.80×10^{0}	136.97	
OB16	5.71×10^{1}	8.65×10^{-1}	184.7	
Average	5.83×10^{1}	8.83×10^{-1}		

APPENDIX E

Observation Bore Hydrographs

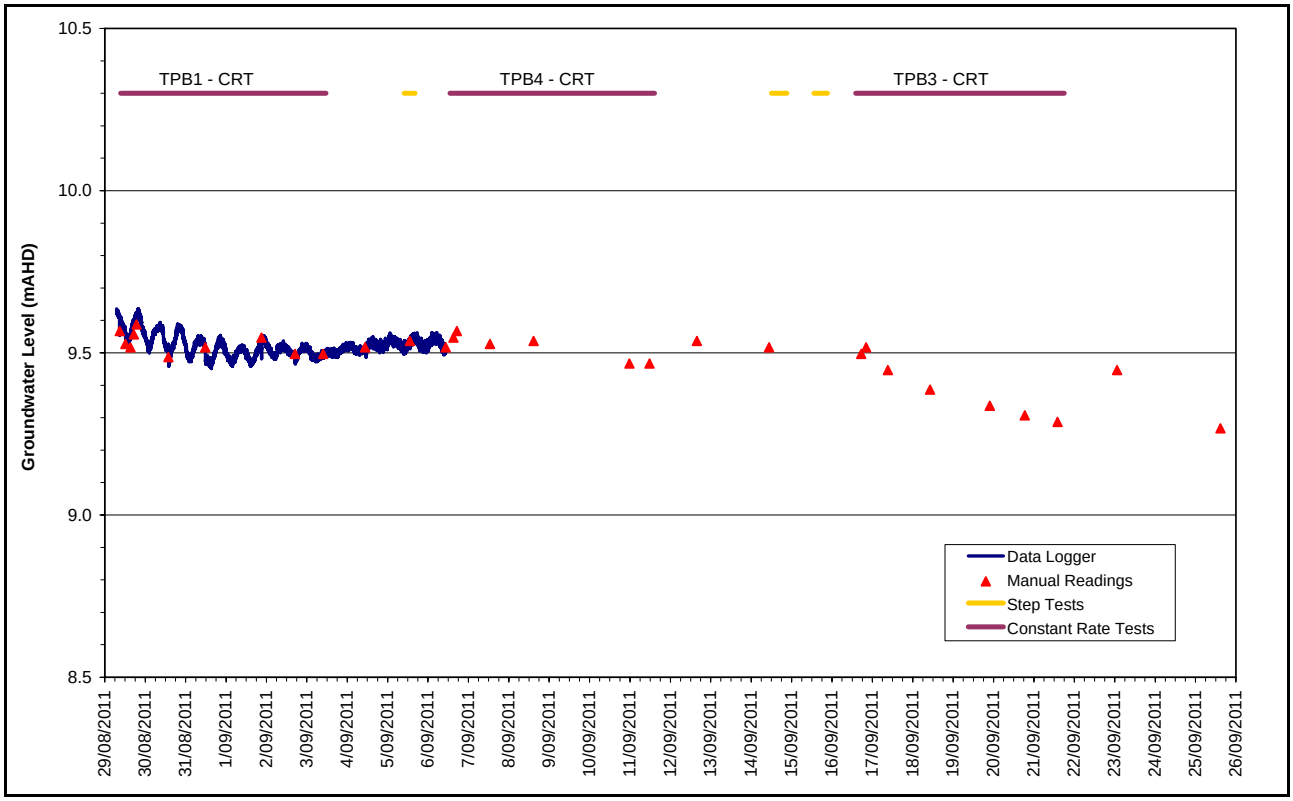


Figure E1: Hydrograph for Observation Bore OB1

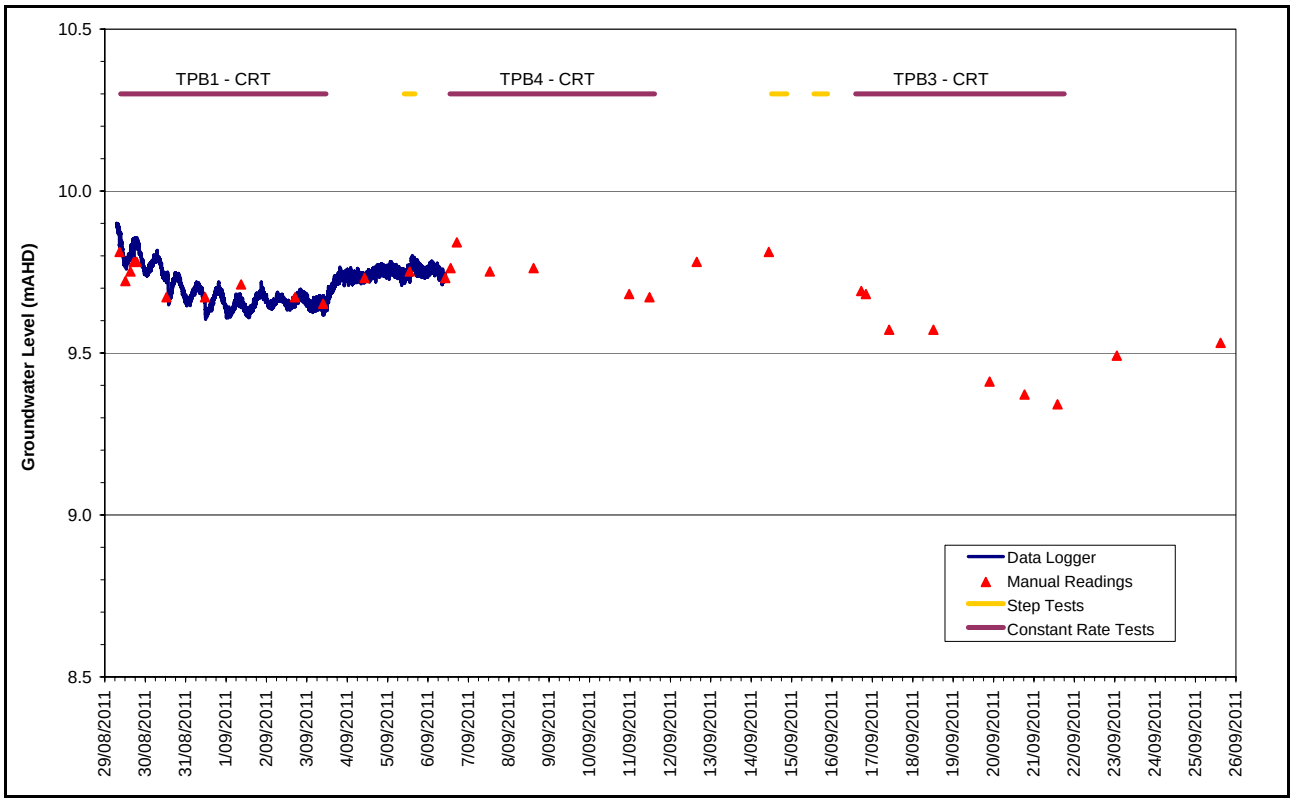


Figure E2: Hydrograph for Observation Bore OB2

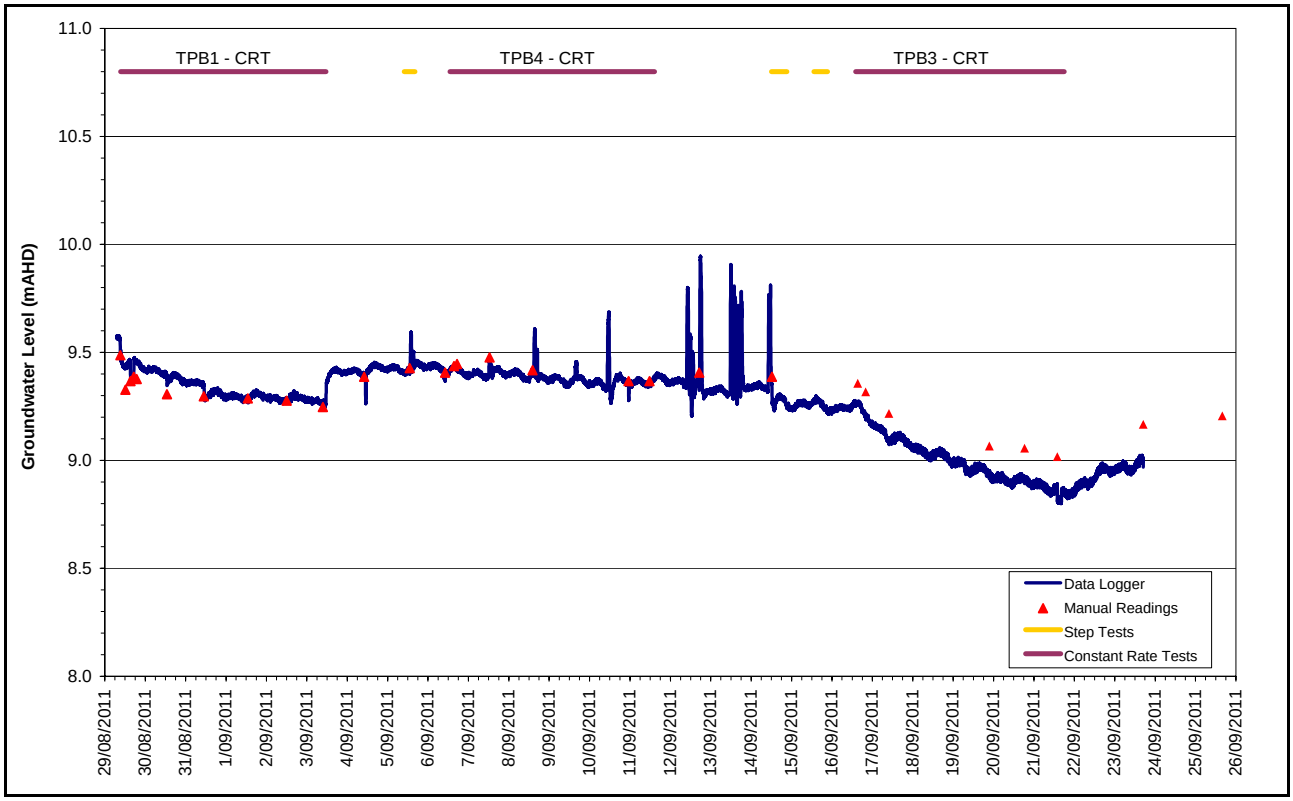


Figure E3: Hydrograph for Observation Bore OB3

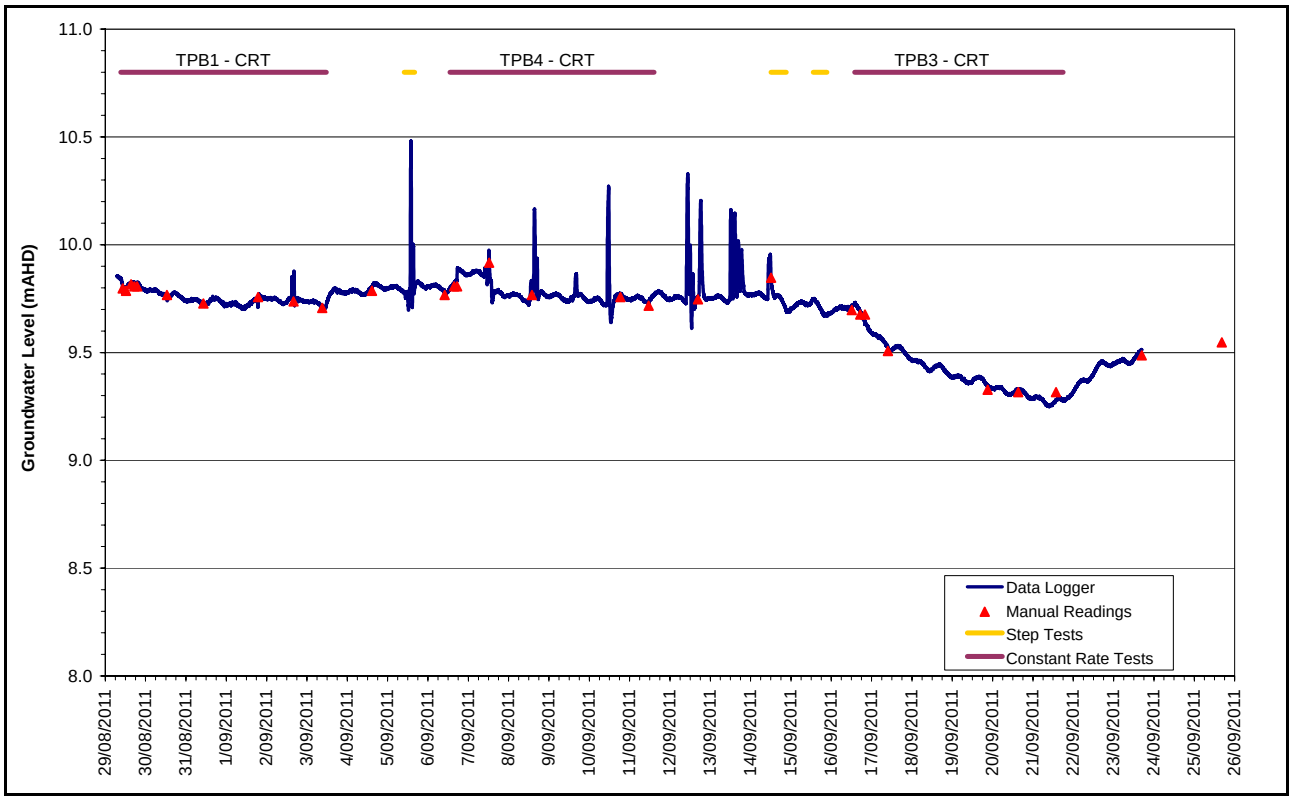


Figure E4: Hydrograph for Observation Bore OB4

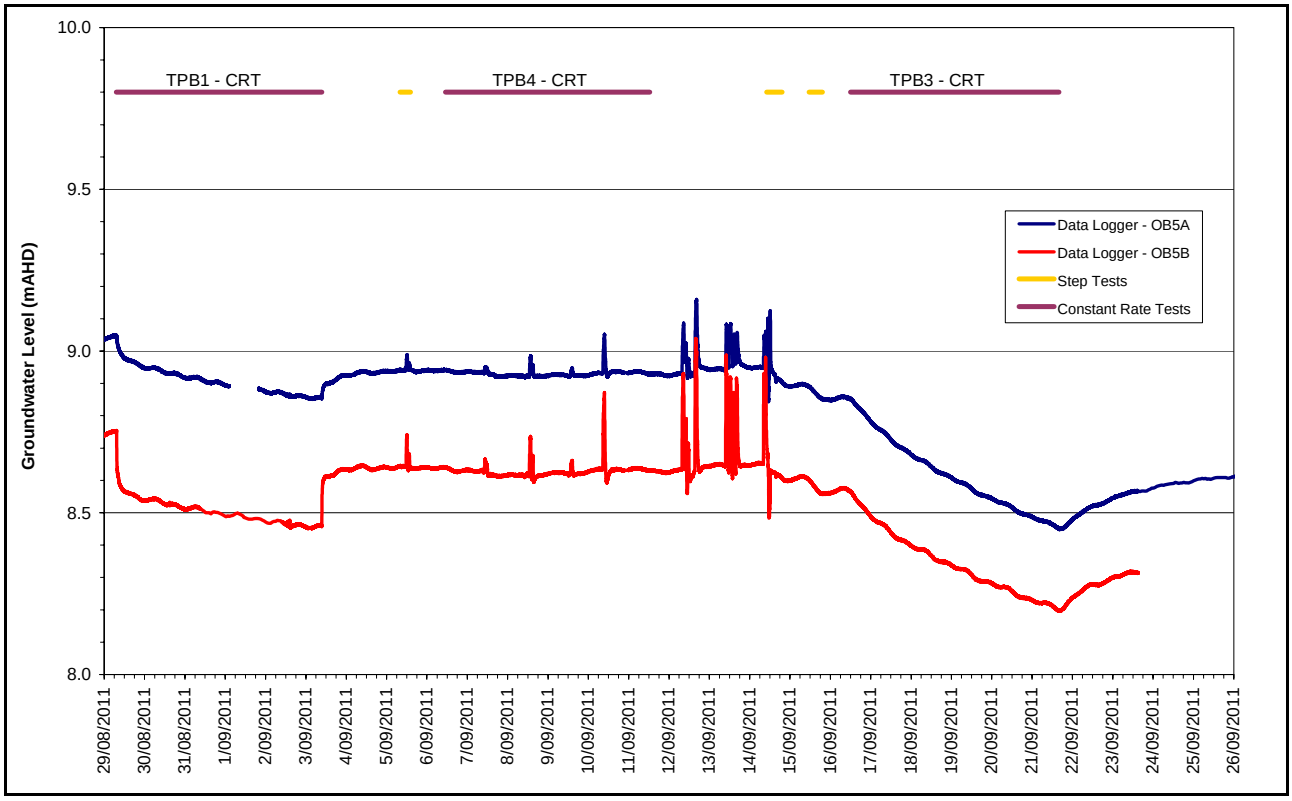


Figure E5: Hydrograph for Observation Bores OB5A and OB5B

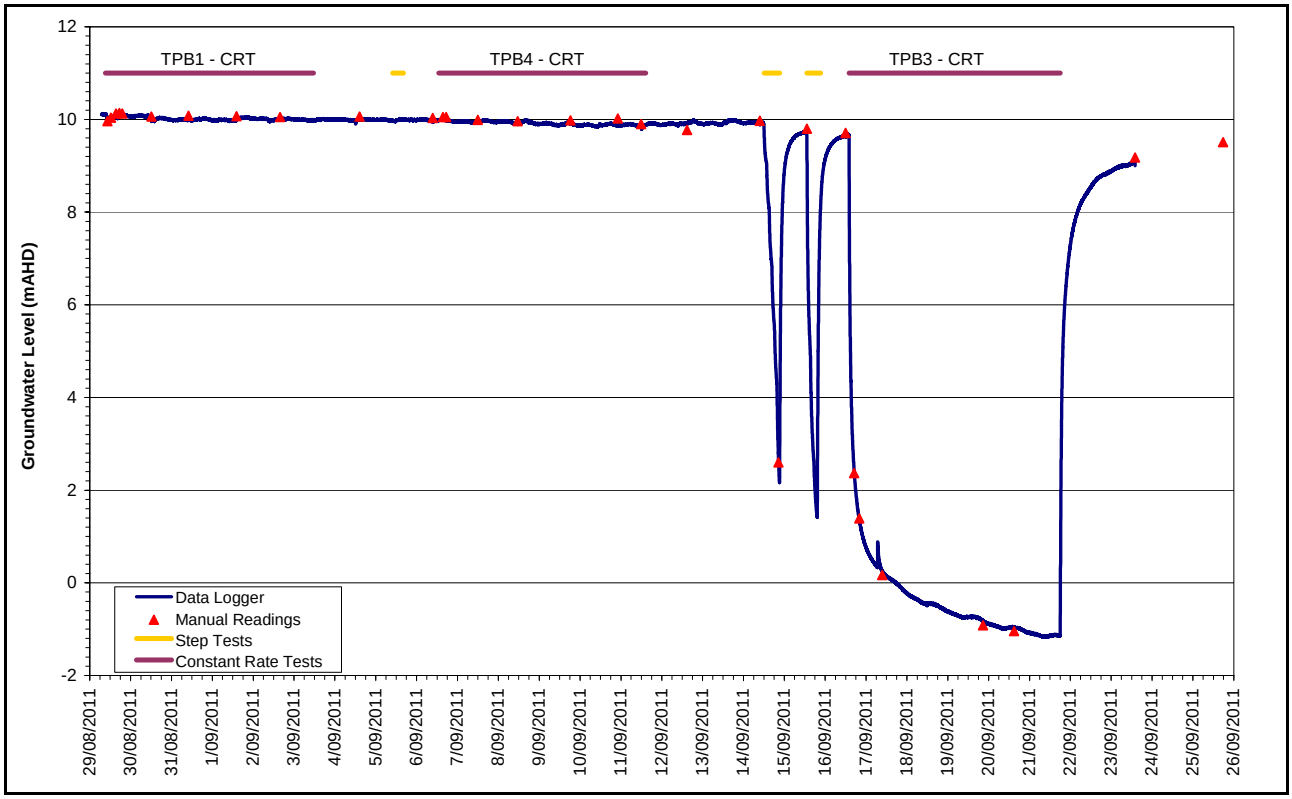


Figure E6: Hydrograph for Observation Bore OB9

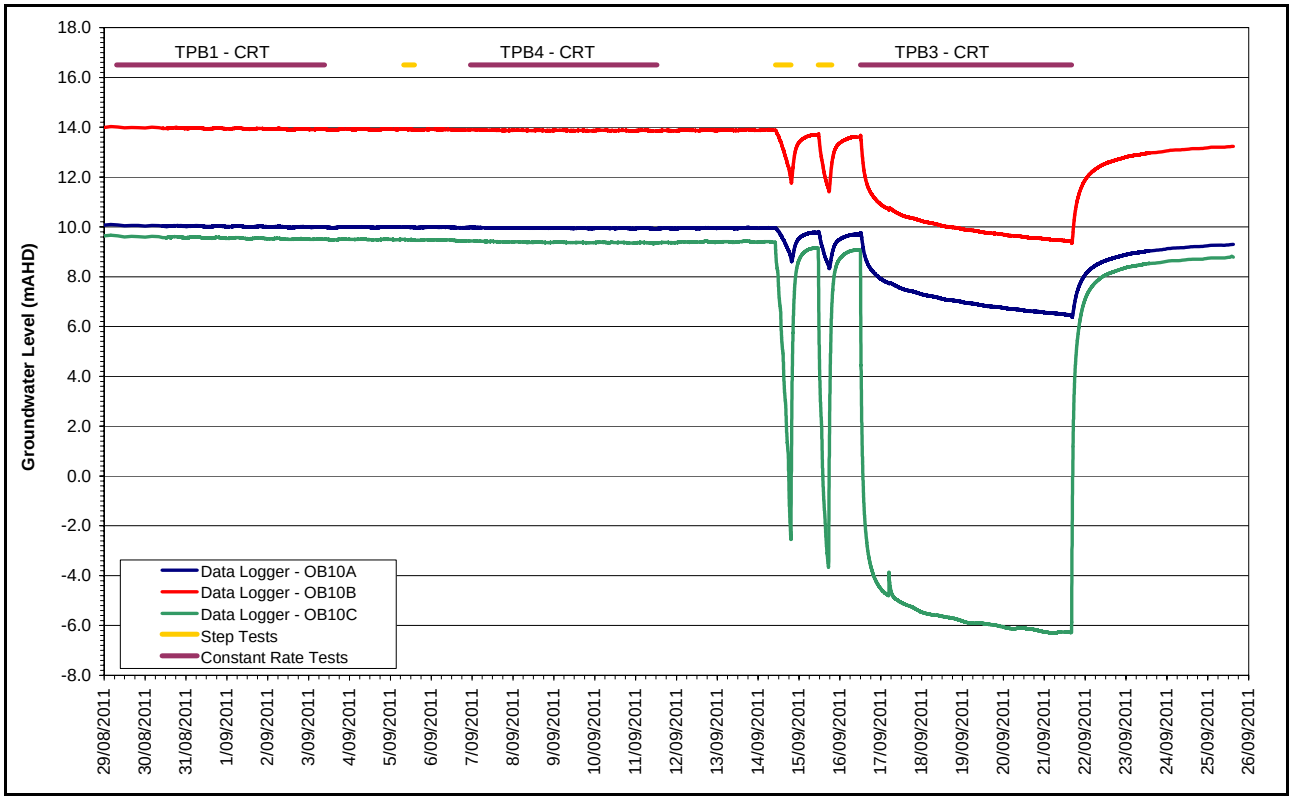


Figure E7: Hydrograph for Observation Bores OB10A, OB10C and OB10D

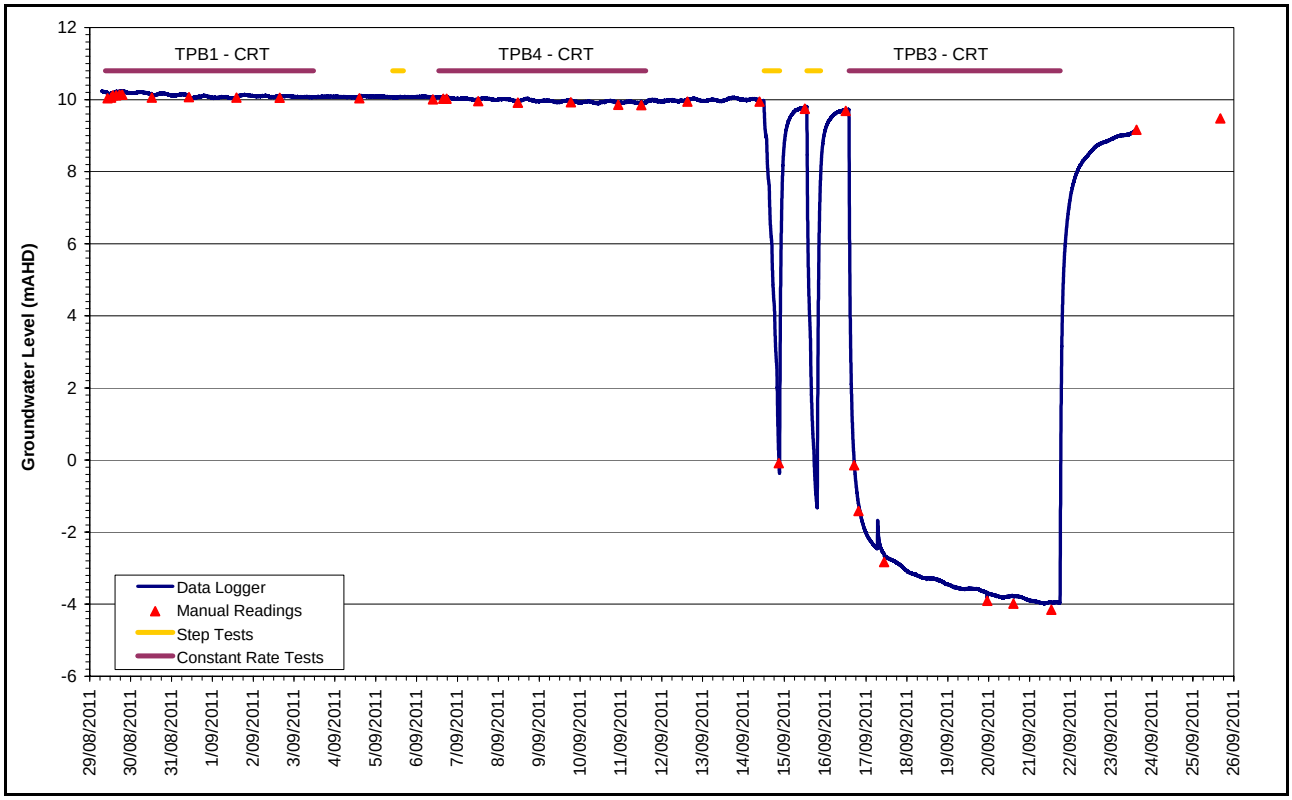


Figure E8: Hydrograph for Observation Bore OB11

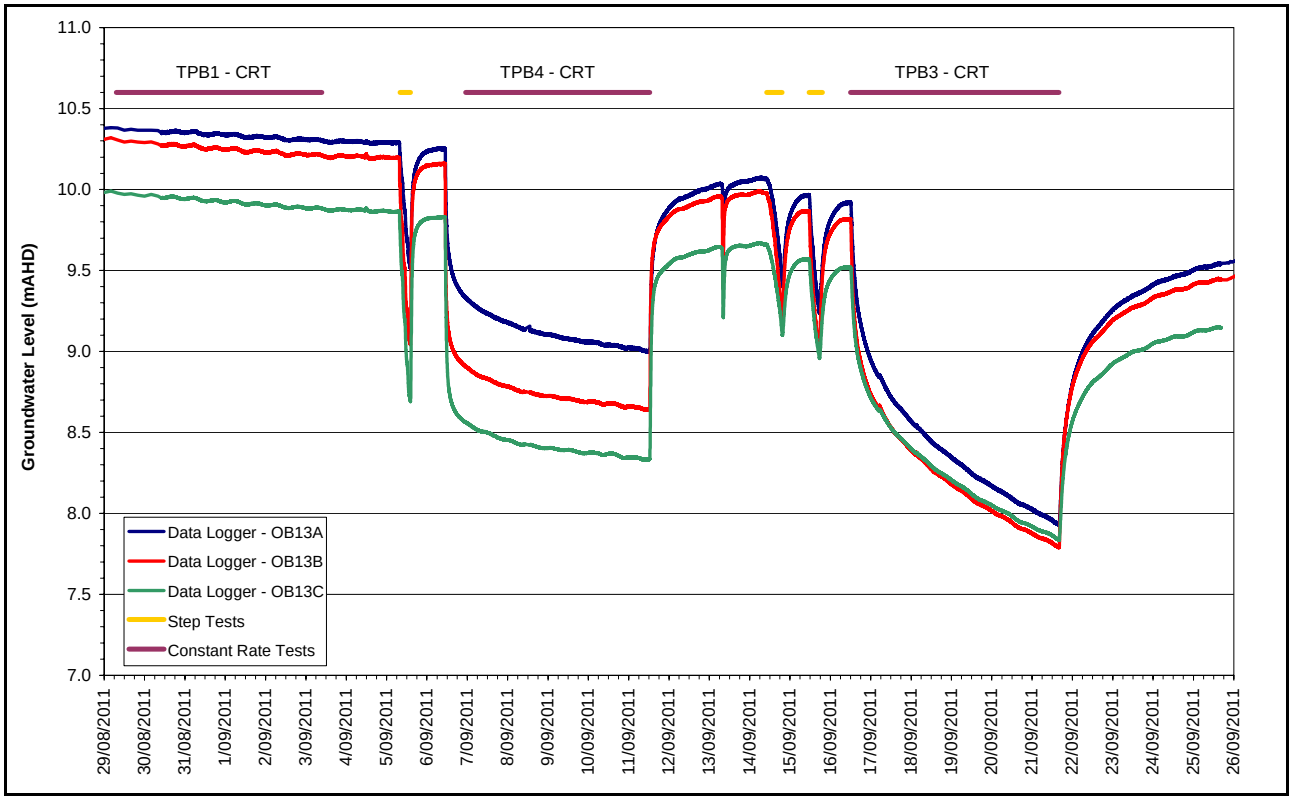


Figure E9: Hydrograph for Observation Bores OB13A, OB13B and OB13C

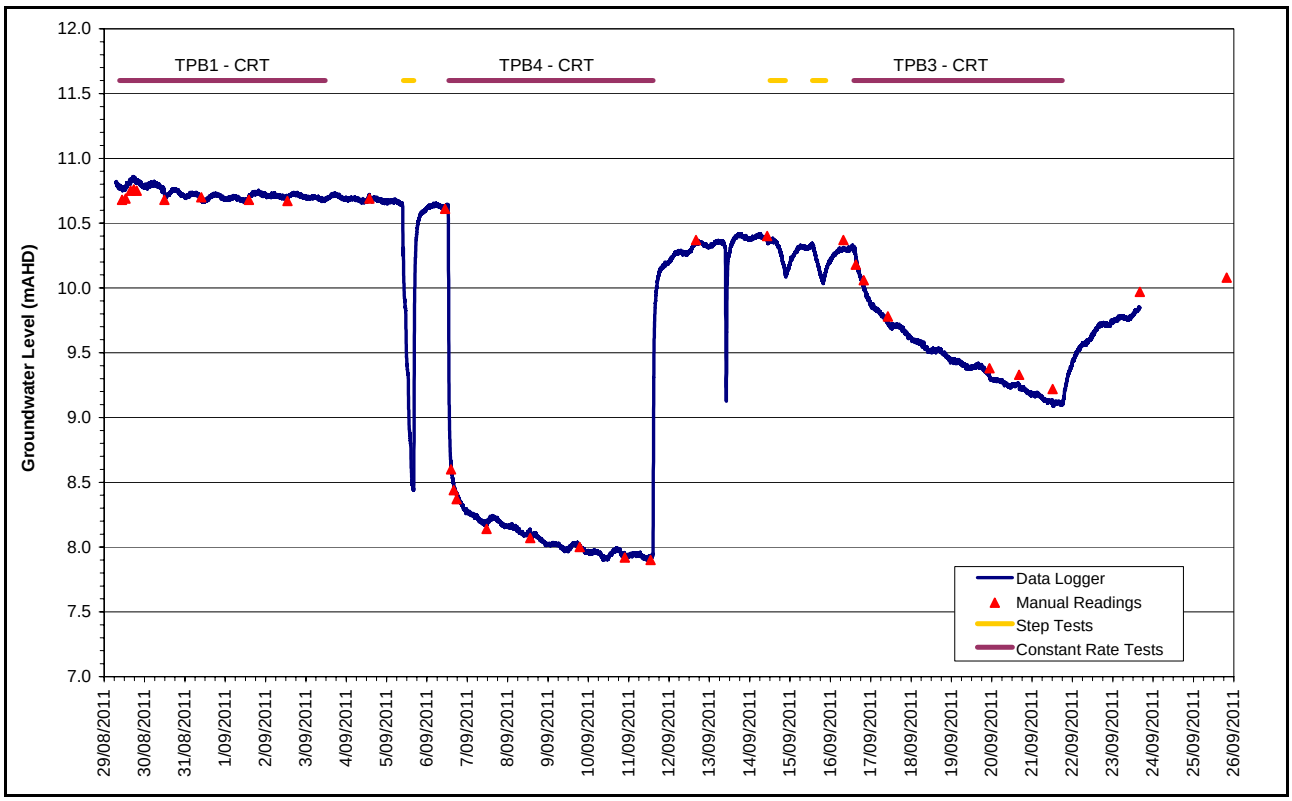


Figure E10: Hydrograph for Observation Bore OB14

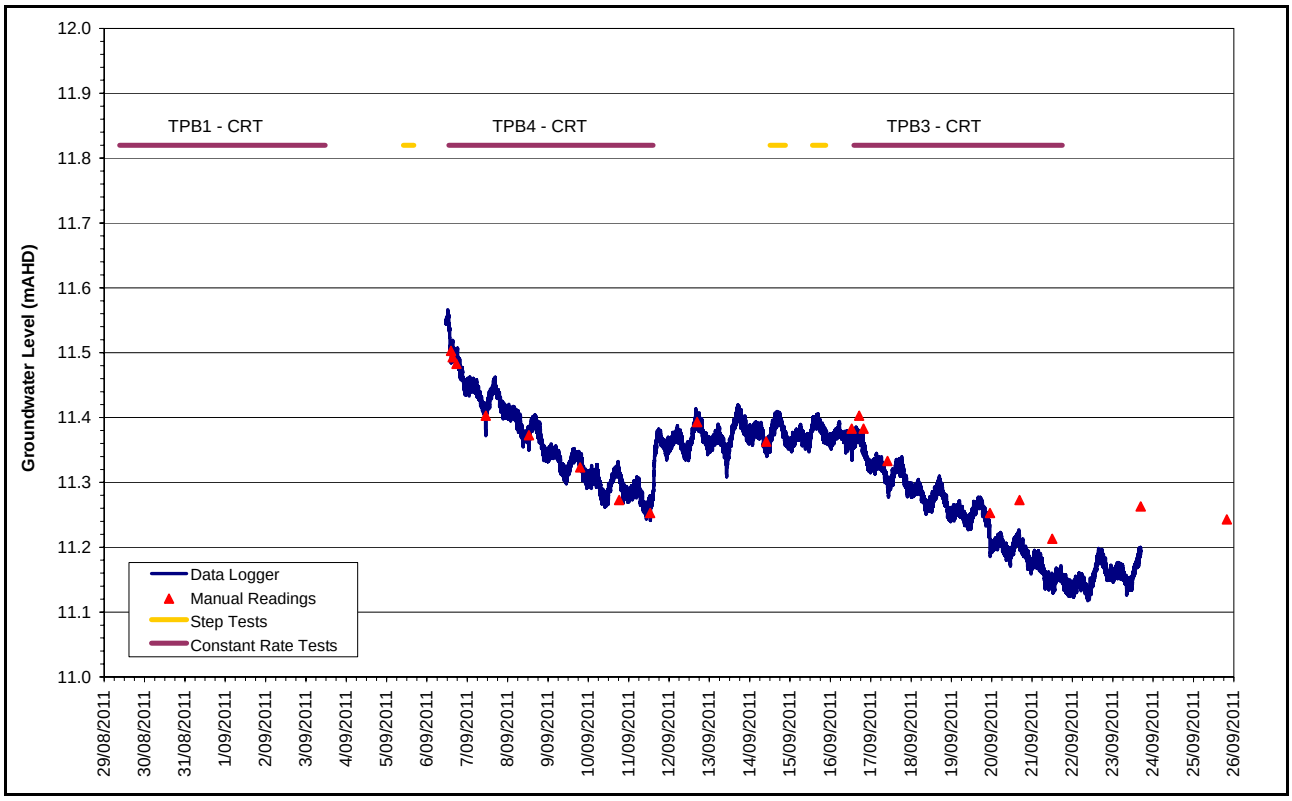


Figure E11: Hydrograph for Observation Bore OB15

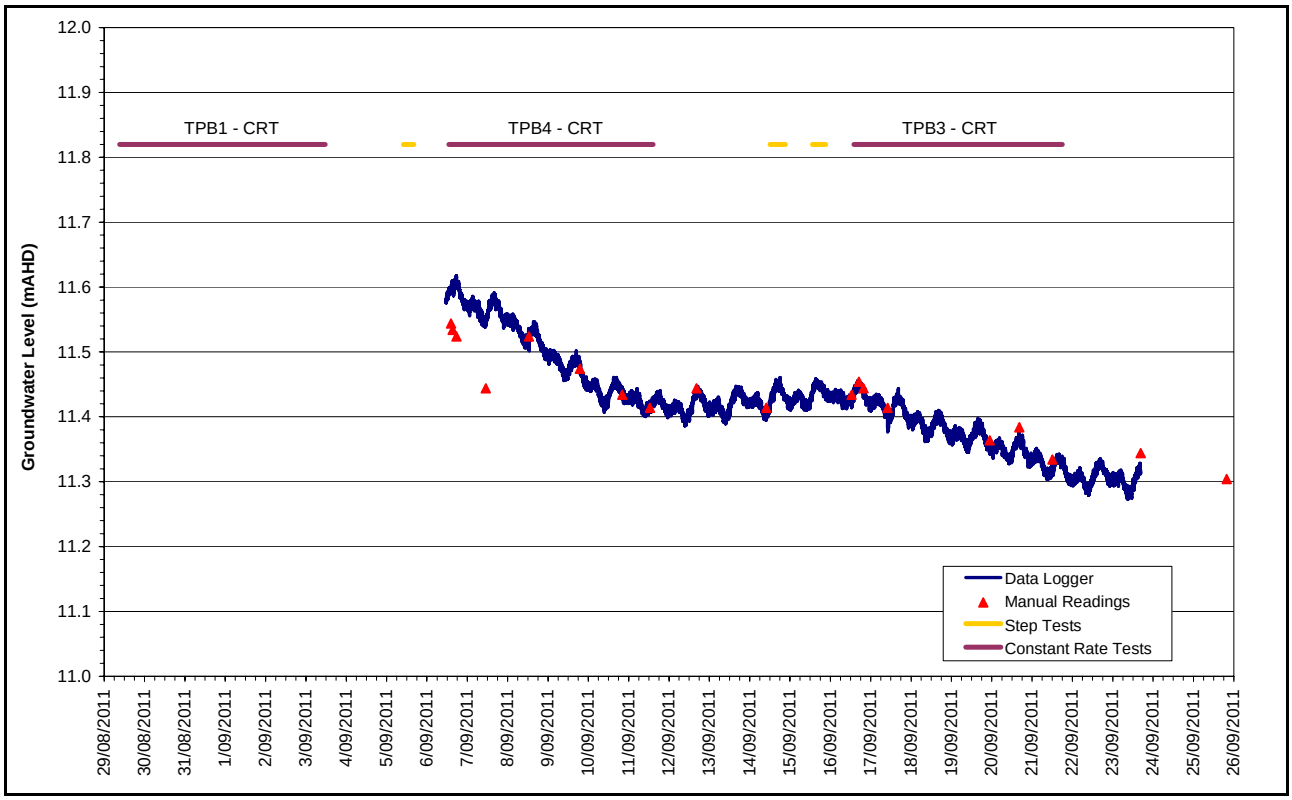


Figure E12: Hydrograph for Observation Bore OB15A

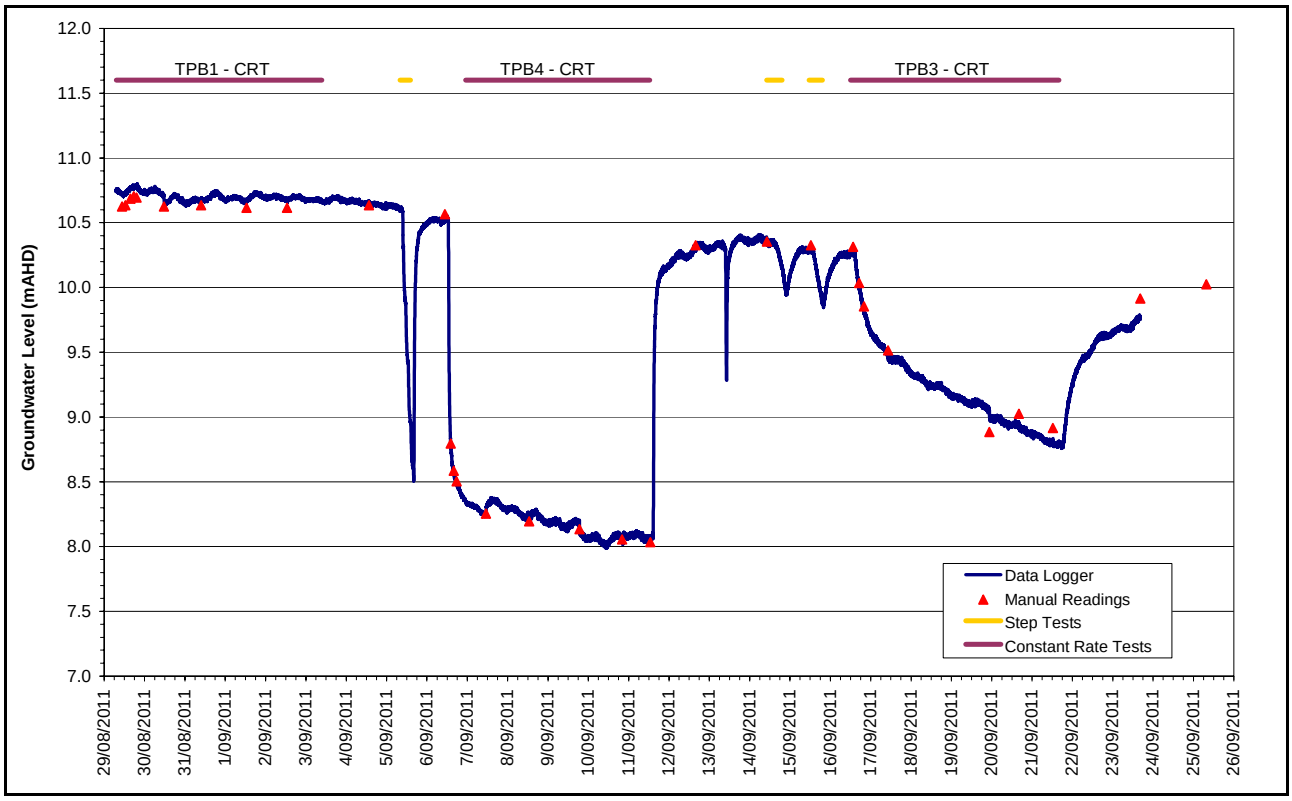


Figure E13: Hydrograph for Observation Bore OB16

APPENDIX F

Laboratory Analysis Certificates

ACCREDITED FOR TECHNICAL COMPETENCE
Accreditation No. 8

ChemCentre
Environmental Chemistry Section
Report of Examination

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Sorby Management Pty Ltd
PO Box 2660
Kununurra WA 6743

Attention: Lubor Hon

Report on: 8 samples received on 19/08/2011

LAB ID	Material	Client ID and Description
11E0323 / 001	water	OB1
11E0323 / 002	water	OB2
11E0323 / 003	water	OB3
11E0323 / 004	water	OB4
11E0323 / 005	water	OB9
11E0323 / 006	water	OB14
11E0323 / 007	water	OB15
11E0323 / 008	water	OB15a

LAB ID			001	002	003	004
Client ID			OB1	OB2	OB3	OB4
Sampled			17/08/2011	17/08/2011	17/08/2011	17/08/2011
Analyte	Method	Unit				
Alkalinity, total	iALK1WATI	mg/L	293	315	360	383
Aluminium	iMET1WCICP	mg/L	0.021	0.087	0.010	0.028
Arsenic	iMET1WCMS	mg/L	0.007	0.007	0.002	<0.001
Barium	iMET1WCICP	mg/L	0.069	0.035	0.017	0.040
Bicarbonate	iALK1WATI	mg/L	357	384	439	467
Boron	iMET1WCICP	mg/L	0.04	0.05	0.04	0.04
Cadmium	iMET1WCMS	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Calcium	iMET1WCICP	mg/L	167	17.4	8.5	46.5
Carbonate	iALK1WATI	mg/L	<1	<1	<1	<1
Chloride	iCO1WCDA	mg/L	361	146	34	351
Chromium	iMET1WCICP	mg/L	<0.001	<0.001	<0.001	<0.001
Cobalt	iMET1WCICP	mg/L	<0.005	<0.005	<0.005	<0.005
Copper	iMET1WCICP	mg/L	<0.002	<0.002	<0.002	<0.002
Electrical Conductivity	iEC1WZSE	mS/m	258	153	86.6	213
Hardness, total	iHTOT2WACA	mg/L	860	260	230	560
Iron	iMET1WCICP	mg/L	0.11	0.91	0.016	0.028
Lead	iMET1WCMS	mg/L	0.0035	0.021	0.052	0.0088
Magnesium	iMET1WCICP	mg/L	107	51.8	51.0	109
Manganese	iMET1WCICP	mg/L	0.34	0.12	0.063	0.006
Mercury	iMET1WCMS	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	iMET1WCMS	mg/L	0.002	0.010	<0.001	<0.001
Nickel	iMET1WCMS	mg/L	0.002	<0.001	<0.001	<0.001
Nitrate	iNTA1WFIA	mg/L	<0.05	<0.05	<0.05	0.13
Nitrite	iNTR1WFIA	mg/L	<0.1	<0.1	<0.1	<0.1
Nitrogen, total	iNP1WTFIA	mg/L	0.18	0.15	0.02	0.03

LAB ID			001	002	003	004
Client ID			OB1	OB2	OB3	OB4
Sampled			17/08/2011	17/08/2011	17/08/2011	17/08/2011
Analyte	**Method**	**Unit**				
pH	iPH1WASE		7.4	7.9	7.6	7.5
Phosphorus, total	iPP1WTFIA	mg/L	0.03	0.02	0.02	0.01
Potassium	iMET1WCICP	mg/L	15.0	10.9	6.5	3.1
Selenium	iMET1WCMS	mg/L	<0.001	<0.001	<0.001	<0.001
Silver	iMET1WCMS	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	iMET1WCICP	mg/L	311	237	41.7	167
Sulphate	iCO1WCDA	mg/L	540	290	44	270
Total suspended solids	iSOL1WPGR	mg/L	380	1400	140	130
Thallium	iMET1WCMS	mg/L	<0.0001	0.0001	0.0002	0.0003
Total dissolved solids (calc)	iSOL1WDCA	mg/L	1400	840	480	1200
Vanadium	iMET1WCICP	mg/L	0.010	0.010	<0.005	<0.005
Zinc	iMET1WCICP	mg/L	<0.005	0.005	0.006	0.007
Benzene*	eBTEX	ug/L	<1.0	<1.0	<1.0	<1.0
Toluene*	eBTEX	ug/L	<1.0	<1.0	<1.0	<1.0
Ethylbenzene*	eBTEX	ug/L	<1.0	<1.0	<1.0	<1.0
Xylene*	eBTEX	ug/L	<2.0	<2.0	<2.0	<2.0
Total BTEX*	eBTEX	ug/L	<5.0	<5.0	<5.0	<5.0
TPH C6-C9*	eTPH	ug/L	<25	<25	<25	<25
TPH C10-C14*	eTPH	ug/L	<25	<25	<25	<25
TPH C15-C28*	eTPH	ug/L	480	630	<100	<100
TPH C29-C36*	eTPH	ug/L	1500	1200	<100	<100
Total TPHs*	eTPH	ug/L	2000	1900	<250	<250

LAB ID			005	006	007	008
Client ID			OB9	OB14	OB15	OB15a
Sampled			17/08/2011	17/08/2011	17/08/2011	17/08/2011
Analyte	**Method**	**Unit**				
Alkalinity, total	iALK1WATI	mg/L	328	510	450	400
Aluminium	iMET1WCICP	mg/L	0.006	0.010	0.012	0.058
Arsenic	iMET1WCMS	mg/L	0.015	0.003	0.001	<0.001
Barium	iMET1WCICP	mg/L	0.011	0.024	0.013	0.007
Bicarbonate	iALK1WATI	mg/L	400	622	549	488
Boron	iMET1WCICP	mg/L	0.04	0.03	0.04	<0.02
Cadmium	iMET1WCMS	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Calcium	iMET1WCICP	mg/L	45.9	68.1	62.9	101
Carbonate	iALK1WATI	mg/L	<1	<1	<1	<1
Chloride	iCO1WCDA	mg/L	168	73	46	246
Chromium	iMET1WCICP	mg/L	<0.001	<0.001	<0.001	<0.001
Cobalt	iMET1WCICP	mg/L	<0.005	<0.005	<0.005	<0.005
Copper	iMET1WCICP	mg/L	<0.002	<0.002	<0.002	<0.002
Electrical Conductivity	iEC1WZSE	mS/m	181	131	105	177
Hardness, total	iHTOT2WACA	mg/L	320	520	480	730
Iron	iMET1WCICP	mg/L	0.021	0.013	0.015	0.040
Lead	iMET1WCMS	mg/L	0.022	0.016	0.0019	0.014
Magnesium	iMET1WCICP	mg/L	50.8	86.1	78.4	116
Manganese	iMET1WCICP	mg/L	0.015	0.007	0.003	0.003
Mercury	iMET1WCMS	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	iMET1WCMS	mg/L	0.001	<0.001	<0.001	<0.001

LAB ID			005	006	007	008
Client ID			OB9	OB14	OB15	OB15a
Sampled			17/08/2011	17/08/2011	17/08/2011	17/08/2011
Analyte	**Method**	**Unit**				
Nickel	iMET1WCMS	mg/L	<0.001	<0.001	<0.001	<0.001
Nitrate	iNTA1WFIA	mg/L	<0.05	<0.05	0.09	0.09
Nitrite	iNTR1WFIA	mg/L	<0.1	<0.1	<0.1	<0.1
Nitrogen, total	iNP1WTFIA	mg/L	<0.02	<0.02	0.06	<0.02
pH	iPH1WASE		7.9	7.7	7.4	7.4
Phosphorus, total	iPP1WTFIA	mg/L	0.01	0.01	0.02	0.03
Potassium	iMET1WCICP	mg/L	4.7	3.1	2.2	2.0
Selenium	iMET1WCMS	mg/L	<0.001	<0.001	0.001	<0.001
Silver	iMET1WCMS	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	iMET1WCICP	mg/L	288	74.0	41.5	94.7
Sulphate	iCO1WCDA	mg/L	360	100	51	150
Total suspended solids	iSOL1WPGR	mg/L	3	1	160	240
Thallium	iMET1WCMS	mg/L	0.0004	0.0003	<0.0001	<0.0001
Total dissolved solids (calc)	iSOL1WDCA	mg/L	990	720	580	970
Vanadium	iMET1WCICP	mg/L	<0.005	<0.005	<0.005	<0.005
Zinc	iMET1WCICP	mg/L	0.042	0.029	0.006	<0.005
Benzene*	eBTEX	ug/L	<1.0	<1.0	<1.0	<1.0
Toluene*	eBTEX	ug/L	<1.0	<1.0	<1.0	<1.0
Ethylbenzene*	eBTEX	ug/L	<1.0	<1.0	<1.0	<1.0
Xylene*	eBTEX	ug/L	<2.0	<2.0	<2.0	<2.0
Total BTEX*	eBTEX	ug/L	<5.0	<5.0	<5.0	<5.0
TPH C6-C9*	eTPH	ug/L	<25	<25	<25	<25
TPH C10-C14*	eTPH	ug/L	<25	<25	<25	<25
TPH C15-C28*	eTPH	ug/L	<100	<100	<100	<100
TPH C29-C36*	eTPH	ug/L	<100	<100	<100	<100
Total TPHs*	eTPH	ug/L	<250	<250	<250	<250

Method	Method Description
eBTEX	Monoaromatic hydrocarbons in waters (outsourced).
eTPH	Total Petroleum Hydrocarbons (outsourced) .
iALK1WATI	Alkalinity (as CaCO3) and constituents by acid titration (APHA 2320B).
iCO1WCDA	Colourimetric analysis by DA (Discrete Autoanalyser), APHA and in house methods.
iEC1WZSE	Electrical conductivity in water compensated to 25C (APHA 2510B).
iHTOT2WACA	Total Hardness as mg/L CaCO3 by calculation from calcium and magnesium (APHA 2340 B).
iMET1WCICP	Total dissolved metals by ICPAES (APHA 3120).
iMET1WCMS	Total dissolved metals by ICPMS (APHA 3125).
iNP1WTFIA	Total Nitrogen by persulphate digestion FIA (APHA 4500N-C,I).
iNTA1WFIA	Nitrite plus Nitrate in water by FIA expressed as Nitrate (APHA 4500NO3-I)
iNTR1WFIA	Nitrite by FIA (APHA 4500NO3-I)
iPH1WASE	pH in water by pH meter (APHA 4500H+)
iPP1WTFIA	Total Phosphorus by persulphate digestion and FIA (APHAP-J,G).
iSOL1WDCA	Total Dissolved Solids (TDS) calculated (ECond * 5.5)
iSOL1WPGR	Suspended Solids (APHA 2540D) and Volatile Suspended Solids (APHA 2540E).

The TPH and BTEX analysis was outsourced to another NATA accredited laboratory, NMI (Accreditation No 2474), their reference Report No. RN872691.

These results apply only to the sample(s) as received. Unless arrangements are made to the contrary, these samples will be disposed of after 30 days of the issue of this report.
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*Analysis not covered by scope of NATA accreditation.

Jenny McGuire
Science Business Manager
Environmental Chemistry Section
19-Sep-2011

ChemCentre

Environmental Chemistry Section

Report of Examination

ACCREDITED FOR TECHNICAL COMPETENCE

Accreditation No. 8

Purchase Order: SM 5

ChemCentre Reference: 11E0394

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PO Box 2660
Kununurra WA 6743

Attention: Lubor Hon

Report on: 2 samples received on 01/09/2011

LAB ID	Material	Client ID and Description
11E0394 / 001	water	OB11
11E0394 / 002	water	TPB1

LAB ID			001	002
Client ID			OB11	TPB1
Sampled			29/08/2011	29/08/2011
Analyte	**Method**	**Unit**		
Alkalinity, total	iALK1WATI	mg/L	428	325
Aluminium	iMET1WCICP	mg/L	0.007	<0.005
Arsenic	iMET1WCMS	mg/L	0.004	<0.001
Barium	iMET1WCICP	mg/L	0.044	0.007
Bicarbonate	iALK1WATI	mg/L	522	397
Boron	iMET1WCICP	mg/L	0.05	0.03
Cadmium	iMET1WCMS	mg/L	<0.0001	<0.0001
Calcium	iMET1WCICP	mg/L	120	63.3
Carbonate	iALK1WATI	mg/L	<1	<1
Chloride	iCO1WCDA	mg/L	361	28
Chromium	iMET1WCICP	mg/L	<0.001	<0.001
Cobalt	iMET1WCICP	mg/L	<0.005	<0.005
Copper	iMET1WCICP	mg/L	<0.002	<0.002
Electrical Conductivity	iEC1WZSE	mS/m	290	77.0
Hardness, total	iHTOT2WACA	mg/L	670	340
Iron	iMET1WCICP	mg/L	<0.005	<0.005
Lead	iMET1WCMS	mg/L	0.0007	0.011
Magnesium	iMET1WCICP	mg/L	91.2	43.1
Manganese	iMET1WCICP	mg/L	0.006	0.015
Molybdenum	iMET1WCMS	mg/L	0.002	<0.001
Nickel	iMET1WCMS	mg/L	0.001	<0.001
Nitrate	iNTA1WFIA	mg/L	<0.05	<0.05
Nitrite	iNTR1WFIA	mg/L	<0.1	<0.1
Nitrogen, total	iNP1WTFIA	mg/L	0.23	0.03
pH	iPH1WASE		7.2	7.3
Phosphorus, total	iPP1WTFIA	mg/L	0.01	<0.01
Potassium	iMET1WCICP	mg/L	7.8	2.3
Selenium	iMET1WCMS	mg/L	<0.001	<0.001
Silver	iMET1WCMS	mg/L	<0.0001	<0.0001
Sodium	iMET1WCICP	mg/L	459	50.0

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LAB ID			001	002
Client ID			OB11	TPB1
Sampled			29/08/2011	29/08/2011
Analyte	**Method**	**Unit**		
Sulphate	iCO1WCDA	mg/L	570	46
Total suspended solids	iSOL1WPGR	mg/L	20	<1
Thallium	iMET1WCMS	mg/L	0.0006	0.0002
Total dissolved solids (calc)	iSOL1WDCA	mg/L	1600	420
Vanadium	iMET1WCICP	mg/L	<0.005	<0.005
Zinc	iMET1WCICP	mg/L	0.075	0.006
Benzene*	eBTEX	ug/L	<1.0	<1.0
Toluene*	eBTEX	ug/L	<1.0	<1.0
Ethylbenzene*	eBTEX	ug/L	<1.0	<1.0
Xylene*	eBTEX	ug/L	<2.0	<2.0
Total BTEX*	eBTEX	ug/L	<5.0	<5.0
TPH C6-C9*	eTPH	ug/L	<25	<25
TPH C10-C14*	eTPH	ug/L	<25	<25
TPH C15-C28*	eTPH	ug/L	<100	<100
TPH C29-C36*	eTPH	ug/L	<100	<100
Total TPHs*	eTPH	ug/L	<250	<250

Method	**Method Description**
eBTEX	Monoaromatic hydrocarbons in waters (outsourced).
eTPH	Total Petroleum Hydrocarbons (outsourced) .
iALK1WATI	Alkalinity (as CaCO3) and constituents by acid titration (APHA 2320B).
iCO1WCDA	Colourimetric analysis by DA (Discrete Autoanalyser), APHA and in house methods.
iEC1WZSE	Electrical conductivity in water compensated to 25C (APHA 2510B).
iHTOT2WACA	Total Hardness as mg/L CaCO3 by calculation from calcium and magnesium (APHA 2340 B).
iMET1WCICP	Total dissolved metals by ICPAES (APHA 3120).
iMET1WCMS	Total dissolved metals by ICPMS (APHA 3125).
iNP1WTFIA	Total Nitrogen by persulphate digestion FIA (APHA 4500N-C,I).
iNTA1WFIA	Nitrite plus Nitrate in water by FIA expressed as Nitrate (APHA 4500NO3-I)
iNTR1WFIA	Nitrite by FIA (APHA 4500NO3-I)
iPH1WASE	pH in water by pH meter (APHA 4500H+)
iPP1WTFIA	Total Phosphorus by persulphate digestion and FIA (APHAP-J,G).
iSOL1WDCA	Total Dissolved Solids (TDS) calculated (ECond * 5.5)
iSOL1WPGR	Suspended Solids (APHA 2540D) and Volatile Suspended Solids (APHA 2540E).

The TPH and BTEX analysis was outsourced to another NATA accredited laboratory, NMI (Accreditation No 2474), their reference Report No. RN874433.

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Jenny McGuire
Science Business Manager
Environmental Chemistry Section
19-Sep-2011

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Report of Examination

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Accreditation No. 8

Purchase Order: SM5
ChemCentre Reference: 11E0424

Sorby Management Pty Ltd
PO Box 2660
Kununurra WA 6743

Attention: Lubor Hon

Report on: 2 samples received on 06/09/2011

LAB ID	Material	Client ID and Description
11E0424 / 001	water	TPB1
11E0424 / 002	water	TPB4

LAB ID			001	002
Client ID			TPB1	TPB4
Sampled			03/09/2011	05/09/2011
Analyte	**Method**	**Unit**		
Alkalinity, total	iALK1WATI	mg/L	303	505
Aluminium	iMET1WCICP	mg/L	<0.005	<0.005
Arsenic	iMET1WCMS	mg/L	<0.001	0.003
Barium	iMET1WCICP	mg/L	0.011	0.021
Bicarbonate	iALK1WATI	mg/L	369	616
Boron	iMET1WCICP	mg/L	0.04	0.05
Cadmium	iMET1WCMS	mg/L	<0.0001	<0.0001
Calcium	iMET1WCICP	mg/L	59.0	92.2
Carbonate	iALK1WATI	mg/L	<1	<1
Chloride	iCO1WCDA	mg/L	51	103
Chromium	iMET1WCICP	mg/L	<0.001	<0.001
Cobalt	iMET1WCICP	mg/L	<0.005	<0.005
Copper	iMET1WCICP	mg/L	<0.002	<0.002
Electrical Conductivity	iEC1WZSE	mS/m	96.4	150
Hardness, total	iHTOT2WACA	mg/L	380	550
Iron	iMET1WCICP	mg/L	<0.005	0.042
Lead	iMET1WCMS	mg/L	0.017	0.0034
Magnesium	iMET1WCICP	mg/L	56.0	78.3
Manganese	iMET1WCICP	mg/L	0.001	0.005
Mercury	iMET1WCMS	mg/L	<0.0001	<0.0001
Molybdenum	iMET1WCMS	mg/L	<0.001	0.001
Nickel	iMET1WCMS	mg/L	0.012	0.009
Nitrate	iNTA1WFIA	mg/L	<0.05	<0.05
Nitrite	iNTR1WFIA	mg/L	<0.1	<0.1
Nitrogen, total	iNP1WTFIA	mg/L	<0.02	<0.02
pH	iPH1WASE		7.0	6.9
Phosphorus, total	iPP1WTFIA	mg/L	0.02	<0.01
Potassium	iMET1WCICP	mg/L	2.5	4.4
Selenium	iMET1WCMS	mg/L	<0.001	<0.001
Silver	iMET1WCMS	mg/L	<0.0001	<0.0001

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LAB ID			001	002
Client ID			TPB1	TPB4
Sampled			03/09/2011	05/09/2011
Analyte	**Method**	**Unit**		
Sodium	iMET1WCICP	mg/L	65.6	140
Sulphate	iCO1WCDA	mg/L	85	170
Total suspended solids	iSOL1WPGR	mg/L	24	<1
Thallium	iMET1WCMS	mg/L	0.0001	0.0007
Total dissolved solids (calc)	iSOL1WDCA	mg/L	530	820
Vanadium	iMET1WCICP	mg/L	<0.005	<0.005
Zinc	iMET1WCICP	mg/L	0.019	0.051
Benzene*	eBTEX	ug/L	<1.0	<1.0
Toluene*	eBTEX	ug/L	<1.0	<1.0
Ethylbenzene*	eBTEX	ug/L	<1.0	<1.0
Xylene*	eBTEX	ug/L	<2.0	<2.0
Total BTEX*	eBTEX	ug/L	<5.0	<5.0
TPH C6-C9*	eTPH	ug/L	<25	<25
TPH C10-C14*	eTPH	ug/L	<25	<25
TPH C15-C28*	eTPH	ug/L	<100	<100
TPH C29-C36*	eTPH	ug/L	<100	<100
Total TPHs*	eTPH	ug/L	<250	<250

Method	**Method Description**
eBTEX	Monoaromatic hydrocarbons in waters (outsourced).
eTPH	Total Petroleum Hydrocarbons (outsourced) .
iALK1WATI	Alkalinity (as CaCO3) and constituents by acid titration (APHA 2320B).
iCO1WCDA	Colourimetric analysis by DA (Discrete Autoanalyser), APHA and in house methods.
iEC1WZSE	Electrical conductivity in water compensated to 25C (APHA 2510B).
iHTOT2WACA	Total Hardness as mg/L CaCO3 by calculation from calcium and magnesium (APHA 2340 B).
iMET1WCICP	Total dissolved metals by ICPAES (APHA 3120).
iMET1WCMS	Total dissolved metals by ICPMS (APHA 3125).
iNP1WTFIA	Total Nitrogen by persulphate digestion FIA (APHA 4500N-C,I).
iNTA1WFIA	Nitrite plus Nitrate in water by FIA expressed as Nitrate (APHA 4500NO3-I)
iNTR1WFIA	Nitrite by FIA (APHA 4500NO3-I)
iPH1WASE	pH in water by pH meter (APHA 4500H+)
iPP1WTFIA	Total Phosphorus by persulphate digestion and FIA (APHAP-J,G).
iSOL1WDCA	Total Dissolved Solids (TDS) calculated (ECond * 5.5)
iSOL1WPGR	Suspended Solids (APHA 2540D) and Volatile Suspended Solids (APHA 2540E).

The TPH and BTEX analysis was outsourced to another NATA accredited laboratory, NMI (Accreditation No 2474), their reference RN875583.

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Jenny McGuire
Science Business Manager
Environmental Chemistry Section
21-Sep-2011

ChemCentre
Environmental Chemistry Section
Report of Examination

ACCREDITED FOR TECHNICAL COMPETENCE
Accreditation No. 8

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Purchase Order: SM 5
ChemCentre Reference: 11E0475

Sorby Management Pty Ltd
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Kununurra WA 6743

Attention: Lubor Hon

Report on: 1 sample received on 13/09/2011

LAB ID	Material	Client ID and Description
11E0475 / 001	water	TPB4

LAB ID	001
Client ID	TPB4
Sampled	11/09/2011

Analyte	Method	Unit	
Alkalinity, total	iALK1WATI	mg/L	488
Aluminium	iMET1WCICP	mg/L	<0.005
Arsenic	iMET1WCMS	mg/L	0.002
Barium	iMET1WCICP	mg/L	0.022
Bicarbonate	iALK1WATI	mg/L	595
Boron	iMET1WCMS	mg/L	0.035
Cadmium	iMET1WCMS	mg/L	<0.0001
Calcium	iMET1WCICP	mg/L	93.8
Carbonate	iALK1WATI	mg/L	<1
Chloride	iCO1WCDA	mg/L	82
Chromium	iMET1WCICP	mg/L	<0.001
Cobalt	iMET1WCICP	mg/L	<0.005
Copper	iMET1WCICP	mg/L	<0.002
Electrical Conductivity	iEC1WZSE	mS/m	134
Hardness, total	iHTOT2WACA	mg/L	540
Iron	iMET1WCICP	mg/L	0.032
Lead	iMET1WCMS	mg/L	0.0011
Magnesium	iMET1WCICP	mg/L	74.0
Manganese	iMET1WCICP	mg/L	0.004
Mercury	iMET1WCMS	mg/L	<0.0001
Molybdenum	iMET1WCMS	mg/L	<0.001
Nickel	iMET1WCMS	mg/L	0.001
Nitrate	iNTA1WFIA	mg/L	<0.05
Nitrite	iNTR1WFIA	mg/L	<0.1
Nitrogen, total	iNP1WTFIA	mg/L	0.03
pH	iPH1WASE		6.8
Phosphorus, total	iPP1WTFIA	mg/L	<0.01
Potassium	iMET1WCICP	mg/L	3.1
Selenium	iMET1WCMS	mg/L	<0.001
Silver	iMET1WCMS	mg/L	<0.0001

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LAB ID	001
Client ID	TPB4
Sampled	11/09/2011

Analyte	Method	Unit	
Sodium	iMET1WCICP	mg/L	86.1
Sulphate (from S)	iMET1WCICP	mg/L	120
Total suspended solids	iSOL1WPGR	mg/L	17
Thallium	iMET1WCMS	mg/L	0.0006
Total dissolved solids (calc)	iSOL1WDCA	mg/L	740
Vanadium	iMET1WCICP	mg/L	<0.005
Zinc	iMET1WCICP	mg/L	0.059
Benzene*	eBTEX	ug/L	<1.0
Toluene*	eBTEX	ug/L	<1.0
Ethylbenzene*	eBTEX	ug/L	<1.0
Xylene*	eBTEX	ug/L	<2.0
Total BTEX*	eBTEX	ug/L	<5.0
TPH C6-C9*	eTPH	ug/L	<25
TPH C10-C14*	eTPH	ug/L	<25
TPH C15-C28*	eTPH	ug/L	<100
TPH C29-C36*	eTPH	ug/L	<100
Total TPHs*	eTPH	ug/L	<250

Method	Method Description
eBTEX	Monoaromatic hydrocarbons in waters (outsourced).
eTPH	Total Petroleum Hydrocarbons (outsourced) .
iALK1WATI	Alkalinity (as CaCO3) and constituents by acid titration (APHA 2320B).
iCO1WCDA	Colourimetric analysis by DA (Discrete Autoanalyser), APHA and in house methods.
iEC1WZSE	Electrical conductivity in water compensated to 25C (APHA 2510B).
iHTOT2WACA	Total Hardness as mg/L CaCO3 by calculation from calcium and magnesium (APHA 2340 B).
iMET1WCICP	Total dissolved metals by ICPAES (APHA 3120).
iMET1WCMS	Total dissolved metals by ICPMS (APHA 3125).
iNP1WTFIA	Total Nitrogen by persulphate digestion FIA (APHA 4500N-C,I).
iNTA1WFIA	Nitrite plus Nitrate in water by FIA expressed as Nitrate (APHA 4500NO3-I)
iNTR1WFIA	Nitrite by FIA (APHA 4500NO3-I)
iPH1WASE	pH in water by pH meter (APHA 4500H+)
iPP1WTFIA	Total Phosphorus by persulphate digestion and FIA (APHAP-J,G).
iSOL1WDCA	Total Dissolved Solids (TDS) calculated (ECond * 5.5)
iSOL1WPGR	Suspended Solids (APHA 2540D) and Volatile Suspended Solids (APHA 2540E).

The TPH and BTEX analysis was outsourced to another NATA accredited laboratory, NMI (Accreditation No 2474), their reference Report No. RN876563.

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Jenny McGuire
Science Business Manager
Environmental Chemistry Section
6-Oct-2011

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Report of Examination

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Purchase Order: SM5
ChemCentre Reference: 11E0510

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PO Box 2660
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Attention: Lubor Hon

Report on: 2 samples received on 16/09/2011

LAB ID	Material	Client ID and Description
11E0510 / 001	water	TPB3
11E0510 / 002	water	OB16

LAB ID			001	002
Client ID			TPB3	OB16
Sampled			15/09/2011	15/09/2011
Analyte	**Method**	**Unit**		
Alkalinity, total	iALK1WATI	mg/L	350	455
Aluminium	iMET1WCICP	mg/L	<0.005	0.024
Arsenic	iMET1WCMS	mg/L	0.022	0.004
Barium	iMET1WCICP	mg/L	0.015	0.057
Bicarbonate	iALK1WATI	mg/L	427	555
Boron	iMET1WCICP	mg/L	0.06	0.05
Cadmium	iMET1WCMS	mg/L	<0.0001	<0.0001
Calcium	iMET1WCICP	mg/L	90.9	96.8
Carbonate	iALK1WATI	mg/L	<1	<1
Chloride	iCO1WCDA	mg/L	269	220
Chromium	iMET1WCICP	mg/L	<0.001	<0.001
Cobalt	iMET1WCICP	mg/L	<0.005	<0.005
Copper	iMET1WCICP	mg/L	<0.002	<0.002
Electrical Conductivity	iEC1WZSE	mS/m	233	226
Hardness, total	iHTOT2WACA	mg/L	500	560
Iron	iMET1WCICP	mg/L	0.063	0.009
Lead	iMET1WCMS	mg/L	0.0014	0.0014
Magnesium	iMET1WCICP	mg/L	66.8	76.9
Manganese	iMET1WCICP	mg/L	0.014	0.035
Mercury	iMET1WCMS	mg/L	<0.0001	<0.0001
Molybdenum	iMET1WCMS	mg/L	0.002	0.002
Nickel	iMET1WCMS	mg/L	0.004	<0.001
Nitrate	iNTA1WFIA	mg/L	<0.05	0.18
Nitrite	iNTR1WFIA	mg/L	<0.1	<0.1
Nitrogen, total	iNP1WTFIA	mg/L	0.04	0.35
pH	iPH1WASE		7.2	7.4
Phosphorus, total	iPP1WTFIA	mg/L	<0.01	<0.01
Potassium	iMET1WCICP	mg/L	5.2	4.5
Selenium	iMET1WCMS	mg/L	<0.001	<0.001
Silver	iMET1WCMS	mg/L	<0.0001	<0.0001

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LAB ID			001	002
Client ID			TPB3	OB16
Sampled			15/09/2011	15/09/2011
Analyte	**Method**	**Unit**		
Sodium	iMET1WCICP	mg/L	359	249
Sulphate	iCO1WCDA	mg/L	470	470
Total suspended solids	iSOL1WPGR	mg/L	<1	9
Thallium	iMET1WCMS	mg/L	0.0007	0.0010
Total dissolved solids (calc)	iSOL1WDCA	mg/L	1300	1200
Vanadium	iMET1WCICP	mg/L	<0.005	<0.005
Zinc	iMET1WCICP	mg/L	0.047	0.092
Benzene*	eBTEX	ug/L	<1.0	<1.0
Toluene*	eBTEX	ug/L	<1.0	<1.0
Ethylbenzene*	eBTEX	ug/L	<1.0	<1.0
Xylene*	eBTEX	ug/L	<2.0	<2.0
Total BTEX*	eBTEX	ug/L	<5.0	<5.0
TPH C6-C9*	eTPH	ug/L	<25	<25
TPH C10-C14*	eTPH	ug/L	<25	<25
TPH C15-C28*	eTPH	ug/L	<100	<100
TPH C29-C36*	eTPH	ug/L	<100	<100
Total TPHs*	eTPH	ug/L	<250	<250

Method	**Method Description**
eBTEX	Monoaromatic hydrocarbons in waters (outsourced).
eTPH	Total Petroleum Hydrocarbons (outsourced) .
iALK1WATI	Alkalinity (as CaCO3) and constituents by acid titration (APHA 2320B).
iCO1WCDA	Colourimetric analysis by DA (Discrete Autoanalyser), APHA and in house methods.
iEC1WZSE	Electrical conductivity in water compensated to 25C (APHA 2510B).
iHTOT2WACA	Total Hardness as mg/L CaCO3 by calculation from calcium and magnesium (APHA 2340 B).
iMET1WCICP	Total dissolved metals by ICPAES (APHA 3120).
iMET1WCMS	Total dissolved metals by ICPMS (APHA 3125).
iNP1WTFIA	Total Nitrogen by persulphate digestion FIA (APHA 4500N-C,I).
iNTA1WFIA	Nitrite plus Nitrate in water by FIA expressed as Nitrate (APHA 4500NO3-I)
iNTR1WFIA	Nitrite by FIA (APHA 4500NO3-I)
iPH1WASE	pH in water by pH meter (APHA 4500H+)
iPP1WTFIA	Total Phosphorus by persulphate digestion and FIA (APHAP-J,G).
iSOL1WDCA	Total Dissolved Solids (TDS) calculated (ECond * 5.5)
iSOL1WPGR	Suspended Solids (APHA 2540D) and Volatile Suspended Solids (APHA 2540E).

The TPH and BTEX analysis was outsourced to another NATA accredited laboratory, NMI (Accreditation No 2474), their reference Report No. RN876825.

The chain of custody listed the sample marks as TPB4 and OB16, however the samples were marked TPB3 and OB16.

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Jenny McGuire
Science Business Manager
Environmental Chemistry Section
4-Oct-2011

ChemCentre
Environmental Chemistry Section
Report of Examination

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Accreditation No. 8

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Purchase Order: SM5
ChemCentre Reference: 11E0567

Sorby Management Pty Ltd
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Kununurra WA 6743

Attention: Lubor Hon

Report on: 1 sample received on 23/09/2011

LAB ID	Material	Client ID and Description
11E0567 / 001	water	TPB3

LAB ID			001
Client ID			TPB3
Sampled			21/09/2011
Analyte	**Method**	**Unit**	
Alkalinity, total	iALK1WATI	mg/L	385
Aluminium	iMET1WCICP	mg/L	<0.005
Arsenic	iMET1WCMS	mg/L	0.008
Barium	iMET1WCICP	mg/L	0.014
Bicarbonate	iALK1WATI	mg/L	470
Boron	iMET1WCICP	mg/L	0.06
Cadmium	iMET1WCMS	mg/L	<0.0001
Calcium	iMET1WCICP	mg/L	90.5
Carbonate	iALK1WATI	mg/L	<1
Chloride	iCO1WCDA	mg/L	303
Chromium	iMET1WCICP	mg/L	<0.001
Cobalt	iMET1WCICP	mg/L	<0.005
Copper	iMET1WCICP	mg/L	<0.002
Electrical Conductivity	iEC1WZSE	mS/m	243
Hardness, total	iHTOT2WACA	mg/L	450
Iron	iMET1WCICP	mg/L	0.050
Lead	iMET1WCMS	mg/L	0.0015
Magnesium	iMET1WCICP	mg/L	55.2
Manganese	iMET1WCICP	mg/L	0.021
Mercury	iMET1WCMS	mg/L	<0.0001
Molybdenum	iMET1WCMS	mg/L	0.002
Nickel	iMET1WCMS	mg/L	<0.001
Nitrate	iNTA1WFIA	mg/L	<0.05
Nitrite	iNTR1WFIA	mg/L	<0.1
Nitrogen, total	iNP1WTFIA	mg/L	0.14
pH	iPH1WASE		7.0
Phosphorus, total	iPP1WTFIA	mg/L	0.05
Potassium	iMET1WCICP	mg/L	4.0
Selenium	iMET1WCICP	mg/L	<0.05
Silver	iMET1WCMS	mg/L	<0.0001

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LAB ID	001
Client ID	TPB3
Sampled	21/09/2011

Analyte	Method	Unit	
Sodium	iMET1WCICP	mg/L	289
Sulphate (from S)	iMET1WCICP	mg/L	434
Total suspended solids	iSOL1WPGR	mg/L	4
Thallium	iMET1WCMS	mg/L	0.0007
Total dissolved solids (calc)	iSOL1WDCA	mg/L	1300
Vanadium	iMET1WCICP	mg/L	<0.005
Zinc	iMET1WCICP	mg/L	0.020
Benzene*	eBTEX	ug/L	<1.0
Toluene*	eBTEX	ug/L	<1.0
Ethylbenzene*	eBTEX	ug/L	<1.0
Xylene*	eBTEX	ug/L	<2.0
Total BTEX*	eBTEX	ug/L	<5.0
TPH C6-C9*	eTPH	ug/L	<25
TPH C10-C14*	eTPH	ug/L	<25
TPH C15-C28*	eTPH	ug/L	<100
TPH C29-C36*	eTPH	ug/L	<100
Total TPHs*	eTPH	ug/L	<250

Method	Method Description
eBTEX	Monoaromatic hydrocarbons in waters (outsourced).
eTPH	Total Petroleum Hydrocarbons (outsourced) .
iALK1WATI	Alkalinity (as CaCO3) and constituents by acid titration (APHA 2320B).
iCO1WCDA	Colourimetric analysis by DA (Discrete Autoanalyser), APHA and in house methods.
iEC1WZSE	Electrical conductivity in water compensated to 25C (APHA 2510B).
iHTOT2WACA	Total Hardness as mg/L CaCO3 by calculation from calcium and magnesium (APHA 2340 B).
iMET1WCICP	Total dissolved metals by ICPAES (APHA 3120).
iMET1WCMS	Total dissolved metals by ICPMS (APHA 3125).
iNP1WTFIA	Total Nitrogen by persulphate digestion FIA (APHA 4500N-C,I).
iNTA1WFIA	Nitrite plus Nitrate in water by FIA expressed as Nitrate (APHA 4500NO3-I)
iNTR1WFIA	Nitrite by FIA (APHA 4500NO3-I)
iPH1WASE	pH in water by pH meter (APHA 4500H+)
iPP1WTFIA	Total Phosphorus by persulphate digestion and FIA (APHAP-J,G).
iSOL1WDCA	Total Dissolved Solids (TDS) calculated (ECond * 5.5)
iSOL1WPGR	Suspended Solids (APHA 2540D) and Volatile Suspended Solids (APHA 2540E).

The TPH and BTEX analysis was outsourced to another NATA accredited laboratory, NMI (Accreditation No 2474), their reference Report No. RN878659.

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Jenny McGuire
Science Business Manager
Environmental Chemistry Section
4-Oct-2011

Appendix 8: Aboriginal Heritage Desktop Analysis

Aboriginal Heritage Desktop Analysis – Kimberley Metals Tenements M80/196, M80/197, M80/285, M80/286 and M80/287

June 2011

Phil Czerwinski

Client:
Kimberley Metals Limited

Land Access SolutionsLAS Pty Ltd
ABN 30 145 835 114

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LAS is not responsible for omissions and inconsistencies that result from information that was not available at the time this report was prepared.

The professional advice and opinions contained in this report do not constitute legal advice.

Spatial Data

Spatial data captured for any sites, as contemplated under the Aboriginal Heritage Act (WA) 1972 (**Site**) in this report has been obtained by using a hand held GPS unit using the GDA94 coordinate system.

Abbreviations

Abbreviation	Definition
AHA	*Aboriginal Heritage Act 1972*
DIA	Department of Indigenous Affairs
GPS	Global Positioning System
KBL	Kimberley Metals Limited
LAS	Land Access Solutions Pty Ltd

Executive Summary

This report documents the results of an Aboriginal heritage desktop analysis of the KBL tenements M80/196, M80/197, M80/285, M80/286 and M80/287 (**the Tenements**).

The Tenements have undergone heritage surveys on two occasions, with members of the Yawoorroong Miriuwung Gajerrong Yirrgeb Noon Dawang Aboriginal group. Although not stated it is assumed the surveys were ethnographic but it is uncertain if there was an archaeological component.

One multi-component site was identified. Site DIA 15427 (Jingil Complex) covers M80/285 and M80/196 completely and approximately 300m of the northern edge of M80197 and M80/286.

There is limited public information on Site Register for DIA 15427 as it is a closed site. Access to the site card will only be granted with permission from Miriuwung & Gajerrong Families Heritage & Land Council.

From a desktop perspective the geology of the Tenements would suggest a low potential for archaeological material however given the Tenements are located over landscape features including rivers and creeklines, the potential for archaeological sites to be located at these features is elevated.

There is some suggestion that outcrop of rocks, hills or ridges that rise above the plain may be ethnographic Sites.

This report makes the following recommendations. KBL may consider:

- Conducting an archaeological survey over those parts of the Tenements they wish to disturb. This may reduce the risk of any Aboriginal person or group claiming a breach of the *Aboriginal Heritage Act 1972*.
- Conducting an ethnographic survey for works that are outside of the CBH Resources Sorby Hills Exploration and Evaluation Program 2007-2008 by Daniel Wholley.
- Submitting a Section 18 for any works that are to disturb a site.
- Ensuring that all future heritage reports include as a minimum the following details
    - The qualifications of the heritage consultant;
    - Details of the selection process for the Aboriginal consultants;
    - Provide geospatial information of the area surveyed and any Sites identified;
    - Clearly details the level of the survey (ie Site ID, work area or programme level); and
    - Clarify if the survey is ethnographic and/or archaeological.

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1 Introduction

Land Access Soultions (LAS) has been engaged by Kimberley Metals Limited (KBL) to undertake an Aboriginal heritage desktop analysis of tenements M80/196, M80/197, M80/285, M80/286 and M80/287 ('the Tenements' – Figure 1).

1.1 Project Brief

The following brief has informed the Aboriginal heritage desktop analysis.

- Summary of obligations under the *Aboriginal Heritage Act 1972.*
- Results of a DIA Register and National and/or World Heritage List.
- Summary and distinction between ethnographic and archaeological sites.
- Review of previous reports relating to the tenements.
- Summary of the type of ethnographic and/or archaeological sites likely to be identified based on the topography and geology of the area.

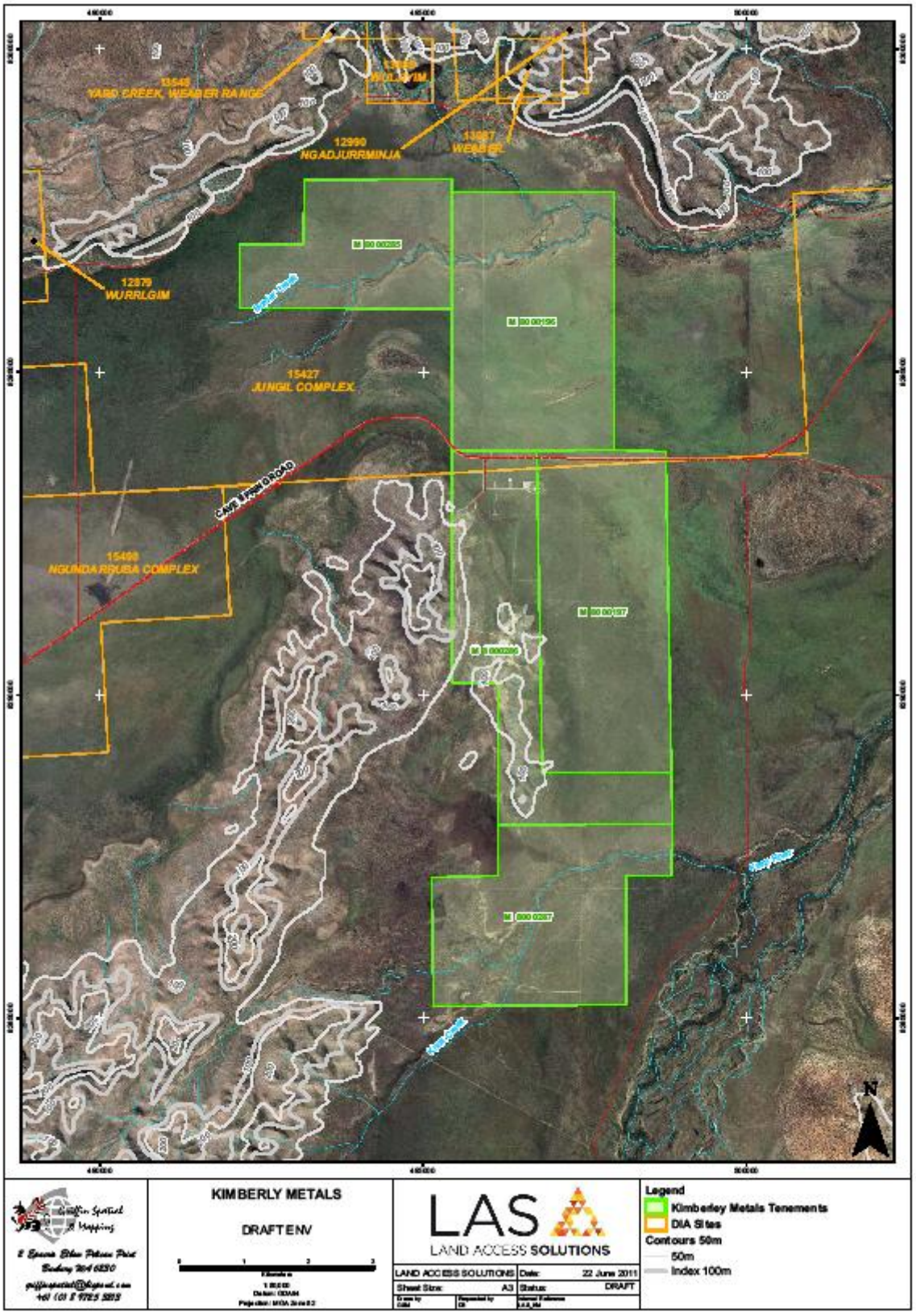


Figure 1: Map of the Tenements and Study Area

2 Aboriginal Heritage Act 1972

All Sites within Western Australia are protected under the AHA. A Site is defined under Section 5 of the Act as follows.

> *(a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;*
> *(b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;*
> *(c) any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State;*
> *(d) any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.*

The most relevant part of the AHA for the mining industry is section 17 which makes it an office to disturb a Site without the consent of the Minister for Indigenous Affairs pursuant to section 18 of the AHA.

The AHA does not stipulate that heritage surveys must be conducted and does not claim that the Register of Aboriginal Sites is an exhaustive list of all sites.

Should you require further:

- Information on submitting a section 18;
- A more detailed explanation of the AHA; or
- Details of the Commonwealth *Aboriginal and Torres Strait Islander Heritage Act 1984*:

All of which limited, if any comment has been made in this document, please contact LAS.

3 Aboriginal Sites

Sites can be broadly categorised into ethnographic (anthropological) and archaeological sites.

3.1 Ethnographic Sites

Ethnographic/anthropological Sites can be generally be defined as those that have living cultural significance to Aboriginal people today (e.g. waterholes with associated stories or law grounds). Ethnographic sites have the potential to cover large tracts of land (e.g. mountain ranges) if these landscape features have significance to Aboriginal tradition.

3.2 Archaeological Sites

Archaeological Site can generally be defined as those which provide physical evidence of past Aboriginal occupation or land use (e.g. artefact scatters, quarries or engravings). Some archaeological Sites, such as rock art/engravings, may also have ethnographic importance.

4 Aboriginal Sites – Heritage Registers

4.1 DIA Site Register

A search of the Aboriginal Sites Register identified one previously recorded Site within the Tenements (Table 1).

DIA ID	Site Name	Site Type	Status	Access
15427	Jungil Complex	Ceremonial, Mythological, Repository/Cache, Skeletal Material/Burial, Man Made structure, Modified Tree, Painting, Engraving, Quarry, Artefact Scatter, Midden/Scatter, Grinding Patches/Groves, Ochre	Permanent Register	Closed

Table 1: Aboriginal sites on the DIA Site Register

Given the status of this site is 'Closed'; it could not be accessed for this desktop study.

4.2 National & World Heritage Lists

The Tenements were not identified in the National & World Heritage Lists.

5 Aboriginal Sites – Previous Research

5.1 Akerman 2007

Between 13-16/08/2007 Anthropologist Kim Ackerman conducted an ethnographic survey over the Tenements.

In summary drill holes P1-P29 were not objected to. In the absence of the Annexure 2 of the Akerman report it is uncertain where these drill holes are but it can be assumed they are PH1 – PH22 as detailed on page 22 of the Sorby Hills Exploration and Evaluation Program 2007-2008 by Daniel Wholley.

Soil sampling and IP surveys within the project area (M08/196-7 and M08/285-7) may be carried out.

In any event the report states that no work is to be completed on *"outcrops of rock, hills or ridges that rise above the general surface level of the plain, are to be disturbed"*. We are unable to map this with any certainty.

Recommendation 4 of the Akerman report refers to an Ord River Irrigation scheme report which clears, presumably, part of the Site DIA 15427 for the purposes of agricultural use. We were unable to obtain a copy of this report.

5.2 Yawooroong Miriuwung Gajerrong Yirrgeb Noon Dawang Aboriginal Corp. 2010

Between August and October 2010 KBL organised meetings and a field trip with relevant senior Traditional Owners and the Yawooroong Miriuwung Gajerrong Yirrgeb Noon Dawang Aboriginal Corporation to assess and possibly redefine the Site boundaries for DIA 15427 (Yawooroong Miriuwung Gajerrong Yirrgeb Noon Dawang 2010). The conclusions and recommendations of this exercise are as follows:

- The most knowledgeable senior Law men and women and Traditional Owners in relation to the project area viewed and discussed the site boundary issue.
- Senior men decided that there are elements of the site complex on the black soil plain, and that the redrawing of the site boundary would not be appropriate.
- Traditional Owners are happy to support a section 18 pursuant to the AHA but only relation to the current programme (proposed drilling as cleared in 2007).
- It was decided that Kimberley Metals would need to apply to DIA for approval under Section 18 to conduct the drilling programme in the delineated areas within this site complex.

- Traditional Owners have requested that the company discuss with them any future programmes that may be planned as a result of the drilling and that these programmes be the subject of separate Section 18 application if required.

5.3 Discussion

From a review of existing survey reports, it is shown that the ethnographic site boundary extends into the tenements and that an adjustment of those boundaries has not been successful.

It also shows that no further ethnographic sites were identified in the area subject to this desktop study.

As the consultants who were involved in the two heritage surveys have not detailed their qualifications, as the reports detail the surveys to be heritage clearances and as they refer to ethnographic sites it is assumed that there was no archaeological component. Accordingly it would appear that no archaeological surveys have been conducted over the Tenements.

5.4 Assessment of Geological Features

In order to ascertain the potential for archaeological and/or ethnographic sites to be within the Tenements, and analysis of the geology of the Tenements has been made in relation to known Aboriginal site location principles (Table 2 & Figure 2).

Rock Type	Comment on Suitability for Aboriginal Artefacts
BioCarbonate	This rock type is primarily low in silica content, and accordingly has low potential for use as a source for artefacts. Silica rich 'pockets' may occur in this rock type, which could be the source of artefacts.
Sandstone	This rock type is primarily low in silica content, and accordingly has low potential for use as a source for artefacts.
Siltstone	This rock type is often low in silica content, and accordingly has low potential for use as a source for artefacts. Silica rich veins may occur in this rock type, which could be the source of artefacts.
Colluvial Sediment / Residual Material / Soil	The suitability of this rock type for artefact material will be dependent on the parent rock.

Table 2: Geological association & Aboriginal sites principles

This geological analysis highlights that the material present in the Tenements has a low potential for material suitable for making flaked stone artefacts, although this statement must be quantified by highlighting the inference is based on a macro level analysis – there is always potential that areas of higher silica content occur in many rock types and these areas are often targeted for quarrying of rock to make stone artefacts.

5.5 Assessment of Landscape

A ridgeline stretches approx. 5 km within M80/286. Maximum elevation is about 100m above sea level. Extensions of Keep River and Knox River are crossing diagonally through M08/287. No ethnographic heritage sites have been identified in relation to those landscape features. However it can be inferred from the following statement in the Akerman report that areas above the plain may have some ethnographic significance and could possibly be sites:

"no outcrops of rock, hills or ridges that rise above the general surface level of the plain, are to be disturbed".

Given the Tenements are located over landscape features including rivers and creeklines, the potential for archaeological sites to be located at these features is elevated. The preservation of archaeological sites along these water courses will be dependent on whether flooding and erosion has altered the landscape to such an extent that any archaeological material has been buried or not.

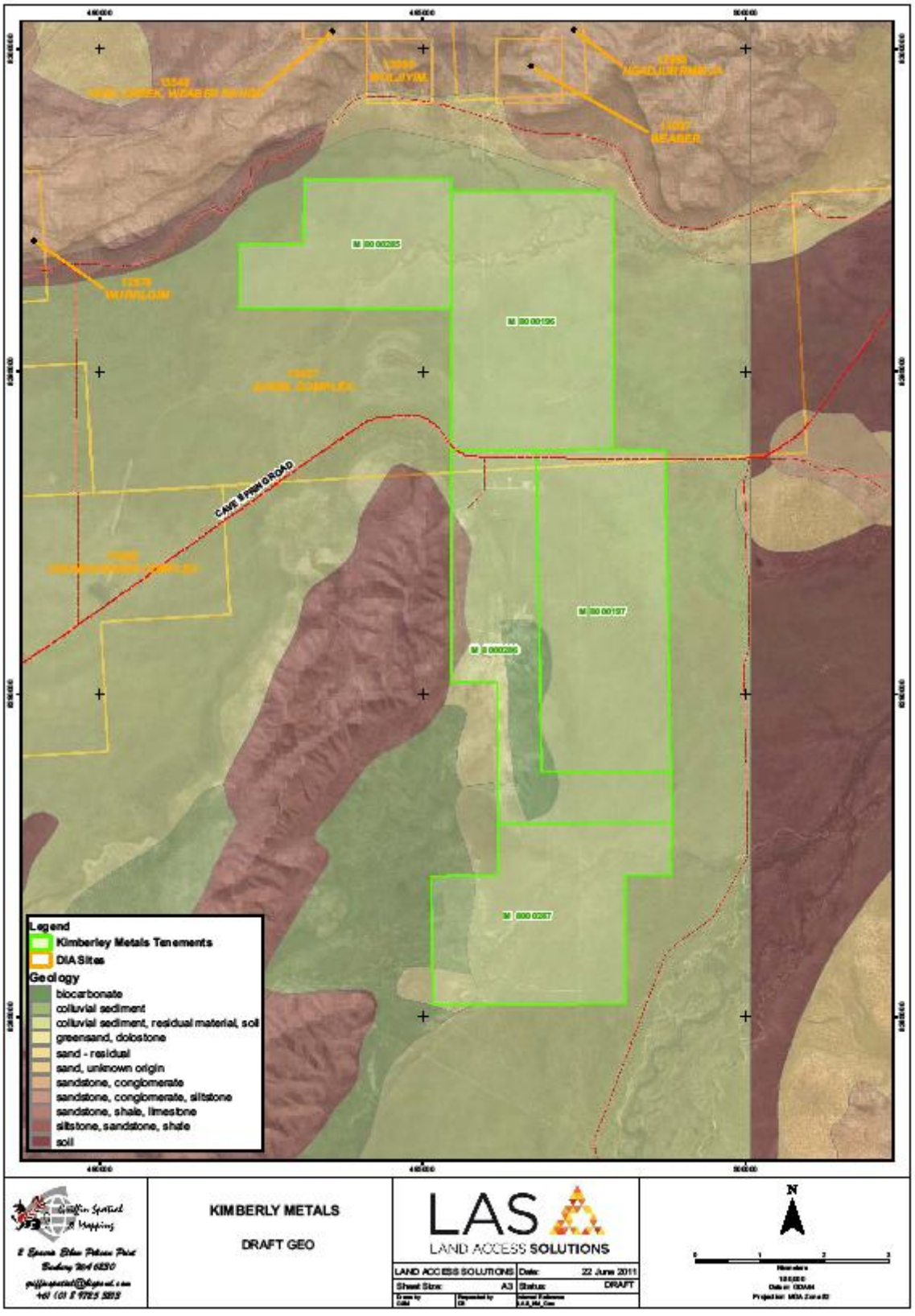


Figure 2: Map of geology within the Tenements

6 Summary & Recommendations

6.1 Summary – Aboriginal Sites

6.1.1 Ethnographic

The Tenements have been ethnographically surveyed. One Aboriginal Site DIA 15427 was identified covering M80/285, M80/196 and the northern portion of M80/286 and M08/197. A subsequent survey was conducted to redefine the site boundary for DIA 15427. As a result of this survey the site boundary was maintained in the original version.

Accordingly the Ackerman report the remaining area is ethnographically cleared for the purposes of Work Programme Clearances which is contained in the on the CBH Resources Sorby Hills Exploration and Evaluation Program 2007-2008 by Daniel Wholley.

It can be inferred from the Akerman report that outcrops of rock, hills or ridges above the plains could be sites.

6.1.2 Archaeological

There would have been no archaeological surveys conducted over the Tenements. The geology and additional environmental factors indicate that there is low potential for archaeological sites within specific landforms, with an elevated level of archaeological potential in proximity to watercourses.

6.2 Recommendations – Aboriginal Sites

This report makes the following recommendations. KBL may consider:

- Conducting an archaeological survey over those parts of the Tenements they wish to disturb. This may reduce the risk of any Aboriginal person or group claiming a breach of the *Aboriginal Heritage Act 1972*.
- Conducting an ethnographic survey for works that are outside of the CBH Resources Sorby Hills Exploration and Evaluation Program 2007-2008 by Daniel Wholley.
- Submitting a Section 18 for any works that are to disturb a Site.
- Ensuring that all future heritage reports include as a minimum the following details
    - The qualifications of the heritage consultant;
    - Details of the selection process for the Aboriginal consultants;
    - Provide geospatial information of the area surveyed and any Sites identified; and
    - Clarify if the survey is ethnographic and/or archaeological.

7 References

Aboriginal Heritage Act 1972

Akerman, K. 2007 *Work Programme Clearances on the CBH Resources Ltd, Sorby Hills and Jeremiah Hills Mining Leases*, *Kununurra*

Yawoorroong Miriuwung Gajerrong Yirrgeb Noon Dawang Aboriginal Corporation 2010 *KIMBERLEY METALS LTD SORBY HILLS PROJECT M80/196, M80/197, M80/285, M80/286, M80/287 (Proposed) Heritage Site Redefinition*

Appendix 9: DIA Heritage Register search results

Search Criteria

Site 15427

Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

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Legend

Restriction

N	No restriction
M	Male access only
F	Female access

Access

C	Closed
O	Open
V	Vulnerable

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

[Reliable] The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.

[Unreliable] The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information reported.

Status

L - Lodged		IA - Information Assessed		ACMC Decision Made
Information lodged, awaiting assessment	→	Information Awaiting ACMC Decision Assessment Only	→	R - Registered Site I - Insufficient information S - Stored Data

*Explanation of Assessment

Sites lodged with the Department are assessed under the direction of the Registrar of Aboriginal Sites. These are not the final assessment.

Final assessment and decisions will be determined by the Aboriginal Cultural Material Committee (ACMC).

Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of sites, especially for sites with an access code “closed” or “vulnerable”. Map coordinates (Lat/Long) and (Easting/Northing) are based on the GDA 94 datum. The Easting / Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '5000000:Z50' means Easting=5000000, Zone=50.

Sites Shown on Maps

Site boundaries may not appear on maps at low zoom levels

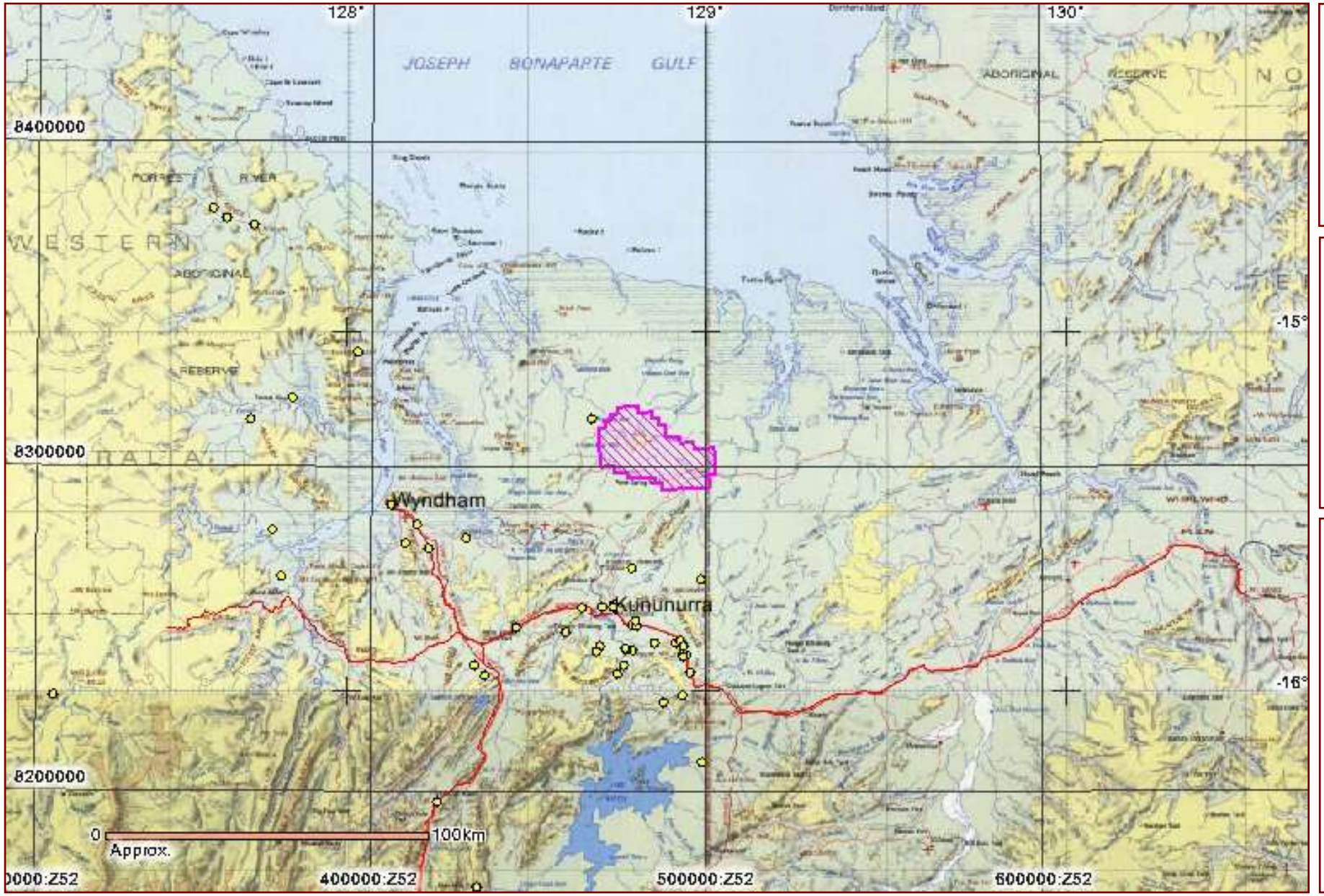
List of Registered Aboriginal Sites with Map

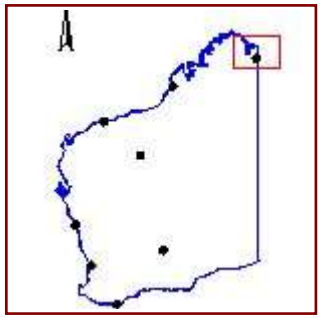
Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
15427	R	C	N	Jungil Complex.	Ceremonial, Mythological, Repository / cache, Skeletal material/Burial, Man-Made Structure, Modified Tree, Painting, Engraving, Quarry, Artefacts / Scatter, Midden / Scatter, Grinding patches / grooves	Ochre	*Registered Informant names available from DIA.	Not available for closed sites	K02926

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Aboriginal Sites Database





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Registered Sites

Town

Map Area

Search Area

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Search Criteria

1 surveys in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 52	
Northing	Easting
8288668	495146
8293380	498479

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[CLOSED]	Closed
[OWE]	Open with exception
[TBD]	To be determined
[RESTRICTED PENDING]	Restricted pending

Survey 1654

Project	Amity Oil, EP 386, Kimberley
Start Date	31 Dec 1997
Proponents	Amity Oil NL
Consultants	N/A
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

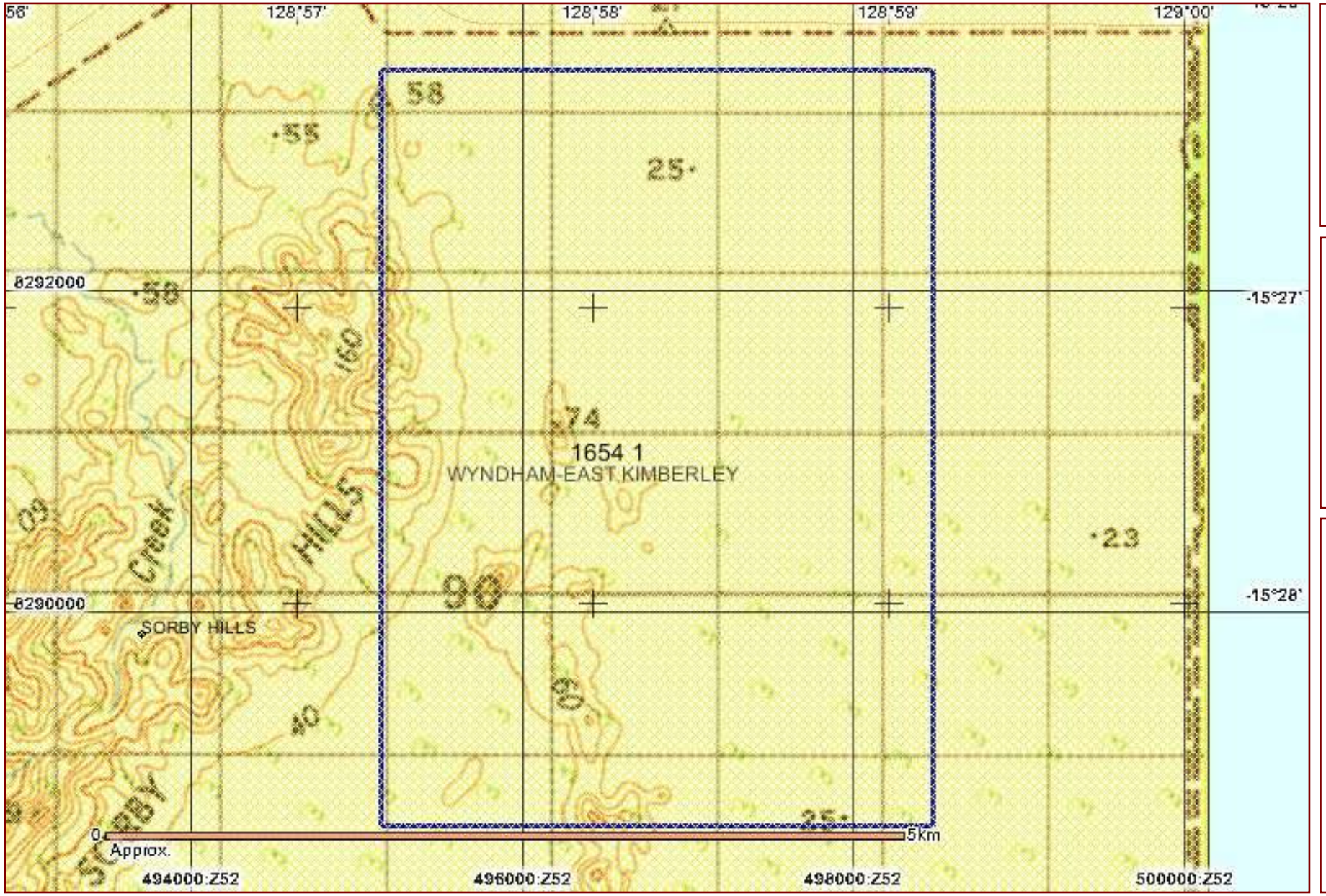
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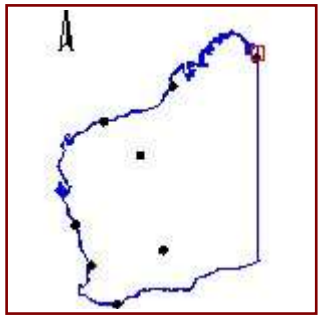
Report ID	Catalogue Number	Title	Recorders	Held At
102298	HSR EK 1998 AMI [CLOSED]	Section 18 Application Ep 386. 1998.	Greg Irwin	DIA

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Accuracy is shown as a code in brackets following the site coordinates.

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Status

L - Lodged		IA - Information Assessed		ACMC Decision Made
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Sites Shown on Maps

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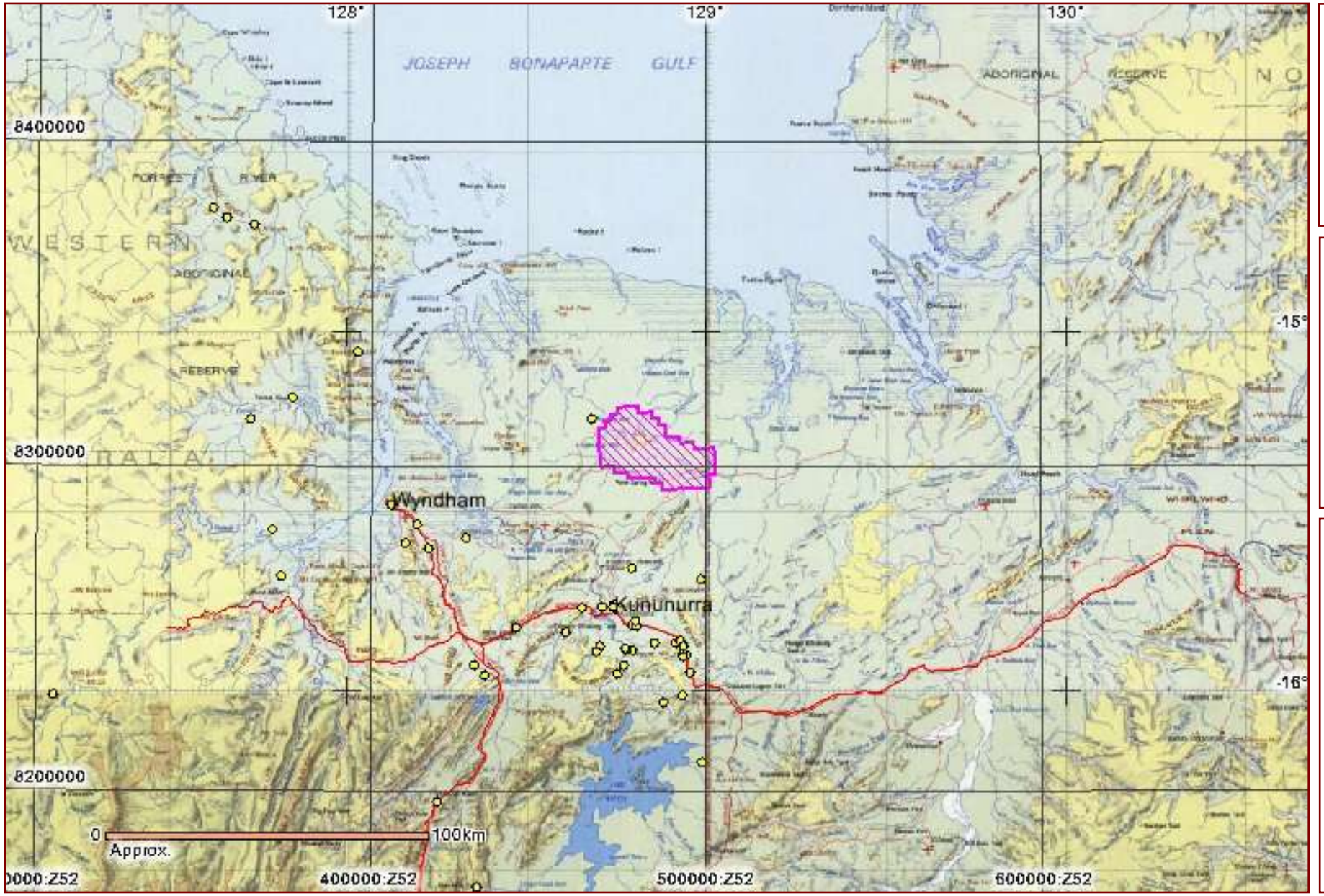
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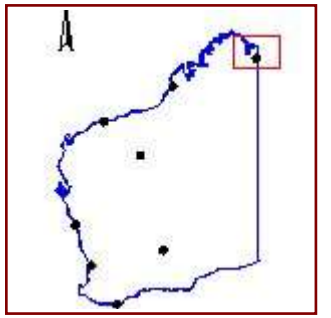
Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
15427	R	C	N	Jungil Complex.	Ceremonial, Mythological, Repository / cache, Skeletal material/Burial, Man-Made Structure, Modified Tree, Painting, Engraving, Quarry, Artefacts / Scatter, Midden / Scatter, Grinding patches / grooves	Ochre	*Registered Informant names available from DIA.	Not available for closed sites	K02926

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Proponents	Amity Oil NL
Consultants	N/A
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

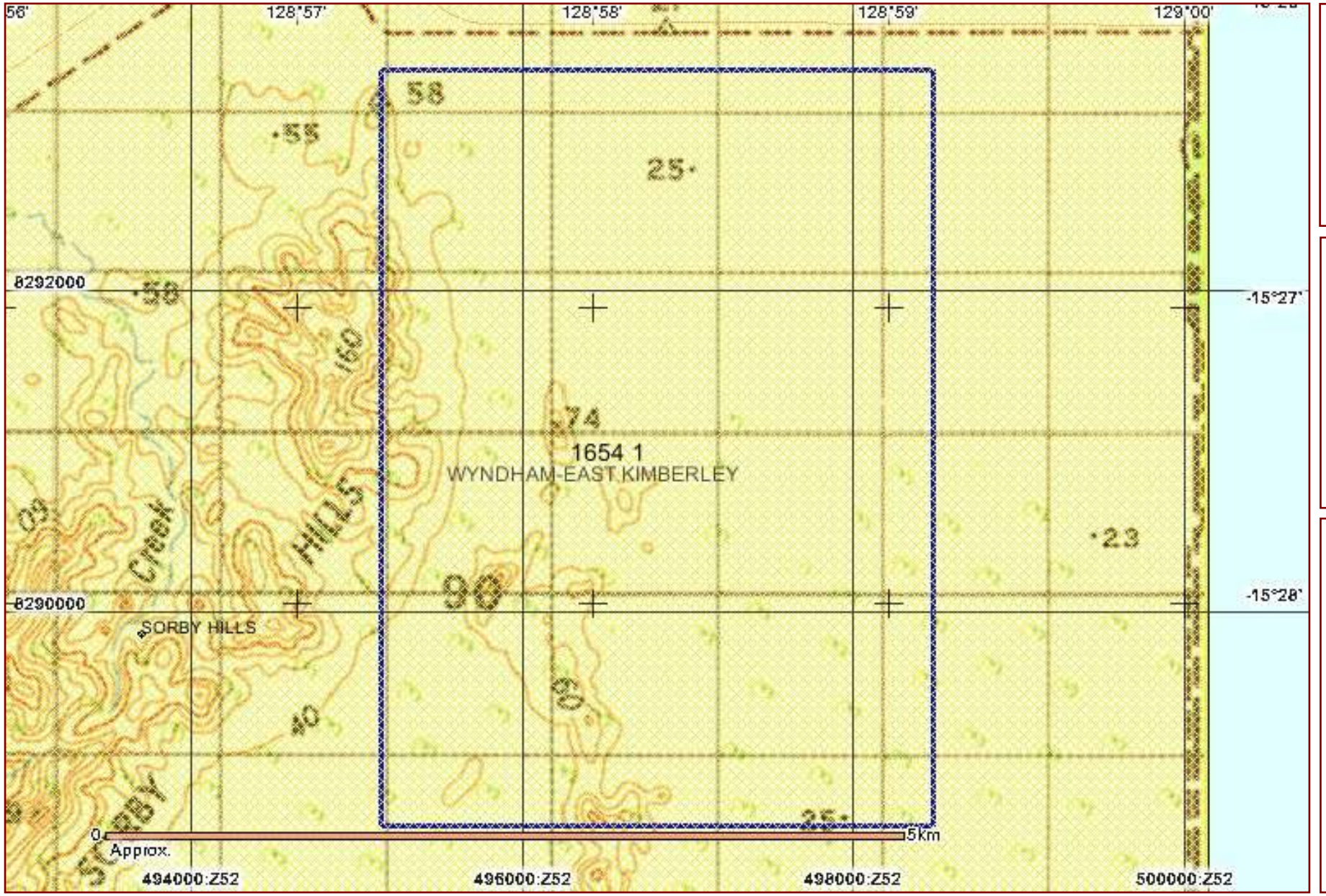
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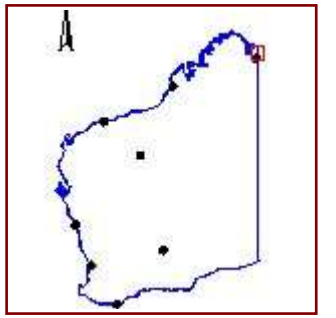
Report ID	Catalogue Number	Title	Recorders	Held At
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Appendix 10: Archaeological and Ethnographic Surveys

Report to the Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Aboriginal Corporation of an Archaeological Assessment of Locations Associated with Proposed Works at the Sorby Mine Site, North of Kununurra, East Kimberley, Western Australia for Kimberley Metals Ltd.

Greg Carver, B Archaeol (Hon), MA
PO Box 667
Mylor SA 5153
0418820260

19th – 21st October 2011

Executive summary

This document details the results of an Archaeological inspection of locations associated with works proposed by Kimberley Metals at the Sorby Mine Site north of Kununurra in the East Kimberley, Western Australia.

The inspections were conducted in three days between 19th and 21st October 2011.

Results
The request clearance area delineated by waypoints 1 – 11 – 31 – 34 – 35 – 33 – 8 – 9 – 10 – 3 – 1 as defined on the maps in Appendices 2 and 3 is **cleared with the condition** that no work is conducted west of the green line extending between WP 11 – 33 as detailed on Map 1 Appendix 2 and with the following modification to the location of the green line:

Point 32 no longer exists, the new western boundary of the work area extends from WP 11 – 31 and continues to points 34 and 35 and then back to 33 as detailed in the GPS map 2 in Appendix 3.

Further details are provided in the Conditions and Conclusions section of this report.

Confidentiality

The information contained in this report should not be disclosed without the authority of the Miriuwung Gajerrong Prescribed Corporation and the Kimberley Metals.

Copyright

This report is subject to copyright and no portion should be copied without the authority of the Miriuwung Gajerrong Prescribed Corporation and the Kimberley Metals.

Disclaimer

To the best of the author's knowledge the information contained in this report is accurate. The author is not responsible for any additional information not disclosed whilst undertaking this project.

Terms and Abbreviations

DIA – Department of Indigenous Affairs.
GPS – Global Positioning System.
KLC – Kimberley Land Council.
MG - Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Aboriginal Corporation
TO – Traditional Owner.
WPC – Work Program Clearance.

Acknowledgments

The author of this report would like to thank all those who participated in this WAC for their assistance before, during and after the clearance. Thanks to Lubor Hon for his assistance in the field and thanks to Dominique Reeves and Franklin Gaffney for their assistance in organising and coordinating all aspects of the clearance.

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1 Introduction

1.1 Background Information

At the Sorby Hills Mine Site, located approximately 50 kilometres north-east of Kununurra (Maps in Appendices 1 and 2) in the east Kimberly, Kimberley Metals are proposing to begin operating an open cut mine for silver, lead and zinc. As part of the works Kimberley Metals proposes to use land on M80/197 and M80/286 for the construction of office buildings, workshops, laydown areas, new haulage roads, tailings dumps and the open cut mine site. Full details of the mining proposal are provided in Appendix 1.

The area is heavily disturbed by previous mineral exploration and mining that has been conducted since the 1970 and into the 1980s. Approximately 900 exploration holes have been drilled in the region during this period. Historic and recent drilling pads along with associated access tracks are visible in many areas. In addition the area has been part of Carlton Hill Station and consequently has cattle yards, cattle watering troughs, a dam, loading ramp, water bores and extensive fencing and station tracks that have disturbed much of the area. Cattle still remain in the area now.

The Miriuwung Gajerrong Traditional Owners requested an archaeological Heritage Clearance be conducted before the new mine commenced. Kimberley Metals agreed with this suggestion to ensure there was nothing of archaeological significance in the area that would be damaged or disturbed during the mining activities. Numerous anthropological inspections have been conducted in the area but very little archaeological work has been conducted previously.

The author of this report was contracted by the Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Aboriginal Corporation (MG Corp) to conduct an Archaeological Work Program Clearance (WPC) to inspect the locations of the proposed works.

Dr Kim Doohan and Mr Joh Bornman were also engaged to conduct further anthropological work in the area with senior Traditional Owners. The results of that work are the subject of a separate report held by MG Corp (Bornman and Doohan 2011).

The Archaeological WPC was conducted over three days from Wednesday the 19th and Friday 21st October 2011.

1.2 Purpose of Investigation and Compliance

The WPC inspections which are the subject of this report were undertaken to assess the potential impact of the proposed work on known places of Aboriginal cultural significance and to identify and locate any previously un-recorded evidence of Indigenous cultural or spiritual significance which might impose constraints on the design or implementation of future work.

It is also intended that the WPC inspections and this report will assist Kimberley Metals to avoid damage, disturbance or interference with Aboriginal sites and objects protected under the *Aboriginal Heritage Act* 1972.

1.3 Aboriginal Heritage Act 1972.

Section 17 of that Act states it is an offence for:
A person who —

> (a) excavates, destroys, damages, conceals or in any way alters any Aboriginal site; or
> (b) in any way alters, damages, removes, destroys, conceals, or who deals with in a manner not sanctioned by relevant custom, or assumes the possession, custody or control of, any object on or under an Aboriginal site, commits an offence unless he is acting with the authorisation of the Registrar under section 16 or the consent of the Minister under section 18.

2 Survey Area

2.1.1 Location

The survey areas are approximately 50 kilometres by road north-east of the township of Kununurra and approximately 2 kilometres west of the Northern Territory - Western Australia border. Kununurra is located in the East Kimberley approximately 100 kilometres south east of Wyndham and approximately 35 kilometres west of the Western Australian – Northern Territory border. The area is traditionally associated with the Miriuwung Gajerrong Traditional Owners.

2.1.2 Environment

Despite being in the tropics Kununurra experiences a steppe climate, with the wet season from late November to March and the dry season from April to early November. The hottest month is November with an average maximum temperature of 39.5°C, and the coolest month is June with an average maximum of 31.0°C. The annual average maximum temperature is 35.6°C, one of the highest in Australia. Overnight temperatures rarely fall below 5.0°C and only fall below 10°C about once a week during June and July. In 1946 Wyndham, to the west, recorded 333 consecutive days of temperatures over 32°C. (www.bom.gov.au).

The mean annual rainfall is about 550mm, although there is considerable variation from year to year. Over 80% of the average annual rainfall occurs between December and March and is associated with thunderstorms and tropical lows or cyclones. It is not uncommon for very little rain to occur for many months. The median rainfall for the months of June to September is zero.

2.1.3 Vegetation.

Vegetation distribution in the eco-region is strongly associated with soil, geological factors, and the high rainfall. Dominant grasses are the tall grass species, especially Sorghum, Heteropogon, Themeda, Chrysopogon, Aristida, and Eriachne spp. Larger canopy trees included bloodwood eucalypts (Corymbia spp.) or, on deeper soils in higher rainfall areas, eucalypt-dominated woodlands with Darwin stringybark

(Eucalyptus tetrodonta) and Darwin woollybutt (E. miniata) and the smaller Acacia spp. (Beard and Sprenger 1984; Petheram and Kok 1983). Boab trees are found in the wide river valleys.

2.1.4 Geology.

The Kimberley region is an area of complex and diverse geology representing a time frame extending from ancient Proterozoic rocks formed more than 1800 million years ago, to the dune systems and sandstones of more recent times. In Devonian times (375-350 million years ago) a large part of the Kimberley was covered by a warm shallow sea with fringing coral reefs. Erosion, geological movement and varying sea levels have changed and sculptured these landform and, as the sea level has fallen to its present level, fossilised materials from old sea beds and coral reefs have been exposed by erosion to form Devonian reefs (Kimberley Development Commission www.kdc.wa.gov.au/kimberley/tk_geo.asp).

3 Field Survey Time Frame

The WPC was conducted in five days between the 19th – 21st October.

4 Methodology

4.1 Desk Top Study

Numerous papers and books discussing stone tool technology in the Kimberly have been written over the years. Some of those consulted for this report include (Akerman 1975, Akerman and Bindon 1995; Akerman et al. 2002; Holdaway and Stern 2004).

4.1.1 Regional Archaeological Research

Previous archaeological research in the wider Kimberley region has recorded Pleistocene occupation dates from between 40,000 and 30,000 years BP. Riwi (Mimbi Caves) was first occupied about 42,000 years BP (Balme 2000) and Widgingarri 1 and 2 on the coast north of Derby and Carpenter's Gap were occupied between 40,000 and 30,000 years BP (O'Connor 1999; McConnell and O'Connor 1997). Research at these sites also identified a long period of abandonment coinciding with a pattern of climate change and an expansion of the arid zone during the Last Glacial Maximum (LGM) (O'Connor 1999; Balme 2000). Widgingarri Shelters 1 and 2 and nearby Koolan Shelter 2, probably occupied by 30,000 years BP (O'Connor 1999:49), were several hundred kilometres inland during the LGM and, together with Riwi in the southern Kimberley, would have been well within the arid zone (Balme 2000:2-4, O'Connor 1999:49, 60). Recent research on the LGM suggests that the onset of this arid period may have been earlier in the arid zone areas and would have therefore influenced the abandonment of living areas because of the increasing scarcity of water and food (Wallis 2001). In addition, palaeobotanical studies at Carpenter's Gap 1 (near Windjana Gorge) found evidence of a reduction in trees and shrubs and an increase in grassland between 30,000 and 15,000 BP (McConnell and O'Connor 1997).

These archaeological sites are in the west Kimberley and are associated with river valleys, although climatic changes during the LGM would have been the same, if not similar in the East Kimberley. The Miriwun rockshelter was excavated by Dortch in 1971 prior to the inundation of the Ord River by the Ord Irrigation Scheme. Miriwun had a basal deposit dated to 18,000 years BP, the height of the LGM. The upper level contained an assemblage of small tools, but the lower levels, dated between 3,000 and 18,000 years BP, was a distinctive early assemblage that included thick, denticulated flakes, adze flakes, core-scrapers, small blades and, among the Pleistocene artefacts, a ground stone axe (Dortch 1972; 77; see also Jones and Bowler 1980).

4.1.2 DIA register of Aboriginal Sites.

A search of the Department of Indigenous Affairs (DIA) Aboriginal Heritage Inquiry System revealed a registered site, Jungil Complex, Site # K 02926 to the north of the Sorby Mine Site. The buffer zone of this site extends into the northern section of Tenements M80/286 and M80/197 but does not extend into the proposed work area. The map defining the relevant buffer zone and site identification numbers is attached in Appendix 6.

4.1.3 Previous Reports

There are a number of previous reports relating to WPCs in the area. These reports are held by MG, KLC and/or the DIA. It is apparent that most of these reports relate to Anthropological work conducted in the area. Hammond *et al* discusses archaeological inspections of areas to the east and west of the mine site but did they did not inspected the proposed work areas related to this WPC. A review of those previous reports relevant to the current WPC is presented below.

Doohan, K. and Bornman J. 2010. *Kimberley Metals Ltd Sorby Hills Project M80/196, M80/197, M80/285, M80/286, M80/287 (Proposed) Heritage Site Redefinition Report to MG Corporation*.

This report discusses the boundaries of DIA Registered Site ID 15427, Site no K02926. It is clear from page 8 of this report that Traditional Owners gave permission for the 2010 drilling program to continue but stipulated further consultation must take place before any mining commences in the area. The report discusses anthropological issues but it is apparent that no specific archaeological survey was conducted.

Akerman, K. 2007. *Work Programme Clearances on the CBH Resources Ltd, Sorby Hills and Jeremiah Hills Mining Leases, Kununurra*. August 2007.

This report appears to have inspected the general area of the mine but no detailed description of the actual areas inspected during the WPC are provided. The importance of certain landscape features are discussed however there is no mention of the archaeology of the area.

Hammond, C., Greenfeld, P., Tonkin, N., Bunting, D., and Hook, F. 2004. *A Report of the Aboriginal Archaeological Assessment of the Ord River Irrigation Stage II Development Area (Priority Inspection Areas), near Kununurra, Western Australia for the Kimberley Land Council*. October 2004.

An extensive archaeological inspection of a large area that includes the Sorby Hills vicinity. Sample area SA 09 that was inspected as part of the survey is due east of the Sorby Hills but does not include the proposed mine site. The report provides general background archaeological information for the region.

Barber, K. and Rumley, H. 1998. *Work Program Clearance Report of the heritage Survey for the Proposed Wesfarmers, Marubeni and Water Corporation Stage One Works of the Ord River Irrigation Area (Stage2) Project*. October 1998.

Extensive anthropological report that mainly discusses areas to the north, east and south of Sorby Hills. Sorby Hills are mentioned but from an anthropological point of view rather than an archaeological perspective. The survey viewed and discussed the Sorby Hills from a distance but did not inspect the proposed work areas.

Turner, Jan. 1987. *Results of a survey to locate Aboriginal sites prior to installation of Telecom DRCS stations in Kununurra - Halls Creek Area, Kimberley, Western Australia.* May 1987.

As part of a larger Work Program the report discusses a site that was inspected north of Sorby Hills but does not include the proposed mine site. The report provides relevant general archaeological background information.

4.2 Field Survey

WPC team members conducted visual inspections of sections of each of the locations and a pedestrian survey of some sections of the proposed areas. Much of the area was inspected by driving through the areas and where points of interest were noted a walking transect was conducted to inspect the region. Thick vegetation covers much of the area making ground visibility difficult. It is possible the thick grass impeded the location of any artefacts that may have been present but this is unlikely considering the landscape is not conducive to Indigenous habitation sites.

4.2.1 Data Collection

Spatial data. A hand-held Garmin GPS was used to record the locations of all aspects of the Work Program Clearance Survey Request (see Appendix 3 for a GPS map and a list of all Waypoints.

Datum: GDA94; Zone reference: 52L

Photographic record. All locations were recorded using an Olympus digital SLR camera. See Appendix 7.

4.2.2 Field Survey Report

Tuesday 18th October 2011

After arrival in Kununurra the consultant met with Kim Doohan and Joh Bornman who were to conduct further anthropological work at the mine site, to discuss logistics for the following day. A second meeting was then conducted with Dominique Reeves – MG lawyer to further discuss the program and logistics.

It was agreed that the consultant would conduct a preliminary investigation of the area with two or three TOs the following day to determine exactly what areas required further archaeological investigation. Then on Thursday the consultant would return with TOs to inspect those areas believed to be a high priority for the location of archaeological material. At the same time on Thursday Joh Bornman would visit the area with senior men to ensure there were no men's issues that needed to be addressed. On Friday the archaeological inspections would continue if necessary. Also on Friday Dr Kim Doohan would visit the area with senior women to ensure there were no women's issues associated with the area that needed to be addressed. It was agreed the consultant would provide an archaeological report to MG and a separate anthropological report would be provided by Kim Doohan and Joh Bornman.

At the conclusion of the meeting the consultant met with Button Jones to arrange a time to conduct the preliminary inspection of the mine site area the following day. It

was agreed for the consultant to collect Mr Jones and Mr Ronny Carlton the following morning at 7:30am.

Wednesday 19th of October 2011.

After collecting Button Jones, Ronny Carlton and Mr Carlton's grandson Dion Jimala a meeting was held to explain the proposed Work Program Clearance. The team then met with Mr Lubor Hon, Sorby Mine Project Engineer, at the MG office. After further discussions the team travelled to the mine site.

On arrival at the mine site a meeting was held (Photo 1) to discuss the proposed inspection areas. It was agreed that Mr Hon would lead the team to each of the proposed work areas that are detailed on the maps and in Appendix 2. It was explained the main areas to be cleared included a plant site and mining infrastructure area that incorporated offices/workshops and lay down/storage sections. This area was delineated by the yellow box on the map. The next area, delineated by the pink boxes on the map, was a tailings dump area. The third area was the open cut mine site indicated by the red circles on the map. In addition there would be a new haulage road, access tracks and pipeline corridors constructed throughout the area.

Mr Hon explained he was unsure of the exact boundaries of the work areas but he requested the majority of the mining lease be inspected and cleared rather than just the areas indicated on the map. This would provide the company with alternative locations for their work areas if required. the TOs discussed that under no circumstances was there to be any work conducted in the actual Sorby Hills. Mr Hon explained that there was a green line marked on the map (Map 1 Appendix 2) and the company would not be conducting any work west of that line. There was one small hill (Photo 2) near the old quarry (Photo 3) and core storage sheds (Photo 4) that would be used for part of the mine infrastructure but no other hills would be touched. The remainder of the work areas and mine site were on the flat black soil plains to the east of the green line.

It was agreed to inspect the main areas delineated on the maps in Appendix 2 and make a final decision after the inspections. The team first conducted a visual inspection of the old quarry site (Photo 3) and the main infrastructure area delineated by the yellow line on Map 1 Appendix 2. It was explained that the majority of the entire area within the yellow line on the maps in Appendix 2 would require clearing to allow new office blocks, workshops, lay down areas, storage areas, etc. to be built. It was noted and discussed that the majority of this area was highly disturbed from previous mining works, cattle yards, vehicle tracks, fences and ongoing station activities.

The team then inspected the location of the old mine site (Photo 5) before continuing to the location of the new tailings dumps (Photo 6) delineated by the pink lines on the maps in Appendix 2. This area was located on black soil plains that once again had been highly disturbed from previous and current drilling programmes conducted since the 1970s. It was explained that the majority of this area would require excavating to approximately 3 m and it would be then filled with mine tailings to height of approximately 3 m above the existing ground level. Once again Mr Hon was unable to identify the exact boundaries of this area.

The team then continued to the approximate location of the southern boundary of C Pod of the new open cut mine site (Photo 7). The team then drove to the eastern boundary E Pod of the proposed new mine site and then continued to northern boundary of E Pod of the mine site (See Maps in Appendix 2 for Pod locations).

It was then decided to continue to the main Weaber Plain road and drive to the north eastern corner of the mining lease (WP 10 Map 2 Appendix 2) to understand the extent of the proposed clearance area.

The team said they were familiar with the area and did not believe there was anything significant on the black soil plains in this section of the Tenement. All agreed that there were no issues with the majority of the area providing the company did not extend the mine or any works into the Sorby Hills. Mr Hon reiterated that there was no mining west of the green line delineated on the maps in Appendix 2. Mr Hon once again restated that he was unsure of the exact boundaries of all the clearance areas but it was agreed he would provide the exact coordinates of the proposed areas after retuning to the office. This would allow the selected TOs and consultant to return tomorrow to inspect and map the actual area with a GPS. This would allow the location of the green line to be inspected to ensure it was sufficiently far enough away from the Sorby Hill and they would not be affected. An archaeological inspection could then be conducted of as much of the area as possible to the east of the green line.

The team returned to Kununurra arriving at approximately 1pm. It was agreed the consultant would collect Dion Jimala and another young man the following morning to assist in a pedestrian survey of the clearance area where possible.

After returning to Kununurra the consultant met with Dominique Reeves to discuss the extension to the proposed clearance areas. Ms Reeves explained that her understanding was that the clearance was only supposed to include the areas delineated by the yellow and pink lines and the mine site to the east of the green line. However Ms Reeves then explained that MG Corp had no issues with the proposed extension to the clearance areas providing the Traditional Owners agreed with the extra area being cleared. The consultant confirmed that the TOs present on the day agreed to the extra area but it also needed to be discussed further with the other senior male and female TOs inspecting the area over the next two days.

The consultant then met with Kim Doohan and Joh Bornman to apprise them of the proposed extension to clearance area. It was agreed that the consultant would meet with Mr Bornman at the mine site tomorrow to further discuss the extension to the proposed clearance areas with the senior men.

Thursday 20th of of October 2011

At 7 am the consultant attempted to collect Dion Jimala and others to assist in the archaeological survey but nobody was available to attend for the day. The consultant then met with Joh Bornman, Button Jones, Ronny Carlton, David Newry and Vincent Bilminga.

It was agreed Mr Biminga would travel with the consultant to assist in the archaeological survey and the remainder of the team would travel with Mr Bornman to discuss any anthropological issues relating to the area.

On arrival at the mine site a meeting was held to discuss extension to the clearance areas requested by Mr Hon yesterday. It was explained that Mr Hon had provided the actual waypoints to the consultant the previous evening (Map 2 Appendix 2 and Maps in Appendix 3). The consultant had downloaded the waypoints into his GPS the previous evening. Throughout the day Mr Biminga and the consultant would track the location of the waypoints provided by Mr Hon to ensure that no areas of significance were going to be encroached upon by the proposed mining activities.

All agreed with the suggestion so the consultant accompanied by Vincent Bilminga proceeded with their inspection while Mr Bornman accompanied the remainder of the team on their inspection of the proposed work areas.

For the remainder of the day the consultant and Mr Vincent Bilminga traversed the proposed areas but no archaeological material was located. This was not considered surprising because the majority of the area was located on black soil plains that are largely considered unsuitable for Aboriginal occupation. Some quartzite hills in the area would have provided suitable material for stone tool construction but no evidence was found to support this theory.

In addition most of the area has been highly disturbed by previous drilling programmes and cattle grazing. Mr Hon had explained that over 900 drill holes had been drilled in the region over the previous years. The drilling pads and associated access tracks required for the drilling programs would have necessitated the clearing of much of this land so any archaeological evidence that may have been present would be destroyed or buried.

Whilst following the green line in the vicinity of Waypoint 31 a limestone hill was located (Photo 8). It was considered unacceptable to include this hill within the cleared area so the green line was detoured around this point. The detour around the hill extends from Waypoint 31 to Waypoint 34 to Waypoint 35 and back to the Green line at Waypoint 33. Waypoint 32 is excluded from the clearance area (see Map 2 in Appendix 3 for further details).

After traversing much of the proposed work areas the consultant and Mr Vincent Bilminga return to Kununurra at approximately 2pm.

After arrival at Kununurra the consultant met with Mr Joh Bornman to discuss the clearance progress. Mr Bornman explained that the senior men that he had consulted with during the day had agreed to clear the extended request area and all but one had signed the clearance map in Appendix 5. Vincent Bilminga also agreed to clear the extended request area before he signed the clearance map.

The consultant discussed the progress with Mr Hon later that afternoon. It was agreed to meet the following day at 7:30 am to provide details of the detour in the western boundary indicated by the green line and the progress of the WPC to the senior women who were to accompany Kim Doohan on their inspection of the area. It was

agreed the consultant would then accompany Mr Hon to show him the exact location of the detour around the limestone hill the following day.

Friday 21st October 2011

The consultant met with Kim Doohan, the senior women and Mr Hon at 7:30am. The consultant showed the team a GPS map that he had downloaded onto a laptop the previous evening. The map detailed where Vince Bilminga and he had inspected the previous day including the details of the western boundary detour around the limestone hill in the vicinity of WP 32.

It was agreed the consultant would meet Mr Hon at the mine site after the women had conducted their survey so he could show him the exact location of the limestone hill. The consultant continued to inspect sections of the proposed clearance areas whilst waiting for Mr Hon and once again no archaeological evidence was located.

After showing Mr Hon the location of the limestone hill he agreed that it should not be a problem for the company to exclude the hill from the work area. He would discuss the exclusion further with Management to confirm but believed it would not be an issue. (It was later confirmed via email [See Correspondence in Appendix 4] that the Kimberley Metals had agreed to exclude the hill from the work area).

After inspecting the hill it was arranged to conduct a final meeting with all consultants and Mr Hon at 2 pm at the MG office. At the final meeting it was agreed the area delineated by waypoints 1 – 33 the maps in Appendices 2 and 3 was cleared with the condition that no work is conducted west of the green line and with the following modification to the location of the green line:

> **Point 32 no longer exists, the new western boundary of the work area commences from point 31 and continues to points 34 and 35 and then back to 33 as detailed in the GPS map in Appendix 3.**

Dr Doohan explained that the women had inspected and cleared the extended clearance area and had all signed the map earlier. Each of the consultants and Mr Hon signed the clearance map presented in Appendix 5.

5 Conditions and Conclusions

No archaeological material was located in the areas inspected during the WPC. However, all mining personnel should be made aware that all Aboriginal material culture is protected under the Aboriginal Heritage Act and it is an offence to damage or destroy any artefacts or sites located. It is possible that sites may be located during the proposed works and if so work must stop immediately until the site can be assessed by a professional Archaeologist or Anthropologist.

The request clearance area delineated by waypoints 1 – 11 – 31 – 34 – 35 – 33 – 8 – 9 – 10 – 3 – 1 as defined on the maps in Appendices 2 and 3 is **cleared with the condition** that no work is conducted west of the green line extending between WP 11 – 33 as detailed on Map 1 Appendix 2 and with the following modification to the location of the green line:

Point 32 no longer exists, the new western boundary of the work area extends from WP 11 – 31 and continues to points 34 and 35 and then back to 33 as detailed in the GPS map 2 in Appendix 3.

It is **requested** that any work opportunities generated by the proposed works be given to the local Traditional owners.

It is **recommended** that an Aboriginal Cultural Awareness Program is implemented by Kimberley Metal Ltd for all mining personnel who will be working on the Sorby Hills Mine Site.

6 Endorsement

In accordance with the advice of the survey team members and their directions in this matter I verify that this report and the survey which was conducted prior to its compilation, were completed in accordance with the wishes of the Native Title parties and that this report is a true and correct record of the decisions which were made.

I believe I have made all the inquires and included all the information I believe relevant and appropriate to identifying and describing Aboriginal sites and objects located within the survey area, consistent with my area of expertise and in accordance within the obligations of my Agreement.

Signed.....

Greg Carver
Archaeologist

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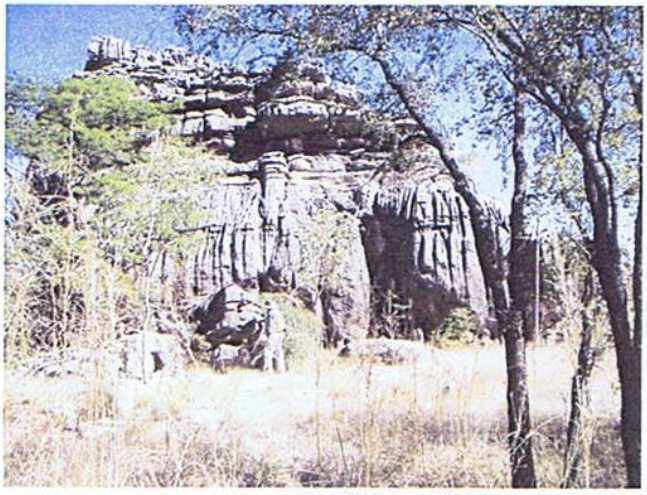
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8 Appendix 1. Mining Proposal.

MINING PROPOSAL

SORBY HILLS SILVER LEAD ZINC PROJECT

KIMBERLEY, WESTERN AUSTRALIA



NOVEMBER, 2011

MINING PROPOSAL FOR THE CONSTRUCTION AND OPERATION OF THE SORBY HILLS SILVER LEAD ZINC PROJECT MINE SITE

Tenements M80/197 & M80/286

Prepared by Sorby Management Pty Ltd with the assistance of Animal Plant Mineral Pty Ltd

This Mining Proposal relates to activities on tenements M80/197 and M80/286.

1.1 Project Overview

Sorby Hills is a major undeveloped Silver Lead Zinc (Ag Pb Zn) deposit; the primary Lead mineral is Galena. The Sorby Hills mining leases contain 13 separate but adjacent mineralised ore pods within the platform carbonate rocks of the Burt Range Formation in the Bonaparte Basin. The ore pods form a linear belt (trending north – south) over 8kms long and up to 1km wide on the eastern margin of the Pincombe Inlier. The deposits have been well defined by extensive exploration.

The shallow nature of the deposits allows for extraction of ore by open cut mining. The Sorby Hills project covers an area of 1782.27ha (tenements M80/197 and M80/286). The project will initially consist of three open cut pits, comprising ore pods C, D and E, which are to be mined sequentially as separate entities, however as mining progresses the three ore bodies will be contained within one larger pit; the focus will be on resources within 70m of the surface. The ore will be processed by flotation and a concentrate produced for export through Wyndham. In addition to the open cut the project will consist of a ROM pad, waste dumps, haul roads, a mill and concentrator, laboratory, road train loading area, tailings dam, access roads, workshop, site office and laydown facilities at Wyndham Port.

400,000 – 600,000Tpa of ore will be excavated from the open pits and processed through the facility to produce 45,000Tpa of concentrate for export to the overseas market. Concentrate will be transported to Wyndham Port via road trains; there will be a maximum of 20 truck movements per week with an average of 12 trucks expected. SMPL are planning to utilise existing Wyndham Port facilities and ship once a month for 11 months each year; shipping consignments will contain approximately 4,000t of concentrate.

The Sorby Hills project will have a very significant impact on the community of Kununurra where SMPL (and subcontractors) will employ and accommodate site personnel. In addition, employment opportunities will be created at the Wyndham Port which may benefit the community of Wyndham. SMPL maintain a high degree of community focus and will develop the Sorby Hills project in line with best practise, community, environmental and safety standards.

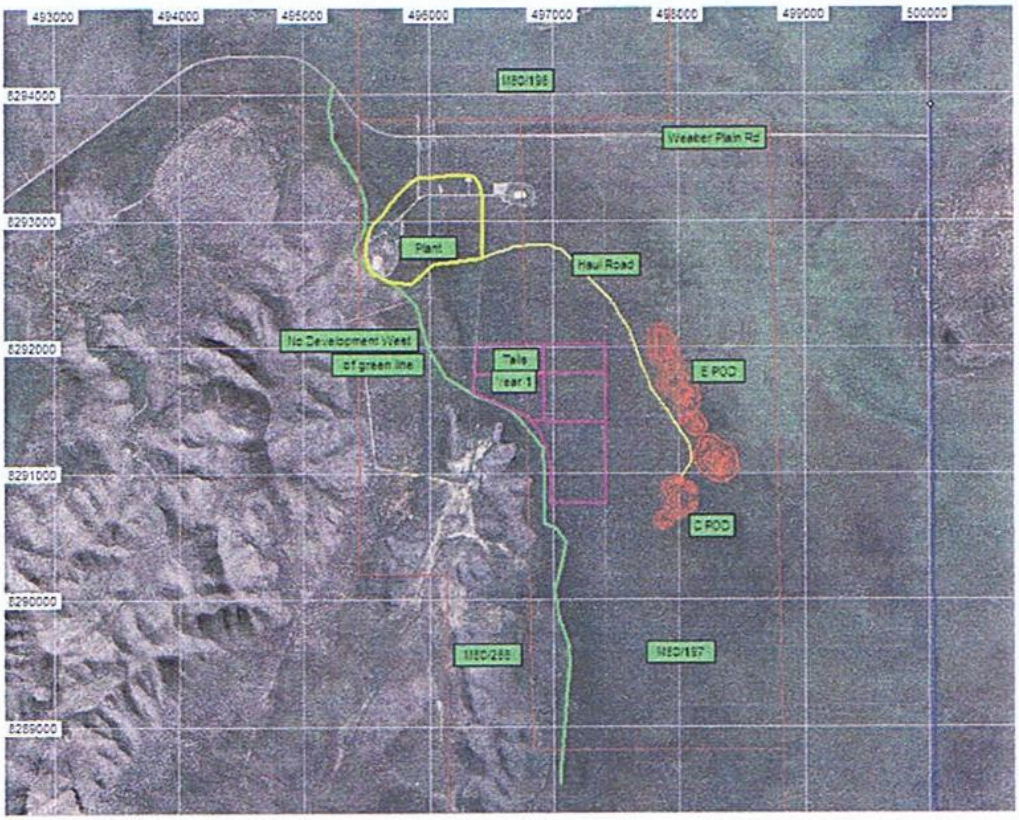
Critical dates for Sorby Hills include:

December 2011	Feasibility
April 2012	Project approvals
May 2012	Commence construction
December 2012	Commissioning
First Quarter 2013	Production
2027	Closure

1.2 Location and Site Layout Plans

Sorby Hills is situated in the north-east Kimberley region of Western Australia close to the Northern Territory border. The Sorby Hills mine site is located approximately 50km by road north-east from the regional centre of Kununurra. The relevant Sorby Hills tenements lie to the east of the currently proposed Ord River expansion stage two, with a common boundary on the north-western edge of the Sorby Hills Project (tenement M80/196). A location map is provided as Plan X.

Detailed site layout plans for the Sorby Hills Project Site are provided as Plan X. This plan illustrates the location and scale of site infrastructure (overlaid on aerial photography and topographic data), along with key aspects of the existing environment such as vegetation communities, creeks and drainage lines, major topographic features and heritage site locations.



1.3 History

The Sorby Hills deposit was discovered in 1971 by Elf Aquitaine. The project area was extensively and systematically explored for carbonate hosted lead and zinc deposits during the 1970's and 1980's by Mr Aquitaine with various joint venture partners. The exploration focused on delineating economic Lead and Zinc resources within the platform carbonate lithologies of the Bonaparte Basin.

Exploration consisted of geochemical surveys, various geophysical surveys and extensive drilling. Base of Overburden geochemical sampling by auger or RAB drilling was used very effectively over most of the project area; the programs targeted the prospective stratigraphy along the main Sorby trend in all of the current mining leases to some extent. Geophysical surveys were used comprehensively. The most effective methods for delineating mineralisation and structure were gradient array and dipole-dipole Induced Polarisation surveys, of which there is complete coverage over the main Sorby trend. Drilling programs at Sorby Hills have been quite intensive and comprehensive; approximately 888 holes were completed for ~95,000m from 1972 to 1988, of these drill holes approximately 374 were diamond holes.

Post 1990 little work was completed and the project was shelved in the late 1990's due to uncertainty surrounding the Ord River expansion scheme. In 2006 CBH Resources Ltd (CBH) reactivated the Sorby Hills project; in 2007 CBH commissioned a review of the economic potential of the Sorby Hills deposits which suggested that the deposits had potential for economic extraction. The results lead to a new phase of exploration which included a desktop review of historic data, a small scale diamond drilling program (13 holes), construction of a wireframe resource model and conceptual mining study. KML acquired the Sorby Hills Project in 2008 and entered into a joint venture agreement with HYG&L for the project in 2010; in late 2010 a 99 hole Reverse Circulation and Diamond drilling program was completed. The joint venture partners wholly own Sorby Management Pty Ltd (SMPL), the proponent currently managing the Sorby Hills Project.

The Sorby Hills project area is situated on land that was once covered by pastoral leases and as such pastoral tracks, cattle yards and other limited infrastructure is present on the tenements. At present cattle graze in the project area but the land will be de-stocked prior to mining. Some remnant disturbed areas and access tracks plus a core storage area are present on the Sorby Hills mining tenements from previous exploration.

1.4 Existing Facilities

There is little infrastructure currently on site. There is an access road linking the Sorby Hills site to the Weaber Plain Road, as well as pastoral and exploration tracks across the tenements. The limited infrastructure includes cattle yards, a dam, water and production bores, a small cattle loading ramp, a diesel pump, a core storage area and some disturbed areas and pads resulting from previous exploration. It is planned to utilise these existing degraded areas for the project's Plant site and other support infrastructure.

SMPL plan to utilise the Weaber Plain Road, Victoria Highway and Great Northern Highway to haul concentrate from the Sorby Hills Mine Site to the laydown facilities at Wyndham port. There will however be minimal utilisation of other public services for the project. Power will be generated on site and water will be sourced from mine dewatering and recycled water from the processing plant.

2 EXISTING ENVIRONMENT

2.1 Regional Setting

The Sorby Hills project area is situated at the north eastern extent of the Sorby Hills Ranges. Tenement M80/286 encompasses a portion of the Ranges and associated foot slopes; to the east of the hills in tenements M80/286 and M80/197 the environment is predominantly broad flood plains of red/grey clay pan (cracking clay) soils with Bohemia trees. Floodwaters draining off the eastern rangelands flow south east towards Knox Creek, however residual water bodies can remain present for extended periods at the base of the ranges.

Mapping for the Interim Biogeographic Regionalisation for Australia (IBRA version 6.1) programme placed the Sorby Hills project area in the Victoria Bonaparte Bioregion. This bioregion comes under the Tropical and Subtropical Grasslands, Savannas and Shrublands Ecoregion which stretches across northern Australia into northern NSW. The Victoria Bonaparte Bioregion continues into the Northern Territory as far as Bradshaw (Department of Sustainability, Environment, Water, Population and Communities, 2011). Within the Victoria Bonaparte Bioregion the vegetation over lowland parts of the survey area has been mapped as 'Tussock grasslands' while upland areas come under 'Tropical Eucalyptus woodland/grasslands'. Tussock grasslands covered an estimated 631,088ha (8.7%) of the bioregion prior to European settlement. By about 1997 this area was little changed at 631,032ha (8.7%). Tropical Eucalyptus woodland/grasslands covered an estimated 4,696,792ha (64.6%) of the bioregion prior to European settlement. By about 1997 this area had been slightly reduced to 4,678,368ha equating to 64.4% (Australian Government, 2011).

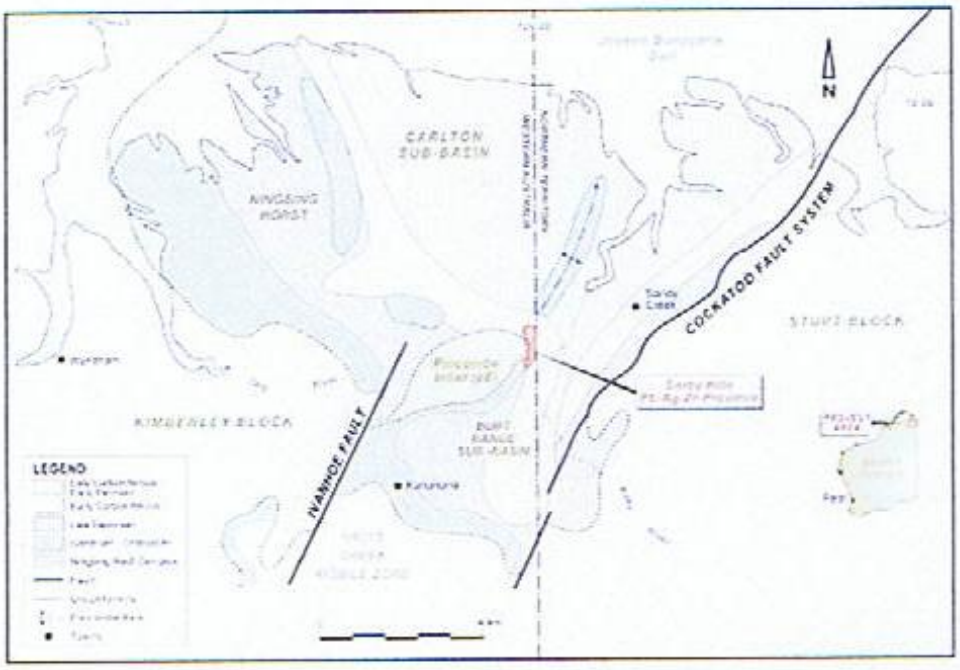
The project area lies in the Gardner Botanical District within the Northern Botanical Province of Western Australia (Beard, 1975) and encompasses the Pinkerton and Ivanhoe Land Systems (Department of Agriculture and Food, 2009).

2.2 Geology

The Sorby Hills mineralisation consists of thirteen discrete carbonate hosted Ag Pb Zn deposits (pods), Pods A – J, Beta Pod East, Beta Pod West and Alpha pod. The pods form a linear north – south belt extending over 8km, sub parallel to the eastern margin of the Pincombe Inlier and within the Burt Range Formation of the Bonaparte Basin.

The Bonaparte Basin unconformably overlies the north eastern margin of the Proterozoic Kimberley block. It is a northward-opening basin (Figure 2-1) of which 10% is currently above sea level; the sediments vary from Cambrian to Tertiary in age. The oldest part of the onshore basin is the Antrim Plateau flood basalts which unconformably overlies the Palaeoproterozoic basement of the Halls Creek orogen. Clastic sediments of the Late Cambrian and Ordovician Carlton Group locally overlie the basalts, after which there is a period of non-deposition and/or erosion from the Ordovician to the Middle Devonian. The onshore basin is dominated by Middle Devonian to early Carboniferous carbonate and clastic sediments, commencing with the Frasnian Cockatoo Group, dominated by sandstones (quartz arenites). During the Famennian, mixed carbonate-clastic sedimentation deposited the Ningbing Group reef complex and the Buttons Formation in the Sorby area. Reef growth was terminated in the Carboniferous, when shelf carbonates and clastics of the Tournaisian Burt Range Formation were deposited in the Sorby area. The Tournaisian carbonates are overlain transgressively by Visean basinal black shales of the Milligans Formation. Above this there is an unconformable contact with the Carboniferous – Permian Kulshill Group composed of fluvio-glacial sandstones.

Figure 2-1: Geological setting of the Sorby Hills mineralisation



There are two important structural trends in the Sorby area, a major set of north east trending faults and an antithetic set of north west trending faults. The north east trending faults are parallel and contiguous with the basement trends in the Pincombe Inlier, and are the major basin-bounding faults. The set includes the Ivanhoe Fault on the western margin and the Cockatoo Fault system on the eastern margin (Figure 2-1). The north west trending set is typified by a large north west trending fault that cuts across the northern part of the prospect area. It is interpreted to form the northern boundary of the Pincombe Inlier. Smaller deposit-scale faults with similar trends are interpreted to control mineralisation within several pods.

The carbonate sequences of the Burt Range Formation are pervasively dolomitised in the area of the Sorby Hills deposits. Dolomitisation has been described to both precede and accompany mineralisation, as mineralisation commonly has dolomite spar gangue. The pods are dominantly shallow dipping stratabound lenses within dolomitic intraclastic and tectonic breccias of the Burt Range Formation. The lenses average 7-10m in thickness, are generally less than 1km long and are 100 to 500m wide. There is some structural control to the mineralisation, with higher grade zones associated with faulting. The pods also appear to sub parallel the two main fault trends.

The Sorby Hills mineralisation is typically lead rich with moderate to high pyrite content and generally low amounts of sphalerite. Galena occurs as massive to semi massive crystalline lenses often in more argillaceous units. The galena occurs as coarse to fine disseminations or as open-space fill in fractures, breccias and vughs. Sphalerite typically predates galena and occurs as colloform open-space fill. Silver values tend to increase as the lead content increases. The upper portions of the deposits are often oxidised and are composed of a variable mix of cerussite and galena.

3 PROJECT DESCRIPTION

3.1 Area of disturbance table

The Sorby Hills Mining Act tenure area covers 12,612.40ha, with this proposal covering an area of 1,782.27ha (tenements M80/197 and M80/286) with a total disturbance area of XX ha.

Table 3-1 indicates the clearing requirements for each tenement associated with the Sorby Hills Mine Site.

Table Error! No text of specified style in document.-1 Indicative areas of disturbance table.*

DISTURBANCES (Ha)	M80/197	M80/286
Open Pits	84 ha	-
Tailings Facilities	125 ha	22 ha
Evaporation area	34 ha	49 ha
Waste Dumps (sulphide present, highly erodible, >25m high)	Waiting for info from Adam	Waiting for info from Adam
Waste Dumps (lower risk)	Waiting for info from Adam	Waiting for info from Adam
ROM Pad	-	4 ha
Plant site and mining infrastructure including office/workshops	-	60 ha
Strip mining (backfilled mining voids)	Pits will be backfilled.	Pits will be backfilled.
Hypersaline pipeline corridors (>15, 000TDS)	-	2.2 ha (2.2km x 10m)
Fresh water pipeline corridors (<15, 000TDS)	2.5 ha (2.5km x 10m)	1 ha (1km x 10m)
Haul roads	12.5 ha (2.5km x 50m)	5 ha (1km x 50m)
Access Tracks	6 ha (1.5km x 40m)	12 ha (3km x 40m)
Hardstand areas	-	Included in Plant Site

Comment [APM1]: These will be temporary – planning to push all waste back into pits

Comment [APM2]: Ultimate land use in closure is agriculture

Landfill Site		2 ha
Historical and areas mined by previous operators		6.6 ha
Total	**TBC**	**TBC**
Tenement Area	***993.91***	***788.36***

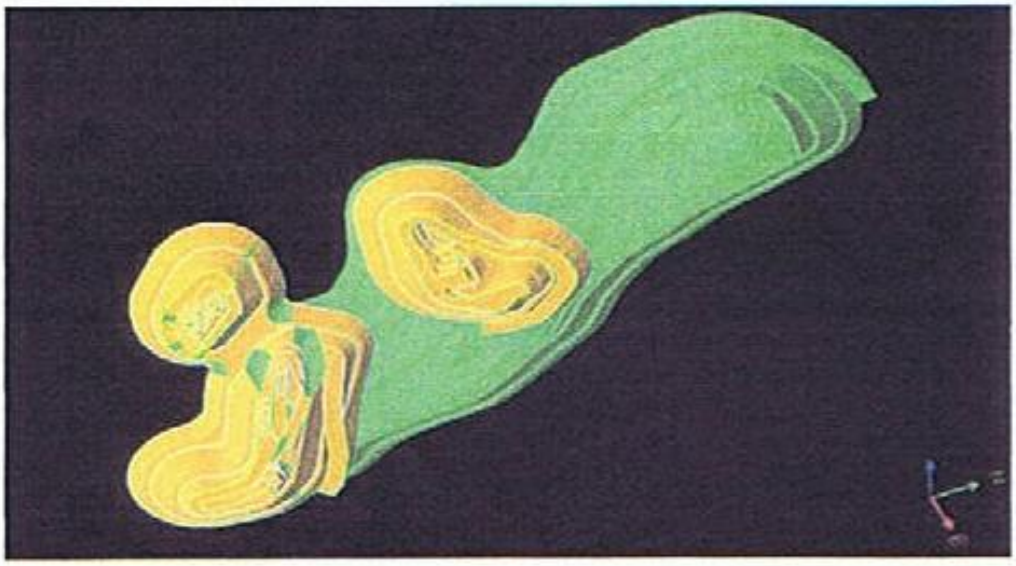
*Areas are indicative only and may vary slightly.

3.2 Mining operations

The Sorby Hills mining operation for the C, D and E pods is planned over a period of 14 years at an ore production rate of 400,000 – 600, 000 tonnes per annum. The mining technique will be consistent with a typical open cut, drill and blast operation.

Initially the C, D and E pods will be mined sequentially as separate entities in three small pits; as mining progresses the three ore bodies will be contained within one larger pit. A 3D modelling image of the final pit design, showing the three separate ore bodies in one pit, is provided in Figure 3-1.

Figure Error! No text of specified style in document.**-2 Sorby Hills C, D and E Pod Final Pit Design Model**



All mining operations will be carried out during dayshift only; the mining technique will consist of:

- Overburden (topsoil and clay) removal; two D10 dozers, four 631 scrapers and one 16H grader will be utilised for this purpose.
- Drill and blast operation to drill, load and blast in pre-defined patterns. Drill crew and plant will consist of a single blast hole drill rig (Sandvick DP1100) with operator, one bomb ute and shot firer and an explosives mobile manufacturing unit (MMU) with operator. Blasting will only take place at designated blast times during dayshift and only when conditions are favourable. Explosives will be stored in an explosives magazine in compliance with the

Explosives and Dangerous Goods Act 2004, the *Dangerous Goods Safety (Explosives) Regulations 2007* and *Australian Standard AS 2187.1:1998, Explosives – Storage, transport and use, Part 1*. Explosives will be stored remote from the mining operations.

- Site geologist and pit technicians will assess broken (blasted) ground to identify and delineate ore, low grade material and waste prior to load and haul commencing in the area.

- The load and haul mining fleet will include a 120 tonne excavator loading four 90 tonne haul trucks, which will transfer ore, low grade material and waste to the respective stockpile areas. Extraction will be predominantly carried out using conventional mining technique, however top loading may be required in some instances, for example in tight areas of the pit or if the pit floor becomes too wet for conventional mining due to rain or dewatering issues. Ore and low grade material will be trucked along the haul road and tipped on the run-of-mine (ROM) pad. Waste material will be stockpiled in designated areas on the eastern edge of the open cut to facilitate backfilling of the pit during rehabilitation.

- The mining fleet will also include support machinery; a 35kl water cart will be required for dust suppression, a grader (140H) will be utilised for general earthworks and maintenance of the truck circuit and a 40 tonne excavator will be on site to pull and maintain the batters, excavate drains and in pit sumps, and provide backup for the 120 tonne excavator.

The overburden in the project area consists of black soil and is approximately 10m in thickness, shallow slope angles of 20 - 25° will be used in this material. The first bench immediately below the black soil cover will be designed as a wide accessible bench; this will be necessary for cleaning as the black soil material will accumulate on the bench and create a hazard. Once into the hard rock below the soil cover the slope angles will be adjusted to a 40 - 45° angle and will be consistent with a typical pit design.

3.3 Ore processing

The processing plant at the Sorby Hills Mine Site will comprise the following components;

- ROM pad and crusher loading facility;
- Primary and secondary crusher, screens and associated fine ore bins;
- Grinding circuit comprising a sag mill and a ball mill;
- Flotation circuit, including flotation tanks, pumps and pipe work; and
- Associated infrastructure including a thickener, electrical switch room, backup generators and diesel storage area.

A flow diagram of the ore treatment process is presented as Appendix

The Mine Site ROM pad will be used to stockpile ore and low grade material prior to processing; material will be delivered by haul trucks and stockpiled according to the material's characteristics. Ore material from these stockpiles will be fed into the crusher hopper using a front-end loader. If required the material will be blended either through creation of secondary stockpiles or during crusher loading operations.

The feed material will be initially crushed using a primary jaw crusher before reporting to a screen; oversize material will be sent to a secondary cone crusher prior to being passed back to the screen. Undersize material from the screen, namely material with a diameter nominally less than 10mm, will

be passed via a conveyor to the fine ore bins for further processing. The capacity of the crushing circuit is approximately 500,000tpa based on 24 hour operations.

Ore material will then be fed from the fine ore bins into the grinding circuit which will comprise two ball mills with diameters of 2.44m and 2.92m. Water will be added to the fine ore material as it enters the ball mills.

Following milling, ground ore material will be mixed with water and passed to the flotation circuit. The ore-water slurry will be mixed with a range of industry standard reagents (Table 3-2); the slurry and reagent mixture will then be passed to a series of tanks where air is blown through the substance. Selected sulphide materials will adhere to these air bubbles, float to the surface and be skimmed off to form a concentrate. The concentrate to be produced by the Sorby Hills operations is of Ag Pb Zn composition. Following skimming the concentrate product will be dried in a filter press and packaged directly into fully sealed and lockable containers for short term on site storage and subsequent transport off site. The tail from the flotation circuit will report to the tailings storage facility. The flotation circuit and filter press are contained within covered concrete bunded areas.

3.4 Concentrate Handling

SMPL endeavour to achieve minimal handling of concentrate by utilising a predominantly mechanised system. Concentrate will be packaged at the final stage of the processing circuit; the concentrate will be dried in a Filter Press and expelled directly into shipping containers (there is no requirement for internal bags or packaging). The Filter Press and container loading dock will be situated within a covered concrete bunker.

SMPL propose to use "Rotainer" shipping containers for the collection, storage and transport of concentrate (Figure 3-1). "Rotainer" containers are purpose built, stackable, bulk ore containers that can be fully sealed with lockable lids.

Figure 3-1 Rotainer Container to be used for the Collection, Storage and Transport of Sorby Hills Concentrate.



Once the containers have been filled to the desired level with concentrate they will be removed from the loading dock and a lid immediately applied and locked. The sealed containers will then be transferred to a designated hardstand area within the Plant site for short term storage prior to transportation off site. "Rotainer" containers carrying concentrate will be transported from site to Wyndham Port via road train.

The Sorby Hills concentrate has a high specific gravity (SG) and is therefore a heavy substance; containers will only be half filled and will be stacked two high as a maximum due to their weight. Load cells will be installed in the loading dock to control the quantity and weight of concentrate placed into each container. SMPL will utilise approximately 180 – 200 containers for the Sorby Hills operation.

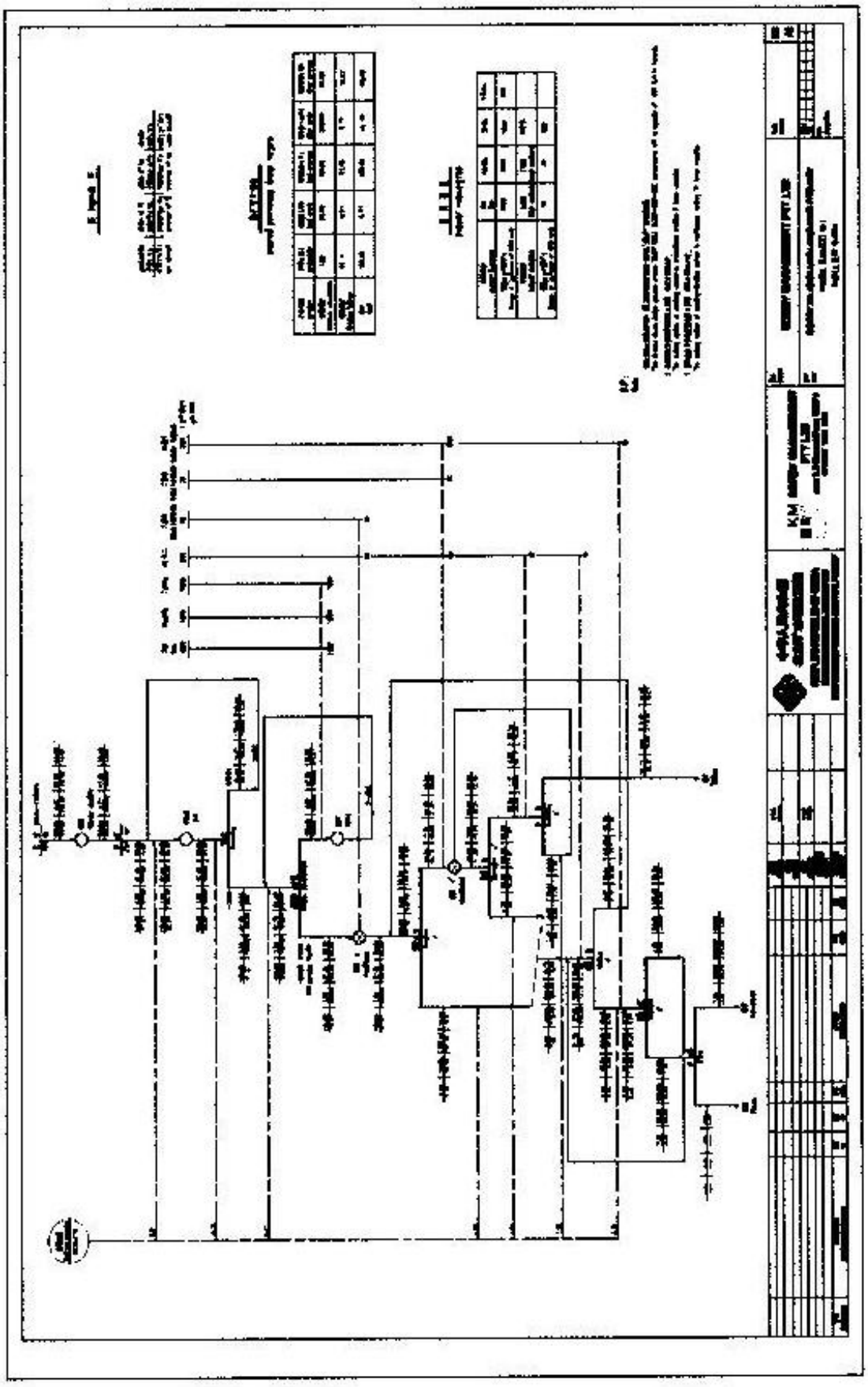
An existing hardstand area with wash down facilities and sumps at Wyndham Port will be utilised by SMPL for container storage. The "Rotainer" containers are designed to be handled by ship cranes and can therefore be easily manoeuvred into position over the ships hold and the contents unloaded by rotation of the container (Figure 3-2). The smooth internal surfaces of the containers enable the contents to be easily emptied with minimal residue remaining. Shipping will be undertaken by a specialist contractor.

Figure 3-2 Rotainer Container attached to a Ships Crane depositing contents into Hold.



Any out of specification product reclaimed from the sumps at the hardstand area and wash down facilities will be collected and back hauled to the Sorby Hills processing facilities in sealed "Rotainer" containers.

Appendix Flow sheet

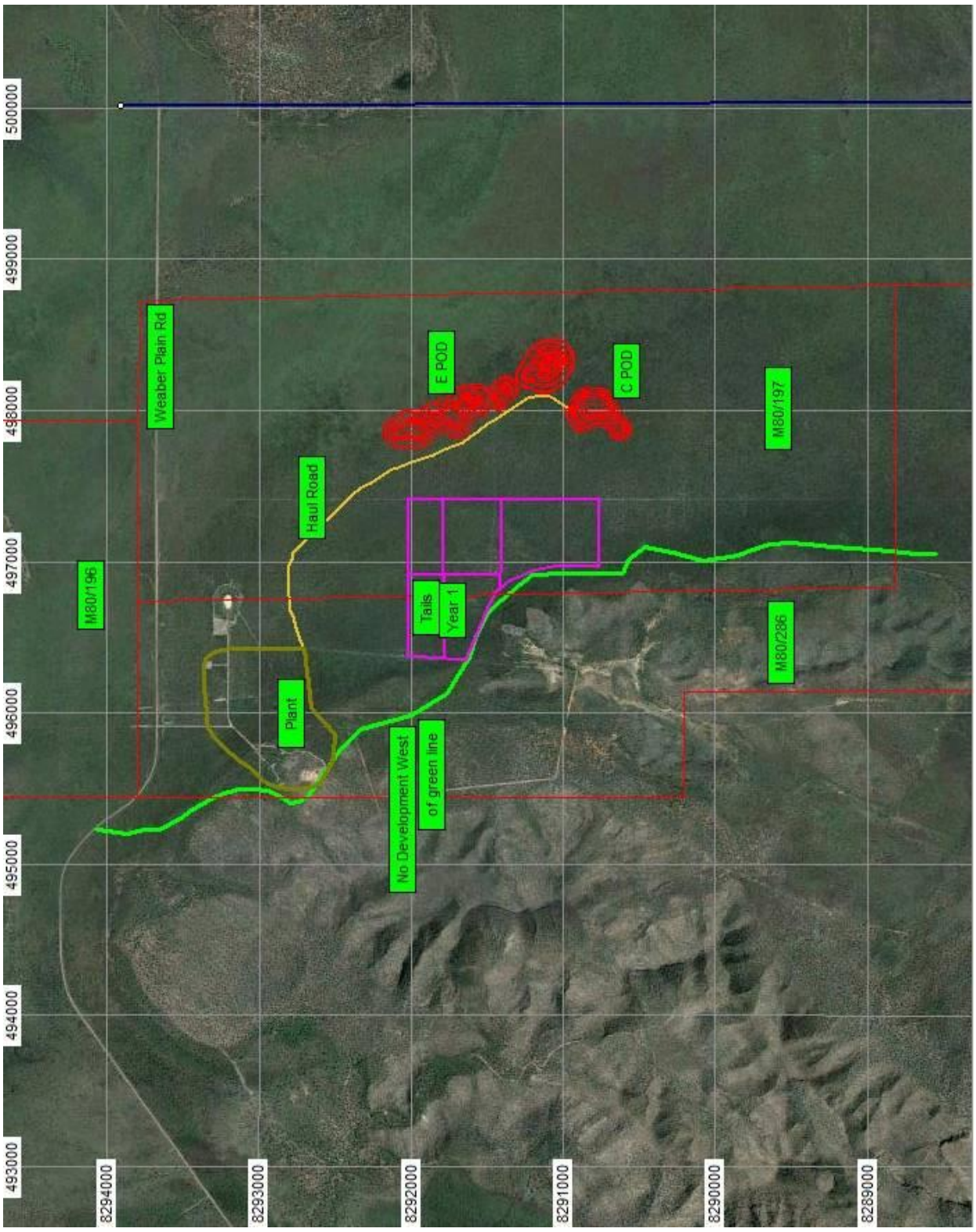


ORD RIVER
ABORIGINAL HERI
MAP
M2 DEVELOPMENT AND PLA
- ARCHAEOLOG
LEGEND
ARCHAEOLOGICAL INFORMATION
CAVE SPRING RANGE

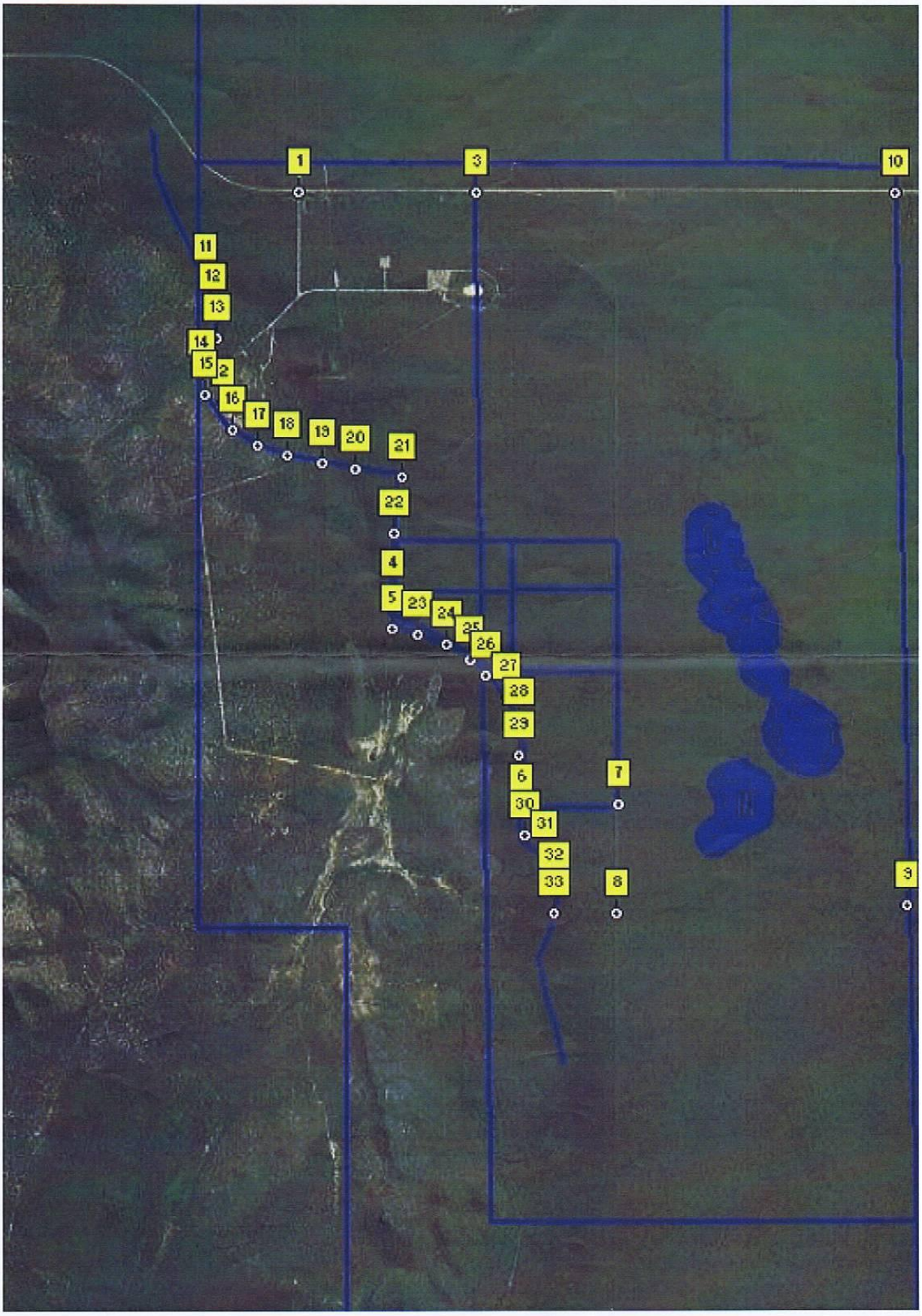

3000m
E POD
D POD
C POD
Haul Road
Tails Modules
Plant Area
Development Divide

9 Appendix 2. Work Program Maps.

9.1 Map 1.

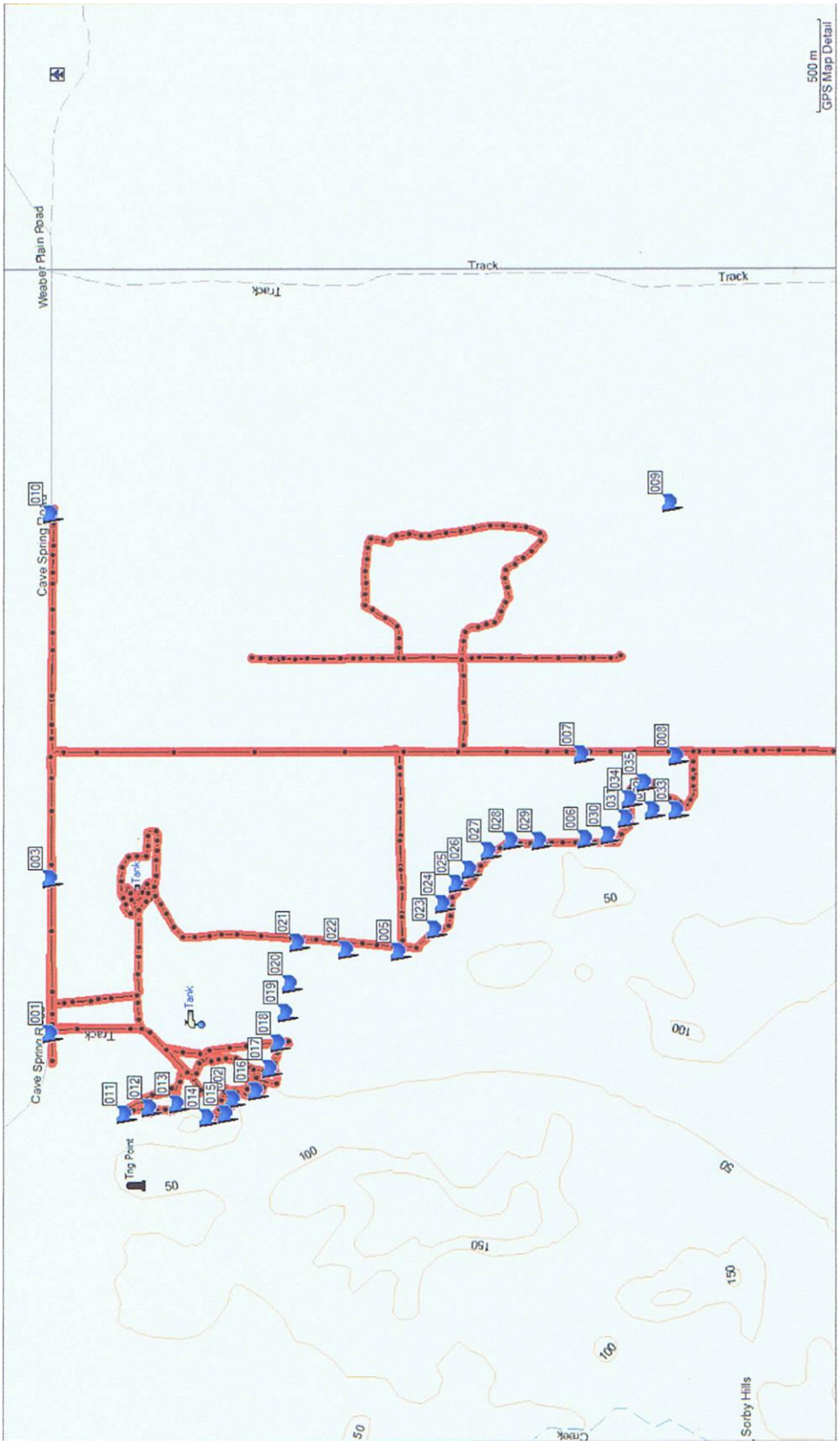


9.2 Map 2. Detail of Extent of Cleared Areas.

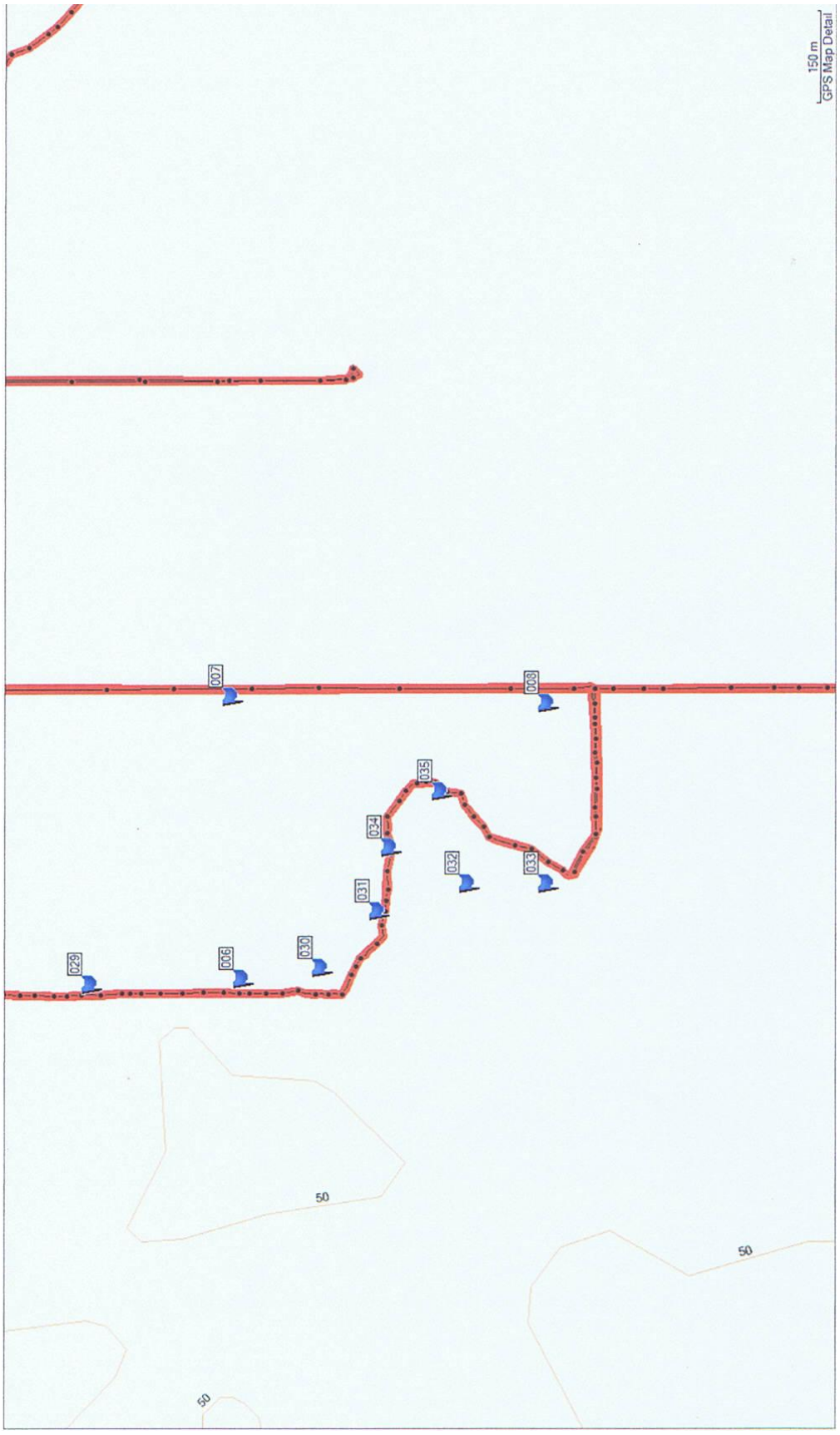


10 Appendix 3. GPS Maps and Waypoint List.

10.1 Map 1. All tracks traversed.



10.2 Map 2. Detail of modification of western boundary of work area.



10.3 WP List.

001	52 L E495912 N8293658
002	52 L E495553 N8292670
003	52 L E496750 N8293659
004	52 L E496354 N8291773
005	52 L E496354 N8291773
006	52 L E496962 N8290767
007	52 L E497423 N8290785
008	52 L E497413 N8290273
009	52 L E498785 N8290310
010	52 L E498730 N8293659
011	52 L E495470 N8293256
012	52 L E495507 N8293118
013	52 L E495525 N8292972
014	52 L E495452 N8292807
015	52 L E495470 N8292707
016	52 L E495599 N8292542
017	52 L E495719 N8292469
018	52 L E495857 N8292423
019	52 L E496023 N8292386
020	52 L E496179 N8292359
021	52 L E496400 N8292322
022	52 L E496364 N8292057
023	52 L E496474 N8291581
024	52 L E496612 N8291536
025	52 L E496723 N8291462
026	52 L E496796 N8291389
027	52 L E496898 N8291288
028	52 L E496953 N8291170
029	52 L E496953 N8291014
030	52 L E496981 N8290639
031	52 L E497073 N8290547
032	52 L E497119 N8290401
033	52 L E497119 N8290273
034	52 L E497177 N8290528
035	52 L E497269 N8290445

11 Appendix 4. Correspondence.

Date: Sunday, October 23, 2011 12:33 AM

From: Lubor Hon <LuborHon@kimberleymetals.com.au>

To: grcarver@bigpond.com <grcarver@bigpond.com>, min2pela@bigpond.com <min2pela@bigpond.com>

Subject: Clearence for Sorby Hills project

Kim, Joh and Greg,

As discussed yesterday I talked to the project manager and he had confirmed that Kimberly Metals has no objections to the agreed modification regarding the west boundary.

Regards,

Lubor Hon

Project Engineer – Sorby Hills Project

Sorby Management Pty Ltd

Kununurra, WA

Mobile: 0438 773 969

---

12 Appendix 5. The Obverse Side of Signed Map 1.

13 Appendix 6. Registered Sites Search for M80/197 and M80/286.

Search Criteria

1 sites in mining tenement 'M 8000197'.

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Legend

Restriction

N No restriction

M Male access only

F Female access

Access

C Closed

O Open

V Vulnerable

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

[Reliable] The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.

[Unreliable] The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information reported.

Status

L - Lodged	IA - Information Assessed	ACMC Decision Made
Information lodged, awaiting assessment	Information Awaiting ACMC Decision Assessment Only	**R - Registered Site** **I - Insufficient information** **S - Stored Data**

***Explanation of Assessment**

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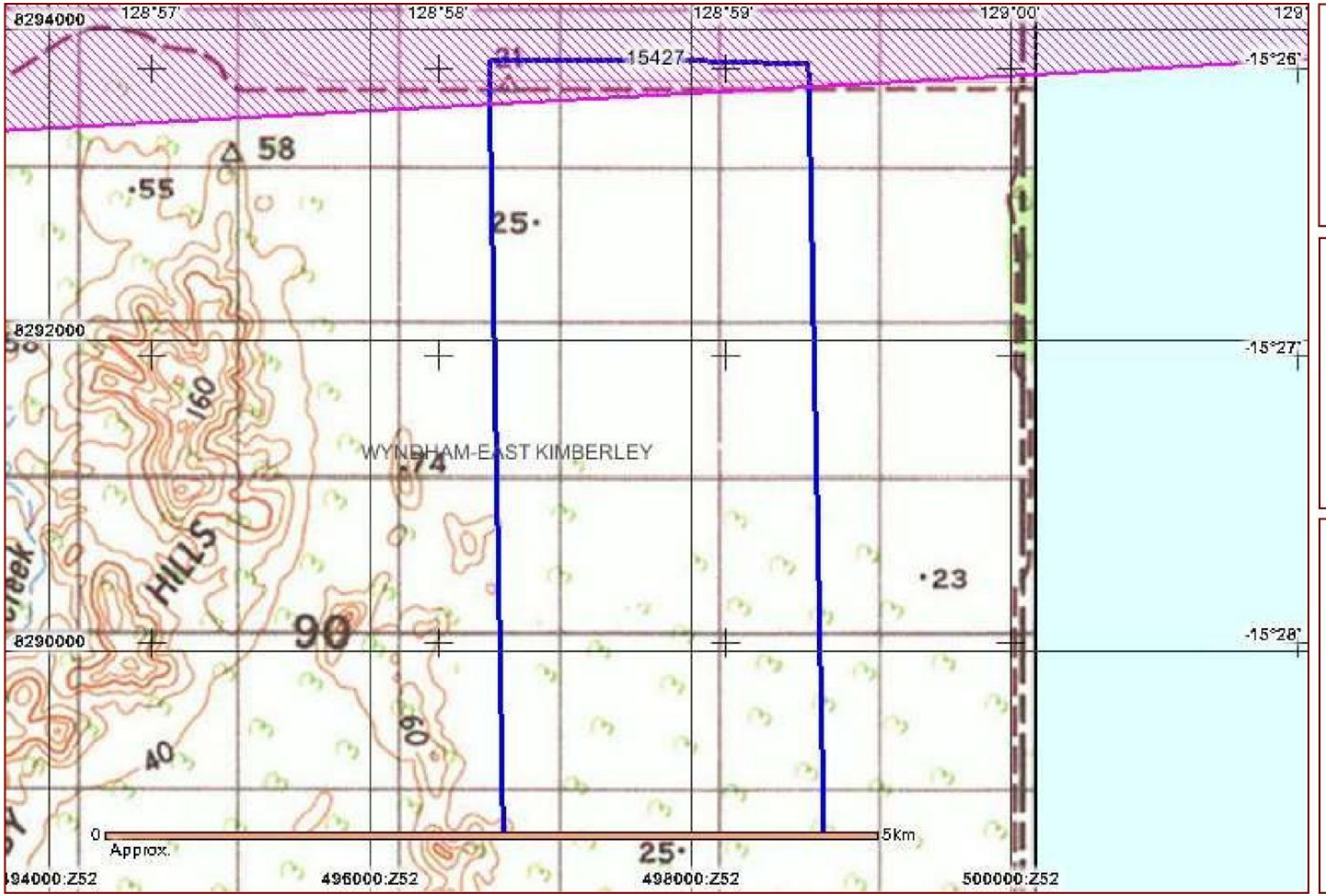
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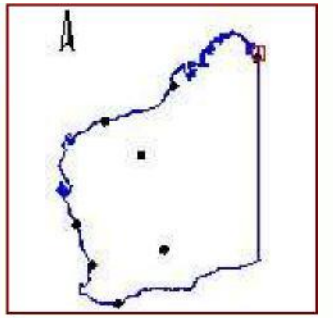
Site boundaries may not appear on maps at low zoom levels

List of 1 Registered Aboriginal Sites with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
15427	R	C	N	Jungil Complex.	Ceremonial, Mythological, Repository / cache, Skeletal material/Burial, Man-Made Structure, Modified Tree, Painting, Engraving, Quarry, Artefacts / Scatter, Midden / Scatter, Grinding patches / grooves	Ochre	*Registered Informant names available from DIA.	Not available for closed sites	K02926

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Legend

Selected Heritage Sites

Registered Sites

Town

Map Area

Search Area

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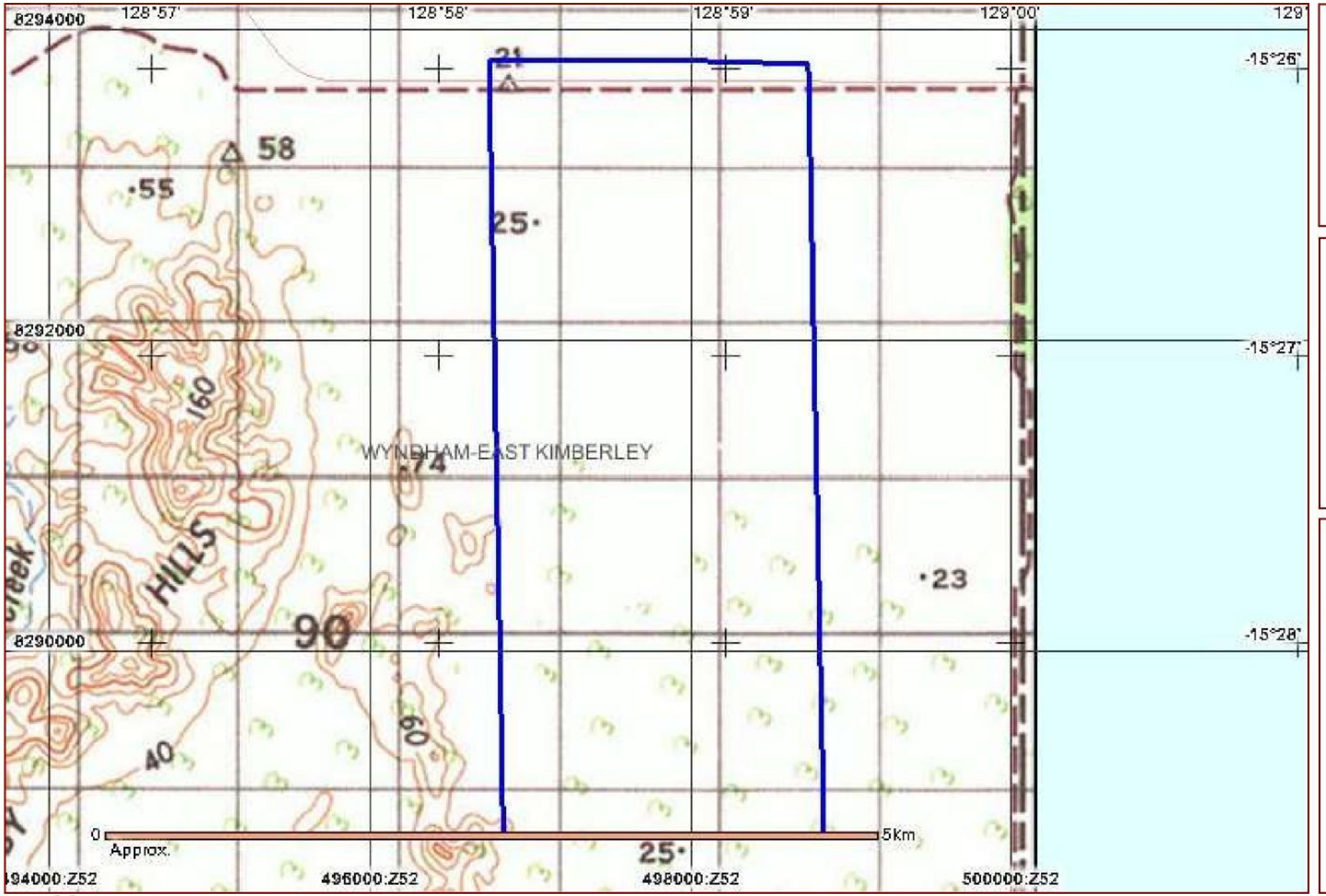
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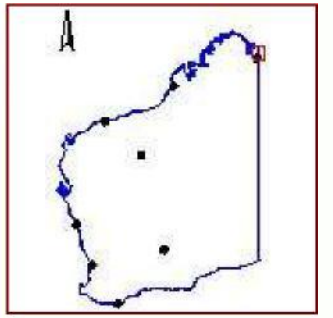
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List of Other Heritage Places with Map

No results





Legend

Selected Heritage Sites

Other Heritage Places

Town

Map Area

Search Area

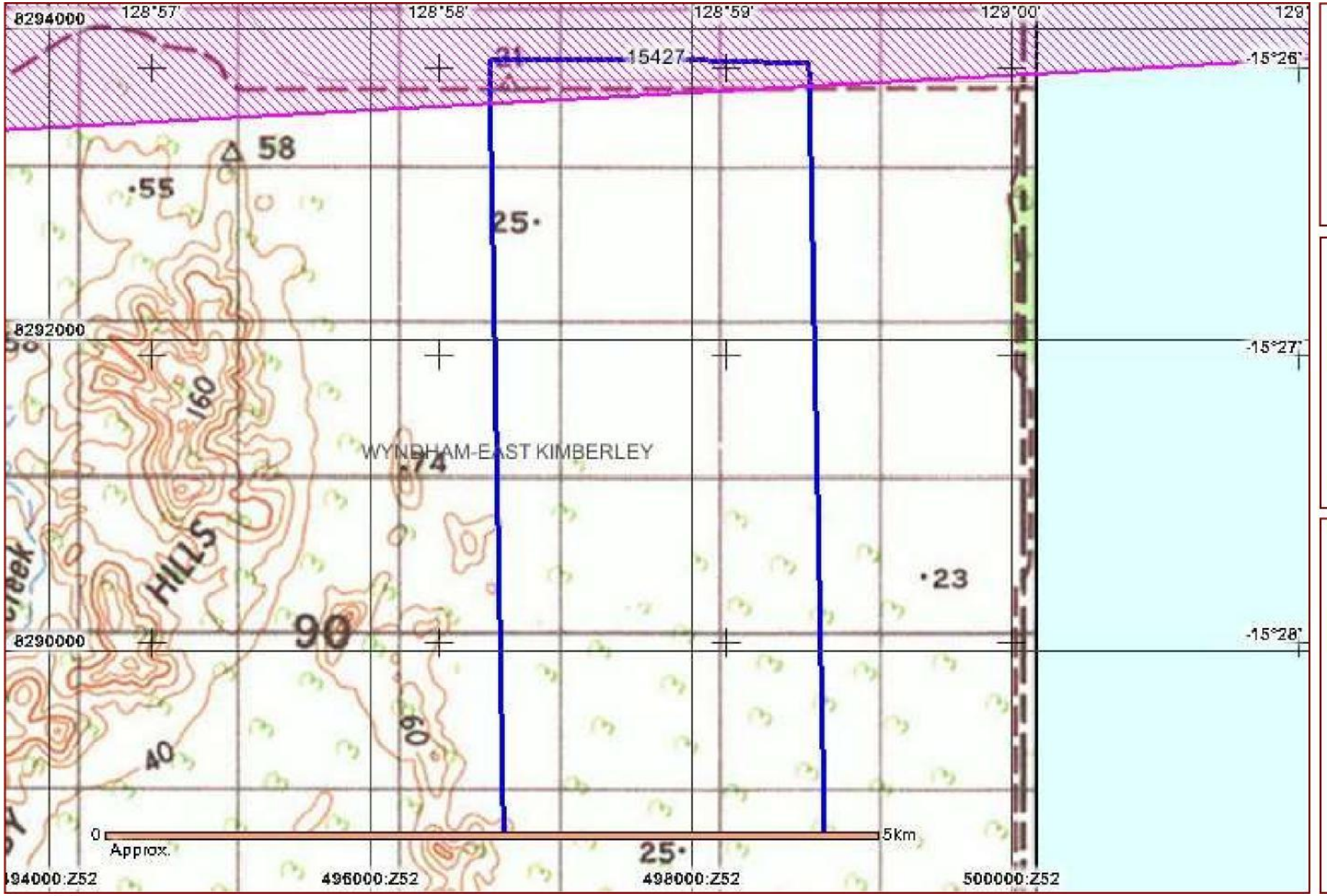
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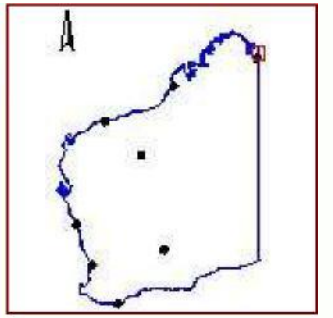
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Map Showing Registered Aboriginal Sites and Other Heritage Places





Legend

Selected Heritage Sites

- Registered Sites Other
- Heritage Places
- Town
- Map Area
- Search Area

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Search Criteria

1 sites in mining tenement 'M 8000286'.

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Access

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O Open

V Vulnerable

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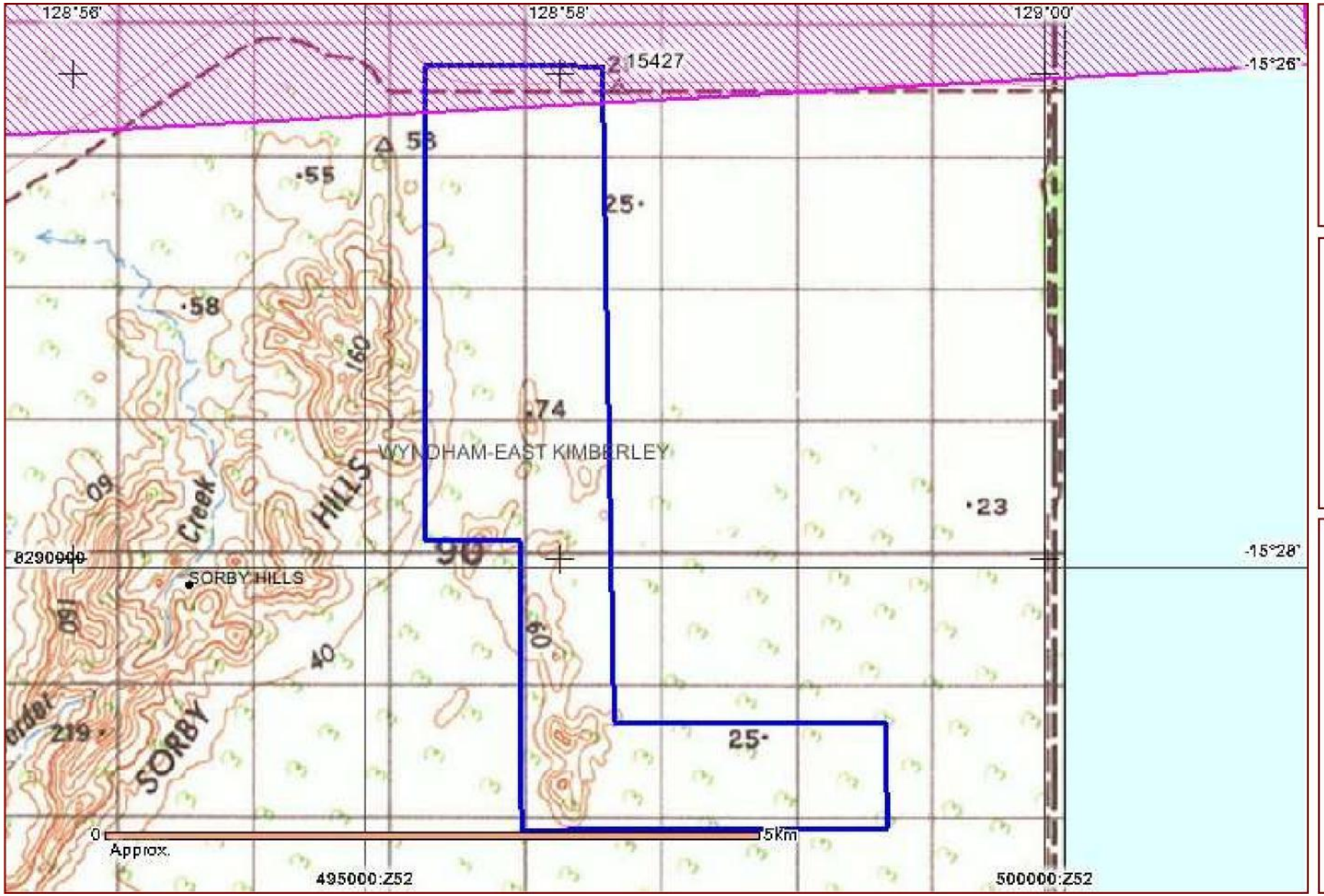
Sites Shown on Maps

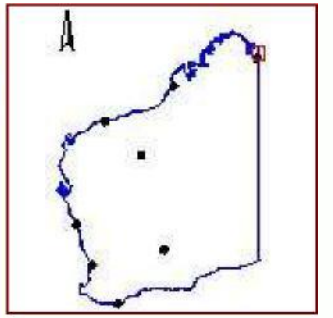
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Legend

Selected Heritage Sites

Registered Sites

Town

Map Area

Search Area

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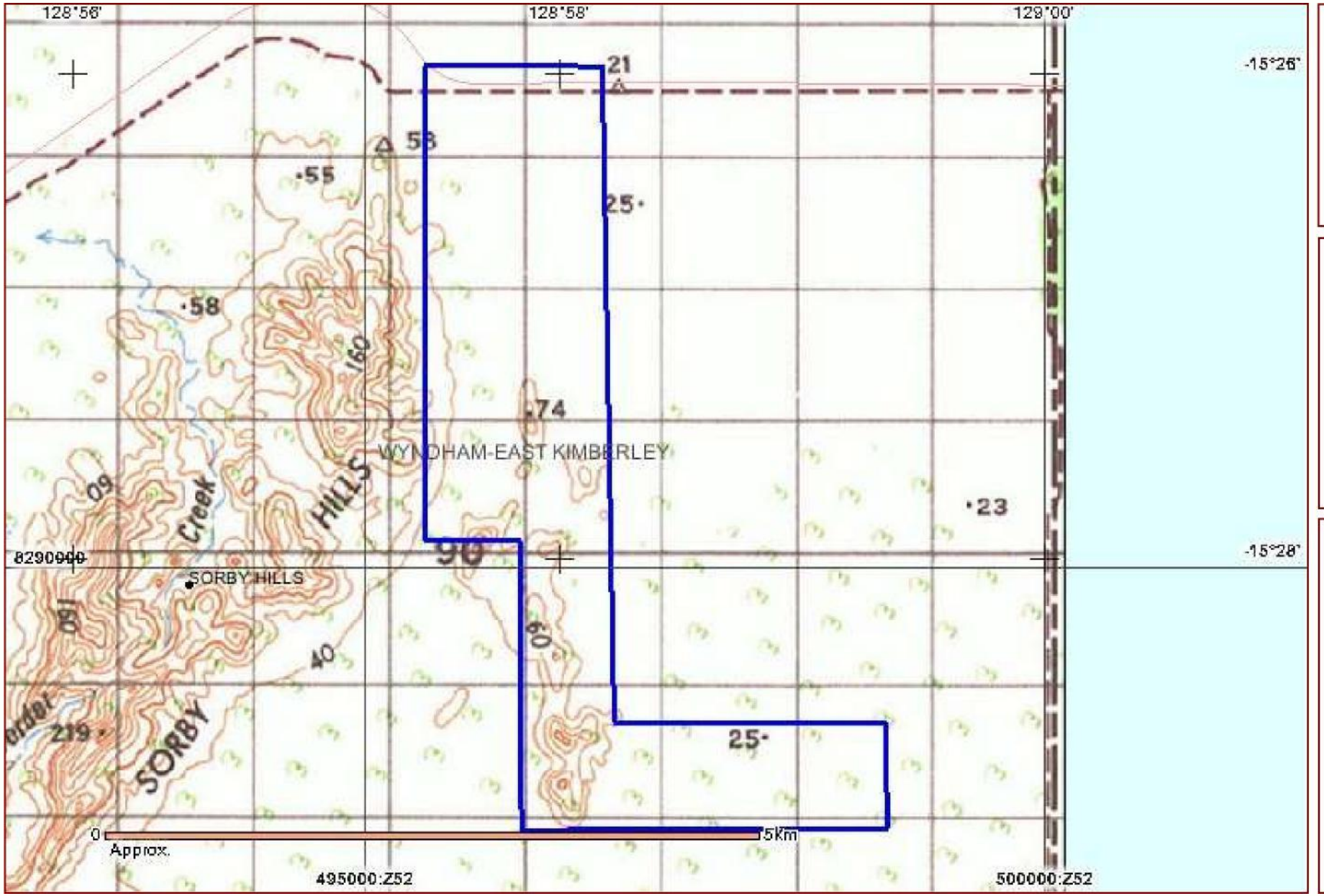
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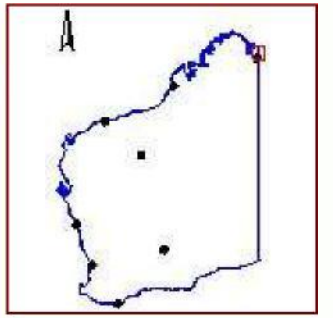
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List of Other Heritage Places with Map

No results





Legend

Selected Heritage Sites

Other Heritage Places

Town

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Photo 4. The core storage sheds.



Photo 5. The old mine site.



Photo 6. The location of the new tailings dumps.



Photo 7. The vegetation on the black soil plains in the vicinity of the new mine site.



Photo 8. The limestone hill located in the vicinity of WP 32.

KIMBERLEY METALS LTD

SORBY HILLS SILVER LEAD ZINC PROJECT

MINING PROPOSAL FOR THE

CONSTRUCTION AND OPERATION OF PROJECT MINE SITE

M80/197 & M80/286

ABORIGINAL HERITAGE SITE SURVEY



Proposed Pit Area

Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Aboriginal Corporation
October 2011

Introduction

This report confirms the results of a heritage survey conducted in October 2011 in relation to the proposed Sorby Hills Silver Lead Zinc Project. The survey was conducted in response to a request dated November 2011 from Sorby Management Pty Ltd, a wholly owned subsidiary of Kimberley Metals. A copy of this proposal is attached to this report as Appendix A.

Kimberley Metals Ltd owns a number of tenements in this region but only portions of tenements M80/197 and M80/286 are the subject of the current mining proposal. A map of the proposed mine layout and the area that was considered during the current survey is attached as Appendix B.

The survey methodology consisted of discussions, informal and formal meetings and field visits with senior Aboriginal men and women. The company was represented in the field by Lubor Hon (Project Engineer – Sorby Hills Project) who explained what the company intends to do at the locations indicated on the map.

Photo deleted for privacy reasons

Image 1 – Lubor Hon discussing project with women in the field (21 Oct 2011)

Two field trips were conducted – consultant Joh Bornman visited the proposed mining and infrastructure areas on the 20th of October with senior men and consultant Dr Kim Doohan visited the same area with senior women on the 21st of October.

Traditional Owners signed the project map as they completed the survey and the consultants, archaeological consultant Greg Carver and Lubor Hon signed the maps at the MG Corporation office on the 21st of October. One copy of the signed maps was given to Lubor Hon as a record of what was agreed to and the second copy is held by MG Corporation.

Previous History

There has been a long history of exploration for base metals in the East Kimberley region and some of the prospects, including the Sorby Hills deposit, were first identified in the 1970's.

The existing leases were the subject of negotiations in the Ord Final Agreement (OFA) but this report is only concerned with the most recent

history of exploration and heritage clearances and most particularly the results of the current survey.

This project area is now being operated by Kimberley Metals Ltd but it was formerly operated by CBH. Heritage clearance surveys were undertaken in 2007 and 2010.

Mining Proposal

The mining proposal as detailed in the attached document (Appendix A), discusses the project history, geology, proposed mining operations, ore processing, concentrate handling and shipping. It is understood that the proposed mine will be a standard open cut mining operation with flotation ore concentration. It is also understood that concentrate is to be shipped by road train to Wyndham in Rotainer containers where it will be transported by ships to the final destination.

The attached map (Appendix B) shows the location of the various sections of the mining operation such as the pit, tailings area and infrastructure area (containing the processing plant, workshops, offices etc.). It is understood from discussions with Lubor Hon that the exact details of how these various sections of the mine will be constructed and operated is yet to be determined but that their geographic location is limited to the area cleared by the clearance teams and indicated on the signed map sheet.

DIA Heritage Inquiry System Search Results

The results of a search of the Department of Indigenous Affairs (DIA) Heritage Inquiry System in relation to the relevant tenements are attached in Appendices C and D. There are no registered sites located within the proposed mining and mine infrastructure area even though a registered site does encroach onto the northern edge of both the tenements under consideration (see discussion below).

<u>Tenement M80/197</u>

The map attached to the search results for this tenement (refer to Appendix C) shows that the site complex (Jungil Complex, site No.K 02926) extends onto the very top of the tenement. The site complex details are: Site ID – 15427; Site No.K 02926; Site Name – Jungil

Complex; Site Type – Ceremonial, Mythological, Repository/Cache, Skeletal Material/Burial, Man Made Structure, Modified tree, Painting, Engraving, Quarry, Artefacts/Scatter, Midden/Scatter, Grinding Patches/Grooves and Ochre. It is on the permanent register and categorised as closed access with no restrictions. A search of the DIA Report Catalogues reveals no supporting reports with information on this site.

Tenement M80/286

As with the site discussed above, the Jungil Complex (site No.K 02926) extends onto the northern edge of the tenement (see search results attached in Appendix D). No reports are listed.

Tenements M80/286, M80/285 and M80/287

Other Kimberley Minerals tenements such as M80/196 and M80/285 are entirely covered by the site mentioned above (Jungil Complex, site no K02926) while tenement M80/287 has no registered sites within its boundaries. These tenements were not considered during the current survey as they are not associated with the proposed mine site. If future exploration is planned in these tenements the impact of those activities on this registered site would have to be considered at that time.

Heritage Survey Methodology

Informal discussions were held with a number of senior Aboriginal men and women prior to the field surveys being conducted. These meetings were focused on matters of cultural heritage relating to the proposed mining and mine infrastructure areas.

There were two separate field visits – the senior men accompanied Bornman (20th) and senior women accompanied Doohan (21st). The field work was conducted separately so as to allow the men to determine if the proposal was likely to impact sites that are restricted to men alone. The women's team was briefed by Greg Carver on the proposed change to the 'green line' boundary (see discussion below) prior to undertaking their site visit. This change was agreed to by the women following the field visit.

Photo deleted for privacy reasons

Image 2 – Greg Carver discussing 'green line' with the women (21 Oct 2011).

The clearances were conducted by 4WD vehicles travelling to the proposed development locations. Whilst in the field Lubor Hon delineated the precise boundaries of the area and activities to be considered by the heritage clearance team. He also presented relevant information and answered questions in the field. The clearance team members appreciated his responses to their enquiries.

Photo deleted for privacy reasons

Image 3 – Senior men and archaeologist Greg Carver discussing project in the field.

Results of the Field Survey (20th and 21st October 2011)

As discussed above, the survey teams were accompanied by Lubor Hon who explained the proposed programme in detail. Following his presentation the teams discussed the proposals in private and came to a conclusion about the impact the proposed mining may have on known heritage sites in the region.

The clearance team members approved the proposed mine development and associated infrastructure on the basis of these facts. People do have other concerns however and these are outlined below.

Greg Carver, in his assessment of the impact of the proposal on the archaeological material in the area, and working with a clearance team member, requested that the "green line" defining the western extent of the project area be moved slightly to exclude a small limestone hill. This change was agreed by both clearance team members. The results of the archaeological survey also indicate that there are no sites of archaeological significance in the proposed development area (Carver 2011).

Issues of Concern to Traditional Owners

Whilst Traditional Owners have no heritage concerns in relation to this project, they do have environmental concerns. The primary concern is in relation to the disposal of water from the site. It is understood that because of a high water table and seasonal rains, the pits have to be

constantly dewatered by a series of bores around them as well as sump pumps.

Traditional Owners are concerned that this water would eventually make its way to the Keep River and farm areas and pollute them. They are fully aware of the toxic potential of lead in the environment and are looking for safeguards that would avoid any adverse impact on the river.

People were also keen to ensure that young local Aboriginal men and women in particular are given the opportunity to obtain training and long term employment at the mine site. People are aware of the obstacles that confront employees and employers in terms of a lack of qualifications, driver's licences, police records etc., but they feel that ways have to be found to overcome these limitations and to get the young community members into long term and meaningful employment.

The Traditional Owners are aware that an agreement to develop the mine is to be negotiated with the company and are very keen to progress all relevant matters in the near future, including but not limited to, the issues that they recently raised during this clearance.

Conclusions/Recommendations

- MG Corporation is satisfied that the most knowledgeable group of senior knowledgeable Aboriginal people in relation to the project area viewed and discussed any potential heritage concerns in relation to the proposed mine and associated infrastructure.

- The heritage clearance teams were satisfied that there were no heritage sites or aspects of heritage sites that would be impacted upon by the proposed Sorby Hills Silver Lead Zinc Project.

- The archaeological clearance team similarly did not find any sites that would be impacted upon by the proposed project.

- The clearance team did have environmental concerns in relation to the project and in particular the disposing of excess water from the mine and the impact it would have on the immediate environment as well as the Keep River.

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- Traditional Owners would like to see young members of their community trained and employed on a long term basis at the mine.
- Traditional Owners are particularly keen to engage in negotiations concerning the development of the mine in the near future.

DRAFT

APPENDIX A

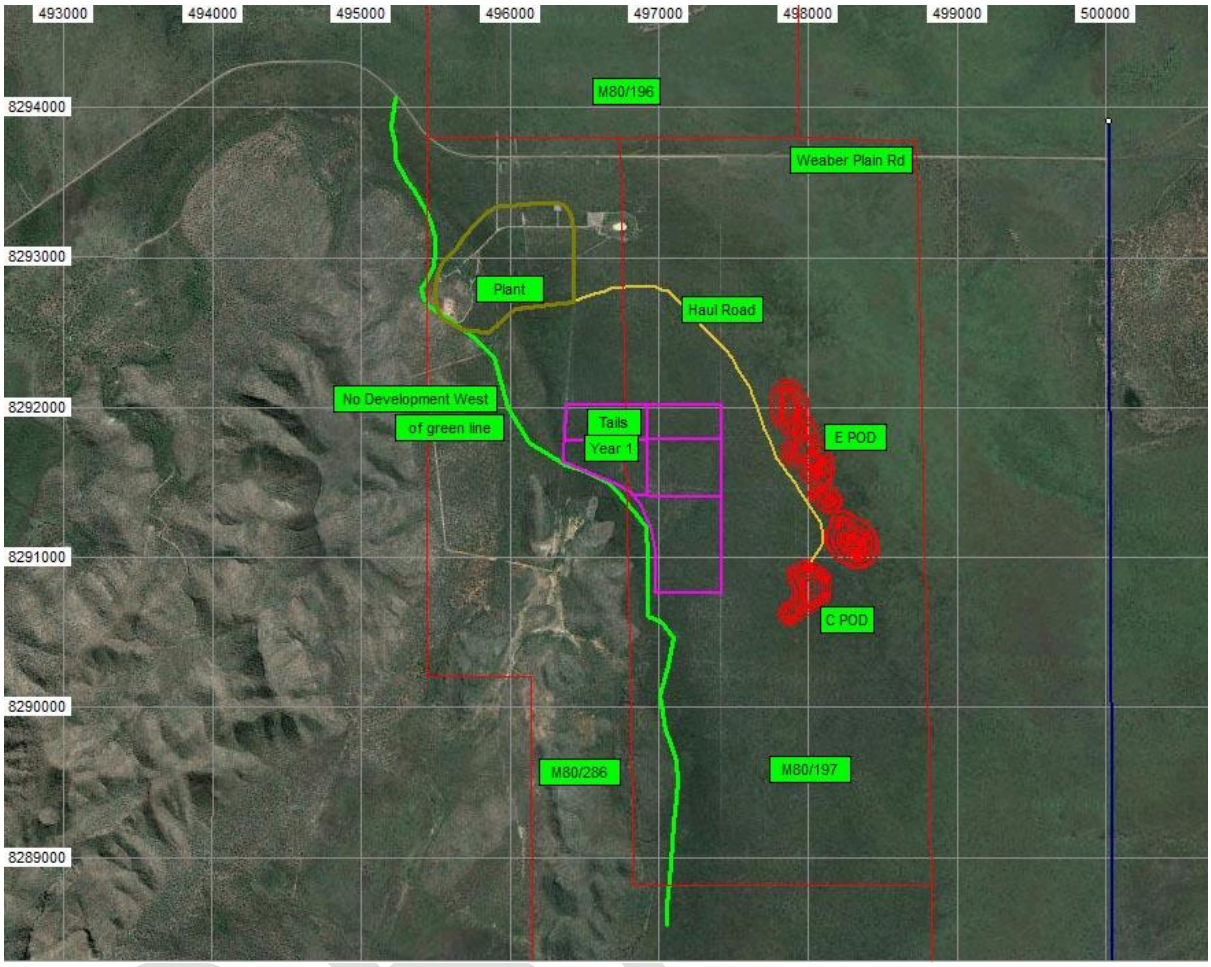
MINING PROPOSAL FROM SORBY MANAGEMENT PTY LTD DATED NOVEMBER 2011

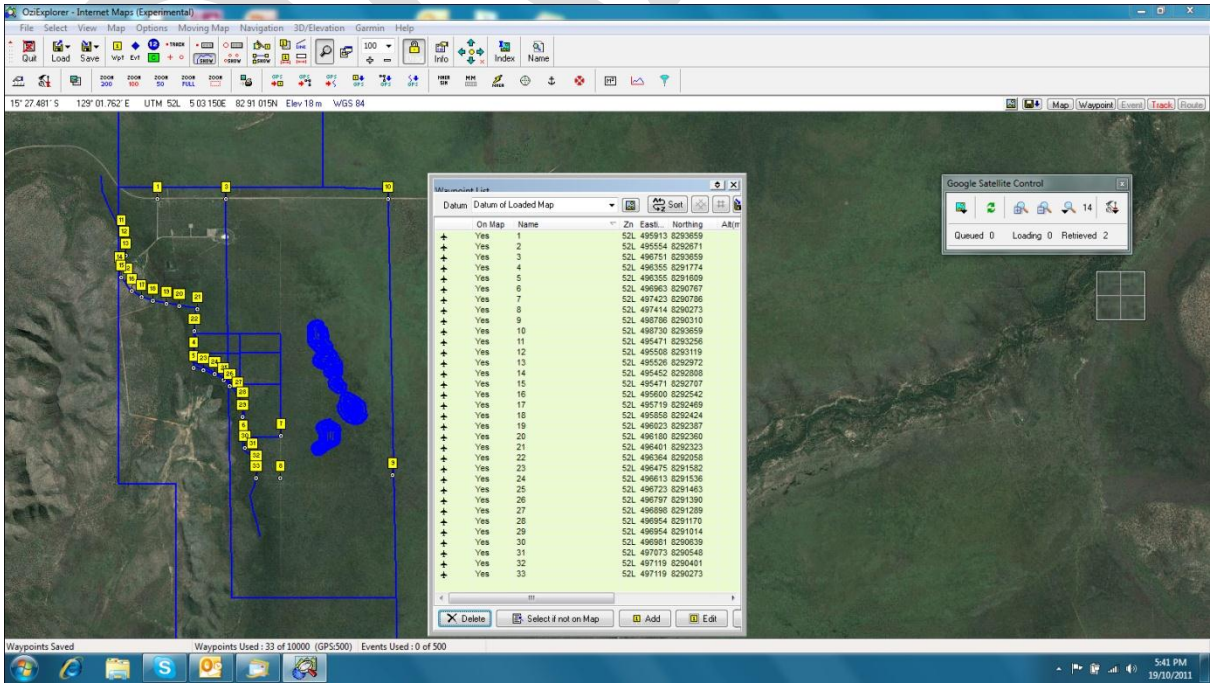
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APPENDIX B

MAP SHOWING PROJECT AREA


493000
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500000
8294000
8293000
8292000
8291000
8290000
8289000
M80/196
Weaber Plain Rd
Plant
Haul Road
No Development West
of green line
Tails
Year 1
E POD
C POD
M80/286
M80/197


OziExplorer - Internet Maps (Experimental)
Google Satellite Control
Waypoints Saved
Waypoints Used : 33 of 10000 (GPS:500) Events Used : 0 of 500

APPENDIX C

DIA HERITAGE INQUIRY SYSTEM RESULTS M80/197

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APPENDIX D

DIA HERITAGE INQUIRY SYSTEM RESULTS M80/286

DRAFT

Appendix 11: Written Correspondence from MG Corporation

Achieving a healthy, wealthy and culturally strong MG community

Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Aboriginal Corporation

(MG Corp) ABN 79 270 210 553

Office: (08) 9166 4800
Fax: (08) 9169 2509

PO BOX 2110, Kununurra WA 6743
admin@mgcorp.com.au
www.mgcorp.com.au

24 October 2011

Ed Newman
Project Manager
Sorby Management Pty Ltd
Level 3, 2 Elizabeth Plaza
NORTH SYDNEY NSW 2060

By E-Mail to ednewman@kimberleymetals.com.au

Dear Ed

Heritage Clearance - Sorby Hills Mining Proposal dated November 2011 in respect of M80/197 and M80/286 (Mining Proposal)

I refer to previous correspondence in respect of the above matter.

Please accept this letter as confirmation on behalf of Yawoorroong Miriuwung Gajerrong Yirrgeb Noon Dawang Aboriginal Corporation (**MG Corporation**) that there are no heritage issues which will prevent the works set out in the Mining Proposal being conducted.

Please do not hesitate to contact me should you wish to discuss issues pertaining to the heritage clearance, or indeed any other issue involving the project, in more detail.

I wish you well in the project and look forward to dealing with Sorby Management Pty Ltd on future matters.

Yours sincerely

Dominique Reeves

Dominique Reeves
Lawyer
MG Corporation

Appendix 12: Stakeholder Consultation Register and Public Communication

Sorby Hills - Silver Lead Zinc Project - Community Information

Who is Involved in the Sorby Hills Project?

The Sorby Hills Silver Lead Zinc Project (Sorby Hills) is being developed by Sorby Management Propriety Limited (SMPL), which is 100% owned by joint venture partners KBL Mining Limited (KBL) – previously Kimberley Metals Ltd - and Henan Yuguang Gold and Lead Group Co., Ltd (HYG&L).

Location and Project Overview

The Sorby Hills project area is situated in the East Kimberley region of WA next to the Sorby Hills located at the north end of the Pincombe Ranges. The project site is located approximately 50km by road north-east from the regional centre of Kununurra; entry to the site will be via an existing access track from the Weaber Plain Road.
The mining tenements (M80/197 and M80/286) lie to the east of the Ord River expansion stage two.

Concentrate Handling and Transport

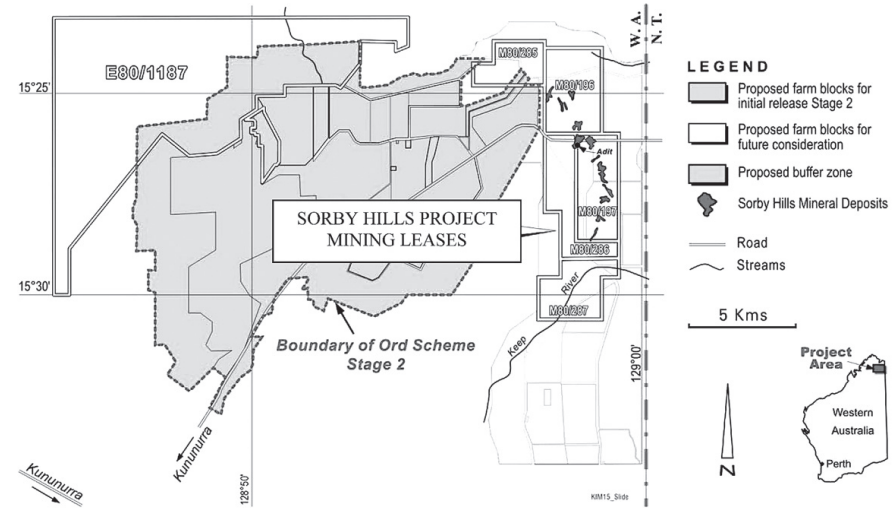
SMPL will produce a Silver, Lead, Zinc concentrate using a flotation process onsite.
The primary minerals are sulphides which have limited solubility when exposed in the environment.
SMPL are acutely aware that the handling (packing, storage, loading and transport) of the Sorby Hills concentrate is an important aspect of the project. SMPL is committed to minimising any risk associated with this phase of the operation.
SMPL and its contactors will implement a range of rules and procedures to all stages of the concentrate handling process.

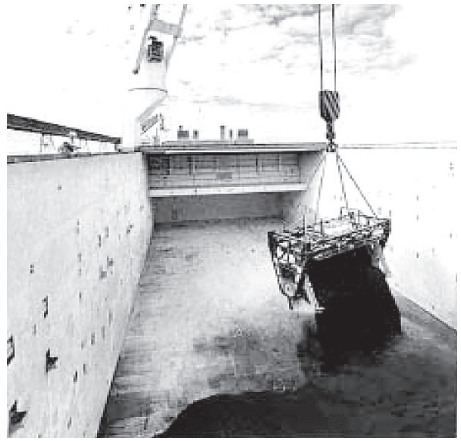
Logistics

SMPL endeavour to achieve minimal direct handling of concentrate by utilising a predominantly mechanised system. Concentrate will be packaged at the final stage of the processing circuit where it will be expelled directly into shipping containers.
"Rotating" shipping containers will be used for the collection, storage and transport of concentrate; "Rotating" containers are purpose built, stackable, bulk ore containers that can be fully sealed with lockable lids.
Containers carrying concentrate will be transported from site to Wyndham Port by 120t road train; trucks will travel via the Weaber Plain Road, Mills Road, Ivanhoe Road, Victoria Highway and Great Northern Highway passing through both Kununurra and Wyndham.
An average of 12 truck movements per week are expected, although up to 20 movements a week could occur following events such as road closures from flooding.
SMPL will utilise existing Wyndham Port facilities and ship once a month for 11 months each year.

Community Focus

- SMPL has an 'employ local' policy and will endeavour to maximise employment of personnel from Kununurra and local indigenous communities
- In addition, employment opportunities will be created at the Wyndham Port which may benefit the community of Wyndham
- SMPL is committed to Indigenous employment and training programs with Indigenous employees already working for SMPL
- SMPL maintain a high degree of community focus and will develop the Sorby Hills project in line with best practise, community, environmental and safety standards





Project Management

Edgar Newman

Project Manager

Sorby Management Pty Ltd

Level 3, 2 Elizabeth Plaza

North Sydney, NSW.

Telephone: (02) 9927 2006

Facsimile: (02) 99272050

ednewman@kimberleymetals.com.au



Management and Safeguards

Packing and Storage

- Concentrate handling will be predominantly mechanised
- Only purpose built "Rotating" containers will be used
- Containers will be fully sealed and locked after filling
- All concentrate residue will be removed from the outside of containers by vacuum
- No container will be stored in a way that compromises the integrity of the container
- Containers will be stored upright and stacked no more than two high

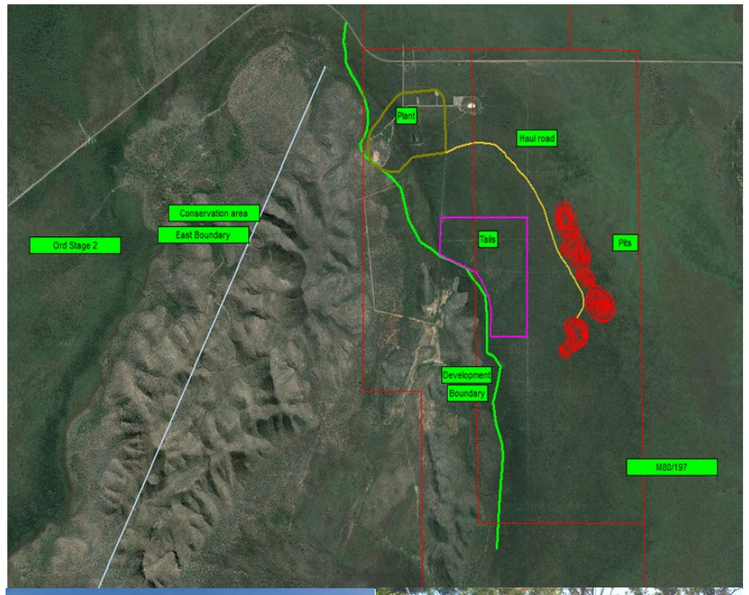
Loading and Transport

- Road trains will pass through wash down facility prior to leaving site
- All drivers will possess the relevant driver training and licensing
- Speed restrictions will be applied and will not be exceeded
- Exhaust breaking will be banned within townships
- Vehicles will be regularly maintained to reduce noise generation
- Haulage trucks will only operate during daylight hours

Port

- On arrival every container will be inspected to check the integrity of the container walls, door seals and locking bolt
- Locks and lids will only be removed from the containers immediately prior to unloading directly into the ship hold.
- Containers are designed to be manoeuvred by the ships crane and unloaded directly into the hold by rotation of the container
- A "misting" system will be utilised for dust suppression; The misting system is a unique fluid system designed to be integrated with the "Rotating" container system

Sorby Hills
Silver Lead Zinc Project
Community Information











Who is Involved in the Sorby Hills Project?

The Sorby Hills Silver Lead Zinc Project (Sorby Hills) is being developed by Sorby Management Propriety Limited (SMPL), which is 100% owned by joint venture partners Kimberley Metals Limited (KML) and Henan Yuguang Gold and Lead Group Co., Ltd (HYG&L).

Kimberley Metals Limited

KML became an independent entity in May 2008; KML's aim is to become an established precious and base metal producer and has assembled a balanced portfolio of assets to achieve this goal. KML's key assets are:

- Sorby Hills Silver Lead Zinc Project (Kimberley, WA);
- Manbarrum Zinc Silver Lead Project (north east NT);
- Mineral Hill Gold—Base Metal Project (central NSW);
- Constance Range Iron Project (north west QLD).

Henan Yuguang Gold & Lead Group Co., Ltd

HYG&L are based in Jiyuan, China; during the past 50 years the corporation has developed into a large integrative enterprise dealing in non-ferrous metals, noble metals, chemicals, coal products, power and mining.

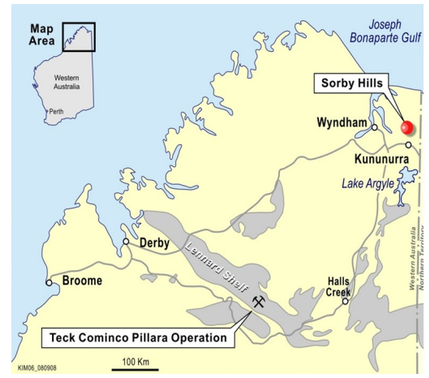
Animal Plant Mineral Pty Ltd

Perth based environmental consultancy specialising in biological surveys and environmental approvals. APM are a highly mobile group with extensive experience in the Kimberley region, including:

- Kimberley Metals Group Iron Ore Project
- Kimberley Liquid natural Gas Project
- Ord Irrigation Expansion

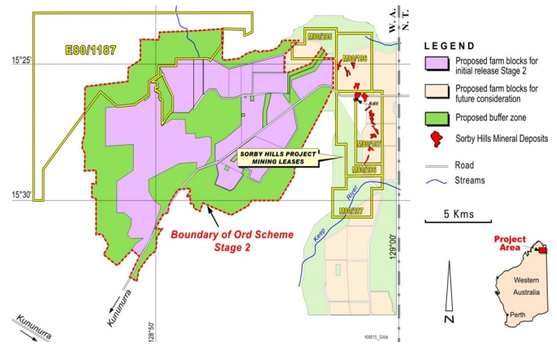
APM have been appointed by SMPL to coordinate and manage the environmental approvals and stakeholder consultation for the Sorby Hills Project.

Location and Project Overview



The Sorby Hills project area is situated in the Kimberley region of WA at the north eastern extent of the Sorby Hills Ranges. The project site is located approximately 50km by road north-east from the regional centre of Kununurra; entry to the site will be via an existing access track from the Weaber Plain Road.

The relevant tenements (M80/197 and M80/286) lie to the east of the currently proposed Ord River expansion stage two.



Sorby Hills is a major undeveloped Silver Lead Zinc (Ag Pb Zn) deposit; the Sorby Hills mining leases contain 13 separate but adjacent mineralised ore pods which form a linear belt (trending north – south) over 8kms long and up to 1km wide.

The shallow nature of the deposits allows for ore extraction by conventional open cut mining; the focus will be on resources within 70m of the surface.

The ore will be processed by flotation and approximately 45,000Tpa of concentrate (Ag Pb Zn) will be produced for export to the overseas market through Wyndham.

It is anticipated that construction will commence in May 2012 and production will begin during the first quarter of 2013.

As of March 2011 the mine life is expected to be at least 14 years.

Community Focus

- SMPL has an 'employ local' policy and will endeavour to maximise employment of personnel from Kununurra and local indigenous communities
- In addition, employment opportunities will be created at the Wyndham Port which may benefit the community of Wyndham
- SMPL is committed to Indigenous employment and training programs with Indigenous employees already working for SMPL
- SMPL maintain a high degree of community focus and will develop the Sorby Hills project in line with best practise, community, environmental and safety standards



Contact Information

Project Management

Edgar Newman
Project Manager
Sorby Management Pty Ltd
Level 3, 2 Elizabeth Plaza
North Sydney, NSW.

Telephone: (02) 9927 2006
Facsimile: (02) 99272050
ednewman@kimberleymetals.com.au

Environmental Approvals

Sharon Arena
Principal Environmental Advisor
Animal Plant Mineral Pty Ltd
68 Westgrove Drive,
Ellenbrook, W.A.

Telephone: (08) 6296 5155
Facsimile: (08) 6296 5199
sharon@animalplantmineral.com.au

Concentrate Handling and Transport

SMPL are acutely aware that the handling (packing, storage, loading and transport) of the Sorby Hills concentrate is an important aspect of the project. SMPL is committed to minimising any risk associated with this phase of the operation.

SMPL and its contactors will implement a range of rules and procedures to all stages of the concentrate handling process.



Logistics

SMPL endeavour to achieve minimal direct handling of concentrate by utilising a predominantly mechanised system. Concentrate will be packaged at the final stage of the processing circuit where it will be expelled directly into shipping containers.

"Rotainer" shipping containers will be used for the collection, storage and transport of concentrate; "Rotainer" containers are purpose built, stackable, bulk ore containers that can be fully sealed with lockable lids.

Containers carrying concentrate will be transported from site to Wyndham Port by 80t road train; trucks will travel via the Weaber Plain Road, Victoria Highway and Great Northern Highway passing through both Kununurra and Wyndham.

An average of 12 truck movements per week are expected, although up to 20 movements a week could occur following events such as road closures from flooding.

SMPL will utilise existing Wyndham Port facilities and ship once a month for 11 months each year.

Concentrate Handling and Transport (continued)

Management and Safeguards

Packing and Storage

- Concentrate handling will be predominantly mechanised
- Only purpose built "Rotainer" containers will be used
- Containers will be fully sealed and locked after filling
- All concentrate residue will be removed from the outside of containers by vacuum
- No container will be stored in a way that compromises the integrity of the container
- Containers will be stored upright and stacked no more than two high

Loading and Transport

- Road trains will pass through wash down facility prior to leaving site
- All drivers will possess the relevant driver training and licensing
- Speed restrictions will be applied and will not be exceeded
- Exhaust breaking will be banned within townships
- Vehicles will be regularly maintained to reduce noise generation
- Haulage trucks will only operate during daylight hours



Port

- On arrival every container will be inspected to check the integrity of the container walls, door seals and locking bolt
- Locks and lids will only be removed from the containers immediately prior to unloading
- Containers are designed to be manoeuvred by the ships crane and unloaded directly into the hold by rotation of the container
- The "RotorMist" system will be utilised for dust suppression; "RotorMist'' is a unique fluid misting system designed to be integrated with the "Rotainer'' container rotation system

Stakeholder Consultation Register - Sorby Management Pty Ltd - Sorby Hills Project

Date	Federal / State / Local Government Department or Company	Position	Person/s	Comms. Method	Topics Covered	Issues Raised	SMPL Response
04-Apr-11	DEC EMB	Environmental Officer	Sandra Thomas	Meeting	Discussion of project overview	Acknowledged the extent of project and agreed that no short range endemic or troglofauna sampling be done	
12-Apr-11	Shire of Wyndham East Kimberley (SWEK)	Vice President	Cr John Moulden	Meeting	Project overview (history, planned operation, surveys etc.)	Sealing of the Weaber Plains Road	
			Katya Tripp			Acquisition of regional data sets on abiotic and biotic data	
			Fiona Kuiper				
	MRWA		Darren Jackson				
			Owen Mclean				
	KBL Mining Limited	Project Engineer	Lubur Hon				
	Animal Plant Mineral	Director and Principal Biologist	Dr Mitch Ladyman				
		Principal Environmental Advisor	Sharon Arena				
		Community Liaison	Anna Price				
	Department of Regional Development and Lands (DRDL)	Director	Peter Stubbs				
			Dr Debra Pearce				
	Dept of Conservation and Environment		Daryl Moncrieff				
			Carmen Standring				
	Department of Water	Water Licensing and Land Use Planning Officer	David Munday				
		Water Licensing and Land Use Planning Officer	Jacinta Thompson				
05-May-11	Sorby Management Pty Ltd (SMPL)	Project Manager	Edgar Newman	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
	Department of Mines and Petroleum (DMP)	Project Manager - Legislation and Compilence	Mike Freeman				
	DMP	Environmental Officer	Justin Robins				
	DMP	Environmental Officer					
	DMP	Manager - Tenure and Native Title Branch	Neil Spencer				
	Land Access	Land Accsess Liaison	Kevin Ridge				
	Department of Regional Development and Lands (DRDL)	Business Manager Ord Expansion	Eugene Carew				
	Shire of Wyndham East Kimberley (SWEK)	Chief Exceutive Officer	Gary Gaffney				
11-May-11	SWEK	Director of Development Services	Nick Kerns	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
	SWEK		Russell Williams				
	Miriuwung Gajerrong Corporation (MG Corporation)	Chairman	Teddy Carlton				
11-May-11	Ord - East Kimberley Expansion Project	Director	Peter Stubbs	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
12-May-11	Department of Environment and Conservation (DEC)	Regional Leader - Industry Regulations	Damien Thomas	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
13-May-11	DEC	Environmental Officer	Carmen Standring	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
	DEC	Land Conservation Officer	Erica Shedley				
	Carlton Hill Station	Manager	Stirling Fearon				
17-May-11	Carlton Hill Station	Chief Operations Officer	Geoff Warrener	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
	DMP	Project Manager - Legislation and Compilence	Mike Freeman				
19-May-11	DMP	Environmental Officer	Justin Robins	Meeting	Environment Specific Project Briefing	Measurement of Thallium levels - sampling of road to Wyndham Waste and tailings characterisation	
	Advent Energy	Chief Exceutive Officer	David Brezze			Tailings management plan Closure plan	
20-May-11	GHD	Hydrogeologist	Greg Muntz	Meeting	Gas usage for Sorby Hills Project Site		
26-May-11	GHD	Hydrogeologist	Laura Ellis	Meeting	Topographic and hydrogeological survey work		
	Chambers of Minerals and Energy	Director	Nicole Roocke				
26-May-11	LAS Pty Ltd	Anthropologist	Justin Svitan	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
	POAGS	Director Bulk logistics	Antony Perkins	Meeting	Heritage and Cultural Survey work		
19-Jun-11	Animal Plant Mineral	Principal HSE Adviser	Sharon Arena	Meeting	Transportation of mineral concentrates		
22-Jun-11	LAS Pty Ltd	Anthropologist	Justin Svitan	Site Visit	Water and Dust Sampling		
27-Jun-11	Gimbulki Resources	Heritage Consultant	Eddie Fry	Meeting	Heritage and Cultural Survey discussions		
28-Jun-11	Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Corporation	Traditional Owner (TO)	Teddie Carlton	Meeting	XXXX		
	Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Corporation	TO	Ronnie Carlton				
	Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Corporation	TO	Button Jones				
	Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Corporation	TO	Jimmy Paddy				
	Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Corporation	TO	Morris Simon				
	Yawoorroong Miriuwung Gajerrong Yirrgeb Noong Dawang Corporation	TO	David Newby				
	EPA	Principal Environmental Officer - Mining and Industrial Assessments	Peter Tapsall				
01-Jul-11	Animal Plant Mineral	Pricipal HSE Adviser	Sharon Arena	Meeting	General Meeting - Sorby Hills Project Overview/Briefing		
	DRDL	Business Manager Ord Expansion	Eugene Carew				
11-Jul-11	Cambridge Gulf Ltd	Chief Exceutive Officer	Tony Shaffer	Meeting	Cultural clearances M80/285		
21-Jul-11	MG Corporation	Chief Exceutive Officer	Franklin Gaffney	Meeting	Use of port facillities		
21-Jul-11	MG Corporation	General Manager	Gus Tampalini	Meeting	Ongoing heritage clearance and general discussions		
	DMP	Chief Dangerous Good Advisor	Peter Drygala				
26-Jul-11	Department of Agriculture	XXXX	Richard George	Meeting	Classification of Sorby Hills Concentrate		
28-Jul-11	SWEK	Shire President	Fred Mills	Meeting	Discussions realting to Ord Stage II information and environmental issues		
29-Jul-11	SWEK	Deirector of Development Services	Nick Kerns	Meeting	Sorby Hills Project Overview		
	DEC	Manager - Licensing and Permitting	Peter Skitmore				
29-Jul-11	Department of Transport (DOT)	Advisor	Micheal Jackson	Meeting	Discussion regarding the transportation and handling of Sorby Hills mineral concentrate		
01-Aug-11	Ord - East Kimberley Expansion Project	Director	Peter Stubbs	Meeting	Discussion regarding the handling and shipment of mineral concentrates		
05-Aug-11	Greg Carver	Archeaologist	Greg Carver	Meeting	Discussion realting to EPA issues that may be faced by the Sorby Hills Project		
17-Aug-11	DEC	Regional Manager (Kununurra)	Daryl Moncrieff	Meeting	Archeaological survey work		
18-Aug-11	Department of Regional Development and Lands (DRDL)	Business Manager Ord Expansion	Eugene Carew	Meeting	General discussion and Sorby Briefing		
26-Aug-11	DMP	Project Manager - Legislation and Compilence	Mike Freeman	Meeting	Land tenure		
26-Aug-11	DEC	Regional Manager (Kununurra)	Daryl Moncrieff	Meeting	PCP/160 and lLand tenure		
01-Sep-11	Kimberley Land council	Agreements Administration	Angela Firman	Meeting	Discussion regarding PCP/160		
21-Sep-11	Shire Wyngham East Kimbeley	All councillors		Email / phone	Heritage documents from KLC library		
04-Oct-11	Dept of Water Kununurra		Kate , Bree, Chris , Gary Humphries , Sharon Arena	Meeting	Project Briefing		
05-Oct-11	DEC Kununurra	Environmental Officer	Carmen Standring	Meeting	Briefing on 2011 Hydrogeology program		
05-Oct-11	MG Corporation	CEO	Franklin Gaffney	Meeting	PMP requirement consultation		
05-Oct-11		Lawyer	Dominique Reeves	Meeting	Cultral Clearance discussions		
	Dept Mine Resource Safety	Mines Inspectors	Yadav Sharma , Lucio Figueiredo, Stephen Kelly, Peter McGough				
11-Oct-11	Department of Regional Development and Lands (DRDL)	Business Manager Ord Expansion	Eugene Carew	MG Corporation	Lawyer	Dominique Reeves	
18-Oct-11	MG Corporation	Lawyer	Dominique Reeves	phone	discussions on current grazing rights over mine area		
18-Oct-11	MG Corporation	Lawyer	Dominique Reeves	Email	Cultral clearance commencment		
18-Oct-11	Department of Regional Development and Lands (DRDL)	Business Manager Ord Expansion	Eugene Carew	phone	discussions MOU re northern Tenemnts		
03-Nov-11		Consultants	Wayne Paul, Jim Engelke	Meeting	Synergy with Sugar Mill development		
14-Nov-11	Chambers of Minerals and Energy	Director	Nicole Roocke	Meeting	Kimberley Regional council meeting		
11-Nov-11	MG Corporation	Lawyer	Dominique Reeves	Meeting	Discussions re Heritage agreements and Ilua		
17-Nov-11	Department Agriculture Kununurra	Hydrogeologist	Richard George	Meeting	Discussion on Ground water issues		
17-Nov-11	Chamber of Commerce and General Public	Manager	Noel Wilson	Meeting	Presentation of Sorby Project		
			See tab: AttList 181111	Presentation	Project Overview (history, planned operation, surveys etc.)		
18-Nov-11	Advent Energy	Corporate Development Manager	Toby Foster	Phone / Email	Gas requirements for project		

Chamber of Commerce and General Public

18 November 2011

1	Allan	Wedderburn	Redspinifex
2	Belinda	Alister	Kununurra Neighbourhood House
3	Nathan	Allister	Survey North
4	Tanielle	Anderson	Kimberley Echo
5	Daniel	Bach	Direct Drilling
6	Julie	Bavington	Discovery Holiday Park
7	David	Bavington	Discovery Holiday Park
8	Richard	Beeck	WannaWork
9	Yale	Bolto	CGL
10	Robbert	Boshammer	Kimberley Fine Diamond
11	Thomas	Breig	Pumphouse
12	Dominique	Breig	Pumphouse
13	Alicia	Bridges	Kimberley Echo
14	Alicia	Bridges	Kimberley Echo
15	Rebecca	Bugg	Just Framed
16	Cally	Bugg	Just Framed
17	Philip	Carlton	Kimberley Training Institute
18	Tony	Chafer	CGL
19	James	Coad	Direct Drilling
20	Dave	Contencin	Survey North
21	Georgi	Contencin	Survey North
22	James	Cottee	Direct Drilling
23	Cherie	Cottee	Direct Drilling
24	Linda	Cunningham	Walkabout Souvenirs
25	Peter	Day	Many Rivers Microfinance
26	Olivia	Day	Kimberley Echo
27	John	Gault	DPC
28	Sue	Gilbert	Town Caravan Park
29	Graeme	Gilbert	Town Caravan Park
30	John	Graham	Argyle Diamond
31	Penney	Hayley	Penney's Prints
32	Fiona	Hewitt	Hidden Valley Caravan Park
33	Richard	Hewitt	Hidden Valley Caravan Park
34	Lubor	Hon	Sorby Management
35	Judy	Hughes	Marriage Celebrant
36	Rihanna	Hunt	Kimberley Echo
37	Liz	Kirkby	Kimberley Development Commission
38	Nadeen	Lovell	Lovell Galery
39	Anthony	Lynch	Whelans
40	Martina	Manners	Kununurra Scenic Bus Tours
41	Peter	Manners	Kununurra Scenic Bus Tours
42	Andrew	McWaters	Direct Drilling
43	David	Menzel	Barradale
44	Roxanne	Mysko	Kimberley Training Institute
45	Ed	Newman	Sorby Management
46	Warren	O'Rafferty	Ascent
47	Wayne	Paul	Stratco
48	Dominique	Reeves	MG Corp.
49	Frank	Rodriquez	
50	Coralie	Spurling	Mouse's Engravings
51	Peter	Stubbs	Budget
52	Sue	Stubbs	Budget
53	Anita	Sutherland	SBCEK
54	Rocky	Sutherland	Guest
55	Scott	Tidswell	Direct Drilling
56	Chris	Turner	Guest
57	Simon	Turpin	Ivanhoe Caravan Park
58	Julie	Turpin	Ivanhoe Caravan Park
59	Rob	Weir	Thumbs up Painting
60	Sue	Weir	Thumbs up Painting
61	Jill	Williams	Direct Drilling
62	Brad	Williams	First National Real Estate
63	Sarah	Williams	First National Real Estate
64	Keith	Wright	2KTours
65	Anne	Wright	2KTours