Kemerton Silica Sand

Public Environmental Review
Extension of Kemerton Silica Sand, Dredge Mining

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Kemerton Silica Sand Pty Ltd

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environmental and water resource consultants

KEMERTON SILICA SAND
PUBLIC ENVIRONMENTAL REVIEW
EXTENSION OF KEMERTON SILICA SAND, DREDGE MINING

NOVEMBER 2009

PREPARED FOR

KEMERTON SILICA SAND PTY LTD

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INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

Kemerton Silica Sand is proposing an extension to the current approved mining operation undertaken by Kemerton Silica Sand Pty Ltd on Lot 32 and Lot 501 Rhodes Road, Wellington. The proposed extension of sand dredging operations is required to access silica sand resources suitable for both glass manufacturing and export. In accordance with the Environmental Protection Act 1986, a Public Environmental Review (PER) has been prepared describing this proposal and its likely environmental effects. The Public Environmental Review is available for a review period of 10 weeks from Monday 9 November 2009 closing on Friday 15 January 2010.

Comments from government agencies and the public will help the EPA prepare an assessment report to make recommendations to government.

Where to get copies of this document
Printed and CD copies of this document may be obtained from:

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Hard copies of the PER may be purchased for $10 or a CD version may be purchased for $5 (including postage and packaging). The document/s may also be accessed through the proponent's website at www.ksspl.com.au or www.mbsenvironmental.com.au

Why write a submission?
A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Electronic submissions will be acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions. In preparing its assessment report for the Minister for the Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992*, and may be quoted in full or in part in each report.

Why not join a group?
If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission
You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

INVITATION

When making comments on specific proposals in the PER:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind
By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the PER;
- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name, and address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is 15 January 2010.

The EPA prefers submissions to be made electronically using one of the following:

- the submission form on the EPA's website: www.epa.wa.gov.au/submissions.asp;
- by email to Douglas.Betts@dec.wa.gov.au

Alternatively submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 33, CLOISTERS SQUARE WA 6850, Attention: Doug Betts; or
- delivered to the Environmental Protection Authority, Level 4, The Atrium, 168 St Georges Terrace, Perth, Attention: Doug Betts; or
- faxed to (08) 6467 5562.

If you have any questions on how to make a submission, please ring the EPA assessment officer, Doug Betts on 6467 5406.

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Kemerton Silica Sand (KSS) is a sand dredging operation located 35 kilometres north of the Port of Bunbury and approximately 150 kilometres south of Perth (Figure 1). The KSS property is freehold land owned by the proponent.

Approval of the existing activity was granted by the Western Australian Minister for the Environment in October 1994 (Ministerial Statement 366) following formal assessment of the project by a Public Environmental Review (PER). An additional approval for the project was granted in 2005 to swap an area approved for mining later found to contain a Threatened Ecological Community with an area with less significant environmental values (Ministerial Statement 703). As part of previous approvals, Kemerton Silica Sand have established the Kemerton Nature Reserve to the east of current mining and processing operations. This contains a number of Critical and High value environmental assets.

Silica sand resources exist across the entire property. Results from baseline surveys and discussions with regulators and other stakeholders identified high environmental values over much of the KSS site. KSS recognised this was likely to constrain access to silica resources. Considerable effort has been made to develop a proposal that would be satisfactory to competing interests of resource development and conservation. The proposed mine extension area contains sufficient silica sand resources to allow mining for about 50 years. Access to the area will enable secure long-term resource extraction to take place and provide sufficient overburden to implement rehabilitation of dredge ponds in mined areas to create functioning wetland environments.

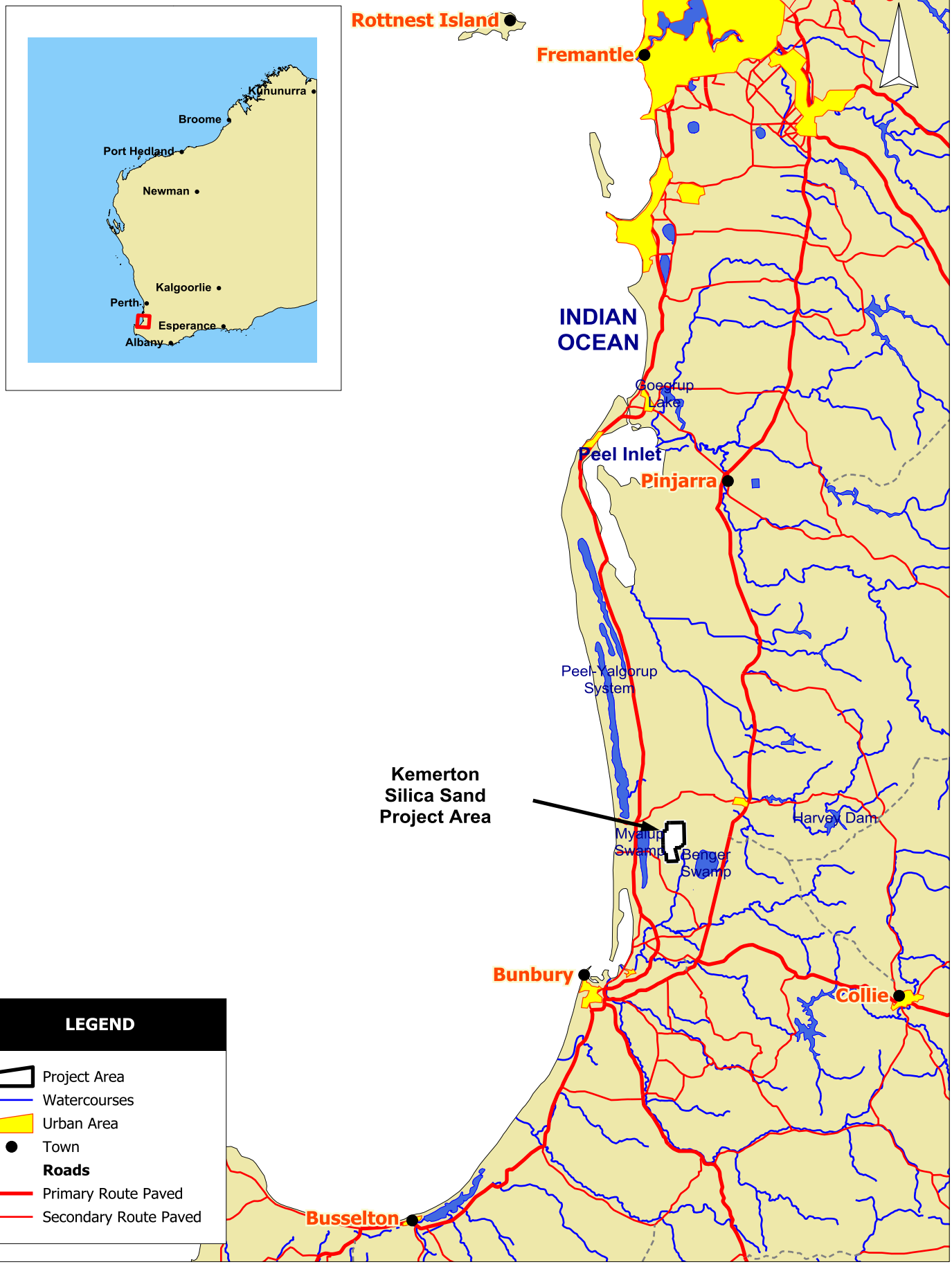
The separate components discussed in this document comprise:

- Kemerton Silica Sand (KSS) site – existing mining operations.
- KSS proposed mine extension area (the current proposal).
- KSS property – the entire Lot 32 and Lot 501 Rhodes Road, Wellington.

1.2 LOCATION

KSS is located in the Shire of Harvey, 2.5 kilometres north of Kemerton Industrial Park and 12 kilometres south-west of the town Harvey, on the Swan Coastal Plain in the south-west of Western Australia. The KSS property consists of 1,326 hectares of freehold land owned by the proponent; mineral rights are to the landowner.

The KSS property is crossed by the north-south 132 kilovolts Bunbury - Cannington No.1 and No.2 electricity transmission line, the 415 kilovolts Harvey-Kemerton transmission line and the Perth-Bunbury natural gas pipeline.



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Scale: 1:800000
Original Size: A4
Grid: Australia GDA94 (50)

0 25 km

Kemerton Silica Sand Pty Ltd

Location Plan

Figure 1

W:\Kemerton Silica Sand\Drawings\Maps 2008\LocationPlan.map 22/10/2009 KSS_LocalityPlan

1.3 JUSTIFICATION OF THE PROPOSED EXTENSION

This proposal is for an extension to the current approved mining operation undertaken by Kemerton Silica Sand Pty Ltd on Lot 32 and Lot 501 Rhodes Road, Wellington. The proposed extension of sand dredging operations is required to access silica sand resources suitable for both glass manufacturing and export.

Approval is being sought to mine an additional 283 hectares (21.3%) of the current KSS property. Of this:

- 20.3 hectares has already been approved for dry mining (Ministerial Statement 366).
- 19 hectares has already been cleared of vegetation (Ministerial Statement 366).
- 55 hectares would be a land swap where KSS would forgo their right to dry mine areas outside of the proposed mine extension area approved as part of previous project approvals in 1994 (Ministerial Statement 366). This includes 12.9 hectares within Kemerton Nature Reserve.

The proposed extension will facilitate long-term management of the site and implementation of long-term environmental management and rehabilitation plans. The land swap would enable protection of 75.3 hectares of Critical Assets as defined by the EPA in return for approval to mine in areas of KSS with lower environmental values. A proposed offset of protecting a further 100.7 hectares of Critical and High value environmental assets by transferring ownership to the State, would see the Kemerton Nature Reserve increase to 417 hectares in total, forming a north south ecological linkage in the area.

1.4 PROPOSED SAND DREDGING OPERATIONS

It is proposed to extract approximately 30 million cubic metres of sand from the site over a period of 50 years at an annual rate of 500,000 to 1,000,000 tonnes per year. The maximum depth of dredging varies between 15 and 22 metres below the water table. Mining is carried out by a suction cutter dredge capable of mining at a rate of 350 tonnes per hour. Sand is pumped from the dredge pond to the Run of Mine (ROM) stockpiles at the processing plant using booster pumps. Slurry from the pond is dewatered using cyclones and sand is discharged onto stockpiles for processing. The water and slimes fraction are returned back to the dredge pond.

Dewatered sand is taken from the ROM stockpiles and transported via conveyor to a coarse screen that removes wood and oversized rocks. Dewatered sand enters the plant on a conveyor belt via a hopper where it is screened and oversize material removed. Sand slurry is deslimed before entering the Flat Bed Classifiers. Silt and clay fraction goes to the thickener where water is recovered and the fines are mixed with other plant tails and returned to the dredge pond for rehabilitation. The Flat Bed Classifiers split sand into course and fine fractions. Some of the course fraction is screened further to make products such as filter sand. The remainder is returned to the dredge pond.

Fine sand is cleaned by agitating the slurry in attritioning cells before feeding it into spiral circuits, which separate heavy minerals from the sand. A wet high intensity magnetic separator removes any remaining iron. Clean sand is fed to trommel screens that remove sand grains greater than 0.5 millimetres which are returned to the dredge pond. The remaining sand

is pumped to cyclones on stackers where it is dewatered prior to being placed in product stockpiles. The remaining moisture drains naturally from the stockpiles.

There are no changes to the existing processing plant as part of this proposal.

1.4.1 Setback Limits

The proposed mine extension area abuts a portion of the property's western boundary with a high voltage power line easement running immediately west of the boundary. There are no dwellings in the vicinity of the KSS property's western boundary and the area is kept clear of substantial vegetation. It is not required to maintain a vegetative setback along the western boundary as a visual screen for adjacent properties. In accordance with local government requirements, a 20 metre setback is provided to allow firebreak construction and perimeter access around the property.

1.4.2 Vegetation Clearing

The proposed mine extension area of 283 hectares consists of 19 hectares of cleared and 264 hectares of vegetated land that will require clearing over the 50 year project life. Vegetation will be cleared in stages of approximately five hectares per year. Vegetation clearing will be confined to areas required for dredge mining and associated activities particularly in front of the expanding dredge pond.

In 1994 approval was granted to clear 75.3 hectares of Bassendean Dune - Central and South vegetation complex, beyond the dredge pond boundary, in a dry mining program (Ministerial Statement 366). These areas identified in Figure 2 of the initial PER, dated July 1993, are reproduced and shown in Figure 2. Only 20.3 hectares of the approved dry mining area is contained in the proposed mine extension area (Figure 2). The remaining 55.0 hectares is located in Kemerton Nature Reserve and other parts of the KSS property.

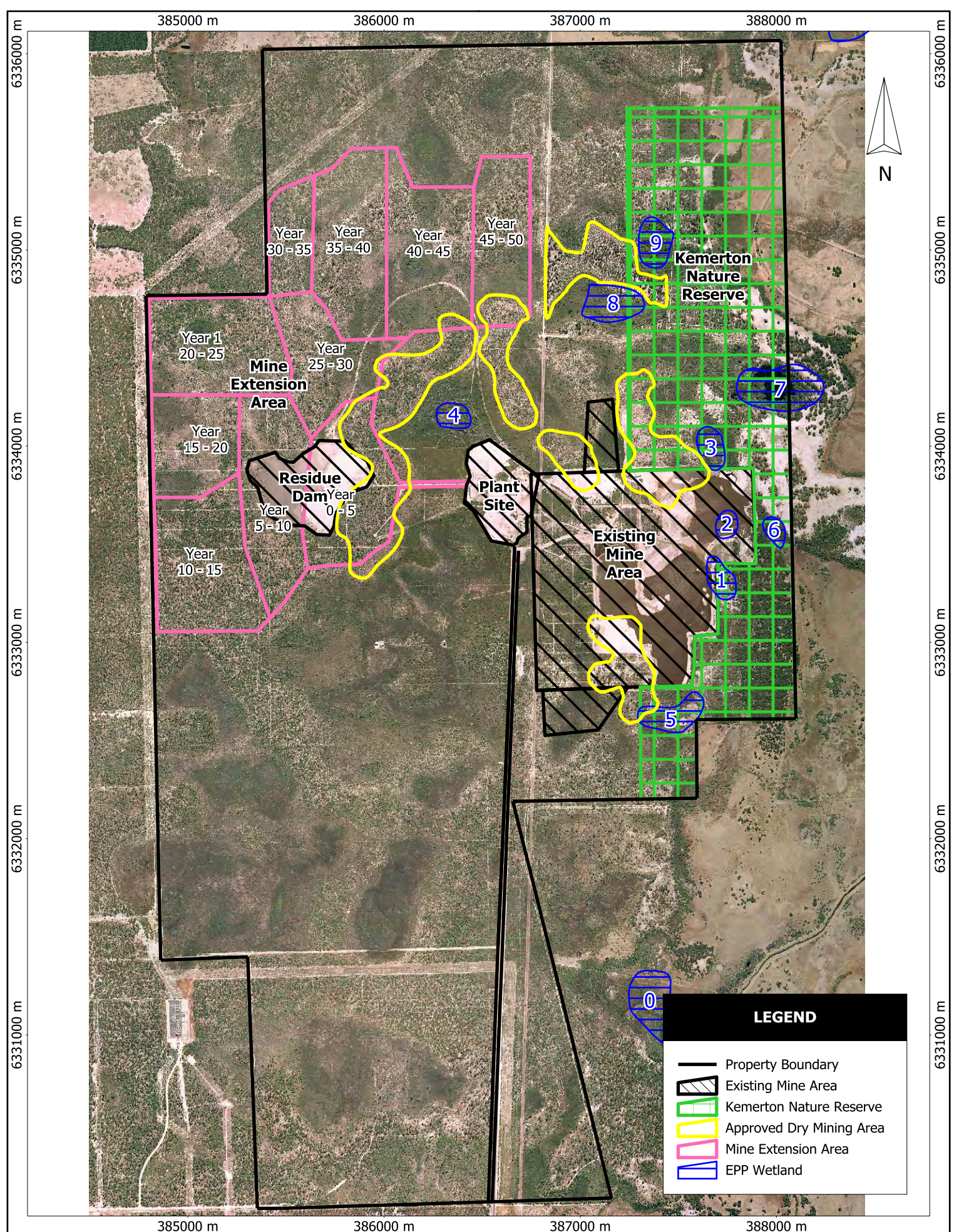
These areas are now considered to have environmental values that make mining less desirable. This application proposes to seek an amendment to the proposed mine extension area, to swap approval to clear 55.0 hectares of the Bassendean Dunes contained in the proposed mine extension area for areas already approved (Figure 2). This will reduce the area of Bassendean woodland disturbed by the project and is discussed further in Section 10.4.

1.4.3 Access and Haulage

The final product is loaded onto trucks and transported 35 kilometres along sealed roads to the Port of Bunbury for export. A 12 kilometre private haul road has been constructed to minimise disturbance to local residents. No change to access is proposed.

1.4.4 Hours of Operation

The current facility operates seven days a week on a 24 hour basis. No change to operating hours is proposed.



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Scale: 1:24000
Original Size: A4
Air Photo: 2006
Grid: Australia MGA94 (50)
0 500 m

Kemerton
Silica Sand Pty Ltd

Site Layout

Figure 2

W:\Kemerton Silica Sand\Drawings\Maps 2009\SiteLayout.map 16/10/2009 SiteLayout

1.5 REHABILITATION

Rehabilitation will be conducted as dredging progresses and completed areas can be isolated as 'rehabilitation cells' from the active dredge pond.

Approximately 80% of silica sand in the extraction zone will be removed, with the post mining landform containing permanent water bodies.

Overburden and sand not suitable for sale, will be returned to the rehabilitation cell where it will be used to create graded beaches or landforms for terrestrial rehabilitation. Shallow areas will be formed to allow seasonal inundation and planted with suitable species of sedges and other vegetation to encourage use of the water body by a number of different fauna species.

Previous and ongoing rehabilitation work has provided KSS with valuable information on rehabilitation techniques for successful outcomes.

1.6 ENVIRONMENTAL FACTORS

1.6.1 Climate

The KSS property is situated in Western Australia's Mediterranean climate zone with wet, mild winters and hot dry summers. Long-term average annual rainfall for Bunbury is 733.5 millimetres with rainfall occurring predominantly during May to October (Bureau of Meteorology, 2008).

1.6.2 Geology and Landforms

The KSS property is situated within the Perth Basin, which extends approximately 20 kilometres eastwards from the coast to the Darling Escarpment. The Swan Coastal Plain lies on top of the Perth Basin. The Swan Coastal Plain is made up of five major geomorphological systems running roughly parallel to the coast. The Bassendean Dune System forms a north–south strip approximately three kilometres wide between Pinjarra Plain to the east and Spearwood Dune System to the west (McArthur, 1991). Dune crests in the Bassendean Dune System reach elevations of approximately 25 mAHD (metres above Australian Height Datum) and low areas have elevations of approximately 10 mAHD. Dune crests in the Spearwood Dune System reach elevations of approximately 50 mAHD immediately west of the KSS property. The general elevation of the Pinjarra Plain is 15 to 20 mAHD.

1.6.3 Acid Sulfate Soils

Studies on ASS have progressed in stages as follows:

- A preliminary desktop literature review of the Kemerton property highlighted the need to investigate the potential for Acid Sulfate Soils (ASS) conditions occurring during the proposed operation expansion (DEC, 2009a). The potential for ASS is evident given the high water table and low lying geomorphology of the area.
- Monitoring conducted in accordance with environmental licence conditions has not shown development of acidity in the dredge pond or surrounding monitoring bores,

suggesting a very low risk of acid generation for future dredging operations. Returned sand residues, backfilled mostly below the water table in the rehabilitation cell, are exposed to minimal free oxygen, further reducing the risk of any possible acidification from Potential Acid Sulfate Soils. This indicates that ASS is unlikely to be a problem in the remaining area.

- An initial ASS assessment of the proposed extension area was undertaken by MBS Environmental in August 2007. Transects portions were sampled in 2007 during the initial assessment. Conclusions from the initial ASS sampling program are:
  - Most potential high acid generating soils are located below the base of the final dredge pond depth (15 to 22 metres), remaining undisturbed under water.
  - There are some potential high acid generating soils within the profile of the mine extension area.
  - High acid neutralising soils occur, which provide significant in-situ buffering capacity for the dredge pond environment.
- In mid 2007, an area south of North Lake was rehabilitated using topsoil and spreading of brush and logs. This area (Edith Cowan University Site 14) is a rehabilitated sumpland near the wetland known as EPP5 and bordering the Muchea Limestone Threatened Ecological Community (TEC). During monitoring, McCullough and Lund (2007) observed low chloride to sulfate ratios in the newly rehabilitated area and expressed concern that this may indicate some acid mine drainage/ASS-type oxidation from disturbance of the intermediate 'coffee rock' layer which may contain Potential Acid Sulfate Soil. In response to this observation, four samples of soil from this area were submitted for chemical analysis to determine the potential for acid generation following oxidation of ASS.

  Three of the four samples tested contained insignificant amounts of ASS materials. In terms of ASS management of these soil samples, no specific management protocols are required, although an ASS Management Plan has been prepared for any future ASS issues that may arise.

It is unlikely that ASS will present a significant issue in the proposed mine extension area. If any issues do arise, the ASS Management Plan will be implemented and adjusted accordingly.

1.6.4 Surface Water

The Wellesley River to the east of the KSS property is the major surface drainage feature. The eastern part of the property is low lying and wetlands have formed in slight depressions. The western portion of the property has slightly higher elevation, but also drains towards Wellesley River. The river flows towards the south-west into Leschenault Estuary.

Surface water occurs on the property in the form of ephemeral wetlands. There are a number of wetlands on the property, nine of which are gazetted under the *Western Australian Environmental Protection (Swan Coastal Plain Lakes) Policy (EPP) 1992*. Six of the gazetted wetlands were transferred from KSS ownership to the Department of Environment and Conservation (DEC) as part of an offset for project approval in 1994.

1.6.5 Groundwater

GHD (2002) undertook a hydrological review of mine extension areas as proposed at that time. The review identified the KSS property occurs within the Perth Basin and is underlain by superficial sediments that rest unconformably on the Leederville formation at a depth of approximately 30 metres.

The KSS property is within the Serpentine groundwater flow system near the crest of the Mialla mound. Recharge to the aquifer system is by direct infiltration of rainfall, particularly in winter and spring when rainfall is more intense. In the property's higher elevation areas the water table occurs at depths of more than 10 metres while in lower areas it may intersect the surface seasonally (GHD, 2002).

The water table fluctuates by approximately two metres in response to seasonal variations in groundwater recharge. Groundwater flow from the Mialla mound is constrained by hydraulic barriers formed by the Harvey River to the north, the coast to the west, Leschenault inlet to the south and Wellesley River to the east. Monitoring data indicates groundwater flows south-eastwards towards the Wellesley River on the KSS property. Groundwater discharge occurs by evapo-transpiration from wetlands and by discharge to the river. Some leakage occurs to the Leederville aquifer at the base of the superficial aquifer.

1.6.6 Vegetation and Flora

1.6.6.1 Vegetation Communities

Vegetation on the KSS property has been mapped in detail by E.M Mattiske and Associates (Mattiske) (1993a, b, c, d) and Bennett (2004). A list of studies identified 24 plant communities and 27 vegetation mapping units, three of which comprise disturbed stages of plant communities (Section 4.6).

Mattiske (2009) conducted detailed statistical similarities and association measures to determine the conservation status of the vegetation communities at KSS in light of the more recent TEC and Priority Ecological Community (PEC) listings. The results indicate very low similarities between the communities defined by Mattiske (2003b) in previous mapping and the Swan Costal Plain dataset (Gibson *et al.* 1994) as defined utilising the Sorenson's Similarity Index or the PATN analyses (Belbin, 1995, Mattiske, 2009). There are some similarities between the communities, but they are not necessarily directly comparable. The presence of some dominant species or species that reflect seasonal swamps do not necessarily indicate a presence of the respective TEC or PEC's. The patterns appear to relate to the continuum nature of many species across the landscape and the need to rely on presence/absence data only (rather than quantitative and structural dominance).

A total of 65 families, 174 genera and 365 plant taxon (including varieties and subspecies) have been recorded on the KSS property (Mattiske, 2003b). Species representation was highest in the Papilionaceae (37 taxon), Myrtaceae (37 taxon), Proteaceae (18 taxon) and Cyperaceae (16 taxon) families. This flora composition is typical of the Bassendean - Central and South vegetation complex as described by Heddle *et al.* (1980). Wetland systems are dominated by species from the Restionaceae, Cyperaceae and Myrtaceae families.

1.6.6.2 Species of Conservation Significance

Detailed flora studies have been conducted for the KSS site and its immediate surrounds over a 10 year period, with 11 botanical studies conducted. A number of species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) *(EPBC Act)* or the *Western Australian Wildlife Conservation Act 1950* (WA) *(WC Act)* have been recorded at the site.

The Critically Endangered and Declared Rare Flora species, *Caladenia procera*, was located in the south-west corner of the KSS property. It was identified by Woodman (2005a) in a follow-up survey for the Kemerton Lateral Pipeline. This location is well outside the proposed mine extension area and will not be disturbed. It is in the area proposed as an environmental offset.

A further nine Priority flora species, defined by the DEC, have been recorded on the KSS property. These are *Boronia juncea* subsp. *juncea* (P1), *Boronia capitata* subsp. *gracilis* (P2), *Acacia semitrullata* (P3), *Dillwynia dillwynioides* (P3), *Cyathochaeta stipoides* (P3), *Goodenia filiformis* (P3), *Acacia flagelliformis* (P4), *Caladenia speciosa* (P4), and *Eucalyptus rudis* subsp. *cratyantha* (P4). One Declared Rare Flora species, *Conostylis micrantha* (R) was located in 1997 by Arbortech Pty Ltd and in 1998 by Ecos Consulting (Aust) Pty Ltd (Ecos), but has not been recorded since. Bennett Environmental Consulting Pty Ltd (Bennett) (2004) undertook a targeted search for all flora species of conservation significance, but did not locate this species and states (pg 8) *"This species is restricted to the Dongara-Mingenew area (WA Herbarium, 2003) so it is likely that the plant collected at Kemerton was misidentified. If the plants were only collected in a vegetative form they could have been Conostylis juncea recorded from the area by Mattiske (2003b)"*.

Within the proposed mine extension area, there are six Priority flora species: *Boronia juncea* subsp. *juncea* (P1), *Acacia semitrullata* (P3), *Dillwynia dillwynioides* (P3), *Goodenia filiformis* (P3), *Caladenia speciosa* (P4), and *Eucalyptus rudis* subsp. *cratyantha* (P4), have been recorded. Recently taxonomic division suggests that *Goodenia filiformis* (P3), is likely to be *Goodenia pulchella* subsp. Coastal Plain B (L. W. Sage 2336) which is not a Priority species (See Bennett, 2004). All Priority flora species within the proposed mine extension area occur elsewhere on the KSS property.

1.6.7 Wetlands

Of nine wetlands on the original KSS property gazetted under the *EPP 1992* (known as EPP wetlands), five have been transferred to DEC to form Kemerton Nature Reserve in 1994. A portion of another (EPP8) is included in Kemerton Nature Reserve and an additional wetland was added to the reserve in a land swap for the Muchea Limestone threatened ecological communities in 2005. One EPP wetland (EPP4) and the balance of EPP8 remain on the KSS property with one EPP wetland incorporated in the approved mine area.

The Water and Rivers Commission (WRC) (2001) evaluated wetlands on the Swan Coastal Plain assigning management categories to provide guidance on the nature of management and protection required for individual wetlands. Three management categories were developed based on the geomorphical characteristics of Conservation, Resource Enhancement or Multiple Use. The geomorphic wetland classification system identifies all wetlands within the proposed mine extension area as Conservation, with two exceptions. The residue sand tailings

disposal area and an upland Bassendean Dune in the north of the proposed mine extension area are both nominated as Multiple Use wetlands.
A separate submission was made to DEC in January 2009 to reclassify the Geomorphic Wetland Database regarding the areas of upland Bassendean Dune within the proposed mine extension area (Martinick Bosch Sell Environmental Pty Ltd, 2009). Contour plans and site vegetation surveys confirm the area mapped as Multiple Use wetland on the DEC database is elevated land containing open woodland of *Jarrah* and *Banksia* and should be reclassified to Dryland. The outcome of the submission is still pending. The PER has been prepared on the basis this area is Bassendean woodland.

Wetlands of the KSS property include sumplands, damplands, floodplains and palusplains depending on the soil, shape and extent of standing water. Each wetland is a mosaic of vegetation units. A marked variation occurs between wetlands in the southern portion of the KSS property to those in the north and between wetlands on the west and east. EPP wetlands occur mostly in the east of the property in Kemerton Nature Reserve situated on clay overlying lateritic soils on the Pinjarra Plain. These wetlands belong to the Keysbrook wetlands suite.

1.6.8 Fauna

Sixteen fauna studies have been conducted within the KSS property since 1993. This included targeted surveys for the Southern Brush-tailed Phascogale (*Phascogale tapoatafa ssp.)*, Chuditch (*Dasyurus geoffroii*), Carnaby's Black-Cockatoos (*Calyptorhynchus latirostris*) and Western Ringtail Possum (*Pseudocheirus occidentalis*). The Chuditch, Carnaby's Black-Cockatoos and Western Ringtail Possum were identified as the primary reason for designating the project as a Controlled Action under the *EPBC Act*. The other studies were conducted over broader areas than the KSS property alone and provide information on fauna at a more regional level (Bamford, 2003a). A considerable body of information on the fauna and their habitat associations of both the KSS property and the Kemerton region are therefore available.

Bamford (2003a) reviewed results of earlier studies focusing on areas of special interest in the western part of the KSS property. Bamford (2003a) produced lists of fauna species present or expected to occur in the Kemerton region and specifically on the KSS property. Where species have not been recorded, but are expected to occur in the area, the preferred species habitat, where such preferences are known to be very specific, were also recorded. Bamford (2003a) concluded that:

- The Kemerton region supports a rich fauna, because it includes a large area of remnant and regrowth native vegetation, while much of the surrounding coastal plain has been developed for agriculture.
- The area supports a high number of S3 species, not formally recognised for conservation significance, but are regionally important. In the Kemerton region, S3 species have declined elsewhere on the Swan Coastal Plain.
- Many species of conservation significance are present in the Kemerton region because it is one of the largest contiguous areas of native vegetation on the Swan Coastal Plain between Bunbury and Perth.

Potentially, 20 native mammals (including nine bat species), 127 bird, 10 frog, 34 reptile and six fish species could be expected to occur in or utilise at times, the KSS area. Of the 197

native animals that are listed as potentially occurring at the site, eight are considered to be endangered/vulnerable or in need of special protection. In addition 7 migratory species may frequent the site at times. Ten DEC priority species may also use the site. Eight introduced species may also be present.

1.6.9 Heritage Values

A heritage survey of the site was conducted and as no heritage sites were found in the proposed mine extension area, there is not expected to be any impacts. The KSS property is freehold land and is not subject to Native Title Claims.

1.6.10 Noise

There are no noise issues from existing dredge or plant operations. It is unlikely that there will be any additional noise emissions from the proposed mine extension, as production will occur at a similar rate. The remote location of noise generating plant and equipment relative to the nearest noise sensitive receptor, means that compliance with regulatory standards will be easily achieved.

1.6.11 Emissions and Dust Suppression

The location of the proposed mine extension area and process plant within the larger KSS property provides a significant buffer distance from any dust generating activity to the nearest sensitive premises. The current and proposed operation is to mine silica sand through dredge mining methods rather than dry mining methods. The sand mining dredge and processing plant uses water to mine, pump and process the ore. No dust is generated from these activities.

Dust emissions have not been a significant environmental issue during the last 10 years of sand mining operations.

1.6.12 Visual Amenity

KSS is located to the north of Kemerton Industrial Park within an area zoned as rural. The property is not in close proximity to any residential areas with the closest residence at least one kilometre from the current operation area. The extension area is well buffered by surrounding vegetation and landforms within the KSS property. Vegetated setbacks will be maintained along the property boundary.

1.6.13 Road Transportation/Traffic

Silica sand has been transported from KSS for over 10 years. It is intended that plant throughput will remain at its current level, so there will not be a significant increase of traffic activity from the operation.

All trucks are well maintained and operated by licensed operators and roads are well maintained as agreed with the local council. Haulage is avoided on Sundays where possible.

1.6.14 Indigenous and Non-Indigenous

An archaeological survey has been conducted on the site and no sites were located.

A search of the local municipality heritage inventory indicated that no sites of historical significance occur on the site.

1.7 SUMMARY OF ISSUES AND ENVIRONMENTAL FACTORS

Environmental factors for the proposed extension of the KSS operations, as determined by the DEC, and management proposals are summarised in Table 1.

Table 1: Summary of Environmental Factors and Management

Environmental Factor	Environmental Objectives	Existing Environment	Potential Impact	Environmental Management	Predicted Environmental Outcome
Integrating Process					
Biodiversity	Maintain biological diversity representing different plants, animals and micro-organisms, the genes they contain and the ecosystems they form, at levels of genetic diversity, species diversity and ecosystem diversity. Through studies carried out for other environmental factors, demonstrate that biodiversity will not be compromised by this proposal.	The Kemerton area is bio-diverse, supporting several vegetation types and fauna of conservation significance. Much of the property is seasonally inundated and supports dampland complexes of dense shrub lands and heaths, with some localised depressions forming seasonal wetlands. *Eucalypt* and *Banksia* woodlands of the Kemerton region have been identified as being significant fauna features. Sections of the property have been subject to historic logging and there is also evidence of extensive brush cutting, particularly in wetland areas. A north-eastern portion of the property has been used historically for grazing and evidence of man-made drains are apparent on the property as past attempts to improve agricultural land. A pine plantation, the majority of which has been logged, was developed in the north-east of the property. Only a few pine trees remain. Dieback disease caused by infection of *Phytophthora cinnamomi* has been identified across the property. 79% of the KSS site is either already infected or not able to be protected from infestation. The property also has 58 introduced plant taxa.	Reduction in biological diversity due to land clearing and habitat removal.	Design project to avoid areas of greatest biodiversity significance. Clearing of native vegetation to be kept to a practical minimum. Populations of Priority species also mapped outside the extension area, reducing risk of negative impact on individual species. Good populations exist within Kemerton Nature Reserve. Rehabilitation of mined areas to provide habitat for native fauna and flora. Continued suspension of grazing activities. Weed and feral animal control programs. Design project to ensure that each type of wetland from the wetland suite is represented in undisturbed areas.	Diversity protected and environmental benefits documented.

Environmental Factor	Environmental Objectives	Existing Environment	Potential Impact	Environmental Management	Predicted Environmental Outcome
Biophysical					
Vegetation and Flora	Maintain species diversity, geographic distribution and productivity of vegetation communities.	A number of flora and vegetation studies have been conducted on site.	The proposal will result in clearing of about five hectares of vegetation per annum over the project's life.	Clearing of native vegetation will be kept to a practical minimum. Topsoil will be stripped and reused in rehabilitation. Rehabilitation including replacing vegetation in suitable areas will be undertaken.	Some loss of vegetation will occur. Rehabilitation will return ecological functions to mined areas.
Declared Rare and Priority Flora Species	Protect Declared Rare and Priority flora, consistent with the provisions of the *WC Act.*	One Rare and nine Priority flora species have been recorded on the property. Five Priority species have been recorded in the mine extension area.	The removal of individuals of Priority flora species will occur, however these species are also represented in other areas of the property which are not in the proposed mine extension area. The one Declared Rare species occurs outside the mining extension area in land proposed as an offset.	Seed collection or plant relocation of Priority species into undisturbed sites or rehabilitation areas will be undertaken. The proposed mine extension area has been selected to avoid impact on Priority flora species as much as possible. No Priority species were found exclusively within the mine extension area.	Impact to individuals of Priority species but negligible impact to species diversity on the KSS property.
Fauna	Maintain abundance, diversity, geographic distribution and productivity of native terrestrial and aquatic fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	A number of fauna studies have been conducted on the site, including targeted surveys for specially protected species.	Progressive clearing of small areas has the potential to reduce the available fauna habitat.	Rehabilitation of the dredge pond and surrounds will return ecological functions to mined areas. Retention of native vegetation in non-mining areas of the KSS property, including EPP wetlands will preserve key fauna habitats.	Impact to individuals of fauna species but negligible impact to species diversity on the KSS property.
Specially Protected (Threatened) and	Protect Specially Protected (Threatened) and Priority fauna and their habitats consistent with	Targeted surveys for specially protected species have taken place. Chuditch were not recorded in the KSS	Clearing of Bassendean woodlands will temporarily reduce	Rehabilitation will return species diversity and density and provide similar and new wetland habitat types.	Negligible impact to specially protected species. Rehabilitation

Environmental Factor	Environmental Objectives	Existing Environment	Potential Impact	Environmental Management	Predicted Environmental Outcome
Priority Fauna	the provisions of the *WC Act* and *EPBC Act.*	property. The KSS property does not have particular value for Carnaby's Black-Cockatoo relative to other sites surveyed in the region.	foraging habitat of Carnaby's and Baudin's Black-Cockatoo. Wetlands of the KSS property support vegetation types that are not suitable for Cockatoo foraging or breeding, therefore limiting the potential impact of this project on this species.	Rehabilitation will include relocation of possible nest sites or mounting of nest boxes in suitable habitat locations outside the proposed mine extension area.	will return ecological functions to mined areas.
Landform	Establish stable, sustainable landforms consistent with intended post-mining land use and surroundings.	The current landform is ephemeral wetlands interspersed by upland areas.	Shallow ephemeral wetlands will be altered to form permanent deeper lakes resulting in alteration of the current landform due to mining.	Rehabilitation will involve a combination of permanent lakes, reconstructed ephemeral wetlands and dune landforms. Monitoring and maintenance will be implemented until rehabilitation is successful.	Rehabilitation will return landform features and ensure they are safe, stable and provide ecological functions. It is acknowledged that the landform will be an altered state with the establishment of permanent wetlands. This is consistent with the surrounding region.
Rehabilitation	Ensure proposal area and any other area affected by the proposal is rehabilitated to a standard consistent with intended post-mining long-term land use.	Rehabilitation has been undertaken in the current mining area. Rehabilitation has and will be continued to be monitored. Techniques and methods will be continually improved, using results of monitoring to research programs.	Change in landform composition as a result of mining, producing permanent lakes where there is currently no permanent surface water features.	Rehabilitation will provide the opportunity for increased habitat of iconic and regionally significant species. These include Water Rat (*Hydromys chrysogaster*), Black-striped Jollytail (*Galaxias nigrostriata*) and various frog and waterfowl species.	Rehabilitation will provide greater diversity of habitat features providing ecological functions for iconic and regionally significant species.
Wetlands	Maintain integrity, functions and environmental values of wetlands.	The KSS property is a system of wetlands interspersed with upland, Bassendean woodland areas.	Establishment of dredge ponds has the potential to cause degradation of nearby wetlands and change characteristics of others.	Maintain buffers around remaining EPP wetlands to avoid impact on these areas. Rehabilitation of dredge ponds and surrounds will create additional wetland habitat.	Negligible long-term impact to surrounding wetlands.

Environmental Factor	Environmental Objectives	Existing Environment	Potential Impact	Environmental Management	Predicted Environmental Outcome
Pollution Management					
Particulates/dust	Ensure air emissions (particulates, greenhouse gases) do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Dust is most likely to be an issue during clearing. Measures have been taken to reduce the likelihood of dust/particulate emissions and no complaints have been received.	Airborne particulate concentrations will not increase due to the extension as throughput will not increase and the mining method will continue to use wet/dredging techniques. Implementation of the project will result in production of greenhouse gases. As the extension will not increase the rate of activities beyond the current approved operation, greenhouse gas emissions are expected to be the same as currently occurs.	Water carts will continue to be used on unsealed surfaces to complement existing auto reticulation to prevent generation of dust and wind erosion. Completed areas will be rehabilitated and revegetated as soon as practicable.	Management of dust emissions will be controlled by a number of measures. Monitoring will be implemented to confirm the success of the management program. Mitigation measures identified will ensure environmental values of air quality are maintained.
Groundwater Quality and Quantity	Maintain or improve groundwater quality to ensure existing and potential uses, including ecosystem maintenance are protected, consistent with draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	The current operation abstracts between 300 - 600 megalitres per annum under licence.	Changes to the hydrological regime may occur due to continued operations affecting adjacent wetlands.	There is valuable site specific data for hydrological modelling sourced from 10 years of operation. This data was used to define buffer distances to wetlands and landform restoration to recreate ephemeral wetland systems. No chemicals which leave harmful residues on the return water are used in sand processing. Groundwater monitoring programs will be expanded and continued. Hydrocarbon storage and handling will be managed to minimise the risk of contamination of groundwater.	Groundwater quality will not be adversely affected by mine activities.

Environmental Factor	Environmental Objectives	Existing Environment	Potential Impact	Environmental Management	Predicted Environmental Outcome
Surface Water Quality	Maintain or improve quality of surface water to ensure existing and potential uses, including ecosystem maintenance are protected consistent with draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	No major watercourses are located within the KSS property. Surface water occurs as wetlands due to topographic expressions of the water table.	Mining has the potential to result in localised alteration of surface run-off regimes. Potential exists for contamination of surface water run-off with sediments.	Water from potentially contaminated catchments will be captured and treated prior to release to natural catchments where necessary.	There will be negligible effect on surface water quality by mine activities.
Acid Sulfate Soils (ASS)	ASS is recognised as a potentially contaminating material, requiring specific consideration and management, if present on a development site.	No ASS problems in the dredge pond or surrounding soils have occurred during 10 years of on-site dredge pond mining. Assessment of the proposed mine extension area showed most potential ASS below the base of the dredge pond. Soils in the dredge profile contain both potential ASS and acid neutralising capacity. This is consistent with current conditions that show no net acid producing potential.	The potential for ASS is present, however historical data and ASS surveys indicate the net acid producing potential for the site is low.	An Acid Sulfate Soils Management Plan (ASSMP) has been prepared and will be implemented should any acidity problems develop.	There will be negligible development of ASS by mine activities.
Noise	Ensure that noise impacts emanating from the proposal comply with statutory requirements and acceptable standards.	The large property size, significant internal buffer distances and significant distance to the nearest residential premises suggest noise is not a key environmental factor. Noise surveys have been conducted on site and no issues have been raised. No complaints from surrounding residents have been received.	Noticeable increase in noise levels for nearby residents.	Noise emissions from equipment planned to be used that is significantly different from current equipment will be assessed. Current noise modelling will be reviewed as required.	There will be negligible effect on noise from mine activities.

Environmental Factor	Environmental Objectives	Existing Environment	Potential Impact	Environmental Management	Predicted Environmental Outcome
Social Surroundings					
Visual amenity	Visual amenity of the area adjacent to the project should not be unduly affected by the proposal.	The extension area is well buffered by surrounding vegetation and landforms within the KSS property. The property is isolated from the majority of sensitive land uses within the region.	Minimal potential impacts on visual amenity are predicted.	A 20 metre vegetated setback will be maintained along the property boundary.	There will be negligible effect on visual amenity from mine activities.
Road transportation/ traffic	Ensure roads are maintained or improved and road traffic managed to meet an adequate standard of level of service and safety and Main Roads Western Australia requirements.	Silica sand is transported by truck 35 kilometres to the port of Bunbury. A 12-kilometre private access sealed road has been established to minimise traffic conflicts. About 12 truck movements of about 70 tonnes each are conducted on a Monday to Friday basis. Campaign trucking also occurs on an as needs basis.	Approval of the extension will not increase daily truck numbers, but will extend the length of time trucks will travel the route.	All trucks will be well maintained and operated by licensed operators. Haulage will be avoided on Sundays where possible. Roads will be maintained in a manner agreed with the local council.	There will be negligible effect on road transport from mine activities.
Indigenous and non-Indigenous cultures	(i) Ensure the proposal complies with requirements of the *Aboriginal Heritage Act 1972* (WA); (ii) Ensure changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.	An archaeological survey has been conducted on the site and no sites were located. A search of the local municipality heritage inventory indicated that no sites of historical significance occur on the site.	No likely impacts on Indigenous or non-Indigenous cultures as no sites have been identified.	If any archaeological sites are discovered during extraction activities, they will be reported in accordance with the provisions of the *Aboriginal Heritage Act 1972* (WA).	There will be negligible effect on heritage matters from mine activities.

2. INTRODUCTION

2.1 BACKGROUND

This proposal is for an extension to the current approved mining operation undertaken by Kemerton Silica Sand Pty Ltd (KSS) on Lot 32, Lot 100 and Lot 501 Rhodes Road, Wellington. The separate components discussed in this document comprise:

- Kemerton Silica Sand (KSS) site – existing mining operations.
- KSS proposed mine extension area (the current proposal).
- KSS property – the entire Lot 32 and Lot 501 Rhodes Road, Wellington.

The KSS property is freehold land owned by the proponent. Approval of the existing activity was granted by the Western Australian Minister for the Environment in October 1994 (Ministerial Statement 366) following formal assessment of the project by a Public Environmental Review (PER).

Dredge mining at the KSS proposed mine extension area will begin in a new dredge pond in the property's west. The proposed mine extension area will consist of 10 cells each with a mine life of about five years. The dredge pond will progress in a west then northerly direction. Following rehabilitation, reformed dredge ponds will remain as lakes and ephemeral wetlands interspersed with upland areas.

A submission was made in 1996/7 by the previous majority owner (Sons of Gwalia Ltd) for a western extension to the approved mining area, however the application was deferred in 1998 to enable further baseline studies to be completed and was withdrawn in 1999 following the release of the *Western Australian Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (*EPP 1992)* by the Western Australian Environmental Protection Authority (EPA).

In December 2002, a revised proposal for a western extension to the mine area (the current proposal), was referred to Environment Australia (now Department of Environment and Water, Heritage and the Arts (DEWHA)) under the *Environmental Protection, Biodiversity and Conservation Act 1999* (Cth) (*EPBC Act).* On 14 March 2003, Environment Australia determined that the proposal was considered a Controlled Action based on the possibility of Chuditch (*Dasyurus geoffroii***)** and Carnaby's (or Short-billed) Black-Cockatoos (*Calyptorhynchus latirostris*) habitat occurring in the area.

In June 2003, a submission regarding the proposal was made to the EPA. The EPA determined that approval for the project by the Western Australian Minister for Environment would be subject to formal assessment using the PER process. An Environmental Scoping Document (MBS, 2004) was approved by the EPA on 27 August 2004. Preparation of the PER was delayed awaiting resolution of the Greater Bunbury Regional Scheme as zoning changes proposed within the Draft Scheme were known to have significant implications for KSS land. This has since been resolved and KSS land retains its rural zoning.

This PER provides details on the environmental assessment of the proposal and describes the design, operation and management of the proposed mining extension. It addresses each of the environmental factors raised by the EPA and those of other interested parties.

2.2 OBJECTIVES

The objectives of this document are to:

- Describe the existing environment and sand dredging operations.
- Describe the proposed works and dredging program.
- Identify potential environmental and social impacts of the proposed project.
- Describe design and management details to be implemented to prevent or minimise potentially adverse impacts.
- Detail the rehabilitation and decommissioning program.
- Describe potential future land use of the KSS property.

2.3 THE PROPONENT

The proponent, who is the property's landowner, is Kemerton Silica Sand Pty Ltd (KSS).

Company Address:	Suite 5 (upstairs) 363-367 Albany Hwy Victoria Park WA 6100		PO Box 786 Victoria Park WA 6979
Postal Address:	PO Box A283 AUSTRALIND WA 6233		
Contact Person:	Mr Yoshihiro Abe		
Position:	Deputy Managing Director		
Tel:	(61-8) 9720 0030	**Fax:**	(61-8) 9720 1406
Email:	yoshihiro.abe@kksspl.com.au		

KSS has appointed MBS Environmental as environmental consultants to help them with the environmental assessment process. Enquiries regarding the PER should be directed to KSS.

2.4 LOCATION

The KSS property is located in the Shire of Harvey, 2.5 kilometres north of Kemerton Industrial Park and 12 kilometres south-west of the town of Harvey, in the south-west of Western Australia (Figure 1). The KSS property consists of 1,326 hectares of freehold land owned by the proponent; mineral rights are to the landowner.

Certificate of title volume 1842 folio 350 is lot 100, volume 1830 folio 340 is lot 501, and volume 2128 folio 998 is lot 32.

2.5 LAND USE

The KSS property is freehold land zoned rural. The southern half of the property is within the outer buffer zone of Kemerton Industrial Park. The outer buffer has been designated Special Control Area No. 2 in order to prevent sensitive land uses, such as residences from encroaching into areas that might be impacted by noise, air emissions, risk or other off-site impacts from the industrial estate at full development.

The property is crossed north-south by the 132 kilovolts Bunbury - Cannington No.1 and No.2 electricity transmission line, the 415 kilovolts Harvey-Kemerton transmission line, the Perth-Bunbury natural gas pipeline and Worsley Refinery lateral gas line.

Kemerton Industrial Park is the largest industrial area in the south-west. Existing heavy industries at the estate include Millennium Inorganic Chemicals and SIMCOA. There are also a number of ancillary industries including BOC Gases, NuFarm-Coogee and Cockburn Cement.

Given its proximity to the industrial estate and distance from any residential areas, it is unlikely zoning of the KSS property will change from rural in the near future. When mining is completed it is expected that land use will remain rural unless areas are reserved for conservation.

As a result of a previous approval process to conduct the current mining operation, 191.4 hectares of the property was transferred to the State in 1994 as an environmental offset. An additional land transfer of 15.6 hectares in 2005 was undertaken to protect an identified Threatened Ecological Community (TEC), Muchea Limestone. Land transfers, totalling 316.3 hectares into the conservation estate are shown in Figure 2. This consists of 206.9 hectares in Kemerton Nature Reserve and 109.3 hectares of the existing mine area in Stage 2 that will be included at the end of mining.

2.6 TIMING OF SAND EXTRACTION OPERATIONS

Sand resources from the western extension area will be progressively required from 2009, initially as pre-stripping overburden for use as backfill to rehabilitate completed cells of the current dredge pond. Silica sand mining in the western extension area is not scheduled to commence until 2010. The proposed mine extension area will consist of 10 cells each with a mine life of five years, progressing in a west then northerly direction (Figure 2). At current extraction rate, the resource from the proposed mine extension area is expected to provide adequate silica sand for 50 years.

Timely progression from the current approved area of sand extraction to the extension area is required to ensure continued product supply to the market. Project approval will allow the company to develop long-term strategic planning, ensure supply, continued employment and customer satisfaction.

2.7 JUSTIFICATION AND PURPOSE

Continuation of an Existing Industry
There are currently 12 staff and three contractors employed at the mine site. All personnel live in the region from Mandurah to Capel. Local companies are responsible for carrying out most maintenance and ancillary service roles, including extra earth moving and road haulage, with economic benefits flowing to the local community.

Supply and Demand for Silica Sand
KSS supplies high quality felspathic silica sand to the container glass and sheet glass markets in Japan and Asia. Sand produced by the operation is unique in that it contains potash feldspar which can be used for soda-lime glass production replacing the need to add feldspar to silica sand in the glass batch process.

Alternative Resources
KSS is the only supplier of high quality felspathic silica sand in the world. Small amounts of poor felspathic silica sand is produced as a by product of clay mining for pottery and ceramic industries. The KSS felspathic silica sand deposit is unique, with no other known deposits existing in the world.

Sustainability
KSS silica sand is primarily used to make glass bottles which are recyclable and reusable, producing less greenhouse gasses than plastic bottles. In an era of increased demand for oil, and dwindling supplies, encouragement of use of glass should be made.

Benefits of the Proposal
Implementing the proposal will have the following benefits:

- Optimum use of land and sand resource in an area identified as being a strategic raw material resource policy area by the Western Australian Planning Commission (WAPC, 2005a).
- Optimum use of existing cleared land within the property.
- Continued use of existing processing facilities and support infrastructure, rather than constructing new infrastructure at an alternative location.
- Continued direct and indirect employment in the Bunbury region.
- Post-mining land use designed to provide a stable landform and a range of options for future use.
- Proposed realignment of the Greater Bunbury Regional Scheme Ecological Linkage corridor slightly to the east of the KSS property, providing a north-south corridor of land through both Kemerton Industrial Park and KSS properties, with secure conservation tenure. This is further discussed in Section 4.15.2.

3. THE PROPOSAL

3.1 PROJECT ALTERNATIVES

3.1.1 Alternatives and Risk

The entire KSS property represents a silica sand resource. The alternatives considered below represent the preferred areas of resource taking into account current zoned land use (rural), resource quality, resource accessibility, location of areas of recognised high conservation value and practical resource extraction issues. Alternatives considered were:

1. Approval for an extension to the far west of the existing approved area (about 25 years duration).
2. Approval for an extension on the southern part of KSS property (about 10 to 15 years duration).
3. Approval for an extension on the northern part of KSS property (about 15 years duration).
4. Approval for an extension in the central part of the KSS property adjacent to the plant (about 10 year's duration).
5. Approval for an extension immediately west of the plant and currently approved area. This alternative has been raised previously with the EPA in 1997 by Sons of Gwalia Ltd, but was formally withdrawn in 1999 as the Company focused on improving the planning basis for the project.
6. Approval for combinations of the four above mentioned target areas.
7. Continue current operations in eastern area only. This would mean that mining would cease in the short term and prevent signing of new long-term contracts. Ownership of Stage 2 land would be transferred to the State of Western Australia. Remaining land would revert to rural use (existing zoning).
8. Continue dredge mining as is and supplement with approved dry mining areas.
9. Sell remaining KSS land prior to conclusion of mining in approved area and allow recommencement of grazing activities in areas not approved for mining.
10. Reconsider interim use of areas not approved for mining for agriculture or plantation forestry (Blue Gums) until mining use approved and dredging is scheduled to commence.
11. Relocation of the existing process plant to a location closer to the proposed future mining areas.

3.1.2 Options Considered

Out of the alternatives listed above, three main options were realistically considered for the KSS property taking risks into consideration:

Option 1: Continue current operations in eastern area only.

Option 2: Continue dredge mining as is and supplement with approved dry mining areas (Dry Mining Option – EPA Ministerial Statement 366).

Option 3: Proposal to extend dredge mining operations in a western extension area and forgo rights to approved dry mining areas (Western Extension Option – this PER).

3.1.3 Risk Based Assessment Approach

Environmental risk assessment is a process that evaluates the likelihood and consequence of environmental impacts occurring as a result of exposure to one or more stressors. One of the advantages of this process is that it allows potential environmental aspects or threats to be considered on the basis of the level of potential risk to the environment. This subsequently assists in prioritising development of management measures to achieve an overall acceptable level of risk. The environmental risk assessment was undertaken in accordance with the principles and guidelines contained in the following:

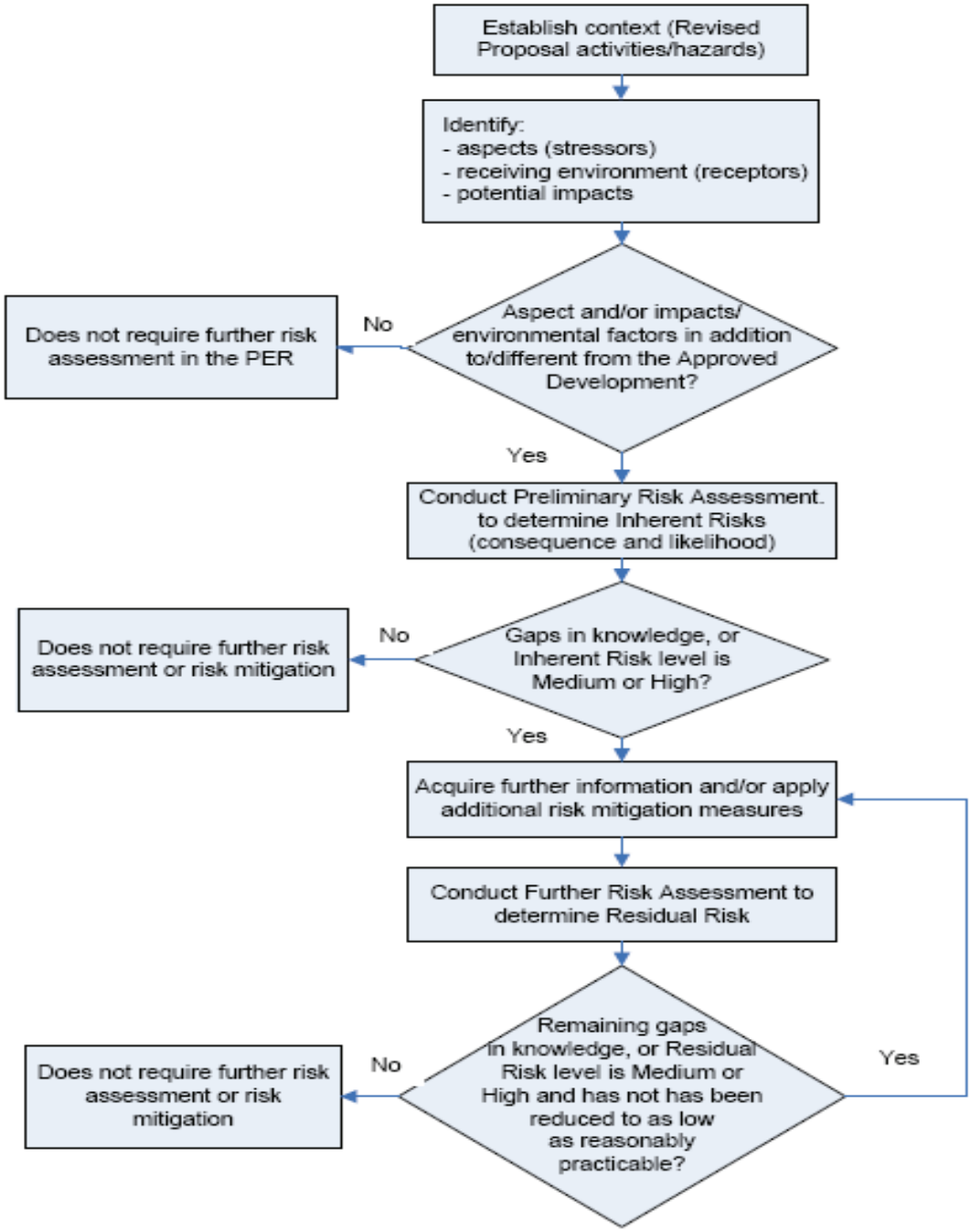
- AS/NZS 4360:2004, Risk Management.
- SAA Handbook 203:2004, Environmental Risk Management – Principles and Process.
- AS/NZS 3931:1998, Risk Analysis of Technological Systems – Application Guide.

The environmental risk assessment process is depicted in Figure 3, and is described in the following sections.

Steps in the Environmental Risk Process:

- Establish the context:
  - Establish the strategic, organisational and risk management context in which the rest of the process will take place. Criteria against which risk will be evaluated should be established and the structure of the analysis defined.
- Risk Identification:
  - Identify what, why and how things can arise as the basis for further analysis.
- Risk Analysis:
  - Determine the existing controls and analyse risks in terms of consequence and likelihood in the context of those controls. The analysis should consider the range of potential consequences and how likely those consequences are to occur. Consequence and likelihood may be combined to produce an estimated level of risk.
- Risk Evaluation:
  - Compare estimated levels of risk against the pre-established criteria. This enables risks to be ranked so as to identify management priorities. If the levels of risk established are low, then risks may fall into an acceptable category and treatment may not be required.
- Risk Treatment:
  - Accept and monitor low-priority risks. For other risks, develop and implement a specific management plan.

Figure 3: Steps in the Environmental Risk Assessment Process



- Monitor and Review:
  - Monitor and review the performance of the risk management system and changes which might affect it.
- Communicate and Consult:
  - Communicate and consult with internal and external stakeholders as appropriate at each stage of the risk management process and concerning the process as a whole. Risk management can be applied at many levels in an organisation. It can be applied at the strategic level and at operational levels. It may be applied to specific projects, to assist with specific decisions or to manage specific recognised risk areas.
  - Risk management is an iterative process that can contribute to organisational improvement. With each cycle, risk criteria can be strengthened to achieve progressively better levels of risk management. For each stage of the process adequate records should be kept, sufficient to satisfy independent audit.

The risk ranking is based on Australian Standard AS/NZ 4360 Risk Management and uses the risk matrix shown in Table 2 and definitions presented in Table 3. The risk matrix defines measures of likelihood and consequence.

Table 2: KSS Risk Matrix

LIKELIHOOD	CONSEQUENCES				
	5 Catastrophic	4 Major	3 Severe	2 Minor	1 Negligible
A Almost Certain	High	High	High	Moderate	Moderate
B Likely	High	High	Moderate	Moderate	Low
C Moderate	High	Moderate	Moderate	Low	Low
D Unlikely	Moderate	Moderate	Low	Low	Low
E Rare	Moderate	Low	Low	Low	Low

Table 3: KSS Risk Likelihood and Consequence Definitions

Likelihood (How likely is the event to occur)		Consequence (Significance of associated environmental impact)	
Rating	**Definition**	**Rating**	**Definition**
A Almost Certain	The event is expected to occur in most circumstances.	**5 Catastrophic**	• Effects widespread; viability of ecosystems or species affected. • Permanent major changes. • Offsite impact.
B Likely	The event probably will occur in most circumstances (e.g. weekly to monthly).	**4 Major**	• Major onsite impact (outside mine extension area); long-term (5+ years) severe effects; rectification difficult. • Significant impact upon Rare and Endangered flora/fauna, TECs/PECs.
C Moderate	The event should occur at some time i.e. once in a while.	**3 Severe**	• Minor onsite impact (within mine extension area); short term (<2 years) effects; easily rectified. • Non compliance. • Minor impact upon Rare and Endangered flora/fauna, TECs/PECs.
D Unlikely	The event could occur at some time.	**2 Minor**	• Effect very localised (within operational cell), very short term (weeks), easily rectified. • Technical divergence.
E Rarely	The event may occur only in exceptional circumstances.	**1 Negligible**	• No effect. • Minor on site effects rectified rapidly with negligible residual effect.

3.2 RISK ASSESSMENT

The three options of continuing operations at KSS were assessed. The objectives of the risk assessment were to:

1. Identify areas of uncertainty that need further study to enable a more accurate assessment of risks to be undertaken.
2. Compare the risks associated with the three options.
3. Identify the preferred option which reduces the risks associated with continuation of the operations to acceptable levels.

3.2.1 Risks of the Current Operations (Option 1)

Initially, the risk assessment examined risks associated with continuation of the current operations. High level risks of the current operations are primarily related to:

- Disturbance to flora and vegetation.
- Disturbance to fauna.
- Disturbance to wetlands.

- Impacts on surface and groundwater quality arising from acidity relating to ASS exposure.
- Disturbance to conservation values of Kemerton Nature Reserve via indirect impacts.
- Rehabilitation failure.

The overall risk to flora and vegetation from continuation of current operations is Moderate. The majority of vegetation for approved operations has already been cleared. Adverse impacts on the Muchea Limestone TEC is considered unlikely as a direct result of the voluntary land swap undertaken by KSS in November 2005 (Ministerial Statement 703) which protects this community in perpetuity. Future mining will further impact on flora and vegetation through direct removal however the risk rating is Moderate and rehabilitation at KSS is demonstrating success.

The overall risk to fauna from continuation of current operations is Low. The majority of fauna species are likely to move into undisturbed areas in Kemerton Nature Reserve and surrounding areas of KSS. In addition, the creation of permanent lakes and the existence of the dredge pond provide a habitat refuge for waterbirds some of which are of conservation significance.

The overall risk to wetlands from continuation of current operations is Low. One EPP wetland (EPP1) lies on the boundary of the existing mine area, but is away from current operations. Indirect impacts on EPP wetlands (3, 4 and 5) are possible as a result of groundwater fluctuations associated with dredge mining. However, KSS is committed to managing the impacts of construction in addition to vesting six other EPP wetlands within Kemerton Nature Reserve. No detrimental impacts have been recorded to date.

The overall risk to surface and groundwater quality from continuation of current operations, in particular due to increasing acidity, is Moderate. Detailed ASS investigations across the KSS property were conducted in 2007. Monitoring has not shown development of ASS during the 10 years of mining to date. Implementation of the Acid Sulfate Soils Management Plan (ASSMP) should ASS become an issue will ensure that current and future mining activities will not reduce water quality of local groundwater or impact upon the ecological value of associated wetlands.

The overall risk related to failure of rehabilitation of disturbed mined areas is Low. KSS is committed to on-going rehabilitation and wetland monitoring and implementing new procedures where required. KSS have engaged the Centre for Ecosystem Management at Edith Cowan University to continue rehabilitation and macroinvertebrate investigations. Processes are in place for implementation of findings from investigations. This continuous improvement process is already resulting in improved rehabilitation performance.

3.2.2 Risks Associated with Dry Mining Option (Option 2)

The dry mining option would mine 75.3 hectares of upland sands outside the current dredge pond within Kemerton Nature Reserve and in areas to the west and north of the current operations (Ministerial Statement 366).

Approximately 12.9 hectares of the dry mining area is located within the Kemerton Nature Reserve. Whilst having transferred the land title to the State for the Kemerton Nature Reserve

area, KSS retain the mineral rights to these areas. Dry mining the approved areas has potential to cause adverse impacts on Kemerton Nature Reserve, specifically those areas around EPP3 and between EPP8 and EPP9. All of the areas within the Kemerton Nature Reserve approved for mining contain Critical Assets as described by the EPA.

In addition to the risks of continuing the current operations, the assessment of risk for the Dry Mining Option is primarily related to:

- Surface and groundwater quality.
- Disturbance to flora and vegetation.
- Disturbance to fauna.
- Disturbance to wetlands including EPP and Conservation Category wetlands.
- Disturbance within the Kemerton Nature Reserve.
- Rehabilitation failure.

The overall risk to surface and groundwater quality from the dry mining option, in particular due to increasing acidity, is considered Low.

The overall risk to flora and vegetation from the dry mining option is High. Mining of areas approved for dry mining will further impact on flora and vegetation through direct removal, although no TECs or Declared Rare Flora (DRF) are within these areas. The predominant vegetation in these areas is remnant native vegetation from the Bassendean – Central and South vegetation complex which is a Critical Asset. It is important to note that dry mining is approved adjacent to and within a portion of EPP5, which is in close proximity to the Muchea Limestone TEC. Mining this are may indirectly impact the TEC.

The overall risk to fauna from the dry mining option occurring is Low. The majority of fauna species are likely to move into undisturbed areas of KSS.
The overall risk to wetlands from the dry mining option is High. Five EPP wetlands (3, 4, 5, 8 and 9) will be impacted indirectly through disturbance to their surrounding catchment. This catchment area is also classified as Conservation Category wetland and is seen by the EPA as a Critical Asset. EPP5 will be directly affected as dry mining is approved in part of the wetland.

The overall risk related to failure of rehabilitation of disturbed mined areas is Moderate. To date, upland restoration at KSS has had mixed success. However, KSS has engaged the Centre for Ecosystem Management at Edith Cowan University to assess and advise on current and future rehabilitation practices. Direct replacement of topsoil from like to like landforms is showing improved success and rehabilitation of upland areas is anticipated to be more successful in the near future.

No further approvals or offsets would be required to undertake dry mining.

3.2.3 Risks of the Proposed Mine Extension Area (Option 3)

The assessment of risk for the Mine Extension Area (Option 3) is primarily related to:

- Disturbance to surface and groundwater quality.

- Disturbance to flora and vegetation.
- Disturbance to fauna.
- Disturbance to wetlands.
- Potential for ASS.
- Rehabilitation failure.

The overall risk to surface and groundwater quality from implementing this option, in particular due to increasing acidity is Moderate. Extensive surface and groundwater monitoring has been undertaken across the KSS property. An ASSMP has been prepared and will be implemented should any acidity occur.

The overall risk to flora and vegetation from implementing this option is High. The mining area has been designed to avoid the only known populations of *Boronia capitata* subsp. *gracilis* (P2) on the KSS property. Whilst some priority flora will be taken through the proposal, none are restricted to the proposed mine extension area and *Acacia semitrullata* (P3) is well represented across the entire property. Some areas of *Agonis flexuosa* vegetation will be impacted by the proposal, but this will only be temporary. *Agonis flexuosa* is known to grow well in rehabilitated areas and KSS are committed to ensure dense stands are returned to their rehabilitated areas.

The overall risk to fauna from this option occurring is Low. The majority of fauna species are likely to move into undisturbed areas of the KSS property. Given the mining operations are progressive, the impact will be gradual and by the time mining has ceased, rehabilitation in the first area of mining will be at least 45 years old. KSS will relocate any Cockatoo hollows to other suitable areas. In addition, as mentioned above, KSS are committed to returning *Agonis flexuosa* to rehabilitation which will provide additional habitat for the Western Ringtail Possum.

The overall risk to wetlands from this option is High. Overall, the mining area has been chosen in an area of the KSS property primarily containing a large area of Bassendean uplands, which will require KSS to remove additional overburden material to extract the feldspathic silica sands. The mining area entirely avoids EPP4 and its surrounding Conservation Category wetland. The boundary of the mining area has been located to avoid a sumpland to the north of the mining area that is known to contain significant values. Some areas of Conservation Category wetland will be mined, but the post-mining landscape will contain some ephemeral wetlands in addition to permanent water bodies, providing additional wetland values to the region in time.

The overall risk of ASS from this option is Moderate. Detailed ASS investigations across the KSS property were conducted in 2007. Monitoring has not shown development of ASS during the 10 years of mining to date. Implementation of the Acid Sulfate Soils Management Plan (ASSMP) should ASS become an issue will ensure that current and future mining activities will not reduce water quality of local groundwater or impact upon the ecological value of associated wetlands.

The overall risk related to failure of rehabilitation of disturbed mined areas is Low. As discussed under the previous options, upland restoration at KSS has had mixed success in the past. Direct replacement of topsoil from like to like landforms is showing improved success

and rehabilitation of upland areas is anticipated to be more successful in the near future. KSS is committed to on-going rehabilitation and wetland monitoring and implementing new procedures where required. KSS have engaged the Centre for Ecosystem Management at Edith Cowan University to continue rehabilitation and macroinvertebrate investigations. Processes are in place for implementation of findings from investigations. This continuous improvement process is already resulting in improved rehabilitation performance.

Risks related to flora, wetlands and fauna habitat associated with this option would be offset by a range of measures to make it environmentally acceptable. This is further detailed in Section 10.4, but would include:

- Undertaking a Land Swap whereby 55 hectares approved for dry mining would not be mined if approval for this proposal is granted. This would protect areas containing Critical and High value environmental assets.
- Transferring ownership to the State of a further 100.7 hectares to increase the Kemerton Nature Reserve to 417 hectares in total. The land to be transferred contains Critical and High value environmental assets.
- Rehabilitating 11 hectares of degraded vegetation within the Kemerton Nature Reserve.

3.3 JUSTIFICATION FOR PROJECT ALTERNATIVE SELECTED

The preferred option for expansion of mining activities at KSS is Option 3. The criteria used to select the preferred option were:

- Proposal meets relevant Federal and State environmental objectives and standards. EPA objectives as described in Section 6 are likely to be able to be achieved.
- Proposal is consistent with the requirements of the Greater Bunbury Regional Scheme. No land zoned as conservation will be mined.
- Protection of areas identified as having high conservation values can be achieved (i.e. protection of areas with known TEC, DRF and Priority flora and habitat of Threatened fauna species, EPP wetlands).
- Minimises impacts on Critical and High value assets as defined by the EPA in Guidance Statement No. 19.
- Proposal provides sustainable economic benefits to proponent, State economy and the local community. Realisation of long-term economic benefits was given high preference i.e. realisation of benefits for current and future generations.
- Efficient and responsible resource use is achieved. Resource use is consistent with the Greater Bunbury Regional Scheme Strategic Minerals and Basic Raw Materials Resource Policy.
- Project would not cause adverse social impacts.

The extent of the silica sand resource on KSS property offers opportunity for considerable flexibility to ensure that the project is designed within environmental constraints to promote a sustainable outcome. When reviewing the alternatives available, it was considered by KSS that a long-term proposal with a very comprehensive long-term land rehabilitation and management plan is likely to have greater stakeholder support than a series of short-term extensions that lack a long-term strategy, plan and commitment.

Benefits identified as resulting from the preferred alternative include:

- It would secure a long-term resource necessary for commercial operation of the project and flow of business benefits to the community. Silica sand markets require long-term stability in supply as users of the sand design and construct plants based on specific supply characteristics with low tolerances for change. Inability to commit to long-term supply would hinder KSS ability to find markets for their product.
- The larger project enables long-term and larger scale land and environmental management programs, complete with short-term (two years), medium term (five to eight years) and long-term (20 plus years) financial, marketing and general management objectives.
- Substantial opportunity for continuous improvement exists. Whilst KSS has committed to implement best practice environmental management as defined by the EPA, changes in knowledge and technology can realistically be expected to occur during the long life of the preferred proposal. Such changes can be incorporated into operational planning to ensure the best environmental and social outcomes are achieved. Some rehabilitation areas will be over 45 years old prior to KSS completing mining.
- Assistance with achievement of EPA objectives of establishing a North-South Ecological linkage in this area (EPA Bulletin 1108) and long term protection of Critical and High Value Assets in perpetuity.
- Protection of Critical and High Value assets currently approved to be mined as part of an offset package (i.e land swap). This includes Conservation Category wetlands which act as catchment for five EPP wetlands. KSS would forgo the right to mine these areas if approval for the mine extension is granted.
- Maintenance of environmental values for a large land area during the life of mining operations. KSS will not conduct grazing throughout the KSS property during the term of mining operations. KSS will also assist with maintenance of weeds and feral animals in the Kemerton Nature Reserve during the life of mining operations.

Option 3 would result in the protection of 882.7 hectares of Critical and High Value assets. Assets avoided include:

- Critically Endangered DRF (*Caladenia procera* species from one known location).
- Priority flora species (populations of *Boronia capitata* subsp. *gracilis* (P2) and *Acacia flagelliformis* (P4)).
- EPP wetlands and associated catchments (EPP4, EPP8).
- Conservation Category wetlands in good condition (428.5 hectares) including recently avoided sump in UFI 1906 to the north of the mine extension area.
- Multiple Use wetlands in good condition (6.5 hectares).
- Resource Enhancement wetlands in good condition (18.9 hectares).
- Remnant vegetation (428.8 hectares of Bassendean – Central and South vegetation complex).

Environmental factors that will be incorporated into detailed design of the project to ensure it is consistent with sustainability objectives of the State of Western Australia include:

- Effective restoration of mined land.

- Use of best practice techniques to prevent pollution.
- Achievement of best practice energy and water efficiency.
- Maintenance of greenhouse gas emissions as low as practicable.
- Achievement of maximum net environmental benefit/conservation gain.
- Biodiversity enhancement.

3.4 KEY CHARACTERISTICS

Key characteristics of the proposed extension of sand dredge mining at KSS are summarised in Table 4.

Table 4: Key Proposal Characteristics

Element	Description
Life of sand dredging	50 years.
Mine extension area	283 hectares. This includes: • 20.3 hectares of approved dry mining. • 19 hectares of existing cleared land. • 55 hectares of land swap for pre-existing dry mining approval.
Hours of operation	24 hours, 7 days per week.
Infrastructure/ancillary equipment/facilities:	
• Internal access roads	The main access road is bitumen and access tracks to the dredge and other infrastructure are limestone.
• Earthmoving equipment	Use existing infrastructure.
• Plant	Use existing infrastructure.
• Transportable offices, ablutions and crib room	Use existing infrastructure.
Sand products	Between 500,000 to 1,000,000 tonnes per annum.
Sandpit details:	
• Depth of excavation	Dredge depth varies between 15 to 22 metres.
• Setback limits:	
– Eastern boundary	N/A
– Southern boundary	N/A
– Western boundary	
• Finished slope of embankments	20 metres. Beaches and dredge pond.
Excavation staging	Figure 2.
Waste disposal	Use existing infrastructure.

3.5 DESIGN CRITERIA

3.5.1 Extractive Areas

The configuration of the dredge pond is determined by the following design criteria:

Felspathic silica sand resource is located below the natural water table. Depending on local topography, the water table can be up to 10 metres below topographic upland and at surface in seasonal wetlands. The resource is overlaid with a cemented ironstone (coffee rock) layer one to two metres thick. This is overlaid by more Bassendean siliceous sand, above the water table, some of which is resource grade and some is waste, the latter categorised as overburden.

Depth of Excavation
The maximum dredging depth varies between 15 and 22 metres.

Setback Limits
A minimum setback of 20 metres to property boundaries will be maintained as is required by the Shire of Harvey.

Finished Slopes of Embankments
Finished slopes will include a zone of shallow beach approximately 30 to 40 metres wide before sloping at a stable angle of repose (approximately one in four) to the base of the rehabilitated lake.

3.5.2 Optimisation of Sand Quantities

As a large proportion of existing material is exported from the site, the final landform will be lower than the pre-mining land surface. Permanent lakes will be created interspersed with upland areas and ephemeral wetlands.

Almost half the proposed mine extension area is in upland locations, comprising a significant proportion of pure silica sand (SiO_2 greater than 99%) which is not primary felspathic ore. There is a large demand for silica sand in Western Australia and KSS will investigate further markets. The remaining sand will be used for backfill of completed cells of the dredge pond and reshaping terrestrial landforms undergoing rehabilitation.

A number of waste streams of oversized silica sand, zircon, ilmenite and feldspar which could be recovered and marketed are produced in the silica sand processing operation. The heavy sand reject stream contains a concentrate of heavy mineral sand in the mined profile. Up to 100 tonnes of this material is produced per week with tests indicating that its chemistry is sufficient to allow further processing. With secondary treatment plants located nearby in Bunbury, processing heavy minerals provides additional optimisation of the sand resource.

Approval for use of silica sand and sale of heavy mineral sand components from the existing operation are being sought via Section 45C submissions to the EPA. This proposal seeks approval for sale of products generated from the mine extension.

3.5.3 Duration of the Proposed Operations

The proposed mine extension area is estimated to have approximately 30 million tonnes of felspathic rich silica sand resources which will last approximately 50 years at the current production rate.

3.5.4 Setback Limits

The proposed mine extension area abuts a portion of the property's western boundary with a high voltage power line easement running immediately west of this boundary. There are no dwellings in the vicinity of the western boundary of the KSS property and the area is kept clear of substantial vegetation. There is no practical reason to maintain a vegetative setback along the western boundary as a visual screen for adjacent properties. A 20 metre setback, the local government requirement, has been provided to allow firebreak construction and perimeter access around the property.

3.6 VEGETATION CLEARING

The proposed mine extension area of 283 hectares has 19 hectares of cleared and 264 hectares of vegetated land that will require clearing over the 50 year project life. Vegetation will be cleared in stages of approximately five hectares per year. Vegetation clearing will be confined to areas required for dredge mining and associated activities, particularly in front of the expanding dredge pond.

Approval has been granted to clear 75.3 hectares of Bassendean Dune vegetation, beyond the dredge pond boundary, in a dry mining program (Ministerial Statement 366). These areas identified in Figure 2 of the initial PER, dated July 1993, are reproduced and shown in Figure 2. Only 20.3 hectares of the approved dry mining area is contained in the proposed mine extension area (Figure 2). The remaining 55.0 hectares is located in the Kemerton Nature Reserve and other portions of the KSS property.

These areas are now considered to have environmental values that make mining less desirable. This proposal seeks an amendment for the mine extension area, to swap approval to clear 55.0 hectares of the Bassendean Dunes contained in the proposed mine extension area for those areas shown in Figure 2. This will reduce the area of Bassendean woodland disturbed by the project. This is further discussed in Section 10.

3.7 TOPSOIL MANAGEMENT

Topsoil will be removed to a depth of approximately 200 millimetres and where possible, will be directly returned to similar landforms under rehabilitation. Where scheduling and seasonal constraints do not allow direct return, topsoil will be stored in stockpiles no greater than three metres high until required for rehabilitation.

3.8 EXTRACTION METHOD

The same sand extraction process proposed for the proposed mine extension area is currently used on the property. Sand mining is a wet process using an electric powered suction cutter dredge capable of mining at a rate of 350 tonnes per hour at a vertical depth of 15 to 22 metres. Sand slurry is pumped from the dredge to a staging hopper where oversize material is removed by screens. The slurry is then pumped to the Run of Mine (ROM) stockpile area near the plant where it is dewatered with cyclones and excess water is pumped back to the dredge pond. The sand is discharged onto stockpiles from where it is fed into the plant by front end loader.

Dewatered sand enters the plant on a conveyor belt via a hopper where it is screened and oversize material removed. Sand slurry is deslimed before entering the Flat Bed Classifiers. Silt and clay fraction goes to the thickener where water is recovered and the fines are mixed with other plant tails and returned to the dredge pond for rehabilitation.

The Flat Bed Classifiers split sand into course and fine fractions. Some of the course fraction is screened further to make products such as filter sand. The remainder is returned to the dredge pond.

Fine sand is cleaned by agitating the slurry in attritioning cells before feeding it into spiral circuits, which separate heavy minerals from the sand. A wet high intensity magnetic separator removes any remaining iron.

Clean sand is fed to trommel screens that remove sand grains greater than 0.5 millimetres which are returned to the dredge pond. The remaining sand is pumped to cyclones on stackers where it is dewatered prior to being placed in product stockpiles. The remaining moisture drains naturally from the stockpiles.

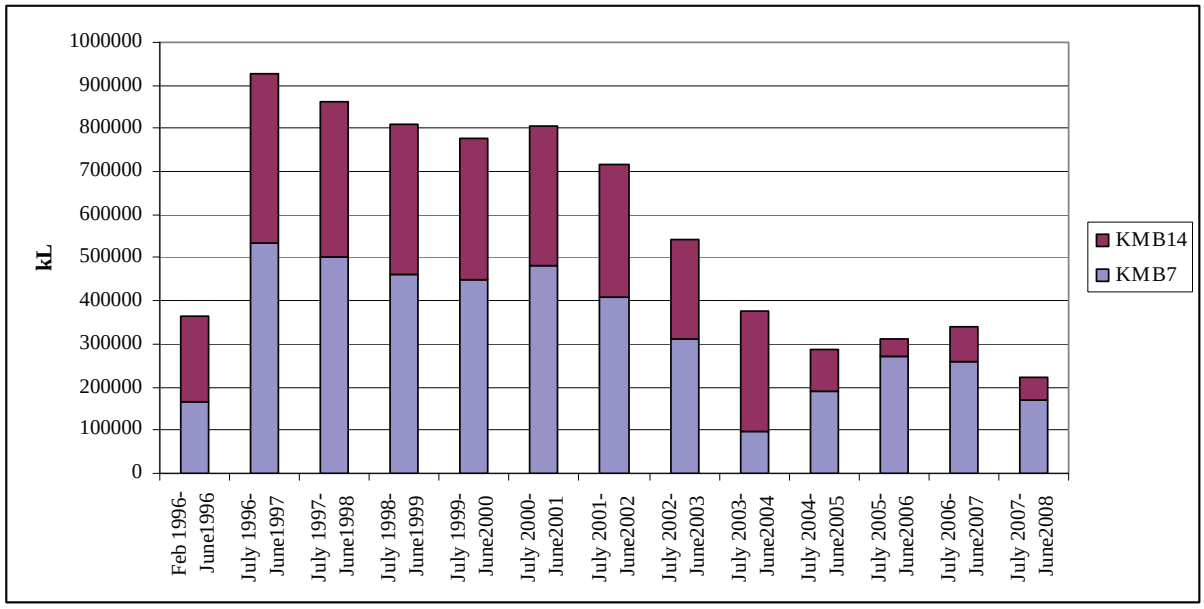
3.9 GROUNDWATER USAGE

Groundwater abstraction at the KSS site is authorised and regulated under terms and conditions of Groundwater Well Licence (GWL) 60367(3), expiry 30 June 2013. This allows a maximum extraction of 1,000,000 kilolitres per year. Extraction during 2006/07 totalled 338,258 kilolitres, or 34 percent of the annual maximum. In August 2007, the groundwater licence was reduced to 660,000 kilolitres. This was achieved as a result of successful water conservation initiatives instigated by KSS. In addition, the annual water entitlement was reduced by the Department of Water (DoW) to reflect water efficiency gains at a time when allocation limits were being revised in the area due to changes to groundwater subarea boundaries. During 2007/08, groundwater extraction totalled 224,224 kilolitres or 34% of the new annual maximum.

Abstraction primarily occurs from bores KMB7 and KMB14. Water is only abstracted from KMB14 when sufficient water can not be sourced from KMB7. Water from production bores is used where clean water is required. Applications include water sprays, where dirty water blocks spray jets, reverse osmosis plant for potable water production with the balance used for makeup water in the process circuit.

Total groundwater abstraction has decreased since July 2003 as a result of resource efficiency initiatives implemented by KSS. The volume of water abstracted from bores has decreased significantly. Chart 1 shows bore water extraction after 2003 has decreased to less than half the amount prior to 2003.

Chart 1: Groundwater Abstraction 1996 - 2008



No change to current groundwater usage in terms of volume of abstraction is proposed. Additional abstraction bores will be developed during the 50 year mine life to replace existing bores which will be disturbed by dredging operations. This will also satisfy recent DoW requirements for spread of abstraction locations over a wider geographic area so each bore draws about 100,000 kilolitres per annum.

3.10 ACCESS AND HAULAGE

The site access road and product haulage route will remain the same. Final stockpiled sand is loaded into trucks and transported 35 kilometres along sealed roads to the Port of Bunbury for export.

3.11 SITE OPERATIONS

3.11.1 Infrastructure

Infrastructure already established on-site includes office buildings for employees, ablutions, workshops, process plant, dredge and dredge pond, a decommissioned settling pond, access roads and tracks. No additional infrastructure will be required.

An infrastructure corridor 25 metres wide will be developed along an existing dirt road as shown in Figure 2. A power line for the dredge, pipe lines for transfer of sand from the

dredge to the plant and return of waste sand to the dredge pond and a light vehicle access road will be located within this corridor.

3.11.2 Equipment

Equipment involved with normal site operations are:

- Komatsu WA470 front end loader.
- Caterpillar 966C front end loader.
- Caterpillar 924G front end loader.
- Two trucks with two trailers each on road tip trucks.

During ship loading at the port:

- Two Caterpillar 988G front end loader.
- Up to 15 double road trains or truck and trailer combinations (on road tippers).

Extra mining or rehabilitation work for one to two months per year:

- Two or three Caterpillar D400 dump trucks.
- Hitachi 870 excavator or equivalent.
- Caterpillar D7R bulldozer.
- Caterpillar 639 scraper.

3.11.3 Communications

Both radio and mobile phones are used for on-site communication.

3.11.4 Vehicle and Dredge Maintenance

Routine servicing of one front end loader only is done on-site, in a fully equipped maintenance workshop. All major repairs, overhauls or maintenance is undertaken off-site. Maintenance and servicing of light vehicles and road haulage trucks is also undertaken off-site. Dredge maintenance is carried out on-site on a routine basis.

No changes are proposed to these procedures.

3.11.5 Fuel and Lubricants

No additional chemical storage facilities will be required for the mine extension.

Existing above ground hydrocarbon storage facilities have concrete floors and side bunds with a minimum capacity of 110% of the largest vessel. Storage of hydrocarbons and chemicals are in compliance with *AS1940-2004: The storage and handling of flammable and combustible liquids* and *Dangerous Goods Regulations*. All of these facilities are located within the processing plant area.

3.11.6 Power

The total estimated electricity usage is approximately 10,000 megawatt hours per annum. This does not represent a change from the existing approved operation.

3.11.7 Waste Management

No change to existing waste disposal practices is required for the mine extension area.

Domestic refuse is disposed of at the local authority landfill site. Waste oil produced on-site is collected by Wren Oil in Picton for recycling. Steel scrap is recycled locally.

3.11.8 Hours of Operation

The current operation is approved for operation 24 hours, seven days a week. However haulage is avoided on Sundays where possible. No change is proposed.

3.12 REHABILITATION

Rehabilitation will be conducted as dredging progresses and completed areas can be isolated as 'rehabilitation cells' from the active dredge pond.

Overburden and sand not suitable for sale will be returned to the rehabilitation cell to be used to create graded beaches or landforms for terrestrial rehabilitation. Shallow areas will be formed to allow seasonal inundation and planted with suitable species.

Rehabilitation undertaken has provided KSS with valuable information on potential rehabilitation techniques for successful outcomes. The rehabilitation process is further discussed in Section 8.

3.13 POST-MINING LANDFORM AND LONG-TERM LAND USE

The mining process will remove 80% of the sand in the extraction zone, creating voids which will remain as lakes after mining. Remaining sand not suitable for sale will be used in rehabilitation as described in Section 3.12. The creation of shallow and deep lakes will allow for a range of fauna habitats to be established. The post mining landform will retain the low lying (wetland) aspect of the property, separated by elevated land, which will be lower than pre mining height.

Long-term land use is to retain existing rural zoning of the property. The current owners do not intend to recommence stock grazing or any other active form of farming on the property.

4. EXISTING ENVIRONMENT

4.1 CLIMATE

The KSS property is situated in a Mediterranean climate zone of Western Australia with wet, mild winters and hot dry summers. Bunbury's long-term average annual rainfall is 733.5 millimetres with rainfall occurring predominantly during May to October (Bureau of Meteorology, 2008). The average annual pan evaporation is 1900 millimetres, exceeding average annual rainfall of 733.5 millimetres by a ratio of more than 2.5:1. Climatic data for Bunbury is presented in Table 5.

The region's summer wind pattern is dominated by local onshore (sea breeze) and offshore (land breeze) winds, with light south-easterlies in the early hours of the morning and at night, and stronger south-westerlies during the day. The winter wind pattern is dominated by an eastward progression of rain bearing low pressure systems and associated cold fronts with north-westerly storms (Bureau of Meteorology, 2008).

Table 5: Climatic Data for Bunbury

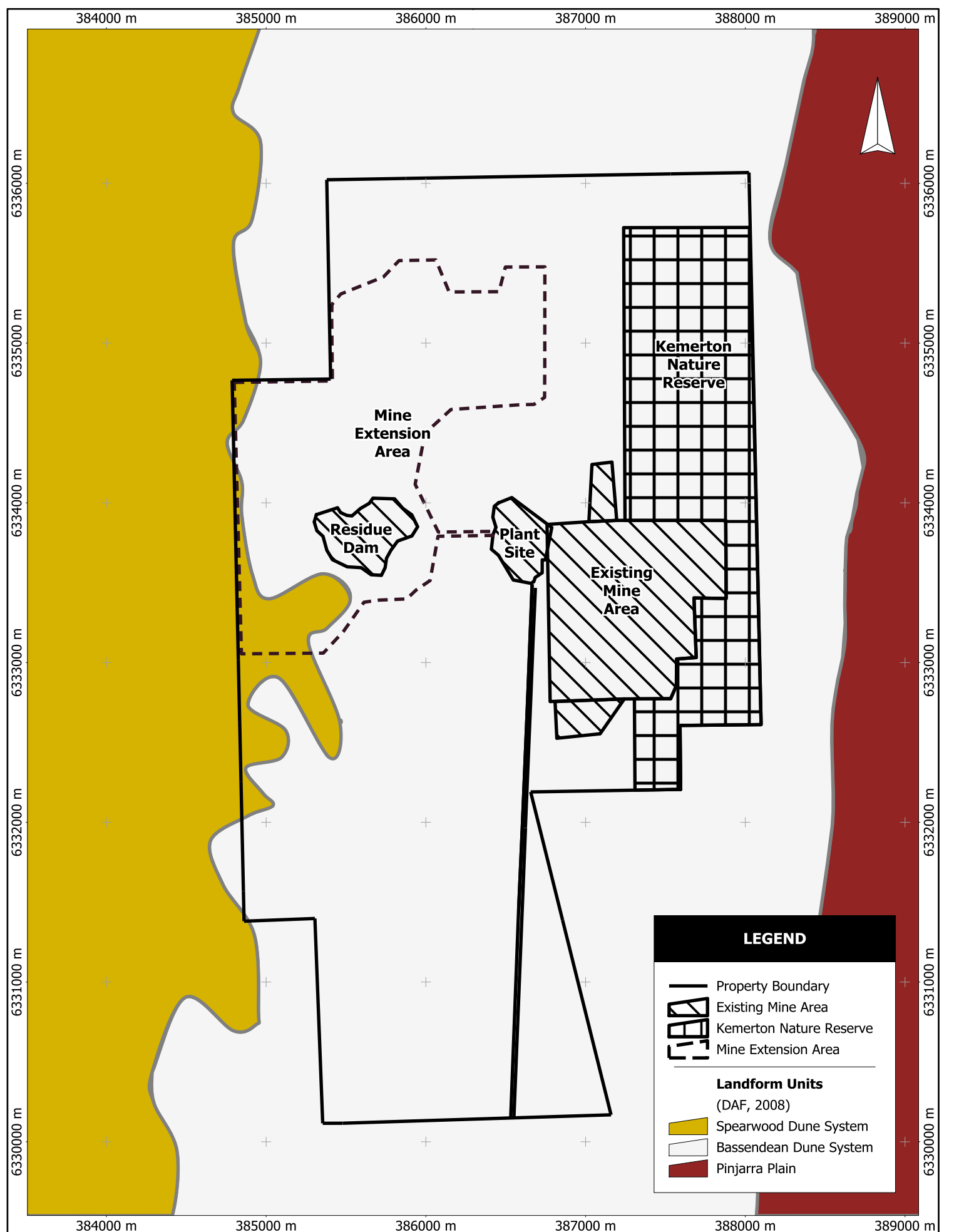
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Long-term Mean													
Max (°C)	29.2	29.8	27.6	23.9	21.1	18.5	17.3	17.3	18.2	20.5	24.3	27	22.9
Min (°C)	15.0	15.5	14.1	11.6	9.5	8.2	7.0	7.6	8.5	9.0	12.1	13.4	11.0
Rainfall (mm)	11.0	6.2	16.8	37.2	98.2	149.2	147.4	131.1	81.4	35.3	20.2	17.9	733.5

Source: Bureau of Meteorology Bunbury records 1995 - 2008.

4.2 GEOLOGY AND LANDFORMS

The geology and landforms of the Darling System have been described and mapped by the Department of Mines Geological Survey Branch (1978), Churchward and McArthur (1978) and more recently by Barnesby and Proulx-Nixon (2000).

The KSS property is situated within the Perth Basin, extending approximately 20 kilometres eastwards from the coast to the Darling Escarpment. The Swan Coastal Plain is made up of five major geomorphological systems running roughly parallel to the coast. From east to west they include the Ridge Hill Shelf at the base of the Darling Scarp, the flat Pinjarra Plain, followed by the aeolian Bassendean, Spearwood and Quindalup Dune Systems (McArthur, 1991). The Bassendean Dune System forms a north–south strip approximately three kilometres wide between Pinjarra Plain to the east and Spearwood Dune System to the west. Dune crests in the Bassendean Dune System reach elevations of approximately 25 mAHD (metres above Australian Height Datum) and low areas have elevations of approximately 10 mAHD. Dune crests in the Spearwood Dune System reach elevations of approximately 50 mAHD immediately west of the KSS property. The general elevation of the Pinjarra Plain is 15 to 20 mAHD. The three landform systems in relation to KSS are shown in Figure 4.



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Landform Systems in Relation to Kemerton Silica Sand

Figure 4

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4.3 SOILS

4.3.1 Soil Systems

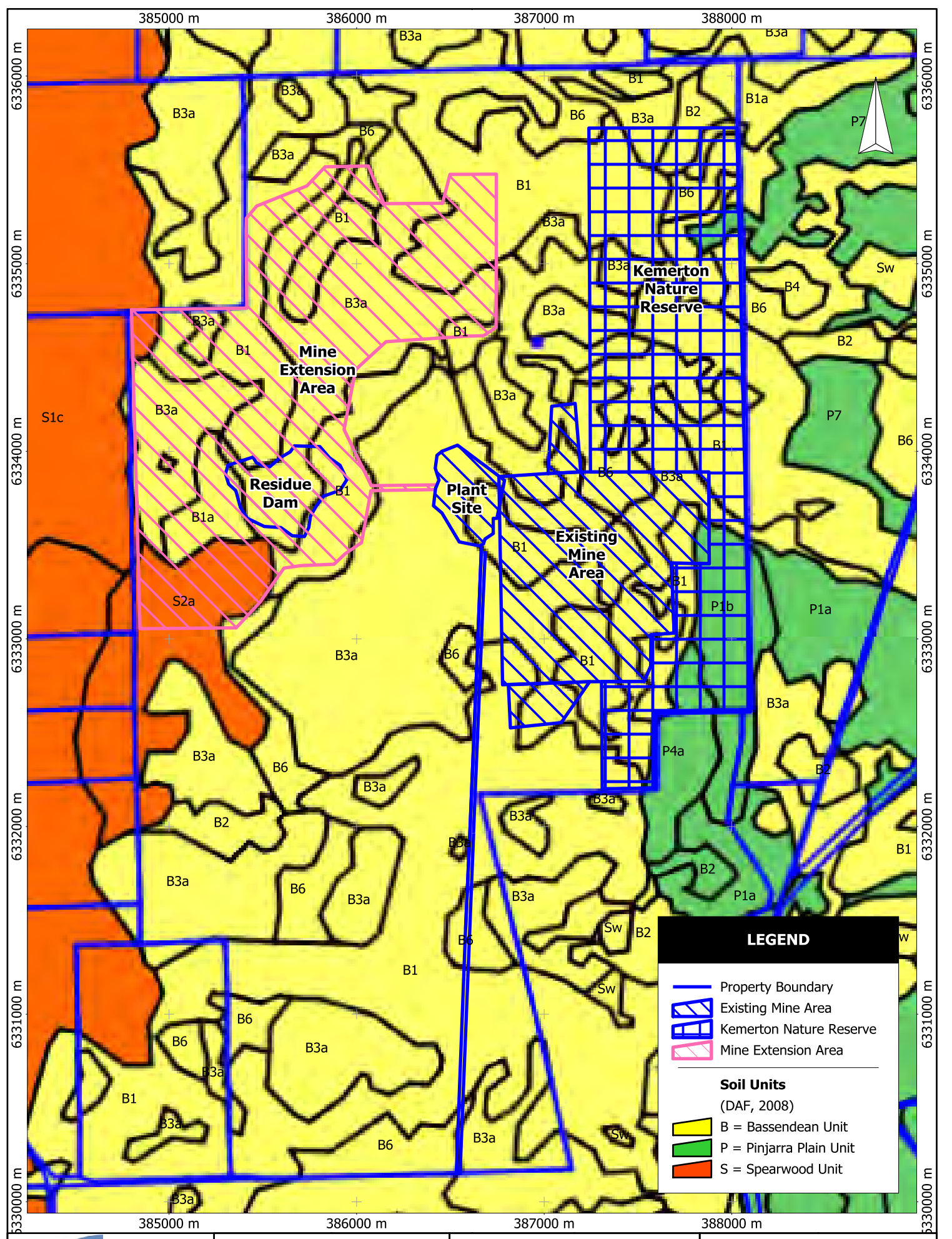
The soils of the KSS property predominately comprise the highly leached, grey siliceous sands of the Bassendean Dune System. The Department of Agriculture, (now the Department of Agriculture and Food (DAF)) published a series of land resource maps for the Swan Coastal Plain, which have now been reproduced and can be accessed electronically from Natural Resource Management (NRM) Info (DAF, 2008). Soil units are shown in Figure 5 and descriptions are presented in Table 6. The following summary points are made in relation to soils of the KSS property:

- The property is predominately located in the Bassendean soil system.
- Portions of the eastern side of the property interface with the Pinjarra Plain System. These areas are now within Kemerton Nature Reserve.
- Portions of the western side of the property interface with the Spearwood Dune System.
- The upland (*Banksia/Jarrah*) woodland predominately corresponds to the B1, B1a and B2 soil units, some upland areas in the west also correspond to S1c and S2a soil units as mapped by DAF (2008).
- The low-lying wetlands generally correspond to the B3a to B6 soil units mapped by DAF (2008).

Table 6: Soil Units Within the KSS Mine Extension Area

Soil Unit	Description
B1	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises. Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 metres. *Banksia* dominant.
B1a	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises. Deep bleached grey sands with an intensely coloured yellow B horizon occurring within 1 metre of the surface. Marri and jarrah dominant.
B2	Flat to very gently undulating well drained sandplain of the surface. Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan at 1 - 2 metres.
B3a	Broad depression and narrow swales between sand ridges. Poorly drained grey and brown sands, with an iron-organic (or siliceous) hardpan at generally <1 metre.
B6	Imperfectly drained sandplain and broad extremely low rises. Deep or very deep grey siliceous sands.
S1c	Dune ridges with slopes up to 15%. Deep bleached grey sands with yellow-brown subsoils.
S2a	Lower slopes (1 - 5%) of dune ridge with minor limestone outcrop. Moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils.

Source: DAF (2008).



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Original Size: A4
Grid: Australia MGA94(50)
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Soil Units of Kemerton Silica Sand

Figure 5

W:\Kemerton Silica Sand\Drawings\Maps 2009\Soil System Units.map 15/10/2009 Soil System Layout

4.3.2 Acid Sulfate Soils

Potential Acid Sulfate Soil problems develop when soils are exposed to air, where sulfide minerals within the soil can oxidise and produce sulfuric acid, in environments where there is insufficient Acid Neutralising Capacity to buffer any acid generated.

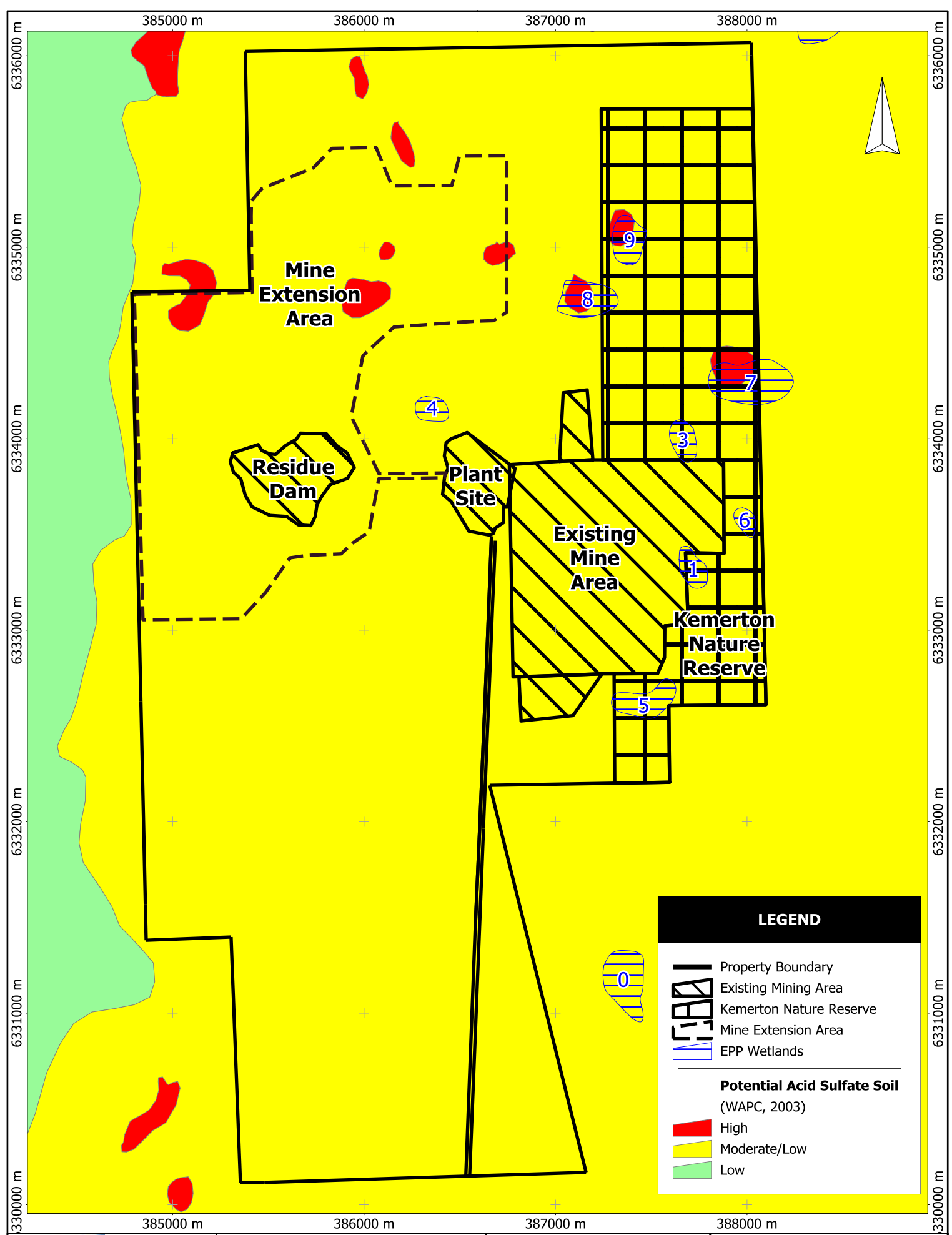
Most of the KSS site is located within an area mapped on the WAPC (2003) Bulletin 64 maps with a moderate to low risk of Acid Sulfate Soils (ASS) occurring at depths greater than three metres, as shown in Figure 6 (WAPC, 2003). There are also two areas listed as being high risk of ASS at less than three metres from the surface.

Dredge mining operations have taken place over the last 10 years at KSS, to a depth of approximately 15 to 22 metres. The base of the silica sand resource is usually bound by the interface of Bassendean and early Jandakot bed systems, characterised by the presence of shells and limestone in the sediments. Monitoring has been conducted in accordance with environmental licence conditions. The monitoring has not shown development of acidity in the dredge pond or surrounding monitoring bores, suggesting a very low risk of acid generation for future dredging operations. Returned sand residues, backfilled mostly below the water table in the rehabilitation cell, are exposed to minimal free oxygen, further reducing the risk of any possible acidification from Potential Acid Sulfate Soil material in these soils.

4.3.2.1 Initial ASS Assessment

The ASS investigation program was designed according to the DEC (2009a) *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* guidelines. Mr Stephen Wong of DEC was consulted on 3 August 2007 specifically in regard to the ASS investigation program for the KSS proposed mine extension area. The design of the program was influenced by the:

- Large amount of data available from the current dredge mining operation.
- Small annual disturbance area of the proposed mine extension area.
- Long duration of the proposed mining program.
- Low to moderate ASS risk ranking of the KSS site according to WAPC information.



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Potential Acid Sulfate Soil Locations Within Kemerten Silica Sand

Figure 6

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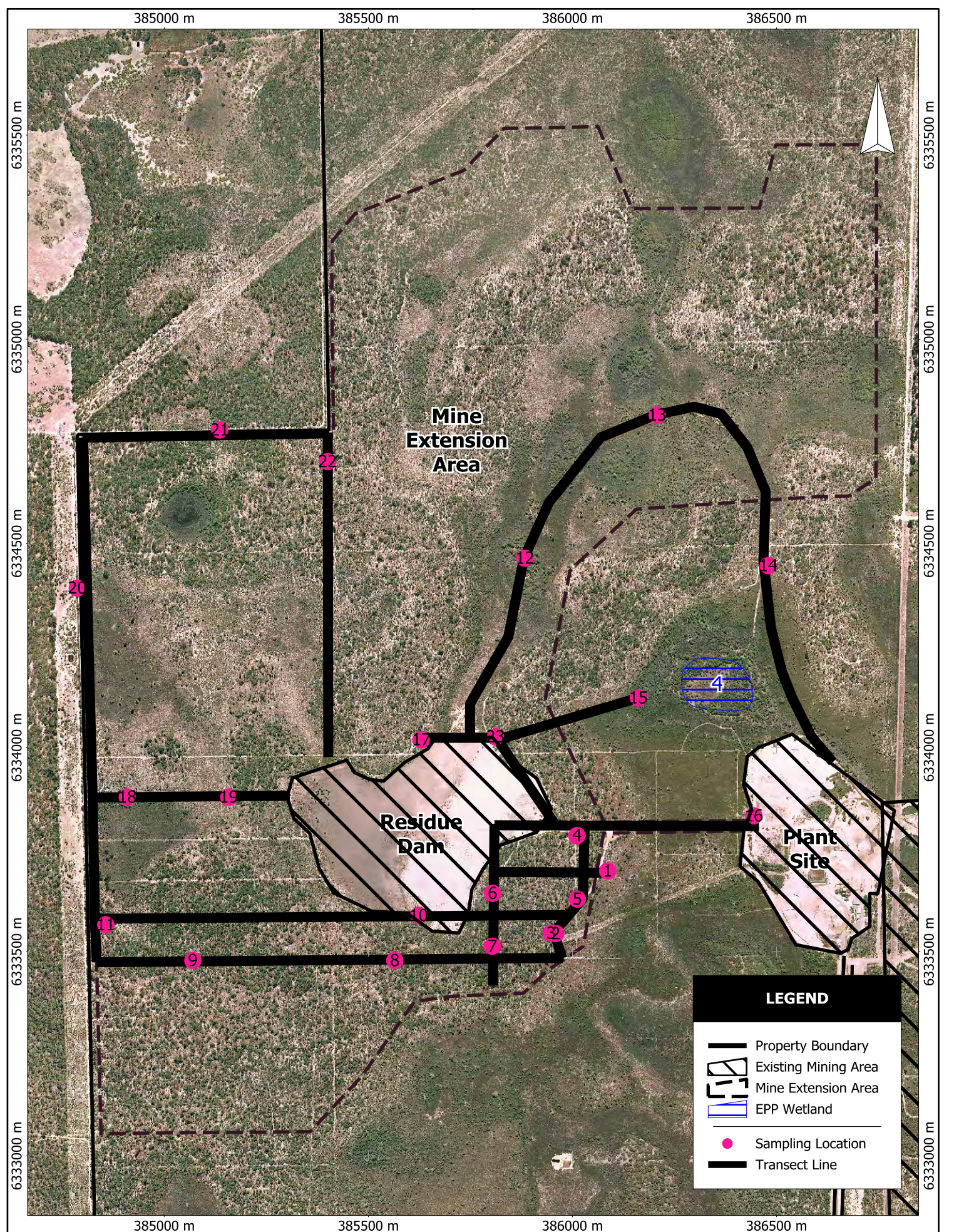
Key aspects of the methods of the ASS investigation program were:

- Transect alignments used existing drill lines and access tracks to avoid the need to clear native vegetation. Transect locations are shown in Figure 7.
- Sampling was conducted at 250 metre spaced holes in the five to 10 year mine area and at 500 metre intervals in future mine areas on transect lines as shown in Figure 7. A total of 23 holes were drilled to depths of up to 20 metres, with complete soil descriptions recorded for each location. Further transects and sampling locations will be investigated as mining proceeds as described in Section 7.2.2.4 as per DEC (2009a) Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes guidelines.
- Field assessment was undertaken at one metre vertical intervals. Assessment at 0.5 metre intervals was considered unnecessary due to the large amount of geological data collected during mineral exploration confirming the unstratified nature of the siliceous Bassendean sands to a depth of 15 to 22 metres below the water table.
- The fine sand tailings area shown in Figure 7 is progressively being processed through the existing process plant. ASS sampling of this area is undertaken approximately three metres below the current surface level as deposited waste material will be removed.
- Field pH (pHF) and pH after oxidation (pHFOX) testing was conducted of all soil samples to provide indications of the likelihood of ASS presence. The pHF test measures the existing acidity of a soil:water paste, and was therefore used to help identify Actual Acid Sulfate Soils (DEC, 2006). The pHFOX test may be used to give an indication of the presence of stored (potential) acidity (DEC, 2006). Based on these results, a selection of samples showing the highest ASS potential were submitted for laboratory analysis using the Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) method. This method is a standardised set of procedures used in assessing environmental impacts of soils suspected of containing pyrite and other iron sulfides which might lead to an ASS problem if disturbed.

This initial ASS assessment of the proposed extension area was undertaken by MBS Environmental in August 2007. The initial assessment provided an indication of the distribution of Actual Acid Sulfate Soil and Potential Acid Sulfate Soil within the extension areas.



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Air Photo Date: 2006
Grid: Australia MGA94 (50)
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Initial Acid Sulfate Soil Survey Sampling Locations

Figure 7

W:\Kemerton Silica Sand\Drawings\Maps 2009\ASS.map 15/10/2009 Acid Sulfate Soils Survey 2007 Layout

Interpretation of results from the SPOCAS test methods involved comparing test results with established action criteria. Published action criteria provided by the NSW Acid Sulfate Soils Management Advisory Committee (ASSMAC) are presented in Table 7.

Table 7: ASSMAC Action Criteria

Type of Material		**Action Criteria, <1,000 tonnes**		**Action Criteria, >1,000 tonnes**	
Texture	**Approx Clay Content (%<0.002 mm)**	**Sulfur Trail S_{POS} %**	**Acid Trail TPA (mole H^+/t)**	**Sulfur Trail S_{POS} %**	**Acid Trail TPA (mole H^+/t)**
Western Australian Action Criteria		*0.03*			*18*
Coarse eg. sands	≤5	0.03	18	0.03	18
Medium eg. loams/ light clays	5 – 40	0.06	36	0.03	18
Fine clays/silts	≥40	0.1	62	0.03	18

The complete report of ASS investigations undertaken is provided in Appendix 1.

A summary of results from the initial ASS investigation, comparing field assessment and laboratory results are presented in Table 8. A summary of results is presented below:

- Field assessment shows the more highly reactive soils (indicated by the difference between the pH_F and pH_{FOX} being greater than four) are generally located below 22 metres. This would indicate the soil profile below the base of the dredge pond (which will remain undisturbed and under water) has a greater potential for acid generation than the mining profile (the top 22 metres).
- When a Titratable Peroxide Acidity level greater than 18 moles H^+/tonne is recorded, the 'action criteria' for sandy soils is exceeded. While many of the samples selected for laboratory analysis exceed the action criteria; they are not universally below 15 metres and are not always highly correlated with high field measurement results. This confirms there is soil present at certain locations within the proposed mine profile which is Potentially Acid Forming.
- A number of samples recorded extremely high Acid Neutralising Capacity values. Taken in context with other locations which are Potentially Acid Forming, the dredge pond is considered likely to have a significant buffering capacity against acid formation. This is consistent with observation and monitoring results of the existing dredge pond over 10 years of active mining.

Conclusions from the initial ASS sampling program are:

- Most potential high acid generating soils are located below the base of the final dredge pond depth (15 to 22 metres), will not be disturbed and will remain under water.
- There are some high potential acid generating soils within the mine profile of the mine extension area.
- There are high acid neutralising soils beneath the dredge pond, providing a significant in-situ buffering capacity.

Table 8: Acid Sulfate Soil Assessment Results

Date	Sample Depth (m)	Field Results				Laboratory Results				
		pH_F	Peroxide Reaction	pH_{FOX}	pH_F-pH_{FOX} range >4	pH_{KCl}	pH_{FOX}	ANC Moles H+/tonne	TAA Moles H+/tonne	TPA Moles H+/tonne
Hole 4										
15/08/2007	5	8.49	-	5.60		7.7	6.1	<2	<2	<2
15/08/2007	12	8.12	-	5.30		6.3	4.0	<2	<2	5
15/08/2007	18	7.97	XX	1.53	6.44	6.2	2.8	<2	<2	25
15/08/2007	21	8.15	XXXX	1.62	6.53	5.8	2.6	<2	<2	48
15/08/2007	26	8.52	X	6.14		9.8	8.2	1372	<2	<2
Hole 10										
14/08/2007	3	7.68	-	5.07		9.6	7.1	33	<2	<2
14/08/2007	11	5.93	-	4.53		5.5	3.8	<2	7	27
14/08/2007	16	5.98	-	2.80		5.5	3.0	<2	5	40
14/08/2007	23	6.20	XXXX	1.47	4.73	5.4	2.3	<2	4	101
14/08/2007	29	6.57	XXXX	1.29	5.28	5.5	2.2	<2	5	369
Hole 15										
14/08/2007	5	6.53	-	5.48		6.4	4.0	<2	<2	0
14/08/2007	12	6.83	XXX	2.49	4.34	6.8	2.5	<2	<2	59
14/08/2007	17	7.33	XXXX	1.91	5.42	6.7	2.8	<2	<2	43
14/08/2007	22	8.51	-	6.65		9.7	8.0	2168	<2	<2
14/08/2007	26	8.49	X	6.24		9.5	8.3	2170	<2	<2
Hole 20										
15/08/2007	3	4.99	X	1.91		9.4	5.7	<2	<2	<2
15/08/2007	7	6.82	-	4.94		5.1	3.2	<2	28	142
15/08/2007	12	7.02	-	4.21		6.3	3.9	<2	<2	11
15/08/2007	18	7.28	XXX	1.91	5.37	5.5	2.5	<2	<2	74
15/08/2007	25	7.68	XXXX	1.51	6.17	5.1	2.4	<2	5	148
15/08/2007	27	7.94	X	1.92	6.02	5.4	2.4	<2	3	81

Note:

Reaction Scale	Rate of Reaction		
-	No reaction.	XX	Moderate reaction.
X	Slight effervescence.	XXX	Vigorous reaction.
		XXXX	Very vigorous reaction, gas evolution and heat generation.

Source: Hey *et al*. (2000).

4.3.2.2 Targeted Survey in the Rehabilitated Area South of North Lake

In mid 2007, a new area south of North Lake was rehabilitated using topsoil and spreading of brush and logs (Figure 1 in Appendix 2). This area (Edith Cowan University Site 14) is a rehabilitated sumpland near EPP5 and bordering the Muchea Limestone TEC. During monitoring McCullough and Lund (2007) observed low chloride to sulfate ratios in the newly rehabilitated area and expressed concern that this may indicate some acid mine drainage/ASS-type oxidation from disturbance of the intermediate 'coffee rock' layer which may contain Potential Acid Sulfate Soil. In response to this observation, four samples of soil from this area were submitted for chemical analysis to determine the potential for acid generation following oxidation of ASS materials.

The samples were delivered by Mark Gell of KSS to MBS on 24 December 2008. The samples were taken at 25 to 35 centimetre depths because the water table was still high at the time of sampling. The samples were marked ASS 001 to 004 and their locations are shown in Figure 8. ASS 001 to ASS 003 were taken from a reconstructed soil profile and ASS 004 was sampled from a soil dump (mud pushed up onto the surface to dry). The samples were described as:

- ASS 001: Light yellow-grey sandy soil.
- ASS 002: Grey sandy soil.
- ASS 003: Organic grey-black sandy soil.
- ASS 004: Grey sandy soil.

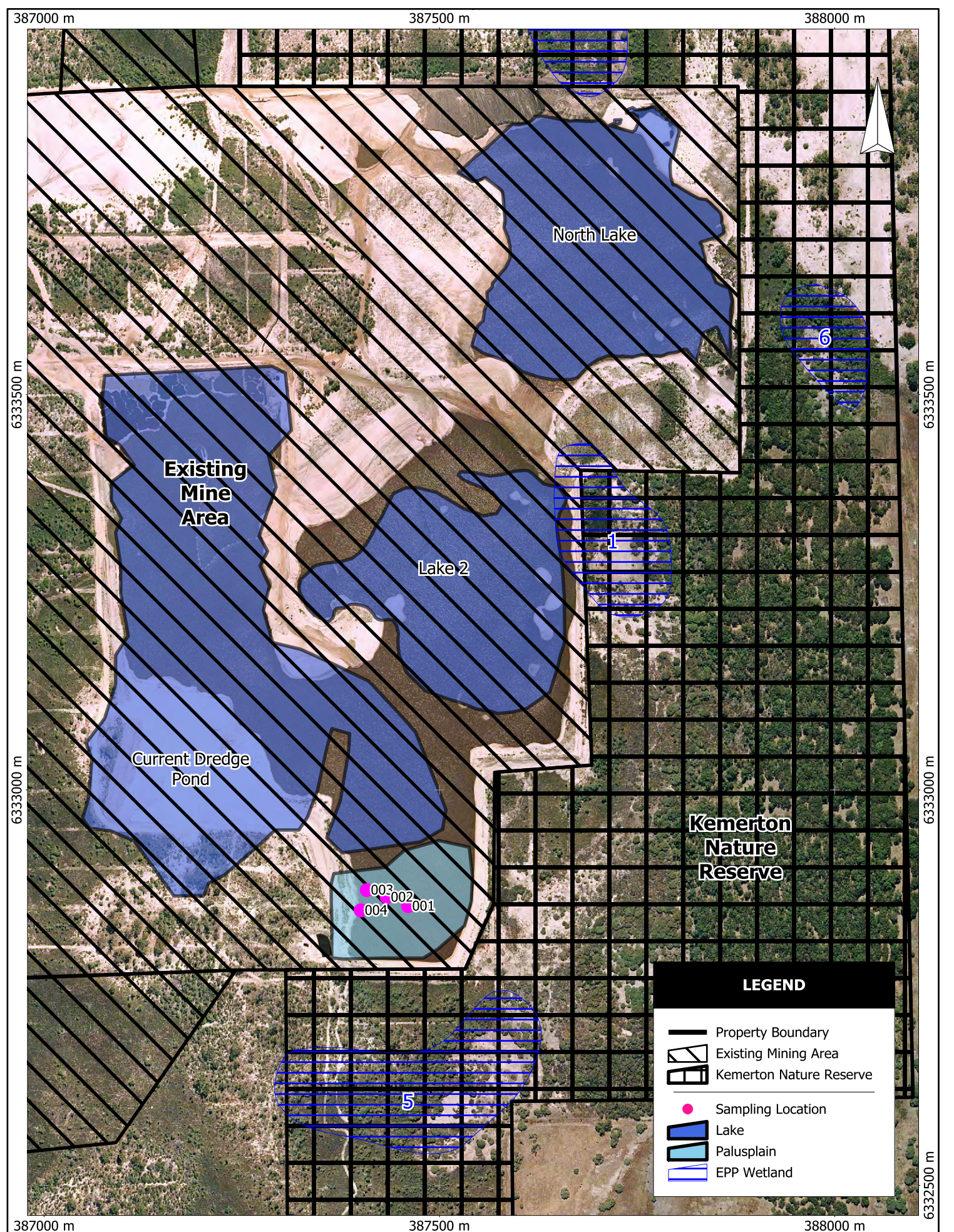
Sampling was conducted in accordance with current DEC guidelines for ASS. All samples were kept in a frozen condition in the period following collection from the field and delivery to the laboratory on 29 December 2008.

Results from the analysis of the <2 millimetre fraction of each sample are presented in Table 9 with a complete report presented in Appendix 2.

Table 9: Results for the Analysis of Four Samples of Soil from KSS

Sample	pH_{KCl}	pH_{ox}	S_p	S_{KCl}	S_{pos}	ANC_e	TAA	TPA
			%	%	%	moles H^+/tonne		
Western Australian Action Criteria					*0.03*			*18*
ASS 001	6.4	6.4	<0.01	<0.01	<0.01	<2	<2	<2
ASS 002	6.0	5.6	0.02	<0.01	0.02	<2	8	<2
ASS 003	6.1	3.5	0.01	<0.01	0.01	<2	8	33
ASS 004	5.8	5.2	0.03	0.01	0.02	<2	13	<2

Note: pH_{KCl} = pH of sample in KCl solution.
pH_{ox} = pH of sample in KCl solution following treatment with hydrogen peroxide.
S_p = Soluble sulfur in solution following treatment with hydrogen peroxide.
S_{KCl} = Soluble sulfur in KCl solution of the untreated sample.
S_{pos} = Peroxide oxidisable sulfur.
ANC_e = Excess Acid Neutralisation Capacity.
TAA = Titratable Actual Acidity.
TPA = Titratable Peroxide Acidity.



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Scale: 1:6000
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Grid: Australia MGA94 (50)
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Targeted Survey Acid Sulfate Soil Sampling Locations

Figure 8

W:\Kemerton Silica Sand\Drawings\Maps 2009\ASS.map 15/10/2009 Acid Sulfate Soils Survey 2008 Layout

The Titratable Actual Acidity and Excess Acid Neutralisation Capacity values recorded for all samples are typical of natural Bassendean sands.

Three of the four samples tested contain insignificant amounts of ASS materials. The other sample (ASS 003) was reported with value for Titratable Peroxide Acidity that exceeded the Action Criteria for sands (18 mole H^+ per tonne), despite containing only trace amounts of pyritic material. It was noted that the reported value of 33 mole H^+ per tonne was obtained in only one of five replicate determinations, with the results for the other four determinations being <2 mole H^+ per tonne. The laboratory report described unusual behaviour of this particular sample during the assay in that the pH of the test solutions increased significantly upon destruction of excess hydrogen peroxide. A possible explanation for this behaviour is that this acidity results from oxidation of reduced ferrous ion (Fe^{2+}) associated with humic organic matter and not iron sulfide minerals. This is presented in more detail in Appendix 2.

It is considered extremely unlikely that significant amounts of acidity will be generated by disturbance of this soil. In terms of ASS management of these soil samples, no specific management protocols are required, although an ASS Management Plan has been prepared for any future ASS issues that may arise.

4.4 SURFACE HYDROLOGY

Wellesley River to the east of the KSS property is the major surface drainage feature. The eastern part of the property is low lying and wetlands have formed in slight depressions. The western portion of the property has a slightly higher elevation, but also drains towards the river. The Wellesley River flows towards the south-west and ultimately into Leschenault Estuary.

Surface water occurs on the property in the form of ephemeral wetlands. Nine wetlands are gazetted under the *EPP 1992*. Six of these gazetted wetlands have been transferred from KSS ownership to DEC as part of an offset for project approval. Wetlands are addressed in more detail in Section 4.9.

In an effort to improve agricultural productivity, previous landowners have attempted to drain parts of the property, however the water table remains less than a metre below the surface. During winter, the water table is sometimes above the surface in broad depressions and wetlands.

4.5 GROUNDWATER

4.5.1 Local Hydrogeology

GHD (2002) undertook a hydrological review of the proposed mine extension area. The review identified that the KSS property occurs within the Perth Basin and is underlain by superficial sediments that rest unconformably on the Leederville formation at a depth of approximately 30 metres. The Leederville formation is approximately 120 metres thick beneath the site and rests unconformably on the Cockleshell gully formation. The superficial sediments contain an unconfined to confined aquifer system, termed superficial aquifer, which

extends between the Darling scarp and the coast. The superficial aquifer has variable hydraulic connection with the underlying Leederville aquifer, depending on permeability of the sediments.

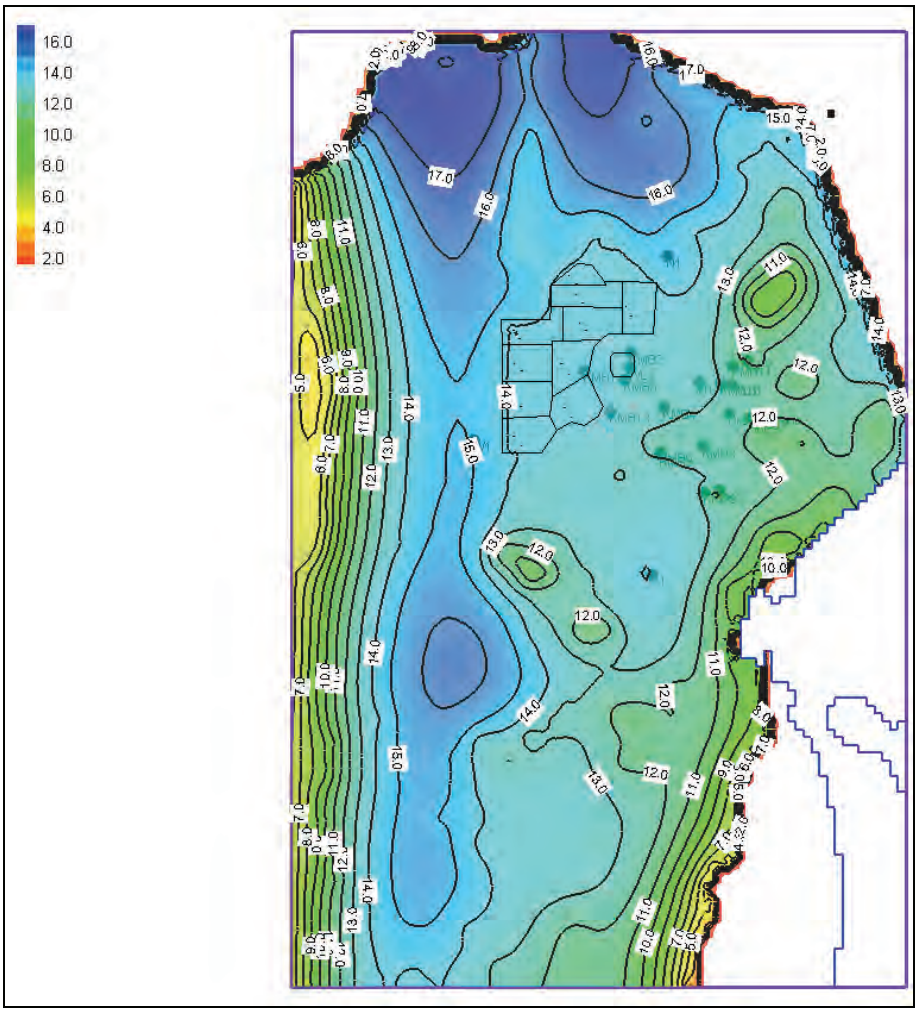
The KSS property is within the Serpentine groundwater flow system near the crest of the Mialla mound approximately 300 metres west of the proposed mine extension area as shown in Figure 9. Recharge to the aquifer system is by direct infiltration of rainfall, particularly in winter and spring when rainfall is more intense. In areas of the KSS property with higher elevations, the water table occurs at depths of more than 10 metres while in the lower areas it may intersect the surface seasonally (GHD, 2002).

The water table fluctuates seasonally by approximately two metres in response to seasonal variations in groundwater recharge. Groundwater flow from the Mialla mound is constrained by hydraulic barriers formed by Harvey River to the north, the coast to the west, Leschenault inlet to the south and Wellesley River to the east. Groundwater flow on the eastern side of the mound (where mining is planned) is predicted to be to the east to south-east towards the Wellesley River. West of the planned mine extension area, flow direction changes so that groundwater flows to the west (Bishnu Gautam (GHD) (2008) pers. comm.). Groundwater discharge occurs by evapo-transpiration from wetlands and by discharge to the river. Some leakage occurs to the Leederville aquifer at the base of the superficial aquifer.

4.5.2 Groundwater Levels

Groundwater monitoring within the KSS property has been undertaken for over 10 years as part of existing operations. Groundwater levels in monitoring bores within the KSS property have historically ranged between 10 to 16 mAHD. The data suggest a low hydraulic gradient across the property to the south-east.

Figure 9: Model Predicted Groundwater Levels at the end of Mining



4.5.3 Groundwater Quality

Groundwater monitoring within the KSS property has been undertaken for over 10 years as part of existing operations. The Rockwater (2008) triennial monitoring report provides an assessment of data and trends on the KSS property from 2005 to 2008. Rockwater (2008) found that groundwater chemical characteristics are highly variable across the KSS property (Appendix 3).

Monthly data were collected over the review period from monitoring bores KMB1, KMB2, KMB4, KMB6, KMB8, KMB10, KMB11, KMB12 and KMB13. Total dissolved solids (TDS) ranged between 50 milligrams per litre (KMB11 in December 2005) and 670 milligrams per litre (KMB4 in February 2006 and KMB12 in May 2007), but for the most part were between 150 and 600 milligrams per litre (Rockwater, 2008). The values are generally below the drinking-water guideline of 500 milligrams per litre (ANZMEC/MCA, 2000).

Groundwater in monitoring bores was acidic to slightly alkaline during the review period, with pH values ranging from 3.2 (KMB6 in December 2007) to 8.6 (KMB4 in October 2005) (Rockwater, 2008). Acidic groundwater pH values recorded for some bores may be a result of oxidation of sulfides and organic material in wetland deposits, affecting down-gradient water quality. High pH values have been recorded previously for KMB4 (2001 – 2004), but the pH

recorded throughout the current review period was neutral. KSS has previously investigated potential causes for these high values and found no evidence to suggest they were influence by their operations. Chemical analyses of groundwater from monitoring bores for various other analytes during the review period revealed no anomalous results. Results for other analytes are within drinking water guidelines, but are also variable.

The Rockwater (2008) report states that groundwater quality results from the monitoring bores fall within historical ranges that could be expected for groundwater from local bores in a similar hydrogeological environment. A comprehensive review of groundwater quality in superficial aquifers of the Swan Coastal Plain between Pinjarra and Bunbury has been reported by Deeney (1989). pH values for groundwater in the Harvey region were found to be variable, ranging from moderately acidic to slightly alkaline. Deeper bores usually recorded neutral to alkaline pH values, especially when alkaline aquifers such as Tamala Limestone or the Ascot Beds were intersected. Kemerton groundwater quality is similar to that recorded in shallow bores located in neutral to acidic sands of the Bassendean soil system.

4.6 VEGETATION AND FLORA

4.6.1 Regional Vegetation Description

Landforms, soils and vegetation of the Swan Coastal Plain have been mapped as landscape units by Churchward and McArthur (1980), vegetation complexes by Heddle *et al.* (1980) and most recently as soil-landscape mapping by Barnesby and Proulx-Nixon (2000). There are strong relationships between landforms, soil types and vegetation.

The KSS property is located within the South Western Botanical Province of Western Australia, in the Darling Botanical District and the Swan Coastal Plain subregion of the Drummond Botanical subdistrict (Diels 1906, Beard 1990). Flora and vegetation of the area has been defined by Beard (1981), Smith (1974) and Heddle *et al.* (1980) at a regional scale.

Regional mapping undertaken by Heddle *et al*. (1980) identified that the majority of the vegetation retained on the KSS property occurs within the Bassendean - Central and South vegetation complex. Vegetation ranges from woodlands of *Eucalyptus marginata* subsp. *marginata* - *Allocasuarina fraseriana* - *Banksia* spp. to low woodlands of *Melaleuca* spp. and sedgelands on the low-lying depressions and swamps. *Banksia attenuata, B. grandis* and *B. menziesii* are common on upper slopes. *B. ilicifolia, B. littoralis* and *Melaleuca preissiana* are common tree species on low lying moisture sites (Heddle *et al.* 1980).

The KSS property abuts the Karrakatta - Central and South vegetation complex to the west of the property (Mattiske, 2003b). The Serpentine River complex occurs in the north-eastern corner of the property, now part of the Kemerton Nature Reserve (Heddle *et al*. 1980). This area has been cleared and previously used as grazed pasture land.

4.6.2 Regional Vegetation Coverage

The Bassendean - Central and South Vegetation complex is the dominant vegetation complex of the KSS property. EPA (2003b) indicates that the total remaining area of vegetation of

Bassendean - Central and South vegetation complex was 27% of the entire Swan Coastal Plain or 39.3% of the Greater Bunbury Region (Appendix 3 and Table 10).

Table 10: Vegetation Remaining on the Swan Coastal Plain and Greater Bunbury Region

Vegetation Complex	Original Area (ha)	Total Area Remaining SCP (ha)	Remaining on SCP (%)	Original Area (ha)	Total Area Remaining in GBR (ha)	Remaining in GBR (%)
Bassendean Complex - Central and South	87,626	23,635	27	23,970	9,430	39.3

Source: EPA (2003b) Bulletin 1108, Appendix 3 Table 4.

The vegetation community types occurring in the Bassendean system are of Super Group 3, including community types 20, 21, 22 and 23 (Gibson *et al.* 1994). Community type 21 is the most likely to occur in the Kemerton region. This community type is divided into three subgroups of which 21b and 21c are more likely to occur at Kemerton:

- **Community 21(a):** This community is primarily *Eucalyptus marginata - Banksia attenuata* woodland, *E. marginata - Corymbia calophylla - B. attenuata* woodland or *B. attenuata* woodland. This sub-community differs from the other two sub-communities by the presence of taxa such as *Sowerbaea laxiflora, Drosera pallida, Leucopogon propinquus* and *Isotropis cuneifolia. Allocasuarina fraseriana* and *Eucalyptus gomphocephala* are also sometimes present.
- **Community 21(b**): Structurally this community is naturally *B. attenuata* or *E. marginata - B. attenuata* woodlands. It is also likely to contain *Acacia extensa, Jacksonia horrida, Laxmannia sessiliflora, Lysinema ciliatum* and *Johnsonia acaulis.*
- **Community 21(c):** This community occupies the low lying wetter sites and is variously dominated by *Melaleuca preissiana, B. attenuata, B. menziesii, Regelia ciliata* and *E. marginata* or *Corymbia calophylla.* Structurally this community type may be either woodland or occasionally shrubland.

In addition to these vegetation communities which provide the broad vegetation structure, a number of wetland communities also occur within the KSS property. According to Gibson *et al.* (1994) these belong to Super Group 2 and include community types 4, 12 and 13.

4.6.3 Flora and Vegetation Surveys

Detailed recordings of vascular plant species have been made during numerous botanical surveys undertaken on the KSS property. Nine baseline botanical studies have been undertaken for KSS on the property area since 1993. Further studies have also been undertaken for other regional projects (Woodman, 2005a) in addition to several rehabilitation studies as detailed in Section 9.7:

1. E.M. Mattiske & Associates (Mattiske), 1993a. Gwalia Consolidated Limited - Kemerton Sand Project. Flora and Vegetation Studies. February 1993 report details December 1992 reconnaissance botanical studies undertaken throughout the entire project area.

2. E.M. Mattiske & Associates (Mattiske), 1993b. Gwalia Consolidated Limited - Kemerton Sand project. Flora and Vegetation Report. June 1993 report details April 1993 vegetation mapping in the project area.

3. E.M. Mattiske & Associates (Mattiske), 1993c. Gwalia Consolidated Limited - Kemerton Sand Project. Updated Flora and Vegetation Report. November 1993 report reviews and supplements flora and vegetation within operational areas undertaken in October 1993.

4. E.M. Mattiske & Associates (Mattiske), 1993d. Gwalia Consolidated Limited - Kemerton Sand Project. Vegetation Mapping of Proposed Transport Corridor. November 1993 report details vegetation and flora studies and mapping undertaken in a 50 metre wide strip along the proposed transport route during October 1993.

5. B. Keighery, 1998. Vegetation and Flora Conservation Values of the Kemerton Silica Sand Project Area. 1998 report for the Department of Environmental Protection.

6. Muir Environmental, 1999. Report of Biological Survey - Phase 1: Kemerton Industrial Estate. 1999 report detailing October to November 1998 biological surveys of Kemerton Industrial Estate.

7. Mattiske Consulting Pty Ltd (Mattiske), 2002c. Kemerton Sand Project Flora and Vegetation. April 2002 report providing an updated summary of previous botanical studies within the Kemerton project area.

8. Mattiske Consulting Pty Ltd (Mattiske), 2003b. Kemerton Silica Sand Review of Flora, Vegetation and Conservation Values on Kemerton Project Area. May 2003 report providing an updated summary of previous botanical studies within the Kemerton project area.

9. Bennett Environmental Consulting Pty Ltd (Bennett), 2004. Kemerton Significant Flora and Wetlands. March 2004 report on the Declared Rare and Priority Flora and wetland assessment at the KSS site.

10. Woodman Environmental Consulting Pty Ltd (Woodman), 2005a. Kemerton Lateral Pipeline: Flora, Vegetation, and *Phytophthora Cinnamomi* Assessment. Unpublished report for Ecos Consulting (Aust) Pty Ltd.

11. Mattiske Consulting Pty Ltd (Mattiske), 2009. Updated Review of Vegetation Communities - Kemerton Silica Sand Pty Ltd. Unpublished memo for Kemerton Silica Sand Pty Ltd, February 2009.

The most comprehensive field studies for the KSS property were undertaken by Mattiske between 1993 and 2003. These have been collated into one report Mattiske (2003b) *Kemerton Silica Sand Review of Flora, Vegetation and Conservation Values on Kemerton Project Area* providing an updated summary of previous botanical studies within the Kemerton property (Appendix 4). The initial main survey was undertaken in 1993 by qualified botanists on a grid recording basis. The area was assessed along east-west grid lines spaced 250 metres apart. Regular recordings were taken along these gridlines. The location of the recordings along the gridlines was based on the variation in the communities, but tended to be between 50 metres and 150 metres apart. At each recording site the trees were recorded in a 20 metre radius and understorey in a five metre radius (Mattiske, 2009).

A comprehensive survey for Declared Rare Flora (DRF) and Priority species and wetland classification was undertaken in spring 2003 by Bennett (2004). Field work was undertaken

in three stages from the 22 to 26 September, 15 to 17 October and 3 – 5 November to ensure that all potential DRF and priority flora within the area was located (Appendix 5). A team of three qualified environmentalists walked transects through the area at 100 metre intervals (Appendix 5). Priority and DRF species found were lodged at the Western Australian Herbarium. Vegetation units of wetlands were recorded as transects were traversed, dominant species of each stratum within the different vegetation units was recorded, together with the presence of standing water and the wetland as a whole was described (Bennett, 2004).

Flora and vegetation surveys were conducted prior to the development of the EPA Guidance Statement; "Guidance for the Assessment of Environmental Factors No. 51 - Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia" (EPA, 2004a). To summarise methods of the Mattiske (1993b, c) reports, a reconnaissance and detailed recording of vascular plant species was undertaken during April 1993 and additional opportunistic collecting of annuals and other species was undertaken in October 1993. The methods also state that the field program involved complete and thorough coverage of the survey area, where "regular recordings were taken at sites within the different communities" (Mattiske, 1993c). Bennett (2004) conducted a thorough survey of the entire KSS property in September, October and November 2003. The surveys focused on DRF and Priority Flora searches in September and October and wetland identification and mapping in November (Bennett, 2004). These report methods are consistent with requirements for a Level 2 survey according to the EPA Guidance Statement 51 (EPA, 2004a).

KSS commissioned Mattiske in December 2008 to undertake a desktop review and update the vegetation communities at KSS in relation to Swan Coastal Plain dataset (Gibson *et al.* 1994) (Appendix 6). A series of analyses were undertaken utilising the Sorenson's Similarity Index (SSI) and PATN clustering analysis (Austin and Belbin 1982; Belbin 1995). The SSI is based on qualitative (presence/absence) data:

$$ISs = \frac{2a}{2a + b + c}$$

Where:

a = number of species common to both sites
b = number of species found in the first site only
c = number of species found in the second site only

The species by site data was analysed utilising the association measures (Austin and Belbin 1982; Belbin, 1995) and flexible UPGMA technique with the PATN program (Blatant Fabrications Pty Ltd 2006). The PATN clustering analysis (Belbin 1995) was used on all species by sites and native species by sites:

$$D = [D_{ik} - D_{jk}] / \{D_{ik} + D_{jk}\}$$

In addition to these surveys, other surveys on flora, fauna and environmental factors have been undertaken by parties for separate projects, within and adjacent to the KSS property. Projects for gas pipelines and a power station in and adjacent to the KSS property have undertaken a range of surveys for environmental assessments for their respective projects.

Other project assessments with surveys relevant to this proposal include:

- Kemerton power station. EPA Bulletin 1121 and Ministerial statement 645.

• Kemerton lateral gas pipeline.	EPA Bulletin 1204 and Ministerial statement 704.
• Kemerton power station enhancement project.	EPA Bulletin 1258 and Ministerial statement 745.

The location of conservation significant vegetation in the KSS property is shown in Figure 10. This comprises:

- Species of conservation significance (DRF and Priority species).
- Threatened Ecological Communities (TEC).
- Significant communities which have similarities to TEC (See Section 4.6.7).
- Trees with hollows suitable for cockatoos.
- Trees with hollows suitable for other vertebrate fauna.

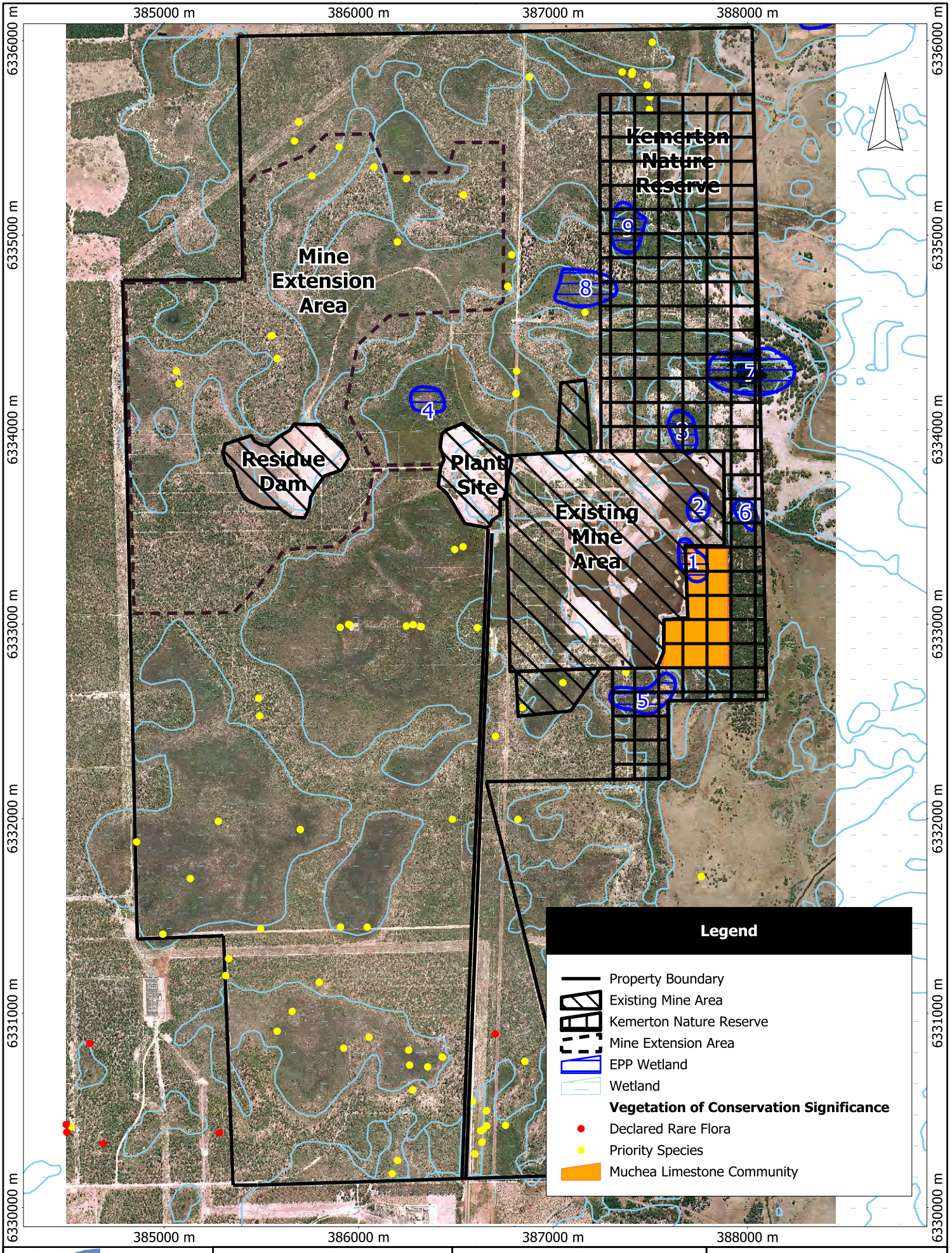
4.6.4 Species of Conservation Significance

Species of flora with conservation significance are defined as Vulnerable, Endangered or Critically Endangered under the *EPBC Act* or Rare or Priority conservation status under the *WC Act*, where their populations are restricted geographically or threatened by local processes.

Threatened species are gazetted under Subsection 18 of Subdivision C of the *EPBC Act* and actions which may or are likely to have a significant impact on listed threatened species or endangered communities are prohibited without approval.

Rare Flora species are gazetted under Subsection 2 of Section 23F of the *WC Act* and therefore it is an offence to remove or damage Rare Flora without ministerial approval. Priority Flora are under consideration for declaration as Rare Flora and are in urgent need of further surveys (P1 to P3) or require monitoring every five to 10 years (P4). DEC recognises these threats of extinction and applies regulations towards population and species protection. Definitions of Declared Rare and the four Priority ratings under the *WC Act* and categories of threatened species under the *EPBC Act* are presented in Table 11.

A search of the *EPBC Act* Protected Matters search tool managed by DEWHA was undertaken on 12 February 2009. Two plant species of conservation significance were identified as potentially occurring in the region surrounding the KSS property, the Critically Endangered *Caladenia procera* and the Vulnerable species *Drakaea micrantha. Caladenia procera* is not within the proposed mine extension area and is found at KSS within the proposed offset area. *Drakaea micrantha* has not been observed during flora surveys at the KSS property.



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Vegetation of
Comservation Significance

Figure 10

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Table 11: Flora Conservation Category Definitions

Conservation Code	Category
Western Australian *WC Act*	
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."
P1	**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. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey."
P2	**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 urgently need further survey."
P3	**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 needs further survey."
P4	**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."
Commonwealth *EPBC Act*	
Extinct	Taxa where there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	Taxa where it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	Taxa that are facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	Taxa which are not critically endangered and is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable	Taxa which are not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	Taxa which are the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) The species is a species of fish. (ii) The species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long-term survival in nature are maximised. (iii) The plan of management is in force under a law of the Commonwealth or of a State or Territory. (iv) Cessation of the plan of management would adversely affect the conservation status of the species.

A search of the DEC's Threatened (Declared Rare) Flora database and the Western Australian Herbarium Specimen database for priority species opportunistically collected in the proposed mine extension area and was conducted in November 2008. The search co-ordinates used

were 33°04' - 33°11' S and 115°43' - 115°50' E (GDA94). Species listed by DEWHA and DEC database searches potentially being present at the KSS property. Other Rare and Priority species listed in previous flora studies at the KSS property are also presented in Table 12. A total of nine DRF, four Priority 1, four Priority 2, 17 Priority 3 and 12 Priority 4 flora species are potentially present in the region surrounding KSS. Of the DRF species, one is Critically Endangered, six are Endangered and three are Vulnerable. *Centrolepis caespitosa* is also listed as Endangered under the *EPBC Act*, but as Priority 4 under the *WC Act*, possibly indicating that taxonomic revision of this species is required or in process.

Table 12: Flora Species of Conservation Significance Potentially Within the KSS Property and Surrounding Region

Species	EPBC Act	WC Act	Potentially present at KSS	Confirmed Present at KSS	Confirmed Present within Mine Extension Area
Caladenia procera	Critically Endangered	DRF	✓	✓	x
Caladenia huegelii	Endangered	DRF	✓	x	x
Centrolepis caespitosa	Endangered	P4	✓	x	x
*Conostylis micrantha**	Endangered	DRF	X	x	x
Diuris purdiei	Endangered	DRF	✓	x	x
Drakaea elastica	Endangered	DRF	✓	x	x
Trithuria occidentalis	Endangered	DRF	✓	x	x
Diuris micrantha	Vulnerable	DRF	✓	x	x
Drakaea micrantha	Vulnerable	DRF	✓	x	x
Diuris drummondii	Vulnerable	DRF	✓	x	x
Boronia juncea subsp. *juncea*		P1	✓	✓	✓
Caladenia uliginosa subsp. *juncea*		P1	✓	x	x
Carex tereticaulis		P1	✓	x	x
Stylidium korijekup		P1	✓	x	x
Boronia capitata subsp. *gracilis*		P2	✓	✓	x
Haloragis aculeolata		P2	✓	x	x
Pterostylis frenchii [#]		P2	✓	x	x
Schoenus capillifolius		P2	✓	x	x
Acacia semitrullata		P3	✓	✓	✓
Aotus cordifolia		P3	✓	x	x
Chamaescilla gibsonii		P3	✓	x	x
Cyathochaeta stipoides		P3	✓	✓	x
Cyathochaeta teretifolia		P3	✓	x	x
Dillwynia dillwynioides		P3	✓	✓	✓
Goodenia filiformis [+]		P3	✓	✓	✓
Grevillea prominens		P3	✓	x	x
Hemigenia microphylla		P3	✓	x	x

Species	EPBC Act	WC Act	Potentially present at KSS	Confirmed Present at KSS	Confirmed Present within Mine Extension Area
Hibbertia spicata subsp. *leptotheca*		P3	✓	x	x
Lasiopetalum membranaceum		P3	✓	x	x
Meionectes tenuifolia		P3	✓	x	x
Myriophyllum echinatum		P3	✓	x	x
Rhodanthe pyrethrum		P3	✓	x	x
Schoenus sp. *Waroona* (GJ Keighery 12235) (pn)		P3	✓	x	x
Stylidium trudgenii		P3	✓	x	x
Verticordia attenuata		P3	✓	x	x
Acacia flagelliformis		P4	✓	✓	x
Anthotium junciforme		P4	✓	x	x
Caladenia longicauda subsp. *clivicola*		P4	✓	x	x
Caladenia speciosa		P4	✓	✓	✓
Conostylis pauciflora subsp. *pauciflora*		P4	✓	x	x
Drosera occidentalis subsp. *occidentalis*^		P4	✓	x	x
Eucalyptus rudis subsp. cratyantha		P4	✓	✓	✓
Hemigenia platyphylla		P4	✓	x	x
Pultenaea skinneri		P4	✓	x	x
Senecio leucoglossus		P4	✓	x	x
Verticordia aurea		P4	✓	x	x

Note: * Likely to have been mis-identified as this species is restricted to the northern sandplains around Geraldton. More likely to have been *Conostylis juncea* (See Bennett, 2004).

\+ Previously recorded as being present. Recently taxonomic division suggests that it is likely to be *Goodenia pulchella* subsp. Coastal Plain B (L. W. Sage 2336) which is not a Priority species (See Bennett, 2004).

Species was *Oligochaetochilus sp.* Yalgorup (G Brockman GBB463) (pn) but is now formally named as *Pterostylis frenchii.*

In addition to these, the Ecological Services Branch of the DEC (Keighery, 1998) suggests that other species noted as uncommon and restricted on the Swan Coastal Plain or at the southern limits of their range may occur within the KSS property. These species are associated with the Muchea Limestone TEC (Keighery and Keighery, 2003). They are:

- An unusual form of *Melaleuca systena* growing to over two metres (possibly an unnamed species of *Melaleuca* in Mattiske 1993b).
- A robust, tall form of *Melaleuca bracteosa* (referred to as *M. brachyphylla* in Keighery, 1998) an uncommon species on the Swan Coastal Plain (possibly an unnamed species of *Melaleuca* in Mattiske 1993b).

- *Hakea trifurcata,* small flowered form previously only known in the Peel-Harvey region.
- *Hibbertia perfoliata,* an uncommon poorly collected species on the Swan Coastal Plain.

Keighery (1998) reports that *Eucalyptus decipiens, Pimelea rosea, Austrostipa falseness, Gahnia trifida* and *Logania vaginalis* were species characteristic of the Muchea Limestone in the Kemerton Nature Reserve, however these were not included in the Interim Recovery Plan in 2000. Furthermore, only *Gahnia trifida* and *Logania vaginalis* were recorded with community D2. Keighery (1998) claims that *Melaleuca acerosa* [*Melaleuca systena*] or *M. brachyphylla* [not on DEC Florabase] are possibly an unnamed species of *Melaleuca* in Mattiske (1993b); however neither of these unidentified species was recorded in D2 or F1 or F3. Whilst it is clear that there are a suite of unusual and significant species in the Kemerton area, these are associated with the Muchea limestone TEC in Kemerton Nature Reserve and outside of the mine extension area.

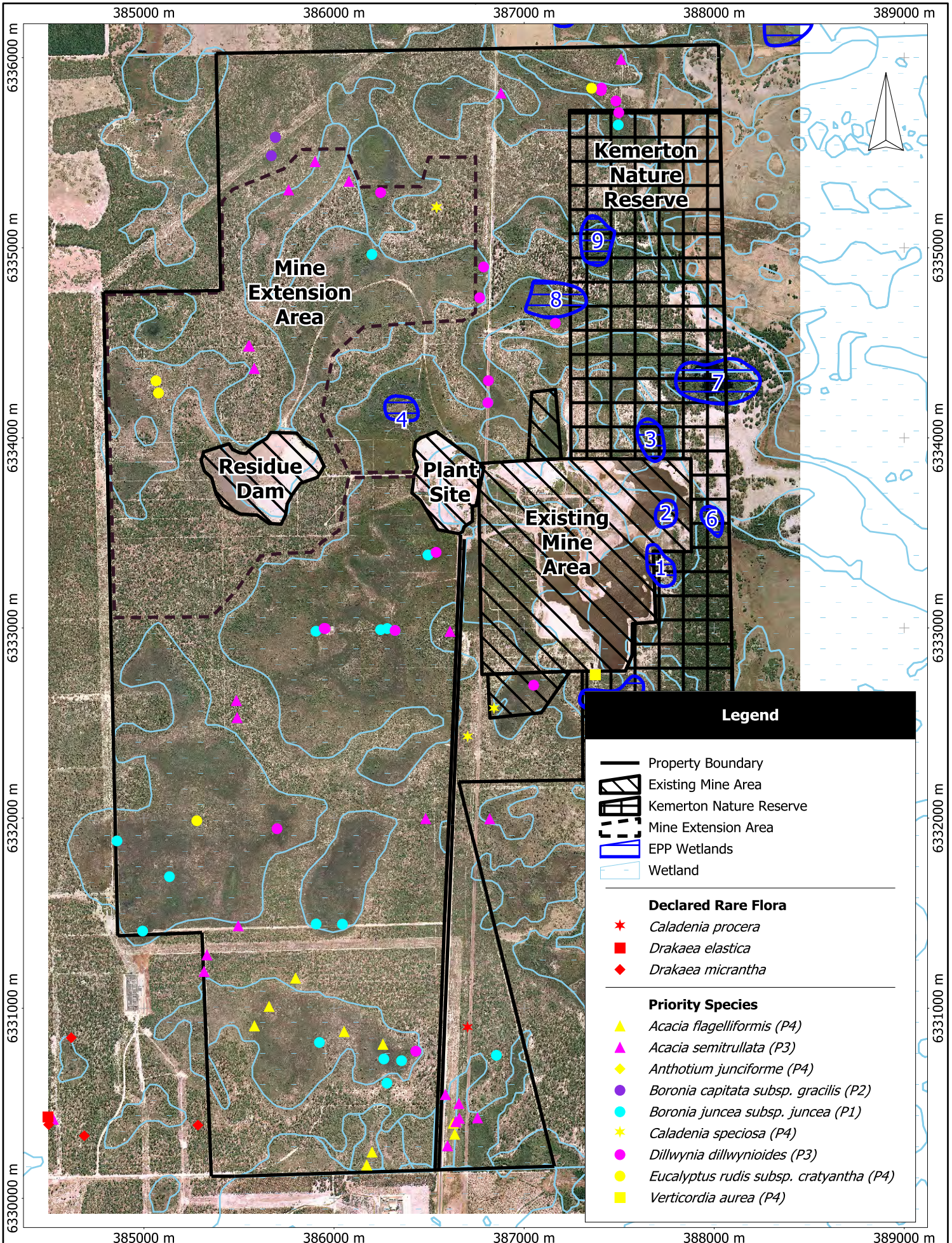
4.6.4.1 Flora of Conservation Significance in the Mine Extension Area

Six flora species of conservation significance are found within the mine extension area: *Boronia juncea* subsp. *juncea* (P1), *Acacia semitrullata* (P3), *Dillwynia dillwynioides* (P3), *Goodenia filiformis* (P3), *Caladenia speciosa* (P4), *Eucalyptus rudis* subsp. *cratyantha* (P4).

Boronia juncea subsp. *juncea* (P1) occurs in low scrub in sand between Bunbury and Mandurah, flowering in April (Mattiske, 2003b). Mattiske (1993c) located four populations in excess of 50 plants, and two of less than three plants in communities H1, H2, F1 (and abutting F1, F3, H1 and H2). In the September 2003 survey, Bennett (2004) found the species to be common throughout many wetlands where standing water was present. Around 100 individuals of this species was recorded at Map Grid of Australia (MGA) 50 6334965 N 386199 E in the proposed mine extension area (Bennett, 2004). *Boronia juncea* subsp. *juncea* (P1) has been recorded at 27 other locations across the KSS property. This species is relatively common throughout the region (Bennett, 2004, Appendix B).

Acacia semitrullata (P3) has been found in wetland areas and sandplains in white/grey sand. The flowering period is June to August. Mattiske (2003b) recorded this species throughout the KSS property. Muir Environmental (Muir) (1999) recorded populations along swamp fringes and damplands. During the Bennett (2004) survey, *Acacia semitrullata* (P3) was found to be very common throughout damp and slightly higher ground within the KSS property. It also occurs as scattered plants throughout the KSS property. This species has been recorded in four locations in the mine extension area. Fifty-five individuals of *Acacia semitrullata* (P3) from four locations (Figure 11) will be removed through progressive mining at KSS. *Acacia semitrullata* (P3) is very common throughout the KSS property, including good populations in the proposed offset areas.

Dillwynia dillwynioides (P3) was located by Bennett (2004) in areas that were currently or recently in standing water. Around 10 individuals of *Dillwynia dillwynioides* (P3) occur at one site in the proposed mine extension area (Appendix 5, Figure 11). *Dillwynia dillwynioides* (P3) is common throughout wetlands on the KSS property with a further 22 sites recorded with many sites with good populations in excess of 20 individuals (Bennett, 2004).



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Scale: 1:25000
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Distribution of Flora Species of Conservation Significance

Figure 11

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Goodenia filiformis (P3) was located by Mattiske (1993b, c) within the KSS property, however, this taxon may not occur in the area due to taxonomic changes since work has been undertaken (Bennett, 2004). It was not recorded during the 2003 surveys by Bennett (2004). *Goodenia filiformis* (P3) is only found near Albany (Bennett, 2004). The species located by Mattiske (1993b, c) within the KSS property is likely to be *Goodenia pulchella* subsp. Coastal Plain B (L.W. Sage 2336) and is not a Priority species (L. Sage, pers. comm. in Bennett, 2004).

Caladenia speciosa (P4) (Sandplain White Spider orchid) inhabits Eucalypt and *Banksia* woodlands in the uplands above paperbark swamps on white, grey or black sand (Mattiske, 2003b). The flowering period is September to October. Mattiske (1993c) recorded this species within the KSS property. *Caladenia speciosa* (P4) was recorded from two sites during the 2003 surveys. One individual of this species was recorded in the proposed mine extension area (Figure 11). A further two individuals were located in the central eastern part of the property (Figure 11, Bennett, 2004).

Eucalyptus rudis subsp. *cratyantha* (P4) was located by Bennett (2004). Often this species occurs as an individual tree, but it was also found in a few locations where it was the dominant tree in the upper storey, particularly in the northern section east of the limestone track (Figure 11). This species has been recorded in two locations in the proposed mine extension area with 10 and 11 individuals recorded at these sites (Bennett, 2004, Appendix B, Figure 11). A further two locations of *Eucalyptus rudis* subsp. *cratyantha* (P4) are recorded outside the proposed mine extension area with 10 and 15 species at these sites.

4.6.4.2 Flora of Conservation Significance Outside of the Mine Extension Area

A further four flora species of conservation significance have been recorded within the KSS property but are not known to occur in the mine extension area. These are *Caladenia procera* (DRF, Critically Endangered), *Boronia capitat*a subsp. *gracilis* (P2), *Cyathochaeta stipoides* (P3) and *Acacia flagelliformis* (P4).

Caladenia procera (DRF) Carbunup King Spider orchid was located just off the proposed natural gas pipeline corridor from Dampier to Bunbury corridor within the south-eastern corner of the KSS property (Woodman, 2005a) (Figure 11). This location has been removed from the proposed mine extension area and will not be disturbed. The location is further discussed in Section 10.

*Boronia capitat*a subsp. *gracilis* (P2) inhabits winter wet swamps and hillsides in white/grey or black sand between Yarloop and Yallingup (Mattiske, 2003b). Mattiske (2003b) recorded this species once on the KSS property in 1993. Bennett (2004) recorded *Boronia capitata* subsp. *gracilis* (P2) along the south-west/north-east power line track in the northern area of the property. There were hundreds of plants in the area, which had recently been disturbed for power line access. The site where Mattiske (2003b) recorded the species was thoroughly searched, but *Boronia capitata* subsp. *gracilis* (P2) was not recorded at this location by Bennett (2004). This plant appears to be a disturbance specialist and it is possible that if the area was disturbed again the plant would return (Bennett, 2004). The species has not been found in the mine extension area.

Cyathochaeta stipoides (P3) was found in wetland adjacent to the north margin of the dredge pond by Keighery (1998). Bennett (2004) was unable to relocate this species and believe it is likely restricted to the area of Muchea limestone.

Acacia flagelliformis (P4) inhabits sandy soils in winter wet areas, flowering between July and September. Mattiske (1993a, b, c, d) recorded this species twice within the KSS property. It was also recorded in Kemerton industrial park by Muir (1999) in a post-fire dampland complex of *Melaleuca pressiana, Calothamnus lateralis* and *Hakea varia*. Muir (1999) considers that other damplands are likely to contain dormant seeds of this species. During the Mattiske (2003b) surveys, *Acacia flagelliformis* (P4) was recorded as reasonably common in the southern section of the KSS property, only being recorded in the wetland to the south of the powerline track on both the east and west sides of the KSS site access road. The species has not been found in the mine extension area.

Species not of conservation significance, but of interest due to their presence at the KSS property and region include:

- *Banksia menziesii* (southern extension). One plant was observed just outside the area surveyed to the east of the fence line, south of the powerline track by Bennett (2004). Mattiske (2003b) observed *Banksia menziesii* in community A3 and G1. The closest known population occurs in the Peel area (Mattiske, 2003b).
- *Verticordia nitens* (southern extension) is common north of Perth but only know from two other areas south of Perth (Mattiske, 2003b). *Verticordia nitens* (southern extension) was recorded to the east of the access road and to the south of where mining is currently occurring by Bennett (2004). Mattiske (2003b) located *Verticordia nitens* in community A3. Bennett (2004) reports that it is likely that *Verticordia nitens* may be associated with the limestone (Muchea Limestone TEC) which occurs in this area as it was not recorded in other areas of the KSS property.
- *Evandra pauciflora* was recorded in many of the wetlands; either as the dominant species or as scattered plants through the wetland (Bennett, 2004). *Evandra pauciflora* is a distinguishing sedge that grows in wetlands in this region and was common in community H1 (Mattiske, 2003b).

Fieldwork undertaken between 22 to 26 September, 15 to 17 October and 3 to 5 November 2003 by Bennett (2004) found that Kemerton Nature Reserve supports species different to those in the remainder of the property. *Gahnia trifida* was recorded in one of the vegetation units at the northern area of the property to the east of the limestone track.

4.6.5 Threatened Ecological Communities and Priority Ecological Communities

A search was undertaken of DEC's Threatened Ecological Communities (TECs) database in November 2008. The search co-ordinates used were 33°04’ - 33°11’ S and 115°43’ - 115°50’ E (GDA94). Two TECs and one PEC occur in the region surrounding KSS:

- Muchea Limestone – Shrublands and woodlands on Muchea Limestone (TEC Endangered).
- Dense shrublands on clay flats (SCP09) (TEC Vulnerable).
- Northern Spearwood shrublands and woodlands (SCP24) (PEC Priority 3).

Muchea Limestone
The Muchea Limestone TEC is listed as Endangered under Western Australian State criteria and Endangered under the *EPBC Act*.

Dense shrublands on clay flats (SCP 9)
This TEC is listed as Vulnerable under the Western Australian State criteria. This TEC is located to the northeast of the property. There are no known occurrences of this TEC on the KSS property.

Northern Spearwood shrublands and woodlands (SCP 24)
This PEC is listed as Priority 3 under Western Australian State criteria. This PEC is characterised by heaths with scattered *Eucalyptus gomphocephala* occurring on deeper soils north of Woodman Point. Most sites occur on the Cottesloe unit of the Spearwood system. The heathlands in this group typically include *Dryandra sessilis, Calothamnus quadrifidus*, and *Schoenus grandiflorus*. There are no known occurrences of this TEC on the KSS property.

4.6.6 Flora

A total of 65 families, 174 genera and 365 plant taxon (including varieties and subspecies) have been recorded on the KSS property (Mattiske, 2003b). Species representation was highest in the Papilionaceae (37 taxon), Myrtaceae (37 taxon), Proteaceae (18 taxon) and Cyperaceae (16 taxon) families. This flora composition is typical of the Bassendean - Central and South vegetation complex described by Heddle *et al.* (1980). Wetland systems were found to be dominated by species from the Restionaceae, Cyperaceae and Myrtaceae families.

4.6.7 Vegetation Communities at KSS

Vegetation within the KSS property was mapped at a detailed level (1:10,000) by Mattiske (1993a, b, c, d). This defined a total of 24 vegetation communities and 27 vegetation mapping units with three of the mapping units comprising disturbed stages of vegetation communities (Mattiske, 2002c). The main communities are:

- Upper slope Open Woodland dominated by *Eucalyptus marginata*, *Banksia* spp. and *Kunzea ericifolia* over *Stirlingia latifolia* and mixed shrubs over *Dasypogon bromelifolius*.
- Lower slope Open Woodland of *E. marginata* - *Banksia* spp. and *Kunzea ericifolia* over *Melaleuca thymoides, Calytrix fraseri* and mixed low shrubs.
- Closed heath of *Astartea scoparia*, *Calothamnus lateralis* and *Cassytha racemosa* over mixed sedges, ranging from partially cleared to relatively pristine. The area also contains wetland vegetation.
- Low closed heath of *Pericalymma ellipticum* and *Hypocalymma angustifolium* over mixed shrubs and mixed sedges, with occasional emergent trees.

The vegetation communities present within the KSS property are presented in Table 13 and shown in Figure 12.

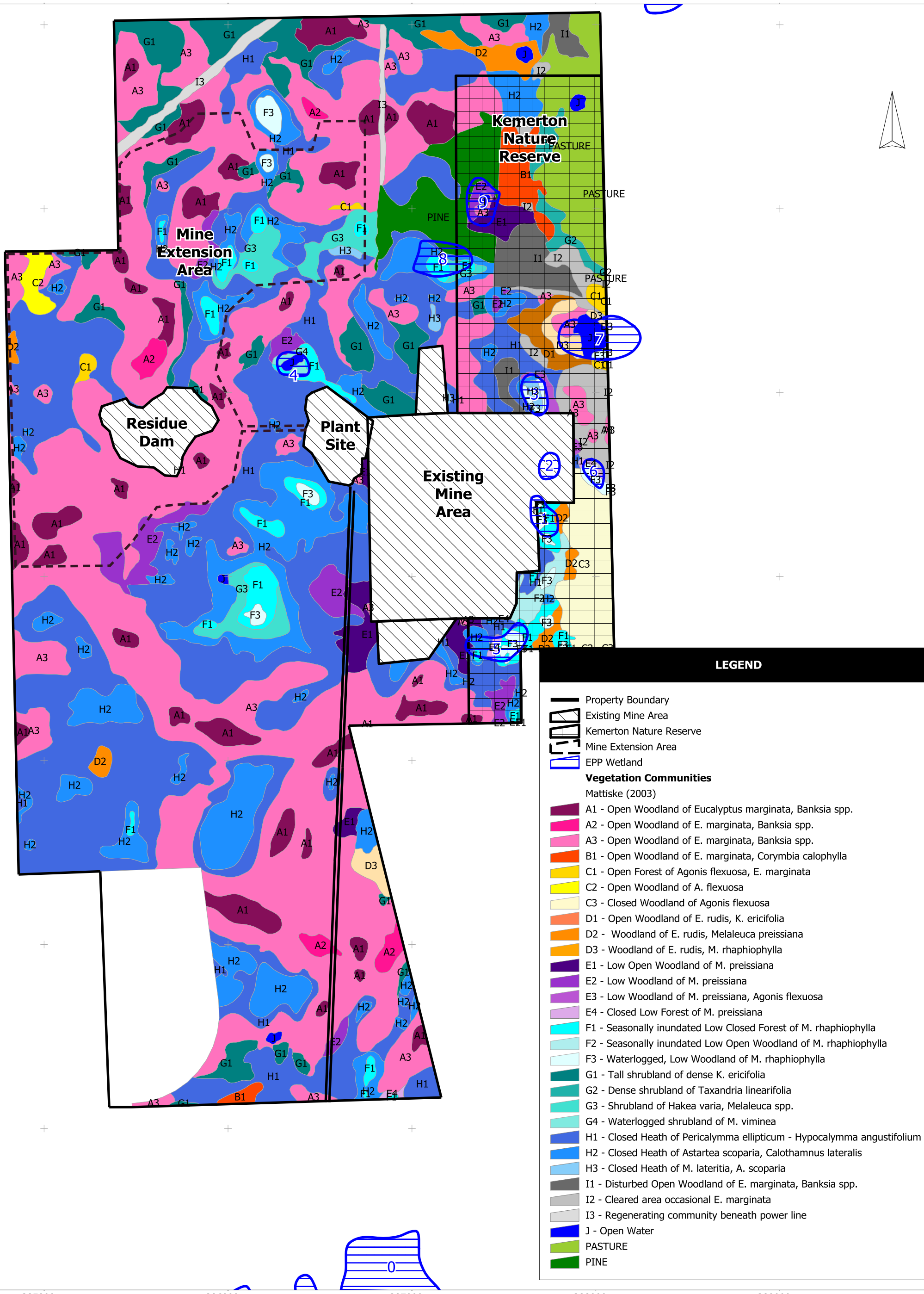
Vegetation communities C3, D1, F2 and G2 located in Kemerton Nature Reserve have not been shown.

Table 13: Description of Vegetation Communities Occurring Within the KSS Property

Community	Description
A	
A - 1	Upper slope Open Woodland dominated by *E. marginata - B. attenuata – B. ilicifolia* and *Kunzea ericifolia* over *Stirlingia latifolia, Calytrix fraseri, Adenanthos meisneri* and mixed shrubs over *Dasypogon bromeliifolius*.
A - 2	Upper slope Open Woodland of *E. marginata - B. attenuata - K. ericifolia* over *Allocasuarina humilis, Stirlingia latifolia* and mixed shrubs.
A - 3	Lower slope Open Woodland of *E. marginata - B. attenuata – B. ilicifolia* and *K. ericifolia* with occasional *Nuytsia floribunda* and *Corymbia calophylla* over *Melaleuca thymoides, Calytrix fraseri, Acacia pulchella* and mixed shrubs.
B	
B - 1	Open Woodland of *E. marginata - Corymbia calophylla* and *K. ericifolia* over *Pericalymma ellipticum* and *Acacia pulchella* over Poaceae spp.
C	
C - 1	Open Forest of *Agonis flexuosa - E. marginata* over grasses.
C - 2	Open Woodland of *Agonis flexuosa* with occasional *B. attenuata, B. ilicifolia* and *Nuytsia floribunda* over mixed shrubs.
C - 3	Closed Woodland of *Agonis flexuosa - Corymbia calophylla - E. rudis* with occasional *B. littoralis*, over *Xanthorrhoea preissii, Macrozamia reidlei* and sparse mixed shrubs and sedges.
D	
D - 1	Open Woodland of *E. rudis* and *K. ericifolia* over *Hypocalymma angustifolium, Xanthorrhoea preissii* and mixed shrubs over mixed grasses and sedges.
D - 2	Woodland of *E. rudis - Melaleuca preissiana* and occasional *B. littoralis* over *Myrtaceae* spp. over mixed sedges.
D - 3	Woodland of *E. rudis - M. rhaphiophylla* over *M. teretifolia* and *Astartea scoparia* over *Lepidosperma longitudinale*.
E	
E - 1	Low Open Woodland of *M. preissiana* and occasional *E. marginata* and *Kunzea ericifolia* over *Hypocalymma angustifolium* and *Calytrix* spp. over *Dasypogon bromeliifolius.*
E - 2	Low Woodland of *M. preissiana* and occasional *Nuytsia floribunda* over *Hypocalymma angustifolium, Pelicalymma ellipticum* and mixed shrubs over mixed sedges.
E - 3	Low Woodland of *M. preissiana* and *Agonis flexuosa* over *Astartea scoparia* and mixed shrubs over *Lepidosperma longitudinale.*
E - 4	Closed Low Forest of *M. preissiana*, with occasional *Corymbia calophylla* over dense *Taxandria linearifolia* over *Pteridium esculentum* and dense *Lepidosperma longitudinale.*
F	
F - 1	Seasonally inundated Low Closed Forest of *M. rhaphiophylla* over *Myrtaceae* spp. over mixed sedges.
F - 2	Seasonally inundated Low Open Woodland of *M. rhaphiophylla* over *M. viminea* and *M. cuticularis* over mixed shrubs over mixed sedges.
F - 3	Waterlogged, Low Woodland of *M. rhaphiophylla* over *Baumea articulata*.
G	
G - 1	Tall shrubland of dense *K. ericifolia* over *Hypocalymma angustifolium* and mixed shrubs over *Meeboldina scariosa*.
G - 2	Dense shrubland of *Taxandria linearifolia*, with occasional *E. marginata* over grasses.

Community	Description
G - 3	Shrubland of *Hakea varia* - *Melaleuca* spp. and *Astartea scoparia* over *Lepidosperma longitudinale* and *Meeboldina coangustata.*
G - 4	Waterlogged shrubland of *M. viminea*.
H	
H - 1	Closed Heath of *Pericalymma ellipticum* - *Hypocalymma angustifolium* shrubs over mixed shrubs over *Meeboldina scariosa*, with occasional emergent *E. marginata, B. attenuata* and *B. ilicifolia*.
H - 2	Closed Heath of *Astartea scoparia – Calothamnus lateralis* and *Cassytha racemosa* over mixed sedges.
H - 3	Closed Heath of *M. lateritia* and *Astartea scoparia* over *Lepidosperma longitudinale* and *Leptocarpus tenax.*
I	
I - 1	Disturbed lower slope Open Woodland of *E. marginata* and *Banksia* spp.
I - 2	Cleared area with occasional *E. marginata* over *Cartonema philydroides*.
I - 3	Regenerating community beneath power line. Sparse *K. ericifolia* over *Aotus gracillima*, *Pimelea angustifolia* and *Pericalymma ellipticum* over mixed sedges.

Further statistical analyses conducted by Mattiske (2009) indicate very low similarities between the communities defined by Mattiske (2003b) and the Swan Costal Plain dataset (Gibson *et al.* 1994) (Table 14, Appendix 6). In the analysis of the native species only, the majority of the Mattiske (2003b) sites did not cluster with the Gibson *et al.* (1994) sites, with the exception of F3 with 14, F2 with 18 and 13 and G4 with 12. In the analysis of all species, C1, C3, D1 and G2 were clustered broadly with 14 and D3 was clustered broadly with 15, 12, 13, 18, 16, 17 and 19. These similarities tend to reflect the presence of species that prefer wetter sites on low lying depressions or swales. Therefore comparisons are based on more subjective interpretations of the dominant species, the general descriptions of the communities and the site/landform considerations (Table 14). This is likely to be due to differences in survey techniques. This more subjective approach leaves interpretation open to mis-leading summaries on relationships.



LEGEND

- Property Boundary
- Existing Mine Area
- Kemerton Nature Reserve
- Mine Extension Area
- EPP Wetland

Vegetation Communities

Mattiske (2003)

- A1 - Open Woodland of Eucalyptus marginata, Banksia spp.
- A2 - Open Woodland of E. marginata, Banksia spp.
- A3 - Open Woodland of E. marginata, Banksia spp.
- B1 - Open Woodland of E. marginata, Corymbia calophylla
- C1 - Open Forest of Agonis flexuosa, E. marginata
- C2 - Open Woodland of A. flexuosa
- C3 - Closed Woodland of Agonis flexuosa
- D1 - Open Woodland of E. rudis, K. ericifolia
- D2 - Woodland of E. rudis, Melaleuca preissiana
- D3 - Woodland of E. rudis, M. rhaphiophylla
- E1 - Low Open Woodland of M. preissiana
- E2 - Low Woodland of M. preissiana
- E3 - Low Woodland of M. preissiana, Agonis flexuosa
- E4 - Closed Low Forest of M. preissiana
- F1 - Seasonally inundated Low Closed Forest of M. rhaphiophylla
- F2 - Seasonally inundated Low Open Woodland of M. rhaphiophylla
- F3 - Waterlogged, Low Woodland of M. rhaphiophylla
- G1 - Tall shrubland of dense K. ericifolia
- G2 - Dense shrubland of Taxandria linearifolia
- G3 - Shrubland of Hakea varia, Melaleuca spp.
- G4 - Waterlogged shrubland of M. viminea
- H1 - Closed Heath of Pericalymma ellipticum - Hypocalymma angustifolium
- H2 - Closed Heath of Astartea scoparia, Calothamnus lateralis
- H3 - Closed Heath of M. lateritia, A. scoparia
- I1 - Disturbed Open Woodland of E. marginata, Banksia spp.
- I2 - Cleared area occasional E. marginata
- I3 - Regenerating community beneath power line
- J - Open Water
- PASTURE
- PINE

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Scale: 1:30,000
Original Size: A3
Grid: Australia GDA94 (50)

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Kemerton Silica Sand Pty Ltd

Vegetation Communities within Kemerton Silica Sand

Figure 12

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Table 14: Comparison of Vegetation Communities at KSS with Gibson *et al.* (1994)

Mattiske Vegetation Community[1]	Comparison with Floristic Community Type[2]			Comments[4]
	Mattiske 2009 Comparison with Gibson[3]	EPASU Comments on Draft PER	TEC/PEC Status	
A1	21a			Some similarity with dominants.
A2	21a			Some similarity with dominants.
A3	21a			Some similarity with dominants.
B1		1b	TEC Vulnerable	Not 1b as 1b on Pinjarra Plain.
C1		21b	PEC - Priority 3	Not 21b as 21b on Ridge Hill and Pinjarra Plain.
C2		21b	PEC - Priority 3	Not 21b as 21b on Ridge Hill and Pinjarra Plain.
C3	11	1b	TEC Vulnerable	Not 1b as 1b on Pinjarra Plain, some overlap with dominants.
D1	11			Some similarity with dominants.
D2	4	Muchea Limestone	TEC Endangered State & Federal	Some similarity with dominants, question over significance.
D3	12			Some similarity with dominants.
E1	4			Some similarity with dominants.
E2	4			Some similarity with dominants.
E3	4			Some similarity with dominants.
E4	4			Some similarity with dominants.
F1	12	Muchea Limestone	TEC Endangered State & Federal	Some similarity with dominants.
F2		7	TEC Vulnerable	7 on Pinjarra Plain, some similarity with dominants.
F3	13	Muchea Limestone	TEC Endangered State & Federal	7 on Pinjarra Plain, 13 due to dominance of Melaleuca.
G1	5/11			Differences based on dominance of shrubs or tree species.
G2	5/11			Differences based on dominance of shrubs or tree species.
G3	5/13			Differences based on dominance of shrubs or tree species.
G4		7	TEC Vulnerable	7 on Pinjarra Plain.
H1	5/11			Differences based on dominance of shrubs or tree species.
H2	5/11			Differences based on dominance of shrubs or tree species.

Mattiske Vegetation Community[1]	Comparison with Floristic Community Type[2]			Comments[4]
	Mattiske 2009 Comparison with Gibson[3]	EPASU Comments on Draft PER	TEC/PEC Status	
H3	5/12			Some similarities with 5 and 12 based on dominants only.
I1	21a	21b	PEC - Priority 3	Disturbed and Degraded 21a, 21b on Ridge Hill/Pinjarra Plain.
I2	21a	21b	PEC - Priority 3	Disturbed and Degraded 21a, 21b on Ridge Hill/Pinjarra Plain.
I3	Disturbed 21a			Disturbed and Degraded.

1 Mattiske (1993a, b, c).
2 Gibson *et al*. (1994).
3 Mattiske (2009).
4 Only low similarities and unclear associations were observed in analyses and therefore there have been variable interpretations on the PEC and TEC's. This largely relates to the reliance on different qualitative measures.

4.6.7.1 Muchea Limestone Threatened Ecological Community (TEC) at KSS

The area of Muchea Limestone TEC within the KSS property was located during a brief field survey by Department of Environmental Protection staff in 1997 (Keighery, 1998). Subsequent work in the area by Muir (1999) and Mattiske (2003b) did not identify any additional areas or extension of the known area.

Keighery and Keighery (2003) visited Kemerton Nature Reserve adjacent to the KSS property in September 2003 to begin detailed documentation of the Muchea Limestone community in this area. The work focused on:

- Estimating the area in which limestone was most apparent in soils.
- Location of a transect of plots to be established in late spring/early summer.

Preliminary mapping of the Muchea Limestone TEC area was determined based on the extent of *Eucalyptus decipiens* and *Corymbia calophylla* dominated native vegetation associated with Muchea Limestone soils with surface or near surface limestone in the KSS property (Keighery, 1998). The Muchea Limestone TEC of Kemerton Nature Reserve is the southern most known location of this community. For this reason, further work was undertaken in October and November 2003 and February 2004.

The known extent of vegetation associated with the Muchea Limestone's soil with surface or near surface limestone in the Kemerton region is located between 387548 E and 6332783 N and 387909 E and 6332783 N (MGA9(50))(Figure 10). Species associated with Muchea Limestone at Kemerton include *Eucalyptus decipiens, Pimelea rosea, Austrostipa flavescens, Gahnia trifida, Verticordia nitens* and *Logania vaginalis* (Keighery and Keighery, 1995). All but one of these species has been identified in the area shown on Figure 10. The uncommon taxa restricted to the Swan Coastal Plain (Keighery and Keighery, 2003) listed in Section 4.6.4 are also found within this TEC at KSS.

Ministerial Statement 703 documented the area of land containing the Muchea Limestone TEC as the subject of a land swap in 2005 which saw 15.6 hectares excised from the approved mine area and added to Kemerton Nature Reserve. Two areas totalling 13.2 hectares were added to the approved mine area to replace this excised portion. Work completed for this Ministerial Statement identified the extent of the communities accepted as being Muchea Limestone (Keighery, 1998).

There has been considerable debate concerning the possible presence of Muchea Limestone in the western area of the property within plant community types D-2, F-1 and F-3. Besides *Eucalyptus decipiens* within community D2, none of the species listed in the Interim Recovery Plan (IRP) for the Muchea Limestone (English and Blyth, 2000) are similar to those listed in any other community at Kemerton (Table 15). Furthermore, according to Keighery (1998) of the species associated with the Muchea Limestone at KSS, only *Gahnia trifida* and *Logania vaginalis* were recorded with community D2. Keighery (1998) claims that *Melaleuca acerosa* [*Melaleuca systena*] or *M. brachyphylla* [not on Florabase] are possibly an unnamed species of *Melaleuca* in Mattiske (1993b); however neither of these unidentified species was recorded in D2 or F1 or F3.

Table 15 Taxa Present in Muchea Limestone TEC and Comparison with KSS Vegetation Communities

Taxa	Muchea Limestone IRP (English and Blyth, 2000)	KSS Muchea Limestone (Keighery, 1998)	Mattiske Vegetation Communities		
			D2	F1	F3
Acacia leptospermoides ssp. *Leptospermoides*	✓				
Allocasuarina lehmanniana	✓				
Alyogyne huegelii var. huegelii	✓				
Apium annuum	✓				
Austrostipa flavescens	✓	✓			
Baeckea robusta	✓				
Boronia juncea subsp. *juncea* (P1)			✓		
Casuarina obesa	✓				
Comesperma integerrimum	✓				
Conostylis candicans	✓				
Darwinia foetida (R)	✓				
Diplopeltis huegelii	✓				
Dodonaea aptera	✓				
Eucalyptus decipiens	✓	✓	✓		
Eucalyptus foecunda	✓				
Exocarpos sparteus	✓				
Gahnia trifida		✓	✓	✓	
Goodenia filiformis (P3)			✓		
Grevillea curviloba subsp. *curviloba* (R)	✓				
Grevillea curviloba subsp. *incurva* (R)	✓				
Grevillea evanescens (P1)	✓				
Hakea trifurcata		✓	✓		
Haloragis aculeolata (P2)	✓				
Hibbertia perfoliata		✓	✓		
Hibbertia spicata subsp. *spicata*	✓				
Lechenaultia linarioides	✓				
Logania vaginalis		✓	✓		
Melaleuca huegelii	✓				
Melaleuca systena	✓	✓			
Pimelea ferruginea	✓				
Pimelea rosa		✓			
Poa ?porphyroclados	✓				
Sencio spanomerus	✓				

Taxa	Muchea Limestone IRP (English and Blyth, 2000)	KSS Muchea Limestone (Keighery, 1998)	Mattiske Vegetation Communities		
			D2	F1	F3
Stylobasium australe	✓				
Thysanotus arenarius	✓				
Wilsonia humilis	✓				

The mine extension area, while containing areas of D2, F1 and F3, does not contain plant associations that define these areas as TEC of Muchea Limestone. *Eucalyptus decipiens* at KSS is restricted to the area defined as Muchea Limestone within the Kemerton Nature Reserve (Libby Mattiske, 2009, *pers. comm*.). Whilst *Eucalyptus decipiens* was only recorded within the Muchea Limestone area within the nature reserve, *Eucalyptus decipiens* is not restricted to limestone and is relatively widespread (Mattiske, 2009). According to the Interim Recovery Plan, the Muchea Limestone TEC "occurs on soils mapped as Muchea Limestone or Plain limestone deposits" (page 3). The ASS investigation of the proposed extension area only located limestone at a depth of 32 metres at Hole 6. All other sites sampled did not indicate the presence of limestone (Appendix 1).

4.6.8 Species Richness

Species richness is defined as a measure of the number of plant species present within a specific area. Species richness of the floristic communities mapped by Mattiske (1993c) is presented in Table 16. As reported in Mattiske (2003a), high species diversity is considered to be 25 to 30 perennial species per 100 square metres. A large portion of vegetation communities recorded on the KSS property are highly diverse, as indicated in Table 14.

4.6.9 Weeds

A total of 58 weed species have been recorded on the KSS property during vegetation surveys. Weed species were most numerous in the Asteraceae (11 taxon), Poaceae (10 taxon) and Papilionaceae (seven taxon) families. The complete list of species identified in the survey is presented in Appendix 4. Weed encroachment into bushland areas has been observed as low with the exception of tracks, and pasture and cleared areas adjacent to farming properties (Mattiske, 2003b).

The most common weed species are annuals or short lived perennials, dominated by *Briza maxima* (Blowfly grass), *Briza minor* (Shivery grass), *Hypochaeris glabra* (Smooth catsear) and *Lagurus ovatus* (Hairs tail grass).

Table 16: Species Richness of Vegetation Communities at the KSS Property

Vegetation Community[1]	Floristic Type [2]	Species Richness [3]
A1	21a	71
A2	21a	46
A3	21a	117
B1	-	36
C1	21b	18
C2	21b	17
C3	11	27
D1	11	16
D2	4	57
D3	12	14
E1	4	28
E2	4	36
E3	4	13
E4	4	9
F1	12	53
F2	7	13
F3	13	7
G1	11	73
G2	11	18
G3	13	19
G4	7	1
H1	11	91
H2	11	54
H3	12	14
I1	21b	-
I2	21b	-
I3	11	-

1 See Table 12 for Description.
2 Mattiske (2003b) Table 4.
3 Mattiske (2002c) Table 4.

Five aggressive weed species have been recorded at the KSS property:

- *Gomphocarpus fruticosus* (Cotton Bush) (P1 and P4 requirements), a Declared Plant pursuant to section 37 of the *Agriculture and Related Resources Protection Act, 1976*:
  - P1 requirements - The movement of plants or their seeds is prohibited within the state. This prohibits the movement of contaminated machinery and produce including livestock and fodder.
  - P4 requirements - The infested area must be managed 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:
    - Within 100 metres inside of the boundaries of the infestation.

  - Within 50 metres of roads and high water mark on waterways.
  - Within 50 metres of sheds, stock yards and houses.

  Cotton Bush control programs have been implemented across the KSS property and have successfully managed infestations. Weed management is ongoing.

- *Typha occidentalis* (Bullrush) occurs seasonally in inundated woodlands. Mattiske (2003b) reported that the disused settling pond is a major area of *Typha orientalis* invasion. Typha control programs have been implemented across the KSS property and have successfully managed infestations. Weed management is ongoing.
- *Watsonia meriana* var. *bulbillifera* (Bulbil Watsonia) on the lower slopes of *E. marginata- Banksia* spp. Woodlands. Control programs have been implemented across the KSS property and have successfully managed infestations. Weed management is ongoing.
- *Chamaecystis palmensis* (Tagasaste) in cleared pasture areas. Control programs have been implemented across the KSS property and have successfully managed infestations. Weed management is ongoing.
- *Centaurea melitensis* (Maltese Cockspur). Control programs have been implemented across the KSS property.

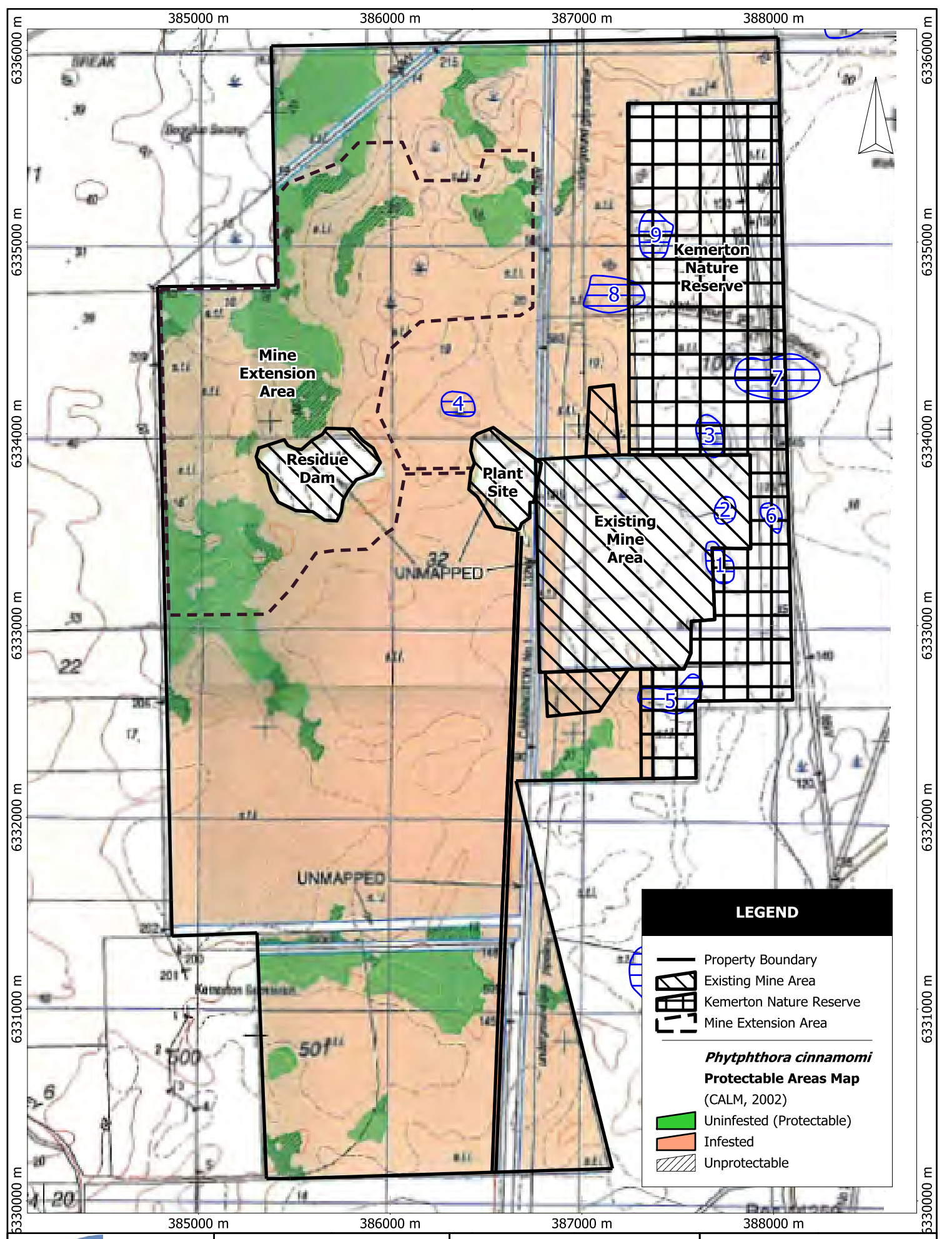
4.7 DIEBACK STATUS

Phytophthora cinnamomi is a soil borne fungus that is a major plant pathogen in the south-west of Western Australia. It is the cause of the plant disease known as dieback. Dieback mapping of the KSS property undertaken by the Department of Conservation and Land Management (CALM) in 2002 indicated that approximately 75% of the property is either dieback infested or can not be protected from dieback. The location of dieback infested and unprotectable areas within the KSS property is shown in Figure 13. The main areas of dieback free and protectable land are the larger Bassendean Dunes. Wetland and lowland areas of the property are either already infested or are unprotectable from the natural spread of the fungus.

The main dieback management tool used on-site is quarantine. Site activities are concentrated around the dredge pond and plant site. With the exception of access to production and monitoring bores, there is no reason for access to other parts of the property. Movement of vehicles into non-production areas of the property is restricted, with permission required from the General Manager with access only made on existing tracks.

4.8 FIRE HISTORY

There have been no fires on the KSS property for the past 15 years apart from a small lightning fire just north of EPP4 which burnt about 2.4 hectares on 26 April 2007. This fire was actively extinguished by KSS.



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Dieback Status of
Kemerton Silica Sand

Figure 13

W:\Kemerton Silica Sand\Drawings\Maps 2009\Dieback.map 15/10/2009 Dieback Layout

4.9 WETLANDS

4.9.1 Wetlands of National Importance

The Government of Australia has made a commitment to identify Australia's most important wetlands. The states, territories and Commonwealth Government, have jointly compiled a Directory of Important Wetlands in Australia. The directory identifies and recognises Australia's nationally important wetlands, provides information about different wetland types and the flora and fauna dependent on these wetland ecosystems.

Wetlands are identified as "Nationally Important" according to six criteria. These criteria are:

1. It is a good example of a wetland type occurring within a biogeographical region in Australia.
2. It plays an important ecological or hydrological role in the major functioning of a major wetland system/complex.
3. It provides important habitat for fauna at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions prevail (e.g. drought).
4. It supports at least one per cent of the national populations of any native plant of animal species.
5. It supports nationally threatened plant or animal species, or ecological communities.
6. It is of outstanding historical or cultural significance.

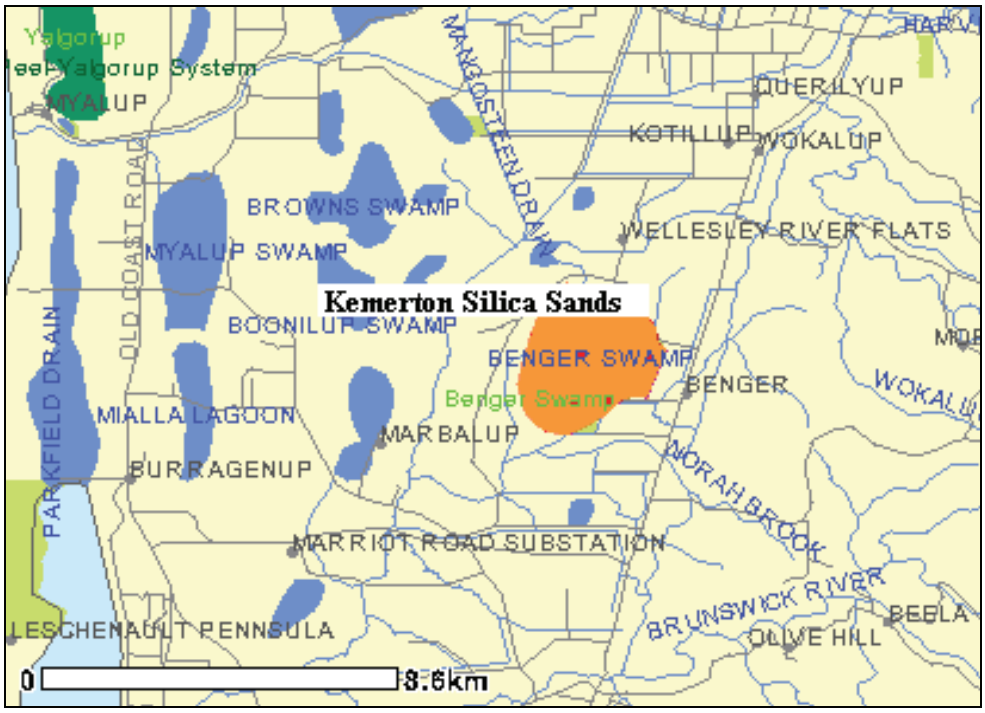
A search of the Directory of Important Wetlands in Australia on the DEWHA (2008a) website found that the KSS wetlands were not “Nationally Important” as shown in Figure 14. The nearest Nationally Important Wetlands to KSS are Benger Swamp and the Peel-Yalgorup System. The Peel-Yalgorup System is also known as a Ramsar wetland and wetland of International Importance.

4.9.2 Wetlands of the Swan Coastal Plain

Approximately 25% of the Swan Coastal Plain between Moore River and Mandurah is classified as wetland. Not all wetlands retain significant ecological values due to the concentration of urban and agricultural development in the region. Most wetlands have been cleared, filled or developed, leaving only 20% of wetlands that were present on the Swan Coastal Plain prior to European settlement (WRC, 2001).

On the original KSS property, nine wetlands were gazetted under the *EPP 1992*. Five of these were transferred to DEC in 1994 to form Kemerton Nature Reserve. A portion of another (EPP8) is also included in the reserve and an additional wetland was added to the reserve in the land swap for the Muchea Limestone TEC in 2005. EPP4 and the balance of EPP8 remain on the KSS property and EPP2 has been lost in the existing approved mine area.

Figure 14: Search of KSS Wetlands in the Directory of Important Wetlands in Australia



Legend

- Ramsar Wetlands
- Important Wetlands
- World Heritage
- Protected Areas
- Rivers and Lakes
- Commonwealth Marine Area

Source: DEWHA (2008a).

The KSS property is located in an area that contains wetlands of the Jandakot consanguineous wetland suite (Semeniuk, 1987). Primary wetlands identified for the Jandakot consanguineous wetland suite are damplands and sumplands, which occur in peat or peaty sand or humic sand overlying quartz sand where the groundwater level is at or near the surface developing water table basins. A classification system was developed based on landform and water permanence (WRC, 2001). Wetland classifications are described in Table 17.

Table 17: Wetland Classification and Descriptions

Water	Landform			
	Basin	Flat	Channel	Slope
Permanently inundated	Lake	River		
Seasonally inundated	Sumpland	Floodplain	Creek	
Seasonally waterlogged	Dampland	Palusplain		Paluslope

Source: WRC (2001).

The WRC (2001) evaluated wetlands on the Swan Coastal Plain to assess the level of significance of a wetland, using the characteristics of landform and water permanence. Each of the management categories provide guidance on the nature of management and protection individual wetlands should be afforded (WRC, 2001). Three management categories were developed based on geomorphic characteristics of Conservation, Resource Enhancement or

Multiple Use. Management objectives and classifications for the specific wetlands located on the KSS property are described in Table 18.

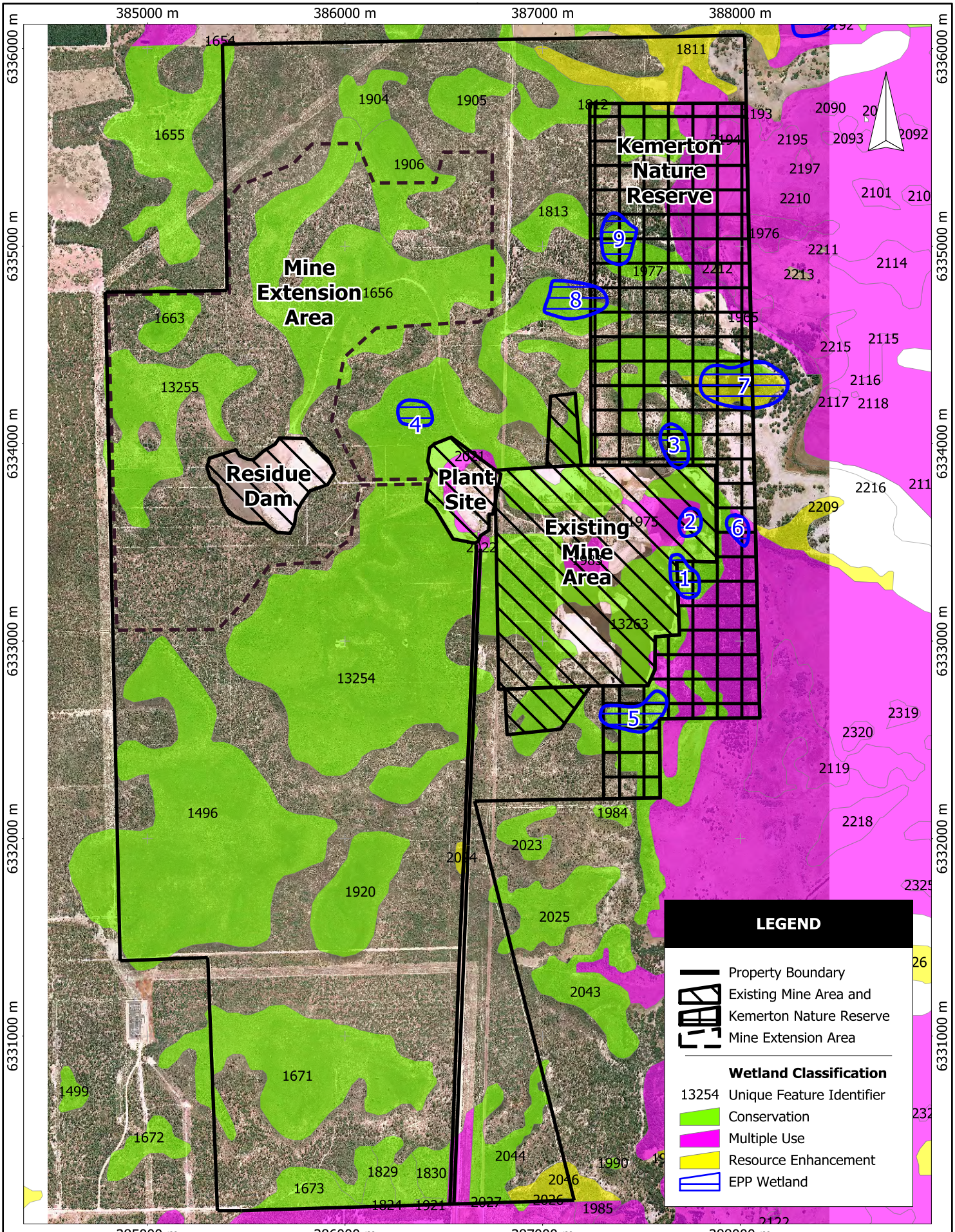
Table 18: Management Categories and Objectives for Wetlands in the Mine Extension Area

Wetland Evaluation	General Description	Wetland Classification	Unique Feature Identifier	Management Objectives
Conservation	Wetlands supporting a high level of ecological attributes and functions.	Dampland	1656	Highest priority wetlands. Objective is preservation of wetland attributes and functions through mechanisms including: • Reservation in National Parks, Crown Reserves and state-owned land. • Protection under Environment Protection policies. • Wetland conservation by owners.
		Dampland	1663	
		Dampland	1904	
		Sumpland	1906	
		Dampland	13255	
Multiple Use	Wetlands with few important ecological attributes and functions.	Dampland	1664	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare. Should be considered in strategic planning eg. drainage, town/landuse planning.
		Dampland	1907	
Resource Enhancement	Wetlands which may have been partly modified, but still support substantial ecological attributes and functions.	-	-	Priority Wetlands. Ultimate objective is for management, restoration and protection towards improving conservation value. The wetlands have the potential to be restored to conservation category which can be achieved by restoring wetland structure, function and biodiversity. Protection is recommended through a number of mechanisms.

Source: WRC Position Statement, (2001).

Wetland categories on the KSS property as detailed in the DEC geomorphic wetlands database are shown in Figure 15. The geomorphic wetland classification system identifies all wetlands within the proposed mine extension area as Conservation, with two exceptions. The residue sand tailings disposal area and an upland Bassendean Dune in the north of the proposed mine extension area are nominated as Multiple Use wetlands.

A separate submission has been made to DEC (2009b) to reclassify the upland Bassendean Dune and the residue dam. Contour plans and site vegetation surveys confirm the area mapped as Multiple Use wetland on the Department's database is elevated land containing open woodland of *Jarrah* and *Banksia*. The PER has been prepared on the basis that this area will be reclassified as Bassendean woodland.



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Scale: 1:25000
Original Size: A4
Air Photo Date: 2006
Grid: Australia MGA94 (50)
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Wetland Classifications of Kemerton Silica Sand

Figure 15

W:\Kemerton Silica Sand\Drawings\Maps 2009\Flora and Wetlands.map 15/10/2009 Wetlands PER

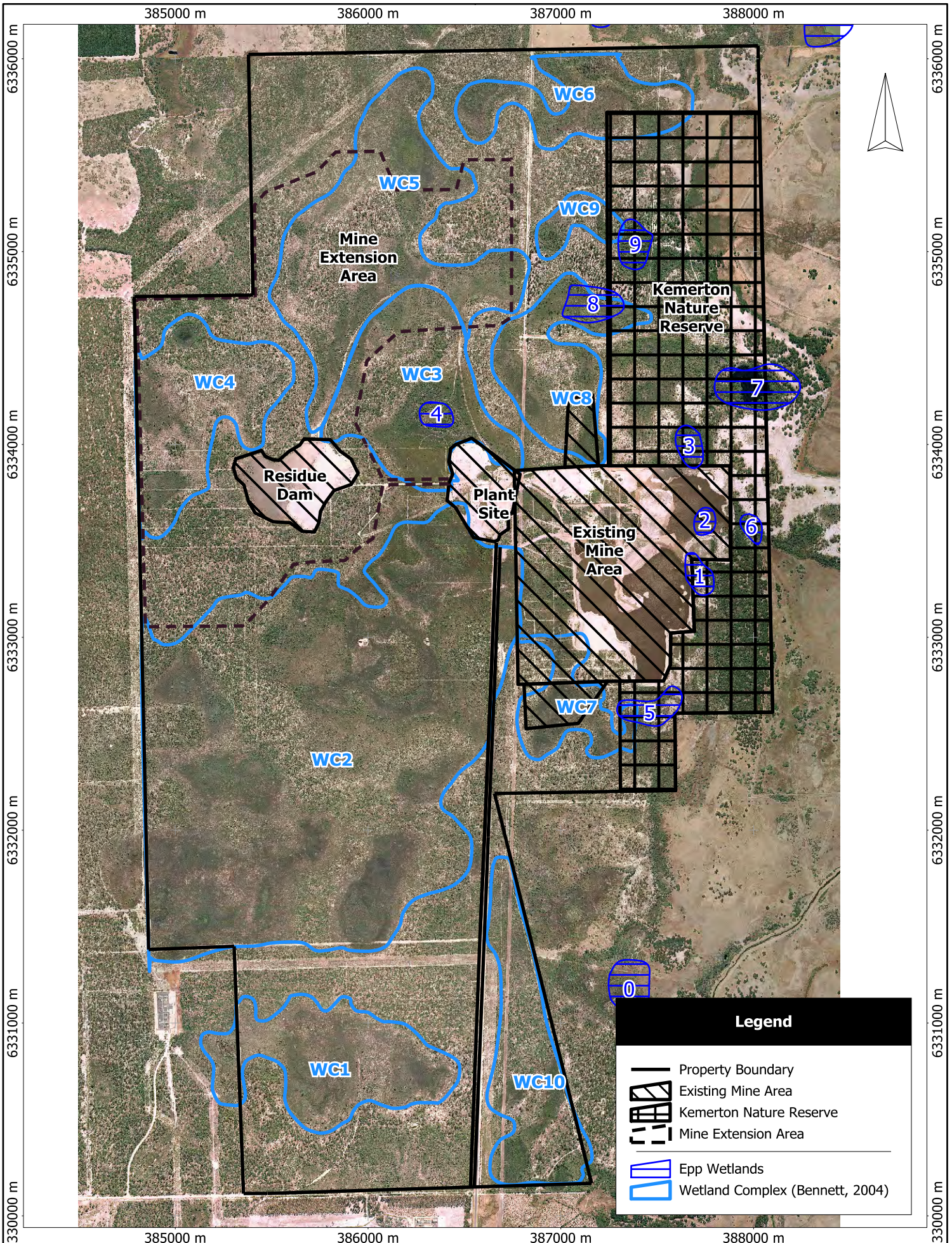
4.9.3 KSS Wetland Types

Wetlands of the KSS property vary between sumplands, damplands, floodplains and palusplains depending on soil, shape and extent of standing water. Each wetland is a mosaic of vegetation units. A marked variation occurs between wetlands in the southern portion of the KSS property to those in the north. Variation also occurs between wetlands in the west and those in the east of Kemerton Nature Reserve, many of which are EPP wetlands. The EPP wetlands occur mostly in the Pinjarra Plains on clay overlying lateritic soils and belong to the Keysbrook wetlands suite (Bennett, 2004).

Mattiske (1993a) conducted a survey of wetlands in the north-east section of the current mining operations. Many of the wetlands surveyed by Mattiske (1993a) are gazetted under the *EPP 1992* and are now part of Kemerton Nature Reserve. Bennett (2004) conducted a survey of wetlands of the entire KSS property in spring 2003 to delineate wetland boundaries and ascertain management categories for each as defined by the EPA (1993). Bennett (2004) found that:

- Twenty different wetlands are present on the KSS property.
- The 20 wetlands can be categorised as 13 palusplains, four sumplands, two damplands and one floodplain.
- Two EPP wetlands are present (EPP4 and part of EPP8). Both are categorised as sumplands.
- Sumplands and damplands are surrounded by palusplains.
- The 20 wetlands were grouped into 10 wetland complexes. These have been assigned taking into consideration the surrounding ground (upland areas) and how the wetlands are interconnected.
- Nine of the 10 wetland complexes are of Conservation Category and one is of Resource Enhancement category. Two of which will be impacted by the mine extension area, WC4 and WC5, consisting of five Conservation Category wetlands, UFI 1656, 1663, 1904, 1906 and 13255.
- Wetlands in the southern section of the KSS property are mostly palusplains (broader seasonally waterlogged flats), however within these palusplains some lower areas occur which hold water for a longer period.
- Damplands occur across the northern portion of the KSS property.
- The central portion of the KSS property is covered broadly by palusplains, but has a number of sumplands which are easily identifiable by their distinctive depressions. Water is retained in the sumplands for long periods in summer.
- A floodplain occurs in the north-eastern section of the KSS property and to the north of Kemerton Nature Reserve. As the floodplain areas approach the Pinjarra Plain, soils contain greater proportions of clay and support extensive herblands.

The location of wetland complexes overlaid on the proposed mine extension area is shown in Figure 16. Characteristics of each wetland in the KSS property and whether the proposed mine extension has a direct impact are presented in Table 19.



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Kemerton Silica Sand Pty Ltd

Wetland Complexes Within Kemerton Silica Sand

Figure 16

W:\Kemerton Silica Sand\Drawings\Maps 2009\Wetland Complexes.map 16/10/2009 Wetland Complexes Layout

Table 19: Description of Wetlands Present at the KSS Property

Wetland Complex on KSS Property	Type	Significant Flora	Mine Extension Area
WC4	Palusplain	Nil	✓
WC3, WC5	Palusplain	Nil	WC5 only
WC4	Palusplain, Sumpland	*Eucalyptus rudis* subsp. *cratyantha* (P4)	✓
WC2	Palusplain	*Acacia semitrullata* (P1), *Boronia juncea* subsp. *juncea* (P1), *Dillwynia dillwynioides* (P3), *E. rudis* subsp. *cratyantha* (P4), *Evandra pauciflora*	x
WC2	Palusplain	*A. semitrullata* (P1), *D. dillwynioides* (P3), *E. rudis* subsp. *cratyantha* (P4), *Evandra pauciflora*	x
WC2	Palusplain, Dampland	*B. juncea* subsp. *juncea* (P1), *Evandra pauciflora*	x
WC1	Palusplain	*A. flagelliformis* (P4), *A. semitrullata* (P3), *B. juncea* subsp. *juncea* (P1), *D. dillwynioides* (P3), *Evandra pauciflora*	x
WC6	Palusplain	Nil	x
WC5	Dampland	Nil	x
WC2	Palusplain	Nil	x
WC5	Sumpland surrounded by Palusplain	*A. semitrullata* (P1), *B. juncea* subsp. *juncea* (P1), *D. dillwynioides* (P3)	✓
WC2, WC6	Floodplain	*A. semitrullata* (P1), *B. juncea* subsp. *juncea* (P1),, *B. capitata* subsp. *gracilis* (P2), *D. dillwynioides* (P3), *E. rudis* subsp. *cratyantha* (P4), *Evandra pauciflora*	x
WC9	Palusplain	*D. dillwynioides* (P3)	x
WC8	Sumpland, EPP8	*D. dillwynioides* (P3)	x
WC8	Palusplain	*B. juncea* subsp. *juncea* (P1), *D. dillwynioides* (P3), *Evandra pauciflora*	x
WC2	Dampland, Palusplain	*A. semitrullata* (P1), *B. juncea* subsp. *juncea* (P1), *D. dillwynioides* (P3), *Evandra pauciflora*	x
WC3	Sumpland, Palusplain EPP4	*Evandra pauciflora*	x
WC4	Palusplain	Nil	✓
WC5	Sumpland, Palusplain	Nil	✓
WC10	Palusplain	*A. flagelliformis* (P4), *A. semitrullata* (P1), *Evandra pauciflora*	x
WC7	Palusplain	*A. semitrullata* (P1), *Caladenia speciosa* (P4), *D. dillwynioides* (P3), *Verticordia nitens*	x

Source: Bennet (2004).

Groundwater modelling done by GHD (Section 7.4.3.2) determined the buffer zone required to protect EPP4, which has resulted in not only EPP4 but also the entire surrounding catchment of the EPP wetland, itself a Conservation Category wetland, being avoided by the proposed mine area. It is considered this modelling work provides a greater functional boundary to the wetland complex than mapping by Bennett (2004) as WC3.

4.9.4 Wetland Vegetation

Mattiske (2003b) described wetlands within the KSS property and their fringing vegetation which support a diverse range of flora. Vegetation communities are closely related to the local water table, climate and soils. Even minor differences in water levels will result in differing vegetation community types and species composition. Consequently wetland integrity and health closely reflects changes in the local water regime, disturbance and fragmentation.

4.9.4.1 Vegetation Mapping

Vegetation was mapped by Mattiske in surveys conducted from December 1992 to October 1993 (Figure 12). Bennett (2004) also surveyed wetland extent and location of species of conservation significance. Of a total of 30 different vegetation communities mapped by Mattiske (2003b), 11 dominate the wetland areas of the KSS property (Table 20).

Table 20: Dominant Wetland Vegetation Communities at the KSS Property

Vegetation Community[1]	Floristic Community Type[2]	Description [1]
C3	11	Closed Woodland of *Agonis flexuosa – E. rudis* and *Corymbia calophylla* with occasional *Banksia littoralis* over *Xanthorrhoea preissii*, *Macrozamia riedlei* and sparse mixed shrubs and sedges.
D1	11	Open Woodland of *E. rudis* and *Kunzea ericifolia* over *Hypocalymma angustifolium, Xanthorrhoea preissii* and mixed shrubs over mixed grasses and sedges.
D2	4	Woodland of *E. rudis – Melaleuca preissiana* and occasional *Banksia littoralis* over Myrtaceae spp. over mixed sedges.
D3	12	Woodland of *E. rudis* and *M. rhaphiophylla* over *M. teretifolia.*
E1	4	Low Open Woodland of *M. preissiana* and occasional *E. marginata* and *Kunzea ericifolia* over *Hypocalymma angustifolium* and *Calytrix* spp, over *Dasypogon bromeliifolius.*
E2	4	Low Open Woodland of *M. preissiana* and occasional *Nuytsia floribunda* over *Hypocalymma angustifolium, Pelicalymma ellipticum* and mixed shrubs over mixed sedges.
E3	4	Low Open Woodland of *M. preissiana* and *Agonis flexuosa* over *Astartea scoparia* and mixed shrubs over *Lepdosperma longitudinale.*
E4	4	Closed low Forest of *M. preissiana* with occasional *Corymbia calophylla* over dense *Taxandria linearifolia* over *Pteridium esculentum* and dense *Lepidosperma longitudinale.*
F1	12	Seasonally inundated Low Closed Forest of *M. rhaphiophylla* over Myrtaceae spp. over mixed sedges.
F2	7	Seasonally inundated Low Open Woodland of *M. rhaphiophylla* over

Vegetation Community[1]	Floristic Community Type[2]	Description [1]
		M. viminea and *M. cuticularis* over mixed shrubs over mixed sedges.
F3	13	Waterlogged Low Woodland of *M. rhaphiophylla* over *Baumea articulata.*

Source: 1 Mattiske (2003b).
2 Gibson *et al.* (1994). In Mattiske (2003b) Table 4.

4.9.4.2 Wetland Condition

Bennett (2004) assessed wetland suites, a combination of one or more of the wetlands, were assessed using the questionnaire in 'A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area – EPA Bulletin 686' (EPA, 1993). This resulted in all being classified as Conservation Category (EPA, 1993; WRC, 2001). The condition of each wetland was also assessed in the spring 2003 wetland survey. Vegetation condition was rated using the Department of Environmental Protection's (2000) rating system where a score of one equates to pristine condition and a score of six equates to a completely degraded condition (Bennett, 2004).

Although very few weeds were present in the wetlands, previous grazing and selective logging has caused alteration to vegetation structure. Removal of grazing pressure since acquisition of the land has meant improvements to vegetation condition. Vegetation condition was scored at level three out of six (very good). This equates to vegetation where the structure is altered and there are obvious signs of disturbance (Department of Environmental Protection, 2000). Very few weeds were recorded within the wetlands but some areas showed evidence of damage by feral pigs (Bennett, 2004).

WC1, in the southern area of the property, contained a number of weeds. It also contained dead or dying *Astartea scoparia* plants. The reason for this is not clear, however it may reflect drier conditions due to a nearby blue gum plantation which prefers waterlogged ground (Bennett, 2004).

Wetland suite WC3 already has infrastructure, including a drain at the wetland. It also includes EPP wetland 4 (Bennet, 2004). WC4 on the western edge of the KSS property is relatively small and would have extended to the west. However, a strip of land to the west of the KSS property has been cleared for power line infrastructure and the wetland complex has been disturbed. While this is also true of WC2, the area of this complex on the KSS property is substantially greater than that of WC4. The wetland function of WC2 is potentially less impeded by clearing to the west of the property.

4.9.4.3 Wetland Vegetation Monitoring

In 2000, Mattiske were commissioned by KSS to review and extend the vegetation monitoring program for EPP4, which was commenced by Ecos in 1999 (2000b). Mattiske were commissioned in response to a wastewater overflow from a drain located north of EPP4. Mattiske initially re-monitored the plots established by Ecos and established additional monitoring transects and quadrats in EPP4. EPP8 was chosen as a more suitable control for comparison with EPP4, rather than EPP9, due to the greater similarities between vegetation communities. However, EPP9 monitoring was continued. The vegetation monitoring was

revised and extended by Mattiske in the early part of 2001, re-monitored in July 2001, January, March and August 2002, March 2003 and March 2004. Monitoring was discontinued as the monitoring program did not detect any vegetation changes attributable to the wastewater spill.

Edith Cowan University's Centre for Ecosystem Management (CEM) were engaged to evaluate rehabilitation at KSS in June 2007 to provide recommendations to help improve restoration success of post-mining environments (van Etten *et al*. 2008b) (Appendix 7). In November 2008, KSS contracted the CEM to report on changes to rehabilitation since 2007 and to evaluate their most recent rehabilitation (van Etten *et al*. 2009) (Appendix 8). Existing permanent monitoring transects (established by Mattiske, 2004b, 2005) and new transects located in six distinct areas of rehabilitation ('Sectors') around North Lake were monitored. Transects were established across several natural wetlands over the same time period. These were to characterise the biotic patterns of such wetlands, identify likely processes which drive or influence such patterns and to examine likely dynamics in vegetation (van Etten *et al*. 2008b). Data analysis included comparisons between transects and previous monitoring in terms of average plant cover, density and species richness. Soil profiles, topsoil characteristics and micro-topography were also measured and compared.

van Etten *et al*. (2008a) have found EPP4 to be unique on the KSS property as a perched wetland with distinct flora and fauna. These reports are provided in Appendix 9 and Appendix 10. EPP4 and the wetland's Conservation Category wetland catchment area, UFI 13254, has been excluded from the proposed mine extension area. On-going monitoring will ensure no adverse impacts result from the proposed mine extension.

4.9.5 Wetland Fauna Survey

Significant fauna in the proposed mine extension area can include wetland invertebrate species, as well as vertebrate fauna associated with wetlands.

The Centre for Ecosystem Management at Edith Cowan University was commissioned to undertake ongoing studies at the KSS property. Their objective was to assess aquatic macroinvertebrate communities and water quality within wetlands in the proposed mine extension area and to assess the condition and conservation status of wetlands within the proposed mine extension area and Kemerton Nature Reserve. Information obtained from this survey has provided a comprehensive ecological knowledge base for existing aquatic invertebrate populations and water chemistry of existing wetlands and rehabilitation ponds. It will continue to provide valuable analogue reference information for post-mining rehabilitation of dredge ponds in the mine extension area.

4.9.5.1 Methodology

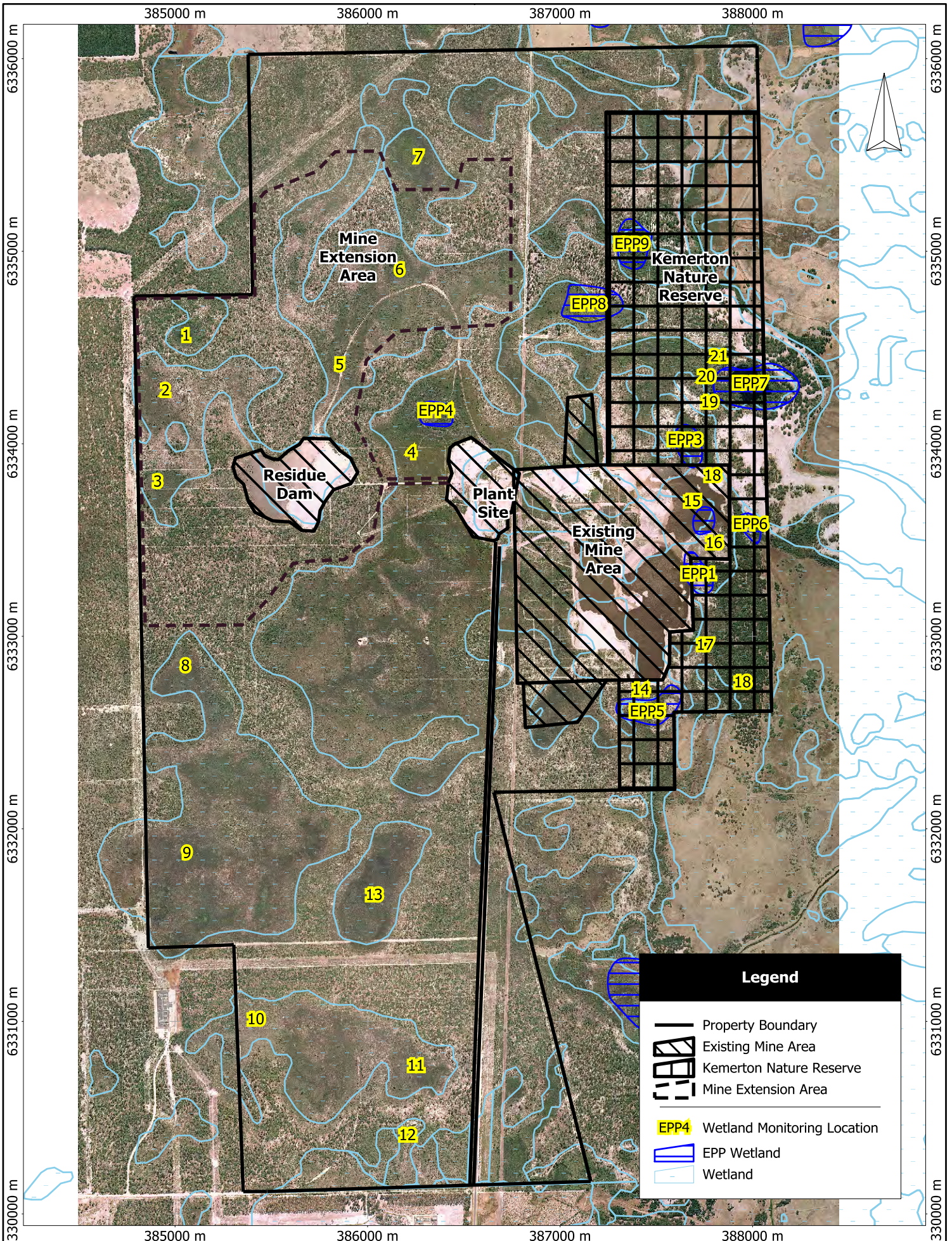
Wetlands in the mine extension area, as well as adjacent EPP wetlands and the rehabilitated dredge pond lake were surveyed by Edith Cowan University on 26 to 28 September and 12 October 2007 (Appendix 11). Early spring was chosen, as this season generally represents the time of peak water levels for wetlands on the Swan Coastal Plain (McCullough and Lund, 2008). All the EPP wetlands and the majority of the wetland areas were identified on aerial photographs. Particular focus was given to Conservation Category wetlands (13255, 1663, 1656 and 1906) that lie in the proposed expansion area.

Seventeen water bodies including 13 natural wetlands were sampled for water quality and macroinvertebrates; a further eight potential wetland sites were visited, but were dry (Table 21 and Figure 17). Areas of seasonal inundation were included for monitoring in the mine extension area, but at the time of monitoring, the wetlands were dry, therefore no baseline data relevant to the proposal is available for comparison. Edith Cowan University recommended further assessment during wet conditions. At each site, the wetland was walked around and notes were taken on habitat type, condition and water depth, where appropriate.

Table 21: Wetlands Surveyed for Aquatic Macroinvertebrates Within KSS Property

Site	Unique Feature Identifier	Replicates/ Habitat	Description of Wetland
1	1663	Dry	Small dampland surrounded by paperbarks.
2	13255	Dry	Low scrub type vegetation, no obvious sign of being a dampland.
3	13255	Dry	Dampland, surrounded by paperbarks.
4	13254	Dry	Dampland surrounding EPP4.
5	1656	Dry	Dampland.
6	1656	Dry	Dampland.
7	1906	Dry	Sumpland.
8	1496	Dry	Dampland.
9	1496	Dry	Dampland.
10	1671	Dry	Dampland.
11	1671	Dry	Dampland.
12	1829	1	Old unrehabilitated dredge pond in the south of the property.
13	1920	Dry	Dampland.
14	-	3	Rehabilitated wetland next to CC5.
15	-	5	North Lake - rehabilitated old dredge pond.
16	-	3	Satellite lake of rehabilitated North Lake.
17	13251	3	Series of small sumplands.
18	13251	3	Paperbark dominated sumpland immediately south-east of dredge pond.
19	1978	3	Paperbark new' - large shallow wetland north-west of EPP7.
20	13263	3	Paperbark new' - small shallow wetland north-west of EPP7.
21	13263	3	Paperbark deep' - deep wetland nor-north west of EPP7.
EP1	-	3	EPP wetland.
EP3	-	4	EPP wetland.
EP4	-	3	EPP wetland.
EP5	-	5	EPP wetland.
EP6	-	4	EPP wetland.
EP7	-	5	EPP wetland.
EP8	-	3	EPP wetland.
EP9	-	3	EPP wetland.

Source: McCullough and Lund (2008).



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Scale: 1:25000
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Grid: Australia MGA94 (50)

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Aquatic Macroinvertebrate Survey
Locations in Kemerton Silica Sand

Figure 17

W:\Kemerton Silica Sand\Drawings\Maps 2009\Macroinvertebrates.map 15/10/2009 Macroinvertebrates Layout

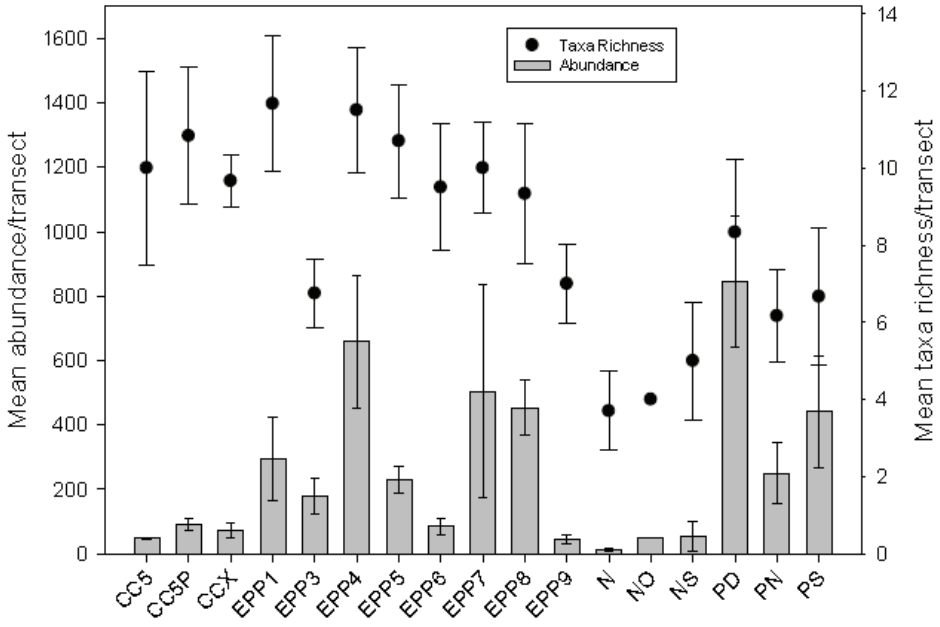
Wetlands were sampled in a stratified design where habitat heterogeneity was apparent. Different aquatic habitat types were identified as shallow and deep open water, and vegetated and bare littoral edge. Aquatic macroinvertebrates were collected with a 250 µm mesh sweep net along a 10 metre transect through each habitat. Each wetland macroinvertebrate sample was replicated at least three times, with up to five replicates for very large water bodies (McCullough and Lund, 2008). Each wetland habitat type was also sampled in replicate for basic physico-chemistry parameters of temperature, dissolved oxygen (DO), specific conductance (conductivity, EC), pH, Oxidation-Reduction Potential (ORP), turbidity and chlorophyll *a* concentration.

Macroinvertebrate sorting began with a big-pick from the two millimetre fraction. The sample filtrate was then placed into a four-channel Bogarov tray and sorted by two passes with an Olympus SZ-STU2 stereo microscope. Macroinvertebrates from both the larger fraction CPOM sieving and from the smaller fraction sorting tray were also identified under the same microscope. Initially, all uncommon (<200 individuals) were sorted, identified and counted. A 20% subsample of the remaining fraction (organic matter and crustacean taxa) was then counted for common taxa (>200 individuals) (McCullough and Lund, 2008).

4.9.5.2 Macroinvertebrate Results

A graph of mean aquatic macroinvertebrate abundance and diversity per transect is provided in Chart 2 Complete macroinvertebrate results are provided in Appendix 11.

Chart 2: Mean Aquatic Macroinvertebrate Abundance and Diversity per Transect



Results of the survey were:

- A total of 147 macroinvertebrate taxa were collected across all sites.
- The majority of species had distributions limited to a single wetland.
- Only one species occurred across all sites (*Necterosoma sp*. larvae).
- Macroinvertebrate communities of EPP wetlands were numerically dominated by zooplankton, chironomid larvae and beetles and bugs.

- The most diverse sites were EPP1 and EPP5.
- EPP1 appears to be permanent and has water quality similar to North Lake suggesting that it might be a suitable reference wetland.
  Source: McCullough and Lund (2008)
- The rehabilitated dredge pond and newly created wetland (Site 14) were less species diverse than the majority of natural wetlands, but Site 4 showed good species diversity, particularly as it had recently been established.
- Aquatic macroinvertebrates of natural wetlands were abundant in most samples with an overall mean of 309±49 (standard error of the mean) macroinvertebrates per sample and a mean of 850 macroinvertebrates per sample recorded from Site 21 (McCullough and Lund, 2008).
- Samples rich in animals were dominated by zooplankton crustaceans including daphnid and other cladoceran families, calanoid copepods and ostracods.
- Natural wetland macroinvertebrate samples were also moderately diverse, with an overall mean of 9±0.0 taxa per sample found across natural wetlands to a maximum of 19 taxa per sample encountered in EPP1 and EPP4 (McCullough and Lund, 2008).
- EPP4 particularly, was dominated by and contained a high abundance of conchostrocans. Nevertheless, the aquatic macroinvertebrate community of EPP 4 appeared to be typical of other KSS wetlands in both number of animals and taxa and also in community composition.
- Habitats within natural wetlands did not appear to demonstrate either significantly different water quality or significantly different macroinvertebrate communities. This may be because many of the taxa encountered in these seasonal wetlands are cosmopolitan and do not have narrow ecological niches that would separate them across the habitats sampled.
- There appeared to be no difference between littoral and open water aquatic macroinvertebrate communities suggesting riparian vegetation is not significant for aquatic macroinvertebrate community structure within the natural wetlands.

Macroinvertebrate samples were collected in 2008 and are currently awaiting analysis. These samples were collected as part of a Masters Research project at Edith Cowan University entitled "*Succession and Predictability of Macroinvertebrates in Seasonal Wetlands*". The study is developing an understanding of how predictable macroinvertebrate community development is between KSS wetlands (what a "typical" community consists of) and what environmental variables are most important to these communities (e.g., water depth, riparian vegetation). As well as providing a generic target and guidelines of wetland habitat requirements for wetland rehabilitation aquatic communities in its own right, this study will also provide information for the Black-striped Jollytail Masters project as well. A final report is expected at the end of 2010.

4.9.5.3 Wetland Water Chemistry Results

Results of the survey were:

- Temperature varied across and within wetlands from 13.9 to 28.2°C and was affected by water depth and shading with the mean temperature across all sites being 19°C.

- pH was variable with natural wetlands generally slightly acidic with pH<7 down to 4.6, whereas EPP1 and the artificial water bodies were slightly alkaline with pH>7 up to 8.5.
- Specific conductance was moderate and typical of seasonal wetlands of the Swan Coastal Plain, ranging from 0.15 to 2.06 milliSiemens per centimetre, but was very variable within and between wetlands.
- Dissolved oxygen was slightly super-saturated (120%) in artificial water bodies to 60% in EPP9 and around 80% in natural water bodies.
- ORP was very variable, but positive across all wetlands, except CC5P, at around 100 mV.
- Turbidity was low in all EPP wetlands, but moderate in artificial water bodies and Conservation Category wetlands.
- Dredge ponds and satellite lakes had significantly different water chemistry to natural KSS wetlands. Relative to natural KSS wetlands, rehabilitated dredge pond North Lake had higher water temperatures, turbidity, DO, pH and SO_4, ammonia and total nitrogen concentrations. North Lake water chemistry was very similar to that of EPP1.

4.10 ADJACENT REGIONALLY SIGNIFICANT AREAS

The project is situated within the System 6 region and Swan Coastal Plain portion of the System 1 subregion.

A search of the database managed by DEWHA (2007) was undertaken in April, 2007. One Wetland of International Significance (Ramsar Site) was identified as the Peel-Yalgorup system (Figure 14). The inclusion of this site in relation to the project is based on it being within a 10 kilometre radius of the system's catchment, even though the project site is outside the catchment boundary. Drainage from the property flows south-east to the Wellesley River, which then flows southwards to the Leschenault Estuary, away from the Peel Yalgorup system. Impact from the project to the Peel Yalgorup system is considered to be negligible.

Ten reserves occur within 10 kilometres and there are 15 reserves within 20 kilometres of the KSS property (DAF, 2008). The location and vegetation complexes present within each reserve are presented in Table 22. Myalup State Forest lies 0.5 kilometres north of the KSS boundary and a large area of native forest which predominately occurs within the Bassendean – Central and South vegetation complex. Two reserves that lie to the south of the KSS property in the Kemerton Industrial Zone buffer also occur within the Bassendean – Central and South Vegetation Complex. The location of each in relation to the KSS property is shown in Figure 18.

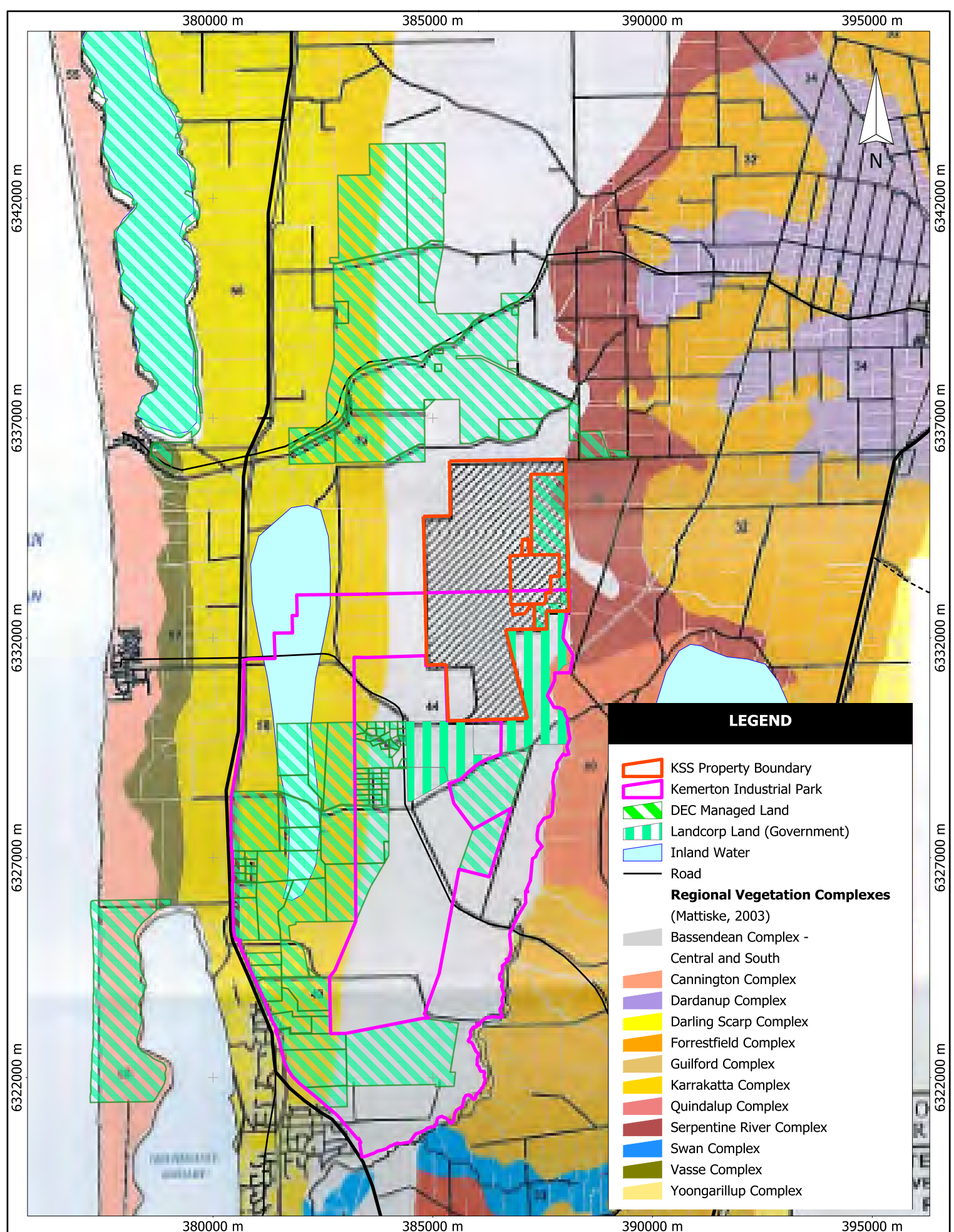
Appendix 3 of the EPA Guidance Statement 10 (EPA, 2003a) outlines a strategy for the identification of regionally significant natural areas in System 6 and part of the System 1 region. Criteria and attributes determining the regionally significant status of natural areas is presented in Table 23 and Table 24. Appendix 3 of EPA Guidance Statement 10 (EPA, 2003a) states the application of the criteria should be undertaken in a staged manner, as 'Representation of Ecological Communities' should be considered first. Other aspects and criteria are then addressed.

Kemerton Nature Reserve lies adjacent to the eastern boundary of the KSS property and was formed as a result of a land transfer from KSS to the state of Western Australia as part of original project approval. The majority of Kemerton Nature Reserve occurs within the Bassendean - Central and South Vegetation Complex with a small area of the Serpentine River Complex occurring in the north-eastern corner of Kemerton Nature Reserve. Seven EPP wetlands occur either wholly or partially within Kemerton Nature Reserve in addition to 17 hectares of a good quality occurrence of the Muchea Limestone TEC.

Table 22: Reserves and Conservation Estate in Proximity to the KSS Property

No.	Reserve Class	Name	Location in Relation to the KSS Property	Vegetation Complex
1	C	Benger Swamp	3 kilometres south-east	Serpentine River (predominant); Cannington
2	A	Byrd Swamp Nature Reserve	0.5 kilometres north-east	Serpentine River Complex
3	A	Conservation Reserve 1763	8 kilometres south-west	Quindalup; Yoongarillup Vasse
4	A	Dwellingup State Forest	20 kilometres north-west	Darling Scarp
5	A	Harris River State Forest	14 kilometres west	Darling Scarp Complex
6	A	Harvey Flats Nature Reserve	15 kilometres north	Bassendean - Central and South
7		Kemerton Nature Reserve	Eastern boundary	Bassendean - Central and South (predominant)
8		Kemerton Industrial Park Reserve	0.7 kilometres east	Bassendean - Central and South
9	C	Leschenault Inlet	7.5 kilometres south-west	Quindalup; Yoongarillup Vasse
10	C	Miscellaneous Reserve 1563	10 kilometres east north-east	Dardanup Complex
11	A	Myalup Swamp and Mialla Lagoon	2.5 to 3.5 kilometres west to south-west	Myalup Swamp = Vasse Mialla Lagoon = Yoongarillup
12	A	Myalup State Forest	0.5 kilometres north	Spearwood; Bassendean - Central and South
13	A	Riverdale National Reserve	12.5 kilometres north	Bassendean - Central and South
14	A	Wellington State Forest	20 kilometres south-east	Darling Scarp Complex
15	A	Yalgorup National Park	5.5 kilometres north-west	Quindalup; Yoongarillup

Source: DAF, 2008



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Original Size: A4
Grid: Australia MGA94 (50)

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Regional Reserves Around Kemerton Silica Sand

Figure 18

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Table 23: EPA Guidance Statement 10

No.	Criteria	Policy	Policy Applicability	Proponent Comment
1	Representation of ecological communities	The general protection of remnant native vegetation on the Swan Coastal Plain portion of System 6 and System 1 regions can be achieved through preferential location of developments in cleared areas (EPA 2003a pg 43).	Seek to: • Retain at least 30% of pre-clearing extent of ecological communities, where >30% of an ecological community remains; and • Preferentially locate developments in cleared areas, particularly where 30% or <30% of pre-clearing extent of the ecological community remains.	• EPA Bulletin 1108 (Table 5, pg 62) records 39.3% of the Bassendean - Central and South complex remaining in the Greater Bunbury Region (GBR). • EPA Bulletin 1108 (Table 5, pg 62) records 27.0% of the Bassendean - Central and South complex remaining on the entire Swan Coastal Plain. • Greater than 30 % still remains in the GBR.
2	Diversity	Areas with a high diversity of landforms, flora and/or fauna species or communities in close association.	Conservation of important areas, by virtue of their richness, diversity or complexity for their physical or biological attributes at the community, species or genetic level.	The proposed mine extension area represents the least diverse area on the KSS property, with the greatest level of disturbance. This is consistent with the principle of avoidance of the most significant environmental features.
3	Rarity	Areas containing rare or threatened communities or species, or species of restricted distribution.	This criterion applies to aspects of the environment which are rare or relatively rare, and can encompass any environmental, biological or ecological feature or phenomenon which can be regarded as outstanding because it is one of the few of its type.	• No DRF or TEC are located within the mine extension area. • Priority species located within the proposed mine extension area are also well represented outside the area.
4	Maintaining ecological processes	Maintenance of ecological processes or natural systems at a regional or national scale.	This criterion applies to areas which are important in the maintenance of existing processes or natural systems. This criterion would normally be used in conjunction with other criteria for the selection of representative areas.	The proposed mine extension area represents less than 31% of the remaining KSS property. The remaining undisturbed area (approximately 900 hectares) will continue to function to maintain ecological processes at a regional level.
5	Scientific or evolutionary importance	Areas containing evidence of evolutionary processes either as fossilised material or as relict species and areas containing unusual or important	This criterion applies to areas which contain evidence of past ecological or biological processes, and unusual or important geomorphologic or geological sites and to areas which have recognised value as research	There are no unique or unusual processes known to occur in the mine extension area.

No.	Criteria	Policy	Policy Applicability	Proponent Comment
		geomorphologic or geological sites. Areas of recognised scientific and educational interest as reference sites or as examples of important environmental processes at work.	sites, type localities or sites having reference or benchmark value.	
6	General criteria for protection of wetland, streamline, estuarine fringing vegetation and coastal vegetation.	Conservation Category wetland areas including fringing vegetation and associated upland vegetation and coastal vegetation within the accepted coastal management zone.	This criterion applies to Conservation management category wetlands, their vegetation (including fringing vegetation) and associated upland vegetation.	• Rehabilitation of wetlands disturbed in the project will occur to return wetland functions to the post mining landscape and open water lakes. • Conservation of additional EPP and Conservation category wetlands is proposed in the Environmental Offsets package (Section 10.4). • EPP4 and the surrounding Conservation Category Wetland will be protected and on-going monitoring of groundwater and vegetation will ensure that the proposed mining does not result in any adverse impacts.

Table 24: Individual Area Attributes

No	Individual Area Attributes	Description	Proponent Comment
1	Size and shape	The lower size limit of 20 hectares given in the Urban Bushland Strategy is accepted as a preferred lowest area limit, but smaller areas are significant where a community is seriously threatened or poorly reserved (less than 10% protected).	The proposed mine extension area is in excess of 20 hectares.
2	Vegetation condition	Remnants in largely undisturbed condition retaining the highest values are preferred. Remnants with basic vegetation structure and floristics intact (bushland) are the next best alternative.	Vegetation condition rating 3 – very good. The area has been previously grazed, but stock has been removed from the property.
3	Uplands and wetlands	Natural areas containing both ecological community groups (uplands and wetlands) support the highest biodiversity and are a focus for protection.	The proposed mine extension area contains both upland and wetland landforms and represents less than 21% of the remaining KSS property. The remaining undisturbed area (approximately 900 hectares) also contains both uplands and wetlands, which will not be disturbed.
4	Ecological communities below 10% and threatened ecological communities	There is a presumption that all areas of remnant native vegetation containing threatened ecological communities or vegetation of the major landform elements of which less than 10% currently remains will be retained and conserved.	There are no threatened ecological communities within the mine extension area.
5	Relationship to other areas	High priority is given to maintenance or establishment of linkage corridors.	EPA Bulletin 1108 on the Greater Bunbury Regional Scheme identified the KSS property as being part of a north–south ecological linkage. A lesser east-west linkage terminates west of the property. Kemerton Industrial Park Strategy Plan (TME *et al.* 2007) includes these linkages. Section 4.15.2 of this document discusses this aspect. This PER proposes to realign the north-south linkage through Kemerton Nature Reserve rather than through the main KSS property. This will secure long-term integrity of this ecological linkage.

4.11 FAUNA

4.11.1 Conservation Significance

Fauna considered to be of conservation significance are listed on state or Commonwealth threatened/migratory species lists or DEC species lists (Table 25 to Table 27). Fauna species have been assessed using data from the following sources:

- *EPBC Act* administered by DEWHA. The *EPBC Act* also requires compilation of a list of migratory species that are recognised under international treaties including the:
  - *Japan Australia Migratory Bird Agreement 1981* (JAMBA). Species listed under JAMBA are also protected under Schedule 3 of the *WC Act*.
  - China Australia Migratory Bird Agreement 1998 (CAMBA).
  - Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA).
  - *Bonn Convention 1979* (The Convention on the Conservation of Migratory Species of Wild Animals).
- *WC Act* administered by DEC.
- DEC Priority Fauna list. A non-legislative list maintained by DEC for management purposes.

Table 25: *EPBC Act* Threatened Fauna Categories

Category	Code	Description
Extinct	E	There is no reasonable doubt that the last member of the species has died.
*Extinct in the Wild	EW	A species: (a) is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame.
*Critically Endangered	CE	A species is facing an extremely high risk of extinction in the wild in the immediate future.
*Endangered	EN	A species: (a) is not critically endangered; and (b) is facing a very high risk of extinction in the wild in the near future.
*Vulnerable	VU	A species: (a) is not critically endangered or endangered; and (b) is facing a high risk of extinction in the wild in the medium-term future.
Conservation Dependent	CD	A species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered.
*Migratory	Migratory	(a) all migratory species that are: (i) native species; and (ii) from time to time included in the species to the Bonn Convention; and (b) all migratory species from time to time included in annexes established under JAMBA, CAMBA and Rokamba; and (c) all native species from time to time identified in a list established under, or an instrument made under, an international agreement approved by the Minister.
Marine	Ma	Species in the list established under s248 of the *EPBC Act.*

Note: * Only species in these categories are matters of national environmental significance under the *EPBC Act.*

Table 26: *Wildlife Conservation Act* Threatened Fauna Categories

Category	Code	Description
Schedule 1	S1	Fauna which is rare or likely to become extinct.
Schedule 2	S2	Fauna which is presumed extinct.
Schedule 3	S3	Birds which are subject to an agreement between the governments of Australia and Japan (JAMBA) relating to the protection of migratory birds and birds in danger of extinction.
Schedule 4	S4	Fauna that is otherwise in need of special protection.

Note: The *WC Act* also uses the categories defined by the *EPBC Act* to further define the status of species in the S1 category.

Table 27: Western Australian DEC Priority Fauna Categories

Category	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring. (Not currently threatened or in need of special protection, but could be if present circumstances change).
Priority 5	P5	Taxa in need of monitoring. (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).

4.11.2 Fauna Habitats

From the perspective of fauna, the most important vegetation and landform features of the Kemerton region in general are (Bamford, 2003a):

- Extensive Eucalypt woodlands primarily in the west and centre of the Kemerton region, but extending into the KSS property. Some of these woodlands are reminiscent of the tall Eucalypt forests of the nearby Darling Escarpment, and it is these woodlands that support a number of the species commonly associated with the Darling 'Scarp' forests. On the KSS property, these woodlands are scattered throughout, but tend to be concentrated in the western part of the site. There are also some woodlands of Peppermint *Agonis flexuosa*, including some isolated stands in the east of KSS around EPP6.
- Banksia woodlands found in the north of the Kemerton region are poorly developed on the KSS property. These woodlands are similar to those of the Perth region.
- Wetlands, ranging from deep, permanent systems in the south-west of the Kemerton region, to seasonal wetlands and extensive damplands of the KSS property. The wetlands and damplands of KSS are mainly in the extreme east and are especially important because they support several significant species, including a relictual population of the Black-striped Jollytail *Galaxiella nigrostriata*. Many of these wetlands have now been vested with DEC to ensure their integrity is maintained.

4.11.3 Fauna Surveys

Fauna surveys have been undertaken at KSS and the surrounding area over a number of years and include:

- Surveys conducted around several wetlands from Mialla Lagoon, south close to Old Coast Road for Alcoa of Australia (Bamford and Watkins 1983).
- Surveys conducted on the KSS property as part of environmental assessment and monitoring for the operations in the period 1993 to 2001 (Ninox Wildlife Consulting 1994, Bamford 1998, 1999, 2000, 2001).
- Studies carried out for the Department of Resource Development over the whole Kemerton region in 1998 to determine the conservation value of the Kemerton Industrial Park Buffer Zone (Bamford 1999).

Sixteen fauna studies have been conducted within the KSS property since 1993 as presented in Table 28. This included targeted surveys for the Southern Brush-tailed Phascogale (*Phascogale tapoatafa ssp.)*, Chuditch (*Dasyurus geoffroii*), Carnaby's Black-Cockatoos (*Calyptorhynchus latirostris*) and Western Ringtail Possum (*Pseudocheirus occidentalis*). The Chuditch, Carnaby's Black-Cockatoos and Western Ringtail Possum were identified as the primary reason for designating the project as a Controlled Action under the *EPBC Act*.

Table 28: Fauna Studies on the KSS Property

No.	Author	Date	Title
1	M.J. Bamford and Ninox Wildlife Consulting	1993	Interim report: Vertebrate fauna of the Kemerton Silica Sand project.
2	Ninox Wildlife Consulting	Jan-93	Report: Vertebrate fauna assessment of the Kemerton Silica Sand project.
3	M.J. Bamford and Ninox Wildlife Consulting	Oct-93	Vertebrate fauna assessment of the Kemerton Silica Sand project.
4	Ninox Wildlife Consulting	Feb-94	The Kemerton Silica Sand project area: Vertebrate fauna assessments December 1992 - December 1993.
5	M.J. & A.R. Bamford	Jan-98	Kemerton Silica Sand Mine: Annual report on Fauna Monitoring Program; 1997.
6	M.J. & A.R. Bamford	Feb-99	Kemerton Silica Sand Mine: Annual report on Fauna Monitoring Program; 1998.
7	M.J. & A.R. Bamford	May-00	Kemerton Silica Sand Mine: Annual report on Fauna Monitoring Program; 1999.
8	M.J. & A.R. Bamford	Jul-01	Kemerton Silica Sand Mine: Annual report on Fauna Monitoring Program; 2000 - 2001.
9	M.J. & A.R. Bamford	Sep-02	Kemerton Silica Sand Pty Ltd: Summary report on Fauna Surveys; 2001 - 2002.
10	M.J. & A.R. Bamford	Feb-03a	Assessment of Fauna values in the KSS property.
11	M.J. & A.R. Bamford	Feb-03b	Kemerton Silica Sand Pty Ltd: Fauna Monitoring 18th December 2002.

No.	Author	Date	Title
12	Wilcox, J. and M.J. Bamford	May-04	The status of the Chuditch (*Dasyurus geoffroii*) in areas proposed for expansion by KSS.
13	M.J. & A.R. Bamford	Jun-04	The utilisation by Short-billed Black-Cockatoos (*Calyptorhynchus latirostris*) of the proposed dredge mining extension area of KSS.
14	McCullough, C.D. & Lund, M.A.	Dec-08	Aquatic macroinvertebrates in seasonal and rehabilitated wetlands of the Kemerton Silica Sand Pty Ltd project area.
15	Galeotti, D.M. , McCullough, C.D. & Lund, M.A.	Jun-08	Current State of Knowledge of the Black-stripe Minnow *Galaxiella nigrostriata* (Pisces: Galaxiidae) in Western Australia.
16	G. Harewood	Feb-09	Fauna Assessment (Level 1) and Targeted Fauna Survey (Western Ringtail Possum and Southern Brush-tailed Phascogale) in the Mine Expansion Area.

Studies carried out for the KSS project provide specific information regarding fauna of the KSS property. The other studies were conducted over broader areas than the KSS property alone and provide information on fauna at a more regional level (Bamford, 2003a). A considerable body of information on the fauna and their habitat associations of both the KSS property and the Kemerton region are therefore available.

Fauna studies carried out in the Kemerton region include opportunistic observations, systematic searching, trapping for reptiles and mammals (approximately 1,000 trap nights in total at all sites at Kemerton), netting for bats and spotlighting. Fauna of the region is considered to be well documented.

From 1997 to 2002, four survey trips occurred every year at similar times to surveys undertaken in previous years, focussing on late summer/early autumn when most or all wetlands are dry, early winter when wetlands begin to fill, late winter/early spring when water levels are high and both waterbirds and Jollytails are breeding, and late spring/early summer when water levels are low.

Waterbird surveys involved a total count of all waterbird species present at each site. In addition, notes were made of their activity, such as roosting or foraging, and the habitat in which the birds are present. Breeding attempts (nests, eggs and/or dependent young) were also recorded (Bamford, 1997).

Sampling of fish involved use of fish-traps and sweep-nets (Bamford, 1997). Trapping and netting were carried out for set time-periods so that sampling was standardised, but subsequent discussions with Dr Howard Gill (Murdoch University) suggested that such standardisation is of little value when sampling small freshwater fish in complex habitats (Bamford, 1997). This is because fish are unevenly distributed in different vegetation types, sampling efficiency varies with vegetation type and the density of the fish varies with the water level. In each wetland containing adequate water, two traps (baited with a mixture of Rabbit pellets and Dog biscuits) were set for 25 - 30 minutes and sweep-netting was carried out for two periods of 10 minutes (Bamford, 1997). Fish caught were measured as an

indication of population structure and growth rates, with large numbers of captures being sub-sampled to avoid holding fish for too long (Bamford, 1997).

Bamford (2003) reviewed results of earlier studies focusing on areas of special interest in the western part of the KSS property. Bamford (2003) produced lists of fauna species present or expected to occur in the Kemerton region and specifically on the KSS property. Where species have not been recorded, but are expected to occur in the area, the preferred species habitat, where such preferences are known to be very specific, were also recorded. Bamford (2003) concluded that:

- The Kemerton region supports a rich fauna, because it includes a large area of remnant and regrowth native vegetation, while much of the surrounding coastal plain has been developed for agriculture.
- The area supports a high number of S3 species, not formally recognised for conservation significance, but are regionally important. In the Kemerton region, these species have declined elsewhere on the Swan Coastal Plain.
- Many species of conservation significance are present in the Kemerton region because it is one of the largest contiguous areas of native vegetation on the Swan Coastal Plain between Bunbury and Perth.

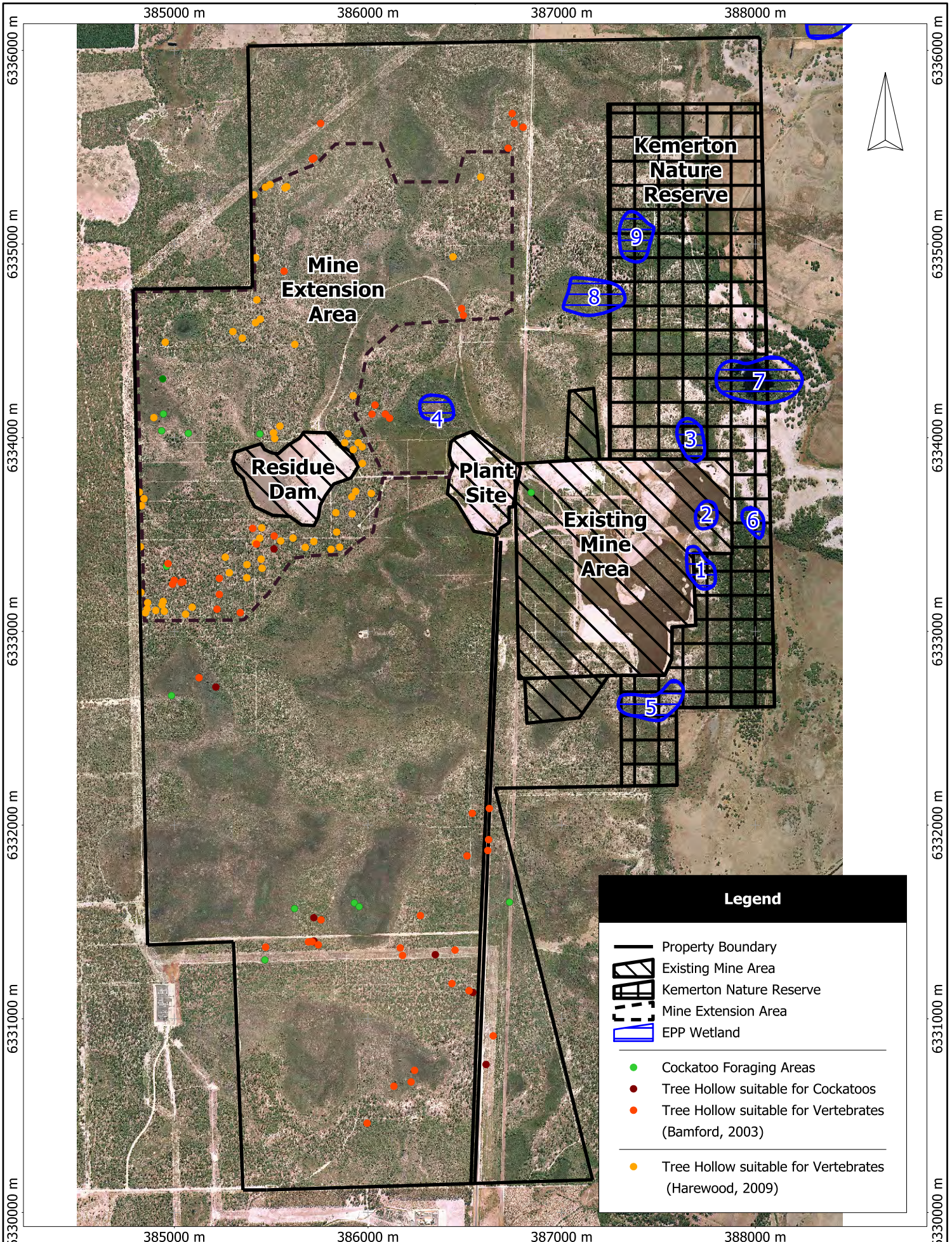
MBS Environmental conducted a review of the latest Bamford fauna surveys and produced a consolidated fauna report which is provided in Appendix 12 (MBS, 2008).

KSS has sponsored a two year Masters Research Program at the School of Natural Sciences at Edith Cowan University on the Jollytail (*Galaxiella nigrostriata*) (Galeotti *et al*. 2008). The research aims to establish which ecological parameters are significant to the conservation of Jollytail populations. This research is on-going and is the final report is expected in February 2010.

KSS commissioned Greg Harewood to conduct a Level 1 terrestrial fauna survey as defined in EPA Guidance Statement 56 (EPA, 2004b) and a targeted survey for the Western Ringtail Possum and the Southern Brush-tailed Phascogale in the proposed mine extension area (Appendix 13). The assessment included a desktop analysis, a daytime site reconnaissance survey that included opportunistic fauna observations, a night time survey and a four night trapping program using Elliot's and cage traps. The field survey was carried out on a number of days and nights between 28 January and 6 February 2009. The location of "habitat" trees identified on site during this survey and others reported by Bamford (2003) are shown in Figure 19.

The results of the targeted inspection of the site for evidence of Western Ringtail Possums failed to find any sign of this species and it is concluded that they are not present on site or are only present rarely as transient individuals (Harewood, 2009). The Southern Brush-tailed Phascogale was captured several times during the trapping program and its use of the site is now confirmed. These species are further discussed in Section 4.11.3.8.

Opportunistic observations of fauna species were made during daytime surveys of the mine extension area. The surveys included a series of transects across the area while searching for fauna or signs of fauna and observations of bird species with binoculars (Harewood, 2009).



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Scale: 1:25000
Original Size: A4
Air Photo Date: 2006
Grid: MGA94(50)
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Kemerton
Silica Sand Pty Ltd

Fauna Habitat Trees and Cockatoo Foraging Areas

Figure 19

W:\Kemerton Silica Sand\Drawings\Maps 2009\Flora and Wetlands.map 15/10/2009 Fauna Habitats Layout

The following information from Bamford (2003) and Harewood (2009) is based on surveys conducted on the KSS property.

Potentially, 20 native mammals (includes nine bat species), 127 bird, 10 frog, 34 reptile and six fish species could be expected to occur in or utilise at times, the KSS area. Of the 197 native animals that are listed as potentially occurring at the site, eight are considered to be endangered/vulnerable or in need of special protection. In addition seven migratory species may frequent the site at times. Ten DEC priority species may also use the site. Eight introduced species may also be present.

4.11.3.1 Freshwater Fish

Freshwater fish recorded within the KSS property include six native species and one introduced species (Table 29).

Table 29: Fish Species

Fish Species	Kemerton Region	KSS Property	Status
Galaxiidae (Jollytails or native minnows)			
Black-striped Jollytail *Galaxiella nigrostriata*	*	*	P3
Western Minnow *Galaxias occidentalis*	*	*	
Percichthyidae (Australian perches)			
Nightfish *Bostockia porosa*	*	*	
Nannopercidae (pygmy-perches)			
Westralian Pygmy-perch *Edelia vittata*	*	*	
Poeciliidae (live-bearers)			
Mosquitofish *Gambusia holbrooki*	*	*	Intro.
Gobiidae (gobies)			
Swan River Goby *Pseudogobius olorum*	+	+	

Source: Bamford (2003) Table 5.
Notes: * Species recorded. + Species expected to occur.
Intro. Species that have been introduced.

In the Kemerton region, only fish species from seasonal wetlands located on the KSS property and Kemerton Nature Reserve have been recorded. Most species are only able to temporarily colonise wetlands in winter, but the Black-striped Jollytail (*Galaxiella nigrostriata*) is a resident. The Black-striped Jollytail (Jollytail) is listed as Priority 3 by DEC.

The Jollytail is restricted to two remnant populations (one at KSS and the other north of Perth) on the Swan Coastal Plain and more widely distributed in the Great Southern region of Western Australia between the towns of Northcliffe to Esperance. It inhabits a range of conditions from fresh water pools, slow-flowing rivers, fast flowing streams, swamps, freshwater lakes and road side ditches.

It can be found in and around submerged vegetation in lakes and swamps and can tolerate acidic water that is tannin stained and with a pH as low as 4.5. It is capable of lying dormant during summer from damp sediments. The Jollytail is widespread when water levels are high,

but relies on a few summer refuge sites, where it survives in deep, cool pools and, when these dry out, retreats to water contained in the burrows of freshwater crayfish (Bamford, 2002; Morgan *et al.* 1998). In 1997, there were five such refuges: EPP5, EPP8, EPP9 and two sites referred to as Flooded Track and West Pool (Bamford, 2002). Each refuge is only a few metres across and the number of fish that survives through summer is low, with the total population probably less than a thousand when the wetlands flood in winter.

The extent of winter/spring dispersal of the Jollytails is dependent upon rainfall and water levels (Bamford, 2002). In years of high rainfall, they disperse widely and some other fish species colonise from the Wellesley River, but these other species (both native and introduced) do not survive in the naturally seasonal Kemerton wetlands (Bamford, 2002). Jollytails disperse into EPP7 when water levels are high and in years when this wetland does not dry out, they survive the summer/autumn period. When it dried out in 1999, however, the fish did not survive due to the absence of a suitable refuge and the fish have not subsequently recolonised it (Bamford, 2002).

Mining has not directly impacted upon Jollytail refuges, but has prevented the fish from dispersing widely as the dredge pond and return drain have created barriers. Mining has altered seasonal water levels in EPP6, resulting in it flooding earlier and holding water for longer than previously, and this became a sixth refuge in about 2000 (Bamford, 2002).

The Jollytails were badly affected by low water levels in winter/spring 2001. The populations in EPP8, EPP9 and Flooded Track died out because these wetlands did not flood or contained too little water to support breeding (Bamford, 2002). In August 2002, fish were only recorded in EPP5, EPP6 and West Pool, with only small numbers of juvenile fish and no adult fish recorded (Bamford, 2002). This suggests that very few adults survived the dry season of 2001/2002, but that breeding did occur. This reduction from six to three populations as a result of low rainfall and water levels is a natural event that has probably happened before, but it emphasises the vulnerability of the Jollytails at Kemerton and the value of creating another refuge (Bamford, 2002). The fish have the potential to recolonise the other wetlands if water levels are high in subsequent years, but the population in West Pool is isolated from those in EPP5 and EPP6 by the Dredge Pond (Bamford, 2002).

The Jollytails disperse widely during high water levels in winter spreading into the western part of the KSS property. There are no known summer refuges for the species in this area of the property (Morgan *et al.* 1998), but there are patches of vegetation consistent with low lying areas in the western part of the property. These areas may retain water for long enough to serve as refuge areas in successive years of average or above average rainfall. They are indicated as vegetation types F-1, F-2 and F-3 on the vegetation map provided by Mattiske (2003b). The habitat requirements of Jollytail are currently being research through a Masters Project at Edith Cowan University as discussed in Section 4.11.2.

KSS has sponsored a two year Masters Research Program at the School of Natural Sciences at Edith Cowan University on the Jollytail (Galaxiella nigrostriata) (Galeotti *et al.* 2008). The research aims to establish which ecological parameters are significant to the conservation of Jollytail populations. Little is know about Jollytail habitat preference at a local wetland scale. It remains unknown what preference larvae, juvenile and adult Jollytail have for typical aquatic habitat features such as emergent vegetation type, shade requirements, submerged logs and woody debris, or the type of benthic substrate. The preferred physico-chemical water properties for Jollytail are also uncertain. To fully understand their habitat requirements,

water properties such as dissolved oxygen, salinity, water depth ranges or flow velocity, are required (Galeotti *et al*. 2008). Knowledge of physico-chemical water properties are important for rehabilitating wetlands for fish re-introductions and baseline information for future monitoring of water quality as an indicator of fish health.

Aestivation (a state of dormancy somewhat similar to hibernation) requirements for Jollytail are not well known. The following research questions will be explored:

- How long Jollytails aestivate.
- Mortality rates while aestivating.
- Effect of groundwater depth below wetlands.
- Effect of substrate type.
- Do Jollytails use crayfish burrows to avestivate?
- Is aestivation necessary to complete the Jollytail life cycle?
- Do physical changes occur while aestivating.

Jollytail have a short (one year) life cycle so it is important that aestivation requirements are considered when designing rehabilitation and conservation management plans (Magoulick *et al.* 2003; Galeotti *et al*. 2008).

Research took place using the three known population areas of Jollytail in south-western Western Australia. Field work was carried out between October and November 2008 and involved three trips to KSS, one to Melaleuca Park north of Perth and an extended trip between Augusta and Walpole. A total of 27 wetlands at six locations were surveyed, with 196 fish caught out of 213 transects. As part of the habitat requirements/analysis, water samples were collected at each wetland and analysed for nutrients and metals. To obtain diet information, macroinvertebrate transects were conducted at all 11 wetlands that were surveyed for fish at KSS. Some of the fish specimens have already been measured for length and weight and then dissected for stomach content analysis and to provide tissue samples for stable isotope analysis. This research is on-going and is the final report is expected in February 2010. The results of the research project will help KSS design and construct rehabilitation that best enhances long-term survival prospects of Jollytails, and investigate ways of protecting Jollytails from the introduced Mosquitofish (*Gambusia*).

The Westralian Pygmy-perch, Western Minnow, Nightfish and introduced Mosquitofish require permanent water and only colonise some wetlands of the KSS property during years of high water levels in winter and spring. They are unlikely to disperse as far as the western part of the KSS property and could not survive there for more than one season. The dredge pond maintains a permanent population of Mosquitofish.

4.11.3.2 Amphibians

Eight out of 10 frog species expected in the Kemerton region have been recorded on the KSS property (Table 30). Most are closely associated with wetlands and all have aquatic larvae. In addition the Moaning Frog, Sand Frog and Banjo Frog range widely in woodland areas outside the breeding season (Bamford, 2003a).

Table 30: Amphibian Species

Frog Species		Kemerton Region	KSS Property	Status
Myobatrachidae (ground frogs)				
Quacking Froglet	*Crinia georgiana*	+	+	
Glauert's Froglet	*Crinia (Ranidella) glauerti*	*	*	
Squelching Froglet	*Crinia (Ranidella) insignifera*	*	*	
Lea's Froglet	*Geocrinia leai*	*	*	
Moaning Frog	*Heleioporus eyrei*	*	*	
Sand Frog	*Heleioporus psammophilus*	+	+	
Banjo Frog	*Limnodynastes dorsalis*	*	*	
Guenther's Toadlet	*Pseudophryne guentheri*	*	*	
Hylidae (tree frogs)				
Slender Tree Frog	*Litoria adelaidensis*	*	*	
Motorbike Frog	*Litoria moorei*	*	*	

Source: Bamford (2003) Table 6.
Notes: * Species recorded. + Species expected to occur.

None of the frog species are of conservation significance, but populations of the Marbled Frog are uncommon on the Swan Coastal Plain (Bush *et al*. 1995).

4.11.3.3 Reptiles

Thirty-four species of reptiles are expected to be located in the Kemerton region although only 13 of these have been recorded on the KSS property (Table 31). With the exception of the Perth Lined Lerista, all may occur on the property as most of these species such as burrowing snakes are cryptic, and are difficult to trap and record (Bamford, 2003a).

Table 31: Reptile Species

Reptile Species		Kemerton Region	KSS Property	Status
Chelidae (side-neck tortoises)				
Long-necked Tortoise	*Chelodina oblonga*	*	*	
Gekkonidae (geckoes)				
Marbled Gecko	*Phyllodactylus marmoratus*	+	+	
Pygopodidae (legless lizards)				
Sandplain Worm Lizard	*Aprasia repens*	+	+	
Burton's Legless Lizard	*Lialis burtonis*	*	*	
Common Scaleyfoot	*Pygopus lepidopodus*	+	+	
Agamidae (dragon lizards)				
Western Bearded Dragon	*Pogona minor*	*	*	
Varanidae (monitors or goannas)				
Gould's Sand Goanna	*Varanus gouldii*	*	+	
Rosenberg's Goanna	*Varanus rosenbergi*	*	*	

Reptile Species		Kemerton Region	KSS Property	Status
Scincidae (skink lizards)				
South west Cool Skink	*Acritoscincus (Bassiana) trilineatum*	*	*	
Fence Skink	*Cryptoblepharus plagiocephalus*	*	*	
	Ctenotus impar	*	+	
Red-legged Skink	*Ctenotus labillardieri*	*	+	
Western Ctenotus	*Ctenotus australis (lesueurii)*	*	+	
King's Skink	*Egernia kingii*	+	*	
Mourning Skink	*Egernia luctuosa*	*	+	
Salmon-bellied Skink	*Egernia napoleonis*	*	*	
	Glaphyromorphus australis	+	+	
	Glaphyromorphus sp.	?	?	
	Hemiergis quadrilineata	*	*	
	Lerista distinguenda (?elegans)	*	*	
Perth Lined Lerista	*Lerista lineata*	?+		P3
Dwarf Skink	*Menetia greyii*	*	*	
	Morethia lineoocellata	*	*	
Bobtail	*Tiliqua rugosa*	*	*	
Typhlopidae (blind snakes)				
	Ramphotyphlops australis	*	+	
Boidae (pythons)				
Southern Carpet Python	*Morelia spilota imbricata*	+	+	S4, P4
Elapidae (front-fanged snakes)				
Crowned Snake	*Notechis coronatus*	+	+	
Bardick	*Notechis curtus*	+	+	
Tiger Snake	*Notechis scutatus*	*	*	
Dugite	*Pseudonaja affinis*	*	*	
Gould's Snake	*Parasuta (Rhinoplocephalus) gouldii*	+	+	
Black-backed Snake	*Parasuta (Rhinoplocephalus) nigriceps*	+	+	
Jan's Bandy-Bandy	*Simoselaps (Vermicella) bertholdi*	*	+	
Black-naped Snake	*Neelaps (Vermicella) bimaculata*		+	

Source: Bamford (2003) Table 7.
Notes: * Species recorded. + Species expected to occur.

The majority of reptile species are likely to be widespread on the KSS property, but will avoid areas that are inundated for long periods of time. The woodland will support the most species, although a few species are aquatic or closely associated with riparian vegetation around wetlands, including the Long-necked Tortoise, South west Cool Skink, the skink *Glaphyromorphus australis*, Mourning Skink and Tiger Snake (Bamford, 2003a).

The Southern Carpet Python is classified as P4 by DEC and classified as S4 under the *WC Act*. This species has a wide distribution within the south-west but is uncommon, occurring north to Geraldton and Yalgoo and east to Pinjin, Kalgoorlie, Fraser Range and Eyre (Storr *et al.* 2002). It could be present in almost any habitat, but requires dense vegetation and tree hollows for shelter. The Southern Carpet Python is known to occur in Banksia woodlands,

Eucalypt woodlands and grasslands of the south-west region of Western Australia. Is present on the KSS property and the general area population densities can be expected to be very low.

The only P3 listed species expected to occur in the region, the Perth Lined Lerista, has not been observed on the KSS property. It could be present in deep sandy soils of Banksia woodland in the north of Kemerton but all recent records in the area are from within near coastal (one to two kilometre) dunes (Bamford, 2008). It is included on the list of species expected to occur in the region on the basis of single records at Yalgorup to the north (Youngson and Harold, 1989) and Busselton to the south (Storr *et al.* 1999), and the presence of suitable habitat (Bamford, 2003a). It is know to occur in the lower west coast from Perth to Leschenault Peninsula (Harewood, 2009). It has also been found at Rottnest Island and Garden Island (Storr *et al.* 1999). If present the Perth Lined Lerista is likely to persist and recolonise rehabilitated areas from adjoining vegetation.

4.11.3.4 Birds

Seventy-six species of birds have been recorded from 129 species expected to occur on the KSS property (Table 32). Bamford (2003) noted the dredge pond attracts waterbirds that inhabit permanent water bodies. This wetland is still in early stages of rehabilitation and will become more attractive to waterbirds as rehabilitation areas develop and riparian vegetation becomes more established.

Table 32: Bird Species

Species		Kemerton Region	KSS Property	Status
Casuariidae (emus and cassowaries)				
Emu	*Dromaius novaehollandiae*	*	*	
Phasianidae (pheasants and quails)				
Brown Quail	*Coturnix ypsilophora*		+	
Stubble Quail	*Coturnix pectoralis*		+	
Anatidae (ducks, geese and swans)				
Black Swan	*Cygnus atratus*	*	*	
Freckled Duck	*Stictonetta naevosa*	+	+	
Australian Shelduck	*Tadorna tadornoides*	*	*	
Pacific Black Duck	*Anas superciliosus*	*	*	
Grey Teal	*Anas gibberifrons*	*	*	
Chestnut Teal	*Anas castanea*	+	+	
Australasian Shoveler	*Anas rhynchotis*	+	+	
Pink-eared Duck	*Malacorhynchus membranaceus*	+	+	
Hardhead (White-eyed Duck)	*Aythya australis*	*	*	
Australian Wood Duck	*Chenonetta jubata*	*	*	
Musk Duck	*Biziura lobata*	*	+	
Blue-billed Duck	*Oxyura australis*	*	+	
Podicepididae (grebes)				
Great Crested Grebe	*Podiceps cristatus*	+	+	
Hoary-headed Grebe	*Poliocephalus poliocephalus*	*	*	
Australasian Grebe	*Tachybaptus novaehollandiae*	*	+	

Species		Kemerton Region	KSS Property	Status
Anhingidae (darters)				
Darter	*Anhinga melanogaster*	*	+	
Phalacrocoracidae (cormorants)				
Great Cormorant	*Phalacrocorax carbo*	*		
Pied Cormorant	*Phalacrocorax varius*	*		
Little Black Cormorant	*Phalacrocorax sulcirostris*	*	+	
Little Pied Cormorant	*Phalacrocorax melanoleucos*	*	*	
Ardeidae (herons and egrets)				
White-faced Heron	*Egretta novaehollandiae*	*	*	
Little Egret	*Egretta garzetta*	+	+	
White-necked Heron	*Ardea pacifica*	*	*	
Great Egret	*Ardea alba*	*	+	Migratory
Cattle Egret	*Ardea ibis*	+	+	Migratory
Rufous Night Heron	*Nycticorax caledonicus*	*	+	
Little Bittern	*Ixobrychus minutus*	+	+	P4
Black Bittern	*Ixobrychus flavicollis*	+	+	P3
Australasian Bittern	*Botaurus poiciloptilus*	+	+	Vulnerable, S1
Plataleidae (ibis and spoonbills)				
Glossy Ibis	*Plegadis falcinellus*	+	+	Migratory
Australian White Ibis	*Threskiornis molucca*	*	*	
Straw-necked Ibis	*Threskiornis spinicollis*	*	+	
Yellow-billed Spoonbill	*Platalea flavipes*	*	+	
Accipitridae (kites, hawks and eagles)				
Black-shouldered Kite	*Elanus axillaris*	*	*	
Square-tailed Kite	*Lophoictinia isura*	+	+	
Whistling Kite	*Haliastur sphenurus*	*	*	
Swamp Harrier	*Circus approximans*	*	*	
Brown Goshawk	*Accipiter fasciatus*	*	+	
Collared Sparrowhawk	*Accipiter cirrhocephalus*	*	*	
Wedge-tailed Eagle	*Aquila audax*	*	*	
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	*		Migratory
Little Eagle	*Hieraaetus morphnoides*	*	+	
Falconidae (falcons)				
Peregrine Falcon	*Falco peregrinus*	+	+	S4
Australian Hobby	*Falco longipennis*	*	*	
Brown Falcon	*Falco berigora*	*	*	
Nankeen Kestrel	*Falco cenchroides*	*	*	
Turnicidae (button-quails)				
Painted Button-quail	*Turnix varia*	*	*	
Rallidae (crakes and rails)				
Buff-banded Rail	*Rallus philippensis*	*	+	
Baillon's Crake	*Porzana pusilla*	*	+	
Spotless Crake	*Porzana tabuensis*	*	+	

Species		Kemerton Region	KSS Property	Status
Australian Crake	*Porzana fluminea*	+	+	
Black-tailed Native-hen	*Gallinula ventralis*	*	+	
Dusky Moorhen	*Gallinula tenebrosa*	*	+	
Purple Swamphen	*Porphyrio porphyrio*	*	*	
Eurasian Coot	*Fulica atra*	*	*	
Scolopacidae (sandpipers)				
Common Greenshank	*Tringa nebularia*	*	*	Migratory
Common Sandpiper	*Tringa hypoleucos*	*	*	Migratory
Recurvirostridae (stilts and avocets)				
Black-winged Stilt	*Himantopus himantopus*	+	+	
Charadriidae (lapwings and plovers)				
Red-capped Plover	*Charadrius ruficapillus*	*	+	
Black-fronted Dotterel	*Elseyornis melanops*	*	*	
Red-kneed Dotterel	*Erythrogonys cinctus*	*	+	
Columbidae (pigeons and doves)				
Laughing Turtle-Dove	*Streptopelia senegalensis*	+	+	Intro.
Common Bronzewing	*Phaps chalcoptera*	*	*	
Crested Pigeon	*Ocyphaps lophotes*	*	+	
Cacatuidae (cockatoos)				
Forest Red-tailed Black-Cockatoo	*Calyptorhynchus banksii* sub. *naso*	*	*	S1
Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	*	*	Endangered, S1
Baudin's Black-Cockatoo	*Calyptorhynchus baudinii*	+	+	Vulnerable, S1
Galah	*Cacatua roseicapilla*	+	+	
Psittacidae (lorikeets and parrots)				
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*	*	+	
Regent Parrot	*Polytelis anthopeplus*	*	*	
Red-capped Parrot	*Purpureicephalus spurius*	*	*	
Western Rosella	*Platycercus icterotis*	*	+	
Australian Ringneck Parrot	*Barnardius zonarius*	*	*	
Elegant Parrot	*Neophema elegans*	*	*	
Cuculidae (cuckoos)				
Pallid Cuckoo	*Cuculus pallidus*	*	*	
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*	*	*	
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	*	*	
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*	*	*	
Strigidae (hawk-owls)				
Barking Owl	*Ninox connivens connivens*	+	+	P2
Southern Boobook Owl	*Ninox novaeseelandiae*	*	+	
Tytonidae (barn owls)				
Masked Owl	*Tyto novaehollandiae*	+	+	P3
Barn Owl	*Tyto alba*	+	+	

Species		Kemerton Region	KSS Property	Status
Podargidae (frogmouths)				
Tawny Frogmouth	*Podargus strigoides*	*	*	
Aegothelidae (owlet-nightjars)				
Australian Owlet-nightjar	*Aegotheles cristatus*	*	+	
Halcyonidae (forest kingfishers)				
Laughing Kookaburra	*Dacelo novaeguineae*	*	*	Intro.
Sacred Kingfisher	*Todiramphus sanctus*	*	*	
Meropidae (bee-eaters)				
Rainbow Bee-eater	*Merops ornatus*	*	*	Migratory
Maluridae (fairy-wrens)				
Southern Emu-wren	*Stipiturus malachurus*	+	+	
Splendid Fairy-wren	*Malurus splendens*	*	*	
Pardalotidae (pardalotes)				
Spotted Pardalote	*Pardalotus punctatus*	*	*	
Striated Pardalote	*Pardalotus striatus*	*	*	
White-browed Scrubwren	*Sericornis frontalis*	*	*	
Western Gerygone	*Gerygone fusca*	*	*	
Weebill	*Smicrornis brevirostris*	*	*	
Inland Thornbill	*Acanthiza apicalis*	*	*	
Western Thornbill	*Acanthiza inornata*	*	*	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	*	*	
Meliphagidae (honeyeaters)				
Red Wattlebird	*Anthochaera carunculata*	*	*	
Western Wattlebird	*Anthochaera lunulata*	+	+	
Singing Honeyeater	*Lichenostomus virescens*	*	+	
White-naped Honeyeater	*Melithreptus lunatus*	+	+	
Brown Honeyeater	*Lichmera indistincta*	*	*	
New Holland Honeyeater	*Phylidonyris novaehollandiae*	*	*	
White-cheeked Honeyeater	*Phylidonyris nigra*	*	*	
Tawny-crowned Honeyeater	*Phylidonyris melanops*	*	+	
Western Spinebill	*Acanthorhynchus superciliosus*	*	*	
White-fronted Chat	*Epthianura albifrons*	*	*	
Petroicidae (Australian robins)				
Scarlet Robin	*Petroica multicolor*	*	*	
Western Yellow Robin	*Eopsaltria griseogularis*	*	+	
Neosittidae (sittellas)				
Varied Sittella	*Daphoenositta chrysoptera*	*	+	
Pachycephalidae (whistlers)				
Golden Whistler	*Pachycephala pectoralis*	*	*	
Rufous Whistler	*Pachycephala rufiventris*	*	*	
Grey Shrike-thrush	*Colluricincla harmonica*	*	*	
Dicruridae (flycatchers)				
Magpie-lark	*Grallina cyanoleuca*	*	*	

Species		Kemerton Region	KSS Property	Status
Grey Fantail	*Rhipidura fuliginosa*	*	*	
Willie Wagtail	*Rhipidura leucophrys*	*	*	
Campephagidae (cuckoo-shrikes)				
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	*	*	
Artamidae (woodswallows)				
Black-faced Woodswallow	*Artamus cinereus*	*	*	
Dusky Woodswallow	*Artamus cyanopterus*	*	*	
Grey Butcherbird	*Cracticus torquatus*	*	*	
Australian Magpie	*Gymnorhina tibicen*	*	*	
Corvidae (ravens and crows)				
Grey Currawong	*Strepera versicolor*	*	*	
Australian Raven	*Corvus coronoides*	*	*	
Motacillidae (pipits and true wagtails)				
Richard's Pipit	*Anthus novaeseelandiae*	*	*	
Hirundinidae (swallows)				
Welcome Swallow	*Hirundo neoxena*	*	*	
Tree Martin	*Hirundo nigricans*	*	*	
Sylviidae (old world warblers)				
Clamorous Reed-Warbler	*Acrocephalus stentoreus*	*	*	
Little Grassbird	*Megalurus gramineus*	*	*	
Zosteropidae (white-eyes)				
Silvereye	*Zosterops lateralis*	*	*	

Source: Bamford (2003) Table 8.
Notes: * Species recorded. + Species expected to occur.

Waterbird surveys from 1997 to 2001 found that most waterbirds in the area rely on EPP7, (Bamford, 2002). Numbers were greatest on this wetland in late summer, indicating that it is used as a dry season refuge. Waterbird numbers have gradually increased on the dredge pond, with largest numbers in late summer. In March 2002, a count of 130 Australian Shelduck on the Dredge Pond was the highest number of this species recorded since counting began on any of the wetlands (Bamford, 2002). Over the course of the five surveys, seven waterbird species were recorded on the Dredge Pond (Bamford, 2002). Dry conditions in the region probably contributed to the abundance of waterbirds on the Dredge Pond, although some reshaping of banks and planting has probably contributed to its attractiveness to waterbirds (Bamford, 2002). Other wetlands support only low numbers of waterbirds, with the most notable feature being a small breeding colony of the Little Pied Cormorant, although this colony was absent for the first time in 2001.

Four species of S1 status are expected in the Kemerton region, three of which have been recorded within the KSS property (Table 32). The Carnaby's Black-Cockatoo (Endangered), Baudin's Back-Cockatoo (Vulnerable) and Forest Red-tailed Black-Cockatoo have been observed foraging in pine plantations and Eucalypt and *Banksia* woodlands.

The Australasian Bittern (Vulnerable) is a waterbird favouring swamps with dense reed cover. There is little habitat of this nature in the Kemerton region, but it is known to inhabit nearby Benger Swamp and may occasionally visit the KSS property. Australasian Bittern is a

nocturnal species which inhabits densely vegetated wetlands, feeding on aquatic animals such as frogs, eels and freshwater crustaceans. It is a solitary nester on the ground in dense wetland vegetation on trampled reeds and other plants (Slater *et al.* 1995). Suitable habitat for the Australasian Bittern within the proposed mine extension area is very limited, it is anticipated that there would be no impact to this species (Harewood, 2009).

Baudin's Black-Cockatoo, is a more specialised feeder of Eucalypts and is restricted to tall Eucalypt forests of the south-west region of Western Australia. This species of Cockatoo nests in large tree hollows, 30 – 40 centimetres in diameter and more than 30 centimetres deep (Saunders, 1974). The property is likely to provide opportunistic pickings from woodlands rather than a continual, reliable food source, feeding on hard seeds such as Banksia, Hakea and introduced pines (Slater *et al.* 1995). Evidence of Baudin's Black-Cockatoo foraging (chewed marri nuts) were observed within the mine extension area. While numerous Banksia cones showing signs of cockatoo foraging (seeds and grubbing) were observed some or all of this activity could be attributed to the Carnaby's and not the Baudin's Black-Cockatoos (Harewoood, 2009). This species is probably a seasonally controlled infrequent visitor to the general area for the purposes of foraging on Marri, Banksia and Flooded Gum, thou the small number of potential nest hollows present and the probability of breeding on site is low (Harewood, 2009).

Carnaby's Black-Cockatoo is confined to the south-west of Western Australia , north to the lower Murchison and east to Ravensthorpe Range and a casual visitor on Rottnest Island (Johnstone and Storr, 1998). Carnaby's Black-Cockatoo has specific nesting requirements. Nests are mostly in smoothed-barked eucalypts, ranging from 2.5 to 12 metres above the ground with an entrance from 23 to 30 centimetres diameter and a depth of 0.1 to 2.5 metres (Johnstone and Storr, 1998). Several small flocks of this species were observed during the survey and evidence of foraging (chewed Jarrah nuts and Banksia cones) although some of this could be attributed to the Forest Red-tailed Black-Cockatoos (Harewoood, 2009). This species is probably a seasonally controlled infrequent visitor to the general area for the purposes of foraging on Marri, Banksia and Flooded Gum, though the small number of potential nest hollows present and the probability of breeding on site is low (Harewood, 2009).

The Forest Red-tailed Black-Cockatoo is restricted to the Eucalypt forests of the south-west of Western Australia. Forest Red-tailed Black-Cockatoos have been found breeding in the Darling Range, and on the Swan Coastal Plain. They feed on the seeds of Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*), Blackbutt (*Eucalyptus patens*) and Sheoak (*Allocasuarina fraseriana*) among others. Birds nest in hollows in Marri or Jarrah with an entrance diameter of 12 to 41 centimetres (Johnstone and Storr, 1998). Several small flocks of this species were observed within the proposed mine extension area during site surveys (Harewood, 2009) and it has previously been recorded by Bamford (2004). As noted in Bamford (2003), the woodlands of the KSS property have been disturbed by logging in the past and now contain few very large trees, reducing the number of large tree hollows suitable for nest sites. This species appears to be a frequent visitor to the KSS property for the purposes of foraging, though the small number of potential nest hollows present and the probability of breeding on site is low (Harewood, 2009).

One species of S4 status is expected in the Kemerton region, although has not been recorded (Table 32). The Peregrine Falcon although widespread, has low numbers on the coastal plain,

including agricultural areas. If it is present in the Kemerton region and the KSS property, its habitat would be nest trees, as it nests in large, shallow hollows found only in very large trees. One P2 species is expected in the Kemerton region, although it has not been recorded (Table 32). The Barking Owl is unlikely to be present at KSS as the property lacks large nest hollows suitable for nesting and roosting (Slater *et al.* 1995).

Two P3 species are expected in the Kemerton region, although they have not been recorded (Table 32). The Black Bittern is a wading bird, likely to feed in open waters, mostly nests in solitary in dense trees overhanging water or mangroves (Slater *et al.* 1995). While it may visit the EPP wetland to the east of the property it is unlikely to use the proposed mine extension area as the extent of suitable habitat is very limited (Harewood, 2009). The Masked Owl is unlikely to be present on the KSS property as it lacks large nest hollows that are suitable for nesting and roosting (Slater *et al.* 1995).

One species of P4 status is expected in the Kemerton region, although has not been recorded (Table 32). The Little Bittern is a wading bird, likely to feed in open waters, mostly diurnally unlike other bitterns. The Little Bittern breeds solitary in reed beds and can be difficult to see, given its skulking lifestyle and reed bed habitat (Slater *et al.* 1995). While it may visit the EPP wetland to the east of the property it is unlikely to use the proposed mine extension area as the extent of suitable habitat is very limited (Harewood, 2009). One of the key rehabilitation factors, described in Section 7.7, is the increased conservation value of summer refuge for waterbirds, provided by rehabilitated dredge pond lakes.

Seven Migratory Species have the potential to occur on the KSS property. Three of these have been recorded, Common Greenshank and Common Sandpiper (only sighted on the dredge pond) and the Rainbow Bee-eater. The Great Egret, Cattle Egret, Glossy Ibis and White-bellied Sea Eagle have not been recorded in site surveys (Table 32). The Common Sandpiper is most likely found on shores of estuaries and rivers throughout Australia (Slater *et al.* 1995). Common Greenshank is a common migrant of coastal mudflats, estuaries, salt marshes, mangroves, lakes and swamps throughout Australia (Slater *et al.* 1995). These two Migratory birds have been found on the KSS property during site surveys (Table 32).

The Great Egret is a water bird and breeds in colonies in trees close to large lakes with reed beds or other extensive wetlands, sometimes apart from other egrets but often with Cormorants and Night Herons (Slater *et al.* 1995). Cattle Egret is a water bird and breeds in colonies in trees usually over water and often with other species (Slater *et al.* 1995). It is possible that the Great Egret and Cattle Egret occur on site, but have not been recorded during site surveys (Table 32).

Fork-tailed Swift spends most of their lives in the air, living on the insects they catch in their beaks (Slater *et al.* 1995). It has not been recorded in surveys and is unlikely to use the site. The Glossy Ibis frequents swamps and lakes throughout much of the Australian mainland, but is most numerous in the north. It has been infrequently recorded in the south-west, but has the potential to use the inundated open areas in wetter months of the year (Harewood, 2009). It is not anticipated to be impacted by the mine extension area.

4.11.3.5 Mammals

Twelve of the 27 species expected to occur on the KSS property have been recorded. Of these, six are introduced species, four S1, three P4 and one P5 species (Table 33). The KSS

property has the potential to support all 27 mammal species recorded or expected in the Kemerton region, and while the majority range widely over available habitats, some have specific preferences (Bamford, 2003a; Harewoood, 2009).

Table 33: Mammal Species

Species		Kemerton Region	KSS Property	Status
Tachyglossidae (echidnas)				
Echidna	*Tachyglossus aculeatus*	+	+	
Dasyuridae				
Chuditch, Western Quoll	*Dasyurus geoffroii*	*	+	Vulnerable, S1
Southern Brush-tailed Phascogale	*Phascogale tapoatafa ssp*	*	*	S1
Peramelidae (bandicoots)				
Quenda or Southern Brown Bandicoot	*Isoodon obesulus*	*	*	P5
Phalangeridae (possums)				
Common Brushtail Possum	*Trichosurus vulpecula*	*	+	
Tarsipedidae (honey possum)				
Honey Possum	*Tarsipes rostratus*	*	*	
Pseudocheiridae (ringtail possum)				
Western Ringtail Possum	*Pseudocheirus occidentalis*	+	+	Vulnerable, S1
Burramyidae (pygmy possums)				
Western Pygmy Possum	*Cercartetus concinnus*	*	*	
Macropodidae (kangaroos and wallabies)				
Quokka	*Setonix brachyurus*	+	+	Vulnerable, S1
Western Grey Kangaroo	*Macropus fuliginosus*	*	*	
Western Brush Wallaby	*Macropus irma*	*	*	P4
Mollosidae (mastiff bats)				
White-striped Bat	*Tadarida australis*	*	+	
	Mormopterus planiceps	+	+	
Vespertilionidae (vesper bats)				
Gould's Wattled Bat	*Chalinolobus gouldii*	*	+	
Chocolate Wattled Bat	*Chalinolobus morio*	+	+	
Western False Pipistrelle	*Falsistrellus mackenziei*	*	+	P4
Southern Forest Bat	*Vespadelus (Eptesicus) regulus*	*	+	
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	*	+	
Gould's Long-eared Bat	*Nyctophilus gouldii*	+	+	
Greater Long-eared Bat	*Nyctophilus major*	*	+	
Muridae (rats and mice)				
Rakali or Water Rat	*Hydromys chrysogaster*	*	*	P4
Moodit or Southern Bush Rat	*Rattus fuscipes*	+	+	
House Mouse	*Mus musculus*	*	*	Intro

Species		Kemerton Region	KSS Property	Status
Black Rat	*Rattus rattus*	*	+	Intro
Leporidae (rabbits and hares)				
Rabbit	*Oryctolagus cuniculus*	*	*	Intro
Canidae (foxes and dogs)				
European Red Fox	*Vulpes vulpes*	*	*	Intro
Felidae (cats)				
Feral Cat	*Felis catus*	*	*	Intro
Suidae (pigs)				
Feral Pig	*Sus scrofa*	*	*	Intro

Source: Bamford (2003) Table 9.
Notes: * Species recorded. + Species expected to occur.

Four S1 species have the potential to occur on the KSS property. One of these species, the Southern Brush-tailed Phascogale has been recorded on the KSS property. The Southern Brush-tailed Phoscogale distribution is usually very sparse, with female home ranges spanning from 20 to 70 hectares and not overlapping with those of unrelated females (Strahan, 1995). Male home ranges are more than double, overlapping with other females and males and expanding greatly during the breeding season (Strahan, 1995). The Southern Brush-tailed Phascogale was captured several times during the trapping program and its use of the site is now confirmed. This species is further discussed in Section 4.11.3.8.

Three S1 species also listed as Vulnerable have the potential to occur on the KSS property but have not been recorded in site surveys. These include the Chuditch, Western Ringtail Possum and the Quokka.

Dasyurus geoffroii, the Chuditch, tend to rely on large trees for habitat and breed in areas where predators are not controlled. This species requires dense bush and scrub to provide abundant cover. An adult female Chuditch may utilise an estimated 66 to 110 den sites within her home range. Typically female Chuditch have a home range of three to four square kilometres and seldom overlap with other females. The male Chuditch has a home range of 15 square kilometres. If the Chuditch does occur on the property it is expected to be in very low numbers considering the home range distance required. Records of the Chuditch is based upon a road-kill specimen found in 1997 on the Old Coast Road to the south-west of the Kemerton region, and one seen crossing Treasure Road in 1998. Wilcox and Bamford (2004) conducted a trapping survey in the western portion of the KSS property to provide specific survey information on the possible presence of the Chuditch; this is described in Section 4.11.3.6.

Pseudocheirus occidentalis or Western Ringtail Possum, tend to be restricted to near coastal areas of peppermint (*Agonis flexuosa*) woodlands and peppermint/tuart associations from Bunbury to Albany (Spearwood vegetation complexes). Tree hollows and dreys in tree canopies are used for their nesting sites. The Western Ringtail Possum has a home range between one and five hectares and can overlap by about 70%. Individual possums use between three and eight different nest sites a year and numerous nest sites are required to support high-density populations. The Western Ringtail Possum is nocturnal and so most active at night. Vegetation on the property is predominantly Bassendean - Central and South

consists of very little Spearwood Dune vegetation assemblages with peppermint (*Agonis flexuosa*), so KSS is a less preferred habitat. Bamford (2003) listed the Western Ringtail Possum as a species known or believed to have become extinct in the Kemerton region since European settlement. It had not been recorded in fauna surveys undertaken at the KSS property prior to 2008. Recent discussions with DEWHA and DEC indicated reintroduction of this species in areas north and west of KSS had seen its distribution increasing. A targeted inspection of the proposed mine extension area in January 2009 for evidence of Western Ringtail Possums failed to find any sign of this species and it is concluded that they are not present on site or are only present rarely as transient individuals (Harewood, 2009). This species is further discussed in Sections 4.11.3.8.

Setonix brachyurus or Quokka prefer densely vegetated areas around swamps and streams and hide in runs among vegetation during the day. Mainland populations are known from only a few locations in the Darling Range and south-west forests. Quokkas have not been recorded in site fauna surveys. Bamford (2003) lists this species as known or believed to have become extinct in the Kemerton region since European settlement.

Two P4 species, the Water Rat and Brush Wallaby, have been recorded on the KSS property. Rakali or Water-Rat is an aquatic species that has been seen in EPP7. It requires permanent or near-permanent water, so probably occurs in all the permanent wetlands of the Kemerton region, and may be a seasonal visitor to the wetlands of the KSS property (Bamford, 2003a). It will probably colonise the dredge pond as rehabilitation proceeds. The Water Rat searches for food along the shoreline and around submerged roots and sunken log. It eats little plant material, preferring large aquatic insects, fish, crustacean, frogs, lizards and small carrion (Strahan, 1995). The Brush Wallaby is widespread in heaths and woodlands.

One P5 species, the Southern Brown Bandicoot prefers sandy soil with scrubby vegetation and low ground cover areas that are burnt out form time to time (Strahan, 1995). They are nocturnal and prefer to stay close to cover when in search of food on the surface of the ground in shallow, conical holes that it digs (Strahan, 1995). The Southern Brown Bandicoot feeds on insects, earthworms and other invertebrates and also eats fungi and other subterranean plant material. It has only been recorded once in the KSS property and at one site elsewhere in the Kemerton region (Bamford, 1999). Much of the KSS property supports low, dense vegetation favoured by the Southern Brown Bandicoot.

The Honey Possum and Western Pygmy Possum have both been recorded on the KSS property. The persistence of the Honey Possum and Western Pygmy Possum is particularly unusual, reflecting the large area and diversity of native vegetation. The Honey Possum is likely to utilise the dense shrublands and heathlands, especially when flowers are available. The diversity of vegetation types, especially in the KSS property but also throughout the Kemerton region, may be an important feature for the Honey Possum (Bamford, 2003a). The Honey Possum is known to inhabit several shrubland and heath sites in the region including the KSS property. It has a diet of nectar and pollen and when foraging, moves in excited darts from blossom to blossom. The Honey Possum is common only on the swan coastal plain heaths of south-western Western Australia where a rich diversity of nectar-producing plants (esp. member of Proteaceae and Myrtaceae) provide it with food throughout the year (Strahan, 1995).

Cercartetus concinnus or Western Pygmy Possum is found in mallee heath and in dry sclerophyll forest, especially where there is an undergrowth of shrubs, such as *Banksias*,

*Grevilleas, Callistemon*s and *Melaleucas* (Strahan, 1995). Being small and nocturnal it is seldom seen, although it frequently moves about on the ground after dark and is very agile among small branches (Strahan, 1995). It sleeps in a leaf-lined nest in a tree hollow or in the leaves or a grass tree. Feral and domestic cats can be a problem, however the reproductive rate of the species is adaptive to heavy predation (Strahan, 1995). The Western Pygmy Possum is known from a single specimen recorded in 1993 in the western part of the KSS property (Ninox Wildlife Consulting, 1994). It is commonly associated with eucalypts so is presumably present in the woodlands of the KSS property and throughout the Kemerton region.

Other mammals may utilise the woodlands of the Kemerton region, including the eucalypt woodlands of the KSS property. The bat species, which may forage widely at night, probably roost in hollow branches and under loose bark of large trees in the woodland (Bamford, 2003a). The Grey Kangaroo is common throughout the region, and also forages widely over adjacent farmland.

Introduced species are well-represented in the mammal fauna and most are likely to be widespread throughout native vegetation in the region. Introduced species found in the locality of the KSS property include cats, foxes, mice, pigs, rabbits and rats.

4.11.3.6 Chuditch Survey

Wilcox and Bamford (2004) conducted a trapping survey in the western portion of the KSS property to provide specific survey information on the possible presence of the Chuditch (*Dasyurus geoffroii***)**. Forty cage traps were deployed around the perimeter of the property to the south, west and north of the current operation, with intervals of 100 metres between traps. Traps were not deployed in areas where the habitat was considered to be unsuitable. Each trap was covered with a Hessian bag and placed alongside or under logs or shrubs. Traps were open for five nights from the 8 to13 May 2004, for a total of 200 trap-nights. Habitat features such as fallen, hollow trees are particularly significant for Chuditch and were noted. No Chuditch, or any other mammals, were trapped during the survey. Despite this, the habitat available on the KSS property is considered suitable for the Chuditch.

Wilcox and Bamford (2004) report that although no Chuditch were trapped during this survey, a small number are clearly present in the region. They have also been recorded in the Leschenault Peninsula Conservation Park, about 10 kilometres to the west. In a trapping study carried out across Kemerton Industrial Park in 1998, no Chuditch were caught (M. Bamford pers. records). This suggests that the Chuditch was scarce in the region at that time. The KSS property was included in a 1992/1993 fauna survey where no Chuditch were recorded (Ninox Wildlife Consulting, 1994).

4.11.3.7 Cockatoo Survey

Craig *et al.* (2004) conducted surveys of the KSS property in November 2003 and May 2004 to provide specific survey information on Carnaby's (or Short-billed) Black-Cockatoos (*Calyptorhynchus latirostris*) utilising the mine extension area.

To determine the number of birds using the KSS property, and to compare these numbers to nearby areas, three transects were set up. One transect ran around the south, west and northern perimeter of the KSS property and the other two transects were located in natural habitat within 10 kilometres of the KSS property. The southern control transect was located

in an area of *Jarrah* forest about 10 kilometres south-south-west of the KSS property and the northern control transect was located in an area of pine plantations, *Banksia* woodland and damplands about five kilometres north of the KSS property. As Carnaby's Black-Cockatoos occur at relatively low densities overall but are grouped into dense, noisy flocks that are highly conspicuous and easy to detect, transects were carried out from a vehicle. This is because the probability of recording any Carnaby's Black-Cockatoos over the short distances covered by foot would be low but the Cockatoos are conspicuous enough to be as easily detected from a vehicle as on foot.

The transect around the south, west and northern perimeter of the KSS property was 11.1 kilometres long, the southern control transect was 8.7 kilometres long and the northern control transect was 10.4 kilometres long. Each transect was surveyed on five occasions between 17 and 20 November 2003, and on eight occasions between 9 and 12 May 2004. Surveys were conducted in a random order to remove any bias associated with time of day or weather. All birds detected were recorded, as well as whether they were perched or flying. In addition, a record was kept of all other sightings of Carnaby's Black-Cockatoos within the KSS property and notes were taken on their behaviour and plant food species.

In order to assess the potential value of the KSS property as breeding habitat for Carnaby's Black-Cockatoos, all potential habitat trees within the proposed extension were examined from the ground. Upon examination trees were classified as either (i) containing no hollow potentially usable by avifauna, (ii) containing hollows potentially usable by avifauna excluding Cockatoos, or (iii) containing hollows potentially suitable for Carnaby's Black-Cockatoos. Assessments of hollow suitability were made entirely on the entrance diameter of the hollows and did not take into account entrance aspect, hollow location (trunk or spout), etc., which are also likely to influence hollow occupation by Carnaby's Black-Cockatoos.

Report conclusions are:

- The value of the KSS property for breeding is low in a regional context, with no evidence of breeding and few suitable nest hollows.
- Parts of the KSS property support suitable foraging habitats being utilised by species at the time of the field surveys. The abundance and density of birds were similar at control sites.
- The value of foraging habitats on the KSS property was similar to or less than the value of foraging habitats at control sites. The value of foraging habitats is difficult to assess as usage of different plant species varies seasonally and information is not available on seed density in different vegetation types.

Seasonal variations, combined with short survey times make it difficult to determine the value of the KSS property as a foraging and breeding habitat compared with surrounding areas. However numerous surveys have been undertaken (Bamford 2001, 2002, 2003a,b, 2004; Bamford and Ninox Wildlife Consulting, 1993; Ninox Wildlife Consulting, 1993, 1994) and there is no evidence that the KSS property has greater value as foraging and breeding habitats than surrounding areas.

4.11.3.8 Western Ringtail Possum and Southern Brush-tailed Phascogale Survey

Daytime Survey

Diurnal inspections of the site were conducted on foot over the study area from 28 to 29 January 2009 for a total period of about 10 hours (Harewood, 2009). The aim of the survey was to inspect and document habitat quality with respect to its ability to support the two targeted species in addition to searching for the presence of dreys, obvious tree hollows, scats and individual along with any evidence of Phascogale usage (Harewood, 2009).

No direct or indirect evidence of either targeted species was found during the survey period (Harewood, 2009). A number of habitat trees additional to that previously identified were recorded (Figure 19). Evidence of the Common Brushtail Possum was found at several locations in the form of scats (Harewood, 2009).

The vegetation units present on the site are shown in Figure 12. The vegetation community that has the highest potential Western Ringtail Possum habitat quality is C2 which consists of an Open Woodland of *Agonis flexuosa*, with occasional *Banksia attenuata*, *B. ilicifolia* and *Nuytsia floribunda* over mixed shrubs. This unit has a limited extent in the study area (less than four hectares) (Harewood, 2009). The other vegetation unit containing Peppermint (C1) was found to only contain a small number of wide spaced Peppermints and its value as Western Ringtail Possum habitat is considered to relatively low in comparison (Harewood, 2009).

Other vegetation units with the study area have little or no value as Western Ringtail Possum habitat except possibly for dispersal habitat, depending on the vegetation structure present. Low shrubland and heaths which make up a significant proportion of the vegetation on site have no Western Ringtail Possum habitat value (Harewood, 2009).

The Southern Brush-tailed Phascogale feeds mainly on cockroaches, beetles, centipedes, spiders and bull ants and is also an occasional predator of small vertebrates (Strahan, 1995). Nectar from flowering eucalypts also forms part of a Phascogale diet. It is only active between dusk and dawn and may use more than 20 nests in a single year, nesting in hollow tree limbs, rotted stumps and globular bird nests, where it sleeps during the day (Strahan, 1995). The documented preferred habitats of the Southern Brush-tail Phascogale are forests and open woodlands that contain hollow-bearing trees generally with a sparse ground cover (Harewood, 2009). The site inspections suggest that almost all of the Jarrah/Banksia Woodland to Open Woodland units present within the study area (A1 and A2) represent potential Phascogale habitat (Harewood, 2009). Areas containing the highest densities of habitat trees may represent the best quality habitat though other less obvious factors may also be important (Harewood, 2009). The study area was also found to contain many log piles made up of large trees previously cleared. These may also be used by Phascogales as daytime refuge sites, in addition to the mapped habitat trees (Harewood, 2009).

Nocturnal Survey

Nocturnal counts involved systematic searching of potential habitats within the proposal area along close spaced traverses, on foot using a head torch (with 6V incandescent bulb). Nocturnal surveys of potential Western Ringtail Possum and Phascogale habitat were carried out on 28 January and 2 February 2009. The survey work involved about 17 kilometres of transects on foot over a period of approximately eight hours. No sightings of either species were made (Harewood, 2009).

Phascogale Trapping Program

A trapping program for Phascogales was carried out between 2 and 6 of February 2009 (four nights), utilising 60 Elliot traps and four cage traps placed within woodland habitats across the site. The locations of each of the 60 small Elliot trap and three cage traps (total - 252 trap nights) are provided in Appendix 13. Traps were preferentially placed at the base of habitat trees and baited with standard universal bait and left open for four nights (Harewood, 2009).

Two Phascogales were captured and evidence of another Phascogale was also found in a closed trap (scats, fur), though this was likely left by the same individual capture on the subsequent night, at the same location (Harewood, 2009).

4.11.4 Listed Conservation Significance Fauna Species

A Threatened and Priority Fauna search was conducted on 17 December 2008 to determine conservation significant species of mammals, birds and reptiles known to occur in the Kemerton region and listed under the *Wildlife Conservation Act.* A search of the database managed by DEWHA was undertaken on 12 December 2008. The results are presented in Table 34. Additional details including the likelihood of species being present within the KSS property and proposed mine extension area are discussed in more detail above.

Table 34: Conservation Significant 1 Fauna Species Likely to be Found at KSS

Species	Type	Common Name	Conservation Status		KSS Property
			WC Act	*EPBC Act*	
Botaurus poiciloptilus	Bird	Australasian Bittern	S1		+
Calyptorhynchus latirostris	Bird	Carnaby's Black-Cockatoo	S1	Endangered	*
Calyptorhynchus banksii sub. *naso*	Bird	Forest Red-tailed Black-Cockatoo	S1		+
Calyptorhynchus baudinii	Bird	Baudin's Black-Cockatoo	S1	Vulnerable	+
Dasyurus geoffroii	Mammal	Chuditch, Western Quoll	S1	Vulnerable	+
Phascogale tapoatafa ssp.	Mammal	Southern Brush-tailed Phascogale	S1		*
Pseudocheirus occidentalis	Mammal	Western Ringtail Possum	S1	Vulnerable	+
Setonix brachyurus	Mammal	Quokka	S1	Vulnerable	+

Source: Bamford (2003).
Notes: * Species recorded. + Species expected to occur.

4.11.5 Iconic Species

There are a number of fauna species recorded on the property that KSS consider iconic at the local level which currently occur in a restricted number of locations. These include:

- Black-striped Jollytail *Galaxiella nigrostriata* (P3) — The Kemerton population is a relict, with other populations known on the Swan Coastal Plain only near Muchea north of Perth and Melaleuca Park 12 kilometres north east of Wanneroo. The main population occurs in wetlands along the

	south coast east of Margaret River.
• Rakali or Water Rat *Hydromys chrysogaster* (P4)	An aquatic species recorded in EPP7 which requires permanent or near permanent water.
• Honey Possum *Tarsipes rostratus*	The Honey Possum is known from several sites in the region including the KSS property, especially in shrubland and heath.
• Western Pygmy Possum *Cercartetus concinnus*	The Western Pygmy Possum is known from a single specimen recorded in 1993 in the western part of the KSS property (Ninox Wildlife Consulting, 1994). It is commonly associated with eucalypts so is presumably present in woodlands of the KSS property and throughout the Kemerton region.

4.11.6 Short Range Endemic Species

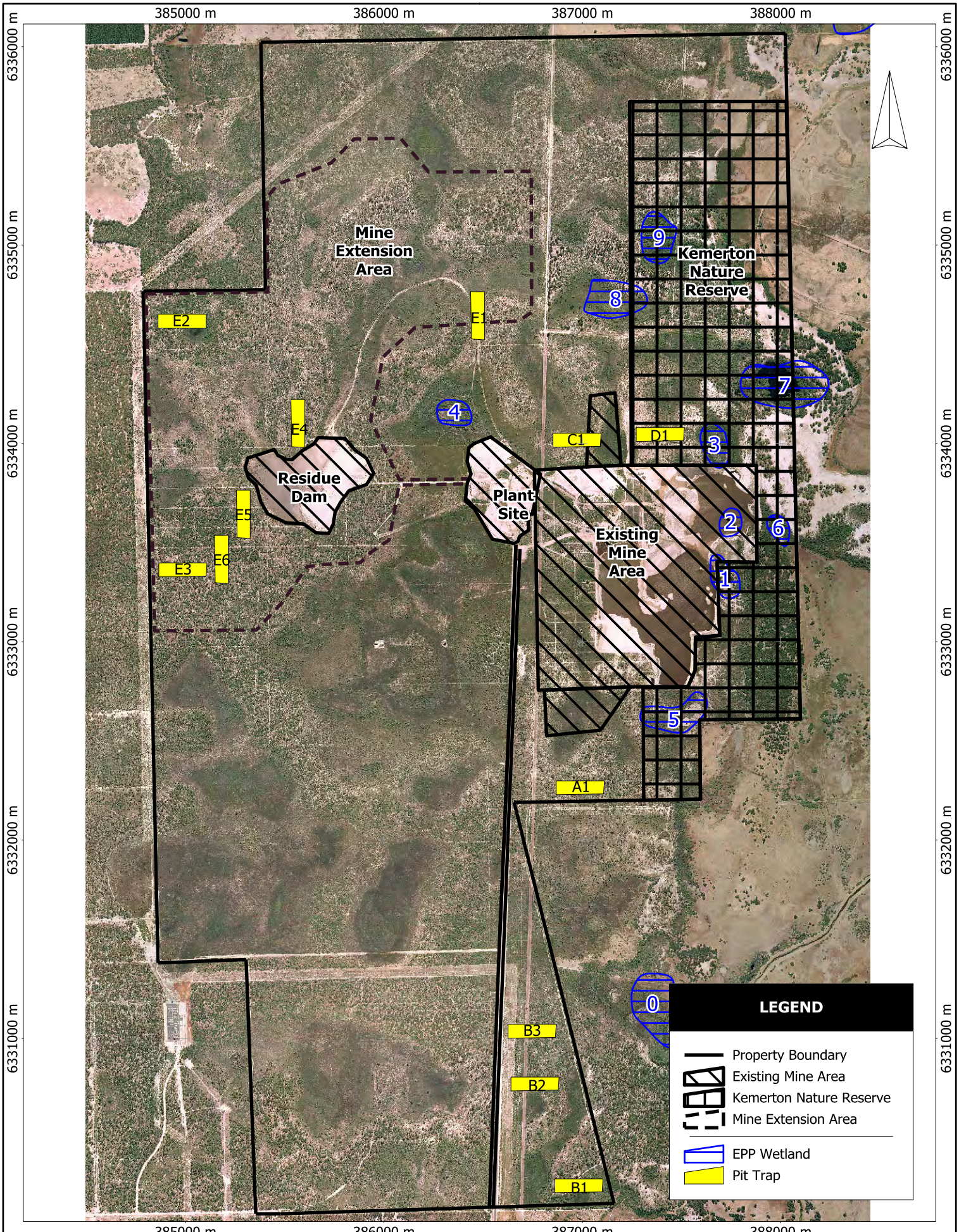
Short-range endemic (SRE) invertebrate species are characterised by small distributions and inability to disperse over large distances. They are highly seasonal and tied to particular habitat types. South and/or east facing slopes are often the most suitable for short-range endemic species as these areas are less prone to the harsh heat of the afternoon sun. Many species are only active at night, but can be located in suitable habitat types such as under rocks, stones or beneath screes, or within layers of leaf litter by direct searching techniques. SRE rich groups include snails, millipedes, and other sedentary groups.

Kinnear and Pentland (2007) from the Centre of Ecosystem Management, School of Natural Sciences, Edith Cowan University, undertook a SRE survey, targeting keystone groups such as millipedes and land snails over the upland sites of the KSS property. There are no unique landform features such as granite outcrops or south facing rocky ridges, where a specific location could be surveyed. Survey methodology focussed on transects over a range of the Bassendean ridges through the property.

Millipedes were selected as the keystone target group as they are known to have speciated throughout the Swan Coastal Plain. The same survey methods used for millipedes are also partially suitable for land snails, so some data could also be obtained for this group. Sampling methodology was wet pit traps together with hand searching of preferred habitats such as litter accumulations and below logs.

At each sampling site, line transects were established extending into the woodland for positioning of pit traps with care taken to avoid edge effects due to tracks, firebreaks, or other obvious disturbed areas. Twelve transects were established, six within the proposed mining extension, five spread across the proposed offset areas and one in the Nature Reserve. Over the period of sampling, most sites had areas of deep, very moist litter and the soil was sufficiently moist that it held a shovel-shape when dug.

The locations of transect lines within the proposed mine extension area and other comparison sites are shown in Figure 20. At the time of the survey (October 2007), conditions were considered suitable for millipedes to be active. All sites contained deep litter and all soil was sufficiently moist. At all sites, substantial faunal activity was observed in moist litter, including the presence of earthworms, termites, isopods and amphipods. Centipedes, mites, and cockroaches were also frequently observed at all sites during hand searches (Kinnear and Pentland, 2007).



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Kemerton Silica Sand Pty Ltd

Short Range Endemics Transect Locations in Kemerton Silica Sand

Figure 20

W:\Kemerton Silica Sand\Drawings\Maps 2009\SRE locations.map 15/10/2009 SRE Survey Layout

Pit traps consisted of square two litre plastic ice cream containers (16.5 x 16.5 x 9.0 centimetres) containing approximately 500 millilitres of ethylene glycol. Ten pit traps were dug in along each transect line 10 metres apart, giving a total of 60 pit traps in the proposed mine extension site, 50 in the proposed offset sites and 10 in the Nature Reserve (Kinnear and Pentland, 2007). The traps were left open for 12 days over the period 26 September – 8 October 2007. Litter accumulations well beyond the line transect were hand-searched for millipedes (and occasionally isopods) for at least 90 minutes (Kinnear and Pentland, 2007).

The complete result of the SRE survey is provided as Appendix 14 and a summary of millipedes collected is presented in Table 35. The survey identified a total of 43 millipedes, however only two were adults. The remainder were juveniles, though all were of the genus *Polydesmida*. They were collected through both the proposed mine extension area and analogue sites, indicating SRE species from this group are not exclusive to the proposed mine extension area (Kinnear and Pentland, 2007). A variety of native isopods (slaters) were also collected. These species also considered SRE occupy moist areas and tend to speciate like millipedes. For this reason, they also provide information on the similarity between survey sites. Four native species were identified spread across both the proposed mine extension and analogue sites.

Table 35: Summary of SRE Survey Results

Site	Taxon	Comments	Number	Method
Mine Extension Area				
E2	Polydesmida	Juvenile male	3	HS
	Polydesmida	Juvenile female	1	PF
	Polydesmida	Juvenile female	2	PF
E3	Polydesmida	Juvenile male	2	HS
	Polydesmida	Juvenile female	2	HS
	Polydesmida	Juvenile female	5	PF
E4	Polydesmida	Juvenile male	3	HS
	Polydesmida	Juvenile female	1	HS
E5	*Antichiropus (variabilis?)*	Adult male (sp. 1)	1	HS
	Polydesmida	Juvenile male	3	HS
	Polydesmida	Juvenile male	1	PF
E6	Polydesmida	Juvenile female	3	HS
	Polydesmida	Adult female	1	PF
	Polydesmida	Juvenile male	1	PF
Remaining KSS Property				
A1	Polydesmida	Juvenile male	1	HS
	Polydesmida	Juvenile female	1	PF
	Polydesmida	Juvenile male	1	PF
B1	Polydesmida	Juvenile male	1	HS
	Polydesmida	Juvenile female	2	HS
	Polydesmida	Juvenile female	2	PF
	Polydesmida	Juvenile male	1	PF

Site	Taxon	Comments	Number	Method
B2	Polydesmida	Juvenile male	1	HS
	Polydesmida	Juvenile male	4	PF
	Polydesmida	Juvenile female	1	PF
B3	Polydesmida	Juvenile male	1	HS
Kemerton Nature Reserve				
D1	Polydesmida	Juvenile female	1	PF

Source: Kinnear and Pentland (2007) Table 2.
Note: PF – Pitfall trap. HS – Hand searching.

The survey also collected a diverse range of other invertebrate groups consisting of cockroaches, spiders, and beetles. Approximately 150 species were found on the KSS property. Although these are not regarded as SRE species, their identification provides a baseline invertebrate dataset for sand dunes throughout the property and demonstrates the degree of similarity between survey sites. A photographic catalogue of the morphospecies has been compiled and will provide a good reference base for any future work that is required (Kinnear and Pentland, 2007).

4.12 ABORIGINAL HERITAGE

A search of the Register of Aboriginal Sites of the Department of Indigenous Affairs (DIA) indicates no archaeological sites recorded in the vicinity of the KSS property.

An Aboriginal heritage survey of the property was undertaken by D. Lantzke and S. Campbell-Smith of McDonald, Hales and Associates in 1993. The survey methodology consisted of archival research, interviews with Nyungar representatives and an inspection of the KSS property in company with Nyungar representatives.

The plant area, dredge pond and sand dunes to be mined were surveyed intensely on foot. Surface visibility away from existing survey tracks was limited (approximately 10%) owing to thick vegetation cover. As a result exposed areas or those areas with little vegetation coverage, were targeted for intensive survey. The rest of the KSS property was examined by a combination of slow-moving vehicle traverses and foot survey Lantzke *et al*. (1993).

No new archaeological or ethnographic sites were discovered in the survey area. One piece of quartz which may be artefactual was located, however the artefactual status of this piece is questionable as it was discovered in a highly disturbed context and does not possess any obvious features.

Lantzke *et al*. (1993) suggest that the absence of archaeological material within the project development site may be a reflection of prehistoric Aboriginal land-use patterns. Previous research in the area has suggested that the focus of resource procurement was largely riverine so other areas would have been used less intensively as links between more favoured locations. Archeologically such behaviour would have resulted in distribution of artefacts across the landscape with highly variable density characteristics (Dunnell and Dancy, 1983). This theory would therefore classify the KSS property as of marginal value to Aboriginals given the close proximity of the Wellesley River to the south-west and further south the

braided stream systems of the Collie and Ferguson Rivers. These would have provided permanent pools and seasonally more secure palusplain wetlands, created by cut off meanders and the retreat of winter floods. To the west are the coastal plain lagoons, Mialla lagoon and Myalup swamp. To the east is the Darling Ranges. Wetlands in the proposed mine extension area may have provided few subsistence opportunities, in comparison to others in the region (Lantze *et al.* 1993).

4.13 NATIVE TITLE

The KSS property is freehold land and not subject to Native Title Claim.

The National Register of Native Title Claims managed by the National Native Title Tribunal was searched on 11 December 2006. The property is located within the area of the Gnaala Karla Booja Native Title Claim WC98/58.

4.14 EUROPEAN HERITAGE SITES

A search of the Heritage Council of Western Australia's database for registered places on the State Heritage Register and the Shire of Harvey's local municipal inventory returned no registered places within, or adjacent to, the KSS property.

4.15 GREATER BUNBURY REGION SCHEME

On 16 October 2007, the Western Australian Government approved the Greater Bunbury Regional Scheme. The KSS property is located within the Greater Bunbury Regional Scheme area, partly within Kemerton Industrial Zone buffer area.

The WAPC prepared the Greater Bunbury Regional Scheme referring it to the EPA (2003) in August 1996, which issued its report and recommendations in September 2003 (Bulletin 1108). The announcement of the finalisation of the Greater Bunbury Regional Scheme by the Minister for Planning and Infrastructure in October 2007 is the culmination of an extensive assessment and review process.

Finalisation of the Greater Bunbury Regional Scheme provides a greater level of certainty in the assessment process with acknowledgement of the Western Australian Government's position after consideration of both environmental and planning processes for the KSS property. Specific outcomes of the finalisation of the Greater Bunbury Regional Scheme for the KSS property are:

- Zoning of the entire KSS property to remain rural.
- The southern portion of the KSS property has remained within Kemerton Industrial Zone Buffer Area – Special Control Area (SCA No. 2). In finalising the Greater Bunbury Regional Scheme, the WAPC noted the primary purpose of SCA No.2 is to provide a buffer for industry at Kemerton, not for conservation or recreation. Including the buffer in Regional Open Space would not reflect the primary purpose of the area.
- The Strategic Minerals and Basic Raw Materials Resource Policy 2005 nominated the KSS property as a strategic mineral area. While the exact boundaries of the policy area

are not consistent with the proposed mine extension area they show an area significantly larger than the current approved mine area (Figure 21). The boundaries conform to earlier proposals that were current at the time of the submission on the Greater Bunbury Regional Scheme. Inclusion of the KSS property in this planning policy reinforces the presumption of support for expansion of the extraction of the mineral resource, beyond the currently approved area.

4.15.1 Kemerton Industrial Park

Landcorp and the Department of Mines and Petroleum (DMP) released the draft Kemerton Industrial Park Strategy Plan (the Strategy Plan) in November 2007. Kemerton Industrial Park is immediately south of the KSS property, with the southern portion of the KSS property included in the industrial buffer area and covered by SCA No.2.

The strategy plan includes a number of key regional environmental factors important to Kemerton Industrial Park. As a large consolidated landholding immediately to the north of Kemerton Industrial Park and partially included in its study area, KSS has the opportunity to integrate key environmental management outcomes for this proposal with strategies detailed in the strategy plan.

4.15.2 Ecological Linkages

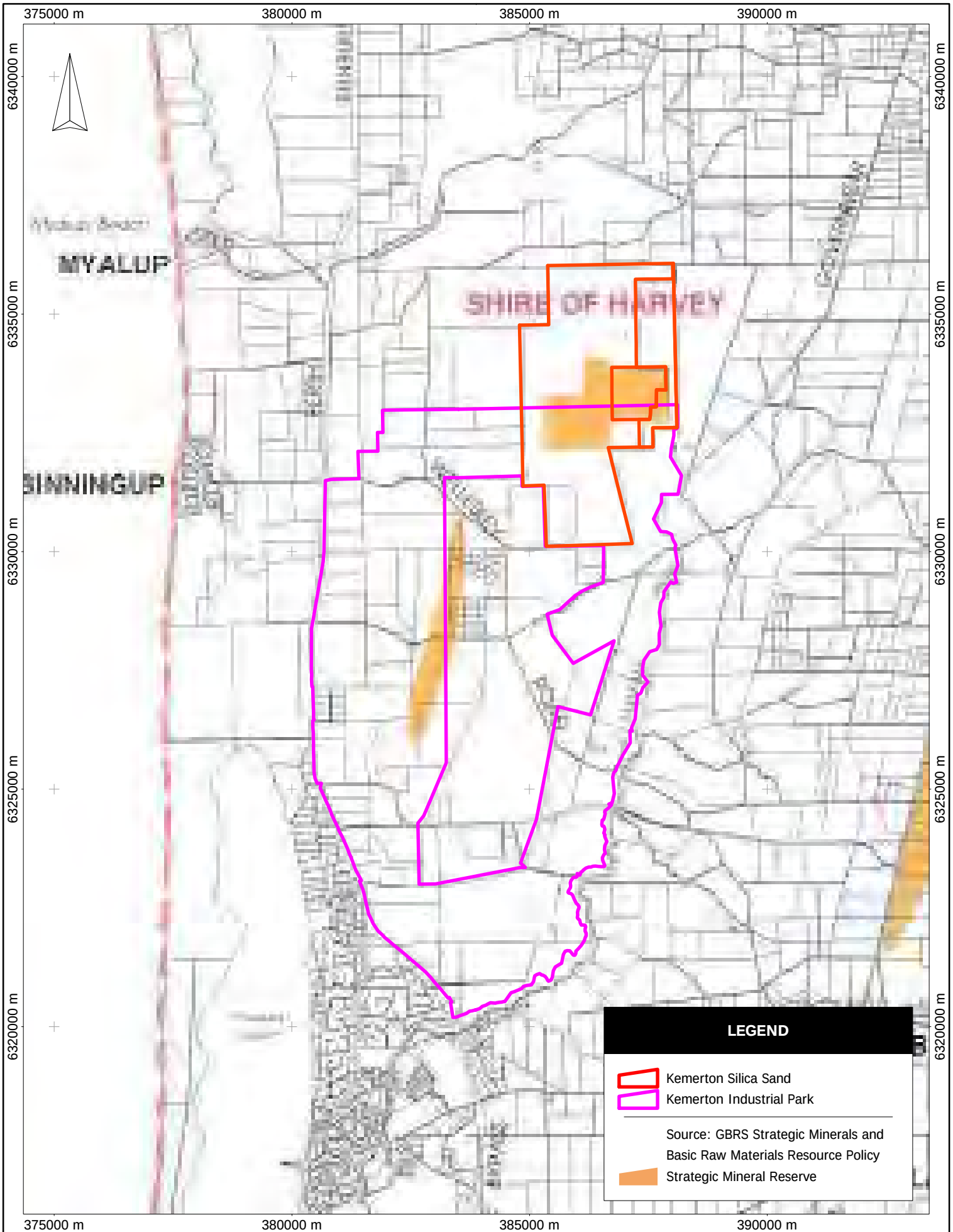
Appendix 4 of the Greater Bunbury Regional Scheme proposes an Ecological Linkages Plan for the greater Bunbury region. Ecological Linkages from Appendix 4 of the Greater Bunbury Regional Scheme are shown in Figure 22. They aim to create regional linkages of ecological communities within and between major landform elements in the greater Bunbury region. The linkages shown in the Greater Bunbury Regional Scheme are conceptual in that exact boundary alignments are not specified, rather a broad corridor is identified which implements the linkage corridor.

The two inland, North-South Ecological Linkages - McLarty/Kemerton/Twin Rivers/Preston River/Gwindinnup (Kemerton Buffer Link; Wellesley River, part Brunswick and Collie Rivers; part Dalyellup/Gelorup/Preston River/Plateau Link) follow the west and east boundaries of Kemerton Industrial Park, encompassing the buffer and constrict together in the north, with the East/west Ecological Linkages - Myalup/Kemerton passing through the middle of the KSS property. The present orientation includes one EPP wetland on private property but entirely avoids the DEC managed Kemerton Nature Reserve (which includes seven EPP wetlands).

KSS proposes realigning the north-south corridor slightly to the east, as shown in Figure 22. This alignment implements the following actions:

- Aligns the linkage with the eastern boundary of the KSS property, to match the eastern boundary of Kemerton Industrial Park.
- Include Kemerton Nature Reserve within the linkage.
- Include the proposed offset addition (shown in light green Figure 22 and discussed in Section 10.4).

This alignment continues to provide a north-south corridor of land through both Kemerton Industrial Park and KSS properties, with secure conservation tenure. It is considered that this action implements the intent of the Greater Bunbury Regional Scheme Ecological Linkages. The alignment continues to allow linkage to existing DEC lands (State Forest) to the north and south of the KSS property. The alignment adjustment also allows for proposed development on the KSS property, in an area nominated for strategic mineral extraction.



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Strategic Raw Materials
Around Kemerton Silica Sand

Figure 21

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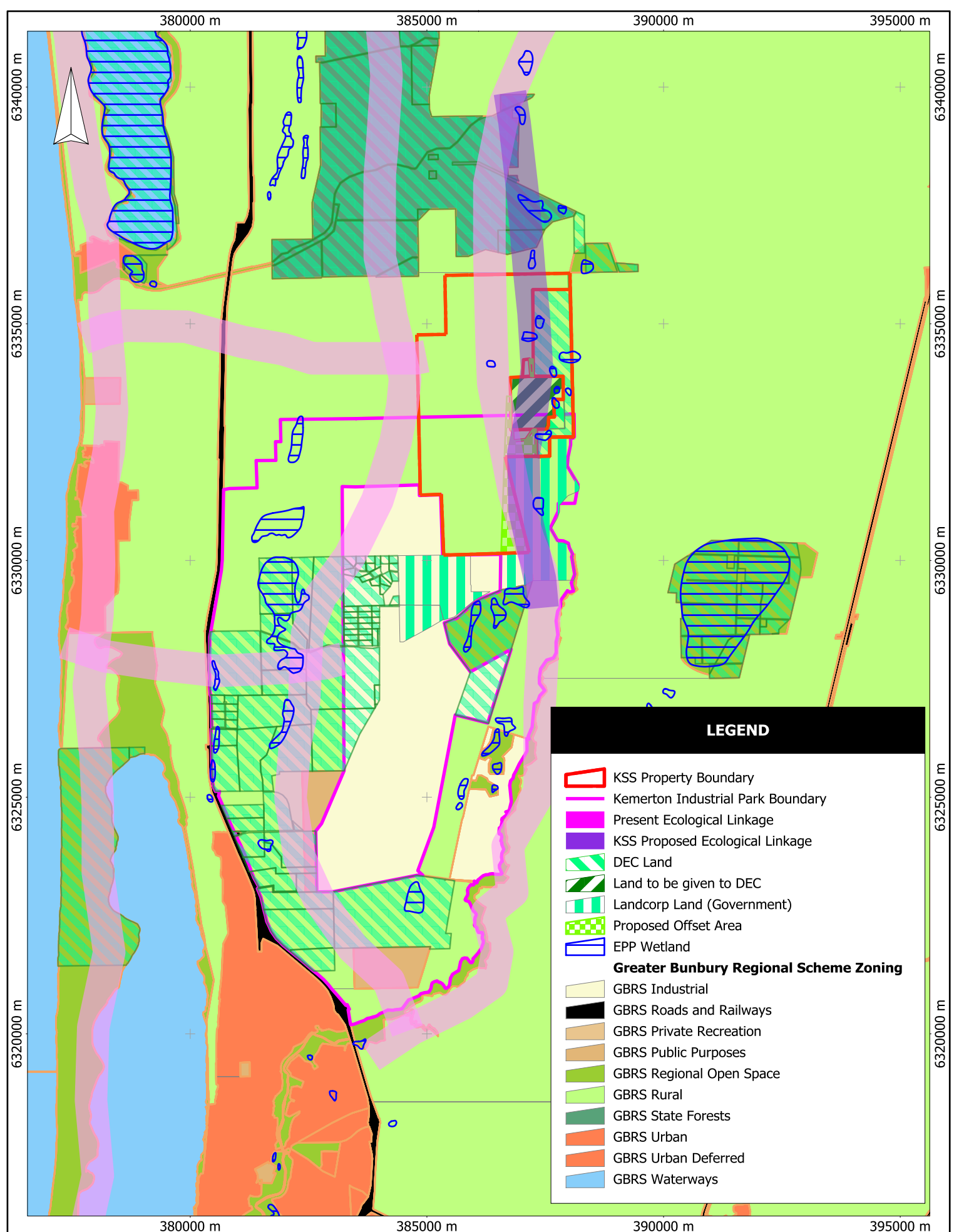

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Scale: 1:100000
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Proposed Changes to Ecological Linkages

Figure 22

W:\Kemerton Silica Sand\Drawings\Maps 2009\Ecological Linkages\EcologicalLinkages.map 19/02/2009 Ecological Linkages

5. STAKEHOLDER CONSULTATION

The environmental approvals process in Western Australia is a public process that includes stakeholder engagement. KSS acknowledges the importance of conducting a comprehensive consultation program and maintaining engagement with all relevant stakeholders throughout the life of the project. The EPA requires evidence of a satisfactory consultation mechanism demonstrating that consultation has been undertaken and relevant environmental concerns have been addressed in the design and management of the proposed extension to dredge sand mining at the property.

The public consultation program was designed to:

- Inform the public about the proposed mine area expansion.
- Record potential concerns, issues and recommendations.
- Aid in the preparation of design and management of the proposed mine expansion, ensuring that public concerns are addressed.
- Provide feedback.
- Establish dialogue with stakeholder groups.

A public consultation program was undertaken to consult with:

- Commonwealth Government:
  - DEWHA.
- State Government:
  - DEC including EPASU.
  - Department of Minerals and Petroleum (DMP).
  - DoW.
  - DPI.
- Local Government:
  - Shire of Harvey.
- Non-Government Organisations and Community Groups:
  - Wildflower Society of Western Australia.
  - Conservation Council of Western Australia.
  - Kemerton Action Group.
  - South-west Environment Centre (Inc).
- Neighbouring Landowners:

The public consultation included:

- Individual meeting with residents.
- Several telephone discussions and meetings with representatives of the Shire of Harvey.
- Meetings with government department representatives.
- Meeting with interest group stakeholders.

- Information field days, news articles and a quarterly newsletter (Appendix 15).

5.1 COMMUNICATION TECHNIQUES

5.1.1 Internet

In late 2006 KSS overhauled and updated its website www.ksspl.com.au. Information included as part of this upgrade:

- Names and contact details of key KSS personnel.
- Copies of company policies including environmental, values and behaviours and community.
- Details about KSS operations including environmental and rehabilitation.
- Copies of annual environmental reports.
- Copies of site newsletters.
- Information about the PER including a copy of the 2004 Scoping Document.
- A direct link with an invitation to comment on the PER.

5.1.2 Newsletters

KSS has produced a two page quarterly or more frequent, newsletter since 2006. Information in the newsletter includes:

- Contact names and contact details of key KSS personnel.
- Information about KSS operations, people and the environment.
- Information about the PER and an invitation to contribute or comment on it.

Newsletters are mailed to all neighbouring land owners, interested stakeholders and added to the KSS web site.

KSS have received phone calls from people viewing the newsletter and requesting to continue receiving the mailout.

5.1.3 Newspaper

KSS occupied the back page of the December 2006 Mining and Resources newspaper supplement. This supplement was included in all rural press publications in the south-west of the state, such as:

- The Bunbury Mail.
- Collie Mail.
- Busselton Mail.
- Harvey Mail.
- Donnybrook-Bridgetown Mail.

The article had a circulation of 43,550 readers and included articles about KSS working with the community and the environment, and details about the PER including contact details and where to find more information.

5.1.4 Presentations

The General Manager of KSS presented to the Mining South West Conference from 27 to 28 February 2008. The presentation covered current KSS developments and an update of plans for future expansion. An information sheet was given to all attendees.

5.1.5 Stall Displays

KSS had display stalls at the Brunswick Junction Show on 28 October 2006. A major display manned by two KSS employees answered questions and gave out information. The display covered the following areas:

- Production: including history, mining, processing, shipping and quality control.
- Markets: including information about glass and glass making.
- Rehabilitation and environmental management.
- Detailed information on the PER.
- Invitation to participate or comment providing contact details.

Any questions which could not be answered were followed up and contact details collected from anyone requesting more information. Comments and concerns were recorded. Apart from people looking for work, the only comments about the PER were from people who either previously owned land or run cattle on the KSS site.

KSS also had a display at the Binningup Spring festival on 6 October 2007. KSS sponsored the kite making and flying demonstration. A display board was set up including:

- Information about KSS operations, rehabilitation and environmental management.
- Information about the PER, including contact details of key personnel, and an invitation to comment.
- Newsletters, business cards available for the public containing key information about the Public Environmental Review and contact details.

The General Manager of KSS was also in attendance to answer questions and provide information. The only comments noted from the public was either interest in what KSS does, looking for work or surprised that glass and TV's are made from local sand.

KSS set up an identical display to the Brunswick Show at Bunbury Port open day on 18 November 2007. The display was manned at all times by two employees who answered questions and gave out information.

KSS conducted a static display within the facilities of the Bunbury Port Authority at the Bunbury Splash festival on 19 - 20 April 2008. KSS did not attend this show, with the static display providing:

- Details of KSS operations, including rehabilitation and the environment.

- Contact names and contact details of key personnel and an invitation for interested persons to participate or comment.
- Business cards with all contact details.

No public feedback was received.

5.2 CONSULTATIONS TO DATE

The General Manager of KSS held one-on-one discussions about mine expansion and the PER process with neighbours and interested parties. These discussions have been conducted on neighbouring properties, by telephone or in the community.

A list of consulted individuals, organisations, groups and agencies conducted during the environmental assessment of the proposed Project are presented in Table 36.

Table 36: Consultation Conducted During the Environmental Assessment

Stakeholder	Date and Type of Consultation	Issues Discussed
EPA Board	Meeting on 26 February 2004.	• KSS Scoping Document presented
EPA	Site visit 24 May 2004	• The site visit was attended by three members of the EPA Board and five members from DEC. The visited lasted for one hour and focused on existing operations and rehabilitation.
EPASU, DEC	Meeting on 7 July 2004	• Discuss a letter dated 22 June 2004 regarding the KSS Scoping Document.
DEC, EPASU and Ecological Services Branch and DEC Bunbury office	Site visit 4 March 2005	• Observe the Muchea Limestone areas and remainder of the project. • Following the visit, KSS provided a copy of recent vegetation and wetland studies to the EPA to assist with recommendations for the land swap.
DEC, EPASU • Tim Gentle	Meeting on 20 April 2007	• Discuss progress on the PER and present the revised mining extension area. • Progress on completing baseline environmental studies was discussed. • Feedback sought regarding issues of concern given the revised mining area.
DEC • Norm Caporn	Meeting on 11 May 2007	• As Above.
Kemerton Action Group • Jeff Tothill and Mike Whitehead	Site visit on 5 December 2007	• The visit lasted for approximately two hours and focused on existing operations and rehabilitation and a brief tour of the proposed western extension area.

Stakeholder	Date and Type of Consultation	Issues Discussed
Shire of Harvey • Councillors and staff	Presentation on 7 December 2007	• The proposed mine expansion area, proposal and why the PER is being undertaken. • Current operations including rehabilitation, markets and community involvement. • Environmental management and Kemerton Nature Reserve. • The PER studies and community consultation. • The PER timeline.
Neighbouring landowners and interested parties	2008	• This involved explaining current operations, rehabilitation and environmental management, as well as the western extension area.
Conservation Council • Tim Nichols Wildflower Society • Brian Moyle	Meeting on 25 June 2008	• Vegetation – the amount of Bassendean - Central and South woodland impacted. • Wetlands – amount of Conservation Category wetlands impacted. • Issue of 'closing out' the transfer of titles from the original project; Kemerton Nature Reserve, by relinquishing rights to the minerals. KSS noted this as an item to address. • Staging – rather than a single 50 year approval. • Rehabilitation – need to demonstrate good outcomes of current rehabilitation. • Groundwater: • Existing water licence. • Abstraction licence. • Groundwater monitoring data. • Groundwater dependent ecosystems. • Monitoring of new areas.
DEC • Chris Bishop, Daniel Coffey, Chris Gilbert, Kim Williams, Tom Kennelly and Neville Welsh	Meeting on 8 July 2008	• Weeds and dieback –hygiene principles to control spread of weeds. • Standards of flora surveys. Surveys predate EPA Guidance statement 51 (2004). Need to confirm methodology with Mattiske and provide information to DEC for review and response. Electronic copies were subsequently provided. • Noise – modelling, measurements and nearest neighbours to confirm that noise is not a significant issue. Light spill and dust. • Groundwater issues. Water drawdown on other users. • ASS – survey undertaken.

Stakeholder	Date and Type of Consultation	Issues Discussed
		• Aquatic macroinvertebrates. MBS Environmental provided information on Edith Cowan University work is developing the baseline dataset against which aquatic rehabilitation completion criteria can be set. • Tree hollows. MBS Environmental responded that historical logging has removed most of the large Jarrah trees (and therefore large Cockatoo size hollows). More small hollows for other fauna. The Cockatoo survey identified tuarts, in the Spearwood system to the west, are more numerous and larger, as they were not historically logged to the extent of Jarrah. Vegetation areas to the west have a much greater nesting habitat. Foraging habitat linked to Bassendean woodland. Wetland vegetation does not support preferred foraging species. Significant proportion of wetlands on the KSS property reduces the importance of foraging, but the woodland is still utilised. Comparisons with adjacent analogue sites indicate the KSS property is no more or less important than adjacent areas. • EPBC referral has been done. Project is a Controlled Action. Bilateral agreement accredits PER process. • Rehabilitation. General discussion on rehabilitation (upland woodlands, wetlands and lakes); topsoil transfer to similar landform types and identifying completion criteria targets. • Dry Mining. General discussion on approved dry mining areas and proposal for 'land swap' areas into the mine extension area. • Offsets general discussion on consideration of offsets for this proposal.
South-west Environment Centre (Inc) (SWEC)	Site visit on 7 December 2008	• The visit lasted for approximately two hours. SWEC members were shown the existing operations including rehabilitation. SWEC members were given a tour of the proposed extension area. EPP and Conservation Category wetlands within KSS and the Kemerton nature Reserve were visited.
EPASU • Ray Claudius and Doug Betts	Meeting on 8 December 2008	• Project timeline.

Stakeholder	Date and Type of Consultation	Issues Discussed
DEWHA	Site visit on 9 December 2008	• The visit lasted for approximately two and a half hours. Current operations were explained to DEWHA representatives and plans for expansion discussed. • DEWHA raised queries regarding the potential Western Ringtail Possum habitat and Cockatoo foraging areas. Current habitat values and potential habitat values for Nationally Significant fauna species were discussed.
DEC • Daniel Coffey, Chris Bishop, Jill Pryde and Alison Beard	Meeting on 11 December 2008	• Flora surveys – level of flora surveys that Mattiske has done over the past 20 – 30 years is acceptable. However, further detail on survey effort is required. • DRF – the KSS property has been extensively surveyed and recently inspected for DRF orchid species. The DRF as suggested in the EPASU comments are not present on the KSS property. Further detail requested in the revised PER. • Vegetation – need to provide detail of TEC/PEC issues – how are the conclusions made in the PER? When is a TEC a TEC? MBS Environmental requested further detail from the DEC Species and Communities Branch on the segregation of communities and TEC/PEC as detailed in the EPASU comments to the Draft PER • Offset area – management area is not ideal. Offsets in Draft PER document does not utilise the standard offset reporting form. DEC requested the PER look at the critical assets and seek an aspirational like for like or better. • Fauna – Cockatoo habitat, lower Banksia woodland in proposed mining area. • Wetlands – DEC has requested PER document refer to Geomorphic Wetlands. A reminder was given that the reclassification of wetlands must be submitted prior to the PER. • Rehabilitation – the issues whether rehabilitation failure is adequately addressed in the PER was raised. Further detail is required.
EPA Service Unit • Doug Betts	Site visit 21 January 2009	• The visit lasted for approximately four hours and focused on existing operations and rehabilitation and a tour of the proposed western extension area.

Stakeholder	Date and Type of Consultation	Issues Discussed
DEC • Daniel Coffey, Chris Bishop, Jill Pryde, Val English, Alison Beard and Wink Lindsay		• Success of rehabilitation of existing mine area, provide current Edith Cowan University work – information wanted on lake depths and water quality. • Fauna surveys – Western Ringtail Possum and other possum species. Little Black Bitterns habitats – Baumea articulata. • Wetland Reclassification areas visited. • Vegetation survey methodology – areas of interest C1, C2 and D2 visited. • DRF species surveys adequate? • Fire history – visit to EPP4. • Offset areas – east to west alignment wanted.

5.3 SUMMARY OF ISSUES

The issues identified during consultation to date are presented in Table 1. The main issues being:

- Impact on Declared Rare Flora and Priority Flora.
- Impacts on TECs and PECs.
- Potential impacts on the Muchea Limestone TEC in the Kemerton Nature Reserve.
- Rehabilitation success.
- Development of acidity of the dredge pond.
- Impact on wetlands.
- Impacts on surface and groundwater quality.
- Management of impacts associated with the proposal.

The main actions that were taken in response to the issues raised by stakeholders are presented in Table 37 and summarised in Table 1:

- The mining area has been modified to avoid areas of high environmental value, including avoiding the *Boronia capitata* subsp. *gracilis* (P2).
- The mining area has been modified to avoid EPP4 and surround Conservation Category wetland and the sumpland to the north of the area with high conservation values.
- Preliminary ASS investigation and preparation of an Acid Sulfate Soils Management Plan (ASSMP).
- Further flora and vegetation investigations.
- Further fauna investigations.

Table 37: Key Issues Raised By Stakeholders

Issue	Proponent's Response	Addressed in PER
Flora and Vegetation		
Impact on conservation significant flora and floristic communities, including TECs and PECs.	Extensive flora and vegetation surveys, including a detailed DRF and wetland study, have been conducted across the KSS property prior to publishing of the EPA Guidance Statements and current TEC and PEC listings. These surveys are of a comparable standard to Guidance Statement 51. Further additional analysis was commissioned, including a DRF and TEC/PEC search in December 2008 and additional analyses including PATN analysis. The TEC/PEC comparisons to the vegetation communities have been updated. The proposed mine extension area has been adjusted to avoid Priority flora. Some PEC areas will be impacted by the proposal. Community C2 is not present elsewhere on the KSS property and will be entirely removed. This community is primarily *Agonis flexuosa* and more representatives of Spearwood vegetation communities to the west where large areas are present.	Section 4.6.4, 4.6.5, Table 13
Relationship between plant communities at KSS and the 'Shrubland and Woodlands on Muchea Limestone' (Muchea Limestone) TEC.	It is acknowledged that the Muchea Limestone areas occur within the southern portion of Kemerton Nature Reserve corresponding with communities D2, F1 and F3. KSS do not believe that this TEC is widespread across the KSS property, as the occurrence of *Eucalyptus decipiens* alone does not define the TEC vegetation community as 'Muchea Limestone'. According to the IRP, the Muchea Limestone TEC "occurs on soils mapped as Muchea Limestone or Plain limestone deposits" (page 3). The ASS investigation of the proposed extension area only located limestone at a depth of 32 metres at Hole 6. All other sites sampled did not find limestone, were sands and encountered shells between 26 – 34 metres below the surfaces. Review of silica sand resource and geology shows that felspathic silica sands wished to be mined do not occur where limestone does thus disturbance of a limestone based vegetation community is undesirable from an economic and environmental perspective.	Section 4.6.7, Table 13
Absence of DRF in the western extension survey area out of a potential eight listed taxa, and only one Critically Endangered, DRF (*Caladenia procera*) was found in the survey of the adjacent KSS landholding.	Targeted surveys for DRF and Priority flora were conducted by Bennett (2004). No DRF were found in the proposed mining area. Numerous surveys have been conducted at the KSS site over several years and no orchids or DRF have been found. It was suggested that the absence of these taxa could be related to flora survey timing and methodology, or an absence of specific environmental factors such as fire. Survey timing and methodology is not considered an issue as the property has been thoroughly surveyed over time and fire has	Section 4.6.4, Table 12, Appendix 4 and Appendix 5

Issue	Proponent's Response	Addressed in PER
	been limited at the property. One fire occurred around EPP4 in 2007, but no other fires have been recorded on the property for the last 10 -15 years. Kingsley Dixon and Ryan Phillips from the Botanical Gardens and Parks Authority indicate that unless a survey was conducted in the immediate 12 months following fire, it is difficult to say if *Diuris purdiei* is present. An inspection of the most likely locations for DRF species in December 2008 did not locate any within the mine extension area. Known locations of *Diuris drummondii* were identified south of KSS land during this survey to confirm survey methodology.	
Impact on Bassendean Central and South Vegetation Complex	Almost 73% of the proposed mine extension area is occupied by two major soil units: • *B1:* Deep bleached grey sands. 98.1 hectares in the proposed mine extension area of a total of 409 hectares on the property (24.0%). • *B3a:* Poorly drained grey and brown sands. 131.8 hectares in the proposed mine extension area of a total of 512.2hectares on the property (25.7%).	Section 7.2.1.3, Table 38
Wetlands		
Impacts and management of high conservation values of the Conservation category wetlands, including the EPP Lakes.	The proposed mine extension area has been positioned to avoid the highest wetland values. EPP4 and the surrounding conservation category wetland are omitted from the proposed mining area and the sumpland to the north of the mining area has been removed as Edith Cowan University found it had high conservation values. KSS have engaged Edith Cowan University to continue wetland and rehabilitation monitoring for the next two years to investigate temporal changes particularly in North Lake and EPP1.	Section 7.6.3.1, Appendix 11
Impact of mining on EPP4 and the buffering Conservation category sumpland UFI 13254.	EPP4 is surface water fed and therefore the proposal should not impact conservation category wetland UFI 13254 or EPP4. The proposed mine extension area boundary was selected based on detailed hydrological modelling of buffer distances for EPP4 to prevent adverse impacts. Monitoring will ensure that any adverse impacts are managed accordingly.	Section 7.6.4
Direct, indirect and cumulative impact of proposed and current mining on wetland health.	There are no permanent water features in the proposed mining area. In general the wetlands are ephemeral. The post-mining landscape will be altered from the pre-mining condition. Approximately half of the area will become permanent lakes. The proposed mine extension area has been defined based on groundwater modelling and identified the buffer distance required to protect EPP4 and its surrounding Conservation category wetland. Modelling indicates a maximum rise in groundwater at EPP4 of 0.1 metres at any	Section 7.7.3, 7.6

Issue	Proponent's Response	Addressed in PER
	time during mining, which is within the natural variability of fluctuations for the surrounding area in the order of 1.5 metres. The predicted drawdown in groundwater is mostly within natural groundwater fluctuation, therefore the impacts on surrounding wetland health should be minor.	
Risk of rehabilitation failure.	Edith Cowan University has been engaged to assess rehabilitation efforts to date. Rehabilitation at KSS has had mixed success however monitoring has shown significant improvements in recent years as a result of implementation of measures recommended by Edith Cowan University, specifically careful harvesting and replacement of topsoil with like landform units. KSS are committed to continuing rehabilitation monitoring and implementing a continuous improvement program to minimise risk of rehabilitation failure.	Section 9.7, Appendix 7, Appendix 8
Direct impacts of altering local topography within the proposed mine extension area impacting local surface and groundwater flows, therefore directly impacting the wetland hydrological regimes.	Rockwater have and will continue to monitor groundwater across the KSS property. No direct impacts of the current mining regime have been found. No external surface drainage occurs within the proposed mining area as all water infiltrates through the permeable Bassendean sands. GHD (2008) have modelled the predicted groundwater drawdown and the greatest drawdown post mining is approximately one metre with the effects concentrated in the west of the mining area. This drawdown will have limited effects on wetlands within KSS (about 1,500 metres) to the north west and south-west of the proposed mining block.	Section 7.4.3.1, 7.6
Indirect impacts of altering hydrological regimes of the wetlands within the remaining area of the KSS property.	GHD (2008) have conducted extensive hydrological modelling of the effects of the proposed mining on the hydrology of the area. The impact of the proposed mining is limited to a small area surrounding the mining area. The majority of the property will not be affected by altered hydrological conditions. The mine extension boundary took into account of hydrological modelling.	Section 7.4.3.2 7.6
Fauna		
Impact on conservation significant fauna	Details of methodology are contained with Appendix 12. The are now provided in the text of the PER in Section 4.11.2.6 and 4.11.2.7	Section 4.11.3.6 and 4.11.3.7.
Chuditch, Western Ringtail Possum and Carnaby's and Baudin's Black Cockatoos are species of interest and could be expected in habitat on KSS property given suitable habitat.	It is understood that Chuditch, Western Ringtail Possums and Quokkas and Baudin's Black Cockatoos may occur within the property, but none have been recorded. Carnaby's Black Cockatoo has been recorded foraging within KSS. Some habitat will be lost through the mining proposal, but this is only temporary as once mining has ceased, post-mining rehabilitation will be at least 45 years old. KSS have committed to continuing exclusion of	Section 7.7

Issue	Proponent's Response	Addressed in PER
	stock and grazing during the term of mining activities for the whole KSS property. This will have benefits for habitat protection for these species.	
Transportations		
Impact of proposal on truck movements.	The proposal will not alter truck movements except that the duration (ie an additional 50 years beyond the current operations) will be extended.	Section 7.12.3
Surface and Groundwater		
Impact of current mining increasing acidity of the dredge pond and future operations.	McCullough and Lund (2008) stated that low $Cl:SO_4$ ratios in the newly rehabilitated area south of North Lake may indicate some acid mine drainage/ASS-type oxidation from disturbance of the intermediate 'coffee rock' layer which may contain PASS. Whilst no definitive trends of falling pH has been recorded in the monitoring data to date (Rockwater, 2008), KSS commissioned an investigation of four samples of soil from the rehabilitated area of North Lake. Three of the four samples tested contain insignificant amounts of ASS materials. Whilst the fourth sample exceeded the Action Criteria for sand, it is considered extremely unlikely that significant amounts of acidity will be generated by disturbance of this soil. In terms of ASS management of these soil samples, no specific management protocols are required, although an ASS Management Plan has been prepared and will be implemented for any future ASS issues that may arise.	Section 4.5.3, Appendix 3
Parameters used to determine if any future reductions in pH are due to mining.	Monitoring will continue and as any problems develop they will be investigated further according to the ASS Management Plan. Trigger levels for water and soil will be finalised in the ASS Management Plan.	Section 7.5.4
Groundwater in the western extension area may flow west or SW.	Modelling results show that there is a ground-water mound approximately 300 metres west of the western extensions. This means Groundwater flow in the eastern side of this mound (where mining is planned) is predicted to be in the East to South East direction. West of the proposed mining area, the groundwater flow direction changes and is to the west.	Section 4.5.1
Impacts of mining on groundwater quality. Groundwater quality is expected to change from 300mg/l to about 1000mg/l TDS after 85 years.	Monitoring indicates that salinity is highly variable across the KSS property with recent data indicating a variability of 70 to 840 milligrams per litre (Rockwater, 2008). Whilst modelling indicates a rise in groundwater salinity is predicted through the proposed mining (GHD, 2008), the rise is not above historic salinity variability across the KSS site. The model cannot predict all variability in salinity and GHD (2008) indicate that the results are very conservative.	Section 7.5.4

Issue	Proponent's Response	Addressed in PER
Monitoring bores KMB 6 and KMB 10 both contain low pH water, with historical lows of pH 3.1 and 3.4 respectively. These values are lower than any recorded by Deeney in the abovementioned study.	Rockwater's annual monitoring reports provide an assessment of data and trends for the period of the review, unless the report is a triennial review required under the conditions new groundwater licence GWL60367(3) (as the 2008 report was). The statement regarding groundwater quality refers to the "area", which perhaps is not clearly defined. It means within local bores in the same hydrogeological environment (i.e. it naturally does not include all bores within the approximately 70 km north-south extent of the Harvey Shallow project nor Harvey Shallow bores that monitor groundwater from formations that have not been intersected by the KSS bores, e.g. the Tamala Limestone). The water quality data are generally within the range of values reported for the Harvey Shallow bores.	Section 4.5.3
Management of adverse effects on groundwater, surface water and wetlands that may be identified via the monitoring data.	KSS will manage impacts on surface water quantity and quality by implementing the following actions: • Regular monitoring of EPP wetlands. • Monitor surface water quality around the active mine area. • Natural surface water flows in the mine extension areas will be maintained. Diversion of surface water will not be required during operation or rehabilitation. Surface water flows of adjoining areas will not be affected by dredging operations. KSS will manage impacts on groundwater quality due to mining activities by implementing the following actions: • Maintain current water usage and continue to implement water saving initiatives. • Measure abstraction volumes. • Continue to monitor the dredge pond and rehabilitated cells and implement measures to balance pH if monitoring results show an increase in acid generation. • Create north to south designed dredge ponds and rehabilitated lakes to reduce water loss by evaporation and reduce impacts from easterly and westerly winds. KSS will manage impacts on groundwater quality due to mining activities by implementing the following actions: • Install additional monitoring bores to allow continued water quality monitoring of aquifer water levels in response to dredge mining and production bore abstraction to ensure no adverse impacts occur to the region's groundwater quantity:	Section 7.3.4 and 7.4.4, Appendix 3

Issue	Proponent's Response	Addressed in PER
	– KMB1 is located about 400 metres up the hydraulic gradient from EPP4. Two monitoring bores will be installed along the western boundary of the property. • Two production bores will be installed, one located about 200 metres north of KMB6 and the other about 200 metres west of KMB6.	
Project Design		
Recommended to stage project over time rather than a single 50 year approval.	Project has been designed with 10 cells to focus mining for five year time periods. This will enable the impact and at any one time to be focus in an area and rehabilitation to proceed immediately after. In the final mining cell, rehabilitation of the first mining cell will be 45 years old. Project is not staged in terms of short term approvals as KSS requires long-term supply contracts to provide certainty of economic future. This also allows longer term land and environmental management planning which is believed will give a better outcome for all stakeholders.	Section 2.6, 3.3
Noise		
Impacts of proposal on noise to neighbours.	KSS commissioned a noise assessment study in 2004 and undertook additional measurements in 2008. The assessment and updated measurements confirmed current operations comply with the *Environmental Protection (Noise) Regulations 1997* at the property boundaries. As no change to operational methods are proposed and no residences are located within two kilometres of the mine extension area, no additional or changed noise impacts are predicted.	Section 7.9.3

5.4 CONSULTATION DURING THE PER PERIOD

This PER is subject to an eight week public review period. During this time, the proposal will undergo further scrutiny by regulators and the community. KSS will maintain contact with stakeholders during this period and will include the following:

- Placing the PER on the KSS website (www.ksspl.com.au) and providing copies to relevant government agencies, NGOs and local libraries.
- Media releases to provide information on the PER and its availability for public review.
- Provision of information to the Shire of Harvey for discussion during council meetings.

5.5 CONSULTATION FOLLOWING THE PUBLIC REVIEW PERIOD

KSS will continue to consult with relevant stakeholders throughout the life of the Project **(Commitment 5.5a)**. Consultation will involve newsletters and presentations to the key stakeholders.

KSS is committed to preparing a Preliminary Decommissioning and Closure Plan (PDCP) within five years of commencing operations in the mine extension area. KSS will consult with stakeholders and aim to provide a framework that will enable stakeholders to be provided with accurate information about, and be involved to an appropriate degree, in mine closure. Further revisions of the closure plan will be developed periodically during the life of project, incorporating results of rehabilitation research, and current government and industry guidelines.

6. ENVIRONMENTAL FACTORS AND MANAGEMENT PLANS

A Scoping Document was prepared in consultation with the EPA to identify environmental factors applicable to the project. Factors were identified through preliminary investigations and consultation with key stakeholders. The factors identified as relevant to the project are presented in Table 1. Objectives, existing environment, potential impact, environmental management and predicted outcome relating to each factor are shown.

KSS considers studies undertaken for the project and experience gained from over a decade of mining operations on the property, in a manner identical to that proposed in this proposal, demonstrate that effective management and mitigation measures can be implemented to ensure adverse environmental impacts are prevented or minimised and the stated EPA environmental objectives met.

6.1 ENVIRONMENTAL IMPACTS

An 'environmental impact' is defined as a modification in the status of the environment by a proposed action. Environmental impacts may affect the natural or social components of the environment and may be positive (beneficial) or negative (adverse). They may occur either as a primary result (direct) or as a secondary result (indirect) of the action, and may be temporary/short duration or permanent/long-lasting. Impacts may vary in magnitude from no change or only a slight discernable change, to a significant change in the status of the environment.

Main environmental impacts associated with the KSS project identified by KSS in consultation with DEC include:

- Vegetation clearing.
- Direct and indirect impacts to wetlands.
- Loss of habitat and disturbance of specially protected fauna species.
- Rehabilitation and closure.
- Change in habitat type after rehabilitation of mined areas i.e. reduction of shallow, ephemeral wetland area and increase in deeper, permanent wetland area.
- Short to medium term reduction in biological diversity of areas cleared for mining. Biodiversity will be restored and in some areas increased on completion of rehabilitation actions.
- Destruction of Priority flora species.
- Potential for acid generation.
- Extraction of about 300,000 kilolitres of groundwater per annum for use in maintaining a dredge pond and in processing. This volume of water is currently abstracted with no adverse impacts on a local or regional scale. Careful management would be required to continue to ensure adverse localised impacts do not occur.
- Further spread of dieback into other areas of the KSS property.

- Disruption to the proposed North-South ecological linkage.

6.2 OPPORTUNITIES FOR NET CONSERVATION GAIN

KSS are aware of the importance of being able to demonstrate that net conservation gain will result from activities undertaken in areas of high conservation significance. Consequently KSS is committed to mining and managing its freehold rural land in a manner that will result in a long-term regional net conservation gain. Actions taken to date that have resulted in achievement of net conservation gain include:

- De-stocking of all KSS land (1,620 hectares) since purchase of the property in 1994. This has led to an improvement in the condition of the vegetation, habitat and wetlands.
- Donation of 206.9 hectares of land with high conservation values to the State of Western Australia including six EPP Wetlands. This land (Kemerton Nature Reserve) is managed by DEC. A binding commitment has been made to donate a further 109.3 hectares of freehold land on completion of mining of Stage 2 area. At the time of agreement for the donation, Sons of Gwalia reportedly understood that this exchange was the total offset to include their Western Extension proposal.
- Implementation of feral animal control programs (pigs, foxes and rabbits).
- Implementation of a weed control program (Cotton Bush, Typha and others).
- Undertaking of fire risk management activities around the property boundaries.

This proposal is designed to avoid adverse impacts on remaining areas within the KSS property that have high conservation value. Extension of mining on KSS owned land will allow long-term environmental management actions to be taken by KSS to further achieve net conservation gain. Failure to allow mining will not by itself ensure any additional conservation gain results other than what has already been achieved through approval of the existing mining operation.

6.3 OPPORTUNITIES FOR BIODIVERSITY ENHANCEMENT

Historically, biodiversity of the KSS site has been detrimentally affected by selective logging, vegetation clearing, grazing of cattle, establishment of pine plantations and construction of drainage channels.

Areas of highest conservation significance in the eastern portion of the KSS property were given to the State of Western Australia as an offset for approval of mining activities in the area known as Stage 2. This area contains six EPP wetlands. KSS have assisted DEC with development of management guidelines for this area and are involved in assisting with implementation of these guidelines.

Methods committed by KSS to enhance the biodiversity of the KSS site and hence the Kemerton region includes:

- Feral animal control (pigs, foxes and rabbits). Control programs have already been undertaken within the KSS property and will continue. KSS will also provide assistance

with feral animal control in the adjacent Kemerton Nature Reserve and for programs co-ordinated by the local Landcare groups.

- Weed control within KSS property, especially removal of Cotton Bush and *Typha* present in some wetlands.
- Research into establishment of populations of Black-striped Jollytail (*Galaxiella nigrostriata*) within rehabilitated dredge ponds.
- Research into re-introduction of conservation dependant fauna species such as the Water Rat (*Hydromys chrysogaster*) and Chuditch (*Dasyurus geoffroii*).
- Continued suspension of grazing activities.
- Continued implementation of dieback and fire control management programs.

6.4 OPPORTUNITIES TO IMPROVE FAUNA HABITAT

Fauna habitat at the KSS site has been degraded historically by human activities, particularly removal of large trees and development of a pine plantation. It is recognised that development of dredge ponds will result in establishment of deeper permanent water bodies as opposed to the typically shallow ephemeral wetlands currently present within the KSS property. This realises different conservation opportunities.

The creation of such fauna habitat on the KSS property will result from extension to mining through:

- Development of shallow wetland fringe type ecosystems around each dredge pond as part of the rehabilitation strategy.
- Development of permanent water bodies.
- Planting of a wide range of local native tree and shrub species as part of the mining rehabilitation program, particularly in areas that have been subject to logging.
- Control of aquatic and terrestrial weeds.
- Continued suspension of grazing activities.
- Feral animal control.

6.5 MANAGEMENT PLANS AND PROCEDURES

The existing operation is managed through a number of plans and procedures. The proposed mine extension area provides future resource for continuation of the current operation. Site infrastructure will remain the same (processing plant, mine dredge, workshop and administration facilities), with minor changes required to reconfigure operations for the western portion of the property.

To manage potential impacts of the proposal on the environment a number of management plans will be developed and implemented. An Environmental Management System is under development for the existing operations. As part of this, the existing Environmental Management Plan (EMP) is under review. Both the Environmental Management System and

EMP will be reviewed and updated to include aspects relevant to the proposed mine extension area after environmental approval is obtained. Specific sections to be included are:

- Fauna management - targeted survey for Chuditch, Southern Brush-tailed Phascogale, Western Ringtail Possum and Quokka prior to annual land clearing to ensure that populations of these Schedule 1 species will not be affected by the planned clearing. If evidence of their presence is found, trapping will be undertaken and captured individuals relocated to suitable alternative sites on the property. Relocation of potential nest hollows, tree hollows and habitat logs and brush.
- Vegetation and rehabilitation management - consolidating the range of scheduled environmental activities, from pre-mining to rehabilitation and monitoring.
- Weed and feral species management.

An Acid Sulfate Soils Management Plan (ASSMP) has been prepared (Appendix 16) and will be implemented should acidity become an issue. The plan provides details on:

- Establishing a staged field survey process in advance of mining to assess potential for ASS generation as a result of proposed operations.
- Design and management strategies to avoid, minimise or mitigate formation of ASS.
- Monitoring and reporting requirements.

KSS reviewed the existing Rehabilitation Management Plan (RMP) to take into account the proposed mine extension. The plan provides details on each aspect of the rehabilitation program. It is an adaptive document including results of ongoing rehabilitation research during the life of the project, and results of regular monitoring and ongoing research in document revisions. It is based on undertaking rehabilitation in line with:

- Undertaking progressive rehabilitation.
- Using landform specific rehabilitation plans, including matching vegetation species selection with specific rehabilitation landform objectives.
- Local seed collection for use in rehabilitation.
- Protection of icon fauna species.
- Introduction of icon fauna species into new areas.
- Undertaking trials and documenting results to allow technical review.
- Undertaking weed and feral animal control.
- Regular monitoring of completed work.
- Scientific review of the success of the rehabilitation program.

KSS will prepare a Preliminary Decommissioning and Closure Plan (PDCP), conforming to the Conceptual Closure Plan as defined in Section 2.3 of the Australian and New Zealand Minerals and Energy Council and the Australian Minerals Industry (represented by the Minerals Council of Australia (2000) *Strategic Framework for Mine Closure*), within five years of commencing operations in the mine extension area. Further revisions of the plan will be developed periodically during the life of project, incorporating results of rehabilitation research, and current government and industry guidelines. This is discussed in more detail in Section 7.13.3.

7. ENVIRONMENTAL RISKS AND MANAGEMENT

7.1 ASSESSMENT OF RELEVANT ENVIRONMENTAL FACTORS

Environmental risk assessment is a process that evaluates the likelihood and consequence of environmental impacts occurring as a result of exposure to one or more stressors. One of the advantages of this process is that it allows potential environmental aspects or threats to be considered on the basis of the level of potential risk to the environment. This subsequently assists in prioritising development of management measures to achieve an overall acceptable level of risk.

The risk ranking is based on Australian Standard AS/NZ 4360 Risk Management and uses the risk matrix shown in Figure 3 and definitions presented in Table 3 in Section 3.1.3.

The following key environmental factors require detailed assessment in the PER:

- Terrestrial Environment:
  - Geology and Landforms (inc. Acid Sulfate Soils).
  - Surface Hydrology.
  - Groundwater.
  - Wetlands.
  - Vegetation and Flora.
  - Fauna.
- Social:
  - Heritage Values.
  - Noise.
  - Road Transportation/Traffic.
  - Visual Amenity.
- Atmospheric Environment:
  - Emissions and Dust – air emissions and greenhouse gas emissions (including reservoir CO_2 injection).
- Decommissioning and Closure:
  - Rehabilitation.

The above key environmental factors associated with the Proposal are addressed in the following sections of the PER in the following format:

- **Environmental Objectives:** details the relevant EPA objective/s.
- **Relevant Standards and Legislation:** defines the key statutory requirements and environmental policy relevant to the environmental factor.
- **Assessment of Potential Risk and Impacts**: contains the detailed assessment of the aspects and potential impacts that were identified in the preliminary environmental risk assessment as having a Medium to High inherent risk level. Risk assessment follows that as detailed in Section 3.2.

- **Management and Mitigation Measures**: lists key management measures, programs and systems that will be implemented.
- **Predicted Residual Environmental Risk**: provides a summary of residual level of risk and includes consideration of the environmental acceptability of the Proposal (and consistency with relevant EPA objectives/policies) and cumulative risk to the environmental factor.

7.2 GEOLOGY AND LANDFORMS

7.2.1 Soils

7.2.1.1 Environmental Objectives

To maintain the integrity, ecological functions and environmental values of soil and landform.

7.2.1.2 Relevant Standards and Legislation

Standards

- Environment Protection Authority, January 2006. *Draft Guidance for the Assessment of Environmental Factors No.6: Rehabilitation of Terrestrial Ecosystems.*

Legislation

- *Environmental Protection Act 1986* (WA).
- *Soil and Land Conservation Act 1945* (WA).

7.2.1.3 Assessment of Potential Risks and Impacts

Soil management, especially topsoil and overburden, is important to success of rehabilitation. Potential impacts identified are:

- Wind and water erosion of topsoil and consequent impacts on revegetation success.
- Loss of soil resources (volume, contained seed, micro-organisms).
- Incorrect topsoil placement.
- Compacting soil surfaces by vehicles and mining equipment.
- Contamination of soil eg. salinity and hydrocarbons.

Potential adverse impacts on soil and landforms are expected to be minimal after implementing the control measures described in Section 7.2.1.4.

The extent of soil unit types in the proposed mine extension area relative to the total in the KSS property (Table 38). Almost 71% of the proposed mine extension area is occupied by two major soil units:

- *B1:* Deep bleached grey sands. 100.8 hectares in the proposed mine extension area of a total of 409.7 hectares on the property (20.4.0%).

- *B3a:* Poorly drained grey and brown sands. 129.1 hectares in the proposed mine extension area of a total of 624.0 hectares on the property (20.7%).

Table 38: Soil Units within the Proposed Mine Extension Area and Predicted Impacts

Soil Unit	Brief Description	Mine Extension Area (ha)	Total Remaining KSS Property *(ha)	% Impacted
B1	Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than two metres.	100.8	494.7	20.4
B1a	Deep bleached grey sands with an intensely coloured yellow B horizon occurring within one metre of the surface.	17.5	24.5	71.4
B2	Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan at depth of one to two metres.	0.0	23.0	0.0
B3a	Poorly drained grey and brown sands, with an iron-organic (or siliceous) hardpan at depth of less than one metre.	129.1	624.0	20.7
B6	Deep or very deep grey siliceous sands.	4.0	169.2	2.4
S1c	Deep bleached grey sands with yellow-brown subsoils.	3.8	5.0	76.0
S2a	Moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils.	28.5	57.8	49.3

Note: * Excludes existing mine area.

The majority of soil units are well represented in other parts of the KSS property. The only soil units with a high (total) percentage of impact from the proposed mine extension area are types B1a, S1c and S2a. B1a soil unit is represented to the north and south of the KSS property and S1c and S2a are representatives of the Spearwood dune system to the property's west. The small extent of these soil units on the KSS property reflects the interface between the Bassendean and Spearwood dune systems on the property. These soil types are well represented in the surrounding region.

7.2.1.4 Management and Mitigation Measures

KSS aims to conserve surface soil to help with long-term site rehabilitation and minimise environmental degradation. Management and mitigation measures to achieve these aims and reduce the risk rating include:

- Wind and water erosion:
  - Strip and stockpile topsoil (where required) in dry and preferably still wind conditions, to minimise dust generation and assist rapid revegetation **(Commitment 7.2.1.4a)**.

  - Control slope gradients to minimise erosion and soil loss. Finished slopes will include a zone of shallow beach approximately 30 to 40 metres wide before sloping at a stable angle of repose (approximately one in four) to the base of the rehabilitated lake **(Commitment 7.2.1.4b)**.
  - Routinely inspect rehabilitated and disturbed surfaces for erosion, particularly after significant rainfall **(Commitment 7.2.1.4c)**.
  - Implement appropriate remediation measures if soil erosion is observed during routine inspections **(Commitment 7.2.1.4d)**.

- Soil management:
  - Place stockpiled topsoil in windrows less than three metres high to minimise loss of seed viability and soil biota **(Commitment 7.2.1.4e)**.
  - Strip and replace topsoil fresh and dry (known as the autumn direct return) to a maximum depth of about 100 millimetres where practicable and place directly onto rehabilitation areas or stockpiles **(Commitment 7.2.1.4f)**.
  - Complete direct replacement wherever practicable **(Commitment 7.2.1.4g)**.
  - Undertake progressive rehabilitation where practicable. All rehabilitation will be performed in accordance with contemporary accepted industry best practice **(Commitment 7.2.1.4h)**.
- Soil compaction:
  - Rip rehabilitation areas on the contour to remove compaction, improve soil structure and improve infiltration capacity if required **(Commitment 7.2.1.4i**).
  - Vehicles and mining equipment will keep to the designated roads. Very little vehicle use is needed as the mining process is dredge operated **(Commitment 7.2.1.4j)**.
- Soil contamination:
  - Refuelling and servicing is carried out at the existing plant **(Commitment 7.2.1.4k)**.
  - Heavy mineral concentrate is recovered and not placed back into the dredge pond **(Commitment 7.2.1.4l)**.
- Rehabilitation management and mitigation measures are discussed in Section 9.

7.2.1.5 Predicted Residual Environmental Risk

KSS will implement management measures described above to mitigate any impact to wind erosion of topsoil and consequent impacts on revegetation success. Due to the nature of creating lakes post mining, excess topsoil will be generated. Excess stored topsoil will be used to assist with landform shaping and used as subsoil. KSS considers established measures and controls are sufficient to maintain environmental values of the property.

Potential soil impacts with their pre and post management risk are presented in Table 39. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16. From this it can be seen that residual risk is low for all potential soil impacts.

Table 39: Potential Soil Impacts Pre and Post Management

Potential Impact	Risk with No Management Measures	Residual Environmental Risk
Wind and water erosion	Moderate	Low
Loss of soil resources	Moderate	Low
Topsoil placement	Moderate	Low
Compaction	Low	Low
Contamination	Low	Low

7.2.2 Acid Sulfate Soils

7.2.2.1 Environmental Objectives

Acid sulfate soils are recognised as a potentially contaminating material, requiring specific consideration and management if present on a development site.

7.2.2.2 Relevant Standards and Legislation

- Department of Environment and Conservation Land and Water Quality Branch, May 2009. *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes*. Acid Sulfate Soils Guideline Series.
- Department of Environment and Conservation, January 2009. *Draft Treatment and Management of Soils and Waters in Acid Sulfate Soil Landscapes*. Acid Sulfate Soils Guideline Series.
- Western Australian Planning Commission, November 2003. *Planning Bulletin No. 64: Acid Sulfate Soils.*

7.2.2.3 Assessment of Potential Risks and Impacts

The potential for ASS development is due to the high water table and low lying topography of the area. Potential ASS issues identified are:

- Contamination of groundwater.
- Contamination of the dredge pond.
- Acidification of the beaches.
- Death/retardation of plant growth.
- Fauna deaths.

Initial survey results over the proposed mine extension area exhibit Non Acid Forming, Potentially Acid Forming and Acid Consuming soil types. The property borders on limestone to the east and the Spearwood system to the west. Drill logs (Appendix IV of Appendix 3) show shell debris at the base of the silica sand resource in a number of holes has been identified in western parts of the property. This, and the results of ASS testing (Appendix 1), confirm that carbonate based Acid Neutralising Capacity is present over much, but not all, of the proposed mine extension area. It is highly unlikely that potential acidity generated by

mining activities will have any measureable effect on either groundwater away from disturbed areas or natural wetland systems.

The risk of acid generation is low, with mining having taken place on site for 10 years and monitoring not showing any development of actual acid formation.

Groundwater monitoring over the property for the last 10 years shows highly variable groundwater results (Appendix III in Appendix 3). A general increase in monitoring frequency in mid 2004 has enabled more confident recognition of trends in the data. pH data trends over the monitoring record vary between sites with some sites indicating rises (KMB11 and KMB12), some showing no change (KMB6, 7, 8, 10 and 14), and others showing early falls from their initial values and stable or slightly rising trends thereafter (KMB1 and 2). There are no definitive trends of falling pH in the monitoring data (John Moncrieff Rockwater, 2008 pers. comm.). The data from the dredge pond fall within the range of values recorded for the bores and wetlands (disregarding anomalously high or low values). Comparatively low pH values (<pH 5 with some seasonal fluctuations) have been present in KMB6 and KMB10 since monitoring commenced (John Moncrieff Rockwater, 2008 pers. comm.).

Data from GHD (2002) and modelling shows that groundwater flow across the KSS site is generally towards the east or southeast except in western areas where flow is towards the west. Consequently, some low pH groundwater (from the vicinities of KMB6 and KMB10) could flow naturally beneath the dredge pond and seep into the pond if the head of water in the pond is below the water table. KMB1 and KMB2 are in areas which are unlikely to be affected by the operations at KSS, based on the implied groundwater flow direction, yet both show small falls in pH over the monitoring record. This could suggest some natural variation of pH in the data (John Moncrieff Rockwater, 2008 pers. comm.). KM12 is located adjacent to and possibly down the hydraulic gradient from the dredge pond, yet no fall in pH is evident in the monitoring data; in fact a small rise in pH has occurred. Results from the groundwater monitoring data show no definitive evidence that mining activities have generated acid at the site (John Moncrieff Rockwater, 2008 pers. comm.).

It is recognised that a low risk of acid generation exists. In the fringing wetland environment, any acidity generated to the rehabilitated lake will be reported to DEC. As wetlands on the KSS property also contain calcitic material at the base of the lake, if any acidity is generated, it will be neutralised.

Small amounts of Potentially Acid Forming material is present in the mined profile as fine pyritic material (50 mg/kg). It is concentrated in the reject stream of the silica sand processing circuit. This reject stream also contains the heavy mineral component of the material mined which is stockpiled at the plant site on a limestone pad and transported off site for secondary processing by a dedicated mineral sand processing company. The waste from secondary processing, with ilmenite removed, is returned to KSS. It still contains some heavy mineral components such as zircon and pyritic material. Approximately 700 tonnes of waste per year is returned to KSS and stockpiled on a limestone pad. KSS intends to further process the waste by removing the zircon, but this is not currently feasible. If removal of remaining heavy minerals occurs, the remaining waste will be blended into sand returned to the rehabilitation cell. The majority of sand returned to rehabilitation cells is located underwater, reducing the potential for oxidation. Some pyritic material may be located in fringe beach areas which are seasonally exposed to oxygen or in reconstructed upland landforms.

7.2.2.4 Management and Mitigation Measures

Although the initial assessment indicates that the soil types in the proposed mine extension area are Non Acid Forming, Potentially Acid Forming and Acid Consuming, most of the potential high acid generating soils are below the base of the final dredge pond depth (22 metres). The soils will not be disturbed and will remain below the water table. High Acid Neutralising Capacity soils will provide significant in-situ buffering capacity assuming they are located in close proximity to the potential acid forming material.

With the approximate 50 year project lifespan, a staged approach to ASS sampling is proposed. Subsequent 'infill' surveys will be conducted to quantify the potential ASS risk in advance of the mining envelope beyond 10 years and verify the results of broader scale initial sampling. The surveys will comprise the following elements:

1. In line with the low to moderate ASS risk ranking indicated for the mine area, sampling is to be undertaken at 250 metre spaced holes.
2. Selection of the transect alignment is designed to target the range of soil types represented within the upcoming year's mine schedule. Field assessment at one metre layers within each zone is considered acceptable by the DEC.
3. Following field testing of soil, a selection of samples with the highest ASS field results will be submitted for laboratory analysis.

If ASS sampling identifies significantly sized high Potentially Acid Forming locations within the proposed pond area, KSS will alter mine plans to reduce the dredge depth to avoid these areas **(Commitment 7.2.2.4a)**.

Where Potentially Acid Forming materials are small in volume, the material will be dredged, however residues will be returned to permanent lakes and will remain below the water in the long-term **(Commitment 7.2.2.4b)**.

KSS will implement a monitoring program to detect any changes attributable to the generation of acid. Ongoing monitoring will continue to record water quality in the dredge pond, rehabilitated cells and surrounding groundwater **(Commitment 7.2.2.4c)**.

Should any acid generation occur due to mining, the ASSMP will be implemented to address any acidity generated **(Commitment 7.2.2.4d)** (Appendix 16).

7.2.2.5 Predicted Residual Environmental Risk

Mitigation measures described will maintain the environmental values of the KSS property and minimise potential for acid formation.

Potential ASS impacts with their pre and post management risk are presented in Table 40. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16. From this it can be seen that residual risk is low for all potential acid sulfate soil impacts.

Table 40: Potential Acid Sulfate Soil Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Contamination of groundwater	Moderate	Low
Contamination of pond	Moderate	Low
Acidification of beaches	Moderate	Low
Death/retardation of plant growth	Moderate	Low
Fauna deaths	Low	Low

7.3 SURFACE HYDROLOGY

7.3.1 Environmental Objectives

Maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

To ensure emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

7.3.2 Relevant Standards and Legislation

Standards

- Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.*
- Australian Government, 1994. *National Water Quality Management Strategy.*
- Department of Water, 2008. *Water Quality Protection Notes.*
- Government of Western Australia, 2003. *State Water Quality Management Strategy for Western Australia No. 2.*
- National Environment Protection Council, November 2003. *Contaminated Sites Management Series - Assessment Levels for Soil, Sediment and Water.*
- Water and Rivers Commission, Department of Mines and Energy and Department of Environmental Protection, 2000a. *Water Quality Protection Guideline No. 6 – Mining and Mineral Processing: Mine Stormwater.*
- Water and Rivers Commission, Department of Mines and Energy and Department of Environmental Protection, 2000b. *Water Quality Protection Guideline No. 11 - Mining and Mineral Processing: Mine dewatering.*

Legislation

- *Environmental Protection Act 1986* (WA).
- *Rights in Water and Irrigation Act 1914* (WA).

7.3.3 Assessment of Potential Risks and Impacts

Potential impacts to surface water quality due to mining activities include:

- Surface water contamination eg. acidity, hydrocarbons and sediment.
- Changing landform and catchment characteristics.

Potential adverse impacts on surface water quantity and quality are expected to be minimal after implementing the control measures described in Section 7.3.4.

7.3.3.1 Surface Water Contamination

Contamination of groundwater from hydrocarbons is addressed in Section 7.4.4. Hydrocarbon storage areas and workshops are already constructed for the current operations on-site. No addition to this infrastructure is required for the mine extension. Minor spillage occurring as a result of accidents or breakdowns to the dredge will continue to be addressed and reported through KSS's accident/incident report procedure. Spillages are removed and disposed off-site, as required in the site's DEC licence.

The potential exists for contamination of surface water within operational ponds with hydrocarbons used within the dredge hydraulics and sediment transferred by slurry pipelines between the dredge and process plant. The risk of contamination of surface water outside of operational areas is low as no sources of contamination exist and no water is discharged from the dredge ponds.

KSS implements industry standard 'duty of care' practices for all on-site chemicals.

Flocculants are added as part of processing operations and waste material returned to the dredge ponds is likely to contain residual flocculants. The flocculent used in sand processing has a Non Hazardous chemical classification with no specific regulations or standards covering storage of this material. The flocculent property binds irreversibly to both inorganic sediment matter (such as clays and silt) and to natural organic acids and precipitates out of solution in sediment. This leaves negligible residue in the supernatant water.

7.3.3.2 Changing Landform and Catchment Characteristics

There are no permanent surface water features located in the mine extension area. Wetlands in the proposed mine extension area are ephemeral, with surface water present only during winter in some years. The soils of the western extension area are highly permeable Bassendean sand. There is little surface runoff from upland locations.

Mining will result in localised alteration of surface profiles.

Post mining landforms will be substantially altered from the pre-mining condition. Approximately half the proposed mine extension area will become permanent lakes as a result of excavation and dredging of the silica sand resource. The resultant lakes will intersect the groundwater table, establishing permanent surface water features.

7.3.4 Management and Mitigation Measures

KSS will manage impacts on surface water quality and quantity due to mining activities by implementing the following actions:

- Surface water contamination:
  - Pipelines between the dredge and processing plant will be located in the infrastructure corridor. They will be fully bunded with purpose built sumps located along the infrastructure corridor with sufficient capacity to hold the pipeline volume in the event of a pipe failure **(Commitment 7.3.4a)**.
  - Regular dredge maintenance to minimise risk of spills and leaks **(Commitment 7.3.4b)**.
  - Any spills of contaminants such as oil or fuel will be immediately cleaned up **(Commitment 7.3.4c)**.
  - Place spill kits in easily accessible locations and provide operator training for hydrocarbon spill response **(Commitment 7.3.4d)**.
- Surface water quantity and quality:
  - Altered design of proposed mine extension area boundary to reduce the impact on EPP4 and conservation category wetlands.
  - Regular monitoring of EPP wetlands for water levels and water quality **(Commitment 7.3.4e)**.
  - Monitor surface water quality around the active mine area **(Commitment 7.3.4f)**.
  - Natural surface water flows in the mine extension areas will be maintained. Diversion of surface water will not be required during operation or rehabilitation. Surface water flows of adjoining areas will not be affected by dredging operations **(Commitment 7.3.4g)**.

7.3.5 Predicted Residual Environmental Risk

KSS will implement management measures described above to mitigate any impact to surface water quality and quantity. KSS considers established measures and controls are sufficient to safeguard against any negative impact on water flows or quality from the project site.

Potential surface water impacts with their pre and post management risk are presented in Table 41. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16. From this it can be seen that one high risk impact remains after implementation of management measures. As this relates to change in landform associated with mining, no additional controls are able to be implemented to prevent or minimise this risk.

Table 41: Potential Surface Water Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Contamination	Moderate	Low
Changing landform and catchment characteristics	High	High

7.4 GROUNDWATER

7.4.1 Environmental Objectives

Maintain or improve the quantity and quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance, are protected.

Ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

7.4.2 Relevant Standards and Legislation

Standards

- Australian Government, 1994. *National Water Quality Management Strategy.*
- Department of Water, 2004. *Water Quality Protection Note: Australian Drinking Water Guidelines No. 6 (ADWG).*
- Department of Water, 2008. *Water Quality Protection Notes.*
- Environment Protection Authority, 2004c. *Position Statement No 4: Environmental Protection of Wetlands.*
- Government of Western Australia, 2003. *State Water Quality Management Strategy for Western Australia No. 2.*
- Water and Rivers Commission, Department of Mines and Energy and Department of Environmental Protection, 2000. *Water Quality Protection Guideline No. 11 - Mining and Mineral Processing: Mine dewatering.*

Legislation

- *Environmental Protection Act,* 1986 (Western Australia).
- *Rights in Water and Irrigation Act*, 1914 (Western Australia).

7.4.3 Assessment of Potential Risks and Impacts

Water is abstracted from local groundwater via two production bores for clean water use in processing operations and to top up dredge ponds in times of higher evaporation. All other water necessary for operations are sourced from the dredge pond where water is recycled and harvested from rainwater inflows. Potential impacts to groundwater quality and quantity due to mining activities relate to migration of pollutants into the groundwater system and the drawdown of the local groundwater system. Potential impacts are:

- Potential for acidification of groundwater through oxidation of sulfides in the soil profile.
- Potential for an increase in groundwater salinity due to extraction.
- Potential for contamination of groundwater due to hydrocarbons.
- Drawdown impacts on neighbouring bores resulting in reduced water availability.
- Altered wetland hydrology outside of the mine extension area.
- Altered wetland hydrology within the mine extension area.

7.4.3.1 Groundwater Monitoring

Groundwater monitoring undertaken since 1995 has not identified significant impacts to water quality or quantity from the current operation. This has been verified in annual groundwater monitoring reports submitted to DoW. Rockwater (2008) provides a detailed description of the site's groundwater monitoring program (Appendix 3).

A groundwater monitoring program is conducted monthly for groundwater levels and quarterly for groundwater quality around the dredge pond and wetland systems.

Groundwater levels in monitoring bores have historically ranged between approximately 10 - 16 metres AHD. Data suggests a general low hydraulic gradient across the property to the south-east. On-site production and monitoring bores as well as wetland monitoring points are presented in Table 42. The location of these bores is shown in Figure 23.

Table 42: Monitoring Sites

Bore	Reduced Level Top of Casing- (metres AHD)	Depth (metres)	Screen/Slots (metres below TOC)	Comments
Production Bores				
KMB7	15.684	29.0	16.5 – 28.5	Constructed 7/4/1995.
KMB14	16.475	30.0	16.6 – 28.6	Constructed 21/12/1995.
Observation Bores				
KMB1	17.597	24.0	11.0 – 23.4	
KMB2	16.814	23.8	11.0 – 23.0	
KMB3	14.708	24.0	10.0 – 24.0	Decommissioned in February 2001, covered during southern extension to dredge pond.
KMB4	16.028	23.0	11.0 – 23.0	
KMB5	16.334	22.0	10.1 – 22.1	Monitoring not required from 2001.
KMB6	15.596	19.0	1.5 – 19.0	Test pumped for 24 hours at 370kL/day.
KMB8	15.667	N/A	N/A	
KMB9	14.456	N/A	N/A	Monitoring not required from 2001.
KMB10	15.28	N/A	N/A	
KMB11	16.156	N/A	N/A	
KMB12	13.829	N/A	N/A	
KMB13	16.06	N/A	N/A	Silted-up in February 2001. Attempts to clear bore are in progress.
Wetland Monitoring Locations				
WL3	15.369	N/A	N/A	Staff gauge; seasonal wetland.
WL4	15.198	N/A	N/A	Staff gauge; seasonal wetland.
WL5	13.603	N/A	N/A	Staff gauge; seasonal wetland. Not monitored.
WL6	13.653	N/A	N/A	Staff gauge; seasonal wetland.
WL7	15.601	N/A	N/A	Staff gauge; seasonal wetland.
WL8	N/A	N/A	N/A	Staff gauge; seasonal wetland.
WL9	N/A	N/A	N/A	Staff gauge; seasonal wetland.

Source: Rockwater (2008) Table 2.

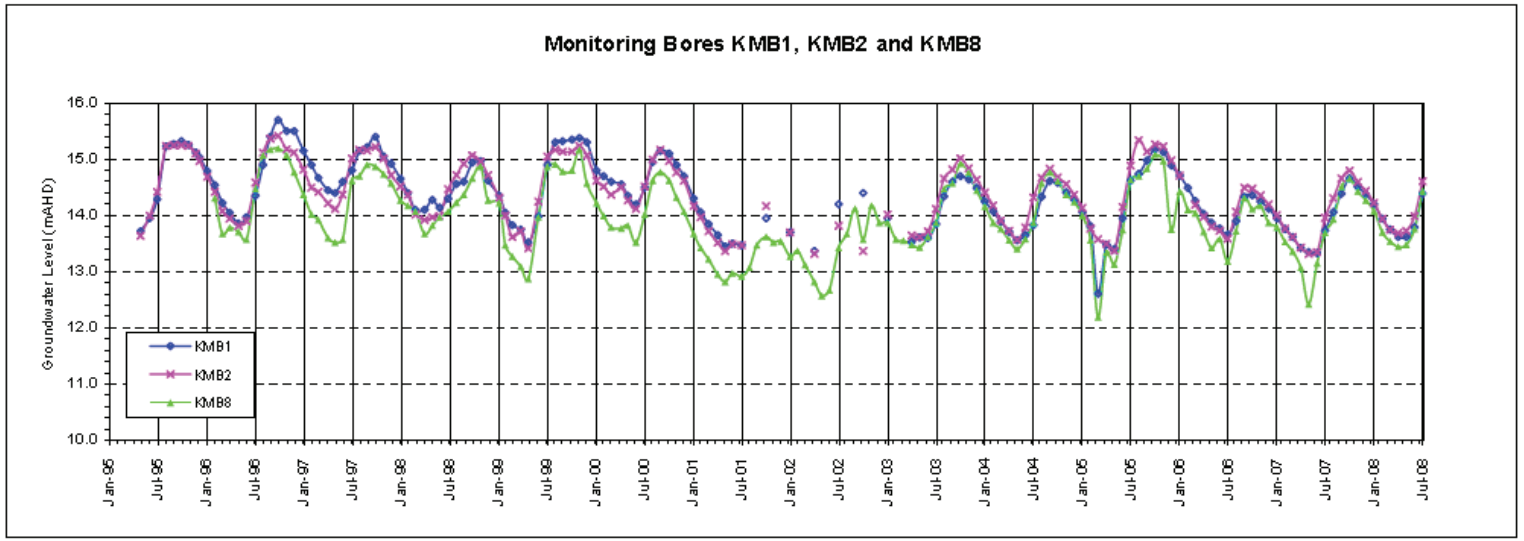
Chart 3 and Chart 4, from Rockwater (2008) are reproduced to show groundwater and wetland monitoring points, closest to the current operation. No significant changes have been detected since monitoring commenced in 1995. Operation in the proposed mine extension area is anticipated to produce similar results for the area surrounding the active dredge pond through the life of mine.

7.4.3.2 Groundwater Modelling

A groundwater flow model was developed to assess mining effects on the local water table and wetlands during mining operations and after completion of mining (GHD, 2008) (Appendix 18). Previous models were extended in calibration to predict potential impact on the surrounding aquifer and wetlands from the previously proposed western extension. This was used as a basis for construction of a new model for the area which included the current proposal area. The three dimensional MODFLOW modelling package was used in conjunction with the Groundwater Modelling System (GMS). A conservative excel based geochemical modelling approach of the salinity evolution in the flow through pit-lake was also proposed (GHD, 2008).

Simulations were undertaken based on a number of dredge pond options for the extension of dredge mining in the proposed mine extension area. The model was checked and calibrated by comparing 12 years of monitoring data, resulting in a correct and verified model. The period of predictive simulations was from 2008 to 2057. The simulations modelled the gradual increase in area of each new dredge pond as mining proceeded, with the whole simulation period represented by a number of models. Individual model timeframes were restricted to five years and the size of the dredge ponds were increased incrementally in zones for each subsequential model to the final pond size. Predicted groundwater levels in the model attained a dynamic equilibrium by the end of the simulation period. Comparisons between predicted water levels and ‘base case’ water levels allow an appraisal of the overall effects of mining on groundwater levels.

Chart 3: Groundwater Levels in Monitoring Bores



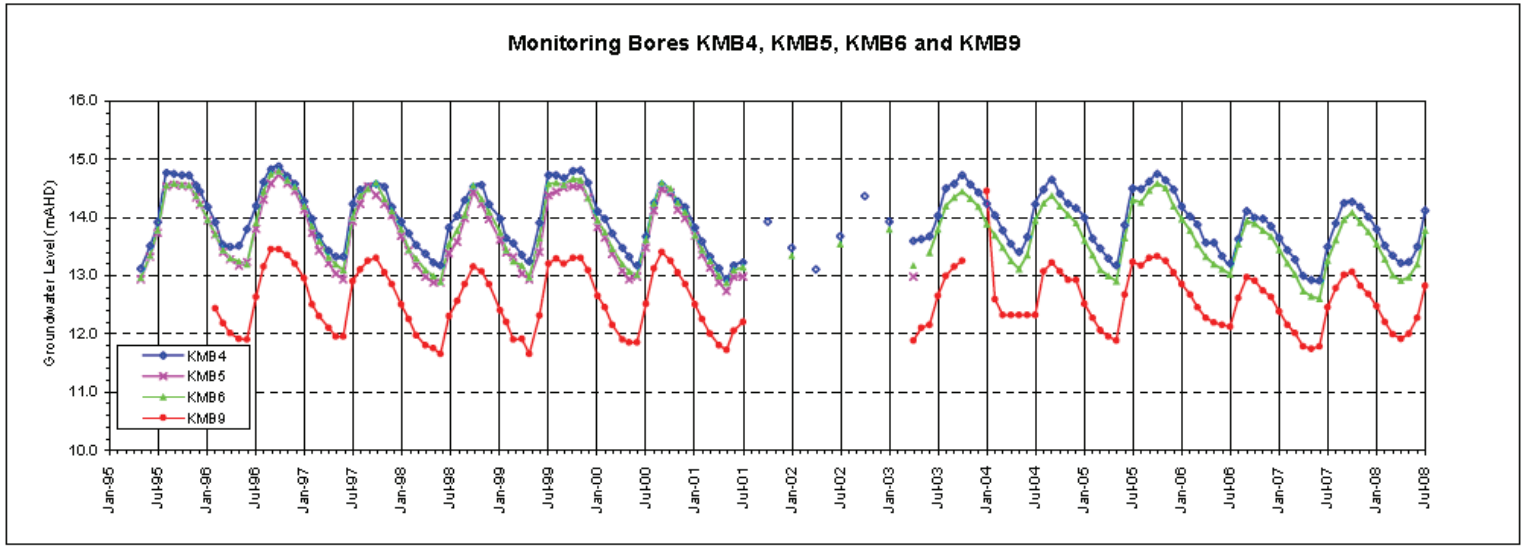
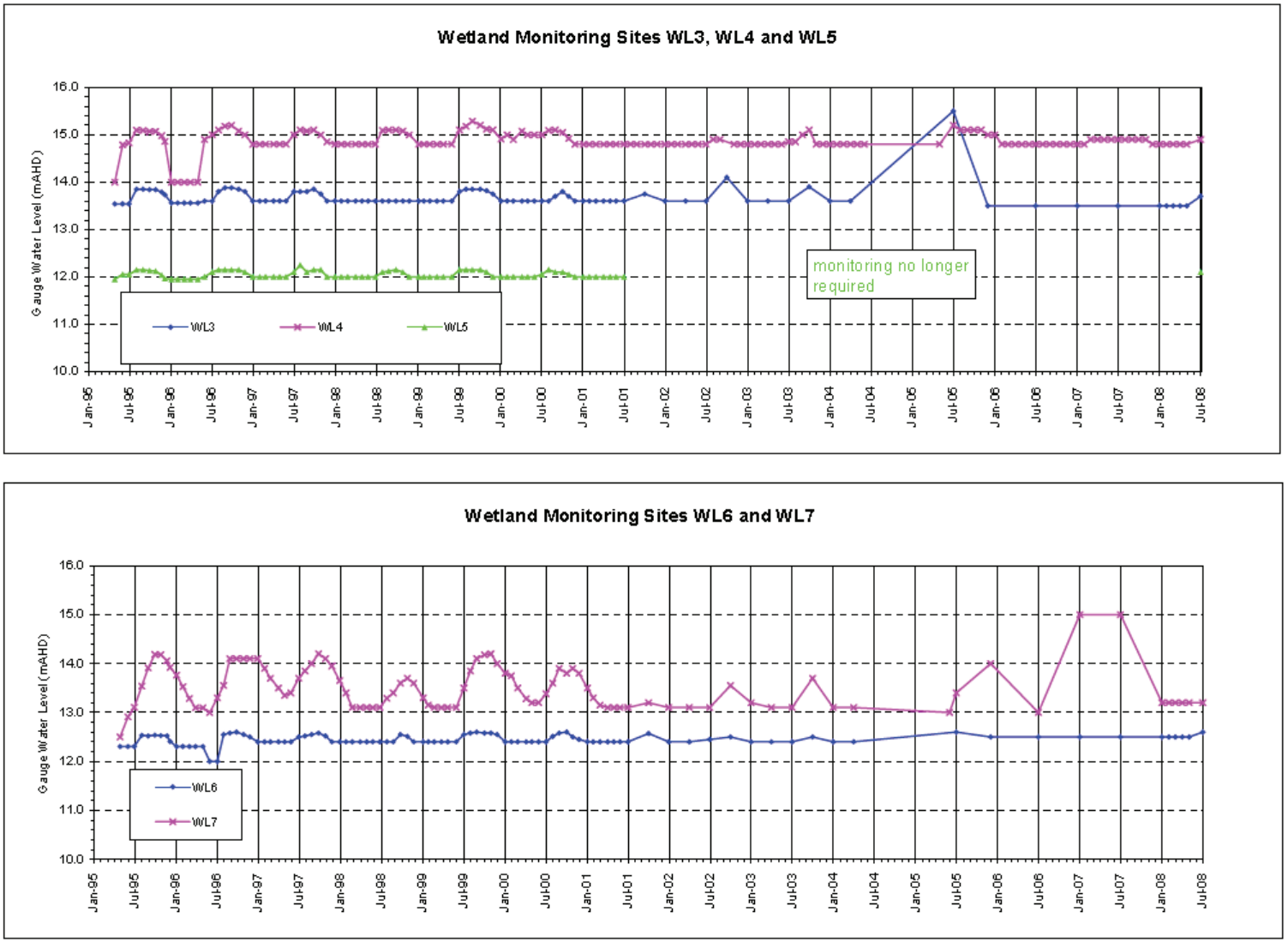
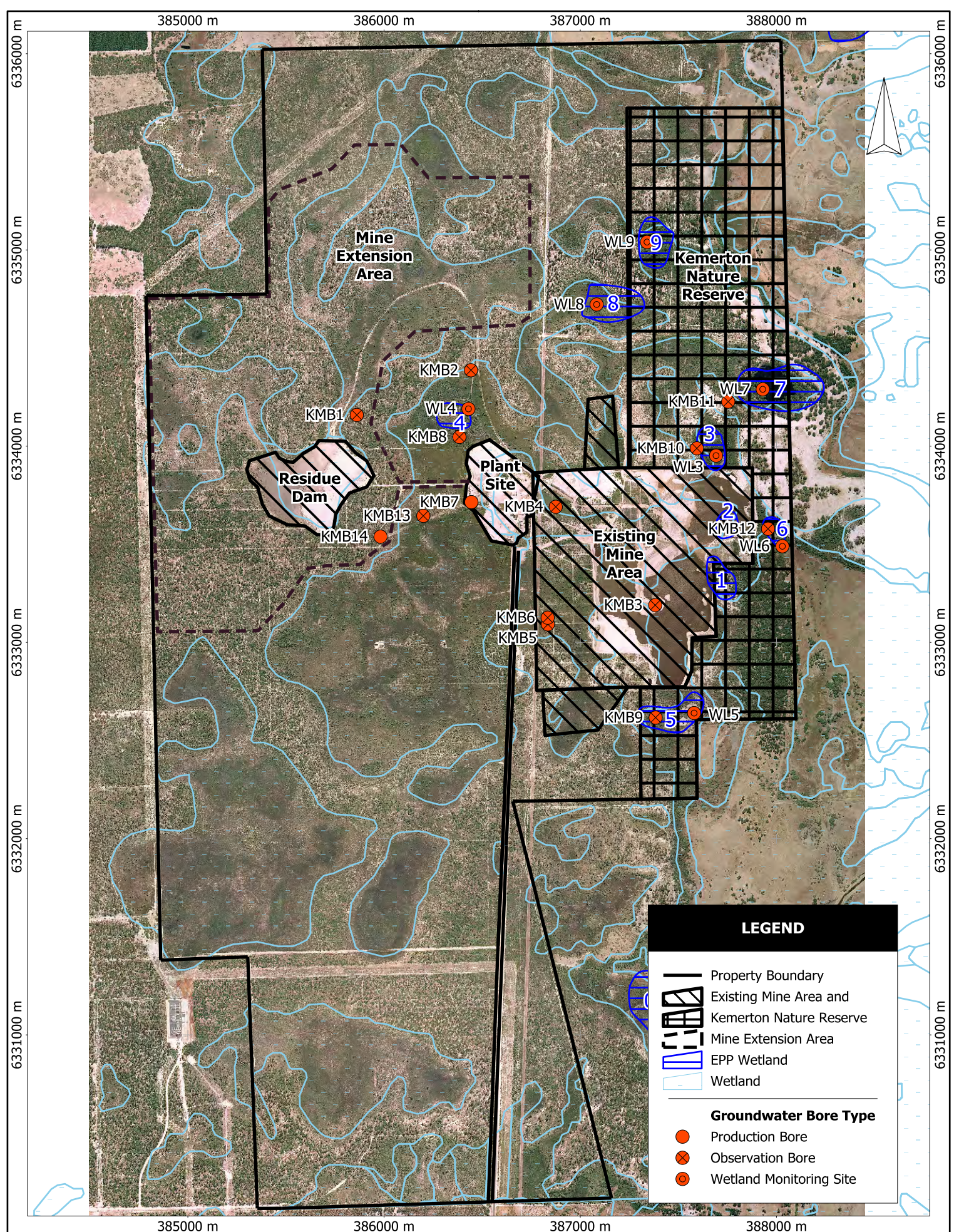


Chart 4: Water Levels in Wetlands



Source: Rockwater (2008).



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Scale: 1:24000
Original Size: A4
Air Photo: 2006
Grid: Australia MGA94 (50)
0 500 m

Kemerton Silica Sand Pty Ltd

Groundwater Bore Locations

Figure 23

W:\Kemerton Silica Sand\Drawings\Maps 2009\Bore locations.map 15/10/2009 Bore Layout Layout

Modelling results, showing a maximum rise in groundwater level in EPP4 due to the proposed mining of less than 0.1 metre as presented in Table 43. This groundwater level rise is unlikely to cause an adverse impact in the environment surrounding the wetland as natural variations in groundwater levels is in the order of 1.5 metres.

Table 43: Change in Water Table at Pit Lake and EPP4

Year	Block	Maximum Predicted Drop in Water Table at Pit Lake (m)	Change in EPP4 (m)
2012	1	0.5	<0.1
2017	2	1.8	<0.1
2022	3	1.6	<0.1
2027	4	1.5	<0.1
2032	5	1.3	<0.1
2037	6	1.3	<0.1
2042	7	1.3	<0.1
2047	8	1.2	<0.1
2052	9	1.2	<0.1
2057	10	1.2	<0.1

Source: GHD (2008).

The area affected at the end of mining compared to the 'base case' (reductions more than 0.2 metres) extends north-west, south-west and west for approximately 1,500 metres from the shoreline. A maximum reduction of approximately 1.2 metres is expected to occur along the western end of the predicted pond. The water level towards the east of the mining area is predicted to rise to an expected maximum of 0.8 metres.

The model was run for an additional 10 years following mine completion, predicting the water table up to the end of December 2067, when groundwater dynamic equilibrium after mining will be re-established. The water level in the western extension pond is predicted at approximately 14 mAHD in 2067. Compared to pre-mining conditions water levels in the pond are expected to decrease by a maximum value of 1.2 metres towards the western end of the pond and increase by a maximum value of 0.8 metres towards the eastern end of the pond, 10 years after completion of mining compared to pre-mining conditions (GHD, 2008).

Water levels in the lakes established as a result of mining are constant with seasonal fluctuations over a smaller range of elevations than the predicted 'base case' water table for the same areas in the model. Lake water levels have an overriding effect on water table levels in adjacent areas. There is a net discharge of water from the model in the lake areas due to increased water losses by evaporation from the open water compared to water losses by evapotranspiration from the same areas in the 'base case', which have below groundwater tables.

Background flow through water quality to the pit lakes is predicted to be relatively good, with an average pH of 6.0 and an average salinity value of approximately 250 milligrams per litre. Predicted groundwater quality indicates that salinity and selected ions in the pit lakes will increase with time. While the increasing trend of salinity, especially following year 60, would

decrease to become almost equilibrium after 85 years, chloride and sulfate will continue to steadily increase over time. pH values are also predicted to increase over time, but depending on groundwater recharge and new freshwater input, may remain in equilibrium with values slightly above circumneutrality (GHD, 2008).

7.4.3.3 Groundwater Usage

Section 3.9 shows plant modifications made in 2003 have significantly decreased groundwater usage and are now approximately one-third of the reduced licensed limit. No changes are anticipated to result from the proposed mine extension. The project is not anticipated to have a significant effect on groundwater quantity.

Post mining groundwater salinity is expected to rise from an initial value of about 300 milligrams per litre to a new equilibrium concentration of about 1,000 milligrams per litre after 85 years. It should be noted that existing groundwater chemical characteristics in the vicinity of the proposed site are highly variable. While average TDS is approximately 250 milligrams per litre, values vary from less than 100 milligrams per litre to approximately 750 milligrams per litre.

Impacts on vegetation due to groundwater rise and changes in quality are likely to be minor. The predicted rise in groundwater at EPP4 is within the range of natural variation and vegetation in this area is adaptable to such fluctuations. TDS in groundwater varies across the KSS property and vegetation will likely be able to adapt to any increase in TDS as a result of mining. Indirect impact on surrounding vegetation by changes as a result of mining, such as the possible draw-down of water table may result in the stress/death of susceptible species, particularly those in the area of seasonal inundation.

The Waters and Rivers Commission Water Quality Protection Note: *Extractive Industries within Public Drinking Water Source Areas* (2000c) and the *Statewide Policy No. 1: Policy and Guidelines for Construction and Silica Sand Mining in Public Drinking Water Source Areas* (1999) provide guidance on factors relevant to this proposal. However, this proposal has significant differences to operations referred to in the above documents. The main difference is the documents describe quarry operations that permanently operate in dry ground, above the water table. The KSS operation employs dredge mining methods, removing sand resources below the water table.

This has important considerations for factors identified in the Water and River Commission documents, specifically relating to minimum separation distance to groundwater levels. The minimum two metre separation to groundwater can not be achieved in dredge mining operations. In line with the principle of risk minimisation, management measures will be implemented to ensure pollution of groundwater does not occur.

A key potential pollutant is hydrocarbons. As the dredge is electrically powered, the only hydrocarbon used on it is hydraulic oil. No diesel is used on the dredge. The storage of hydrocarbons at the plant site is designed to comply with AS 1940:2004.

KSS considers the groundwater acidification risk is Low. The same dredge mining as proposed in this document has taken place on the property for over a decade, extracting groundwater and creating post mining lakes. Groundwater monitoring undertaken over this period has not identified significant acid generation. This is further discussed in Section 7.2.

7.4.4 Management and Mitigation Measures

KSS considers the risk of impacting groundwater is low. The same dredge mining proposed in this document has been undertaken on the property for over a decade, extracting groundwater and creating post mining lakes.

Management measures will ensure the project is implemented in line with the principle of risk minimisation to reduce groundwater pollution.

KSS will manage impacts on groundwater quality and quantity due to mining activities by implementing the following actions:

- Monitor the dredge pond and rehabilitated cells. Implement measures to balance pH if monitoring results show an increase in acid generation **(Commitment 7.4.4a)**.
- Any spills of contaminants such as oil or fuel will be immediately cleaned up **(Commitment 7.4.4b)**.
- Place spill kits in easily accessible locations and provide operator training for hydrocarbon spill response **(Commitment 7.4.4c)**.
- Maintain current water usage and continue to implement water saving initiatives **(Commitment 7.4.4d)**.
- Measure abstraction volumes **(Commitment 7.4.4e)**.
- Install additional monitoring bores to allow continued water quality monitoring of aquifer water levels in response to dredge mining and production bore abstraction to ensure no adverse impacts occur to the region's groundwater quantity:
  - KMB1 is located about 400 metres up the hydraulic gradient from EPP4.
  - Two monitoring bores will be installed along the western boundary of the property **(Commitment 7.4.4f)**.
- Two production bores will be installed, one located about 200 metres north of KMB6 and the other about 200 metres west of KMB6 **(Commitment 7.4.4g)**.
- Create north to south designed dredge ponds and rehabilitated lakes to reduce water loss by evaporation and impacts associated with easterly and westerly winds **(Commitment 7.4.4h)**.

The quality of groundwater is not expected to be affected from the operation for the following reasons:

- No chemicals with the potential to pollute water supplies are used during processing.
- Process wastes have a low risk of generating acid.
- Location and storage of hydrocarbons and mechanical servicing facilities are to industry standards (AS 1940:2004), to avoid impact on groundwater.
- Modelled separation distances to EPP wetlands are incorporated into the mine plan to avoid significant change to groundwater levels at EPP4.
- Location and design of rehabilitated cells will incorporate monitoring results and model outputs to mitigate local changes to groundwater levels.
- Periodic review of actual versus predicted groundwater modelling.

7.4.5 Predicted Residual Environmental Risk

KSS will implement management measures described above to mitigate any impact to groundwater quantity. The above measures will ensure the effect of the project on groundwater resources of the region are maintained at a manageable level.

Potential groundwater impacts with their pre and post management risk are presented in Table 44. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16. From this it can be seen that residual risk has been reduced through implementation of mitigation measures. Residual risk remains high for altered wetland hydrology within the mine extension area. No additional management measures are available to reduce this risk. The offset package described in Section 10.4 has been proposed to address the residual risk aspects. Management measures will reduce risk of impact on the groundwater resource and wetland hydrology outside of the mine extension area.

Table 44: Potential Groundwater Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Contamination (salinity)	High	Low
Contamination (acidification)	Moderate	Low
Contamination (hydrocarbons)	Moderate	Low
Depletion of groundwater resource	High	Moderate
Altered wetland hydrology outside of mine extension area	High	Moderate
Altered wetland hydrology within mine extension area	High	High

7.5 VEGETATION AND FLORA

7.5.1 Environmental Objectives

To maintain abundance, species diversity, geographic distribution and productivity of vegetation communities through the avoidance or management of adverse impacts and improvement in knowledge.

Protect Declared Rare and Priority flora and flora species of conservation significance consistent with the provisions of the *WC Act* and the *EPBC Act.*

7.5.2 Relevant Standards and Legislation

Standards

- Environment Protection Authority, 2000. *Position Statement No. 2: Environmental Protection of Native Vegetation in Western Australia.*

- Environment Protection Authority, 2006a. *Guidance Statement No. 10: Level of Assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of the System 1 Region.*

Legislation

- *Conservation and Land Management Act 1984* (WA).
- *Environmental Protection and Biodiversity Conservation Act 1999* (Cth).
- *Environmental Protection (Clearing of Native Vegetation) Regulations, 2004* (WA).
- *Environmental Protection Act 1986* (WA).
- *Wildlife Conservation Act 1950* (WA).

7.5.3 Assessment of Potential Risks and Impacts

The proposed mining extension involves clearing native vegetation of the Bassendean - Central and South vegetation complex and Spearwood vegetation complex. The proposed mine extension area of 283 hectares has 19 hectares of cleared land and 264 hectares of native vegetation that will require clearing over the 50 year project life. Of this, 20 hectares have already been approved for dry mining. Total land clearing requested for this proposal is thus in effect 244 hectares.

Approximately five hectares of land will be cleared each year, varying over the life of mine. Progressive revegetation in completed mining areas will reduce the total area disturbed at any one time. The 50 year project mine life will be sufficient to demonstrate, through monitoring, that rehabilitation meets progressive and final rehabilitation targets. This is discussed further in Section 8.

- Potential impacts on vegetation communities as a result of project implementation are:
  - Loss of vegetation as a result of land clearing. Loss will be permanent in some locations and temporary in others.
  - Altered vegetation distribution patterns post rehabilitation. Rehabilitated landforms will differ in total area compared to the pre-existing condition.
  - Impact on Muchea Limestone TEC.
  - Impact on PECs.
- Potential impacts to Declared Rare and Priority Flora as a result of project implementation are:
  - Removal of individual plants of conservation significance within the proposed mine extension area, including *Boronia juncea* subsp. *juncea* (P1), *Acacia semitrullata* (P3), *Dillwynia dillwynioides* (P3), *Caladenia speciosa* (P4) and *Eucalyptus rudis* subsp. *cratyantha* (P4).
- Potential indirect impacts from mining are:
  - Impact on individual plants of conservation significance outside the proposed mine extension area.
  - Indirect impact on surrounding vegetation by changes resulting from mining, such as possible draw-down of the water table may result in stress/death of susceptible species, particularly those in the area of seasonal inundation.

– Clearing and earthworks resulting in potential for spread of weeds and increased erosion.
– Clearing and earthworks resulting in potential for spread of dieback.

7.5.3.1 Impact on Vegetation Communities

The extent of vegetation community types in the proposed mine extension area relative to the total KSS property is presented in Table 45. Almost 95% of the proposed mine extension area is occupied by three major vegetation community types:

- Type A1 – A3: Woodland to Open Woodland of Eucalyptus marginata - Banksia species. 154.2 hectares in the proposed mine extension area of a total of 481.5 hectares on the property (32.0%).
- Type G1 – G4: Shrubland of Myrtaceae and Proteaceae species. 20.0 hectares in the proposed mine extension area of a total of 87.5 hectares on the property (22.9%).
- Type H1 – H3: Closed Heath of Myrtaceae species. 73.9 hectares in the proposed mine extension area of a total of 468.9 hectares on the property (15.8%).

Table 45: Vegetation Communities Within the Proposed Mine Extension Area and Predicted Impacts

Community	Brief Description	Mine Ext. Area (ha)	Total Remaining KSS Property *(ha)	% Impacted
A - 1	Open woodland of *Eucalyptus. Marginata and Banksia* spp.	21.8	59.6	36.6
A - 2	Open woodland of *E. marginata - B. attenuata - Kunzea ericifolia*	2.7	7.8	34.6
A - 3	Open woodland of *E. marginata - B. attenuata - B. ilicifolia*	129.7	414.1	31.3
B - 1	Open Woodland of *E. marginata - Corymbia calophylla* and *K. ericifolia*	0.0	10.8	0.0
C - 1	Open forest of *Agonis flexuosa - E. marginata*	1.7	3.5	48.6
C - 2	Open woodland of *A. flexuosa*	4.0	4.2	95.2
C - 3	Closed Woodland of *Agonis flexuosa - Corymbia calophylla - E. rudis*	0.0	21.8	0.0
D - 1	Open Woodland of *E. rudis* and *K. ericifolia*	0.0	5.7	0.0
D - 2	Woodland of *E. rudis - Melaleuca Preissiana*	0.7	11.8	0.6
D - 3	Woodland of *E. rudis – M. rhaphiophylla*	0.0	6.7	0.0

Community	Brief Description	Mine Ext. Area (ha)	Total Remaining KSS Property *(ha)	% Impacted
E - 1	Low open woodland of *M. preissiana*	0.0	15.5	0.0
E - 2	Low woodland of *M. preissiana*	4.6	24.0	19.2
E - 3	Low Woodland of *M. preissiana* and *Agonis flexuosa*	0.0	1.6	0.0
E - 4	Closed low forest of *M. preissiana*	0.0	1.5	0.0
F - 1	Low closed forest of *M. rhaphiophylla*	5.0	26.3	19.0
F - 2	Seasonally inundated Low Open Woodland of *M. rhaphiophylla* over *M. viminea* and *M. cuticularis*	0.0	4.6	0.0
F - 3	Low woodland of *M rhaphiophylla*	0.6	10.6	0.1
G - 1	Tall shrubland of *K. ericifolia*	9.8	60.2	16.3
G - 2	Dense shrubland of *Taxandria linearifolia*	0.0	6.9	0.0
G - 3	Shrubland of *Hakea varia - Melaleuca* spp.	10.2	19.2	53.1
G - 4	Waterlogged shrubland of *M. viminea*	0.0	1.2	0.0
H - 1	Low closed heath of *Pericalymma. ellipticum - Hypocalymma angustifolium*	61.7	341.2	18.1
H - 2	Closed heath of *Astartea. scoparia - Calothamnus lateralis*	11.5	125.3	9.2
H - 3	Closed heath of *M. lateritia - A. scoparia*	0.7	2.4	29.1
I - 1	Disturbed open woodland	0.0	17.0	0.0
I - 2	Cleared area occasional *E. marginata*	0.0	17.1	0.0
I - 3	Regenerating community	0.0	8.3	0.0
J	Open water	0.0	6.0	0.0
Pasture	Pasture	0.0	33.4	0.0
Pine	Pine	0.0	26.4	0.0

Note: * Excludes existing mine area and Lot 501.

The majority of communities are well represented in other parts of the KSS property. The only communities with a high (total) percentage of impact from the proposed mine extension area are types C1 and C2. These communities are similar to the Karrakatta – Central and South and Yoongarillup vegetation complexes further to the west of the KSS property. A small pocket of C1 exists in Kemerton Nature Reserve which is likely representative of the Serpentine River vegetation complex. The small extent of these vegetation types on the KSS

property reflects the interface between the Pinjarra Plain and the Bassendean and Spearwood dune systems on the property. These vegetation types are well represented in the surrounding region.

As the majority of the Swan Coastal Plain has been cleared and modified for agricultural and urbanisation activities, any large consolidated portion of native vegetation is regarded as having regional significance. Consolidated areas of native vegetation extend to the north, south and west of the KSS property. The area eastwards is largely cleared and used for farming. Vegetation communities present in the KSS property provide both a north-south and a partial east-west corridor. These have the potential to be significant for native fauna movement through the area.

7.5.3.2 Impact on Declared Rare and Priority Flora

Species of conservation significance in this context are defined as DRF, Priority species or species identified as being uncommon or at the edge of their range. The distribution of species of conservation significance identified by Bennett (2004) is shown in Figure 11.

The Critically Endangered, DRF species, *Caladenia procera*, was located in the south-west corner of the KSS property. It was identified by Woodman (2005a) in a follow-up survey for the Kemerton lateral pipeline. This location is in an area proposed as an offset outside the proposed mine extension area and will not be disturbed. *Caladenia procera* was declared Rare in April 2002 under the *WC Act 1950*. It currently meets the International Union for Conservation of Nature (IUCN) and Natural Resources (2001) Red List Category Critically Endangered under criteria C1 as there is a total of less than 250 plants, with a continuing decline in the number of adult plants and available habitat. The main threats are land clearing, road and firebreak maintenance, weed invasion, inappropriate fire regimes and grazing (Stack and English, 2004).

One DRF species, *Conostylis micrantha*, was recorded in surveys undertaken by Ecos (1998) and Arbotech Pty Ltd (1997). This species is thought to be restricted to the Dongara-Mingenew area (Bennett, 2004). Subsequent surveys undertaken by Mattiske (2003b) and Bennett (2004) failed to locate the species however a similar species, *Conostylis juncea* was identified. It was concluded the earlier recording of the DRF species was a misidentification.

Nine Priority flora species have been recorded on the KSS property (Table 12). Six of these Priority species have been recorded in the proposed mine extension area (Table 46). One of these species, *Goodenia filiformis* (P3), is likely to be *Goodenia pulchella* subsp. Coastal Plain B (L. W. Sage 2336), which is not a Priority species due to recent taxonomic revision (Bennett, 2004).

Table 46: Priority Species Impacted by Mining in the Proposed Extension Area

Priority Species	Total No. of Individuals Recorded (approx)	Mine Ext. Area (No. of Individuals)	Remaining KSS Property (No. of Individuals)	% Impacted (approx)
Acacia semitrullata (P3)	276	55	221	19.9
Boronia juncea subsp. *juncea* (P1)	1,544	100	1,444	6.5
Caladenia speciosa (P4)	3	1	2	33.3

Priority Species	Total No. of Individuals Recorded (approx)	Mine Ext. Area (No. of Individuals)	Remaining KSS Property (No. of Individuals)	% Impacted (approx)
Dillwynia dillwynioides (P3)	570	10	560	1.8
Eucalyptus rudis subsp. *cratyantha* (P4)	142	17	125	12.0

Note: The total number and percentage impacts are approximate as Bennett (2004) did not record exact population numbers for all species as some were abundant. It is likely percentages are greater than the actual percentage impacted.

The proposed mine extension area is located in a portion of the site with the least impact on species of conservation significance. KSS considers this fulfils the principle of avoidance outlined in EPA Guidance Statements 55 and 19. Flora surveys also show no Priority species are exclusively located in the mine extension area. Populations of all Priority species occur outside the proposed mine extension area that will not be disturbed by the project. This ensures the risk of negative impact from the project on individual Priority species is low. This outcome is consistent with the protection of biodiversity as detailed in Table 1.

Boronia capitata subsp. *gracilis* (P1) and one population of *Dillwynia dillwynioides* (P3) are located close to the boundary of the proposed mine extension area (Figure 11). Adjustment of the mine boundary has occurred to avoid direct impact to these locations, especially given these are the only known records of *Boronia capitata* subsp. *gracilis* (P1) on the KSS property. *Acacia semitrullata* (P3) is scattered throughout many wetlands on the KSS property and over 100 individuals were recorded at one site (Bennett, 2004). Some scattered plants of *Acacia semitrullata* (P3) occur throughout parts of the mine extension area. It is acknowledged that populations of *Acacia semitrullata* (P3) will be affected by this proposal, but is not restricted to the mining extension area. Population counts recorded by Bennett (2004) identified that 20% of the population *Acacia semitrullata* (P3) will be affected through the proposed mining. This is an underestimate as the "scattered plants" of *Acacia semitrullata* (P3) throughout the KSS property have no population counts recorded (Bennett, 2004).

The other four Priority species in the mining extension area are located in areas not scheduled to be mined until late in the project. *Eucalyptus rudis* subsp. *cratyantha* (P4) will not be removed until 25 years from project commencement. There are two good populations of *Eucalyptus rudis* subsp. *cratyantha* (P4) within the KSS property, one in the north near the boundary of Kemerton Nature Reserve, and the other in the south-west in good quality bushland, with 17 individuals requiring removal. The proposed mining should not adversely affect the population of this species.

Populations of *Boronia juncea* subsp. *juncea* (P1), *Dillwynia dillwynioides* (P3) and *Caladenia speciosa* (P4) will not be affected until 40 years after commencement of mining. *Boronia juncea* subsp. *juncea* (P1) is scattered throughout the KSS property and occurs in excess of 100 individuals at the edge of wetlands (Bennett, 2004). The presence of this species is confined to locations which are seasonally inundated and is consistent with earlier survey work by Mattiske (1993a, b, c, d) and Muir (1999) that recorded this species in the eastern damplands of the site. These correspond to the chain of EPP wetlands now located in Kemerton Nature Reserve. Approximately 100 individuals of *Boronia juncea* subsp. *juncea* (P1) will be impacted through the proposed mining, which is 6.5% of the population in the KSS property.

Dillwynia dillwynioides (P3) is also very common across the KSS property with 50 individuals recorded in *Astartea scoparia/Kunzea glabrescens* thicket (Bennett, 2004). Ten individuals will be removed through the proposed mining, which is 2% of the population in the KSS property.

Caladenia speciosa (P4) is not a common component of the flora of the KSS property with one individual to be removed as a result of mining in the proposed extension area and two others occurring outside the mining area.

7.5.3.3 Indirect Impacts from Mining

Extracting silica sand from the proposed mine extension area may also have impacts on vegetation outside the proposed mine extension area. These impacts would not be related to direct disturbance, such as clearing, but more likely to be the result of changes to groundwater levels or topographic changes.

Ten years of previous mining on-site and monitoring has not resulted in any recorded impact on surrounding vegetation. Modelling predicts the change in groundwater levels at EPP4 over the next 50 years will be negligible, at less than 0.1 metre. Post mining groundwater salinity is expected to rise from an initial average value of 300 milligrams per litre to reach a new equilibrium concentration of 1000 milligrams per litre after 85 years. This change is only slightly more than existing variability in water quality around the site. Over an extended period it is not expected this change will result in significant affects to vegetation and fauna. Groom *et al.* (2000) reported localised tree death within 200 metres around a production bore on the Gnangara groundwater mound in the early 1990's, which lowered water levels by 2.2 metres. Banksia ilicifolia was the most susceptible to groundwater drawdown in tandem with extreme summer temperatures and lower than average rainfall, resulting in poor groundwater recharge (Groom *et al.* 2000). Modelled post mining changes to groundwater levels are predicted to be about half this amount (1.2 metres) a few hundred metres from the dredge ponds (Appendix 18). It is not anticipated these values will result in significant tree death around the dredge ponds.

7.5.4 Management and Mitigation Measures

Ongoing development of monitoring methodology and rehabilitation techniques will occur during the life of mine. Further assessments over time will plot the development of rehabilitated areas against analogue sites and progression towards defined scores that are set as completion targets.

Monthly water level and quarterly water quality groundwater monitoring will continue in the proposed mine extension area and around wetland systems. Monitoring within 200 metres of bores and dredge ponds will provide an indication if trees are under stress. Monitoring will continue to identify any changes to groundwater occurring from the project. Monitoring should target susceptible species, particularly *Banksia ilicifolia* and other *Banksia* and *Melaleuca* species on upland areas rather than seasonally inundated areas. Additional groundwater monitoring bores will be installed. This is discussed in Section 7.4.4.

KSS will minimise the impact on vegetation communities through the following measures:

- Progressive clearing of an average of five hectares per year **(Commitment 7.5.4a)**.

- Delineate areas to be cleared with survey pegs and flagging tape before clearing starts. Company supervisors will oversee clearing works **(Commitment 7.5.4b)**.
- Undertake surveys of areas planned to be cleared in the short term to identify plants suitable for translocation, seed collection or collection of propagating material for use in the annual rehabilitation program **(Commitment 7.5.4c)**.
- Progressive rehabilitation to encourage colonisation from surrounding vegetative areas **(Commitment 7.5.4d)**.

KSS will minimise the impact on Declared Rare and Priority Flora through the following measures:

- Seed collection and cuttings of Priority Species **(Commitment 7.5.4e)**.
- KSS has carefully chosen a proposed mine extension area where there will be the least effect on species of conservation significance and fauna habitat. The proponent considers this fulfils the principle of avoidance outlined in EPA Guidance Statements 55 and 19.

KSS will minimise indirect impacts from mining through the following measures:

- Continue to undertake detailed monitoring of rehabilitated areas to ensure short, medium and long-term rehabilitation objectives are achieved. Monitoring to be carried out on a regular basis to assess **(Commitment 7.5.4f)**:
  - Physical stability of the landform of rehabilitated areas.
  - Success of vegetation and fauna re-colonisation in rehabilitated areas.
  - Water quality and ecology of lakes.
  - Monitoring should also be conducted within 200 metres of groundwater abstraction bores and dredge ponds to target susceptible species, particularly *Banksia ilicifolia*, and other *Banksia* and *Melaleuca* species.
- Weed and dieback hygiene will continue to be implemented during all operations and will include the following provisions **(Commitment 7.5.4g)**:
  - All vehicles and machinery will arrive at the proposed mine extension area clean and free from soil, mud, soil slurry and vegetation material, in accordance with the Weed Inspection List.
  - Soil and vegetation stripped from the mine area will be stored in marked areas.
  - No soil or vegetation material will be transported around the proposed mine extension area.
  - Movement of vehicles into non-production areas of the property is restricted, with permission required from the General Manager.

KSS expects to obtain acceptable environmental outcomes because:

- High quality remnant vegetation areas, with remaining understorey and wetlands will not be mined.
- Rehabilitation will be undertaken using seed collected from plants within the KSS property.
- The project will not result in significant loss of biodiversity, as the majority of remnant species will be able to be regenerated from seed preserved in topsoil and returned during

the rehabilitation program. Hand planting may be necessary for recalcitrant species which do not establish readily from seed such as grasses and sedges.

7.5.5 Predicted Residual Environmental Risk

KSS will implement management measures described above to mitigate impacts on vegetation communities through progressive rehabilitation to encourage colonisation from surrounding vegetative areas. Significant flora species are well represented in remaining areas of the KSS property and will be returned to the post-mining landscape during rehabilitation. It is not anticipated that indirect impacts from mining will have an affect on surrounding vegetation. It is considered that the management measures proposed will achieve the EPA objectives of maintaining species diversity and populations of Priority species on the KSS property.

Potential vegetation and flora impacts with their pre and post management risk are presented in Table 47. From this it can be seen that the residual risk associated with vegetation and flora impacts is likely to be high for three potential impacts (loss of vegetation due to clearing, altered vegetation distribution post mining and dieback) and moderate for two potential impacts (weeds and impact on PECs). Management measures have been developed to address these impacts, however residual risk has not always decreased significantly as a direct result. The offset package described in Section 10.4 has been proposed to address the remaining residual risk. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 47: Potential Vegetation and Flora Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Loss of vegetation as a result of land clearing	High	High
Altered vegetation distribution post rehabilitation	High	High
Impact on Muchea Limestone TEC	Moderate	Low
Impact on PEC's	Moderate	Moderate
Removal of individual plants of conservation significance within the mine extension area.	Moderate	Low
Impact on DRF and Priority flora outside of the mine extension area	Low	Low
Impact on flora species due to drawdown	Low	Low
Weeds	Moderate	Moderate
Dieback	High	High

7.6 WETLANDS

7.6.1 Environmental Objective

Maintain the integrity, ecological functions and environmental values of wetlands.

7.6.2 Relevant Standards and Legislation

Standards

- Western Australian Planning Commission, 2005b. *Guideline for the Determination of Wetland Buffer Requirements.*

Legislation

- Environment Protection Authority. December 1992. *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (EPP 1992).*
- Environmental Protection Authority, 2008c. *Guidance Statement 33: Environmental Guidance for Planning and Development.*
- Environment Protection Authority, 2004c. *Position Statement No. 4: Environmental Protection of Wetlands.*
- *Environmental Protection Act 1986* (WA).

7.6.3 Assessment of Potential Risks and Impacts

Potential impacts on wetlands as a result of project implementation are:

- Loss of Conservation Category wetlands.
- Change in wetland type post mining.
- Indirect impacts on adjoining wetlands.

7.6.3.1 Direct Impacts

Nine wetlands within the KSS property are protected under the *EPP 1992*. The *EPP 1992* aims to maintain environmental values of wetlands on the Swan Coastal Plain; however it also provides a mechanism for mining lakes if authorisation under the *Environmental Protection Act 1986* (WA) is granted.

Wetland EPP2 has been directly impacted by the current operations at the KSS property, for which approval was granted in 1994 via Ministerial Statement 366. Eight EPP wetlands have not been affected by the current operation. Six of them have already been protected by inclusion into an offset area, with a seventh wetland partly included. The offset area has been vested in the State under management of DEC as Kemerton Nature Reserve.

The proposed mine extension area has been defined based on groundwater modelling work which identified the buffer distance required to protect EPP4 and its surrounding wetland catchment from mining induced groundwater changes (Appendix 18). Wetlands in the southern portion of the KSS property were excluded from the mining area based on condition assessment and consideration of flora species of conservation significance. This implements the EPA principle of avoidance of a critical asset, as discussed in Section 10.2.1.

Direct impact to conservation category wetlands in the proposed mine extension area will occur as areas are mined and local topography will change as a result of sand extraction. This will result in removal of both Bassendean upland and ephemeral wetland areas. Rehabilitation will return some ephemeral wetlands and interconnecting uplands, and permanent lakes will be a significant new addition to the local landscape.

Five Conservation Category wetlands, UFI 1656, 1663, 1904, 1906 and 13255 will be impacted by mining in the extension area, of which four are damplands and one is a sumpland. van Etten *et al.* (2008a) and McCullough *et al.* (2007) have found EPP4 to be unique on the KSS property as a perched wetland with distinct flora and fauna. The proposed mine extension area has been carefully chosen to avoid the highest wetland values. EPP4 and the wetland's Conservation Category wetland catchment area (UFI 13254) are omitted from the proposed mining area and the sumpland to the north of the mining area has been removed as van Etten *et al*. (2008) it had high conservation values. On-going monitoring will ensure no adverse impacts result from the proposed mine extension. KSS have engaged Edith Cowan University to continue wetland and rehabilitation monitoring for the next two years to investigate temporal changes particularly in North Lake and EPP1.

7.6.3.2 Indirect Impacts

EPP4 and a portion of EPP8 remain on the KSS property. Indirect impacts to these wetlands may be caused by altered groundwater regimes associated with ongoing groundwater abstraction or release of contaminants from dredge mining activities or return of waste streams to the dredge pond.

The Western Australian Planning Commission (2005) document *Guideline for the Determination of Wetland Buffer Requirements* provides a series of steps to identify wetlands, define their function area, establish the separation requirement, apply it to the proposal and assess ability to achieve the management objective. The GHD (2008) modelling implements this process for EPP4. Groundwater change at EPP4 as a result of mining is to be less than 0.1 metre as presented in Table 43. It also shows the expected maximum drawdown range at the dredge pond lake (pit lake) between 0.5 to 1.8 metres. The GHD (2008) report includes the following modelling exercise outcomes:

- The affected area at the end of mining compared to the 'base case' (reductions of more than 0.2 metres) extends north-west, south-west and west for approximately 1,500 metres from the shoreline. A maximum reduction of approximately 1.2 metres is expected to occur along the western end of predicted pond.
- The water level towards the east of the mining area is predicted to rise to a maximum of 0.8 metres.

This data determines the extent of possible indirect impacts to surrounding wetlands. The model was calibrated against 12 years of site specific data from monitoring bores and wetlands with satisfactory correlations between predicted and measured results. In comparison, annual recorded groundwater fluctuation in monitoring bores on site is approximately one metre, placing the maximum groundwater changes from mining in the same order of magnitude as experienced annually.

The data is also important in determining design levels for rehabilitated wetlands. The level and slope of beaches in rehabilitated cells will be designed as ephemeral wetlands, providing a combination of seasonal inundation areas, permanent shallow areas and sandbars. The post mining groundwater level is critical in designing these attributes. This is described further in Section 8.

7.6.3.3 Cumulative Impacts

Wetlands in the proposed mine extension area are part of a larger set of wetlands on the property interspersed with upland Bassendean woodland. Wetland classification using geomorphic characteristics of landform and water permanence result in wetland types as presented in Table 17. There are no existing permanently inundated wetlands in the mine extension area. Bennett (2004) assessed all wetlands on the property using the methodology outlined in EPA (1993a), Bulletin 686.

Wetlands in the proposed mine extension area fall into palusplains or sumplands categories. The residue sand tailings disposal area and an upland Bassendean Dune in the north of the proposed mine extension area are nominated as Multiple Use wetlands. A separate submission has been made to DEC (2009b) to reclassify the upland Bassendean Dune and the residue dam.

The 283 hectare proposed mine extension area comprises:

- 110.7 hectares of Conservation Category wetland.
- 19.1 hectares of disturbed land.
- 122.1 hectares of Bassendean upland, of which 11 hectares of Bassendean low-lying areas and 20.3 hectares are approved for dry mining.
- 31.9 hectares of Spearwood upland.

As a result of sand extraction during the mine life, the most significant landform change will be creation of a series of lakes, interspersed with seasonal wetlands and upland woodlands. The composition of different landform units in the proposed mine extension area are presented in Table 48. Approximate rehabilitation areas have been determined which show the following affects on landform types as a result of implementation of the project:

- About 60% of the proposed mine extension area will become permanent lakes, in an area of the property where none currently exist.
- Approximately half the upland areas will be replaced by permanent lakes.
- Approximately two-thirds of ephemeral wetlands will be replaced by permanent lakes.
- Existing residue sand disposal area will be re-treated and the disturbed area will be rehabilitated.

Table 48: Landform Changes from Mining

	Upland (ha)	Ephemeral [1] (ha)	Lakes and Beaches (ha)	Disturbed Land (ha)	Total Mine Extension Area (ha)
Existing environment	154	110	0	19	283
Post mining [2]	65	48	170	0	283
Change [2]	-89	-62	+170	-19	

Note: 1: Palusplain, Dampland, Sumpland or Floodplain as shown in Table 17.
2: Approximate areas.

Bamford (2003) reported that an important wetland function in the existing mine area is as a summer drought refuge. The existing dredge pond and rehabilitated cell are already providing this function.

Approximately 110 hectares (16%) of the property's total wetland area will be disturbed over the 50 year mine life. This will be offset by progressive rehabilitation of 48 hectares of ephemeral wetlands and 170 hectares of permanent lakes, increasing the total area of wetlands by 98 hectares. To complement the system currently dominated by ephemeral wetlands, the diversity of wetland types will also increase with the introduction of permanent lakes and associated beaches. The addition of permanent lakes will provide additional summer drought refuge and provide a measure of protection for water dependant species in a drying future climate.

7.6.4 Management and Mitigation Measures

KSS has carefully chosen a proposed mine extension area that reduces impacts on EPP4 and adjoining Conservation Category wetlands. EPP4 appears to be a perched wetland, primarily receiving water inflows from the surrounding Conservation Category wetland which effectively acts as a catchment to EPP4. The proposed mine extension area should therefore not impact Conservation Category wetland UFI 13254 or EPP4. Monitoring will ensure that any adverse impacts are managed accordingly.

A regular annual monitoring program for reference wetlands and rehabilitated wetlands and lakes will be established, to include the wetlands sampled in the 2007 and 2008 study (McCullough and Lund, 2008). Annual monitoring will include vegetation and flora, fish, macroinvertebrates and physico-chemical parameters **(Commitment 7.6.4a)**.

Frequency and survey methods are presented in Table 49. The number of times per year to sample for macroinvertebrates will be determined following a more intensive sampling frequency over one year. No monitoring from 2011 onwards has currently been planned.

Developing a greater understanding of successful rehabilitation of completed dredge ponds into wetlands with ecological functions is a key component of the project's environmental strategy. The Centre for Ecosystem Management at Edith Cowan University was commissioned to undertake research into wetland monitoring and monitoring of the rehabilitated lakes of the completed dredge mining area.

This is a component of rehabilitation efforts for the current mine but also a prelude to rehabilitation in the mine extension area. KSS have engaged Edith Cowan University to continue wetland and rehabilitation monitoring for the next two years. Ongoing research will develop suitable and sustainable rehabilitation and completion criteria. This is described further in Section 9.8.

KSS will create north to south designed dredge ponds and rehabilitated lakes to reduce water loss by evaporation and impacts associated with easterly and westerly winds **(Commitment 7.4.4h)**.

KSS will manage impacts on groundwater quality and quantity due to mining activities by implementing the management and mitigation measures described in Section 7.4.4.

Table 49: Recommended Environmental Monitoring of KSS Waterbodies

Wetland Type	Vegetation and Flora		Fisheries		Aquatic macroinvertebrates		Physico-chemical*	
	Survey Method	Frequency	Survey Method	Frequency	Survey Method	Frequency	Survey Method	Frequency
Reference Wetlands (includes EPP wetlands and selected conservation category)	Perpendicular transects starting at the shore line and extending 50 metres, each with 10 x 2 metre x 2 metre quadrats along the transect line.	Annually (Spring)	Electric-fishing and trapping	Annually (September)	250 µm mesh sweep net along a 10 metre transect through each habitat. Each wetland macroinvertebrate sample was replicated at least three times, with up to five replicate for very large water bodies.	Annually (September)	Temperature, dissolved oxygen (DO), pH, oxidation reduction potential (ORP), electrical conductivity (EC), chlorophyll a, metal suite, total nitrogen (TN), ammonia (NH3), nitric oxides (NOx), total phosphorus (TP), soluble reactive phosphorus (SRP).	Monthly
Rehabilitated Wetlands	Perpendicular transects starting at the shore line and extending 50 metres, each with 10 x 2 metre x 2 metre quadrats along the transect line.	Annually (Spring)	Electric-fishing and trapping	Annually (September)	250 µm mesh sweep net along a 10 metre transect through each habitat. Each wetland macroinvertebrate sample was replicated at least three times, with up to five replicate for very large water bodies.	Annually (September)	Temperature, DO, pH, ORP, EC, Ch a, Metal suite, TN, NH3, NOx, TP, SRP.	Monthly
Rehabilitated Lakes	Perpendicular transects starting at the shore line and extending 50 metres, each with 10 x 2 metre x 2 metre quadrats along the transect line.	Annually (Spring)	Electric-fishing and trapping	Annually (September)	250 µm mesh sweep net along a 10 metre transect through each habitat. Each wetland macroinvertebrate sample was replicated at least three times, with up to five replicate for very large water bodies.	Annually (September)	Temperature, DO, pH, ORP, EC, Ch a, Metal suite, TN, NH3, NOx, TP, SRP.	Monthly

Note: * Physico-chemical parameters must have levels-of-detection appropriate to relevant environmental guidelines.

7.6.5 Predicted Residual Environmental Risk

The principles of avoidance and rectification have been used to minimise impacts and maintain the integrity, ecological functions and environmental values of wetlands on the KSS property. The measures listed will ensure the project does not have significant adverse effects on wetlands in the KSS property.

Potential wetland impacts with their pre and post management risk are presented in Table 50. From this it can be seen that the residual risk associated with impacts on wetlands is Moderate to High despite implementation of management measures. This is a direct result of mining causing a change in pre existing wetland condition. The offset package described in Section 10.4 is proposed to assist with addressing the residual risk. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 50: Potential Wetland Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Loss of Conservation Category wetlands	High	High
Indirect impacts on adjoining wetlands	High	Moderate
Change in wetland type post mining	High	High

7.7 FAUNA

7.7.1 Environmental Objectives

To maintain abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

Protect Specially Protected (Threatened) and Priority fauna and their habitats consistent with the provisions of the *WC Act.*

7.7.2 Relevant Standards and Legislation

Standards

- Environment Protection Authority, 2002. *Position Statement No. 3 - Terrestrial Biological Surveys as an Element of Biodiversity Protection.*
- Environment Protection Authority, 2006b. *Guidance Statement No. 10: Level of Assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of the System 1 Region.*
- Environment Protection Authority, 2004b. *Guidance Statement No. 56 - Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia.*

Legislation

- *Environmental Protection Act 1986* (WA).
- *Environmental Protection and Biodiversity Conservation Act, 1999* (Cth).
- *Wildlife Conservation Act 1950* (WA).

7.7.3 Assessment of Potential Risks and Impacts

The range of fauna studies reported in Section 4.11.2 covers the entire KSS property, and in some cases, the surrounding region. The studies found that fauna of the KSS property consists of many of the species likely to occur in the region, however, there is no evidence the proposed mine extension area has greater value by containing unique species or habitat, than other parts of the property or surrounding region.

The greatest potential impact to fauna is from changing habitat types, as a result of altered landform in the post mining environment such as the creation of extensive areas of permanent water bodies in a location where none currently exist. Returning habitat function of ephemeral wetland and upland areas and, over time, a proportion of pre-mining environmental values, is considered achievable with rehabilitation.

With the 50 year mine life disturbing 283 hectares, an average of only five hectares per year will be cleared. With this slow rate of habitat removal in a local area surrounded by vegetation, it is considered most mobile fauna will naturally relocate to adjacent areas before clearing occurs. Fauna with limited mobility, such as short range endemic species are discussed in Section 7.7.3.2. With the exception of iconic species discussed in Section 4.11.5, specific capture and relocation programs for other fauna is not considered to be warranted with such small scale clearing.

Eighty percent of vegetation on the property will be retained, including heavily vegetated seasonal wetlands. It is unlikely that proposed sand extraction will have significant adverse impacts on fauna species.

Impacts on species of National Environmental Significance are discussed in Section 8.1.

Impact can have both positive and negative components.

Positive Impacts

Normally only the natural wetland EPP7 on the KSS property and Kemerton Nature Reserve (Figure 15) contains permanent surface water. After an extremely dry winter period, this wetland dried up in the 2006/07 summer, with the dredge pond lake being the only permanent water body on the property.

Fauna surveys reflect that fauna associated with permanent water are currently poorly represented on the site. Five of the seven migratory bird species are waterbirds. Site observations indicate North Lake has become a major attraction for waterbirds that would not normally occur on the property. It is still in an early stage of rehabilitation and will become more attractive to a range of waterbirds as riparian vegetation becomes established. There will be an increased number of permanent water bodies in the post-mining landform, providing greater diversity of habitats on the property.

The creation of additional permanent water bodies is expected to provide greater habitat availability for reintroduction and maintenance of iconic threatened and regionally significant species, such as the Black-striped Jollytail *(Galaxiella nigrostriata).* As the proposed mine extension area contains no permanent water bodies, it is likely that the Jollytail would only be temporarily present during times of high water levels in wet winters. The post-mining landform provides opportunity for permanent Jollytail populations to become established in the property's western portion.

Open water in the greater Bunbury region and the Swan Coastal Plain has been significantly reduced, through draining, urbanisation and disturbance. The creation of new open water will be a positive environmental impact.

Reconstructed seasonally inundated and water logged locations also provide nursery areas for frog populations. Sumplands, separate to margins of permanent lakes, will provide nursery frog ponds, even if the lakes are colonised by Gambusia. As these areas will dry out over summer, no residual population of Gambusia will exist in these sumplands.

Negative Impacts
Negative impacts result from the loss of habitat during mining and the period after, when rehabilitation is developing and ecological functions slowly return to the post mining landform.

7.7.3.1 Impact on Specially Protected Fauna

Cockatoos
A targeted survey of the proposed mine extension area of habitat used by the Carnaby's Black-Cockatoos (*Calyptorhynchus latirostris*) found that utilisation of the KSS property was comparable to control sites located five to 10 kilometres away. The survey concluded the proposed mine extension area did not possess any unique value for cockatoos, above other wooded areas in the region. The value of foraging habitat on the KSS property was assessed to be similar to or less than the value of foraging habitat at control sites (Craig *et al*. 2004). The proposed action will result in a temporary reduction in foraging habitat for Cockatoo, although the post mining landform will contain Proteaceous species, which Cockatoos favour (Cale, 2003). The proposed action is not considered likely to have significant long-term impacts on cockatoo habitat.

Chuditch
A trapping study for Chuditch (*Dasyurus geoffroyi*) was undertaken in May 2004 with no Chuditch trapped during the survey. In a trapping study carried out across the Kemerton Industrial area in 1998, no Chuditch were caught. The KSS property was included in a separate 1992/1993 fauna survey and Chuditch were not recorded on that occasion.

As discussed in Wilcox and Bamford (2004), small numbers of Chuditch are known to be present in the region, based on observations made in the late 1990s and recorded sightings in the Leschenault Peninsula Conservation Park, approximately 10 kilometres to the west. This suggests that Chuditch may be able to slowly re-colonise the area. However, feral predator (fox and cat) management is considered vital to the success of a re-colonisation program.

Survey results on the specially protected Chuditch confirm that the proposed mine extension area is not known to contain populations of this species. While low numbers of animals may

inhabit the wider region, there are no records of Chuditch on the KSS property or the mine extension area.

Quokka

Setonix brachyurus or Quokkas have not been recorded in site fauna surveys (Bamford, 2003). Mainland populations are known from only a few locations in the Darling Range and south-west forests. Bamford (2003) lists this species as known or believed to have become extinct in the Kemerton region since European settlement. Harewood (2009) lists the quokka as omitted from the proposed mine extension area principally due to lack of suitable habitat or known local extinction.

Western Ringtail Possum

The predominant vegetation complex on the property is Bassendean - Central and South, with some minor woodlands and forest of *Agonis flexuosa*. However, the Western Ringtail Possums prefer peppermint dominated forest near the coast, so it seems the habitat available on the KSS property is unfavourable. Bamford (2003) listed the Western Ringtail Possum as a species known or believed to have become extinct in the Kemerton region since European settlement. It had not been recorded in fauna surveys undertaken at the KSS property prior to 2004.

A targeted survey for Western Ringtail Possum was undertaken in January 2009 in response to consultation with DEC and DEWHA that indicated reintroduction of this species to areas north of KSS had occurred in recent years and individuals had reportedly been observed adjacent to KSS. The results of a targeted inspection of the site for evidence of Western Ringtail Possum failed to find any sign of this species and it is concluded that they are not present on site or are only present rarely as transient individuals, suggesting that the Western Ringtail Possum is currently not utilising vegetation on site as potential habitat. This is thought to be primarily because of the general poor quality of the habitat present and because of historical events that have resulted in the localised extinction of the species in this specific area. There is some potential for individuals to either be present now in very low densities or to at times move into the area from nearby areas of better habitat quality or known extant populations (Harewood, 2009).

Southern Brush-tailed Phascogale

Harewood (2009) conducted a targeted survey for Southern Brush-tailed Phascogale within the proposed mine extension area at Kemerton. This included mapping the potential Phascogale habitat (extent and quality) and a trapping program. The trapping program was conducted over four nights utilising baited Elliot and cage traps positioned in potential habitat. Harewood (2009) found that almost all of the Jarrah/Banksia Woodland to Open Woodland Communities present within the proposed mine extension area (Mattiske (2003b) vegetation communities A1 to A3) represent potential Phascogale habitat. Areas with the highest densities of habitat trees represent the best habitat, though other factors are likely to be important. Phascogales may also use log piles of previously cleared trees for daytime refuge.

Two Phascogales were captured within the proposed mine extension area and evidence of another was found (Appendix 13). The location of Phascogales within the proposed mine extension area indicates they are likely present in other areas on the KSS property. The proposed action is not considered likely to have significant long-term impacts on Phascogale

habitat given the small scale nature of mining and the ability of Phascogales to relocate to surrounding areas.

7.7.3.2 Impacts on Iconic Species

There are a number of fauna species recorded on the property that KSS consider iconic at the local level which currently occur in a restricted number of locations. A key objective of the rehabilitation program is to re-establish preferred habitat for these species and to increase numbers and distribution of these species in the KSS property.

Black-striped Jollytail

Palusplain wetlands throughout the proposed mine extension area do not support populations of Black-striped Jollytail. This species is restricted to a few EPP wetlands on the eastern side of the property in the Kemerton Nature Reserve. The creation of both permanent lakes and seasonally inundated wetlands in the post mining environment provides the opportunity to expand habitat for this local iconic species.

A key element in achieving the objective of expanding the range of Black-striped Jollytail is exclusion of the introduced pest fish Gambusia (*Gambusia holbrooki*) from dredge ponds in the mine extension area. This introduced fish has been present in the dredge pond of the existing operation for many years.

There is good evidence from around Perth and Australia that Gambusia negatively impact on frog populations (by attacking tadpoles) (Sommer, 1997) and macro invertebrate communities (McCullough, 1998; Ling, 2004). It is suspected that Gambusia may also impact on Jollytail populations, the significance of which is not known.

KSS has sponsored a two year Masters Research Program at the School of Natural Sciences at Edith Cowan University on the "Ecological requirements and population genetics of remnant black-stripe minnow (Pisces: Galaxiidae, *Galaxiella nigrostriata*) populations in seasonal wetlands of south-western Australia." There are four study components to the project: habitat and diet preferences, aestivation requirements and population genetic structure. All components will provide information to help conserve this threatened species, direct wetland rehabilitation requirements and may be used to identify habitats likely to contain 'new' populations. The results of the research project will help KSS design and construct rehabilitation that best enhances long-term survival prospects of Black-striped Jollytails, and investigate ways of protecting Black-striped Jollytails from Gambusia.

The primary method of excluding Gambusia from the proposed mine extension area is through quarantine (not allowing the fish to enter the dredge pond in the first place). Once established in a permanent water body, Gambusia is difficult, if not impossible, to eradicate.

Gambusia can not survive desiccation, so seasonally inundated wetlands are also proposed in rehabilitated areas, to complement permanent rehabilitated lakes. These will provide refuge and nursery areas for Black-striped Jollytails, frogs and macro invertebrates in the event that Gambusia does enter rehabilitated lakes.

Water Rat

The Water Rat (*Hydromys chrysogaster*) usually lives near permanent water bodies of which there are none in the proposed mine extension area. Water Rats eat large aquatic insects, fish,

crustaceans, frogs and lizards and make nests in tunnels in banks or occasionally in logs. On-going research by Edith Cowan University into establishing dense understorey, returning habitat logs and rocks, return of aquatic vertebrate and invertebrate species to the dredge ponds will provide preferred habitat for this native mammal (McCullough *et al*. 2007; McCullough and Lund, 2008). This may have positive impacts on the Species in the long-term.

Possums
Bamford (2003) notes that the persistence of the Honey Possum and Western Pygmy Possum on the KSS property is particularly unusual, reflecting the large area and diversity of native vegetation.

The Honey Possum is known from several sites in the region including the KSS property, especially in shrubland and heath. The Western Pygmy Possum is known from a single specimen recorded in 1993 in the western part of the KSS property (Ninox Wildlife Consulting, 1994). It is commonly associated with Eucalypts so is presumably present in the woodlands of the KSS property and throughout the Kemerton region. The mine schedule (Figure 2) indicates this area will not be accessed until five years from commencement of operations. Relocation of nest hollows in undisturbed areas on the property (Figure 10) for use by other bird and mammal species will offset habitat lost through development. Rehabilitation using nectar producing plants of the Proteaceae and Myrtaceae families will continue to provide habitat and foraging areas for both Possum species.

7.7.3.3 Impacts on Short Range Endemic Species

The short range endemic survey did not identify any invertebrate species unique to the mine extension area. As such, negative impacts are considered unlikely as they are well represented elsewhere. No specific management measures are considered necessary to protect the biodiversity of terrestrial invertebrate species.

7.7.3.4 Impacts on Other Fauna

Bamford (2003) noted that the Kemerton region supports a rich fauna. Of particular note is the number of priority species, being species that are not of formally recognised conservation significance, but that are at least regionally important, mainly due to their decline elsewhere on the coastal plain. Management measures for a number of these species are discussed in Section 7.7.4.3

7.7.4 Management and Mitigation Measures

The remaining undisturbed 900 hectares of the KSS property is considered to provide sufficient refuge habitat for fauna temporarily displaced by mining activities. Undisturbed wetland and upland woodland abut the mine extension area, providing opportunity for faunal re-colonisation from these areas as rehabilitation establishes.

Targeted programs aim to expand habitat for fauna currently with a restricted range on the property. As a result, long-term impact of clearing on fauna is expected to be limited. As rehabilitation areas mature to provide preferred habitats, re-colonisation from adjacent undisturbed areas is expected to occur.

KSS aims to protect the biodiversity of fauna species on the KSS property. Management and mitigation measures to achieve these aims and reduce risk are discussed below.

7.7.4.1 Conservation Significance 1 Species

- Conduct surveys to identify potential Cockatoo tree hollows prior to annual land clearing and to determine whether any hollows are actually in use by Cockatoos. Tree hollows suitable for Cockatoos that are not being actively used at the time, will be relocated to other areas, preferably within newly rehabilitated areas or remounted on trees outside the mine extension area. If this is not practical, hollows will be replaced with similar sized nest boxes **(Commitment 7.7.4a)**. Tree hollows suitable for Cockatoos may be used by Carnaby's Black-Cockatoo, but Baudin's Black-Cockatoo is not expected to nest in the Kemerton region.
- Planting of tree species likely to develop hollows and provide Cockatoo habitat in the long-term **(Commitment 7.7.4b)**.
- Control slope gradients to minimise erosion and soil loss. Finished slopes will include a zone of shallow beach approximately 30 to 40 metres wide before sloping at a stable angle of repose (approximately one in four) to the base of the rehabilitated lake **(Commitment 7.2.1.4c)**.
- Minimising the amount of vegetation that will be cleared at any one time. Progressive clearing of an average of five hectares per year will be carried out in Autumn when species are less likely to be breeding **(Commitment 7.7.4d)**. This will enable any Threatened or Migratory Fauna species to migrate to other areas of the KSS property.
- Progressive rehabilitation mining with local provenance seed to encourage colonisation from surrounding vegetative areas, to re-establish vegetation and hence fauna **(Commitment 7.7.4e)**. Rehabilitation will provide restored habitat for recolonisation over time.
- Conduct targeted survey for Chuditch, Western Ringtail Possum and Quokka prior to annual land clearing to ensure that populations of these Vulnerable species will not be affected by the planned clearing. If evidence of their presence is found, trapping will be undertaken and captured individuals relocated to suitable alternative sites on the property **(Commitment 7.7.4f)**.
- Erecting nest boxes suitable for use by Western Ringtail Possums where annual surveys show Possums are present in areas planned to be cleared in the short term. Nest boxes will be placed in adjacent undisturbed areas where suitable foraging habitat is present **(Commitment 7.7.4g)**.
- Planting areas of peppermint (*Agonis flexuosa*) within upland woodland areas to be rehabilitated post mining. Peppermint trees will be planted in clumps to encourage interlocking branches **(Commitment 7.7.4h)**.
- Pre-clearance surveys will be undertaken within suitable habitat to determine the presence/absence of targeted vertebrate conservation significance species will not be affected by the planned clearing. If evidence of their presence is found, trapping will be undertaken and captured individuals relocated to suitable alternative sites on the property **(Commitment 7.7.4i)**.

7.7.4.2 Iconic Species

- The pest species Gambusia negatively impacts frog and possibly Black-striped Jollytail populations. Therefore quarantine of the mine extension dredge ponds to prevent the pest species Gambusia being transferred from the existing mine area will be achieved by **(Commitment 7.7.4j)**:
  - Cleaning all dredging equipment and pipes prior to relocation to the mine extension area.
  - Preventing direct pumping of water from existing dredge ponds to the proposed mine extension area ponds.
- On-going research by Edith Cowan University into establishing dense understorey, returning habitat logs and rocks, return of aquatic vertebrate and invertebrate species to the dredge ponds will provide preferred habitat for the Water Rat.
- Selection of appropriate species in rehabilitated areas to provide food resource for target Possum species (McCullough *et al.* 2007; McCullough and Lund, 2008).
- Funding a two year masters research program for the Black-striped Jollytail **(Commitment 7.7.4k)**. Findings are intended to assist with identification of habitat requirements to assist Jollytail introductions as part of rehabilitation activities.

7.7.4.3 Other Fauna Species

- Relocate habitat logs and brush for ground dwelling fauna. Habitat logs and brush are re-spread in areas undergoing rehabilitation as part of current operations **(Commitment 7.7.4l)**. This practice will continue.
- Further macroinvertebrate and wetland research funded through Edith Cowan University to establish baseline conditions as analogues for future rehabilitation **(Commitment 7.7.4m)**.
- Relocation of nest hollows in undisturbed areas on the property for use by other bird and mammal species will offset habitat lost through the development **(Commitment 7.7.4n)**.
- Foxes, feral cats, rabbits and wild pigs are all present on the KSS property. KSS will continue to undertake feral animal control to minimise impacts from feral animals on native species **(Commitment 7.7.4o)**.

A suitably qualified and licensed person will be commissioned to undertake pre-clearance surveys. Any fauna captured will be relocated to nearby vegetation on the property, outside the proposed clearing boundary, which approximates their existing habitat. Fauna relocation needs to consider not only the schedule constraints arising from site activity, but also constraints due to seasonal breeding and activity cycles of different fauna. For example:

- The breeding season for Cockatoo species can be from July to March, with eggs being laid generally from July to November. Clearing trees and hollow relocation is to be scheduled for periods when eggs or young are not in the nest.
- Possums breed mostly in winter and young leave the nest at six to seven months old (late summer). Clearing of trees and hollow relocation is to be scheduled for periods when young are not in the nest.

These constraints indicate an optimum fauna relocation period of early autumn (March and April). This schedules the sequential activities of relocating fauna, clearing vegetation, topsoil striping and relocating all in March, April and early May.

7.7.5 Predicted Residual Environmental Risk

The proponent considers these measures provide an acceptable outcome for the environmental objectives of maintaining abundance, diversity and distribution of Fauna species and habitats.

Potential fauna impacts with their pre and post management risk are presented in Table 51. As can be seen from this, residual risk is assessed to be moderate for three species namely Carnaby's Black-Cockatoo (forging habitat), Rainbow Bee-eater and Southern Brush-tailed Phascogale. Residual risk has been assessed as low for all other potential fauna impacts. The detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 51: Potential Fauna Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Impact on Baudin's Black-Cockatoo	Low	Low
Impact on Carnaby's Black-Cockatoo foraging habitat	High	Moderate
Impact on Carnaby's Black-Cockatoo breeding habitat	Moderate	Low
Impact on Forest Red-tailed Black-Cockatoo	Low	Low
Impact on Australasian Bittern	Low	Low
Impact on Common Greenshank	Low	Low
Impact on Common Sandpiper	Low	Low
Impact on Rainbow Bee-eater	High	Moderate
Impact on Peregrine Falcon	Low	Low
Impact on Western Ringtail Possum	Moderate	Low
Impact on Chuditch	Low	Low
Impact on Quokka	Low	Low
Impact on Southern Brush-tailed Phascogale	High	Moderate
Impact on Southern Brown Bandicoot	High	Low
Impact on South-west Carpet Python	Low	Low
Impact on Black-striped Jollytail	Low	Low
Impact on Water Rat	Low	Low
Impact on Honey Possum and Western Pygmy Possum	Moderate	Low
Impact on CS2 and CS3 species	High	Low
Impact on other Migratory Birds	Low	Low

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Impact on EPP4 macroinvertebrates	High	Low
Impacts on SRE population	High	Low
Removal of tree hollows	High	Low
Feral animal introduction/population increase	High	Low

7.8 HERITAGE VALUES

7.8.1 Environmental Objectives

Ensure the proposal complies with requirements of the *Aboriginal Heritage Act 1972* (WA).

Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.

7.8.2 Relevant Standards and Legislation

The *Aboriginal Heritage Act 1972* (WA) protects and preserves any site or object which is of significance to Aboriginal people. Under Section 17 of the *Aboriginal Heritage Act 1972* (WA), it is an offence to disturb any Aboriginal site. If development is likely to impact a site, the consent of the Minister for Indigenous Affairs is required under Section 18 of the *Aboriginal Heritage Act 1972* (WA).

7.8.3 Assessment of Potential Risks and Impacts

The potential impact on heritage values as a result of project implementation is that mining may disturb a site of Aboriginal significance.

No archaeological site is recorded on the DIA database on or in the vicinity of the KSS property. A heritage survey of the site has also been conducted. No sites have been found in the area of the proposed extension on the KSS property, so no impact is expected.

KSS property is freehold land and is therefore not subject to any Native Title Claims.

7.8.4 Management and Mitigation Measures

In the event that an archaeological site or a site of cultural importance to Aboriginal people is discovered, the proponent will immediately inform the DIA **(Commitment 7.8.4a)**.

7.8.5 Predicted Residual Environmental Risk

Environmental objectives for this factor will be met.

Potential heritage value impacts with their pre and post management risk are presented in Table 52. As can be seen, the risk of disturbance of an Aboriginal site of significance is

assessed as low. The detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 52: Potential Heritage Values Impact Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Mining may disturb a site of Aboriginal significance	Low	Low

7.9 NOISE

7.9.1 Environmental Objective

To protect the amenity of the community from noise impacts associated with development or land use by ensuring statutory requirements and acceptable standards are met.

To avoid unacceptable adverse impacts on the natural environment, including native fauna.

7.9.2 Relevant Standards and Legislation

Legislation

- *Environmental Protection (Noise) Regulations* 1997.
- *Mines Safety and Inspection Regulations* 1995.

7.9.3 Assessment of Potential Risks and impacts

Potential noise impacts as a result of project implementation are:

- Impact on residents.
- Impact on fauna.

The proposed mine extension area is in the central west area of the KSS property, maintaining significant distances to the northern, southern and eastern boundaries. The western boundary abuts large uncleared rural landholdings, which contain two commercial sand pit operations, with no noise sensitive premises in close proximity.

The large size of the KSS property provides significant buffer distances to adjacent noise sensitive premises. The nearest residential premises are located approximately 1.4 kilometres to the north and 3.6 kilometres to the north-east of the mine extension area. The nearest main road is located more than five kilometres south of the mine extension area.

Sound pressure levels were measured at the north, east, south and western boundaries of the KSS property at a height of 1.2 metres above ground level using equipment complying with regulation 22 of the *Environmental Protection (Noise) Regulations* 1997 (Lloyd Acoustics, 2004). Noise monitoring of the existing operations took place from 19 - 23 April 2004. Results are summarised in Table 53.

Table 53: Noise Measurement Results from the KSS Boundary

Measurement Location		L_{Amax} Noise Level dB(A)	L_{A1} Noise Level dB(A)	L_{A10} Noise Level dB(A)
Assigned Noise Level		**80**	**75**	**60**
North Boundary	Maximum	79.3	65.7	46.5
	Minimum	26.1	25.6	25.3
	Average	43.1	34.5	30.1
East Boundary	Maximum	72.6	65.5	54.5
	Minimum	27.0	25.0	24.5
	Average	46.2	41.3	36.3
South Boundary	Maximum	73.7	65.5	58.7
	Minimum	26.7	25.8	25.4
	Average	49.3	43.3	36.0
West Boundary	Maximum	79.7	57.0	54.3
	Minimum	27.8	27.1	26.8
	Average	45.5	38.9	35.3

Source: Lloyd Acoustics (2004).

Results show that noise emissions from the KSS site comply with regulations at the property boundary. Lloyd Acoustics (2004) found that the dredge and processing plant exhibit tonal characteristics in close proximity, but are generally not audible at the property boundary so penalties would not be applied, and even with a +5 dB penalty for tonality, the operations would still comply with regulations.

In addition, noise measurements made at the property boundary on 6 March 2008 by Ian Wheeler of Acoustics and Calibration Consultants confirmed that KSS compiles with noise regulations.

7.9.4 Management and Mitigation Measures

Noise levels will not be increased from that already generated by the existing operation. Noise is not considered to be a key environmental issue for the following reasons:

- There will be no net increase in noise from current levels, which are known to comply with legislation.
- There are large distances from the mine extension are to residences.
- Low noise levels are emitted from equipment used.

Occupational noise management measures will continue to be applied to operational areas of the mine.

No specific additional noise management measures are proposed for the project.

7.9.5 Predicted Residual Environmental Risk

The remote location of noise generating plant and equipment, relative to the nearest noise sensitive receptor, means that compliance with regulatory standards is considered to be easily achieved.

Potential noise impacts with their pre and post management risk are presented in Table 54. As can be seen from this, all noise risks are assessed to be low. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 54: Potential Noise Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Impact on residents	Low	Low
Impact on fauna	Low	Low

7.10 EMISSIONS AND DUST

7.10.1 Environmental Objective

Ensure that air emissions (particulates, greenhouse gases) do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

7.10.2 Relevant Standards and Legislation

There is no single regulatory standard for ambient dust levels for residential areas in Western Australia. A review of a range of standards is provided below.

1. The *Environmental Protection (Kwinana Atmospheric Wastes) Policy 1992* (Kwinana EPP) has specified levels of pollutants (including particulates) in defined zones around the Kwinana industrial area are presented in Table 55.

Table 55: Kwinana EPP Atmospheric Wastes Policy

Area	Description	Standard (TSP ug/m^3)	Limit (TSP ug/m^3)	Averaging Period
A	Central industrial area	150	260	1 day
B	'Transition area' some residential	90	260	1 day
C	Residential areas	90	150	1 day

2. In 1998, the National Environment Protection Council set health-based ambient air quality standards for six pollutants, including particles as Particulate Matter (PM_{10}). The standards and goal are presented in Table 56.

Table 56: NEPC Air Quality Standard

Pollutant	Averaging Period	Maximum Concentration	Goal within 10 years – Maximum Allowable Exceedences
Particles as PM10	1 day	50ug/m^3	5 days per year

3. In 1996, the Department of Environmental Protection established an interim Particulate Matter PM_{10} target of 150 micrograms per cubic metre for Port Hedland. This equates to Total Suspended Particulates of approximately 290 micrograms per cubic metre using the above conversion factor.

4. The Department of Environmental Protection (1996) published a guideline for land development sites and impacts on air quality. Although directed primarily at Perth's urban development industry, it contains information for all projects that have the potential to generate dust. The limit stated in the guideline is 1000 micrograms per cubic metre of air, measured as Total Suspended Particulates, over 15 minutes.

The National Pollution Inventory emission estimation techniques provide a relationship between Total Suspended Particulates and Particulate Matter PM_{10} for fugitive dust emissions as presented in Table 57.

Table 57: NPI Conversion Factors

Factor	Reference	Conversion Factor
Blasting	A1.1.1.9	PM_{10} = 52% of TSP
Drilling	A1.1.1.8	PM_{10} = 0.31/0.59 (52.5%) of tsp
Wind erosion	A1.1.15	PM_{10} = 50% of TSP

Using the National Pollution Inventory factor of Particulate Matter PM_{10} = 50% of Total Suspended Particulates, the Kwinana EPP and the 1996 DEP guideline can be converted to Particulate Matter PM_{10} as shown below.

- Area B and C standard (Table 55): Total Suspended Particulates 90 micrograms per cubic metre equates to Particulate Matter PM_{10} 45 micrograms per cubic metre.
- Area A standard and Area C limit (Table 55): 150 micrograms per cubic metre equates to Particulate Matter PM_{10} 75 micrograms per cubic metre.
- Area A and B limit (Table 55): 260 micrograms per cubic metre equates to Particulate Matter PM_{10} 130 micrograms per cubic metre.
- 1,000 micrograms per cubic metre Total Suspended Particulates over 15 minutes equates to 500 micrograms per cubic metre Particulate Matter PM_{10}.

The review of various guidelines, targets and standards above demonstrates:

- There is no single standard currently being applied specifying 'acceptable' residential/ sensitive area dust levels.
- There is a three-fold range in standards that has been applied over a 24 hour average period (45 to 130 micrograms per cubic metre Particulate Matter PM_{10}).

7.10.3 Assessment of Potential Risks and Impacts

Potential dust and emissions impacts as a result of project implementation are:

- Offsite aesthetics.
- Decrease in vegetation condition.
- Increase in greenhouse gas emissions.

7.10.3.1 Dust

Dust generated from the mine area has the potential to affect environmental values. The sand mining dredge and processing plant use water to mine, pump and process ore. No dust is generated from these activities. Ancillary activities that may potentially emit dust are:

- Clearing of vegetation and topsoil.
- Movement of topsoil.
- Excavation of overburden.
- Wind erosion from topsoil or overburden stockpiles.
- Traffic on unsealed mine site access roads.

The scale of potentially dust generating activities will not increase from current operations, but the location will change. Given the large distance to the nearest sensitive receptor (more than one kilometre), and the short duration of activities with potential to generate dust, it is considered unlikely that dust emissions will adversely affect neighbouring residences. Control mechanisms used by current operations have proved effective in preventing or minimising impacts.

7.10.3.2 Gaseous Emissions

Greenhouse gases are generated (directly) from burning of diesel in on-site earth moving equipment and light vehicles and (indirectly) from use of electricity, which has been produced by the burning of fossil fuels.

All fixed on-site plant including the dredge is electrically powered. Gaseous emissions on-site result from burning of fuel by earthmoving equipment and light vehicles, and loading and hauling of silica sand to the Port of Bunbury.

Indirect greenhouse emissions for the generation of electricity has been calculated using the Department of the Environment, Water, Heritage and the Arts (December 2006) *Australian Greenhouse Office Factors and Methods Workbook*. The workbook describes emission factors for scope 2 and scope 3 emissions.

The emission factor for scope 2 covers emissions from fuel combustion at power stations associated with consumption of purchased electricity from the grid. The emission factor for scope 3 covers both emissions from the extraction, production and transport of fuels used in the production of purchased electricity (i.e. fugitive emissions and stationary and mobile fuel combustion emissions) and emissions associated with electricity lost in transmission and distribution on the way to the consumer (from both fuel combustion and fuel extraction).

Total estimated electricity usage is approximately 10,000 Megawatt hours per annum. Using the emission factors in the workbook, total full fuel cycle (scope 2 + scope 3) indirect emissions are 9,360 tonnes per annum CO_2 equivalent.

Mining equipment and light vehicles use 200,000 litres of diesel as direct on-site fuel. Using the emission factors in the workbook, emissions from diesel use is 600 tonnes per annum CO_2 equivalent. These emissions will not alter in the proposed mining area as the same equipment will be used.

7.10.4 Management and Mitigation Measures

Management of emissions is controlled by a number of standard industry measures. Periodic monitoring will be implemented to confirm success of the management program.

The location of the proposed mine extension area and process plant within the large KSS property provides a significant buffer distance to the nearest sensitive premises from any dust generating activity. In the decade of existing sand mining operations, dust emissions have not been a significant environmental issue. As the proposed mine extension area will operate using the same process and equipment as current operations, it is not anticipated dust emissions will pose a significant environmental impact.

The following management and mitigation measures will be implemented to minimise and control dust:

- Disturbance of vegetation will be kept to a minimum **(Commitment 7.10.4a)**.
- As the resource is pumped to and from the dredge pond rather than transported in conventional 'haul trucks', the majority of vehicle movement on unsealed internal access roads are 4WD light vehicles **(Commitment 7.10.4b)**.
- A water cart is used to suppress dust on all unsealed access roads when required **(Commitment 7.10.4c)**.
- A road sweeper periodically sweeps the main apron where loading of vehicles is carried out **(Commitment 7.10.4d)**.
- Auto-reticulation is used in stockpile and permanent road areas **(Commitment 7.10.4e)**.
- Site personnel will visually monitor dust levels during earth moving activities and dredging operations **(Commitment 7.10.4f)**.

The following management and mitigation measure will be implemented to minimise air emissions:

- Earth moving equipment and the dredge will be regularly maintained and serviced to manufacturer's specifications to ensure efficient running and optimum fuel consumption, thereby minimising exhaust emissions **(Commitment 7.10.4g)**.

7.10.5 Predicted Residual Environmental Risk

Given the management and mitigation measures listed above, it is considered that the environmental values of air quality will be maintained.

Annual greenhouse gas emissions are not likely to significantly change from the currently approved project.

Potential dust and greenhouse gas emissions impacts with their pre and post management risk are presented in Table 58. As can be seen from this, all risks are assessed to be low. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 58: Potential Dust and Greenhouse Gas Emissions Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Offsite aesthetics	Low	Low
Decrease in vegetation condition	Low	Low
Increase in greenhouse gas emissions	Low	Low

7.11 VISUAL AMENITY

7.11.1 Environmental Objective

To ensure that visual amenity is considered and measures are adopted to reduce adverse visual impacts on the surrounding environment as low as reasonably practicable.

7.11.2 Assessment of Potential Risks and Impacts

Potential impacts on visual amenity as a result of project implementation are:

- Offsite aesthetics.
- Light pollution.

The extension area is well buffered by surrounding vegetation and landforms within the KSS property. The property is isolated from the majority of sensitive land uses within the region. The nearest residential premises are located approximately 1.4 kilometres to the north and 3.6 kilometres to the north-east of the mine extension area. The nearest main road is located more than five kilometres south of the mine extension area.

In 1996 KSS had complaints about light spill from a local astronomer and the lack of action to address it. In April 1997, KSS organised Pielite to visit the site and conduct a light survey. Pielite indicated that KSS could adjust some lights to reduce light spill. The run of mine stockpile lights were changed as a result and no further issues have arisen.

7.11.3 Management and Mitigation Measures

Visual amenity is not considered to be a key environmental issue for the following reasons:

- The large distances to residences and main roads from the mine extension area. There are no dwellings on properties to the west of the KSS property boundary.

- A 20 metre vegetated setback will be maintained along the property boundary. This has been provided to allow firebreak construction and perimeter access around the property and as a visual screen for adjacent properties.
- No changes to existing infrastructure are proposed. The proposed mine extension area is not visible from residences on adjoining properties or public roads.

7.11.4 Predicted Residual Environmental Risk

There will be negligible effect on visual amenity from mine activities.

Potential visual amenity impacts with their pre and post management risk are presented in Table 59. As can be seen, the residual risk associated with visual amenity impacts is low. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 59: Potential Visual Amenity Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Offsite aesthetics	Low	Low
Light pollution	Low	Low

7.12 ROAD TRANSPORTATION/TRAFFIC

7.12.1 Environmental Objectives

Ensure that traffic activity from the project does not adversely impact on the social surroundings.

Ensure that roads are maintained or improved and road traffic managed to meet an adequate standard of level of service and safety and Main Roads Western Australia requirements.

7.12.2 Assessment of Potential Risks and Impacts

Potential impacts resulting from transport/traffic as a result of project implementation are:

- Noise.
- Product spillage.
- Fauna deaths.
- Increase in dust emissions.
- Increase in greenhouse gas emissions.

The mine extension will not increase silica sand truck traffic above existing approved levels, but will extend the number of years that trucks will be travelling this route.

Transport of silica sand has been occurring from the property for over 10 years. Plant throughput is intended to remain at its designed throughput level, so the proposal will not result in an increase in traffic activity from this operation.

A proportion of Bassendean sand (non felspathic silica sand) is suitable for sale in the local area as construction sand. This sand will be transported off-site and add to truck movements carting silica sand to Bunbury, but it will not increase the total truck movements off site. All trucks are well maintained and operated by licensed operators and roads are maintained as agreed with the local council. Haulage is avoided on Sundays where possible. This has been addressed via a Section 45C modification to the existing Ministerial Statement 366.

KSS has not increased truck movements off-site, but indicated that campaign trucking will occur on an as-required basis and may not be limited to 10 regularly spaced campaigns per year. KSS has two full time road trains, each with two trailers, which carry 70 tonnes of silica sand and are covered with tarps. The current truck frequency is six to seven loads per day for each road train, from Monday to Friday and occasional Saturdays. Trucking generally occurs during daylight hours (5 am to 5 pm) although current approval is for 24 hour trucking. During ship loading trucking can occur from 4 am to 10 pm with up to 7,000 tonnes loaded by road trains in 12 hours.

7.12.3 Management and Mitigation Measures

Transport is not considered a key environmental factor for the following reasons:

- Road train transport has not been an issue with the public in the past.
- A 12 kilometre private haul road has been constructed to minimise disturbance to local residents. All trucks are well maintained and operated by licensed operators.
- If product is spilled it will be remediated immediately **(Commitment 7.12.3a)**.
- KSS employees are committed to driving to the designating speed limits to reduce potential for fauna deaths **(Commitment 7.12.3b)**.
- Transport is not considered a key environmental factor as it occurs on existing sealed roads and no significant issues have occurred since the operation commenced.
- All trucks are well maintained and operated by licensed operators.
- The mine extension will not increase silica sand truck traffic above existing approved levels, but will extend the number of years that trucks will be travelling this route.

No significant changes to the existing operations will result from a mining area extension. No change is requested in this document for site access or haulage.

7.12.4 Predicted Residual Environmental Risk

By continuing to implement management measures outlined above, there will be negligible effect on road transport from mine activities.

Potential road transportation/traffic impacts with their pre and post management risk are presented in Table 60. As can be seen from this, residual risks resulting from transport/traffic are all low. A detailed description of the potential impacts, risk assessment and management measures is provided in Appendix 16.

Table 60: Potential Road Transportation/Traffic Impacts Pre and Post Management

Potential Impact	Risk No Management Measures	Residual Environmental Risk
Noise	Moderate	Low
Product spillage	Low	Low
Fauna deaths	Low	Low
Increase in dust emissions	Moderate	Low
Increase in greenhouse gas emissions	Moderate	Low

7.13 DECOMMISSIONING AND CLOSURE

7.13.1 Environmental Objectives

The objective of decommissioning and closure planning is to describe strategies necessary to adequately address environmental issues at the completion of operations. The strategies are designed to ensure maintenance free closure in the long-term.

7.13.2 Standards and Legislation

Standards

- Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (ANZMEC/MCA), 2000. *Strategic Framework for Mine Closure.*
- Australian Minerals Industry, 2000. *Code for Environmental Management.*
- Environmental Protection Authority, January 2006b. *Draft Guidance for the Assessment of Environmental Factors No.6: Rehabilitation of Terrestrial Ecosystems.*
- Chamber of Minerals and Energy Western Australia Inc., 2000. *Mine Closure Guideline for Mineral Operations in Western Australia.*
- Department of Minerals and Energy of Western Australia, 2001. *Draft Criteria for Mine Closure.*
- Environment Australia, 2002. *Best Practice Environmental Management in Mining.*
- Minerals Council of Australia, 1999. *Mine Closure Policy.*
- Minerals Council of Australia, 1998. *Mine Rehabilitation Handbook.*

7.13.3 Management and Mitigation Measures

The 50 year mine life of the current proposal does not require detailed closure planning at this time. KSS will prepare a Preliminary Decommissioning and Closure Plan (PDCP), conforming to the Conceptual Closure Plan as defined in Section 2.3 of the Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (2000) guidelines within five years of commencing operations in the proposed mine extension area **(Commitment 7.13.4a)**.

Further revisions of the plan will be developed periodically during the life of mine, incorporating results of rehabilitation research and current government and industry guidelines. A final plan will be prepared two years prior to mine closure, consistent with the Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (2000) guidelines.

KSS believes implementation of management measures described above will serve to mitigate any impacts associated with implementing the proposal and result in an acceptable environmental outcome at closure of the operations.

8. ENVIRONMENTAL PROTECTION AND BIODIVERSITY CONSERVATION ACT TRIGGERS

Matters protected by the Commonwealth *EPBC Act* are known as matters of National Environmental Significance and include:

- World and National Heritage Places.
- Wetlands of International Importance.
- Listed Threatened species.
- Listed migratory species.
- Nuclear actions.
- Commonwealth Marine Area.

The KSS project was deemed a Controlled Action under the *EPBC Act* on 14 March 2003. The controlling actions triggered by the proposal are:

- Wetlands of International Importance (Sections 16 and 17B).
- Listed Threatened species and communities (Sections 18 and 18A).
- Listed migratory species (Sections 20 and 20A).

8.1 POTENTIAL SOURCES OF IMPACT TO MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Potential sources of impact to Wetlands of International Importance, listed Threatened species and listed migratory species were identified in Section 8.2.1, 8.2.2 and 8.2.3 respectively. In summary the key potential sources of impact to matters of National Environmental Significance include:

- Clearing of about 264 hectares of land resulting in temporary and in some instances permanent loss of vegetation and habitat.
- Altered vegetation distribution patterns post rehabilitation. Rehabilitated landforms and associated vegetation will differ in total area compared to the pre-existing condition (Table 48).
- Change in post mining landform to create permanent lakes with fringing ephemeral wetlands. This will result in reduced upland habitats compared to the existing landform.

8.2 ASSESSMENT OF POTENTIAL RISKS AND IMPACTS

8.2.1 Wetlands of International Importance

The KSS extension area occurs on the Swan Coastal Plain, bound by Wellesley River to the east and south-east, and Harvey River to the north of the property. The Peel-Yalgorup system is listed as a Wetland of International Importance under the 1971 Ramsar Convention on

Wetlands, especially as a habitat for Waterfowl. This site lies about five kilometres to the north-west of the KSS extension area and is separated from the mine by Harvey River.

The Peel-Yalgorup system incorporates the largest and most diverse estuarine complex in south-west Australia and is an important area for waterbirds. The system supports more than 20,000 waterbirds annually with in excess of 150,000 birds recorded on an individual occasion (Ramsar Convention of Wetlands, 2005). The Peel-Yalgorup system regularly hosts over 1% of the populations of at least six migratory shorebird species including Red-necked Avocet (*Recurvirostra novaehollandiae*), Red-necked Stint (*Calidris ruficollis*), Red-capped Plover (*Charadrius ruficapillus*), Banded Stilt (*Cladorhynchus leucocephalus*), Caspian Tern (*Sterna caspia*) and Fairy Tern (*Sterna nereis*) (Ramsar Convention of Wetlands, 2005). Of these, only the Red-capped Plover (*Charadrius ruficapillus*) has been recorded in the Kemerton region and is expected to occur on the KSS property (Bamford, 2003a).

Groundwater level data from the KSS mine site indicates that groundwater flow is in a south-east direction towards Wellesley River, which lies between KSS and Benger Swamp (GHD, 2002). The Harvey River forms a hydraulic barrier between the KSS site and the Peel-Yalgorup system. The addition of permanent water bodies within the post-mining landscape has the potential to provide an additional summer refuge for waterbirds, adding conservation value to this area (Bamford, 2003a). This is highly likely to occur given the current use of the existing dredge pond by Pacific Black Ducks, Australian Shellducks, sandpipers and plovers. Therefore the proposed mine extension is not likely to have a significant adverse impact on the ecology of the Peel-Yalgorup System. Rather, the addition of permanent water features will likely enhance the ecology of the wider region.

8.2.2 Listed Threatened Species

A search of the *EPBC Act* Protected Matters database was completed on 19 June 2002 between coordinates -33.10 degrees south, 115.80 degrees east, -33.10 degrees south, 115.77 degrees east, -33.16 degrees south , 115.76 degrees east and -33.16 degrees south , 115.79 degrees east with a one kilometre buffer. Given the time since the initial database search and preparation of this assessment document, an additional *EPBC Act* Protected Matters database search was completed on 12 February 2009 between coordinates -33.08 degrees south, 115.73 degrees east, -33.08 degrees south, 115.82 degrees east, -33.17 degrees south, 115.72 degrees east and -33.17 degrees south, 115.82 degrees east with a two kilometre buffer.

Three mammals, nine plant and two bird species listed as Threatened under the *EPBC Act* were identified as potentially occurring in the proposed mine extension area. Numerous flora and fauna surveys have been undertaken at KSS and the surrounding area over a number of years as described in Section 4.6.3 and 4.11.3 respectively. This included targeted surveys for the Chuditch (*Dasyurus geoffroii*), Carnaby's Black-Cockatoo (*Calyptohynchus latirostris*) and Western Ringtail Possum (*Pseudocheirus occidentalis)* and a targeted DRF and Priority flora search (Bennett, 2004). Species listed as Threatened under the *EPBC Act* likely to be found at KSS are presented in Table 61. They are discussed in more detail in the following sub sections.

Table 61: Species Listed as Threatened under the *EPBC Act* Likely to be Found at KSS

Species	Type	Common Name	*EPBC Act* Status	Recorded in Site Specific Surveys
Dasyurus geoffroii	Mammal	Chuditch	Vulnerable	x
Pseudocheirus occidentalis	Mammal	Western Ringtail Possum	Vulnerable	x
Setonix brachyurus	Mammal	Quokka	Vulnerable	x
Calyptohynchus baudinii	Bird	Baudin's Black-Cockatoo	Vulnerable	x
Calyptohynchus latirostris	Bird	Carnaby's Black-Cockatoo	Endangered	✓
Caladenia procera	Plant	Carbunup King Spider Orchid	Critically Endangered	✓
Caladenia huegelii	Plant	Grand Spider Orchid	Endangered	x
Centrolepis caespitosa	Plant		Endangered	
Diuris purdiei	Plant	Purdie's Donkey Orchid	Endangered	x
Drakaea elastica	Plant	Glossy-leaved Hammer Orchid	Endangered	x
Trithuria occidentalis	Plant	Swan Hydatella	Endangered	x
Diuris micrantha	Plant	Dwarf Bee-orchid	Vulnerable	x
Drakaea micrantha	Plant	Dwarf Hammer-orchid	Vulnerable	x
Diuris drummondii	Plant	Tall Donkey Orchid	Vulnerable	x

8.2.2.1 Chuditch *(Dasyurus geoffroii)*

Whilst the Chuditch originally utilised a wide variety of habitats across Australia, including woodlands, forests, beaches and deserts, they are now restricted to south-western Australia occupying around 5% of their original range with the population believed to be less than 6,000 individuals (Orell and Morris, 1994). The major remaining populations occur in remnant Jarrah forest, although small numbers are patchily distributed. Dense vegetation undergrowth is important for Chuditch.

Chuditch tend to rely on large trees for habitat and breed in areas where predators are not controlled. This species requires dense bush and scrub in order to provide abundant cover also thought to reduce their vulnerability to predators (Orell and Morris, 1994). Over a year, an adult female Chuditch may utilise an estimated 66 to 110 logs and burrows within her home range. Typically female Chuditch have a home range of three to four square kilometres and seldom overlap with other females. The male Chuditch has a home range of 15 square kilometres (Orell and Morris, 1994). Given these home ranges, if the Chuditch does occur on the property, it is expected to be in very low numbers (Wilcox and Bamford 2004).

Wilcox and Bamford (2004) conducted a trapping survey in the western portion of the KSS property to provide specific survey information on the possible presence of the Chuditch. No Chuditch, or any other mammals, were trapped during the survey. Wilcox and Bamford

(2004) report that although no Chuditch were trapped during this survey, small numbers are clearly present in the region. They have also been recorded in the Leschenault Peninsula Conservation Park, 10 kilometres to the west. In a trapping study carried out across the Kemerton Industrial Park in 1998, no Chuditch were caught (M. Bamford pers. records). This suggests that at least at that time, the Chuditch was scarce in the region.

Survey results on this specially protected species confirm that the proposed mine extension area has not been identified as containing known populations. While low numbers of animals may inhabit the wider region, there are no records of animals on the KSS property or the mine extension area. Despite this, the habitat available on the KSS property is considered suitable for Chuditch. Vegetation clearance associated with the proposed mine extension has the potential to have a small impact on the habitat and population of the Chuditch.

Vegetation clearance associated with the proposed mine extension has the potential to impact on the habitat and population of the Chuditch by removing an area of thick remnant vegetation, thereby reducing the possible habitat range of this species. Given Chuditch have not been recorded in recent (Wilcox and Bamford 2004) or historical (Ninox Wildlife Consulting, 1994) surveys, it seems unlikely that the KSS property provides a preferred habitat for this species.

8.2.2.2 Western Ringtail Possum *(Pseudocheirus occidentalis)*

Western Ringtail Possum's tend to be restricted to near coastal areas of peppermint (*Agonis flexuosa*) woodlands and peppermint/tuart (*Eucalyptus gomphocephala*) associations from Bunbury to Albany (Karrakatta – Central and South and Yoongarillup vegetation complexes located on the Spearwood Dune System). Tree hollows and dreys in tree canopies are used for nest sites. The Western Ringtail Possum has a home range between one and five hectares and can overlap by about 70%, however individual possums use between three and eight different nest sites a year and numerous nest sites are required to support high-density populations. The Western Ringtail Possum is nocturnal and so most active at night (DEWHA, 2008b).

The predominant vegetation complex on the property is Bassendean - Central and South, with some minor woodlands and forest of *Agonis flexuosa*. However, the Western Ringtail Possums prefer peppermint dominated forest near the coast, so it seems the habitat available on the KSS property is unfavourable. Bamford (2003) listed the Western Ringtail Possum as a species known or believed to have become extinct in the Kemerton region since European settlement. It had not been recorded in fauna surveys undertaken at the KSS property prior to 2004.

A targeted survey for Western Ringtail Possum was undertaken in January 2009 in response to consultation with DEC and DEWHA that indicated reintroduction of this species to areas north of KSS had occurred in recent years and individuals had reportedly been observed adjacent to KSS. The results of a targeted inspection of the site for evidence of Western Ringtail Possum failed to find any sign of this species and it is concluded that they are not present on site or are only present rarely as transient individuals, suggesting that the Western Ringtail Possum is currently not utilising vegetation on site as potential habitat. This is thought to be primarily because of the general poor quality of the habitat present and because of historical events that have resulted in the localised extinction of the species in this specific area. There is some potential for individuals to either be present now in very low densities or

to at times move into the area from nearby areas of better habitat quality or known extant populations (Harewood, 2009).

8.2.2.3 Quokka *(Setonix brachyurus)*

The Quokka (*Setonix brachyurus*) is endemic to south-western Australia and is now restricted to Rottnest and Bald Islands and only 25 mainland site, most of which are National Parks. One record is known from a swamp in State Forest near Dwellingup and other may still occur in forest near Manjimup and Collie (Maxwell *et al.* 1996). Quokkas used to occur in low lying scrub from the coast to jarrah-marri forest, but they are now restricted to swamps with dense vegetation (Maxwell *et al.* 1996).

Quokkas have not been recorded in site fauna surveys of the KSS site. Bamford (2003) lists this species as known or believed to have become extinct in the Kemerton region since European settlement. It is considered unlikely that the mine extension will have adverse impacts on this species given the known range is highly restricted to undisturbed areas.

8.2.2.4 Baudin's Black-Cockatoo *(Calyptohynchus baudinii)*

Baudin's Black (or Long-billed) Cockatoo is endemic to the south-west of Western Australia, and the KSS proposed mine extension area is located within the known distribution range for this species. It is a more specialised feeder of Eucalypts and tends to be favour moist, heavily forested areas dominated by Marri, Karri and Jarrah species (DEWHA, 2008c). Suitable habitat is limited on the KSS area as historic logging has removed most large Eucalypt trees.

Baudin's Black-Cockatoo was not recorded in site surveys in November 2003 and May 2004 (Craig *et al.* 2004). Evidence of Baudin's Black-Cockatoo foraging (chewed marri nuts) were observed within the mine extension area, while numerous Banksia cones showing signs of cockatoo foraging (seeds and grubbing) were observed (Harewoood, 2009). Some or all of this activity could be attributed to the Carnaby's and not the Baudin's Black-Cockatoos (Harewoood, 2009). While Baudin's Black-Cockatoo may visit woodlands of the property, it is unlikely to use the area extensively. Significant impacts on this species from the proposed action are likely to be a reduction in habitat due to an altered post-mining landscape.

8.2.2.5 Carnaby's Black Cockatoo *(Calyptohynchus latirostris)*

Carnaby's Black (or Short-billed) Cockatoo is endemic to south-western Australia. Carnaby's Black-Cockatoo is reliant on native remnant woodlands, predominantly Salmon Gum (*Eucalyptus salmonophloia*) or Wandoo (*E. wandoo*), shrubland or heath dominated by Proteaceous species. Carnaby's Black-Cockatoo use large hollows in live or dead eucalypts to breed. They then forage in higher rainfall coastal areas including woodlands, heath, pine plantations and orchards. The habitat range has significantly decreased and become fragmented since 1970 and the Cockatoos have disappeared from a third of their breeding range. A breeding population is known to occur around the Bunbury region. The KSS site is within foraging range of this population (Bamford, 2003a; Cale, 2003).

Craig *et al.* (2004) conducted surveys of the KSS property in November 2003 and May 2004 to provide specific survey information on the possible utilisation by Carnaby's Black-Cockatoos of the mine extension area. The value of the KSS property for breeding was assessed to be low in the regional context, with no evidence of breeding and few potentially suitable nest hollows present. The value of foraging habitat on the KSS property was assessed

to be similar to or less than the value of foraging habitat at control sites. However, the value of foraging habitat is very difficult to assess as usage of different plant species varies seasonally and information is not available on seed density in different vegetation types. Carnaby's Black-Cockatoo has been recorded in site surveys in November 2003 and May 2004 (Craig *et al.* 2004). Harewood (2009) sighted several small flocks of Carnaby's Black-Cockatoo within the proposed mine extension area at KSS. Numerous examples of foraging activity (chewed jarrah nuts and Banksia cones, pine cones and marri nuts) were observed within the mine extension area. Some or all of this activity could be attributed to Baudin's or Forest Red-tailed Black-Cockatoos (Harewoood, 2009). Carnaby's Black-Cockatoo is a frequent visitor to the general area for foraging. Two potential nest hollows are present within the mine extension area, although the probability of breeding on site is considered low (Harewood, 2009).

The survey concluded the proposed mine extension area did not possess any unique value for cockatoos, above other wooded areas in the region (Craig *et al.* 2004). Carnaby's Black-Cockatoo does use the KSS property for foraging and it is likely to be an important area given much of the Swan Coastal Plain has been cleared (Bamford, 2003a). Craig *et al.* (2004) considered the KSS property is likely to provide opportunistic pickings from woodlands rather than a continual, reliable food source and as such, Carnaby's Black-Cockatoo is likely to be a transitional species and a seasonal visitor. The proposed action will result in a temporary reduction in foraging habitat for Carnaby's Black-Cockatoo, although the post mining landform will contain Proteaceous species, which the Cockatoo favours (Cale, 2003). The proposed action is not considered likely to have significant long-term impact on Carnaby's Black-Cockatoo.

8.2.2.6 Carbunup King Spider Orchid *(Caladenia procera)*

Caladenia procera (Carbunup King Spider Orchid) is listed as Critically Endangered under the *EPBC Act* and DRF under the *WC Act.* It is a tuberous, perennial herb growing up to 90 centimetres high with linear hairy leaves and the flowers are greenish-yellow with heavily clubbed sepals, labellum with a purple tip from September to October.

The Carbunup King Orchid is known from five small scattered populations over an area from Bunbury to Carbunup. The Carbunup King Spider Orchid prefers rich clay loam, alluvial flats. Dominant vegetation type is Jarrah-Marri woodland amongst dense low shrubs and sedges. Prior to settlement, this was probably a common species, but its distribution has been heavily cleared (Pers comm., Ryan Phillips, 2008).

Carbunup King Spider Orchid has been located just off the corridor within the south-eastern corner of the KSS property (Figure 11). This location is removed from the proposed mine extension area and will not be disturbed. The location is further discussed in Section 10.

8.2.2.7 Grand Spider Orchid *(Caladenia huegelii)*

Caladenia huegelii (Grand Spider Orchid) is listed as Endangered under the *EPBC Act* and DRF under the *WC Act*. It is a tuberous, perennial herb growing up to 60 centimetres high with linear hairy leaves and the flowers are red with cream margins.

The Grand Spider Orchid is known from 39 small scattered populations over a wide area from Perth to Albany. The Grand Spider Orchid does not require fire to germinate, however tends to be restricted to Bassendean sands or where they meet with Spearwood sands. Dominant

vegetation type is *Banksia* woodland (often fairly low in the landscape, but not always) sometimes with a *Jarrah* or *Marri* overstory and usually occurs with mixed *Banksia/Kunzea* (Pers comm., Ryan Phillips, 2008). Prior to settlement, this was probably a common species, but its distribution has been heavily cleared (Pers comm., Ryan Phillips, 2008).

Caladenia huegelii has not been recorded within the KSS property or surrounding area (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Caladenia huegelii.*

8.2.2.8 Centrolepis caespitosa

Centrolepis caespitosa is listed as Endangered under the *EPBC Act*, but is currently only listed as Priority 4 under the *WC Act.* Given that this species in listed as Priority 4 under the *WC Act*, taxonomic revision may indicate it needs to be removed from the federal listing. It is a minute annual herb (forming a rounded cushion up to 25 millimetres across) with green leaves and flowers from October to December.

Centrolepis caespitosa is known from 34 small scattered populations over a wide area from Perth to Albany. *Centrolepis caespitosa* prefers wet flats in brown grey clay loam and laterite in *Eucalyptus decipiens*, *E. marginata* low open mallee open shrubland over very open herbland/grassland/sedgeland.

Centrolepis caespitosa has not been recorded within the KSS property or surrounding area (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Centrolepis caespitosa.*

8.2.2.9 Purdie's Donkey Orchid *(Diuris purdei)*

Diuris purdei (Purdie's Donkey Orchid or Double Tails) is listed as Endangered under the *EPBC Act* and DRF under the *WC Act.* It is tuberous perennial herb growing up to 35 centimetres high, with yellow flowers from September to October.

Purdie's Donkey orchid is known from 10 small scattered populations around Perth and requires fire to germinate. The few recent records of this species in the Western Australian herbarium are recorded from wet grey/black sand or sandy loam. There has been considerable variation between sites in the composition of the surrounding vegetation (Pers comm., Ryan Phillips, 2008).

Diuris purdei has not been recorded within the KSS property or surrounding area (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Diuris purdei.*

8.2.2.10 Glossy-leaved Hammer Orchid *(Drakaea elastica)*

Drakaea elastica (Glossy-leaved Hammer Orchid or Praying Virgin) is listed as Endangered under the *EPBC Act* and DRF under the *WC Act.* It is a tuberous perennial herb growing up to 30 centimetres high, with glossy green heart-shaped leaves with and a solitary stem.

Glossy-leaved Hammer-orchid is known from 16 small scattered populations over a wide area from Perth to Busselton. Glossy-leaved Hammer-orchid or Praying virgin does not require

fire, although habitat preferences are predictable. It occurs low in the landscape (but not seasonally wet), generally under *Kunzea* thickets among *Banksia* (Pers comm., Ryan Phillips, 2008). For the most accurate census of population numbers, survey in July-August are best for looking for leaves. The leaves will start to wilt in a dry year by late September. It usually grows with other *Drakaea* species (Pers comm., Ryan Phillips, 2008).

A population of 35 plants of *Drakaea elastica* was found in 2007 growing with *Drakaea micrantha* (DRF), approximately 830 metres to the south-east of the KSS property. *Drakaea elastica* has not been recorded within the KSS property (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Drakaea elastica.*

8.2.2.11 Swan Hydatella *(Trithuria occidentalis)*

Trithuria occidentalis (Swan Hydatella) is listed as Endangered under the *EPBC Act* and DRF under the *WC Act.* It is a reddish annual herb growing up to 30 centimetres high, with red flowers and purple-red anthers.

Swan Hydatella is known from 11 small scattered populations around Perth. It prefers grey-brown clay, soft and damp low-lying situations adjoining winter-wet swamps in Open shrubland of *Melaleuca lateritia* to 1.5 metres tall with open ground between shrubs.

Trithuria occidentalis has not been recorded within the KSS property or surrounding area (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Trithuria occidentalis.*

8.2.2.12 Dwarf Bee-orchid *(Diuris micrantha)*

Diuris micrantha (Dwarf Bee-orchid) is listed as Vulnerable under the *EPBC Act* and DRF under the *WC Act.* It is a tuberous, perennial herb growing up to 60 centimetres high with yellow spotted brown flowers from September to October.

The Dwarf Bee-orchid is known from six small scattered populations around Perth. Dwarf Bee-orchid does not require fire to germinate, however the soil type and co-occurring vegetation is very variable. It is probably dependent on seasonal moisture rather than specific vegetation or soil type (Pers comm., Ryan Phillips, 2008).

A population of six plants of *Diuris micrantha* has been found growing with *Drakaea micrantha* (Vulnerable, DRF), approximately 2.8 kilometres to the south of the KSS property along the Dampier to Bunbury natural gas pipeline corridor (Woodman, 2005a). *Diuris micrantha* has not been recorded within the KSS property (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Diuris micrantha.*

8.2.2.13 Dwarf Hammer-orchid *(Drakaea micrantha)*

Drakaea micrantha (Dwarf Hammer-orchid) is listed as Vulnerable under the *EPBC Act* and DRF under the *WC Act.* It is a tuberous, terrestrial herb growing up to 30 centimetres high with a flower 1.2 to 2.5 centimetres long. It has silvery-grey heart-shaped leaves with prominent green veins.

The Dwarf Hammer-orchid is known from 32 small scattered populations over a wide area from Perth to Albany with secure populations in Frankland National Park. The Dwarf Hammer-orchid prefers infertile grey sands in *Banksia*, *Jarrah* (*Eucalyptus marginata*) and Common Sheoak (*Allocasuarina fraseriana*) woodland or forest. It is often found under thickets of Spearwood (*Kunzea ericifolia*) (DEWHA, 2008d). The species likes disturbed areas, including cleared fire breaks or open sandy patches where competition from other plants has been removed. The Dwarf Hammer-orchid does not require fire to flower and is known to occur in the same habitat on the coastal plain as *D. elastica* (Pers comm., Ryan Phillips, 2008).

Drakaea Micrantha has been found in a number of locations to the south and south-east of the KSS property from 2004 to 2008. *Drakaea micrantha* has not been recorded within the KSS property (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Drakaea micrantha.*

8.2.2.14 Tall Donkey Orchid *(Diuris drummondii)*

Diuris drummondii (Tall Donkey Orchid) is listed as Vulnerable under the *EPBC Act* and DRF under the *WC Act.* It is a tuberous, perennial herb growing up to 95 centimetres high with yellow and brown flowers from November to January.

The Tall Donkey Orchid is known from 24 small scattered populations over a wide area from Perth to Albany with secure populations in Frankland National Park. It occurs on a wide variety of soil types, but requires swamps that are moist well into summer. No areas in the proposed extension area stay moist well into summer, so it is unlikely that this species is present. The structure and composition of the vegetation does not appear to be important, however, flowering generally requires fire, but some populations appear to be able to flower well without fire (Pers comm., Ryan Phillips, 2008).

A population of 34 plants of *Diuris drummondii* was found in 2007 growing one kilometre to the south of the KSS property along the Dampier to Bunbury natural gas pipeline corridor (Woodman, 2005a). *Diuris drummondii* has not been recorded within the KSS property (Mattiske, 1993a, b, c, d, 2003b; Bennett, 2004; Woodman, 2005a). The proposed action is not considered likely to have significant impact upon the population of *Diuris drummondii.*

8.2.3 Listed Migratory Species

As well as the *EPBC Act*, migratory species may also be protected under three international treaties to which Australia is a signatory. These treaties are:

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn).
- China – Australia Migratory Bird Agreement (CAMBA).
- Japan – Australia Migratory Bird Agreement (JAMBA).
- Republic of Korea – Australia Migratory Bird Agreement (ROKAMBA).

A search of the *EPBC* Protected Matters database identified five migratory bird species that might occur in the KSS area. Species together with their *EPBC Act* status, habitat requirements and an indication of whether they have been recorded in the proposed mine

extension area are presented in Table 62. These species in relation to KSS are discussed in more detail in the following subsections.

Table 62: Migratory Species Listed Under the *EPBC Act* that May Occur Within the KSS Area

Species	EPBC Status	Habitat[1]	Recorded in Site Specific Surveys
Migratory Wetland/Marine Birds			
White Egret (*Ardea alba*)	Migratory (CAMBA, JAMBA)	Shallows of rivers, estuaries, tidal mudflats, freshwater wetlands	x
Cattle Egret (*Ardea ibis*)	Migratory (CAMBA, JAMBA)	Wetlands, tidal mudflats, pastures, croplands.	x
Fork-tailed Swift (*Apus pacificus*)	Migratory (Marine only) (CAMBA, JAMBA, ROKAMBA)	Largely aerial	x
Glossy Ibis *(Plegadis falcinellus)*	Migratory (CAMBA, JAMBA)	Well vegetated wetlands, pastures, rice fields, floodwater, floodplains or occasionally saline wetlands, mangroves and mudflats.	x
Migratory Terrestrial Birds			
White-bellied Sea-Eagle (*Haliaetus leucogaster*)	Migratory (CAMBA)	Coasts, islands, estuaries, inlets, large rivers, inland lakes and reservoirs.	x
Rainbow Bee-eater (*Merops ornatus*)	Migratory (JAMBA)	Open woodlands with sandy/loamy soil.	✓

Source: [1] Pizzey and Knight (2003).

8.2.3.1 Migratory Terrestrial Bird Species

Two terrestrial bird species have potential to occur in the KSS property, namely the White-bellied Sea-Eagle (*Haliaetus leucogaster*) and the Rainbow Bee-eater (*Merops ornatus*). The White-bellied Sea-Eagle has been observed in the region, but not on the KSS property, while the Rainbow Bee-eater was recorded on the KSS site in January 2002 and in the Kemerton region (Bamford, 2003a).

The White-bellied Sea-Eagle is normally found inland along major rivers and requires trees greater then 30 metres in height or coastal/riverine cliffs in which to nest. The species may occasionally fly over the site due to its proximity to the ocean and Leschennault Inlet, but is very unlikely to forage or nest on site (Harewood, 2009).

The Rainbow Bee-eater is a common summer migrant to southern Australia but in the north they are resident (Morcombe, 2003). The Rainbow Bee-eater prefers open woodlands with sandy or loamy soils and open country of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest and farmlands (Morcombe 2003). Breeds underground in areas of

suitable soft soil firm enough to support tunnel building (Harewood, 2009). Recorded in the KSS property it is probably a relatively common seasonal visitor to the general area.

The proposed mine extension area will result in the loss of habitat during the mining phase and the period after, when rehabilitation is developing and ecological functions slowly return to the post mining landform. An average of only five hectares per year will be cleared of the 283 hectares, over the 50 year life of mine. With this slow rate of habitat removal in a local area surrounded by vegetation, it is considered birds will naturally relocate to adjacent areas in advance of clearing.

Eighty percent of vegetation on the property will be retained, including heavily vegetated seasonal wetlands. It is unlikely that proposed sand extraction will have a significant impact on migratory terrestrial bird species.

8.2.3.2 Migratory Wetland Bird Species

Three migratory wetland bird species have potential to occur on the KSS property namely the White or Great Egret (*Ardea alba*), Cattle Egret (*Ardea ibis*) and the Glossy Ibis (*Plegadis falcinellus).* All these species inhabit tidal mudflats and margins or shallows of watercourses, inland swamps or dams.

The Great Egret has been observed in the Kemerton region in previous studies, but not on the KSS property (Bamford, 2003a). The Cattle Egret has not been observed in the region or on the KSS property (Bamford, 2003a).

The Glossy Ibis is both migratory and nomadic. Its range expands inland after good rains, but its main breeding areas seem to be inn the Murray-Darling Basin of New South Wales and Victoria, the Macquarie Marshes in New South Wales, and in southern Queensland. Glossy Ibis often move north in autumn then return south to their main breeding areas in spring and summer (Pizzey and Knight 2006). Infrequently recorded in south-west, there is small potential for it to use some inundated open areas in wetter months of year.

The EPP wetlands may be utilised from time to time by the listed migratory waterbird species. The EPP wetlands occur mostly to the eastern side of the KSS property with six of these EPP wetlands transferred to DEC to ensure their long-term protection. Site investigations into groundwater indicate that significant impacts on wetlands and associated values for listed species are not likely (GHD, 2002). The proposed mine extension area has been defined based on groundwater modelling work which identified the buffer distance required to protect EPP4 and its surrounding wetland catchment from mining induced groundwater changes (Appendix 18).

Fauna surveys reflect that fauna associated with permanent water are currently poorly represented on the site (Bamford, 2003a). Site observations indicate North Lake has become a major attraction for waterbirds that would not normally occur on the property. This lake is still in early stages of rehabilitation and is likely to become more attractive to a range of waterbirds as riparian vegetation continues to establish. There will be an increased number of permanent water bodies in the post mining landform, providing a greater diversity of habitats on the property. The proposed mine extension area currently contains no permanent water bodies and the creation of new open water will be a major environmental advantage for migratory wetland species.

Wetlands on the KSS site are not recorded as providing important habitat for listed migratory waterbirds. There is not expected to be any adverse impacts upon the conservation status of any migratory wetland bird species.

8.2.3.3 Migratory Marine Bird Species

One migratory marine bird species, the Fork-tailed Swift (*Apus pacificus*) might occur in the proposed mine extension area.

The Fork-tailed Swift is potentially a very occasional summer visitor to the study area but is entirely aerial and largely independent of terrestrial habitats (Harewood, 2009). It migrates to Australia from Siberia and northern Asia, and is found throughout the mainland, particularly in the centre and west.

No impact on this species is anticipated as it is likely to be only a very infrequent visitor to the general area. No specific management measures recommended.

8.3 MANAGEMENT AND MITIGATION MEASURES

Potential impacts to matters of National Environmental Significance will be addressed through

- Create north to south designed dredge ponds and rehabilitated lakes to reduce water loss by evaporation and impacts associated with easterly and westerly winds **(Commitment 7.4.4h)**. These areas have the potential to increase the conservation significance of the area by providing additional habitat for migratory waterbirds.
- Conducting surveys to identify potential Cockatoo tree hollows prior to annual land clearing to ensure hollows are not currently being used for breeding. Tree hollows suitable for Cockatoos will be relocated to other areas, preferably within newly rehabilitated areas. Hollows will either be remounted on trees outside the mine extension area, or if this is not practical, replaced with similar sized nest boxes **(Commitment 7.7.4a)**. Tree hollows suitable for Cockatoos may be used by Carnaby's Black-Cockatoo, but Baudin's Black-Cockatoo is not expected to nest in the Kemerton region. Relocated tree hollows may provide habitat for other fauna species. Utilisation will be recorded in scheduled rehabilitation monitoring programs.
- Planting of tree species likely to develop hollows and provide Cockatoo habitat in the long-term **(Commitment 7.7.4b)**.
- Progressive clearing of an average of five hectares per year will be carried out in Autumn when species are less likely to be breeding **(Commitment 7.7.4d)**. This will enable any Threatened or Migratory Fauna species to migrate to other areas of the KSS property.
- Progressive rehabilitation with local provenance seed to encourage colonisation from surrounding vegetative areas, to re-establish vegetation and hence fauna **(Commitment 7.7.4e)**.
- Conducting targeted survey for Chuditch, Western Ringtail Possum and Quokka prior to annual land clearing to ensure that populations of these Threatened species will not be affected by the planned clearing. If evidence of their presence is found, trapping will be

undertaken and captured individuals relocated to suitable alternative sites on the property **(Commitment 7.7.4f)**.

- Erecting nest boxes suitable for use by Western Ringtail Possums where annual surveys show Possums are present in areas planned to be cleared in the short term. Nest boxes will be placed in adjacent undisturbed areas where suitable foraging habitat is present **(Commitment 7.7.4g)**.
- Planting areas of peppermint (*Agonis flexuosa*) within upland woodland areas to be rehabilitated post mining. Peppermint trees will be planted in clumps to encourage interlocking branches **(Commitment 7.7.4h)**.
- Mitigation measures include assisting with rehabilitation of 11 hectares of degraded Bassendean woodland within and adjacent to Kemerton Nature Reserve, weed and feral pig control in Kemerton Nature Reserve to increase habitat quantity and quality for Cockatoos and other fauna species.
- Kemerton Nature Reserve established and expanded as a north-south ecological link between remnant vegetation.
- Providing offset areas in addition to the previously agreed offsets areas of the Kemerton Nature Reserve and the current mining area. Offsets are discussed in more detail in Section 10.

9. REHABILITATION

9.1 ENVIRONMENTAL OBJECTIVES

Establish stable, sustainable landforms consistent with intended post-mining land use and surroundings.

Ensure areas affected by the proposal are rehabilitated to a standard consistent with intended post mining long-term land use.

9.2 RELEVANT STANDARDS AND LEGISLATION

Standards

- Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, 2000. *Strategic Framework for Mine Closure.*
- Australian Minerals Industry, 2000. *Code for Environmental Management.*
- Environmental Protection Authority, January 2006. *Draft Guidance for the Assessment of Environmental Factors No.6: Rehabilitation of Terrestrial Ecosystems.*
- Chamber of Minerals and Energy WA Inc., 2000. *Mine Closure Guideline for Mineral Operations in Western Australia.*
- Department of Minerals and Energy of Western Australia, 2001. *Draft Criteria for Mine Closure.*
- Environment Australia, 2003. *Best Practice Environmental Management in Mining.*
- Minerals Council of Australia, 1999. *Mine Closure Policy.*
- Minerals Council of Australia, 1998. *Mine Rehabilitation Handbook.*

9.3 ASSESSMENT OF POTENTIAL RISKS AND IMPACTS

The KSS property is freehold rural zoned land. Stock grazing took place on the property until 15 to 20 years ago. The property also has a history of timber and brush cutting and has been drained. The majority of the property still remains under native vegetation. It is intended to rehabilitate the post mining landform with native species and continue to exclude stock from the property. The land will retain its rural zoning and remain as private property with limited public access, other than to scientific research organisations and special interest groups.

Rehabilitation will take time to establish before it reaches a standard that meets regulatory, company and community objectives.

Potential impacts related to rehabilitation of the proposed mine extension area are:

- Inadequate rehabilitation leading to poor reinstatement and recovery of terrestrial vegetation and habitat.
- Weed introduction during mining activities.

- Weed introduction during rehabilitation as a result of using non-local seed or seed that is not certified 'weed free'.

9.4 REHABILITATION MANAGEMENT PLAN

KSS has prepared a Rehabilitation Management Plan (RMP) for its existing operations (Appendix 19). This has recently been revised to include provision for expansion of the mine area. The RMP provides details on each aspect of the rehabilitation program**.**

The RMP is an adaptive document, which will review results of ongoing rehabilitation research during the life of mine and include results in subsequent document revisions. The RMP is based on undertaking rehabilitation in line with:

- Progressive rehabilitation.
- Site based seed collection.
- Match species selection for different rehabilitation landforms.
- Detailed rehabilitation plans for each landform type.
- Protection of specially protected, Declared Rare and iconic species.
- Provision of specific habitat features, such as logs with hollows.
- Introduce iconic species into new areas.
- Undertake trials and research on specific projects.
- Weed control.
- Feral animal control.
- Implement a monitoring schedule for completed works.
- Implement a reporting and review schedule for the plan.

KSS will continue to revise the Rehabilitation Management Plan on a regular basis to ensure it remains relevant and effective **(Commitment 9.4a)**.

9.5 REHABILITATION LANDFORM PLAN

The mining method used to extract silica sand is a continuous dredging process. Ore is pumped from the dredge to the existing processing plant. Residual sand material is returned to the dredge pond. This process allows progressive rehabilitation to occur.

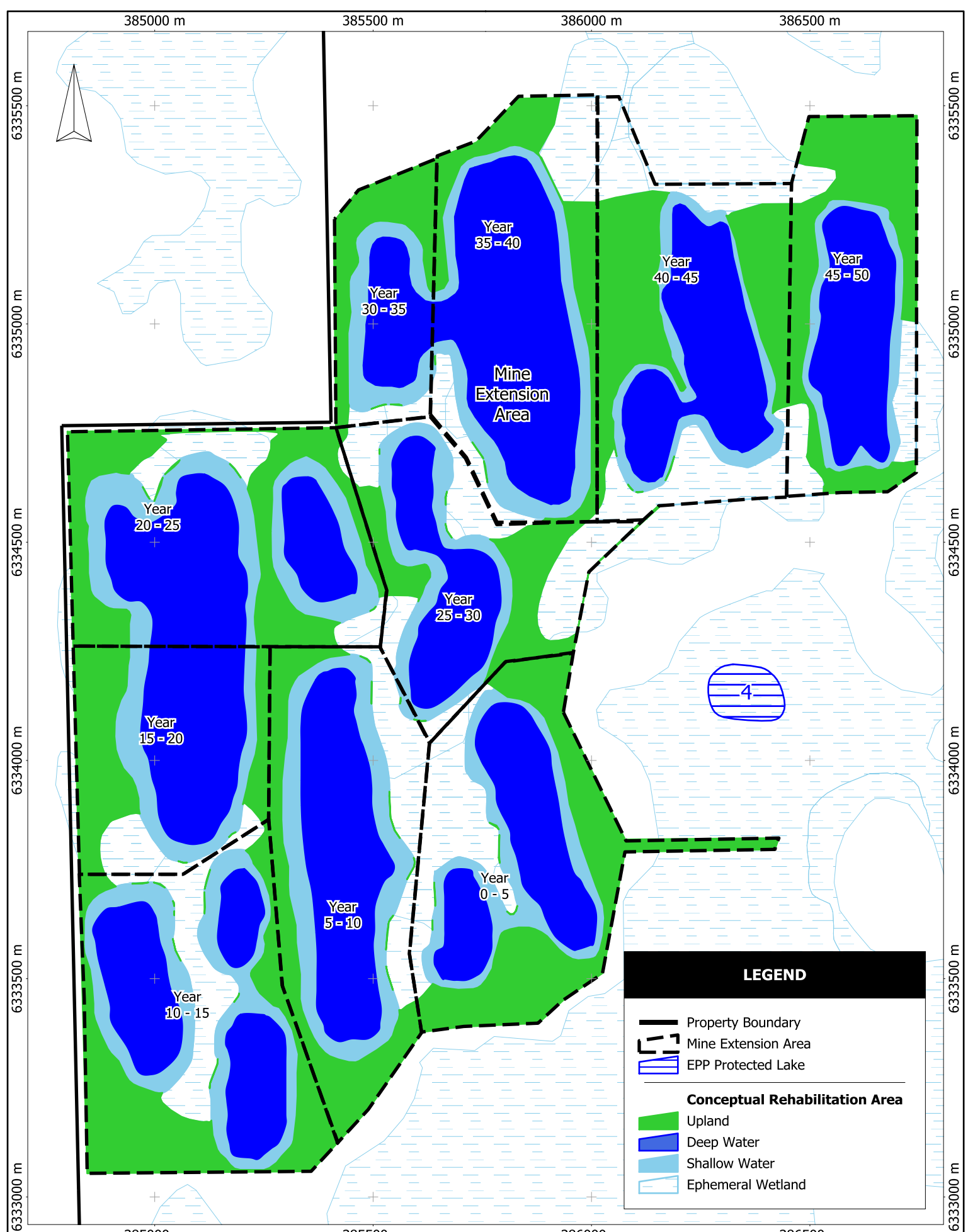
Returned sand is used to build embankments within the pond, isolating completed portions of the pond from the active dredging area. The completed lakes undergo further backfilling to restore beaches and other landforms prior to return of topsoil and vegetative establishment.

A conceptual rehabilitation landform plan has been prepared and is shown in Figure 24. This shows the change in general landform which will result from mining. Change in post mining landforms are summarised in Table 48. Both show the extent of permanent water bodies that will occupy the site on completion of mining (approximately half the total mine extension area). The remaining land will be rehabilitated as ephemeral wetlands interspersed with

upland landforms, although the latter will generally not be as high as those that existed before mining. The conceptual rehabilitation landform and wetland profiles are shown in Figure 25 and Figure 26. KSS will establish flora species from similar communities mapped in the pre-mining survey in each of these differing landform types.

Taking into account initial outcomes of investigations by Edith Cowan University on lake geometry, the conceptual rehabilitation landform plan shows ponds which have been orientated on a north-south alignment as much as possible. Given predominant winds over the property are east in summer and west/south-west in winter, this will reduce wave action and consequent shore erosion compared to east-west orientated ponds.

Development of final detailed landform design will be undertaken progressively, incorporating outcomes of rehabilitation research during the life of mine.



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Scale: 1:11000
Original Size: A4

0 250 m

Kemerton
Silica Sand Pty Ltd

Conceptual Rehabilitated Landform Plan

Figure 24

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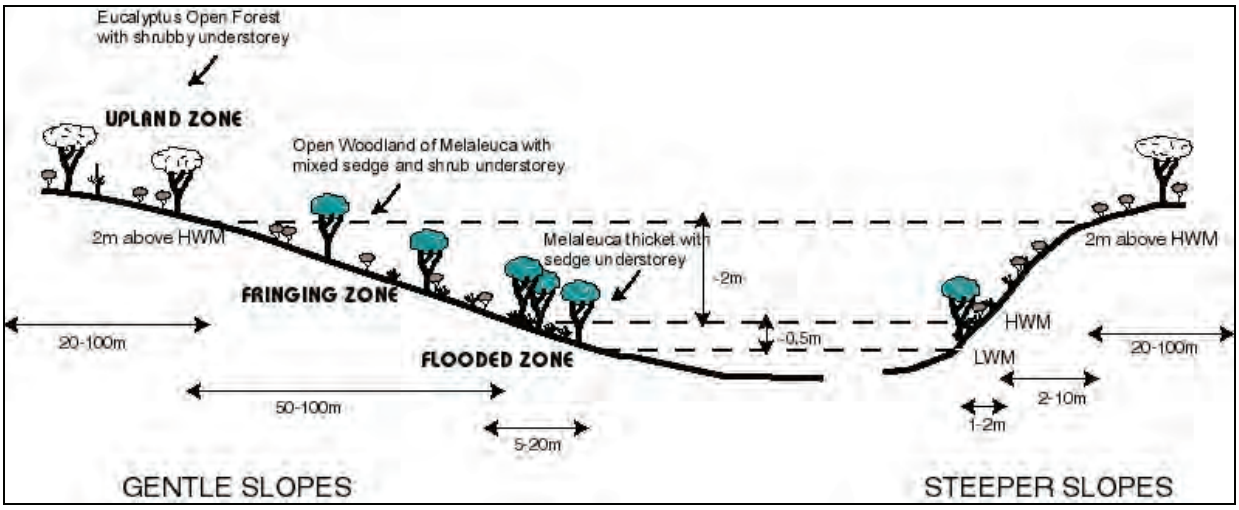
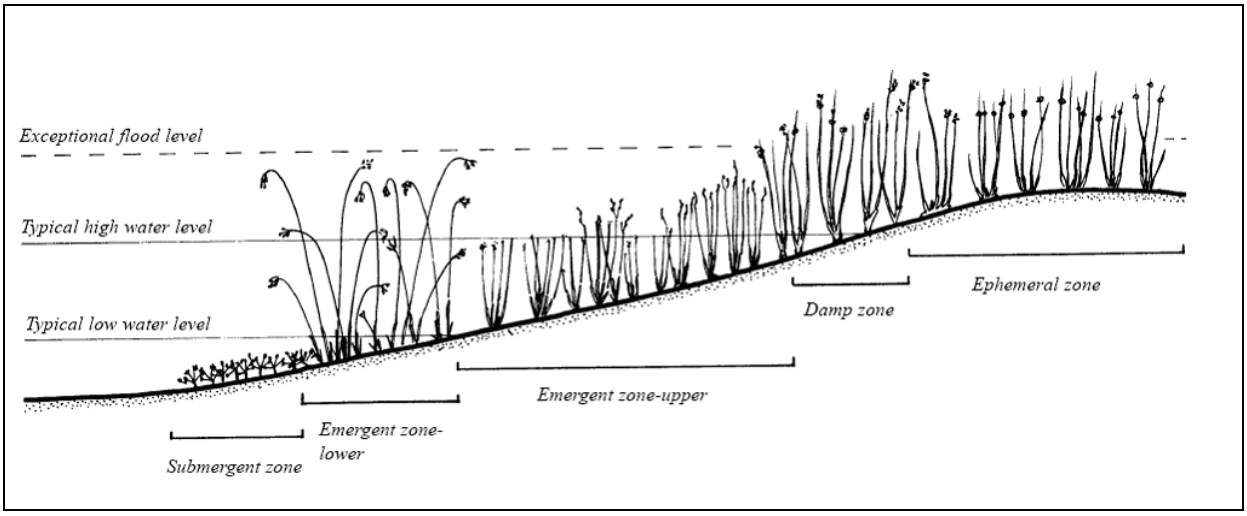
Figure 25: Conceptual Rehabilitation Landform Profile



Source: Water and Rivers Commission (2001).

Figure 26: Conceptual Rehabilitation Wetland Profile



Source: Water and Rivers Commission (2000).

9.6 REHABILITATION PROGRAM CONSIDERATIONS

The rehabilitation program will take into account the following aspects.

9.6.1 Landform Restoration

KSS aim to construct a diversity of lake shapes, beach angles and island refuges in rehabilitated cells. This will involve reconstructing surrounding terrestrial landforms including ephemeral wetlands and drylands.

Landform effects on the proposed mine extension area are presented in Table 48. As a result of mining, there is a net change in landform type where:

- 170 hectares of permanent lakes and beaches will replace 62.7 hectares of existing ephemeral wetlands, 57.1 hectares of Bassendean upland, 31.9 hectares of Spearwood

upland and 19 hectares of disturbed land historically used for process sand residue. Rehabilitation of permanent lakes represents a further reduction in net loss associated with the project. It will provide expanded habitat for iconic species such as the Black Striped Jollytail and Water Rat present on the property in restricted locations and additional habitat including summer drought refuge for waterbirds.

- Post mining rehabilitation will return approximately 48 hectares of ephemeral wetlands and 65 hectares of upland.

9.6.2 Woodland Rehabilitation

KSS recognises the importance of establishing vegetation in dryland areas of the post mining landform. *Banksia* woodland topsoil provides a rich and useful seed source for rehabilitation of *Banksia* woodland communities in the southwest of Western Australia (Rokich *et al.* 2000).

9.6.3 Specialised Habitat Restoration for Terrestrial Fauna

Specialised habitat restoration that is being included in the rehabilitation program includes:

- Conduct surveys to identify potential Cockatoo tree hollows prior to annual land clearing to ensure hollows are not currently being used for breeding. Tree hollows suitable for Cockatoos will be relocated to other areas, preferably within newly rehabilitated areas. Hollows will either be remounted on trees outside the mine extension area, or if this is not practical, replaced with similar sized nest boxes **(Commitment 7.7.4a)**.
- Planting of tree species likely to develop hollows and provide Cockatoo habitat in the long-term **(Commitment 7.7.4b)**.
- Erecting nest boxes suitable for use by Western Ringtail Possums where annual surveys show Possums are present in areas planned to be cleared in the short term. Nest boxes will be placed in adjacent undisturbed areas where suitable foraging habitat is present **(Commitment 7.7.4g)**.
- Planting areas of peppermint (*Agonis flexuosa*) within upland woodland areas to be rehabilitated post mining. Peppermint trees will be planted in clumps to encourage interlocking branches **(Commitment 7.7.4h)**.
- Relocate habitat logs and brush for ground dwelling fauna. Habitat logs and brush are re-spread in areas undergoing rehabilitation as part of current operations **(Commitment 7.7.4l)**. This practice will continue.
- Research habitat requirements for specialised fauna, such as the Water Rat, Honey Possum and Western Pigmy Possum. Examples include:
  - Selection of appropriate species in rehabilitated areas to provide food resource for target Possum species.
  - Much of the KSS property supports low, dense vegetation favoured by the Southern Brown Bandicoot. Progressive rehabilitation will encourage colonisation from surrounding vegetative areas.
  - On-going research by Edith Cowan University into establishing dense understorey, returning habitat logs and rocks, return of aquatic vertebrate and invertebrate species to the dredge ponds. This will provide preferred habitat for native mammals.

9.6.4 Wetland Rehabilitation

KSS recognise the importance of successfully establishing fringing vegetation around lakes and establishing ephemeral wetland vegetation. Establishment of a representative riparian margin around rehabilitated dredge ponds is considered to be important, not just from a value in its own right, but also to help achieve water quality that will better mirror that of surrounding natural wetlands. Establishment of even a simple sedgeland margin (e.g. *Schoenoplectus validus)* around rehabilitated areas appears to significantly improve macroinvertebrate structure to that of a more natural community (McCullough and Lund, 2008). EPP1 appears to be a potential analogue for the dredge ponds.

The Centre for Ecosystem Management and Edith Cowan University conducted an assessment of the rehabilitation at KSS in mid 2007 and then later reviewed changes in November 2008 (van Etten *et al.* 2009). Overall, there has been a slight to modest improvement in rehabilitation with plant cover increasing more substantially in low-lying areas closer to the lake. The monitoring indicated that good to excellent ecological restoration can be achieved at KSS post-mining through the use of fresh topsoil matched to the topographic position in the landscape where it originated.

9.6.5 Rehabilitated Lake Ecology

KSS aims to ensure water quality in the rehabilitated lakes is capable of re-establishing aquatic algae, invertebrate and vertebrate fauna populations.

Edith Cowan University has undertaken a baseline ecological assessment in the existing dredge pond and rehabilitation lakes for physical (water chemistry) and biological attributes. This work is part of an ongoing rehabilitation research program to re-establish ecological functions in wetlands and lakes of the post mining environment. Preliminary sample analysis show abundant aquatic macroinvertebrates, dominated by zooplankton crustacean including daphnid and other cladoceran families, calanoid copepods and ostracods. There appeared to be no difference between littoral and open water aquatic macroinvertebrate communities suggesting riparian vegetation is not significant for aquatic macroinvertebrate community structure of these wetlands (McCullough and Lund, 2008).

9.6.6 Specialised Habitat Expansion for Aquatic Fauna

The rehabilitation program includes establishing populations of the Black-striped Jollytail in lakes and ephemeral wetlands of the post mining landform and expanding their distribution on the KSS property. More detail is given in Section 4.11.5.

Monitoring of these rehabilitated wetlands will occur to ensure water quality and ecology functions are sufficiently established to enable survival of introduced fish.

9.7 REHABILITATION MONITORING

9.7.1 Site Specific Monitoring

Periodic assessment of rehabilitation undertaken in the existing mine area has occurred. The following 19 reports have been prepared:

1. Arbortech Pty Ltd, 1997. Kemerton Silica Sand Environmental Monitoring Report 1997. Annual report outlining quarterly flora monitoring conducted within the project area during 1997.

2. Ecos Consulting (Aust) Pty Ltd, 1998. Kemerton Silica Sand Environmental Monitoring Report 1998. Annual report outlining quarterly flora monitoring conducted within the project area during 1998.

3. Bamford, M.J. and Bamford, A.R. 1998. Kemerton Silica Sands Mine. Annual report on fauna monitoring program; 1997. Unpublished report by Bamford Consulting Ecologists for Arbotech, Perth.

4. Bamford, M.J. and Bamford, A.R., 1999. Kemerton Silica Sand Mine. Annual Report on Fauna Monitoring Program, 1998. Unpublished report by Bamford Consulting Ecologists for Ecos Consulting (Aust) Pty Ltd, Perth.

5. Ecos Consulting (Aust) Pty Ltd, 2000a. Rehabilitation Trials Final Assessment Report. May 2000. Kemerton Silica Sand Pty Ltd.

6. Ecos Consulting (Aust) Pty Ltd, 2000b. Assessment of Impacts on Sedimentation on Wetland Four. Unpublished report prepared for Sons of Gwalia, June 2000.

7. Ecos Consulting (Aust) Pty Ltd, 2000c. Establishing of Monitoring Quadrats at Kemerton Silica Sand. Unpublished report prepared for Sons of Gwalia, August 2000.

8. Mattiske Consulting Pty Ltd, 2001a. Vegetation Monitoring of Wetlands at Kemerton. April 2001. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

9. Mattiske Consulting Pty Ltd, 2001b. Vegetation Monitoring of Wetlands at Kemerton. July 2001. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

10. Mattiske Consulting Pty Ltd, 2002a. Vegetation Monitoring of Wetlands at Kemerton. February 2002. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

11. Mattiske Consulting Pty Ltd, 2002b. Vegetation Monitoring of Wetlands at Kemerton. March 2002. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

12. Mattiske Consulting Pty Ltd, 2003a. Vegetation Monitoring of Wetlands at Kemerton. March 2003. Unpublished report prepared for GHD and Kemerton Silica Sands.

13. Mattiske Consulting Pty Ltd, 2004a. Vegetation Monitoring of Wetlands at Kemerton. March 2004. Unpublished report prepared for Kemerton Silica Sands. March 2004 report on the vegetation monitoring finding of fieldwork undertaken in EPP wetlands 4, 8 and 9.

14. Mattiske Consulting Pty Ltd, 2004b. Assessment of Rehabilitated Wetland Areas – Kemerton Silica Sands Limited – Kemerton Operations. May 2004. Unpublished report prepared for Kemerton Silica Sands.

15. Mattiske Consulting Pty Ltd, 2005. Assessment of Rehabilitated Wetland Areas – Kemerton Silica Sands Limited – Kemerton Operations. September 2005. Unpublished report prepared for Kemerton Silica Sands.

16. McCullough, C., Lund, M. and van Etten, E., 2007. Synthesis of Existing Data and Knowledge Gaps for the Rehabilitation of Kemerton Silica Sand Mine Dredge Ponds. Unpublished report for Kemerton Silica Sand.

17. van Etten, E., McCullough, C.D. and Lund, M.A., 2008a. Synopsis of Wetland Characterisation Study: Potential Implications for P.E.R. Centre for Ecosystem

Management Report No. 2008-17a, Edith Cowan University, Perth, Australia. Unpublished report for Kemerton Silica Sand Pty Ltd.

18. van Etten, E., McCullough, C.D. and Lund, M.A., 2008b. Evaluation of Rehabilitation Efforts at the Kemerton Silica Sand Pty Ltd Project Area (June 2007). Centre for Ecosystem Management Report No. 2008-10, Edith Cowan University, Perth, Australia. Unpublished report for Kemerton Silica Sand Pty Ltd.

19. van Etten, E., McCullough, C.D. and Lund, M.A., 2009. Evaluation of Post-Mining Rehabilitation at the Kemerton Silica Sand Pty Ltd Project Area (October 2008). Centre for Ecosystem Management Report No. 2008-10, Edith Cowan University, Perth, Australia. Unpublished report for Kemerton Silica Sand Pty Ltd.

Mattiske (2005) reported that rehabilitation of the eastern margin of the current dredge pond commenced in early 2001 when topsoil was spread. Additional seedlings were planted in 2002. Transects were monitored in 2004 and 2005. Although 14 weed species were recorded, vegetation to the east and south-east of the pond were growing strongly (Mattiske, 2005), but vegetation to the north-east of the lake was not as vigorous. Mattiske (2005) believes that a combination of water logging, wind exposure and/or soil compaction may be impeding plant growth. In winter 2006, remedial actions were undertaken to address these issues.

KSS has engaged the Centre for Ecosystem Management at Edith Cowan University as rehabilitation consultants for the next three years, to conduct ongoing research and development of the rehabilitation program for completed mine areas. Ongoing research and monitoring will include such aspects as assessment of fringing terrestrial rehabilitation and wetlands, water quality and invertebrate populations.

Assessment of exiting rehabilitation was made through re-measurement of existing permanent monitoring transects established by Mattiske and Edith Cowan University in 2007 (van Etten *et al.* 2008b). van Etten *et al.* (2008b) identified six distinct rehabilitation areas (Sectors) around the northern dredge pond based on location and age of rehabilitation. These are presented in Table 63 and shown in Figure 27. One monitoring transect was measured in each of the six distinct rehabilitation sectors. Transects were also established across several natural wetlands over the same time period to characterise the biotic patterns of such wetlands, identify likely processes which drive or influence such patterns and to examine likely dynamics in vegetation (van Etten *et al*. 2008b). Each monitoring transect was positioned transverse to the slope and extended from the lake shoreline to the end of the rehabilitation at the top of the slope. Transects varied in length from 80 to 200 metres. At each five metre interval along transects a two by two metre sampling quadrat was established and the cover and abundance of each plant species was recorded.

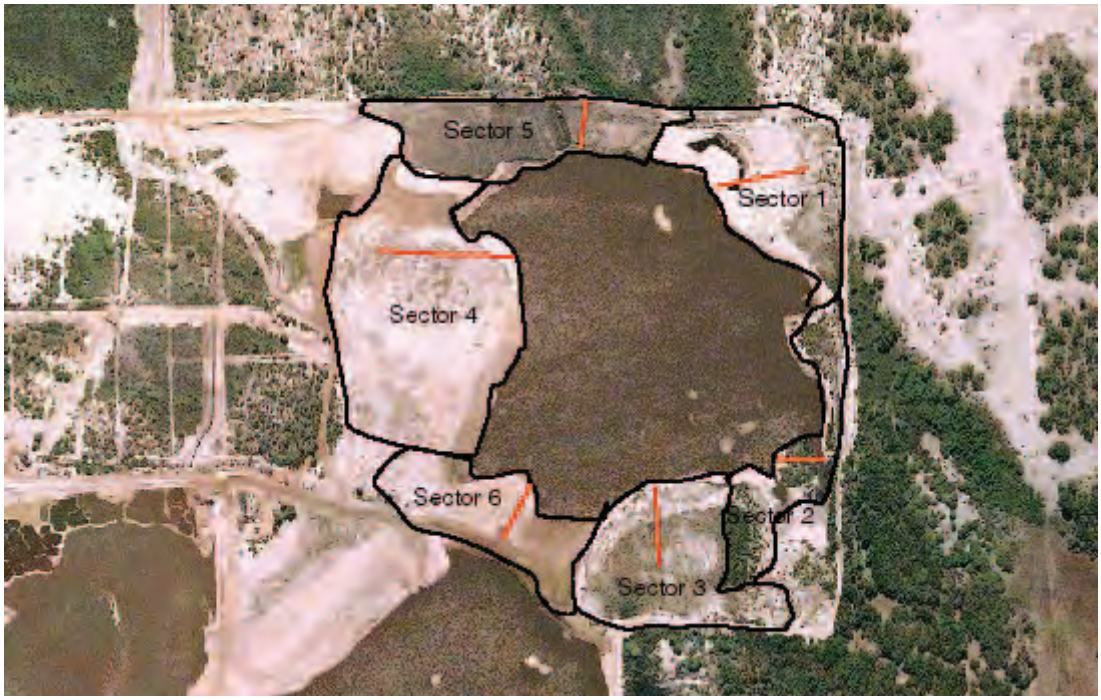
The measurements of natural wetlands also facilitated comparisons to rehabilitation. This was achieved through comparing:

- Structural attributes of the vegetation.
- Plant composition using the multivariate techniques of ordination.
- Comparing dominance and diversity patterns within plant communities.
- Soil and topographic features.

Table 63: Summary of Rehabilitation History and Monitoring around North Lake

Sector	Monitoring Transect	Area (ha)	Treatment(s)	Monitoring History
1 (north-east)	Mattiske #1	~2	**Feb 2001:** contoured and spread with topsoil (and understorey debris). **Autumn/winter 2002:** ripped on contour, herbicide treatment and planting of seedlings; fertilised and covered with tree bags. **Autumn 2006:** ripped, hand-seeded, brushed, herbicide and fertilised/limed.	March 2004: Mattiske August 2005: Mattiske June 2007: CEM October 2008: CEM
2 (east)	Mattiske #4	~2	**Feb 2001:** contoured and spread with topsoil (and understorey debris). **Autumn/winter 2002:** minor ripping on contour, herbicide treatment and planting of seedlings (in gaps only); fertilised and covered with tree bags.	March 2004: Mattiske August 2005: Mattiske June 2007: CEM October 2008: CEM
3 (south-east)	Mattiske #5	~1	**Feb 2001:** contoured and spread with topsoil (and understorey debris). **Autumn/winter 2002:** major ripping on contour, herbicide treatment, planting of seedlings' fertilised and covered with tree bags. **Autumn 2006:** hand-seeded and fertilised/limed.	March 2004: Mattiske August 2005: Mattiske June 2007: CEM October 2008: CEM
4 (west)	Mattiske #7	~4	**April 2003:** contoured and spread with 20 cm topsoil (and understorey debris).	March 2004: Mattiske August 2005: Mattiske June 2007: CEM October 2008: CEM
5 (north)	New Transect (#10)	~2	**Autumn 2006:** contoured and spread with 10 year old, stored topsoil (with some understorey debris).	June 2007: CEM October 2008: CEM
6 (south)	New Transect (#9)	~2	**Autumn 2006:** contoured and spread with direct fresh topsoil return (understorey debris). Most topsoil from dampland Area. Upland soil placed on higher ground.	June 2007: CEM October 2008: CEM

Figure 27: Aerial Photograph from 2006 Showing Rehabilitation Sectors Around North Lake



Source: van Etten *et al*. (2009).
Note: Position of monitoring transects are shown by red lines.

In November 2008, Edith Cowan University reported changes to rehabilitation in the existing mine areas since 2007. Monitoring has shown a slight to modest improvement in rehabilitation since monitoring in mid 2007 (van Etten *et al*. 2009) (Appendix 8). This improvement can be attributed to moist conditions provided by above average late autumn and early winter rains. This improvement was despite observations of drought death over a particularly dry summer and previous year (2007 was close to the driest year on record). Plant cover showed the most marked increase from the previous year, with plant abundance and species richness generally stable overall (van Etten *et al*. 2009).

Generally plant cover increased more substantially in low-lying areas closer to North Lake, with new species appearing more readily in such areas (van Etten *et al*. 2009). Areas higher in topographic profile have seen the loss of typically fringing/flooded zone species. Therefore it is apparent that some degree of species sorting according to moisture and flooding preferences is occurring. Natural recolonisation in lower areas by sedges, Melaleucas and other wetland species is seemingly also occurring (van Etten *et al*. 2009).

Site differences revealed in previous monitoring were mostly maintained and can be clearly related to differences in rehabilitation technique (van Etten *et al*. 2009). This and previous monitoring confirm that good to excellent ecological restoration can be achieved at KSS through the use of fresh topsoil. Matching of topsoil to topographic position is demonstrating improved overall rehabilitation success. Recent rehabilitation of low-lying areas using topsoil has achieved excellent results at KSS (van Etten *et al*. 2009).

Rehabilitation monitoring results indicate that some areas of the existing operation are rehabilitating well and others require fine-tuning. By combining this information with that gleaned from the literature on mine-site rehabilitation/restoration, as well as from expert

opinion and current accepted practice at other mine sites of south-west Western Australia, a general set of recommended rehabilitation principles and strategies have been derived for future practice at KSS. The RMP for KSS addresses these issues and Edith Cowan University will continue to provide expert advice on improving rehabilitation success at KSS. The RMP will be updated regularly as knowledge increases.

9.7.1.1 Recent Rehabilitation of Wetland Area

In mid 2007, a new area south of North Lake was rehabilitated using topsoil and spreading of brush and logs. A monitoring transect was established in this area (Transect 11) and monitored for the first time in November 2008 (van Etten *et al*. 2009).

This area is low lying, and at November 2008, contained large areas submerged by water. Areas under shallow water or waterlogged had very high plant cover in the order of 60 - 100% (van Etten *et al*. 2009). This represents prolific growth over one year post rehabilitation and confirms the readiness for plant establishment in low lying areas which are flooded or waterlogged for most of the year as long as appropriate (i.e. wetland or fringing wetland) topsoil is used (van Etten *et al*. 2009).

Although visually the area appeared dominated by a single species (*Juncus pallidus*), the species richness was relatively high with an average of eight species per four metre squared quadrat (highest of 10 per quadrat). Most of the species were rushes, sedges and related species. Encouragingly many seedlings of Melaleuca and other Myrtaceous shrubs typical of fringing wetlands were found, particularly in quadrats close to the deep water edge. This suggests that more diverse structure and typical fringing wetland structure of paperbarks and other shrubs may develop over time (van Etten *et al*. 2009).

The RMP will be updated regularly as knowledge increases.

9.7.2 Kemerton Area Monitoring

Success of rehabilitation from historical disturbance associated with installation of the Dampier to Bunbury gas pipeline approximately 25 years ago provides a local benchmark and precedent demonstrating that high standards of rehabilitation are achievable in the Kemerton area. Woodman (2005b) undertook comparative surveys of regenerated vegetation in the gas easement with adjacent undisturbed areas. Results indicated that wetland communities along the easement have recovered to a level where regenerating communities closely resemble adjacent undisturbed vegetation. Upland woodland communities have not regenerated to the same extent as wetland communities, though the requirement to remove trees from the easement to protect the integrity of the pipe has significantly contributed to this. This information was noted by the EPA in Bulletin 1204.

Current best practice techniques for rehabilitation have improved since the 1980s. With the proposed 50 year mine life and results from the 25 year old rehabilitation, KSS considers achievable completion criteria can be set for rehabilitation areas to closely resemble similar undisturbed vegetation communities within the life of mine.

9.8 COMPLETION CRITERIA

The EPA (2006a) requires completion criteria to be sufficiently stringent to ensure overall rehabilitation objectives are met. The criteria must also be designed to allow effective reporting and auditing to define an endpoint for rehabilitation activities. Guidelines published by the Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia (2000) for completion criteria state they should:

1. Be specific enough to reflect a unique set of environmental, social and economic circumstances.
2. Be flexible enough to adapt to changing circumstances without compromising objectives.
3. Include environmental indicators suitable for demonstrating that rehabilitation trends are heading in the right direction.
4. Undergo periodic review resulting in modification if required due to changed circumstances or improved knowledge.
5. Be based on targeted research resulting in more informed decisions.

Completion criteria, objectives and interim targets specific to the project including consideration of soil stability, vegetation cover, diversity, species richness and abundance, fauna and hydrology criteria are presented in Table 64. Rehabilitation completion criteria will be assessed by periodic monitoring of rehabilitation areas against similar undisturbed locations (analogue sites), with similar landform and vegetation characteristics. Interim targets will be reviewed against ongoing rehabilitation monitoring results during the life of mine, with progression towards defined scores set as staged completion targets **(Commitment 9.8a)**.

Rehabilitation, closure planning and completion criteria are adaptive processes that change during the project life, as a result of rehabilitation monitoring, research and evolving industry best practice. KSS will continue to update these aspects in operational documents, such as the RMP, during the life of mine.

9.9 PREDICTED RESIDUAL ENVIRONMENTAL RISK

KSS considers that implementation of rehabilitation management measures as presented in Table 64 will serve to mitigate potentially negative impacts associated with implementing the proposal. It is acknowledged that the post mining landscape will be different to the existing landscape. KSS has consulted numerous experts and determined a scenario which enables responsible resource extraction resulting in an altered environmental setting. The post mining environment has been designed to re-establish the variability in habitats in addition to enhancing migratory waterbird use of the area due to establishment of permanent water bodies. These permanent water bodies may be important for migratory waterbirds in the future in a drying climate scenario.

Table 64: Rehabilitation Closure Criteria, Objectives and Interim Targets

Criteria	Objective	Interim Targets
Hydrology		
Water quality and quantity	Quality and flows of surface and groundwater are to be consistent with pre-mining values. Hydrological management is required for effective establishment of vegetation and to ensure site stability.	Monitoring showing surface water quality consistent with pre-mining levels or licenced values. Monitoring showing groundwater levels consistent with modelled forecast or licenced levels.
Landform		
Soil stability	Soil profiles reconstructed to ensure vegetation establishment and landform stability.	Rehabilitated areas should have no active erosion rills greater than 10 metres long by 0.1 metres deep. Finished slopes will include a zone of shallow beach of approximately 30 to 40 metres wide before sloping at a stable angle of repose (approximately one in four) to the base of the rehabilitated lake.
Vegetation		
Richness (diversity)	Total number of plant species found in monitoring quadrats. Specified targets are based on site survey data. Setting appropriate targets requires knowledge of similar habitats and proportion of plant species unlikely to recruit or propagate from seed in the short term. On-going monitoring of control sites is essential to track changes due to lowering rainfall and other adverse impacts regionally separate to mining operations.	Rehabilitated areas achieving progressive targets. Targets to be reviewed based on ongoing monitoring results.
Density	The number of native plants, weeds and bare ground measured in quadrats.	Rehabilitated areas achieving an interim target of 50% density to analogue sites after five years. Interim targets to be reviewed based on on-going monitoring results.
Cover	Sustainable rehabilitation requires vegetation cover to be sufficient to stabilise landforms and soils and exclude weeds. In most cases, completion criteria based on relative cover (percentage of area) is used.	Rehabilitated areas achieving an interim target of 50% cover to analogue sites after five years. Interim targets to be reviewed based on ongoing monitoring results.

Criteria	Objective	Interim Targets
Weed management	Effective weed management requires: (a) Low relative cover of minor weeds. (b) Absence or isolation of major environmental weeds capable of becoming dominant at the expense of native plants.	Monitoring and photographic records showing weed species in native vegetation rehabilitation areas limited to levels that do not affect plant growth and survival. Declared weed species controlled over rehabilitated areas and the KSS site.
Pests and diseases	Effective management of alien or native species of animals, fungi or microbes that can have major impact on plant survival and productivity.	All vehicles moving through dieback infested areas are subject to standard hygiene control measures. Soil and vegetation disturbance limited to dry conditions.
Fauna		
Tree hollow relocation	Relocation of small nest hollows suitable for vertebrates in undisturbed areas and placement of habitat logs in areas undergoing rehabilitation.	Complete relocation/replacement of hollows as soon as practicable.
Iconic species	Re-establish preferred habitat for the Honey and Western Pygmy Possums in the KSS property.	Target restoration of habitat characteristics such as shrubby revegetation with abundant nectar and tree/log hollow rather than number of animals, as they may be quite rare in the first place.
Feral animal control	1080 baiting using meat, eggs and oats will be carried out on the KSS property. If 1080 baiting is not acceptable due to close proximity to neighbours (<2 kilometre radius), trapping programs for foxes and feral cats, pigs and Pindone baiting for rabbits will be used.	Complete 200 hectares of trapping per annum. Feral animal densities are particularly dense in Kemerton Nature Reserve and efforts will be concentrated in this and other parts of the KSS property.
Lakes		
Cover	Sustainable rehabilitation requires the cover of emergent (beach) vegetation to be sufficient to stabilise landforms and soils and exclude weeds.	Rehabilitated areas achieving an interim target of 50% cover to analogue sites after five years. Interim targets to be reviewed based on ongoing monitoring results.
Iconic Species	Criteria for aquatic iconic species (Water Rat, Jollytail) as well as waterbird utilisation.	Introduction of Jollytail to rehabilitated lakes upon completion of mining.

Source: EPA (2006a).

10. ENVIRONMENTAL OFFSETS

10.1 RELEVANT STANDARDS AND LEGISLATION

Standards

- Environment Protection Authority, 2006c. *Environmental Offsets Position Statement No. 9.*
- Environment Protection Authority, 2008a. *Environmental Protection Bulletin No. 1 Environmental Offsets – Biodiversity.*
- Environment Protection Authority, 2008b. *Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986). Environmental Offsets – Biodiversity. No. 19.*
- Department of Environment, Water, Heritage and the Arts, 2007a. *Draft Policy Statement 4.1: Use of Environmental Offsets Under the Environmental Protection and Biodiversity Conservation Act 1999 (Cth).*
- Department of Environment, Water, Heritage and the Arts, 2007b. *Use of Environmental Offsets Under the Environmental Protection and Biodiversity Conservation Act 1999 (Cth) – Discussion Paper.*

The EPA (2008a) defines environmental offsets as environmentally beneficial activities undertaken to counterbalance an adverse environmental impact and achieve a net environmental benefit outcome.

10.2 REQUIREMENT FOR ENVIRONMENTAL OFFSETS

EPA Guidance Statement No 19 requires several criteria to be assessed to determine whether projects have residual environmental impacts and as such whether it is appropriate to consider environmental offsets. The EPA lists these criteria as:

- Significant adverse impacts to assets.
- Exhaustion of mitigation options.
- Significance of environmental impacts.

These criteria are discussed in more detail in the following subsections.

10.2.1 Critical Assets

The proposed mine extension is considered to have significant impacts on critical and high value assets as defined by the EPA in Position Statement No. 9. Potential impacts on Critical Assets within the proposed mine extension area are described in Table 65.

Table 65: Potential Impacts on Critical Assets

Critical Asset Type	Amount
Remnant native vegetation (Bassendean – Central and South vegetation complex)*	122.1 ha
Remnant native vegetation (Spearwood vegetation complex)*	31.9 ha
Conservation Category Wetlands	110.7 ha
Acacia semitrullata (P3)	55
Boronia juncea subsp. *juncea* (P1)	100
Caladenia speciosa (P4)	1
Dillwynia dillwynioides (P3)	10
Eucalyptus rudis subsp. *cratyantha* (P4)	17

Note: * Assumes wetland UFI 1907 is reclassified to elevated land containing Bassendean – Central and South vegetation complex.

10.2.2 Mitigation Sequence

In preparing this proposal, KSS has developed management and mitigation measures to minimise adverse residual impacts over time. Design of the project described within this proposal has taken into account the EPA's preferred mitigation sequence of:

- Avoid.
- Minimise.
- Rectification.
- Reduction.

Table 66 details how KSS has addressed the EPA preferred mitigation sequence. Following implementation of this sequence, KSS consider that an offsets package is likely to be required by the EPA.

Table 66: Implementation of EPA Mitigation Sequence in Project Design

Mitigation Sequence Item	How Addressed by KSS
Avoid	Proposed mine extension area avoids impacts on 882.7 hectares of Critical Assets located above silica sand resources. Critical assets avoided include: • Critically Endangered, DRF (*Caladenia procera* species from one known location). • Priority flora species (populations of *Boronia capitata* subsp. *gracilis* (P2) and *Acacia flagelliformi*s (P4)). • EPP wetlands and associated catchments (EPP4, EPP8). • Conservation Category wetlands in good condition (428.5 hectares) including recently avoided sump in UFI 1906 to the north of the mine extension area. • Multiple Use wetlands in good condition (6.5 hectares). • Resource Enhancement wetlands in good condition (18.9 hectares). • Remnant vegetation (428.8 hectares of Bassendean – Central and South vegetation complex).

Mitigation Sequence Item	How Addressed by KSS
	Proposed land swap avoids impacts on 75.3 hectares of disturbance of Critical Assets previously approved for dry mining. This includes avoidance of disturbance of: • 0.31 hectares of EPP5. • 11.1 hectares of Conservation Category wetlands (1.2 hectares of which is in the Kemerton Nature Reserve). Of which: – 0.62 hectares of the catchment of EPP3. – 2.65 hectares of the catchment of EPP4. – 0.06 hectares of the catchment of EPP5. – 0.05 hectares of the catchment of EPP8. – 0.56 hectares of the catchment of EPP9. • 63.9 hectares of remnant native vegetation (Bassendean – Central and South vegetation complex (11.4 hectares of which is in the Kemerton Nature Reserve)).
Minimise	• Impacts on Critical and High Value Assets has been minimised by proposing a proposed mine extension area which proposes mining of about 24.2 % of the known silica sand resource in order to protect environmental values. • Clearing is to be staged. • Rehabilitation methodology will minimise long-term impacts on groundwater resources (quality). • Comprehensive commitments made within PER to prevent or minimise adverse environmental impacts on a range of environmental aspects.
Rectification	• Progressive rehabilitation over a 50 year life of mine planned. • Comprehensive RMP developed and research is well advanced to ensure continuous improvement process in place for rehabilitation. The RMP will be updated regularly as knowledge increases. • Disturbed areas from previous activity on the KSS property will be more effectively rehabilitated as part of the proposal. Material obtained from the mine extension will allow improved rehabilitation of existing dredged areas. • Re-establishment of Priority flora species addressed within rehabilitation plans. • Re-establishment of habitat for conservation significant fauna species addressed within Rehabilitation Management Plan.
Reduction	• Progressive rehabilitation over mine life to reduce impact of disturbance. • Reduced annual water consumption via improved efficiency. • Significant funds committed to research to allow continuous improvement in rehabilitation of dredge ponds and re-establishment of conservation significant fauna within rehabilitated dredge ponds. Formal agreements entered into for such research programs.

10.2.3 Significance of Impact

When assessing the referral for the proposed mine extension, the EPA considered the potential impacts were significant enough to warrant undertaking formal assessment at the level of PER and set an eight week public consultation period.

KSS considered the type and amount of Critical Assets likely to be impacted and the mitigation options able to be proposed and practically implemented in the long-term. Using Figure 1 of EPA Guidance Statement 1 as a reference, KSS considers that significant residual environmental impacts are likely to result from this proposal. As such an offsets package has been developed and is proposed within this document.

10.3 PREVIOUS OFFSETS

Three separate events contributed to the overall conservation area offset for the existing KSS project. The total offset area is shown in Figure 28.

1. Nine wetlands on the KSS property have been gazetted as EPP wetlands under the *EPP 1992*. Following formal assessment of the initial project through a PER, five of these lakes were vested with the State on 24 November 1998 as part of the Ministerial Conditions of approval granted in October 1994 (Ministerial Statement 366). This area of 191.4 hectares is now known as Kemerton Nature Reserve. Freehold land rights for the Kemerton Nature Reserve were transferred to the State in August 1999. KSS retains mineral rights to this area. KSS maintains the rights to dry mine approximately 12.8 hectares of land within the Kemerton Nature Reserve as per Ministerial Statement 366.

2. In 2003, botanical surveys identified the listed TEC known as Muchea Limestone in the south-east corner of the approved mining envelope (see Section 4.6.4). In November 2005, Ministerial Statement 703 authorised a land swap transferring 13.2 hectares of KSS freehold land into the approved mining envelope in exchange for transfer of 15.6 hectares from the approved mining boundary containing the TEC and EPP1 into Kemerton Nature Reserve.

3. The current mine area, approved in 1994, is also to be vested with the State within six months of the completion of mining. This area is 109.3 hectares.

At the completion of mining in the existing approved area, the above mentioned areas totalling 316.3 hectares will be vested with the State for conservation purposes. This area contains six EPP wetlands, half of EPP8 and a known TEC. Critical Assets within the current Kemerton Nature Reserve are presented in Table 67.

Table 67: Current Kemerton Nature Reserve Critical Assets

Critical Asset Type	Amount
Remnant native vegetation (Bassendean – Central and South vegetation complex)	72.7 ha
EPP Wetlands	18.2 ha
Conservation Category wetland	51.8 ha
Multiple Use wetland	62.6 ha

Critical Asset Type	Amount
Resource Enhancement wetland	1.6 ha
Muchea Limestone TEC	15.6 ha
Dillwynia dillwynioides (P3)	20
Boronia juncea subsp. *juncea* (P1)	20

10.4 PROPOSED OFFSET PACKAGE

Position Statement No. 9 and Guidance Statement No. 19 provide information regarding development of offset packages. Principles applied by the EPA to environmental offsets are:

A. Environmental offsets should only be considered after all other reasonable attempts to mitigate adverse impacts have been comprehensively examined and exhausted.

B. An environmental offsets package should address both direct offsets and contributing offsets.

C. Environmental offsets should ideally be 'like for like or better'.

D. Positive environmental offset ratios should apply where risk of failure of the offset project in the long-term is apparent.

E. Environmental offsets must entail a robust and consistent assessment process.

F. Environmental offsets must meet all statutory requirements.

G. Environmental offsets must be clearly defined, publicly registered, transparent, auditable and enforceable.

H. Environmental offsets must ensure a long lasting benefit.

Details of the proposed environmental offset package are contained in Appendix 20. This format is consistent with that presented in Figure 3 and Appendix 2 of EPA Guidance Statement No.19. The offset package proposed includes both Direct and Contributing offsets as defined by EPA Position Statement No. 9.

10.4.1 Direct Offsets

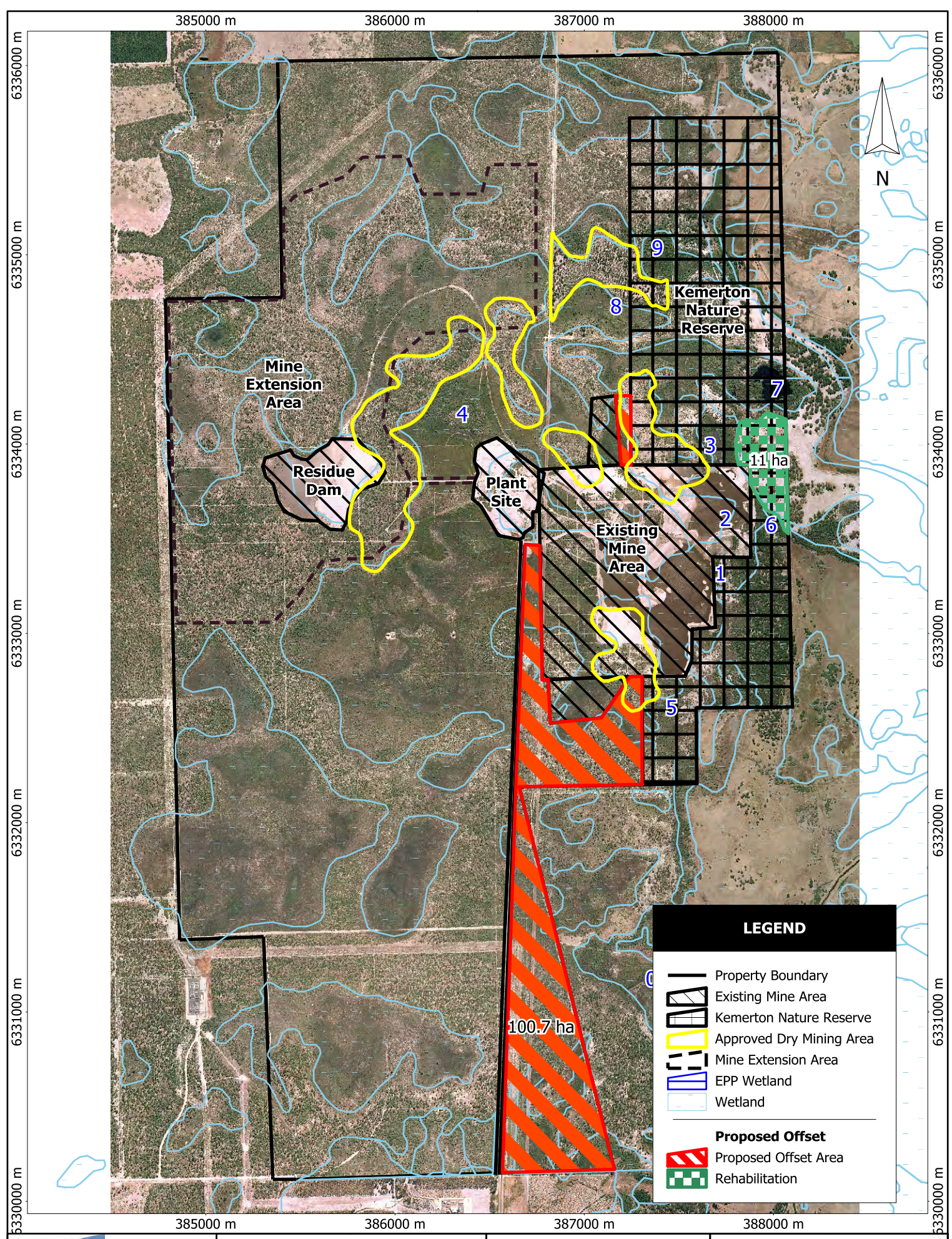
Direct offsets are ameliorative actions that will occur away from the impact site and will counterbalance the adverse environmental impact with the aim of achieving no environmental difference (i.e. no net loss). Direct offsets in terms of the sub types presented in EPA Position Statement No. 9 are presented in Table 68 and shown in Figure 28.

Table 68: Proposed Direct Offsets

Offset Sub Type	Offset Details	Area (ha)
Restoration	Not applicable.	
Rehabilitation	Improving vegetation condition and habitat value of an area of degraded Bassendean woodland in Kemerton Nature Reserve between EPP6 and EPP7. This area was historically grazed and	11

Offset Sub Type	Offset Details	Area (ha)
	logged. Rehabilitation will involve: • Control of weeds. • Control of feral animals. • Application of local native seed. This will be undertaken in consultation with the land owners (DEC) and Western Power.	
Acquiring Land for Conservation	Transferring land containing critical and high value environmental assets to the State. Critical value assets include: • 0.01 hectares of EPP5 wetland. • 24.1 hectares of Conservation Category wetland. • 2.6 hectares of Multiple Use wetland. • 4.0 hectares of Resource Enhancement wetland. • 70.0 hectares of Bassendean - Central and South vegetation complex. • Population of the Critically Endangered, DRF species *Caladenia procera.* • Populations of Priority flora; *Acacia semitrullata* (P3) and *Acacia flagelliformis* (P4), *Boronia juncea* subsp. *juncea* (P1), *Caladenia speciosa* (P4). • Most southern extent of *Verticordia nitens*. This would increase the total size of Kemerton Nature Reserve to 417.0 hectares. The location of the proposed area of transfer is shown in Figure 28.	100.7
Forgoing Right to Disturb	Forgoing the existing right to mine Bassendean - Central and South vegetation complex via dry mining methods in areas outside of the current dredge pond (Ministerial Statement 366 approval). Approximately 20.3 hectares of this 75.3 hectares is located within the proposed mine extension area. Forgoing this right to mine would prevent disturbance within Kemerton Nature Reserve and protect Conservation Category wetland catchment areas for EPP wetlands. Specifically, forgoing the right to dry mine in the approved areas would protect: • 11.4 hectares of Bassendean - Central and South vegetation complex, within the Kemerton Nature Reserve. • 35.3 hectares of Bassendean - Central and South vegetation complex outside of the Kemerton Nature Reserve and not included in the proposed mine extension area. • 0.3 hectares of EPP5. • 6.8 hectares of Conservation Category Wetland outside of the Kemerton Nature Reserve and 1.2 hectares of surrounding Conservation Category Wetland within the Kemerton Nature Reserve. Of which: – 0.62 hectares of the catchment of EPP3. – 2.65 hectares of the catchment of EPP4. – 0.06 hectares of the catchment of EPP5. – 0.05 hectares of the catchment of EPP8. – 0.56 hectares of the catchment of EPP9.	75.3

Offset Sub Type	Offset Details	Area (ha)
	KSS would forgo this right if the mine extension is approved as it recognises that since original approval was granted in 1994, additional baseline studies undertaken by KSS have shown that these areas have environmental values that make mining less desirable.	
Re-establishment	Transfer of land as described above would provide an ecological linkage from north to south of the KSS property. Establishment of the North-South Ecological Linkage - McLarty/Kemerton/Twin Rivers/Preston River/Gwindinnup (Kemerton Buffer Link; Wellesley River, part Brunswick and Collie Rivers; part Dalyellup/Gelorup/Preston River/Plateau Link) was stated as desirable by the EPA in Bulletin 1108 and is included in the Greater Bunbury Regional Scheme. The land area included in Kemerton Nature Reserve would include critical assets as six EPP wetlands, 51.8 hectares of Conservation Category wetlands, 62.6 hectares of Multiple Use wetlands, 1.6 hectares of Resource Enhancement wetlands and 72.7 hectares of Bassendean - Central and South vegetation complex. It would also include 15.6 hectares of the Muchea Limestone TEC on the interface between the Pinjarra Plain and the Bassendean Dune System.	



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Scale: 1:25000
Original Size: A4
Air Photo 2006
Grid: Australia GDA94 (50)
0 500 m

Kemerton
Silica Sand Pty Ltd

Proposed Offset Area

Figure 28

W:\Kemerton Silica Sand\Drawings\Maps 2009\Offsets.map 15/10/2009 Offset Layout

10.4.2 Contributing Offsets

Contributing offsets are defined (EPA, 2006) as environmentally beneficial activities undertaken to complement and enhance direct offset activities. They may not immediately assist in achieving a net environmental benefit outcome, but materially add to environmental knowledge, research, management and protection and ultimately lead to improved environmental outcomes. Contributing offsets in terms of the sub types presented in EPA Position Statement No 9 are summarised in Table 69.

Table 69: Proposed Contributing Offsets

Offset Sub Type	Offset Details	Approximate $ Value
Protection	KSS maintains fencing around its freehold property boundaries to minimise threats from external sources. This has assisted in significantly protecting critical and high value assets since KSS assumed land ownership. KSS provides a buffer to the Kemerton Nature Reserve from threats such as pastoral activities (specifically grazing), fire, weeds, feral animals and unauthorised access.	
Removal of Threats	KSS will conduct regular weed, feral animal and fire control on all areas of land transferred from KSS freehold ownership to the State and KSS land for the duration of mining activities (50^+ years). KSS currently provides information regarding weed outbreaks, use by feral animals, and harmful unauthorised access and land degradation to assist DEC in management of the Reserve. KSS has removed livestock from all areas of KSS freehold land. Livestock will not be introduced to any KSS freehold land during the duration of mining activities (50^+ years).	
Management	KSS has assisted with development of the Kemerton Nature Reserve Interim Management Plan. It will assist with review of the management plan and finalisation of the Kemerton Nature Reserve Management Plan.	
Banking, Credit Trading or Trust Fund	Not applicable.	
Research	KSS has an agreement with Edith Cowan University to fund a Masters project looking at the ecological requirements and population genetics of remnant Black-striped Jollytail populations in seasonal wetlands of south-western Australia. KSS will contribute about $52,000 for this project and provide assistance for field based work. KSS has committed to funding further macroinvertebrate and wetland research at Edith Cowan University to establish baseline conditions as analogues for future rehabilitation.	52,000 20,000

10.4.3 Land Swap

As discussed in Section 3.6, initial project approval in 1994 included dry mining of 75.3 hectares of nominated Bassendean upland areas on the KSS property outside the dredge mining boundary. These sand resources have not been accessed by the company to date.

In the context of the current proposal, 55.0 of the 75.3 hectares approved for dry mining remains outside the mine extension boundary. These areas are located on dunes surrounding EPP4, dunes adjacent to EPP3, EPP5, EPP8 and EPP9 and within Kemerton Nature Reserve. Dry mining other areas, with lesser environmental attributes, is considered a more appropriate option than implementing the approval given in 1994.

In a process similar to the land swap for the Muchea Limestone TEC (Ministerial Statement 703, November 2005), KSS proposes to exchange 55.0 hectares of the approved dry mining areas, shown in Figure 28, that are either outside the existing mine area or mine extension area, with upland Bassendean areas located inside the mine extension area. This proposal has been included in Table 68 as a direct offset under the heading "Forgoing the Right to Disturb". EPA Position Statement No 9 and Guidance Statement No 19 do not specifically address this type of offset, however it is considered by KSS to be an important component of the proposed offset package for the mine extension.

Transferring 55.0 hectares from the current dry mining approval to the proposed mine extension area will:

- Prevent the need to disturb Bassendean upland areas outside of the proposed mine extension area.
- Reduce the need for additional clearing of Bassendean - Central and South vegetation complex within the mine extension area to 46.7 hectares.
- Consolidate all mine activities into two discrete areas of the KSS property.
- Make maximum use of sand resources in designated mine areas.
- Prevent disturbance of catchments of five EPP wetlands (EPP3, 4, 5, 8 and 9). Mining of the approved areas, whilst not directly disturbing the EPP wetlands, would detrimentally impact their environmental values.
- Prevent future mining of 12.6 hectares within the existing Kemerton Nature Reserve.

10.5 ASSESSMENT OF POTENTIAL RISKS AND IMPACTS

10.5.1 Impacts on Critical Assets

KSS considers the residual impact from implementing the proposal will not result in a significant adverse impact on Critical Assets. The land area of Critical Assets contained within the existing Kemerton Nature Reserve, proposed mine extension area, proposed additional offset areas and the residual KSS property are presented in Table 70. From this it can be seen that impacts on Critical Assets have been minimised and significant areas of these have either been formally protected in perpetuity by transfer of ownership to the State or given long-term protection through contributory offset commitments made by KSS i.e. protection from grazing.

Table 70: Critical Asset Summary for KSS

Critical Asset Type	Kemerton Nature Reserve	Mine Extension Area #	Proposed Offset	Dry Mining Area ^	Remaining KSS Property
Remnant Native Vegetation (ha)					
Bassendean – Central and South vegetation complex	72.7	104.9	70.0+	46.7	428.1
Spearwood vegetation complex	-	31.9	-	-	-
Wetlands (ha)					
EPP Wetlands	18.2	-	0.01	0.31	5.6
Conservation Category wetland	51.8	107.6	24.1	8.0	422.85
Multiple Use wetland	62.6	-	2.6	-	6.5
Resource Enhancement wetland	1.3	-	4.0	-	18.9
Not Assessed	0.3	-	-	-	-
Threatened Ecological Communities (ha)					
Muchea Limestone TEC	15.6	-	-	-	-
DRF Species (number of plants)					
Caladenia procera (Critically Endangered, DRF)	-	-	1	-	-
Priority Flora Species (number of plants) *					
Acacia flagelliformis (P4)	-	-	9	-	99
Acacia semitrullata (P3)	-	55	29	-	192
Boronia capitata subsp. *gracilis* (P2)	-	-	-	-	11
Boronia juncea subsp. *juncea* (P1)	20	100	1	-	1,423
Caladenia speciosa (P4)	-	1	2	-	-
Dillwynia dillwynioides (P3)	20	10	-	-	540
Eucalyptus rudis subsp. *cratyantha* (P4)	-	17	-	-	108
Verticordia aurea (P4)	1	-	-	-	-

Note: # Includes existing approved dry mining area.

\+ Does not include restoration of 11 hectares of degraded woodland within Kemerton Nature Reserve.

^ Does not include proposed mine extension area.

* Some records contain no population numbers; therefore it is assumed that at least one plant was recorded.

When considering the Critical Assets potentially affected by the mine extension proposal, three critical elements can be identified:

1. Where adverse impacts to a native terrestrial vegetation complex would result in a 30% or less representation of the pre-clearing extent of that vegetation complex in a bioregion (noting however that this threshold has been exceeded in some areas).
2. Having regard for DRF and the Priority Species List prepared by DEC.
3. Conservation Category Wetlands not included in an Environmental Protection Policy may be viewed in the context of whether they have medium to long-term survival of their environmental values. The underlying presumption is that they would normally be considered a Critical Asset.

The following explanation is provided for each of these Critical Asset elements.

10.5.1.1 Representation

The EPA (2007) acknowledges that most vegetation complexes on the Swan Coastal Plain are already below the recommended threshold level for biological diversity. Targets of retaining greater than 30% natural vegetation in each complex can not be uniformly met. This is the case for the Bassendean - Central and South vegetation complex, which is the main vegetation complex within the KSS property. Implementing the project will not create the condition where these vegetation units fall below the 30% threshold. The lowest recommended level for conservation has been recommended to be 'at least 10%' although it is believed that at least 20% should be retained under natural vegetation to ensure biodiversity and soil conservation (EPA, 2007).

The extent of the 'area' is also extremely important in placing this threshold for biological diversity in context. The bioregion referenced against the current proposal is the entire Swan Coastal Plain, a large and diverse area encompassing the Perth Metropolitan Region. KSS submits that reference of the project against the entire Swan Coastal Plain is inappropriate, given extensive clearing has occurred in the Perth Metropolitan Region. Only 27% of the Bassendean – Central and South vegetation complex remains on the whole of the Swan Coastal Plain (EPA, 2004a). This area is below 30%, stated in the *National Objectives and Targets for Biodiversity Conservation 2001-2005* (Commonwealth of Australia, 2001) and the Offsets Guidance Statement. The 'average' for the entire Swan Coastal Plain is made up of 39.3% remaining in the Greater Bunbury Region and only 24% remaining in the Perth Metropolitan Region (EPA, 2003b). By using an average of the entire Swan Coastal Plain, development in the Greater Bunbury Region is potentially penalised and constrained due to significant historical clearing that has occurred in the Perth Metropolitan Region.

The proponent requests that this project is assessed against criteria within its local geographical region; that is the Greater Bunbury Region.

It is further acknowledged the EPA has approved other public and private proposals on the Swan Coastal Plain within and surrounding the KSS property, indicating that this factor is not an 'absolute' determinant of a project's acceptance or rejection by the EPA (and a degree of judgement is applied).

The finalisation of the Greater Bunbury Regional Scheme by the Western Australian Government is addressed in Section 4.15. The southern portion of the KSS property lies within the Kemerton Industrial Zone Buffer Area – Special Control Area (SCA No. 2). The primary purpose of SCA No. 2 is to provide a buffer for industry at Kemerton, not conservation or recreation. State Forest No. 16 lies 0.5 kilometres north of the KSS boundary and a large area of native forest which predominately occurs within the Bassendean – Central and South vegetation complex. Two reserves that lie to the south of the KSS property in the Kemerton Industrial Zone buffer also occur within the Bassendean – Central and South vegetation complex. Section 4.10 details the number of regional reserves within close proximity to the KSS property.

The inclusion of the KSS property as a designated mineral resource area in the final Greater Bunbury Regional Scheme Strategic Minerals and Basic Raw Materials Resource Policy (WAPC, 2005a) confirms the Western Australian Government position that at a regional level,

this property has been identified for ongoing extraction of minerals. While the boundaries of the policy area are not exactly consistent with the proposed mine extension area (they conform to earlier proposals that were current at the time of the submission on the Greater Bunbury Regional Scheme), they do show an area significantly larger than the current approved mine area. The boundaries were changed in this proposal to have less of an environmental impact. Inclusion of the KSS property in this planning policy and showing an area greater than the existing approved mine limit reinforces the presumption of expansion of extraction of mineral resource beyond the current approved area.

Over the 50 year mine life, 122 hectares of Bassendean Dune System within the Bassendean - Central and South vegetation complex will be disturbed, representing 19% of this category in the entire property. Sixty five hectares will be rehabilitated over the life of mine, implementing the "Rectify" component of on-site mitigation presented in Table 66.

KSS proposes to assist with a contributory offset package to rehabilitate 11 hectares of degraded Bassendean upland areas in Kemerton Nature Reserve.

10.5.1.2 DRF and Priority Species

Vegetation and flora surveys show the proposed mine extension area contains no DRF and few Priority species relative to other locations on the property (Section 7.5). KSS has used the principle of avoidance as much as possible to limit impact on Priority species. These species are also represented in other locations on the property which will not be disturbed, so the biodiversity 'risk' to any Priority species on the total property is considered low. Rehabilitation can include seed/tissue collection from these species to replace individuals lost due to mining. KSS considers implementing avoid and rectify components of on-site mitigation to totally replace any loss of Priority species associated with the project. There is no residual impact on this Critical Asset which needs to be addressed in an offset proposal.

The south-eastern area proposed as a direct offset contains a known record of *Caladenia procera* (Critically Endangered, DRF) species according to the *WC Act* (Woodman, 2005a). This and other proposed offset areas contain good populations of Priority flora in addition to good quality remnant vegetation. KSS consider that these areas are Critical Assets and as part of mitigation for proposed mining, commit to managing these areas in a similar manner to Kemerton Nature Reserve. This includes weed and feral pig control.

10.5.1.3 Conservation Category Wetlands

Over the 50 year mine life, 110.7 hectares of Conservation Category wetlands will be disturbed, representing 16.0% of this category in the entire property. Forty-eight hectares (43.6%) will be rehabilitated over the mine life, implementing the "Rectify" component of on-site mitigation shown in Figure 24.

A total of approximately 170 hectares of lakes and beaches will be formed, representing a wetland type not currently represented in the mine extension area. This comprises a mixture of approximately 63 hectares of shallow beach area and 107 hectares of deep open water. Developing ecological functions in these lakes provides additional habitat and biodiversity previously absent or limited on the property. This includes summer refuge for waterbirds and expanded habitat for iconic species such as the Black-striped Jollytail and Water Rat. KSS considers creation of this new habitat type represents a further environmental benefit to be offset against the net loss of former Bassendean woodland and ephemeral wetland.

10.5.2 Impacts on Landform Types

The impact of the total mining extension proposal in terms of impact on landform units is presented in Table 71. From this it can be seen that a total net difference of $^{+}$145.0 hectares will result after rehabilitation and implementation of offsets.

Table 71: Impacts on Landform Units

	Upland Bassendean Areas (ha)	Upland Spearwood Areas (ha)	Disturbed Land	Ephemeral Wetlands (ha)	Lakes (ha)	Lake Beach (ha)	Total (ha)
Mining Extension Proposal							
Proposed mine area	122.1	31.9	19.0	110.7	0	0	-283.7
Dry mining approved area	17.2	0	0	3.1	0	0	-20.3
Rehabilitated after mining	65.0	0	0	48.0	107.0	63.0	283.0
Post mining difference	-74.4	-31.9	-19.0	-65.8	+107.0	+63.0	-21.1
Offsets							
Forgo dry mining	46.7	0	0	8.3	0	0	+55.0
Land transfer	70.0	0	0	30.7	0	0	+100.7
Land rehabilitation	11.0	0	0	0	0	0	+11.0
Total offset	+127.7	0	0	+39.0	0	0	+166.7
Total Net Difference	**+53.3**	**-31.9**	**-19.0**	**-26.8**	**+107.0**	**+63.0**	**+145.6**

10.6 RESIDUAL ENVIRONMENTAL IMPACT

Review of the proposed mine extension and implementation of the offset package described within this section shows that:

- As a result of proposed mining, there is a net change in landform type with permanent lakes fringed with ephemeral wetlands and shallow lake beaches separated by uplands being created to replace ephemeral wetlands and Bassendean and Spearwood Dune uplands.
- Post mining rehabilitation will return approximately 48 hectares of ephemeral wetlands and 65 hectares of upland. This is a net change of 43.8% and 59% respectively.
- Potential exists to create additional habitat for the nationally significant Western Ringtail Possum within the upland areas as part of the rehabilitation program. This would assist with its long-term conservation in the Bunbury region.
- Creation of approximately 170 hectares of permanent lakes (including up to 63 hectares of shallow beaches) post mining represents a reduction in net loss associated with the project. It has potential to provide expanded habitat for conservation significant fauna such as the Black –striped Jollytail present on the property in restricted locations and additional habitat for waterbirds including migratory species. Creation of permanent water sources in a drying climate is seen to have value for a range of conservation significant species.
- Significant offsets will be made to compensate for losses. This will result in:
  - 165.4 hectares of additional offsets being made.

- 116.7 hectares of existing Bassendean uplands being protected in perpetuity in addition to the 11.0 hectares of existing degraded Bassendean upland being restored and 65 hectares to be rehabilitated after implementation of the mining proposal.
- 39.0 hectares of existing ephemeral wetlands being protected in perpetuity.
- 100.7 hectares of additional Critical Assets being protected in perpetuity.
- Protection of one DRF and eight Priority flora species with an estimated total of approximately one and 41 plants respectively in perpetuity.
- Creation of the desired north-south ecological linkage in the Kemerton area with a total of 417.0 hectares having being transferred to the State to form the Kemerton Nature Reserve as a direct result of silica sand mining activities in the Kemerton area.

10.7 PREDICTED RESIDUAL ENVIRONMENTAL RISK

By implementing both site rehabilitation and direct and contributory elements of the proposed offset package, KSS considers the EPA objective of achieving a 'no net environmental loss' or aspirationally a 'net environmental benefit' is reached.

Rehabilitation will return a proportion of landform types disturbed by mining. New permanent lakes will supplement rehabilitation of ephemeral wetlands and Bassendean woodland.

The offset proposal provides protection in perpetuity of additional Critical and high value assets and formalisation of a long-term contributory partnership of management of the Kemerton Nature Reserve. The offset area directly contributes to establishment of the North-South Ecological Linkage in the Kemerton area stated as desirable by the EPA in Bulletin 1108.

11. ENVIRONMENTAL MANAGEMENT COMMITMENTS

Environmental commitments are presented in Table 72.

Table 72: Environmental Commitments

Aspect	No.	Action	Timing
Stakeholder Consultation	**5.5a**	KSS will continue to consult with relevant stakeholders throughout the life of the Project.	During operations in the mine extension area.
Soils	**7.2.1.4a**	Strip and stockpile topsoil (where required) in dry and preferably still wind conditions, to minimise dust generation and assist rapid revegetation**.**	Prior to scheduled clearing in advance of mining and during operations in the mine extension area.
	7.2.1.4b	Control slope gradients to minimise erosion and soil loss. Finished slopes will include a zone of shallow beach approximately 30 to 40 metres wide before sloping at a stable angle of repose (approximately one in four) to the base of the rehabilitated lake.	During operations in the mine extension area.
	7.2.1.4c	Routinely inspect rehabilitated and disturbed surfaces for erosion, particularly after significant rainfall.	
	7.2.1.4d	Implement appropriate remediation measures if soil erosion is observed during routine inspections**.**	
	7.2.1.4e	Place stockpiled topsoil in windrows less than three metres high to minimise loss of seed viability and soil biota**.**	
	7.2.1.4f	Strip and replace topsoil fresh and dry (known as the autumn direct return) to a maximum depth of about 100 millimetres where practicable and place directly onto rehabilitation areas or stockpiles.	
	7.2.1.4g	Complete direct replacement wherever practicable.	
	7.2.1.4h	Undertake progressive rehabilitation where practicable. All rehabilitation will be performed in accordance with contemporary accepted industry best practice.	
	7.2.1.4i	Rip rehabilitation areas on the contour to remove compaction, improve soil structure and improve infiltration capacity if required.	

Aspect	No.	Action	Timing
	7.2.1.4j	Vehicles and mining equipment will keep to the designated roads. Very little vehicle use is needed as the mining process is dredge operated.	
	7.2.1.4k	Refuelling and servicing is carried out at the existing plant.	
	7.2.1.4l	Heavy mineral concentrate is recovered and not placed back into the dredge pond.	
Acid Sulfate Soils	**7.2.2.4a**	If ASS sampling identifies significantly sized high Potentially Acid Forming locations within the proposed pond area, KSS will alter mine plans to reduce the dredge depth to avoid these areas.	During operations in the mine extension area.
	7.2.2.4b	Where Potentially Acid Forming materials will be mined in small volumes; however residues will be returned to permanent lakes and will remain below the water in the long-term.	
	7.2.2.4c	KSS will implement a monitoring program to detect any changes attributable to the generation of acid. Ongoing monitoring will continue to record water quality in the dredge pond, rehabilitated cells and surrounding groundwater.	
	7.2.2.4d	Should acid generation occur due to mining, the ASSMP will be implemented to address any acidity generated.	
Surface Hydrology	**7.3.4a**	Pipelines between the dredge and processing plant will be located in the infrastructure corridor. They will be fully bunded with purpose built sumps located along the infrastructure corridor with sufficient capacity to hold the pipeline volume in the event of a pipe failure.	Prior to scheduled clearing in advance of mining and during operations in the mine extension area.
	7.3.4b	Regular dredge maintenance to minimise risk of spills and leaks.	
	7.3.4c	Any spills of contaminants such as oil or fuel will be immediately cleaned up.	
	7.3.4d	Place spill kits in easily accessible locations and provide operator training for hydrocarbon spill response.	
	7.3.4e	Regular monitoring of EPP wetlands for water levels and water quality.	
	7.3.4f	Monitor surface water quality around the active mine area.	
	7.3.4g	Natural surface water flows in the mine extension areas will be maintained. Diversion of surface water will not be required during operation or rehabilitation. Surface water flows of adjoining areas will not be affected by dredging operations.	

Aspect	No.	Action	Timing
Groundwater	**7.4.4a**	Monitor the dredge pond and rehabilitated cells. Implement measures to balance pH if monitoring results show an increase in acid generation.	During operations in the mine extension area.
	7.4.4b	Any spills of contaminants such as oil or fuel will be immediately cleaned up.	
	7.4.4c	Place spill kits in easily accessible locations and provide operator training for hydrocarbon spill response.	
	7.4.4d	Maintain current water usage and continue to implement water saving initiatives.	
	7.4.4e	Measure abstraction volumes.	
	7.4.4f	Install additional monitoring bores to allow continued water quality monitoring of aquifer water levels in response to dredge mining and production bore abstraction to ensure no adverse impacts occur to the region's groundwater quantity. • KMB1 is located about 400 metres up the hydraulic gradient from EPP4. • Two monitoring bores will be installed along the western boundary of the property.	
	7.4.4g	Two production bores will be installed, one located 200 metres north of KMB6 and the other 200 metres west of KMB6.	
	7.4.4h	Create north to south designed dredge ponds and rehabilitated lakes to reduce water loss by evaporation and impacts associated with easterly and westerly winds.	
Flora and Vegetation	**7.5.4a**	Progressive clearing of an average of five hectares per year.	Prior to scheduled clearing in advance of mining and during operations in the mine extension area.
	7.5.4b	Delineate areas to be cleared with survey pegs and flagging tape before clearing starts. Company supervisors will oversee clearing works.	
	7.5.4c	Undertake surveys of areas planned to be cleared in the short term to identify plants suitable for translocation, seed collection or collection of propagating material for use in the annual rehabilitation program.	
	7.5.4d	Progressive rehabilitation to encourage colonisation from surrounding vegetative areas.	During operations in the mine extension area.
	7.5.4e	Seed collection and cuttings of Priority Species.	Prior to scheduled clearing in advance of mining.

Aspect	No.	Action	Timing
	7.5.4f	Continue to undertake detailed monitoring of rehabilitated areas to ensure short, medium and long-term rehabilitation objectives are achieved. Monitoring to be carried out on a regular basis to assess: • Physical stability of the landform of rehabilitated areas. • Success of vegetation and fauna re-colonisation in rehabilitated areas. • Water quality and ecology of lakes. • Monitoring should also be conducted within 200 metres of groundwater abstraction bores. • Dredge ponds to target susceptible species, particularly *Banksia ilicifolia*, and other. • Banksia and Melaleuca species.	During operations in the mine extension area.
	7.5.4g	Weed and dieback hygiene will be implemented during all operations and will include the following provisions**:** • All vehicles and machinery will arrive at the KSS property clean and free from soil, mud. • Soil slurry and vegetation material, in accordance with the Weed Inspection List. • Soil and vegetation stripped from the mine area will be stored in marked areas. • No soil or vegetation material will be transported around the proposed mine extension area. • Movement of vehicles into non-production areas of the property is restricted, with permission required from the General Manager.	
Wetlands	**7.6.4a**	A regular annual monitoring program for reference wetlands and rehabilitated wetlands and lakes will be established, to include the wetlands sampled in the 2007 and 2008 study (McCullough and Lund, 2008). Annual monitoring will include vegetation and flora, fish, macroinvertebrates and physico-chemical parameters.	During operations in the mine extension area.
	7.4.4h	Create north to south designed dredge ponds and rehabilitated lakes to reduce water loss by evaporation and impacts associated with easterly and westerly winds.	

Aspect	No.	Action	Timing
Fauna	**7.7.4a**	Conduct surveys to identify potential Cockatoo tree hollows prior to annual land clearing to ensure hollows are not currently being used for breeding. Tree hollows suitable for Cockatoos will be relocated to other areas, preferably within newly rehabilitated areas. Hollows will either be remounted on trees outside the mine extension area, or if this is not practical, replaced with similar sized nest boxes.	Prior to scheduled clearing in advance of mining.
	7.7.4b	Planting of tree species likely to develop hollows and provide Cockatoo habitat in the long-term.	After operations in the mine extension area.
	7.7.4c	Control slope gradients to minimise erosion and soil loss. Finished slopes will include a zone of shallow beach approximately 30 to 40 metres wide before sloping at a stable angle of repose (approximately one in four) to the base of the rehabilitated lake.	
	7.7.4d	Progressive clearing of an average of five hectares per year will be carried out in Autumn when species are less likely to be breeding.	Prior to scheduled clearing in advance of mining.
	7.7.4e	Progressive rehabilitation with local provenance seed to encourage colonisation from surrounding vegetative areas, to re-establish vegetation and hence fauna.	During operations in the mine extension area.
	7.7.4f	Conduct targeted survey for Chuditch, Western Ringtail Possum and Quokka prior to annual land clearing to ensure that populations of these Vulnerable species will not be affected by the planned clearing. If evidence of their presence is found, trapping will be undertaken and captured individuals relocated to suitable alternative sites on the property.	Prior to scheduled clearing in advance of mining.
	7.7.4g	Erecting nest boxes suitable for use by Western Ringtail Possums where annual surveys show Possums are present in areas planned to be cleared in the short term. Nest boxes will be placed in adjacent undisturbed areas where suitable foraging habitat is present.	Prior to scheduled clearing in advance of mining.
	7.7.4h	Planting areas of peppermint (*Agonis flexuosa*) within upland woodland areas to be rehabilitated post mining. Peppermint trees will be planted in clumps to encourage interlocking branches.	After operations in the mine extension area.
	7.7.4i	Pre-clearance surveys will be undertaken within suitable habitat to determine the presence/absence of targeted vertebrate conservation significance species will not be affected by the planned clearing. If evidence of their presence is found, trapping will be undertaken and captured individuals relocated to suitable alternative sites on the property.	Prior to scheduled clearing in advance of mining.

Aspect	No.	Action	Timing
	7.7.4j	Quarantine of the mine extension dredge ponds to prevent Gambusia being transferred from the existing mine area will be achieved by: • Cleaning all dredging equipment and pipes prior to relocation to the mine extension area. • Preventing direct pumping of water from existing dredge ponds to the mine extension area ponds.	Prior to scheduled clearing in advance of mining.
	7.7.4k	Funding a two year master's research program for the Black-striped Jollytail. Findings are intended to assist with identification of habitat requirements to assist Jollytail introductions as part of rehabilitation activities.	During operations in the existing mine area.
	7.7.4l	Relocate habitat logs for ground dwelling fauna. Habitat logs and brush are re-spread in areas undergoing rehabilitation as part of current operations. This practice will continue.	During operations in the mine extension area.
	7.7.4m	Further macroinvertebrate and wetland research will be funded through Edith Cowan University to establish baseline conditions as analogues for future rehabilitation	During operations in the mine extension area.
	7.7.4n	Relocation of nest hollows in undisturbed areas on the property for use by other bird and mammal species will offset habitat lost through the development.	Prior to scheduled clearing in advance of mining.
	7.7.4o	Foxes, feral cats, rabbits and wild pigs are all present on the KSS property. KSS will continue to undertake feral animal control to minimise impacts from feral animals on native species. This will include control of pigs, foxes and rabbits.	During operations in the mine extension area.
Heritage Values	**7.8.4a**	In the event that an archaeological site or a site of cultural importance to Aboriginal people is discovered the proponent will immediately inform the DIA.	During operations in the mine extension area.
Emissions and Dust	**7.10.4a**	Disturbance of vegetation will be kept to a minimum.	During operations in the mine extension area.
	7.10.4b	As the resource is pumped to and from the dredge pond rather than transported in conventional 'haul trucks', the majority of vehicle movement on unsealed internal access roads are 4WD light vehicles.	
	7.10.4c	A water cart is used to suppress dust on all unsealed access roads when required.	
	7.10.4d	A road sweeper periodically sweeps the main apron where loading of vehicles is carried out.	
	7.10.4e	Auto-reticulation is sued in stockpile and permanent road areas.	

Aspect	No.	Action	Timing
	7.10.4f	Site personnel will visually monitor dust levels during earth moving activities and dredging operations.	
	7.10.4g	Earth moving equipment and the dredge will be regularly maintained and serviced to manufacturer's specifications to ensure efficient running and optimum fuel consumption, thereby minimising exhaust emissions.	
Road Transportation/Traffic	**7.12.3a**	If product is spilled it will be remediated immediately.	During operations in the mine extension area.
	7.12.3b	KSS employees are committed to driving to the designating speed limits to reduce fauna deaths.	
Decommissioning and Closure	**7.13.4a**	KSS will prepare a Preliminary Decommissioning and Closure Plan, conforming to the Conceptual Closure Plan as defined in Section 2.3 of the Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (2000) guidelines within five years of commencing operations in the proposed mine extension area.	During operations in the mine extension area.
Rehabilitation	**9.4a**	KSS will continue to revise the Rehabilitation Management Plan on a regular basis to ensure it remains relevant and effective.	During operations in the mine extension area.
	9.8a	Rehabilitation completion criteria will be assessed by periodic monitoring of rehabilitation areas against similar undisturbed locations (analogue sites), with similar landform and vegetation characteristics. Interim targets will be reviewed against ongoing rehabilitation monitoring results during the life of mine, with progression towards defined scores set as staged completion targets.	During operations in the mine extension area.

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13. REFERENCES

Austin, M. P. and Belbin, L., 1982. *A New Approach to the Species Classification Problem in Floristic Analysis*. Australian Journal of Ecology, 7: 75-89.

AS/NZS, 1998. *Risk Analysis of Technological Systems – Application Guide (3931:1998)*. Standards Australia. Standards New Zealand. Sydney/Wellington.

AS/NZS, 2004b. *Risk Management (4360:2004)*. Standards Australia/Standards New Zealand. Sydney/Wellington.

Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.*

Australian Government, 1994. *National Water Quality Management Strategy*.

Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (ANZMEC/MCA), 2000. *A Strategic Framework for Mine Closure*. Environment Australia, Canberra.

Australian Minerals Industry, 2000. *Code for Environmental Management*.

Arbortech Pty Ltd, 1997. *Kemerton Silica Sand Environmental Monitoring Report*. Unpublished report for Kemerton Silica Sand Pty Ltd.

Bamford, M.J. and Bamford, A.R. (Bamford), 1998. *Kemerton Silica Sand Mine. Annual Report on Fauna Monitoring Program; 1997*. Unpublished report by Bamford Consulting Ecologists for Arbotech, Perth.

Bamford, M.J. and Bamford, A.R. (Bamford), 1999. *Kemerton Silica Sand Mine. Annual Report on Fauna Monitoring Program, 1998*. Unpublished report by Bamford Consulting Ecologists for Ecos Consulting, Perth.

Bamford, M.J. and Bamford A.R. (Bamford), 2000. *Kemerton Silica Sand Mine: Annual Report on Fauna Monitoring Program; 1999*. Unpublished report by Bamford Consulting Ecologists, for Kemerton Silica Sand Pty Ltd.

Bamford, M.J. and Bamford A.R. (Bamford), 2001. *Kemerton Silica Sand Mine: Report on Fauna Monitoring Program; 2000 - 2001*. Unpublished report by Bamford Consulting Ecologists, for Kemerton Silica Sand Pty Ltd.

Bamford, M.J., and Bamford A.R. (Bamford), 2002. *Kemerton Silica Sand Pty Ltd: Summary Report on Fauna Surveys; 2001 – 2002*. Unpublished report by Bamford Consulting Ecologists, for Kemerton Silica Sand Pty Ltd.

Bamford, M.J. and Bamford, A.R. (Bamford), 2003a. *Assessment of Fauna Values in the KSS Property*. Unpublished report by Bamford Consulting Ecologists, for Kemerton Silica Sand Pty Ltd.

Bamford, M.J. and Bamford, A.R. (Bamford), 2003b. *Kemerton Silica Sand Pty Ltd: Fauna Monitoring 18th December 2002*. Unpublished report by Bamford Consulting Ecologists, for Kemerton Silica Sand Pty Ltd.

Bamford, M.J. and Bamford, A.R. (Bamford) 2004. *The Utilisation by Short-Billed Black-Cockatoos (Calyptorhynchus latirostris) of the Proposed Dredge Mining Extension Area of Kemerton Silica Sands*. Unpublished report by Bamford Consulting Ecologists, for Kemerton Silica Sand Pty Ltd.

Bamford, M.J. and Bamford, A.R. (Bamford), 2008. *Fauna Assessment of the Proposes South Binningup Development*. Unpublished report for RPS Consulting/Mirvac.

Bamford, M.J. and Watkins, D., 1983. *Kemerton Wetlands: The Vertebrate Fauna and its Regional Significance*. Unpublished report to Alcoa of Australia, Perth.

Barnesby, B.A. and Proulx-Nixon, M.E., 2000. *Land Resources from Harvey to Capel on the Swan Coastal Plain, Western Australia - Sheets 1 and 2*. Land Resources Maps No. 23/1 and 23/2. Agriculture Western Australia.

Beard, J.S., 1981. *Vegetation Survey of Western Australia-Swan*. University of Western Australia Press.

Beard, J.S., 1990. *Plant Life of Western Australia*. Kangaroo press, NSW.

Belbin L., 1995. PATN Pattern Analysis Package. CSIRO Division of Wildlife and Ecology, Lyneham ACT.

Bennett Environmental Consulting Pty Ltd, June 2004. *Kemerton: Significant Flora and Wetlands*. Unpublished Report for MBS Environmental.

Blatant Fabrications Pty Ltd, 2006. *PATN version 3.11*.

Bureau of Meteorology (BOM), 2008. *Climate Statistics for Australian Locations*. Monthly Climate Statistics Bunbury. Retrieved 5 September 2008 from: http://www.bom.gov.au/clim_data/cdio/tables/text/IDCJCM0039_009965.csv.

Bush, B., Maryan, B., Brown-Cooper, R. and Robinson, D., 1995. *A Guide to the Reptiles and Frogs of the Perth Region*. University of Western Australia Press, Perth. In Bamford, M.J. and A.R., 2003a. Assessment of Fauna Values in the KSS Property. Unpublished report for Kemerton Silica Sand Pty Ltd.

Cale, B., 2003. *Carnaby's Black-Cockatoo (Calyptohynchus latirostris) Recovery Plan 2002 - 2012*. Department of Conservation and Land Management, Wanneroo. Retrieved on the 25 September 2008 from http://www.dec.wa.gov.au/pdf/plants_animals/threatened_species/frps/carnabys_wmp36.pdf.

Chamber of Minerals and Energy Western Australia Inc., 2000. *Mine Closure Guideline for Mineral Operations in Western Australia*.

Churchward, H.M. and McArthur, W.M., 1978. *Landforms and Soils of the Darling System.* In Atlas of Natural Resources of the Darling region, Western Australia. Prepared for the Department of Conservation and Environment. Government Printer, Perth.

Commonwealth of Australia, 2001. *National Objectives and Targets for Biodiversity Conservation 2001-2005*. Commonwealth of Australia, Canberra.

Craig, M., Bamford, M, and Wilcox, J., 2004. *The Utilisation by Short Billed Black-Cockatoos (Calyptorhynchus latirostris) of the Proposed Dredge Mining Extension Area of Kemerton Silica Sand*. Unpublished report for Kemerton Silica Sand Pty Ltd.

Deeney, A.C., 1989. *Geology and Groundwater Resources of the Superficial Formations Between Pinjarra and Bunbury, Perth Basin; Western Australia Geological Survey, Report 26, Professional Papers, p. 31-57.*

Department of Agriculture and Food, 2008. NRM Info. Retrieved 12 September 2008 from http://spatial.agric.wa.gov.au/slip/framesetup.asp.

Department of Environment and Conservation (DEC), Contaminated Sites Branch, Environmental Regulation Division, 2009a. *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes.* Acid Sulfate Soils Guideline Series.

Department of Environment and Conservation (DEC), Contaminated Sites Branch, Environmental Regulation Division, 2009b. *Draft Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes*. Acid Sulfate Soils Guideline Series.

Department of Environmental Protection, 1996. *Land Development Sites and Impacts on Air Quality: A Guideline for the Prevention of Dust and Smoke Pollution from Land Development Sites in Western Australia.*

Department of Environmental Protection, 2000. *Bush Forever*. Government of Western Australia. Western Australian Planning Commission, Perth.

Department of the Environment, Water, Heritage and the Arts, 2006. *Australian Greenhouse Office Factors and Methods Workbook.*

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2007. Species Profile and Threats Database (SPRAT). Retrieved on the 29 March 2007 from http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.

Department of the Environment, Water, Heritage and the Arts, 2007b. *Use of Environmental Offsets Under the Environmental Protection and Biodiversity Conservation Act 1999 – Discussion Paper*.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2008a. Australian Wetlands Database. Retrieved on the 25 July 2008 from http://www.environment.gov.au/water/publications/environmental/wetlands/database/.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2008b. *Pseudocheirus occidentalis in Species Profile and Threats Database*, Department of the Environment, Water, Heritage and the Arts, Canberra. Retrieved on the 25 September 2008 from http://www.environment.gov.au/sprat.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2008c. *Calyptorhynchus baudinii in Species Profile and Threats Database*. Department of the

Environment, Water, Heritage and the Arts, Canberra. Retrieved on the 25 September 2008 from http://www.environment.gov.au/sprat.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2008d. *A Statement for the Purposes of Approved Conservation Advice (s266B of the Environment Protection and Biodiversity Conservation Act 1999) Approved Conservation Advice for Drakaea micrantha (Dwarf Hammer-orchid).* Retrieved on the 18 September 2008 from http://www.environment.gov.au/biodiversity/threatened/species/pubs/81853-conservation-advice.pdf.

Department of Minerals and Energy of Western Australia, 2001. *Draft Criteria for Mine Closure*.

Department of Mines Geological Survey Branch, 1978. *Geology and Mineral Resources of the Darling System*. Atlas of Natural Resources, Darling System, Western Australia. Prepared for the Department of Conservation and Environment.

Department of Water, 2004. *Water Quality Protection Note: Australian Drinking Water Guidelines No. 6 (ADWG).*

Department of Water, 2008. *Water Quality Protection Notes.*

Diels, L., 1906. *Die Pflanzenwelt von Western Australian sudlich des Wendekreises.* Vegn. Erde 7, Leipzig: In Beard J.S., 1981. Vegetation Survey of Western Australia-Swan.

Dunnell, R. and Dancy, W., 1983. *The Siteless Survey: a Regional Scale Data Collection Strategy*. Advances in Archaeological Method and Theory 6:267-285.

Ecos Consulting (Aust) Pty Ltd, 1998. *Kemerton Silica Sand Environmental Monitoring Report*. Unpublished report prepared for Sons of Gwalia.

Ecos Consulting (Aust) Pty Ltd, 2000a. *Rehabilitation Trials Final Assessment Report. May 2000*. Unpublished report prepared for Sons of Gwalia.

Ecos Consulting (Aust) Pty Ltd, 2000b. *Assessment of Impacts on Sedimentation on Wetland Four*. Unpublished report prepared for Sons of Gwalia, June 2000.

Ecos Consulting (Aust) Pty Ltd, 2000c. *Establishing of Monitoring Quadrats at Kemerton Silica Sand*. Unpublished report prepared for Sons of Gwalia, August 2000.

English, V. and Blyth, J., 2000. *Shrubland and Woodlands on Muchea Limestone Interim Recovery Plan 2000 - 2003. Interim Recovery Plan No. 57*. Department on Conservation and Land Management.

Environment Australia (now Department of Environment and Water, Heritage and the Arts (DEWHA)) under the Environmental Protection, Biodiversity and Conservation Act 1999 (EPBC Act).

Environment Australia, 2002. *Best Practice Environmental Management in Mining*.

Environment Australia, 2003. *Best Practice Environmental Management in Mining*.

Environmental Protection Authority (EPA), 1993. *A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area*. Bulletin 686, EPA, Perth.

Environment Protection Authority (EPA), 2000. *Position Statement No. 2: Environmental Protection of Native Vegetation in Western Australia*.

Environment Protection Authority (EPA), 2002. *Position Statement No. 3 - Terrestrial Biological Surveys as an Element of Biodiversity Protection.*

Environmental Protection Authority (EPA), 2003a. *Level of Assessment for Proposals Affecting Natural Areas Within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region. Guidance Statement 10.*

Environmental Protection Authority (EPA), 2003b. Greater Bunbury Region Scheme. Report and Recommendations of the Environmental Protection Authority. Bulletin 1108. EPA Perth.

Environmental Protection Authority (EPA), 2004a. *Guidance for the Assessment of Environmental Factors No. 51. Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.*

Environment Protection Authority (EPA), 2004b. *Guidance Statement No. 56 - Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia.*

Environment Protection Authority (EPA), 2004c. *Position Statement No 4: Environmental Protection of Wetlands.*

Environment Protection Authority (EPA), 2006a. *Guidance Statement No. 10: Level of Assessment for Proposals Affecting Natural Areas Within the System 6 Region and Swan Coastal Plain portion of the System 1 Region*.

Environmental Protection Authority (EPA), 2006b. *Draft Guidance for the Assessment of Environmental Factors No 6. "Rehabilitation of Terrestrial Ecosystems"*.

Environmental Protection Authority (EPA), 2006c. *Environmental Offsets. Position Statement No. 9.*

Environment Protection Authority (EPA), 2008a. *Environmental Protection Bulletin No. 1 Environmental Offsets – Biodiversity.*

Environment Protection Authority (EPA), 2008b. *Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986).* Environmental Offsets – Biodiversity. No. 19.

Environmental Protection Authority (EPA), 2008c. Guidance Statement 33: Environmental Guidance for Planning and Development.

Galeotti, D.M., McCullough, C.D. and Lund, M. A., 2008. *Current State of Knowledge of the Black-stripe Minnow Galaxiella nigrostriata (Pisces: Galaxiidae) in Western Australia*. Edith Cowan University, Centre for Ecosystem Management Report 2008-12. Unpublished report to Kemerton Silica Sands Pty. Ltd., Perth, Western Australia. http://www.ecu.edu.au/chs/cem/CSML-ECU/ecology.htm

GHD, 2002. *Proposed Western Extension: Assessment of the Impact on Groundwater of Extending Mining on the Kemerton Silica Sand Property*. Unpublished Report for Kemerton Silica Pty Ltd.

GHD, 2008. *Report for Proposed Western Extension. Impact Assessment of Mining on Groundwate*r. Unpublished Report for Kemerton Silica Sand Pty Ltd.

Gibson, N., Keighery, B., Keighery, G., Burbidge, A. and Lyons, M., 1994. *A Floristic Survey of the Southern Swan Coastal Plain*. Unpublished report for the Australian Heritage Commission, Department of Conservation and Land Management and Conservation Council of Western Australia.

Government of Western Australia, 2003. *State Water Quality Management Strategy for Western Australia No. 2*.

Groom, P K., Froend, R H., Mattiske, E.M., 2000. *Impact of Groundwater Abstraction on a Banksia Woodland, Swan Coastal Plain, Western Australia*. Ecological Management & Restoration 1 (2), 117–124.

Harewood, G., 2009. *Fauna Assessment (Level 1) and Targeted Fauna Survey (Western Ringtail Possum and Southern Brush-tailed Phascogale) in the Mine Expansion Area*. Unpublished Report for Kemerton Silica Pty Ltd.

Heddle, E.M., Loneragan, O.W. and Havel, J.J., 1980. *Vegetation Complexes of the Darling System*. In Department of Conservation and Environment. Atlas of Natural Resources Darling System Western Australia. University of Western Australia Press.

Hey, K.M., Ahern, C.R. and Watling, K.M, 2000. *Using Chemical Field Tests to Identify Acid Sulfate Soils Likelihood*. Acid Sulfate Soils: Environmental Issues, Assessment and Management, Technical Papers, Brisbane, June 2000. Department of Natural Resources.

International Union for Conservation of Nature and Natural Resources 2001. *IUCN Red list of Threatened Species*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge. Retrieved on the 18 September 2008 from UK.http://www.iucnredlist.org/info/categories_criteria2001.

Johnstone R.E. and Storr G.M., 1998. *Handbook of Western Australian Birds. Volume 1: Non-passerines (Emu to Dollarbird)*. Western Australian Museum, Perth.

Keighery, B., 1998. *Vegetation and Flora Conservation Values of the Kemerton Silica Sand Project Area*. Unpublished report to Department of Conservation and Environment.

Keighery B.J. and Keighery G.J., 2003. *Muchea Limestones of the Kemerton Silica Sand Project Area*. An unpublished report for the Department of Environmental Protection and Department of Conservation and Land Management.

Keighery, G.J. and Keighery, B.J., 1995. *Muchea Limestones - Floristics*. Unpublished report to Australian Nature Conservation Authority Natural Reserves Network and Department of Conservation and Environment.

Kinnear, A. and Pentland, C., 2007. *Kemerton Terrestrial Invertebrate ERS Survey*. Unpublished report to MBS Environmental. Centre for Ecosystem Management School of Natural Sciences Edith Cowan University.

Lantzke, D., Campbell - Smith, S. and McDonald, E., 1993. *Report of an Aboriginal Heritage Survey: Kemerton Silica Sand Project, Western Australia*. Unpublished report for John Consulting Services. McDonald Hale and Associates, West Perth.

Ling, N., 2004. *Gambusis in New Zealand: Really Bad or Just Misunderstood?* New Zealand Journal of Marine and Freshwater Research 38: 473-480. In McCullough, C.D., 1998. The voracious mosquitofish: Gambusia or Damnbusia? Forest and Bird. In McCullough, C., Lund, M. and van Etten, E. 2007 Synthesis of Existing Data and Knowledge Gaps for the Rehabilitation of Kemerton Silica Sand Mine Dredge Ponds. Unpublished report for Kemerton Silica Sand Pty Ltd.

Lloyd Acoustics, 2004. *Assessment of Noise Emissions Associated with the Kemerton Silica Sand Project*. Unpublished report for Kemerton Silica Sand Pty Ltd.

Magoulick D.D. and Kobza R.M., 2003. *The Role of Refugia for Fishes During Drought: A Review and Synthesis*. Freshwater Biology 48, 1186-1198.

Martinick Bosch Sell Environmental Pty Ltd (MBS), 2004. *Extension to Dredge Mining Operation: Scoping Document.* Unpublished report for Kemerton Silica Sand Pty Ltd.

Martinick Bosch Sell Environmental Pty Ltd (MBS), 2008. *Kemerton Silica Sand: Collation of Fauna Reports on the KSS Property*. Unpublished report for Kemerton Silica Sand Pty Ltd.

Martinick Bosch Sell Environmental Pty Ltd (MBS), 2009. *Kemerton Silica Sand, Kemerton, Western Australia. Reclassification of Geomorphic Wetlands*. Unpublished report prepared for Kemerton Silica Sand Pty Ltd, January 2009.

Mattiske, E.M. and Associates (Mattiske), 1993a. *Gwalia Consolidated Limited - Kemerton Sand Project: Flora and Vegetation Studies. Report One - February 1993*. Unpublished report prepared for John Consulting Services.

Mattiske, E.M. and Associates (Mattiske), 1993b. *Gwalia Consolidated Limited - Kemerton Sand Project: Flora and Vegetation. Report Two - June 1993*. Unpublished report prepared for John Consulting Services.

Mattiske, E.M. and Associates (Mattiske), 1993c. *Gwalia Consolidated Limited - Kemerton Sand Project: Updated Flora and Vegetation Report. Report Three - November 1993*. Unpublished report prepared for John Consulting Services.

Mattiske, E.M. and Associates (Mattiske), 1993d. *Gwalia Consolidated Limited - Kemerton Sand Project: Vegetation Mapping of Proposed Transport Corridor. Report Four - November 1993*. Unpublished report prepared for John Consulting Services.

Mattiske Consulting Pty Ltd (Mattiske), 2001a. *Vegetation Monitoring of Wetlands at Kemerton. April 2001*. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

Mattiske Consulting Pty Ltd (Mattiske), 2001b. *Vegetation Monitoring of Wetlands at Kemerton. July 2001*. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

Mattiske Consulting Pty Ltd (Mattiske), 2002a. *Vegetation Monitoring of Wetlands at Kemerton. February 2002*. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

Mattiske Consulting Pty Ltd (Mattiske), 2002b. *Vegetation Monitoring of Wetlands at Kemerton. March 2002*. Unpublished report prepared for GHD and Sons of Gwalia Ltd.

Mattiske Consulting Pty Ltd (Mattiske), 2003a. *Vegetation Monitoring of Wetlands at Kemerton. March 2003*. Unpublished report prepared for GHD and Kemerton Silica Sand Pty Ltd.

Mattiske Consulting Pty Ltd (Mattiske), 2003b. *Kemerton Silica Sand Review of Flora, Vegetation and Conservation Values on Kemerton Project Area*. May 2003 report providing an updated summary of previous botanical studies within the Kemerton project area.

Mattiske Consulting Pty Ltd (Mattiske), 2004a. *Vegetation Monitoring of Wetlands at Kemerton. March 2004*. Unpublished report prepared for Kemerton Silica Sand Pty Ltd. March 2004 report on the vegetation monitoring finding of fieldwork undertaken in EPP wetlands 4, 8 and 9.

Mattiske Consulting Pty Ltd (Mattiske), 2004b. *Assessment of Rehabilitated Wetland Areas – Kemerton Silica Sands Limited – Kemerton Operations*. May 2004. Unpublished report prepared for Kemerton Silica Sand Pty Ltd.

Mattiske Consulting Pty Ltd (Mattiske), 2005. *Assessment of Rehabilitated Wetland Areas – Kemerton Silica Sands Limited – Kemerton Operations*. September 2005. Unpublished report prepared for Kemerton Silica Sand Pty Ltd.

Mattiske Consulting Pty Ltd (Mattiske), 2009. *Updated Review of Vegetation Communities - Kemerton Silica Sand Pty Ltd.* Unpublished memo for Kemerton Silica Sand Pty Ltd, February 2009.

Maxwell, S., Burbidge, A.A. and Morris, K., 1996. *The 1996 Action Plan for Australian Marsupials and Monotremes*. Wildlife Australia, Environment Australia. Retrieved 25 September from http://www.environment.gov.au/biodiversity/threatened/publications/action/marsupials/23.html.

McCullough, C.D., 1998. *The Voracious Mosquitofish: Gambusia or Damnbusia?* Forest and Bird. In McCullough, C., Lund, M. and van Etten, E., 2007. Synthesis of Existing Data and Knowledge Gaps for the Rehabilitation of Kemerton Silica Sand Mine Dredge Ponds. Unpublished report for Kemerton Silica Sand Pty Ltd.

McCullough, C., Lund, M. and van Etten, E., 2007. *Synthesis of Existing Data and Knowledge Gaps for the Rehabilitation of Kemerton Silica Sand Mine Dredge Ponds*. Unpublished report for Kemerton Silica Sand Pty Ltd.

McCullough, C. and Lund, M., 2008. *Aquatic Macroinvertebrates in Seasonal and Rehabilitated Wetlands of the Kemerton Silica Sand Pty Ltd Project Area*. Mine Water and Environment Research/Centre for Ecosystem Management Report No. 2008-16, Edith Cowan University, Perth, Australia. Unpublished report to Kemerton Silica Sand Pty Ltd.

Minerals Council of Australia, 1998. *Mine Rehabilitation Handbook.*

Minerals Council of Australia, 1999. *Mine Closure Policy*.

Mines Safety and Inspection Regulations, 1995.

Morcombe, M., 2003. *Field Guide to Australian Birds*. Steve Parish Publishing, Archerfiled, Queensland.

Morgan, D.L., Gill, H.S. and Potter, I.C., 1998. *Distribution, Identification and Biology of Freshwater Fish in South Western Australia*. Records of the Western Australian Museum Supplement No 56.

Muir Environmental, 1999. *Report of Biological Survey - Phase 1: Kemerton Industrial Estate. Vol 1 Report and Vol 2 Appendices*. Unpublished Report for Landcorp. In Mattiske Consulting Pty Ltd. May 2003. Kemerton Silica Sand: Review of Flora, Vegetation and Conservation Values on Kemerton Project Area. Unpublished report for Kemerton Silica Sand Pty Ltd.

National Environment Protection Council, November 2003. *Contaminated Sites Management Series - Assessment Levels for Soil, Sediment and Water*.

Ninox Wildlife Consulting, 1993. *Report: Vertebrate Fauna Assessments of the Kemerton Silica Sand Project*. Unpublished report for Kemerton Silica Sand Pty Ltd.

Ninox Wildlife Consulting, 1994. The Kemerton Silica Sand project area: Vertebrate fauna assessments December 1992 - December 1993. Unpublished report for Kemerton Silica Sand Pty Ltd.

Orell, P. and Morris, K., 1994. *Chuditch Recovery Plan 1992 – 2001. Western Australia Wildlife Management Program No. 13.* Western Australia Department of Conservation and Land Management, Wanneroo. Retrieved on the 25 September 2008 from http://www.environment.gov.au/biodiversity/threatened/publications/recovery/chuditch/pubs/chuditch.pdf.

Pizzey, G. and Knight, F., 2003. *The Field Guide to the Birds of Australia.* Harper Collins Publishers, Sydney, Australia.

Ramsar Convention of Wetlands, 2005. Peel-Yalgorup System – Wetlands of International Importance. Retrieved 16 September 2008 from http://www.peel-harvey.org.au/pdfs/Projects/P-H%20Ramsar%20Brochure%202007.pdf

Rights in Water and Irrigation Act, 1914. (Western Australia).

Rockwater Pty Ltd, 2008. *Kemerton Silica Sand Pty Ltd. Groundwater Monitoring Review. July 2005 to June 2008 (GWL 60367(2&3)).* Unpublished report prepared for Kemerton Silica Sand Pty Ltd, September 2008.

Rokich, D., Dixon, K.W., Sivasithamparam, K. and Meney, K.A., 2000. *Topsoil Handling and Storage Effects on Woodland Restoration in Western Australia.* Restoration Ecology 8(2): 196-208.

SAA Handbook, 203:2004. *Environmental Risk Management – Principles and Process*. Jointly published by Standards Australia International Ltd, Sydney, NSW and Standards New Zealand, Wellington, NZ.

Semeniuk, C.A., 1987. *Wetlands of the Darling System -a Geomorphic Approach to Habitat Classification.* J. Roy. Soc. West. Aust. 69: 95-111. In EPA 1993. A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain. Bulletin 686.

Slater, P., Slater, P. and Slater, R., 1995. *The Slater Field Guide to Australian Birds*. Lansdowne Publishing Pty Ltd, Sydney, Australia.

Smith, F.G., 1974. *Vegetation Survey of Western Australia: Vegetation Map of the Collie Sheet, 1:250,000.* Department of Agriculture. In Department of Conservation and Environment 1980. Atlas of Natural Resources Darling System Western Australia. University of Western Australia Press.

Sommer, B., 1997. *Predation by Gambusia holbrockii (Girard) (Pisces: Poecillidae) on Tadpoles: Feeding Trials and Microhabitat Utilisation in Two Contrasting Wetlands on the Swan Coastal Plain.* BSc 9hons0 thesis, Edith Cowan University, Perth, Australia. In McCullough, C., Lund, M. and van Etten, E. 2007 Synthesis of Existing Data and Knowledge Gaps for the Rehabilitation of Kemerton Silica Sand Mine Dredge Ponds. Unpublished report for Kemerton Silica Sand.

Stack, G. and English, V., 2004. *Carbunup King Spider Orchid (Caladenia procera) Interim Recovery Plan 2004 – 2009. Interim Recovery Plan No. 175*. Department of Conservation and Land Management. Retrieved 18th September 2008 from http://www.dec.wa.gov.au/pdf/plants_animals/threatened_species/irps/cal_pro_irp175.pdf.

Storr, G M., Smith, L.A and Johnstone, R.E., 1999. *Lizards of Western Australia. I Skinks*. 2nd Edition. WA Museum, Perth. In Bamford, M.J. and A.R. 2003a. Assessment of Fauna Values in the KSS Property. Unpublished report for Kemerton Silica Sand Pty Ltd.

Storr, G.M., Smith, L.A. and Johnstone R.E., 2002. *Snakes of Western Australia*. Revised Edition, WA Museum, Perth.

Strahan, R. (Ed.), 1995. *The Mammals of Australia*. Australian Museum/Reed Books, Sydney.

Thompson McRobert Edgeloe (TME), Coffey Environments and William James Landscape Architect, 2007. *Kemerton Industrial Park Strategy Plan*. Prepared for Landcorp and Department of Industry and Resources.

van Etten, E., McCullough, C.D. and Lund, M.A., 2008a. *Synopsis of Wetland Characterisation Study: Potential Implications for P.E.R.* Centre for Ecosystem Management Report No. 2008-17a, Edith Cowan University, Perth, Australia. Unpublished report for Kemerton Silica Sand Pty Ltd.

van Etten, E., McCullough, C.D. and Lund, M.A., 2008b. *Evaluation of Rehabilitation Efforts at the Kemerton Silica Sand Pty Ltd Project Area (June 2007).* Centre for Ecosystem Management Report No. 2008-10, Edith Cowan University, Perth, Australia. Unpublished report for Kemerton Silica Sand Pty Ltd.

van Etten, E., McCullough, C.D. and Lund, M.A., 2009. *Evaluation of Post-Mining Rehabilitation at the Kemerton Silica Sand Pty Ltd Project Area, November 2008.* Centre for Ecosystem Management, Edith Cowan University, Perth, Australia. Unpublished report for Kemerton Silica Sand Pty Ltd.

Waters and Rivers Commission, 1999. *Statewide Policy No. 1: Policy and Guidelines for Construction and Silica Sand Mining in Public Drinking Water Source Areas.*

Water and Rivers Commission, Department of Mines and Energy and Department of Environmental Protection, 2000a. *Water Quality Protection Guideline No. 6 – Mining and Mineral Processing: Mine Stormwater*.

Water and Rivers Commission, Department of Mines and Energy and Department of Environmental Protection, 2000b. *Water Quality Protection Guideline No. 11 - Mining and Mineral Processing: Mine Dewatering.*

Waters and Rivers Commission, Department of Mines and Energy and Department of Environmental Protection, Water Quality Protection Note, 2000c. *Extractive Industries within Public Drinking Water Source Areas.*

Waters and Rivers Commission (WRC), 2001. *Position Statement: Wetlands*.

Western Australian Herbarium, 1998. FloraBase - The Western Australian Flora. Department of Environment and Conservation. Retrieved on the 24 September 2008 from http://florabase.dec.wa.gov.au/.

Western Australian Planning Commission (WAPC), 2003. *Acid Sulfate Soils. Planning Bulletin 64.* ISSN 1324-9142.

Western Australian Planning Commission (WAPC), 2005a. *Greater Bunbury Region Scheme: Strategic Minerals and Basic Raw Materials Resource Policy 2005.*

Western Australian Planning Commission (WAPC), 2005b. *Guideline for the Determination of Wetland Buffer Requirements.*

Wilcox, J. and Bamford, M.J. 2004. *The Status of the Chuditch (Dasyurus geoffroyi) in Areas Proposed for Expansion by KSS.* Unpublished report for Kemerton Silica Sand Pty Ltd.

Woodman Environmental Consulting Pty Ltd (Woodman), 2005a. *Kemerton Lateral Pipeline: Flora, Vegetation, and Phytophthora Cinnamomi Assessment*. Unpublished report for Ecos Consulting (Aust) Pty Ltd.

Woodman Environmental Consulting Pty Ltd (Woodman), 2005b. *Kemerton Lateral Pipeline: Rehabilitation Plan*. Unpublished report for Ecos Consulting (Aust) Pty Ltd.

Youngson, K. and Harold, G., 1989. *A Range Extension of the Skink Lerista lineate*. West. Aust. Nat. 17(8).