TIWEST PTY LTD

COOLJARLOO WEST PROJECT

FLORA AND VEGETATION ASSESSMENT

September 2009

woodmanenvironmentalconsulting

A.C.N. 088 055 903

DOCUMENT REVISION HISTORY

Revision	Description	Originator	Reviewed	Date
REVA	draft report for client review	BT	GW	20-03-09
REV0	final report	BT	GW/CW	8-06-09
REV1	risk assessment incorporated	BT	GW/CW	17-08-09
REV2	final report	BT	GW/CW	15-09-09

WEC REF: Tiwest08-19-01

DISCLAIMER

This document is prepared in accordance with and subject to an agreement between Woodman Environmental Consulting Pty Ltd ("Woodman Environmental") and the client for whom it has been prepared ("Tiwest") and is restricted to those issues that have been raised by the Client in its engagement of Woodman Environmental and prepared using the standard of skill and care ordinarily exercised by Environmental Scientists in the preparation of such Documents.

Any organisation or person that relies on or uses this document for purposes or reasons other than those agreed by Woodman Environmental and the Client without first obtaining the prior written consent of Woodman Environmental, does so entirely at their own risk and Woodman Environmental denies all liability in tort, contract or otherwise for any loss, damage or injury of any kind whatsoever (whether in negligence or otherwise) that may be suffered as a consequence of relying on this document for any purpose other than that agreed with the Client.

TABLE OF CONTENTS

APPENDICIES

FIGURES

TABLES

EXECUTIVE SUMMARY

Tiwest Pty Ltd (Tiwest) commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) to conduct detailed flora and vegetation studies of the Cooljarloo West exploration leases (E70/2345, E70/2346), primarily to assess potential environmental impacts from a proposed exploration program and to provide information to mitigate impacts (Figure 1).

Experienced botanists carried out the structural plant community mapping in November 2008. Data collected previously within the project area by Woodman Environmental during studies for the Empire Oil 3D Seismic Survey Program (WEC 2006a) were also used to produce the final vegetation map (Figure 2).

A total of 286 detailed recording sites were positioned within the Cooljarloo West project area during the studies conducted by Woodman Environmental between 2005 and 2008. A total of 617 native plant taxa and 42 introduced (weed) taxa have been recorded within the Cooljarloo West project area during the surveys. The Declared Plant (weed) *Moraea flaccida* was recorded at 3 locations during the surveys. This species is listed as a P1 species, prohibiting the movement of plants, seeds and contaminated machinery within the state (DAF 2009).

A total of four Declared Rare Flora species were recorded during the surveys as listed below:

- *Andersonia gracilis*
- *Anigozanthos viridis* subsp. *terraspectans*
- *Eremophila glabra* subsp. *chlorella*
- *Macarthuria keigheryi*

A total of 31 Priority Flora species were recorded during the surveys. There are an additional 22 Priority Flora species historically known from the project area (Figure 4).

A total of 22 structural plant communities were described and mapped within the project. None of the plant communities recorded correspond with listed Threatened Ecological Communities (TECs) as defined by the Department of Environment and Conservation (DEC 2009e).

Community T5 (Cooljarloo Swamp) may correspond with the PEC 'Priority 1– 'Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs' and may possibly represent a restricted community. The potential underground mound spring associated with Community W4 adjacent to Woolka Rd may be regionally restricted. Community W8 was also restricted within the project area (representing only 11.6ha) and may also be regionally restricted.

Exploration drilling within the Falcon and Cooljarloo West project areas have the potential to adversely impact flora and vegetation. Potential impacts include:

- Disturbance to plant communities. Full clearing of vegetation will not be required along exploration drill lines as drill rigs and associated vehicles drive over existing low vegetation and avoid trees. Occasionally a rubber tyred loader will be used to flatten vegetation for vehicle access where it is too high or thick for light vehicles and drill rigs to drive over.

- Loss of individuals of significant flora species. There are a number of Declared Rare and Priority Flora species that may potentially be located within areas to be disturbed

- Risk of fire – Vehicle movement and machinery operation has the potential to cause fires in densely vegetated areas

- Negative impacts to conservation values of reserves – Part of the project area is located within Reserve No. A40916. Introduction of weeds or plant diseases, or ignition of a wildfire during drilling activities could impact the conservation value of the reserve.

- Potential introduction and spread of weeds and plant diseases such as *P. cinnamomi* by ground disturbance activities and vehicle traffic.

- Indirect impacts – Ground disturbance activities may impact surface drainage patterns and cause drainage shadows or ponding, impacting on the health of the flora

The following recommendations are made based on the results of the flora and vegetation surveys and are relevant for future works within the Falcon and Cooljarloo West project areas:

- Where possible all wetlands should be avoided (Table 11) to minimise erosion impacts and disturbances to local drainage patterns.

- Where possible, proposed drilling programs should utilise existing cleared access tracks to minimise clearing

- Proposed drilling programs should avoid all known locations of DRF species (Table 8) and poorly known significant flora species (Table 9).

- Potential impacts to DRF species *Macarthuria keigheryi* and *Andersonia gracilis* may be supported with a 'Permit to Take' application

- Proposed drilling programs should consider the framework summarised in Table 11 for impacts to FCTs and plant communities recorded in the Falcon and Cooljarloo West project areas. This will identify communities requiring avoidance or additional survey to appropriately manage impacts to restricted (<50ha) communities and DRF species.

- Weed and *P. cinnamomi* hygiene measures in the form of an integrated hygiene management plan for proposed drilling programs should be implemented.

- Quadrat based floristic assessments should be conducted if proposed drilling programs identify viable orebodies for mining. This will provide the appropriate level of investigation and regional context to support an impact assessment under the *Environmental Protection Act 1986*.

1. INTRODUCTION

Tiwest operate a number of exploration leases (E70/2345, E70/2346) located west of the current mining operations (Cooljarloo West) within M268SA. These leases are located predominantly within Private Property (pastoral leases) and Unallocated Crown Land, with a small section encompassing Reserve No. A40916.

Tiwest commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) to conduct detailed flora and vegetation studies of the Cooljarloo West area (the project area) to support proposed drilling programs and provide the basis for further floristic studies required for an Environmental Impact Assessment. This report collates and utilises data from the 2008 survey in addition to data obtained from a number of previous studies. Data sources include:

- Reconnaissance survey (structural vegetation mapping) of the Falcon area (WEC 2006a)
- Comprehensive survey (Floristic Community Type mapping) of the Falcon area (WEC 2007a, 2009)
- Reconnaissance survey (structural vegetation mapping) for the Empire Oil Mullering Onshore 3D Seismic Survey Program (WEC 2006b)
- Declared Rare and Priority Flora locations obtained from the Tiwest database (2009)
- Declared Rare and Priority Flora locations obtained from the DEC (2009c)
- Historical locations of TECs as listed and provided by the DEC (2009d)

Flora and vegetation assessments for Environmental Impact Assessments have been conducted in accordance with the Environmental Protection Authority (EPA) document "Guidance for the Assessment of Environmental Factors No. 51" – Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia (EPA 2004). Due to the location of the survey area and the presence of Declared Rare Flora (DRF) and endemic species and communities and the nature of the proposed impact being Low, the level of investigation conducted was Level 1, incorporating background research and a reconnaissance survey.

1.1 AIMS

The aim of this project was to obtain information on the plant communities and flora species in remnant native vegetation within the project area. Information collected during these surveys will facilitate management of impacts to flora and vegetation for proposed exploration programs and provide data for additional impact assessments for future mining should it be considered.

The tasks required to meet this aim were:

Vegetation

1. Review and collate existing data on soil and vegetation within the survey area.
2. Map the plant communities within the survey area from aerial photography followed by ground confirmation.
3. Collect quantitative data from sites located within each plant community.
4. Review the conservation status of each plant community and its sensitivity to disturbance.
5. Record the condition of the vegetation.

Flora

1. Review and collate existing data on Conservation Significant Flora including Declared Rare and Priority Flora in the survey area.
2. Produce a list of the vascular plant species recorded within each community, based on site data as well as opportunistic collecting.

2. BACKGROUND

The project area is located within the Irwin Botanical District (Northern Sandplains Region), within the Southwest Botanical Province as defined by Beard (1990). Dominant plant families within the Irwin Botanical District include Proteaceae (*Grevillea, Banksia*), Myrtaceae (*Eucalyptus, Melaleuca*), Mimosaceae (*Acacia*), Casuarinaceae (*Casuarina, Allocasuarina*), Asteraceae (daisies), Chenopodiaceae (salt bushes) and Poaceae (grasses).

The project area is located within the SWA2 – Swan Coastal Plain Subregion (Environment Australia 2000) and is bordered by the GS3 – Lesueur Sandplain and SWA1 – Dandaragan Plateau subregions. The SWA2 subregion is characterised by colluvial and aeolian sand, alluvial river flats and coastal limestone (Mitchell *et. al.* 2001). The subregion generally features heath and/or Tuart Woodlands on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes, and Marri on colluvial and alluvials, and includes a complex series of wetlands (Mitchell *et. al.* 2001). Expressions of ecotones remnant of the GS3 and SWA2 subregions have contributed to the floristic diversity within the project area.

The project area is located on the borders of the Guilderton, Jurien and Bassendean Vegetation Systems as described by Beard (1979).

The Guilderton System features the recent sand dunes of the coastal belt and is the northern extension of the Quindalup Dunes of the Swan Coastal Plain. The dunes consist of white sands succeeded by thickets of *Acacia cyclops*. In areas with frequent burning the vegetation is typically heath or low scrub dominated by Acacia lasiocarpa and Melaleuca acerosa. On flats and interdunes the vegetation climaxes to thickets of *Allocasuarina lehmanniana* and on salt flats saltbush, samphire and *Melaleuca thyoides* are dominant. Unvegetated drift sands are a feature within the Guilderton System (Beard 1979).

The Jurien System is located within the older coastal limestone belt and is the northern extension of the Spearwood Dunes on the Swan Coastal Plain. The vegetation is typically *Banksia prionotes* woodlands over tall shrubs such as *Banksia sessilis* and *Calothamnus quadrifidus*. Patches of *Acacia spathulata* heath are found on shallow soils, *Banksia* woodlands on deep white sands and stunted *Eucalyptus gomphocephala* in depressions (Beard 1979).

The Bassendean System is a flat undulating plain with low ridges of bleached sand interspersed with swampy flats underlain by calcareous soils. On well drained soils *Banksia* woodlands are dominant whereas swampy areas give rise to heaths of a mix of species including *Acacia lasiocarpa, Melaleuca acerosa, Banksia telmatiaea, Calytrix aurea, Calytrix flavescens, Verticordia densiflora* and *Verticordia drummondii*. Samphires and *Frankenia* spp. are found within salt pans whereas deeper swamps typically consist of woodlands of *Melaleuca rhaphiophylla, Eucalyptus rudis* and *Banksia littoralis* over species such as *Hypocalymma angustifolium, Acacia rostellifera, Melaleuca thyoides* and *Casuarina obesa* (Beard 1979).

The project area is located within the Minyulo and Mimegarra Suites as defined by Semeniuk (1994). The Minyulo Suite is located in the vicinity of Mullering Brook and consists of a series of sumplands, damplands and creeks within the Bassendean System. The creek transports sediment and flushes water from the associated floodplains and palusplains. The presence of an undisturbed buffer of vegetation surrounding the Mullering Brook enhances the biological values of this suite.

The Mimegarra Suite is represented further north of the private property (Duffy). This suite is locally significant as it contains a number of seasonal freshwater sumplands and damplands within a generally water deficient area (Semeniuk 1994). The basins provide habitat nodes for fauna and the majority are surrounded by undisturbed vegetation which provide hydrological buffers.

Vegetation associations related to physiognomy within the project area were described by Shepherd *et. al.* (2002). There are three vegetation associations located within the project area (Figure 5). These vegetation associations have over 50 percent of pre-european extent remaining and a reasonable percentage of current extent (over 10 percent) held within reserves (Table 1).

Table 1: Description, Pre-european Extent, Current Extent and Reservation Status of Vegetation Associations Related to Physiognomy in the Cooljarloo West Project Area (Shepherd *et. al.* 2002)

Vegetation Association	Description	Current Extent (ha)	Percentage of Pre-european Extent Remaining	Percentage Held Within IUCN Class Reserves
129	Bare areas; drift sand	60,576	63.6	45.8
1026	Mosaic: Shrublands; *Acacia rostellifera*, *A. cyclops* (in the south) & *Melaleuca cardiophylla* (in the north) thicket / Shrublands; *Acacia lasiocarpa* & *Melaleuca acerosa* heath	63,149	89.3	53.0
1030	Low woodland; *Banksia attenuata* & *B. menziesii*	91,250	65.6	14.6

2.1 PREVIOUS SURVEYS WITHIN THE PROJECT AREA AND REGION

Mapping of structural plant communities within the Mullering area (located within the Cooljarloo West project area) was undertaken by Woodman Environmental in 2005 and 2006 to support an environmental management plan for the proposed Empire Oil Mullering Onshore 3D Seismic Survey program (WEC 2006b). A total of 454 native plant taxa and 32 introduced species were recorded within the Mullering project area. The Declared Plant (weed) *Moraea flaccida* was recorded during the surveys. This species is listed as a P1 species, prohibiting the movement of plants, seeds and contaminated machinery within the state (DAF 2009).

A total of 13 DRF and Priority Flora species were recorded during the surveys as listed below:

Andersonia gracilis	DRF
Macarthuria keigheryi	DRF
Anigozanthos viridis subsp. *terraspectans*	DRF
Eremophila glabra subsp. chlorella	DRF
Melaleuca clavifolia	P1
Onychosepalum microcarpum	P1
Schoenus pennisetus	P1
Acacia benthamii	P2
Banksia dallanneyi subsp. *pollosta*	P3
Baeckea sp. Perth Region (R.J. Cranfield 444)	P3
Haloragis foliosa	P3
Banksia platycarpa	P4
Verticordia lindleyi subsp. *lindleyi*	P4

A total of 25 structural plant communities were described and mapped within the Mullering project area as listed below:

Forests

F1: Low Forest dominated by *Banksia attenuata* over mixed herbaceous species dominated by *Anarthria laevis* on brown sand

Woodlands

W1: Woodland dominated by *Eucalyptus decipiens* subsp. *decipiens* over mixed shrubs and herbs dominated by *Austrostipa compressa* on grey sand

W2: Open Woodland of *Eucalyptus rudis* over mixed shrubs on grey sand

W3: Low Woodland of *Eucalyptus todtiana*, *Banksia attenuata* and *Banksia menziesii* over mixed shrubs on grey sand

W3d: Degraded areas of Community W3

W4: Low Woodland dominated by *Banksia prionotes* over mixed shrubs on brown sand

W5: Open Low Woodland of *Melaleuca preissiana* and *Banksia attenuata* over mixed shrubs on brown sand

W5a: Open Woodland of *Melaleuca preissiana*, *Banksia attenuata* and *Melaleuca rhaphiophylla* over mixed shrubs on brown loamy sand on the crest of a low rise

W6: Low Woodland to Low Forest dominated by *Melaleuca rhaphiophylla* on grey sand in a swamp

W6d: Degraded areas of Community W6

Scrub

S1: Dwarf Scrub dominated by *Melaleuca systena* and mixed shrubs and herbs on grey sand

S2: Dwarf Scrub dominated by *Tecticornia indica* subsp. *bidens* over mixed herbs and sedges on grey sand in a swamp

Thickets

T1: Thicket of *Melaleuca viminea* subsp. *viminea* over herbs and sedges on grey sand in swamps and creeks

T2: Thicket dominated by *Acacia rostellifera* on grey sand with occasional limestone outcropping

T3: Thicket of *Melaleuca lateritia* and *Melaleuca teretifolia* over herbs and sedges on grey clay in a swamp

Heaths

H1: Dense Heath dominated by *Banksia telmatiaea* with mixed shrubs on grey sand

H2: Dense Heath dominated by *Beaufortia squarrosa* over mixed shrubs and herbs on grey sand

H3: Dense Heath dominated by *Melaleuca seriata* over mixed shrubs on grey sand

H4: Heath dominated by *Banksia armata* var. *armata* and *Gastrolobium plicatum* and mixed shrubs on brown sand

H5: Heath dominated by *Calothamnus quadrifidus* and *Hakea obliqua* subsp. *parviflora* and mixed shrubs on white sand

H6: Heath of mixed shrubs on yellow sand with limestone outcropping

H7: Heath dominated by *Banksia telmatiaea* and *Beaufortia squarrosa* and mixed shrubs and sedges on brown sand in a swamp

H8: Heath dominated by *Allocasuarina lehmanniana* subsp. *lehmanniana* and mixed shrubs and sedges on grey sandy clay in a swamp

H9: Dense Low Heath dominated by *Calothamnus quadrifidus* over mixed shrubs and sedges on grey sand

H10: Low Heath dominated by *Melaleuca systena* on yellow sand on dunes

H11: Low Heath dominated by *Melaleuca brevifolia, Melaleuca seriata* and *Grevillea thelemanniana* subsp. Coojarloo (B.J. Keighery 28 B) (P1) over mixed shrubs on grey sand in a drainage basin

Sedges

SE1: Very Open Tall Sedgeland dominated by *Gahnia trifida* on grey sandy clay in swamps

Mosaics and Other Codes

M1: Mosaic of Low Woodland of *Banksia ilicifolia, Banksia menziesii, Banksia attenuata* and *Eucalyptus todtiana* over mixed shrubs on brown sand; and Low Heath dominated by *Acacia pulchella* var. *glaberrima* and *Calothamnus quadrifidus* and mixed shrubs on grey clayey sand

M2: Mosaic of Heath dominated by *Banksia telmatiaea* and mixed shrubs on brown sand; and Low Sedgeland dominated by *Chorizandra enodis* with *Melaleuca lateriflora* subsp. *acutifolia* on brown clayey sand

D1: Disturbed Forest of *Casuarina obesa* over mixed weeds on brown clay

D2: Disturbed Thicket dominated by *Allocasuarina* ?*lehmanniana* over mixed shrubs and herbs

D3: Disturbed Woodland of *Eucalyptus* ?*decipiens* over pasture

CL: Cleared Areas

F: Seasonally inundated wetland floor associated with Community T1

None of the communities recorded corresponded with listed Threatened Ecological Communities (TECs) as defined by the Department of Environment and Conservation (2009e). However, plant community W5a was noted as being unusual and restricted regionally.

Woodman Environmental has conducted numerous surveys within the Falcon area to identify, assess and manage risks to flora and vegetation associated with proposed mining operations and potential drawdown impacts (WEC 2006a, 2007a, 2009). A total of 391 native plant taxa and 23 introduced (weed) taxa have been recorded within the Falcon project area during studies conducted by Woodman Environmental between 2005 and 2008. A total of 23 DRF and Priority Flora species were recorded during the surveys (Table 2).

Table 2: Declared Rare Flora and Priority Flora Species Recorded within the Falcon Project Area during Surveys Conducted by Woodman Environmental, 2005- 2008

Species	Conservation Status	Project Area	
		Falcon Area	Extension Area
Andersonia gracilis	DRF	*	
Angianthus micropodioides	P3	*	
Anigozanthos viridus subsp. *terraspectans*	DRF	*	
Baeckea sp. Perth Region (R.J. Cranfield 444)	P3	*	*
Banksia platycarpa	P4	*	*
Calectasia palustris	P1		*
Conospermum scaposum	P3	*	
Haloragis ?foliosa	P3		*
Hensmania stoniella	P3	*	*
Hypocalymma serrulatum	P3		*
Jacksonia carduacea	P3	*	*
Lasiopetalum lineare	P3	*	*
Lepidobolus densus ms	P3	*	
Macarthuria keigheryi	DRF		*
Malleostemon sp. Cooljarloo (B. Backhouse s.n. 16/11/88)	P1	*	
Melaleuca clavifolia	P1	*	*
Onychosepalum nodatum	P3	*	*
Platysace ramosissima	P3	*	
Schoenus pennisetis	P1	*	
Schoenus griffinianus	P2	*	
Stylidium hymenocraspedum ms	P2	*	
Thysanotus glaucus	P4	*	
Verticordia lindleyi subsp. *lindleyi*	P4	*	

A total of 11 Floristic Community Types (FCTs) within 2 supergroups were mapped and described within the Falcon area during the quantitative surveys (WEC 2009). Supergroup 1 represented Heath, Scrub and Forest sites in wet areas on lowerslopes, flats, drainage lines and basins. Supergroup 2 comprised woodlands and heaths on deeper sands on mid to upperslopes and swales.

Supergroup 1

FCT1: Heath dominated by *Banksia telmatiaea* and/or *Melaleuca viminea* subsp. *viminea* on grey or brown sandy clay in drainage lines and basins

FCT2: Heath dominated by a mix of species including *Melaleuca brevifolia*, *M. rhaphiophylla* and *M. lateriflora* subsp. *acutifolia* interspersed with stands of *Viminaria juncea* on grey or brown sandy clay on lowerslopes, flats and basins

FCT3: Heath dominated by *Banksia telmatiaea* and *Regelia ciliata* on grey sand over clay on lowerslopes and flats

FCT4: Scrub of *Viminaria juncea* over Heath of *Banksia telmatiaea* and *Regelia ciliata* on grey or brown sand in wet basins

FCT4/9a: Mosaic of FCTs 4 and 9a

FCT5: Species rich Heath dominated by *Banksia telmatiaea* and various other species including *Beaufortia squarrosa*, *Kingia australis* and *Regelia ciliata* on brown or grey sand on lowerslopes, flats and depressions

FCT5/9a: Mosaic of FCTs 5 and 9a

FCT6: Heath dominated by *Pericalymma spongiocaule* with emergent *Banksia littoralis* on grey sandy clay in swales

FCT6/9a: Mosaic of FCTs 6 and 9a

FCT7: Heath dominated by *Melaleuca rhaphiophylla* and *M. viminea* subsp. *viminea* on grey-black clay in basins

FCT8: Low Forest to Open Low Woodland dominated by *Banksia littoralis*, *Melaleuca preissiana* or *M. rhaphiophylla* with Thickets of *Acacia saligna* on grey sandy clay or occasionally ironstone on lowerslopes and basins

Supergroup 2

FCT9a: Low Woodland of *Banksia attenuata*, *B. menziesii* and *Eucalyptus todtiana* with occasional *Banksia ilicifolia* over Heath on grey or white sand on mid to upperslopes

FCT9b: Low Woodland of *Banksia ilicifolia* and *Eucalyptus todtiana* over Low Heath on grey sand in swales

FCT10: Low Forest to Low Woodland of *Banksia prionotes* and *Eucalyptus todtiana* over Low Heath on brown or yellow sand on mid to upperslopes

FCT11: Low Heath dominated by *Calothamnus sanguineus*, *Hakea incrassata*, *H. lissocarpha* and *Hibbertia* spp. on grey or brown sandy clay with lateritic gravel on midslopes and swales

None of the FCTs recorded within the Falcon project area corresponded with listed Threatened Ecological Communities (TECs) as defined by the Department of Environment and Conservation (2009e). The most restricted FCTs recorded were FCT 6 and FCT 7.

Woodman Environmental conducted a survey for DRF species along proposed drill lines within the Cooljarloo West project area during 2006 (WEC 2007b). A total of three DRF species were recorded during the surveys as listed below:

Andersonia gracilis	DRF
Anigozanthos viridis subsp. *terraspectans*	DRF
Macarthuria keigheryi	DRF

Western Botanical (2004) undertook a survey of 24 proposed drill lines located within the Falcon lease areas (Retention License 70/15) in 2004. A total of nine Priority Flora species, one possible DRF species, and two undescribed species were recorded during the survey. Priority Flora species recorded were:

Conospermum scaposum	P3
Banksia dallanneyi subsp. *pollosta*	P3
Banksia tortifolia	P3
Hensmannia stoniella	P3
Jacksonia carduacea	P3
Lasiopetalum lineare	P3
Platysace ramosissima	P3
Verticordia lindleyi subsp. *lindleyi*	P4
Banksia platycarpa	P4

Potentially *Anigozanthos viridis* subsp. *terraspectans* (DRF) was recorded, however specimens were unable to be positively identified at the time. Two potentially new species, *Dryandra nivea* subsp. Cooljarloo (G Cockerton 3423) and *Isopogon buxifolius* subsp. Cooljarloo (GC 2001) were also recorded, however specimens of these were not vouchered at the Western Australian Herbarium (WAHerb), and are currently unrecognised by the WAHerb. The collection historically recorded by Western Botanical (2004) as *Isopogon buxifolius* subsp. Cooljarloo (GC 2001) correlates with *Isopogon* sp. Badgingarra (A.S. George 14200) (P1). In addition, the collection *Dryandra nivea* subsp. Cooljarloo (G Cockerton 3423) is now considered to be *Banksia nivea* subsp. *nivea* (pers. comm. A. George).

Rockwater Pty Ltd (2008) undertook a survey of 365 drill holes along approximately 117km of drill lines and access tracks within exploration tenements 70/2345 and 70/2346 in 2008. A total 21 Priority Flora species and four DRF species were recorded during the survey as listed below:

Andersonia gracilis	DRF
Anigozanthos viridis subsp. *terraspectans*	DRF
Eremophila glabra subsp. *chlorella*	DRF
Macarthuria keigheryi	DRF
Chordifex reseminans	P1
Melaleuca clavifolia	P1
Schoenus pennisetis	P1
Isopogon sp. Badgingarra (A.S. George 14200)	P2
Stylidium hymenocraspedum	P2
Schoenus griffinianus	P3
Angianthus micropodioides	P3
Baeckea sp. Perth Region (R.J. Cranfield 444)	P3
Conospermum scaposum	P3
Banksia dallanneyi subsp. *pollosta*	P3
Eryngium pinnatifidum subsp. *palustre*	P3
Frankenia glomerata	P3
Hensmania stoniella	P3
Jacksonia carduacea	P3
Lasiopetalum lineare	P3
Onychosepalum nodatum	P3
Verticordia amphigia	P3
Anigozanthos humilis subsp. *chrysanthus*	P4
Banksia platycarpa	P4
Thysanotus glaucus	P4
Grevillea thelemanniana subsp. Cooljarloo (B.J. Keighery 28B)	P1

Recent taxonomic work conducted by Greg and Bronwen Keighery of the Department of Environment and Conservation have identified additional new taxa within the region of the project area. *Grevillea thelemanniana* subsp. Coojarloo (B.J. Keighery 28 B) P1 was previously recognized as *Grevillea preissii* and is now considered to be conservation significant. This species has been collected by Woodman Environmental within the Mullering area (WEC 2006b) and Falcon area (WEC 2009). *Petrophile* sp. Coojarloo (name unpublished) has been collected further west of the Coojarloo West project area within remnant vegetation adjacent to Woolka Rd. This species is currently being considered to be given a conservation status of P1 in the near future.

3. METHODS

3.1 PRELIMINARY MAPPING

Aerial photography of the project area was initially interpreted at a scale of 1:10,000. Maps provided were overlain with information provided by various Department of Environment and Conservation (DEC) databases (DEC 2009c,d) including the Threatened (Declared Rare) Flora Database, WAHerb Database and Threatened Ecological Community (TEC) Database in addition to historical data provided by Woodman Environmental (2006a&b, 2007a&b, 2009) and Tiwest (2009).

3.2 FIELD SURVEY

Experienced botanists carried out the structural plant community mapping in November 2008. Structural plant community mapping (no plots) was chosen over quadrat based floristic community mapping for the following reasons:

1. The mineral exploration will have a Low impact on the vegetation therefore only a Level 1 survey (EPA 2004) is required
2. Plotless mapping allows for more sample locations in less time than quadrat based studies making it ideal for assessing areas for species composition and finding uncommon taxa when compared to quadrat studies

Plant collections were undertaken under the following licenses:

- Greg Woodman SL008043 75-0708 (DRF)
- Bianca Taylor SL008044 80-0708 (DRF)
- David Coultas SL008065 79-0708 (DRF)
- Kylie Greenacre SL008064 78-0708 (DRF)
- Brendan Stratton SL008068

All areas surveyed were traversed by vehicle and on foot to map vegetation boundaries. Detailed recording sites were taken at each community boundary change and regularly within communities. At each site a standard recording sheet was used to ensure the consistent collection of flora and site data. At each site the following information was collected within a 20m radius:

- Site location (including GPS co-ordinates, GDA Zone 50);
- Surface soil type, colour and presence of outcropping;
- Position of site in the local landscape;
- Site condition, including fire history and presence of any disturbance (as defined by Bush Forever (Government of Western Australia 2000);
- Height and cover of any tree species present;
- Height and cover of dominant vascular understorey plant species present;
- Presence of any other vascular plant species, including significant species; and
- Vegetation structure (as defined by Muir (1977)).

A total of 155 recording sites were established within the project area during 2008 (Figure 1, 2). A historical summary of the sampling regimes used within the Cooljarloo West project area and Falcon project area during various surveys conducted by Woodman Environmental is provided in Table 3.

Table 3: Summary of Sites and Quadrats Established Within the Cooljarloo West Project Area and Falcon Area During Various Studies Conducted by Woodman Environmental

Project Area		Sampling Regime	Reference
Cooljarloo West	2008 Survey	155 detailed recording sites	-
	Mullering Area	131 detailed recording sites	WEC 2006b
Falcon		37 detailed recording sites	WEC 2006a
		96 quadrats*#	WEC 2007a, 2009

*quadrats 10m x 10m
#includes 16 regional quadrats

An adaptation of the Muir (1977) classification of vegetation structure was used to describe the plant communities, as this has been used for the majority of historical vegetation studies in the region. This adaption utilises the vegetation classification system described in Table 1 in Muir (1977) and omits the use of floristic and soil codes which have been replaced by full Genus and Species labels in addition to descriptions of surface soils.

Where possible, the conservation status of each plant community was determined by referring to available regional studies in addition to comparisons with the Threatened Ecological Community (TEC) database provided by the Department of Environment and Conservation (2009e).

Specimens of all plant species that were not identifiable in the field were collected for identification at the Western Australian Herbarium (WAHerb). Plant species nomenclature used in this report follows Packowska and Chapman (2000). All names were checked using the Max Database to ensure their validity. The conservation status of all species collected was checked using the current Department of Environment and Conservation list (DEC 2009f). Conservation status code definitions are presented in Appendix A.

All specimens of conservation significant species (including range extensions) collected from the project area will be submitted to the WAHerb upon completion of the project.

4. RESULTS

4.1 FLORA

A total of 617 native plant taxa and 42 introduced (weed) taxa were recorded within the Cooljarloo West project area during studies conducted between 2005 and 2008. Collectively, a total of 657 native plant taxa and 49 introduced taxa have been recorded by Woodman Environmental during various studies conducted within Tiwest Cooljarloo leases (Appendix B).

The Declared Plant (weed) *Moraea flaccida* (One-leaf Cape Tulip) was recorded at 3 locations during the surveys. This species is listed as a P1 species, prohibiting the movement of plants, seeds and contaminated machinery within the state (DAF 2009).

A total of 34 DRF and Priority Flora species were recorded during the surveys conducted within the Cooljarloo West project area by Woodman Environmental between 2005 and 2008. A summary of DRF and Priority Flora species recorded within the project area and Falcon area by Woodman Environmental in addition to data provided by Tiwest (2009) and the Department of Environment and Conservation (DEC 2009c) is provided in Table 4. Appendix A provides a description of conservation status codes (DEC 2009a).

Table 4: DRF and Priority Flora Species Recorded within the Project Area and Falcon Area during Surveys Conducted by Woodman Environmental 2005- 2008 in Addition to Data Provided by Tiwest (2009) and the Department of Environment and Conservation (DEC 2009c)

Species	Conservation Status	Falcon Area	Cooljarloo West*	No. of Locations~
?*Malleostemon* sp. Cooljarloo (B. Backhouse s.n. 16/11/88)	P1	FCT5	-	1
Acacia benthamii	P2	-	H3	1
Andersonia gracilis	DRF	FCT1, FCT2, FCT3, FCT5, FCT6	H4, (H6), T4, (W3), (H5), (H7)	>350
Angianthus micropodioides	P3	FCT1, FCT2, FCT5	H1, H2, H4, S1, T4, T1, W1	32
Anigozanthos humilis subsp. *chrysanthus*	P4	-	H4	1
Anigozanthos viridis subsp. *terraspectans*^	DRF	FCT2, FCT5	H1, H4, (H5), (W3), W1, T4, W3/H4,	36
Arnocrinum gracillum	P2	-	W3	6
Baeckea sp. Perth Region (R.J. Cranfield 444)	P3	FCT2, FCT3, FCT5, FCT11	H4, T4, W1, W3, W7, H5, H4/T4, H4/W1	58
Banksia dallanneyi subsp. *pollosta*	P3	-	H4, W3	3
Banksia platycarpa	P4	FCT3, FCT5, FCT9a, FCT11	T4, T4, W3, W7	160
Beaufortia bicolor	P3	-	W3, H5	3
Beaufortia eriocephala	P3	-	H6	1
Calectasia palustris	P1	FCT3, FCT11	-	9
Chordifex chaunocoleus	P4	-	H4	5
Chordifex reseminans	P1	-	H4, H5	4
Conostephium magnum	P4	-	PP	1
Conospermum scaposum	P3	FCT5, FCT9a	H4, H5, W5, W7, T3, W3	89
Desmocladus biformis	P3	-	W3	1
Eremophila glabra subsp. *chlorella*	DRF	-	(W3), H1, H4	3
Eryngium pinnatifidum subsp. *palustre*	P3	-	H4, S1	3
Eucalyptus johnsoniana[#]	DRF	-	PP	1
Frankenia glomerata^	P3	-	H1, H4, S1, T4	13
Grevillea thelemanniana subsp. Coojarloo (B.J. Keighery 28 B)	P1	FCT2, FCT3, FCT5	W1, (W3), T4/H4, H4, H3, T4, S1, T1, H1, T3, (H5)	51

Table 4: DRF and Priority Flora Species Recorded within the Project Area and Falcon Area during Surveys Conducted by Woodman Environmental 2005- 2008 in Addition to Data Provided by Tiwest (2009) and the Department of Environment and Conservation (DEC 2009c)

Species	Conservation Status	Falcon Area	Cooljarloo West*	No. of Locations~
Goodenia ?trichophylla	P3	-	W3, H5	2
Haloragis foliosa^	P3	FCT3	T2d	2
Hensmania stoniella	P3	FCT5, FCT9a, FCT9b	W3, T1	112
Hibbertia helianthemoides	P3	FCT5	-	2
Hypocalymma serrulatum	P3	FCT8, FCT11	-	6
Hypocalymma tetrapterum	P3	FCT5	-	6
Isopogon sp. Badgingarra (A.S. George 14200)	P2	FCT2, FCT3, FCT4, FCT5, FCT9b, FCT11	H4, T3, (W3), S1	81
Jacksonia carduacea	P3	FCT3, FCT5, FCT9a	W3, H4	24
Lasiopetalum lineare	P3	FCT9a, FCT10	H5, W3, W4	70
Lepidobolus densus ms	P3	FCT10	-	1
Leucopogon sp. Yanchep (M. Hislop 1986)	P3	-	W3/W5	1
Loxocarya gigas	P2	-	H4	1
Lyginia excelsa	P1	-	H4	1
Macarthuria keigheryi	DRF	FCT9a	(H4), W3, W7, T4/H4, H5, T4	154
Melaleuca clavifolia^	P1	FCT3, FCT9a, FCT9b, FCT10, FCT11	H4, H5, H5, W3, W4, W5, W7, H7, W6, W3/W1, W3/H4	584
Meionectes tenuifolia	P3	-	H4	2
Onychosepalum microcarpum	P1	-	H4, H5	8
Onychosepalum nodatum	P3	FCT2, FCT3, FCT5, FCT9a	H4, W3	32
Platysace ramosissima	P3	FCT5, FCT9a, FCT9b	H4, H5, W3	97
Schoenus griffinianus	P3	FCT9b	H4, W3	5
Schoenus natans	P4	-	W1	1
Schoenus pennisetis	P1	FCT5	H5, H4, T1, T4 , W3	29
Stenanthemum sublineare	P2	-	W3	1
Stylidium hymenocraspedum ms^	P2	FCT9a	W3, S1	13
Stylidium aceratum	P2	-	T1	1

Table 4: DRF and Priority Flora Species Recorded within the Project Area and Falcon Area during Surveys Conducted by Woodman Environmental 2005- 2008 in Addition to Data Provided by Tiwest (2009) and the Department of Environment and Conservation (DEC 2009c)

Species	Conservation Status	Falcon Area	Cooljarloo West*	No. of Locations~
Stylidium longitubum	P3	-	S1, H1, W1, T4	5
Thysanotus glaucus	P4	FCT9a	W3	5
Verticordia lindleyi subsp. *lindleyi*	P4	FCT5, FCT9a, FCT9b	H4, H5, W3	26
Verticordia amphigia	P3	-	T4/H4	1
Villarsia submersa	P4	-	W1	1

*note brackets () indicate atypical habitats that are a product of edge effects of mosaic communities that were not mapped or historical data points collected when GPS datums were not as accurate (+/- 200m) in comparison with todays GPS datums (+/- 7m)
^includes locations where species not positively identified ie *Melaleuca* ?*clavifolia*
the recording of *Eucalyptus johnsoniana* in the project area is erroneous. The latitude and longitude details for herbarium record PERTH 05220459 do not match the locality details (Tootbardie Rd)
~locations refer to the number of GPS points within the database and are not related to number of plants

Andersonia gracilis (DRF) (Plate 1) is a straggly shrub to 0.5m with pink and purple flowers between September and November (DEC 2009f). It is known from 4 localities between Kojonup and Wongonderrah Rd, a range of approximately 360km. This species has been recorded within the Birdwhistle Nature Reserve and Wongonderrah Nature Reserve (DEC 2009g) and prefers winter wet habitats. A total of 137 locations of *Andersonia gracilis* are found in the project area, within communities H4, H5, H6, H7, T4 and W3.

Plate 1: ***Andersonia gracilis*** **photos by K. Atkins and M. Hislop**

Anigozanthos viridis subsp. *terraspectans* (DRF) (Plate 2) is a perennial herb to 0.2m with green and yellow flowers between August and September (DEC 2009f). It is known from 11 localities between Boonanarring and Wongonderrah Rd, a range of approximately 80km. This species has been recorded within Reserve No. A40916 and prefers winter wet habitats (DEC 2009g). A total of 25 locations of *Anigozanthos viridis* subsp. *terraspectans* are found in the project area, within communities H1, H4, H5, T4, W1,W3 and W3/H4.

Plate 2: ***Anigozanthos viridis*** **subsp.** ***terraspectans*** **photo by B. and B. Wells**

Macarthuria keigheryi (DRF) (Plate 3) is a perennial herb to 0.2m with green and white flowers between September and March (DEC 2009f). It is known from 7 localities between Perth and Wongonderrah Rd, a range of approximately 165km (DEC 2009g). This species has not been recorded within secure tenure within the conservation estate. *Macarthuria keigheryi* is a short lived (<5 years) disturbance opportunist that regenerates after fire from rootstock and seed stored in the topsoil. A total of 130 locations of *Macarthuria keigheryi* are found in the project area, within communities H4, T4, T4/H4,W3 and W7.

Plate 3: ***Macarthuria keigheryi*** **photos by G. Keighery**

Eremophila glabra subsp. *chlorella* (DRF) (Plate 4) is a sprawling shrub to 1m with green and yellow flowers between July and November (DEC 2009f). It is known from 8 localities between Quairading and Arrowsmith River, a range of approximately 340km (DEC 2009g). This species has been recorded within Reserve No. C971 and Mogumber

Nature Reserve and prefers clay soils within winter-wet habitats. A total of 4 locations of *Eremophila glabra* subsp. *chlorella* are found in the project area within communities H1, H4 and W3.

Plate 4: ***Eremophila glabra*** **subsp.** ***chlorella*** **photos by A. Brown**

A number of poorly known taxa and range extensions were recorded within the project area (Table 5)

Table 5: Poorly Known Taxa and Range Extensions Recorded within the Cooljarloo West Project Area

Species	Conservation Significance
Drosera closterostigma	range extension 50km north
Myriocephalus helichrysoides	range extension 75km north
Villarsia submersa (P4)	range extension 65km north
Stenanthemum sublineare (P2)	range extension 100km north
Angianthus pygmaeus	range extension 50km north
Schoenus natans (P4)	range extension 75km north
Stylidium aceratum (P2)	range extension 150km north

A collection of a *Conospermum* species previously collected within the Cooljarloo West project area and reported by Woodman Environmental Consulting (2009) as a potential new species is now known to be *Conospermum scaposum* (P3).

4.2 VEGETATION

4.2.1 Cooljarloo West Project Area

A total of 22 structural plant communities were described and mapped within the Cooljarloo West project area during studies conducted by Woodman Environmental between 2005 and 2008. A photographic record of the communities recorded is provided in Appendix D.

Forests

F1: Low Forest of *Casuarina obesa* and *Melaleuca* spp. over scattered low shrubs on brown sandy loam on lowerslopes and drainage flats

Community F1 is located in the west of the project area on loamy soils adjacent to drainage basins. The overstorey is dominated by *Casuarina obesa* and *Melaleuca rhaphiophylla*. Common understorey species included *Melaleuca brevifolia* and *Melaleuca lateriflora* subsp. *acutifolia* over a mixture of herb species. A total of 22 vascular plant taxa were recorded within Community F1.

Woodlands

W1: Low Woodland to Dense Low Forest of *Melaleuca rhaphiophylla* over Low Sedges on brown sand over clay in basins

This plant community was mapped in isolated pockets throughout the project area within seasonally damp basins and areas fringing open water bodies. The understorey is typically dominated by *Lepidosperma longitudinale* with emergent shrubs such as *Melaleuca teretifolia* and *Acacia saligna* depending on water regimes. A total of 124 vascular plant taxa were recorded within Community W1.

W2: Low Woodland to Low Forest of *Eucalyptus rudis* or *Corymbia calophylla* and *Melaleuca* spp. over Low Scrub or Scrub on grey or brown sand or clay on lowerslopes, drainage lines and basins

A total of five occurrences of Community W2 are located throughout the project area along small drainage lines and basins. The overstorey is typically dominated by *Eucalyptus rudis* and *Melaleuca rhaphiophylla* with scattered shrubs such as *Acacia saligna* and *Xanthorrhoea preissii*. A total of 81 vascular plant taxa were recorded within Community W2.

W3: Low Woodland to Low Forest of *Banksia attenuata* and *Banksia menziesii* with occasional *Eucalyptus todtiana* over Heath dominated by *Eremaea pauciflora* and/or *Hibbertia hypericoides* on brown or grey sand on lower to midslopes

Community W3 was the dominant woodland mapped throughout the project area. The Heath understorey is species rich and *Melaleuca clavifolia* (P1) is commonly seen. In parts the understorey is dominated by *Acacia pulchella* var. glaberrima or *Jacksonia*

nutans reflecting recent fire history (<5yrs) and intensity. A total of 342 vascular plant taxa were recorded within Community W3.

W4: Open Low Woodland of *Banksia attenuata*, *Banksia menziesii* and *Melaleuca preissiana* over Low Heath on brown sand in swales and low rises

This community was recorded in the south of the project within small swale areas. The presence of a number of wet species including *Melaleuca preissiana*, *Beaufortia squarrosa* and *Phlebocarya ciliata* indicates that the water table is close to the surface. This community is comparable to Community W3 - the sandy soils support a species rich heath with similar suites of species. The occurrence of W4 adjacent to Woolka Rd within the Mullering area is situated on the crest of a low rise. *Eucalyptus rudis and Melaleuca rhaphiophylla* are present at this location and are likely to be associated with an underground mound spring. A total of 131 vascular plant taxa were recorded within Community W4.

W5: Low Woodland to Low Forest of *Banksia prionotes* over Low Scrub or Heath dominated by *Acacia spathulifolia* on brown over yellow sand on low rises

Community W5 was recorded in the south west of the project area adjacent to drainage areas. The overstorey is dominated by *Banksia prionotes* with occasional *Banksia attenuata* and *Banksia menziesii*. Common understorey species included *Acacia spathulifolia*, *Melaleuca systena* and *Allocasuarina lehmanniana* subsp. *lehmanniana* reflecting the coastal position of Community W5 within the project area. A total of 123 vascular plant taxa were recorded within Community W5.

W6: Low Woodland to Low Forest of *Banksia prionotes* and *Banksia attenuata* over Heath on yellow sand on upperslopes

Community W6 was recorded in the east of the project area on low rises with deep yellow sands. The understorey is quite variable in composition and notable species include *Allocasuarina humilis*, *Hibbertia hypericoides* and *Leptospermum erubescens*. A total of 60 vascular plant taxa were recorded within Community W5.

W7: Open Low Woodland of *Banksia ilicifolia*, *Banksia menziesii* and *Banksia attenuata* over Heath on brown sand on lowerslopes

Community W7 was recorded in the south of the project area on lowerslopes adjacent to drainage areas. This community may be considered to be an ecotone between Community W3 and the wetter communities recorded within the project area- floristic analysis is required to determine whether this unit is delineated from Community W3. The occurrences to the south-east of the project area could be mapped using field observations and aerial interpretation. However, it is likely that this community is more extensive within the project area than reported, forming mosaics between wet and dry communities. Wet indicator species recorded within Community W7 include *Banksia telmatiaea*, *Beaufortia squarrosa*, *Hypocalymma angustifolium*, *Isopogon* sp. *Badgingarra* (A.S. George 14200) (P2) and *Melaleuca seriata*. A total of 71 vascular plant taxa were recorded within Community W7.

W8: Woodland dominated by *Eucalyptus decipiens* subsp. *decipiens* over mixed shrubs and herbs on grey sand on lowerslopes

A total of 3 small occurrences of Community W8 were mapped in the south of the project area within swale areas and lowerslopes adjacent to basins. The overstorey is dominated by *Eucalyptus decipiens* subsp. *decipiens* with occasional *Banksia prionotes* and *Banksia attenuata*. The understorey is dominated by *Austrostipa compressa* reflecting the recent fire history of this community at the time of survey (< 1yr). A total of 38 vascular plant taxa were recorded within Community W8.

Thickets

T1: Scrub to Thicket dominated by *Melaleuca lateriflora* subsp. *acutifolia* on brown or grey clay or loamy clay in basins

Community T1 was recorded in the central portions of the project area on loams and clays in small basins. Common overstorey species included *Melaleuca viminea* subsp. *viminea*, *Grevillea thelemanniana* subsp. Coojarloo (B.J. Keighery 28 B) (P1) and *Melaleuca rhaphiophylla*. Emergent rushes and sedges included *Gahnia trifida* and *Chaetanthus aristatus*. A number of salt tolerant species (*Melaleuca brevifolia*, *Tecticornia indica* subsp. *bidens* and *Samolus repens* var. ?*paucifolius*) were recorded within this community in areas adjacent to samphire salt pans. A total of 72 vascular plant taxa were recorded within Community T1.

T2: Thicket of *Allocasuarina lehmanniana* subsp. *lehmanniana* over Open Low Sedges on grey clay in basins

This community was recorded in the west of the project area within coastal basins associated with the Guilderton System. The understorey is dominated by *Gahnia trifida* and *Baumea juncea* with emergent *Melaleuca rhaphiophylla*. Saline areas within the basin feature herb fields of salt tolerant species such as *Triglochin mucronata* and *Wilsonia backhousei* (see photo on front cover). A total of 65 vascular plant taxa were recorded within Community T2.

T3: Scrub to Thicket dominated by *Acacia saligna*, *Viminaria juncea* and *Melaleuca rhaphiophylla* (stunted form) on grey or brown sand over clay on lowerslopes, drainage lines and minor basins

A total of two isolated occurrences of Community T3 were recorded in the east of the project area within small basins. This community is similar to Community W1, however the absence of dominant sedges within the understorey and the emergence of thickets of *Acacia saligna* and *Viminaria juncea* indicate that the soils are inundated for a lesser period of time. A total of 59 vascular plant taxa were recorded within Community T3.

T4: Scrub to Thicket dominated by *Melaleuca rhaphiophylla* and *Melaleuca viminea* subsp. *viminea* on brown or grey sand over clay in basins

Community T4 was recorded predominantly in the southern portion of the project area with isolated occurrences adjacent to the Falcon area in the north. Common species

included *Regelia ciliata*, *Hakea varia* and *Goodenia pulchella* subsp. Coastal Plain A (M. Hislop 634). A total of 154 vascular plant taxa were recorded within Community T4.

T5: Thicket of *Melaleuca lateritia* and *Melaleuca teretifolia* over rushes and sedges on grey clay in a swamp

Community T5 was recorded within the grey clay soils of Cooljarloo Swamp to the south of the project area. The understorey is dominated by *Lepidosperma longitudinale* and an unidentified *Meeboldina* species. A total of 5 vascular plant taxa were recorded within Community T5, represented by only one detailed recording site.

Heaths

H1: Low Scrub to Heath dominated by *Melaleuca brevifolia* on brown sand over clay in drainage lines and basins

Community H1 was recorded throughout the project area within drainage lines and basins with shallow sands over clay. Common species included *Verticordia densiflora*, *Calothamnus hirsutus*, *Conostylis aculeata* subsp. *spinuligera* and *Grevillea thelemanniana* subsp. Coojarloo (B.J. Keighery 28 B) (P1). A total of 81 vascular plant taxa were recorded within Community H1.

H2: Heath to Thicket of a mix of species including *Allocasuarina lehmanniana* subsp. *lehmanniana*, *Acacia cyclops*, *Melaleuca viminea* subsp. *viminea* and *Regelia ciliata* on brown or grey clay in basins

Community H2 was recorded in the west of the project area within basins associated with the Guilderton System. A number of coastal species were recorded within this community (*Leucopogon parviflorus*, *Acacia cyclops*, *Acacia rostellifera* and *Samolus junceus*). A total of 28 vascular plant taxa were recorded within Community H2.

H3: Heath to Thicket dominated by *Allocasuarina lehmanniana* subsp. *lehmanniana* or *Melaleuca systena* on yellow or white sand on dunes

Community H3 was recorded in the west and south-west of the project area on sand dunes associated with the Guilderton System. Common species included *Anthocercis littorea*, *Clematis linearifolia*, *Spyridium globulosum*, *Leucopogon parviflorus* and *Schoenus grandiflorus* which are typically coastal species or indicators of calcareous soils. A total of 72 vascular plant taxa were recorded within Community H3.

H4: Heath dominated by a mix of species including *Banksia telmatiaea, Regelia ciliata and Melaleuca seriata* with occasional Scrub or Open Scrub of *Hakea obliqua* subsp. *parviflora* on grey or brown sand on lowerslopes, flats and drainage basins

This community is widespread throughout the project area and features a species rich heath on sandy soils in low lying areas adjacent to larger drainage basins. The emergence of a scrub layer of *Hakea obliqua* subsp. *parviflora* is likely to be a

reflection of fire history. Common species included *Beaufortia squarrosa*, *Xanthorrhoea preissii*, *Conostylis aculeata* subsp. *spinuligera* and *Verticordia densiflora*. A total of 308 vascular plant taxa were recorded within Community H4.

H5: Heath dominated by *Allocasuarina humilis* and *Melaleuca seriata* with emergent *Eucalyptus todtiana* and *Nuytsia floribunda* on brown sand on midslopes

Community H5 is located in the south of the project area on sandy soils with occasional lateritic gravel. Common understorey species included *Hibbertia hypericoides*, *Eremaea pauciflora* and *Melaleuca clavifolia* (P1). A total of 215 vascular plant taxa were recorded within Community H5.

H6: Heath of *Allocasuarina microstachya* and *Banksia armata* var. *armata* on brown silty sand over laterite on low rises

Community H6 was recorded in a number of small pockets in the south of the project area on sandy soils over lateritic gravel. Only one recording site was positioned within this community, with other notable species including *Beaufortia eriocephala* (P3), *Melaleuca seriata* and *Hakea incrassata*. A total of 41 vascular plant taxa were recorded within Community H6.

H7: Low Heath dominated by *Gastrolobium oxylobioides* and *Hakea* spp. on brown sand over laterite on midslopes and low rises.

This community was recorded in the south of the project area on sands over lateritic gravel. Common species included *Calothamnus sanguineus*, *Hibbertia hypericoides*, and *Hakea incrassata*. A total of 89 vascular plant taxa were recorded within Community H7.

Samphire Salt Pans

S1: Samphire salt pans dominated by *Tecticornia indica* subsp. *bidens* and/or *Sarcocornia* ?*blackiana* on brown or grey clay in basins

Community S1 was predominantly recorded in the west of the project area on saline flats. Emergent shrubs include *Melaleuca brevifolia*, *Melaleuca rhaphiophylla* and *Melaleuca viminea* subsp. *viminea*. Common species included *Calandrinia* sp. Kenwick (G.J. Keighery 10905), *Frankenia pauciflora*, *Isotoma scapigera* and *Lawrencia squamata*. A total of 43 vascular plant taxa were recorded within Community S1.

Mosaic Communities

Most of the mosiac communities recorded during the surveys were mapped in the south of the project area. As shown on Figure 2, this area of the project is the most complex in terms of vegetation communities and this reflects the variable soil units located within this area. These soil units are a reflection of the position of the project area within the landscape, which predominantly lies within the Bassendean System and is bordered by the Guilderton, Lesueur and Jurien Systems. A number of plant communities were

within ecotones of these soil complexes and could not be cleanly differentiated out in the field or on the aerial photographic maps at a scale that would allow presentation.

The largest mosiac community was recorded in the west of the project area (W3/W5). This community records the interchange between coastal species associated with recent dunes of the Guilderton System and species associated with the older dunes of the Bassendean System.

4.2.2 Distribution of Communities Recorded Within Tiwest Cooljarloo Leases by Woodman Environmental Between 2005 and 2008

An attempt has been made to align the plant communities recorded within the Cooljarloo West project area with previous studies conducted by Woodman Environmental within the Falcon project area (Table 6).

Table 6: Comparison of Communities Recorded Within the Cooljarloo West Project Area and Falcon Project Area

Cooljarloo West Project Area Plant Community	Falcon Project Area Floristic Community Type (FCT)
F1	-
W1	-
W2	-
W3	FCT9a
W4	-
W5	-
W6	FCT10
W7	FCT9b
W8	-
T1	FCT2
T2	-
T3	FCT8
T4	FCT7
T5	-
H1	FCT2
H2	-
H3	-
H4	FCT1, FCT3, FCT4, FCT5
H5	-
H6	-
H7	FCT11
S1	-
-	FCT6

The Cooljarloo West project area was structurally mapped using data collected from detailed recording sites. The Falcon area was initially surveyed using similar structural mapping methods, however this data was superseded with statistical based analyses (quadrats) and mapped according to Floristic Community Type (FCT) to support future

mining. The comparisons made in Table 6 can only be confirmed using statistical based analysis and FCT mapping within the Cooljarloo West project area.

This comparison demonstrates that FCT6 within the Falcon project area is unlikely to occur within the Cooljarloo West project area and may potentially represent a restricted community. FCT6 is located on the border of the Lesueur and Bassendean Systems. Similar communities have not been recorded within the Cooljarloo leases during studies conducted by Western Botanical (2002) or Mattiske Consulting (1996, 1997).

In addition, plant community H4 (*Banksia telmatiaea* heath) is structurally similar to a number of FCTs recorded within the Falcon project area. *Banksia telmatiaea* heaths are widespread throughout the Falcon and Cooljarloo West project areas. The species composition of these heath communities is strongly influenced by fire age and intensity and position in the landscape (distance to watertable). The floristics of these communities is not yet fully understood. A wider understanding of the distribution of *Banksia telmatiaea* heaths beyond the Falcon leases could be attained by using statistical based analyses and FCT mapping of the Cooljarloo West project area. It is recommended that these studies be conducted within the Cooljarloo West project area following the exploration drilling phase, should Tiwest proceed with additional studies to support and facilitate future sand mining in this area.

The number of hectares (ha) each plant community recorded within the Cooljarloo West project area was calculated to determine relative distributions and identify communities that may potentially be locally and/or regionally restricted (Table 7).

Table 7: Hectares Calculated for Each Community Recorded Within the Cooljarloo West Project Area

Plant Community	No. of Hectares*	Located Within Reserve No. A40916
W8	11.6	no
T5	17.2	no
H6	19.7	no
H7	19.7	yes
T3	19.9	no
F1	20.6	no
W4	23.6	yes
W6	24.4	no
T2	31.1	no
W7	44.4	yes
W2	60.7	no
H2	133.7	no
H1	179.5	no
T1	224.9	no
W1	240.5	yes
T4	343.5	yes
S1	455.8	no
W5	502.9	no
H3	1067.6	no
H5	1242.2	yes
H4	4829.6	yes
W3	13896.8	yes

* does not include disturbed vegetation or mosaics

The dominant plant communities recorded throughout the project area were H4 and W3. These communities are predominantly associated with the Bassendean System (Figure 5) and are distributed throughout the Cooljarloo West and Falcon areas.

The most restricted plant communities recorded were W8 and T5. Community W8 is associated with the lower slopes of dunes and may potentially occur further south within the Jurien System. Community T5 is located within the Bassendean System within Cooljarloo Swamp. This community was mapped at a single location and may potentially be restricted. Community W4 was generally found in swale areas, however one occurrence adjacent to Woolka Rd was recorded on a low rise. The presence of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* within this site is indicative of an underground mound spring. Structurally, this site is similar to other occurrences of W4 mapped within swale areas and has been mapped as such. However, quadrat based studies may further delineate this occurrence from community W4, potentially representing a restricted community.

Cooljarloo Spring (location 346029mE 6607267mN) is a potential Groundwater Dependant Ecosystem as defined by the Hydrogeological Record Series (Department of Environment 2005). The watertable is very close to the surface and recharge is via direct infiltration of rainfall through Guildford Sands. This site corresponds with Community H1 mapped immediately south of the private property (Duffy).

4.2.3 Threatened Ecological Communities

There are no Threatened Ecological Communities (TECs) known from within the project area (DEC 2009d). None of the plant communities recorded correspond with listed TECs as defined by the Department of Environment and Conservation (DEC 2009e).

Community T5 may be similar to the Priority Ecological Community (PEC) 'Priority 1– 'Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs'. This claypan community is characterised by the presence of *Eleocharis keigheryi* (DRF) and *Hydrocotyle lemnoides* (P4) in addition to a number of amphibious taxa (*Glossostigma diandrum, Villarsia capitata*). These species were not recorded within community T5 however this community was only represented by one detailed recording site. Additional surveys would be required to determine whether this community represents a PEC. This could be further defined during potential quadrat based studies within the Cooljarloo West area.

5. RISK ASSESSMENT FOR FUTURE EXPLORATION DRILLING PROGRAMS

5.1 FLORA

5.1.1 Declared Rare Flora (DRF)

Proposed drilling programs within the Falcon and Cooljarloo West leases have the potential to impact four DRF species, *Andersonia gracilis*, *Anigozanthos viridis* subsp. *terraspectans*, *Eremophila glabra* subsp. *chlorella* and *Macarthuria keigheryi*. These species and their potential habitats are summarised in Table 8.

Table 8: DRF Species Located Within the Falcon and Cooljarloo West Leases

Species	Community Types Where Recorded*		EPBC Act 1999 Rank	Comments
	Falcon Area	Cooljarloo West		
Andersonia gracilis	FCT1, FCT2, FCT3, FCT5	H4, T4	Endangered	Drill lines within these communities will require surveying in accordance with the *Wildlife Conservation Act* 1950. There is likely to be sufficient local data to support a 'Permit to Take' for this species. Surveys may be conducted out of Spring however this species is best recognised when in flower between Sept-Nov.
Eremophila glabra subsp. *chlorella*	-	H1, H4	-	Drill lines within these communities will require surveying in accordance with the *Wildlife Conservation Act* 1950. This species is taxonomically recognisable throughout the year and is considered uncommon in the local area, occurring in isolated small populations. Due to the small number of plants known in the local area and limited regional data available, a 'Permit to Take' for this species will require extensive regional surveys.
Anigozanthos viridis subsp. *terraspectans*	FCT2, FCT5	H1, H4, W1, T4, W3/H4	Vulnerable	Drill lines within these communities will require surveying in accordance with the *Wildlife Conservation Act* 1950. This species survives as seed in the topsoil and germinates post fire, with leaves senescing over the summer period. Areas of habitat that have not been burnt recently (<3years) are unlikely to have populations above ground. This species is difficult to distinguish from other species within the 'viridis' group without collections within the flowering period (August to November). There is limited local and regional data available for this species – a 'Permit to Take' will require additional regional surveys.
Macarthuria keigheryi	FCT9a	W3, W7, H5, H4	Endangered	Drill lines within these communities will require surveying in accordance with the *Wildlife Conservation Act* 1950. This species survives as seed in the topsoil and germinates post fire. It is a perennial herb that will die back for a short period of time over the summer period (late January to February) and survive as rootstock. Areas of habitat that have not been burnt recently (<3years) are unlikely to have significant populations above ground.

* only includes typical habitats

5.1.2 Priority Flora Species

A total of 48 Priority Flora species are known from the Falcon and Cooljarloo West leases (Appendix E). The majority of these species have large ranges, extensive habitats and populations located in secure tenure within the Conservation Estate. With these factors in consideration, it is anticipated that proposed drilling programs will have minimal impact on the local distributions of these species due to the linear nature of the disturbance proposed and minimal disturbance to the topsoil - full clearing of vegetation will not be required as drill rigs and associated vehicles drive over existing low vegetation and avoid trees. Occasionally a rubber tyred loader will be used to flatten vegetation for vehicle access where it is too high or thick for light vehicles and drill rigs to drive over.

A number of these species are considered to be poorly known (particularly in the Cooljarloo area) or have restricted ranges (Table 9). It is recommended that the locations of these species will be avoided during drilling operations until further population data becomes available.

Table 9: Poorly Known Priority Flora Species Located Within the Falcon and Cooljarloo West Leases

Species	No. Locations	Community Types Where Recorded	Comments	Recommendations
?*Malleostemon* sp. Cooljarloo (B.Backhouse s.n. 16/11/88) P1	1	FCT5	Species not found regionally in secure tenure and has a restricted range (30km), only known from 1 location within the Falcon Lease	Species is located outside of proposed drawdown and clearing areas in Falcon. Proposed drilling should avoid this location and the immediate habitat (buffer 100m) until further population data is available (337473mE 6617963mN)
Chordifex reseminans P1	4	H4, H5	Only 4 regional localities known for this species. Is likely to be uncommon within the Cooljarloo area	Proposed drilling should avoid these locations and the immediate habitat (buffer 100m) until further population data is available: 338499mE 6614214mN 337759mE 6614034mN 344789mE 6605146mN 344431mE 6603065mN
Lepidobolus densus P3	1	FCT10	Although this species has a large range, this record represents a locality hole (50km) for its distribution and habitat may be uncommon in the Falcon area	Proposed drilling should avoid this location and the immediate habitat (buffer 100m) until further population data is available (338740mE 6618483mN)
Lyginia excelsa P1	1	H4	This species has a very restricted range (15km) and is known from only 2 regional localities.	Proposed drilling should avoid this location and the immediate habitat (buffer 100m) until further population data is available (338117mE 6609508mN)
Stylidium aceratum P2	1	T1	Collection previously only known from 1 locality north of Perth and represents a 100km range extension. Collection has been confirmed by 2 x taxonomic specialists working on the *Stylidium* group. The specimen is a little unusual in form and has been lodged at the WAHerb.	Proposed drilling should avoid this location and the immediate habitat until further population data is available (338649mE 6612700mN)

5.2 VEGETATION

A total of 11 plant communities recorded in the Cooljarloo West area occupy less than 50ha and are potentially restricted (Table 10).

Table 10: Plant Communities within the Cooljarloo West Project Area with <50ha Distribution

Plant Community	No. of Hectares*	Comments	Recommendations	Located Within Reserve No. A40916
W8	11.6	very small representation within project area, possibly located further south within the Jurien System	drilling operations should avoid community	no
T5	17.2	may represent a PEC and has very small representation within project area	drilling operations should avoid community, additional survey required within community before any proposed impacts to discern whether represents a PEC	no
H6	19.7	very small representation within project area	drilling operations should avoid community	no
H7	19.7	very small representation within project area	drilling operations should avoid community	yes
T3	19.9	very small representation within project area	drilling operations should avoid community	no
F1	20.6	small representation within project area	drilling operations should avoid community	no
W4	23.6	small representation within project area, the occurrence adjacent to Woolka Rd within Mullering is likely to be associated with an underground mound spring and is considered to be significant	drilling operations should avoid community	yes
W6	24.4	community represented beyond project area (see WB 2003, Mattiske 1996, 1997)	No requirement to avoid community	no
T2	31.1	small representation within project area	drilling operations should avoid community	no
W7	44.4	likely to be more widespread throughout the project area forming mosaics between dry woodland communities and water gaining areas	there is no requirement for drilling operations to avoid the mapped locations of this community, however note that this community will require searching for DRF species (see Table 8)	yes

* does not include disturbed vegetation or mosaics

5.3 SUMMARY OF POTENTIAL IMPACTS OF DRILLING PROGRAMS

A summary of each FCT and plant community recorded in the Falcon and Cooljarloo West project areas is provided in Table 11. This will assist in the development of Risk Management Plans for future proposed drilling programs. Shaded areas within the table denote wetland communities that should be avoided where possible to minimise erosion impacts and disruptions to local drainage patterns.

Table 11: FCT and Plant Communities within the Falcon and Cooljarloo Leases Requiring Additional Survey or Avoidance during Exploration Drilling

FCT/Plant Community	Environmental Issues	Comments
W1	habitat for DRF (Avt)	requires survey
W2	none	-
W3	habitat for DRF (Mk)	requires survey
W4	represented by <50ha	avoid community
W5	none	-
W6	represented by <50ha	avoid community
W7	habitat for DRF (Mk)	requires survey
W8	represented by <50ha	avoid community
T1	none	-
T2	represented by <50ha	avoid community
T3	represented by <50ha	avoid community
T4	habitat for DRF (Ag, Avt)	requires survey
T5	represented by <50ha	avoid community
S1	none	-
H1	habitat for DRF (Egc, Avt)	requires survey
H2	none	-
H3	none	-
H4	habitat for DRF (Ag, Avt, Mk)	requires survey
H5	habitat for DRF (Mk)	requires survey
H6	represented by <50ha	avoid community
H7	represented by <50ha	avoid community
F1	represented by <50ha	avoid community
FCT1	habitat for DRF (Ag) represented by <50ha	avoid community
FCT2	habitat for DRF (Ag, Avt)	requires survey
FCT3	habitat for DRF (Ag)	requires survey
FCT4	none	-
FCT5	habitat for DRF (Ag, Avt)	requires survey
FCT6	represented by <50ha	avoid community
FCT7	represented by <50ha	avoid community
FCT8	none	-
FCT9a	habitat for DRF (Mk)	requires survey
FCT9b	represented by <50ha, however community likely to more extensive throughout Cooljarloo West area in mosaics between wet and dry communities	-
FCT10	represented by <50ha however similar communities represented beyond project area (see WB 2003, Mattiske 1996, 1997)	-
FCT11	none	-

note: Ag denotes *Andersonia gracilis*, Egc; *Eremophila glabra* subsp. *chlorella*, Mk; *Macarthuria keigheryi* and Avt; *Anigozanthos viridis* subsp. *terraspectans*
note: shading denotes wetlands

6. DISCUSSION AND RECOMMENDATIONS

6.1 POTENTIAL IMPACTS OF EXPLORATION DRILLING

Exploration drilling within the Falcon and Cooljarloo West project areas have the potential to adversely impact flora and vegetation. Potential impacts include:

- Disturbance to plant communities. Full clearing of vegetation will not be required along exploration drill lines as drill rigs and associated vehicles drive over existing low vegetation and avoid trees. Occasionally a rubber tyred loader will be used to flatten vegetation for vehicle access where it is too high or thick for light vehicles and drill rigs to drive over.

- Loss of individuals of significant flora species. There are a number of Declared Rare and Priority Flora species that may potentially be located within areas to be disturbed

- Risk of fire – Vehicle movement and machinery operation has the potential to cause fires in densely vegetated areas

- Negative impacts to conservation values of reserves – Part of the project area is located within Reserve No. A40916. Introduction of weeds or plant diseases, or ignition of a wildfire during drilling activities could impact the conservation value of the reserve.

- Potential introduction and spread of weeds and plant diseases such as *P. cinnamomi* by ground disturbance activities and vehicle traffic.

- Indirect impacts – Ground disturbance activities may impact surface drainage patterns and cause drainage shadows or ponding, impacting on the health of the flora

6.2 RECOMMENDATIONS

The following recommendations are made based on the results of the flora and vegetation surveys and are relevant for future works within the Falcon and Cooljarloo West project areas:

- Where possible all wetlands should be avoided (Table 11) to minimise erosion impacts and disturbances to local drainage patterns.

- Where possible, proposed drilling programs should utilise existing cleared access tracks to minimise clearing

- Proposed drilling programs should avoid all known locations of DRF species (Table 8) and poorly known significant flora species (Table 9).

- Potential impacts to DRF species *Macarthuria keigheryi* and *Andersonia gracilis* may be supported with a 'Permit to Take' application.

- Potential impacts to DRF species *Anigozanthos viridis* subsp. *terraspectans* and *Eremophila glabra* subsp. *chlorella* may require regional surveys to collect population data to support a'Permit to Take' application.

- Proposed drilling programs should consider the framework summarised in Table 11 for impacts to FCTs and plant communities recorded in the Falcon and Cooljarloo West project areas. This identifies communities requiring avoidance or additional survey to appropriately manage impacts to restricted (<50ha) communities and DRF species.

- Weed and *P. cinnamomi* hygiene measures in the form of an integrated hygiene management plan for proposed drilling programs should be implemented.

- Quadrat based floristic assessments should be conducted if proposed drilling programs identify viable orebodies for mining. This will provide the appropriate level of investigation and regional context to support an impact assessment under the *Environmental Protection Act 1986*.

7. REFERENCES

Beard, J.S. (1979)
The Vegetation of the Moora and Hill River Areas, Western Australia. Map and Explanatory Memoir 1:250,000 series. Vegmap Publications, Perth.

Beard, J.S. (1990)
Plant Life of Western Australia. Kangaroo Press, Perth.

Department of Agriculture and Food (2009)
Declared Plants in Western Australia. Online database www.agric.wa.gov.au

Department of Environment (2005)
The hydrogeology of groundwater dependent ecosystems in the Northern Perth Basin. Hydrogeological Record Series HG11 2005. Department of Environment.

Department of Environment and Conservation (2009a)
Declared Rare and Priority List for Western Australia. www.florabase.calm.wa.gov.au/conservationtaxa

Department of Environment and Conservation (2009b)
Definitions, Categories and Criteria for Threatened Ecological Communities. www.naturebase.net

Department of Environment and Conservation (2009c)
Interogation of DEC's Threatened Flora Databases and WAHerb Specimen Records, data provided by CAD Resources March 2009.

Department of Environment and Conservation (2009d)
Interrogation of DEC's Threatened Ecological Communities database, provided by CAD Resources March 2009.

Department of Environment and Conservation (2009e)
Threatened Ecological Communities endorsed by the Minister for Environment (Dec 2006). www.dec.wa.gov.au

Department of Environment and Conservation (2009f)
FloraBase. Publicly available database www.naturebase.net/florabase.

Department of Environment and Conservation (2009g)
Naturemap. Publicly available database http://naturemap.dec.wa.gov.au

Environment Australia (2000)
Revision of the Interim Biogeographical Regionalisation for Australia (IBRA) and Development of Version 5.1. – Summary Report. Department of Environment and Heritage, Canberra.

Environmental Protection Authority (2004)
Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation surveys for Environmental Impact Assessment in Western Australia, No. 51, June 2004. Unpublished report produced by the Environmental Protection Authority, Western Australia.

Government of Western Australia (2000)
Bush Forever Volume 2 Directory of Bush Forever Sites. Published by the Department of Environmental Protection, Perth.

Mattiske Consulting Pty Ltd (1996)
Vegetation Survey Vacant Crown Land Cooljarloo. Unpublished report prepared for Tiwest Joint Venture.

Mattiske Consulting Pty Ltd (1997)
Vegetation Survey 27000 South Area Cooljarloo. Unpublished report prepared for Tiwest Joint Venture.

Mitchell, D. Williams, K. and Desmond, A.(2001)
Swan Coastal Plain 2 (SWA2 – Swan Coastal Plain Subregion). A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002. Published report available online at www.naturebase.net.

Muir, B.G. (1977)
Biological Survey of the Western Australian Wheatbelt. Part 2. Records of the Western Australian Museum, Supplement No. **3**.

Paczkowska, Grazyna, and Chapman, Alex R. (2000).
The Western Australian Flora: A Descriptive Catalogue. Published by The Wildlife Society (Inc.), Western Australian Herbarium (CALM) and Botanic Gardens & Parks Authority, Perth.

Rockwater Pty Ltd (2008)
Flora Survey For Cooljarloo West Exploration Drilling Programme. Unpublished report prepared for Tiwest Pty Ltd, May 2008.

Semeniuk, V. (1994)
Ecological Assessment and Evaluation of Wetlands in the System 5 Region. Unpublished report prepared for the Australian Heritage Commision.

Shepherd, D., Beeston, G and Hopkins, A. (2002)
Native Vegetation in Western Australia. Extent, Type and Status. *Resource Management Technical Report 249*. Department of Agriculture, South Perth.

Tiwest (2009)
Interrogation of the Tiwest flora databases. Data provided by CAD Resources, March 2009.

Western Botanical (2002)
Major Habitat Mapping Cooljarloo Minesite North Mine Region, July 2002. Unpublished report prepared for Tiwest Joint Venture.

Western Botanical (2004)
DRF and Priority Species survey on proposed drill line extension for Retention License 70/15. Unpublished report prepared for Tiwest Joint Venture, June 2004.

Woodman Environmental Consulting (2006a)
Cooljarloo North (Falcon) Tenements: Flora, Vegetation and Phytophthora cinnamomi Assessment. Unpublished report prepared for Tiwest Pty Ltd, March 2006

Woodman Environmental Consulting (2006b)
Mullering Onshore 3D Seismic Survey Flora, Vegetation and Phythophthora cinnamomi *Assessment.* Unpublished report prepared for Empire Oil and Gas NL, December 2006.

Woodman Environmental Consulting (2007a)
Falcon Mineral Sands Project: Flora and Vegetation, Local and Regional Conservation Significance. Unpublished report prepared for Tiwest Pty Ltd, March 2007

Woodman Environmental Consulting (2007b)
Cooljarloo West, Phase 1 Drilling. Flora and Vegetation Assessment. Unpublished report prepared for Tiwest Joint Venture, January 2007.

Woodman Environmental Consulting (2009)
Falcon Mineral Sands Project. Area of Potential Water Drawdown. Flora and Vegetation. Unpublished report prepared for Tiwest Pty Ltd, March 2009.