

Nutrient Management Plan

Keysbrook Mineral Sand Project Keysbrook, Western Australia

Prepared for:

Matilda Zircon Limited



May 2012

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ENVIRONMENTAL

NUTRIENT MANAGEMENT PLAN

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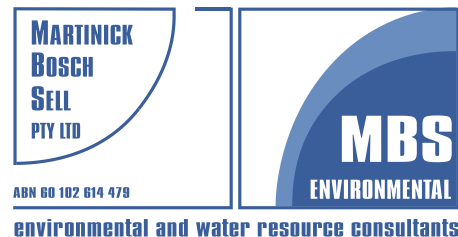


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1. INTRODUCTION

Matilda Zircon Limited (Matilda Zircon) are planning to develop an open cut mineral sand mine and primary processing plant within an area of rural land near the small townships of Keysbrook and North Dandalup (Figure 1). The project area is located within the Peel Harvey catchment of the Swan Coastal Plain. The mining area of 1,354 hectares is located on privately owned land, actively used for grazing.

The project will involve extraction of mineral sands from a series of locations across the Keysbrook mine area. This will require development of shallow pits to access the ore body and construction of a primary processing plant. Ore will be mined by a scraper and screened before being processed. The heavy mineral concentrate (HMC) will be separated from the quartz sand and clay fractions. The quartz sand and clay waste will be returned to the mined areas and the landform will be reinstated to approximately pre-mining contours.

The ore is hosted totally within the superficial (Bassendean sand) profile on the site. The depth of the open pit will range from one to two metres in the flat sandplain locations up to six metres in the undulating dunal rises.

Mining of the Keysbrook mineral sand deposit involves clearing of some remnant native vegetation. The local landscape has already been heavily cleared for agricultural uses.

As the project lies within the Peel Harvey catchment, a Nutrient Management Plan (NMP) is required to ensure that nutrient export from the project area does not increase the nutrient load to the Peel Harvey estuarine system. The Peel Inlet and Harvey Estuary are subject to annual blooms of nuisance algae resulting from leaching of soluble phosphorus and nitrogen from the sandy soils within the catchment area on the Swan Coastal Plain.

1.1 PURPOSE

This NMP has been developed to satisfy the requirements of a condition of approval of the project according to Ministerial Statement 810 pursuant to the provisions of the Environmental Protection Act 1986. The purpose of this NMP is to ensure the proposal assists in meeting the water quality objectives of the Peel-Harvey Water Quality Improvement Plan (EPA, 2008).

According to Ministerial Statement 810, the objectives of this NMP are to:

- Outline a program to monitor nutrient levels within the proposal area and at the downstream boundary of the proposal area.
- Identify nutrient trigger levels consistent with the Peel-Harvey Water Quality Improvement Plan.
- Identify management actions should a trigger level be reached.

Upon approval from the CEO of the Department of Environment and Conservation (DEC), Matilda Zircon shall implement this NMP and make it publicly available (including any revisions).

The primary objective of the NMP is to minimise the export of nutrients, especially phosphorus and nitrogen, from the project area during operational and decommissioning phases of the project.

1.2 RELEVANCE TO OTHER PLANS

As a condition of approval of the project, Ministerial Statement 810 also required the development of a Weed and Dieback Management Plan (WDMP), a Rehabilitation Management Plan (RMP), a Water Management Plan (WMP) and an Acid Sulphate Soils Management Plan (ASSMP). Implementation of this NMP will require consideration of objectives in these other management plans.

In particular, the objectives of the NMP are closely aligned to those of the WMP.

1.3 SITE CLEARING

The total project area is 1,354 hectares. Of this, 1,174 hectares (87%) is open pasture with scattered trees and 180 hectares (13%) is parkland cleared native vegetation ranging from good to completely degraded condition. Of this, 180 hectares, 75 hectares will be protected for conservation in the long term.

Matilda Zircon proposes to clear the remaining 105 hectares of parkland cleared vegetation over an eight year period and to implement a progressive rehabilitation program to ensure no net loss of vegetation in the longer term. The rehabilitation program aims to achieve a net environmental gain over the present situation by consolidating vegetated areas and establishing corridor linkages, in contrast to the fragmentation that currently exists.

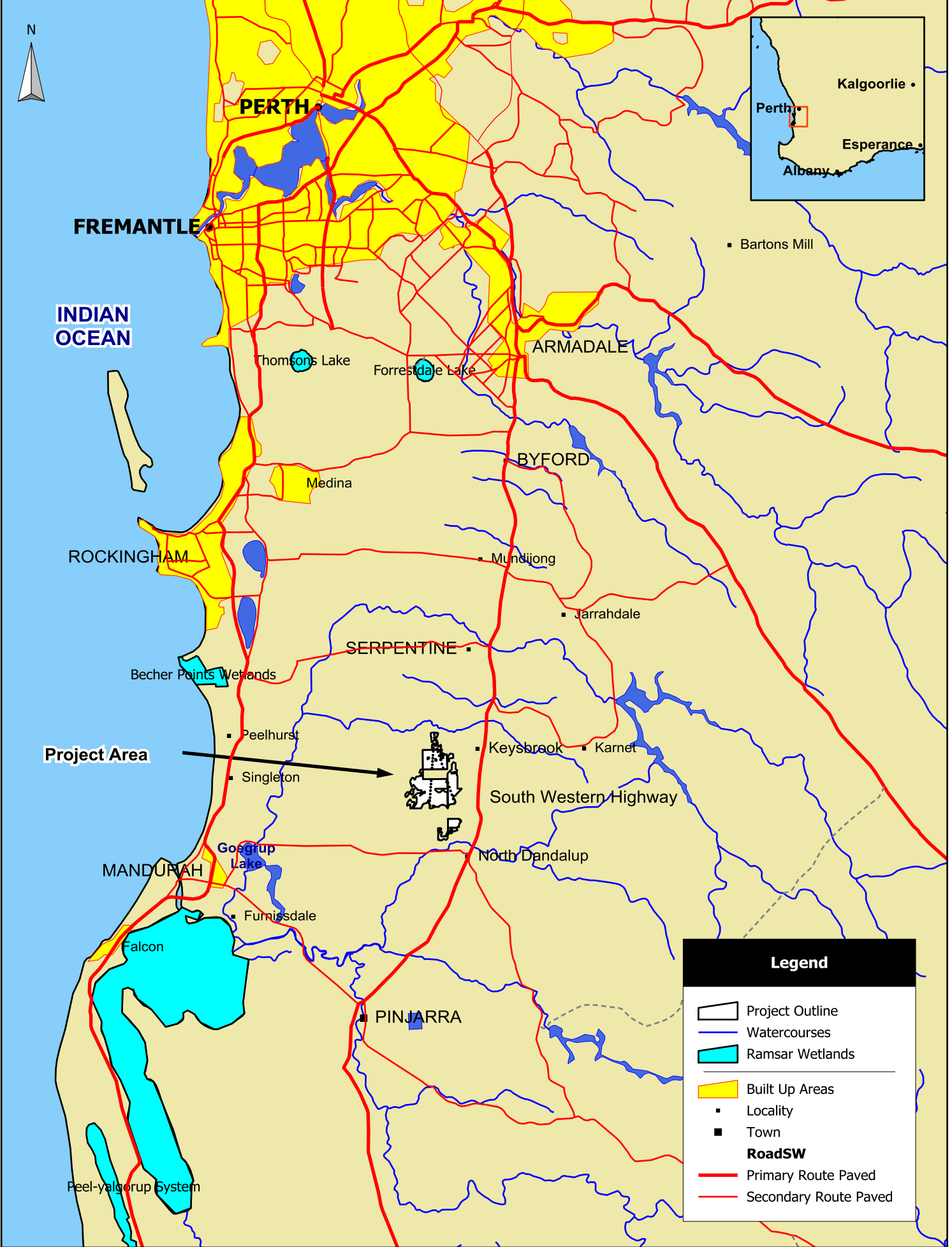
1.4 ANNUAL PLAN AND SCHEDULE

The mining operation is a continuous process, with the rate of movement of the mine cell dependent on the depth of the orebody in a particular location. At an average pit depth of two metres, the mine will advance at approximately 10 to 12 hectares per month.

With 87% of the mine area in existing cleared paddocks, much of the pre-mining preparation work will only involve stripping of pasture and topsoil from the area to be mined.

As a normal part of mine management, a detailed annual mine plan will be prepared. This annual plan is required in order to:

- Detail the location of orebodies, anticipated tonnes and grade and to establish production targets for the year.
- Plan and schedule the rate of movement of the mine cell and relocation of infrastructure required to support the mine extensions.
- Liaise with relevant landowners on the location of activity on individual properties.



2. EXISTING ENVIRONMENT

2.1 REGIONAL SETTING

The proposed mine is situated along the eastern edge of the Swan Coastal Plain approximately 70 kilometres south of Perth, near the small townships of Keysbrook and North Dandalup. It is located two to seven kilometres west of the Darling Scarp and elevation in the area varies between 22 and 48 metres AHD. The topography of the mine area is flat to very gently undulating.

The mining area of 1,354 hectares is located on privately owned rural zoned land. A large portion of the mine area has been cleared for grazing activities. Patches of remnant native vegetation also remain, ranging from stands of trees over pasture grass with little to no understorey to areas of trees with a partially-intact understorey.

2.2 LAND SYSTEMS

The geomorphology of the Swan Coastal Plain comprises a series of accretionary marine deposits eroding a gently dipping Tertiary alluvial surface. The whole marine assemblage is overprinted by Quaternary fluvial and aeolian deposits. On the eastern side of the Swan Coastal Plain the marine deposits and dunes are interlayered with fluvial deposits producing a strongly variable sequence with depth, but broad areas of similar deposits in horizontal layers.

2.3 SOILS

The heavy mineral resource is hosted within the dunes of the Bassendean Sand, which partly covers mottled clayey sand or a pisolitic ironstone-clay unit of the Guildford Formation, also referred to as the Pinjarra Plain. Figure 2 shows the distribution of these soils through the mine area. Table 1 describes the soil types shown in Figure 2.

Table 1: Description of Soil Types

Soil Type	Description
Bassendean Dune and Sandplains	
B1	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than two metres; banksia dominant.
B1a	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands with an intensely coloured yellow B horizon occurring within one metre of the surface; marri and jarrah dominant.
B2	Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan one to two metres.
B4	Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 metres by clay or less frequently a strong iron-organic hardpan.
B5	Shallowly incised stream channels of minor creeks and rivers with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 metres by clay or less frequently a strong iron-organic hardpan.
B6	Sandplain similar to B4 with imperfectly drained deep or very deep grey siliceous sands.
Pinjarra Plain	
P1a	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity.
P1b	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Moderately deep pale sand to loamy sand over clay; imperfectly drained and moderately susceptible to salinity in limited areas.
P1c	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Deep pale brown to yellowish sand to sandy loam over clay; imperfectly drained and moderately susceptible to salinity in limited areas.
P2	Flat to very gently undulating plain with deep alkaline mottled yellow duplex soils which generally consist of shallow pale sand to sandy loam over clay.
P7	Seasonally inundated swamps and depressions with very poorly drained variable acidic mottled yellow and grey sandy duplex and effective duplex soils.
P8	Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline grey and yellow duplex soils to uniform bleached or pale brown sands over clay.
P11	Shallow brown loamy soils or less commonly, very shallow sands over ironstone pavement which is a clear barrier to drainage.

2.3.1 Bassendean Dunes

The dominant soil parent materials within the Bassendean system are highly leached quartzose sands. The more easterly dunes are higher, at up to six metres above the plain level, and better defined. The Bassendean Dunes form a series of subdued low relief dunes, sandplains and intervening swamps adjacent to and partly overlying the finer textured soils of the Pinjarra Plain (Guildford Formation). Some inland movement by wind action has also occurred. The majority of the soils are podzols. Soils in the eastern part of the unit are more severely leached than those to the west. The mine is within the eastern part of the unit.

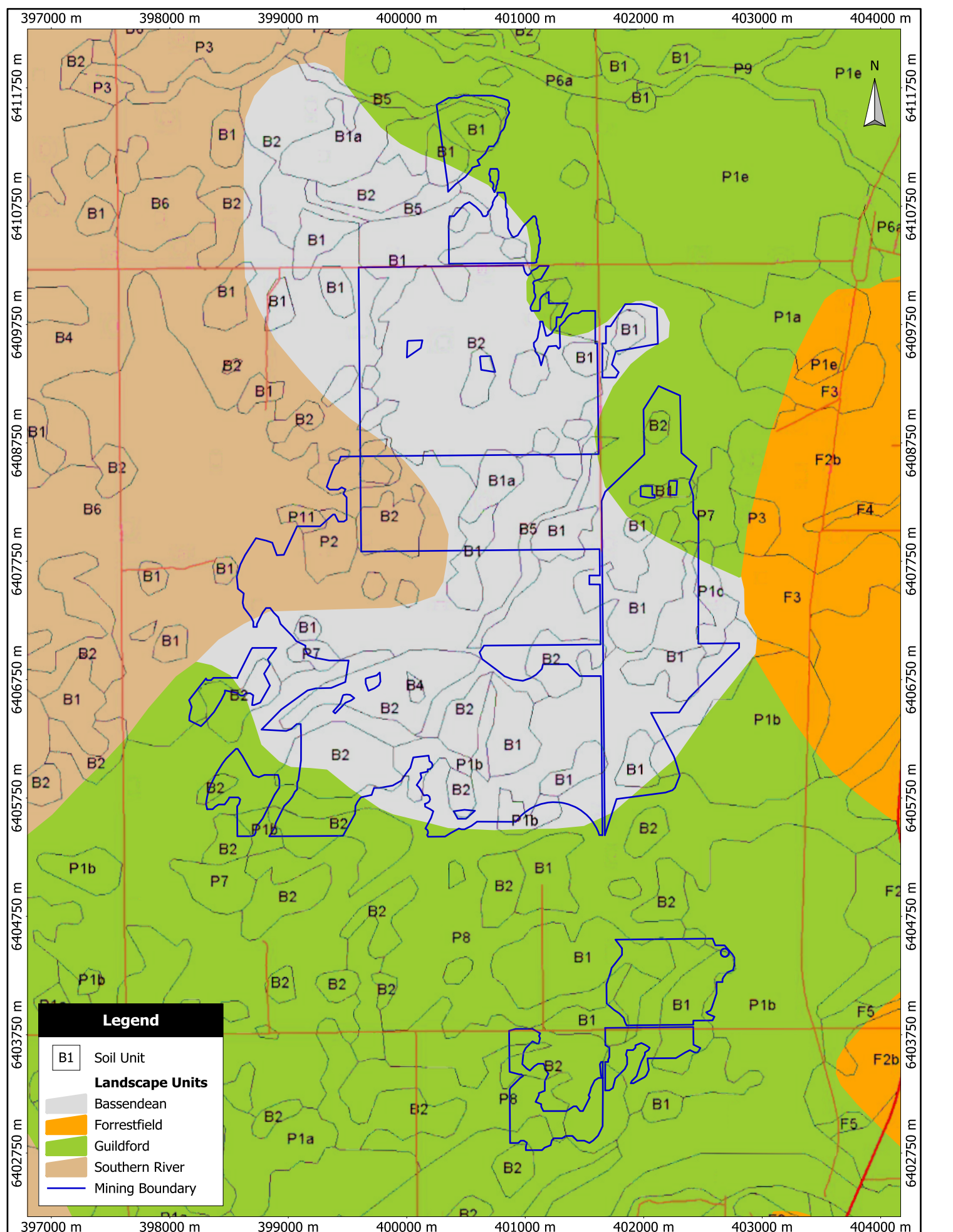
In their natural state, soils within the Bassendean system are extremely infertile and have a limited low stock carrying capacity unless supplemented with fertilisers containing phosphorus, nitrogen, sulphur and potassium. The high silica content results in poor nutrient retention capacity which leads to high losses of mobile nutrients, including nitrate-nitrogen and soluble phosphate, by leaching. Other limitations to high productivity include natural soil acidity and a propensity for being water repellent (hydrophobic).

2.3.2 Pinjarra Plain

The soils of the Pinjarra Plain have largely formed from unconsolidated alluvial material of Tertiary and Quaternary Age. The depositional systems can be grouped into following three main types based on soil parent material:

- The older alluvium occurring in extensive flat plains and forming imperfect to poorly drained soils - mottled yellow duplex soils and mottled yellow or greyish brown gradational earths.
- Fine textured alluvium of generally intermediate age, in areas of lowest relief and forming very poorly drained soils - uniform cracking black grey or yellow-grey clays.
- The youngest alluvium occurring along the major present river systems and forming well to moderately well-drained soils - red duplex or gradational soils and uniform reddish brown loams or earthy sands.

Pinjarra Plain soils are more fertile than the leached sands of the Bassendean system. The higher silt and clay contents provide increased water holding capacity and nutrient adsorption.



3. NUTRIENT EXPORT RISKS

3.1 NUTRIENT EXPORT PATHWAYS

The following pathways for export of nutrients from the project area to the environment have been identified:

- Erosion of organic matter and fine soil particles from topsoil stockpiles.
- Wind erosion of organic matter and fine soil particles from recently rehabilitated land surfaces.
- Removal of nutrients in vegetation by clearing. Although this process will not necessarily result in direct transport of nutrients into the Peel Harvey catchment, it is likely to reduce base saturation of the soil, particularly the poorly buffered Bassendean sands. This may result in soil acidification and hinder rehabilitation efforts.
- Mineralisation of soil organic matter following vegetation clearing and disturbance of topsoil.
- Transport of nutrients from grazing areas to riparian zones in faeces and urine from cattle.
- Inefficient use of chemical fertilisers to maintain or increase livestock production. This may occur by:
 - Selection of inappropriate fertilisers, such as those containing high concentrations of water-soluble phosphorus or other nutrients that are not limiting productivity.
 - Excessive application rates, especially on soils with very low adsorption capacity.
 - Applying water soluble fertilisers immediately before or during high rainfall events.
- Treatment and disposal of waste water including sewage.
- Processing chemicals containing nitrogen or phosphorus compounds.

3.2 SOILS IN THE MINING AREA

According to the map presented as Figure 3 based on information provided by the Natural Resource Assessment Group of the Department of Agriculture and Food, the soil types situated within the project area have a moderate to extremely high risk of phosphorus export. The risk is slightly lower in the southern and eastern sections of the project area in which the soils are dominated by duplex soils of the Pinjarra Plain. The dominant soil types of the north western section are deep sands of the Bassendean dune series. These soils are composed mainly of silica sands, which have very low assimilative capacity for phosphorus.

Composite samples of the sand profile (generally the top two metres) were collected as part of baseline studies to analyse the major nutrients nitrogen (N), phosphorus (P) and potassium (K). The results indicated a very low nutrient bank available in the sand profile of the site.

To provide more detailed information on the potential of an immobile nutrient bank within the Bassendean sand profile that could be mobilised during mining and processing operations, additional soil sampling was undertaken in September 2006. Samples were collected at 0.5 metre intervals and a composite sample for the entire hole. One profile (Hole 1) was sampled to 3.5 metres below ground level on a dunal rise. Two other profiles (Holes 2 and 3) were collected in low lying sand profiles within the water table.

Parameters tested were total phosphorus, Phosphorus Retention Index (PRI), water soluble phosphorus [P (H₂O)] and phosphorus extractable in 0.01 M CaCl₂ [P (CaCl₂)]. The results are presented in Table 2.

The results indicate the following:

- The total phosphorus values are consistent with those reported in the first study.
- The surface layer of Hole 1 has an elevated total phosphorus value which suggests it has received an application of fertiliser at some time.
- The surface layer of Hole 1 has a very low PRI, consistent with the soil characteristics of the B1 unit.
- Consistent with the elevated phosphorus value and the very low PRI, the surface layer of Hole 1 also has the highest water soluble (leachable) value tested.
- There are no other elevated banks of total phosphorus in Hole 2 or 3.
- Holes 2 or 3 have very high PRI values when compared to typical values for Bassendean Sands. This suggests the presence of iron minerals or iron-organic materials in the B-horizon, which are often found in B4 and B5 phases of the Bassendean Sands.
- The composite sample of each hole showed similar results to the individual samples.
- The water soluble values are extremely low, indicating there is no significant leachable fraction.

The total phosphorus values therefore dominantly comprise phosphorus in a form that is not water soluble. It is most likely in forms such as organic material (fine roots) and bound onto clay, iron and aluminium complexes. This phosphorus can only be exported from the site as physical particles (i.e. in sediment) rather than as soluble phosphorus dissolved in water.

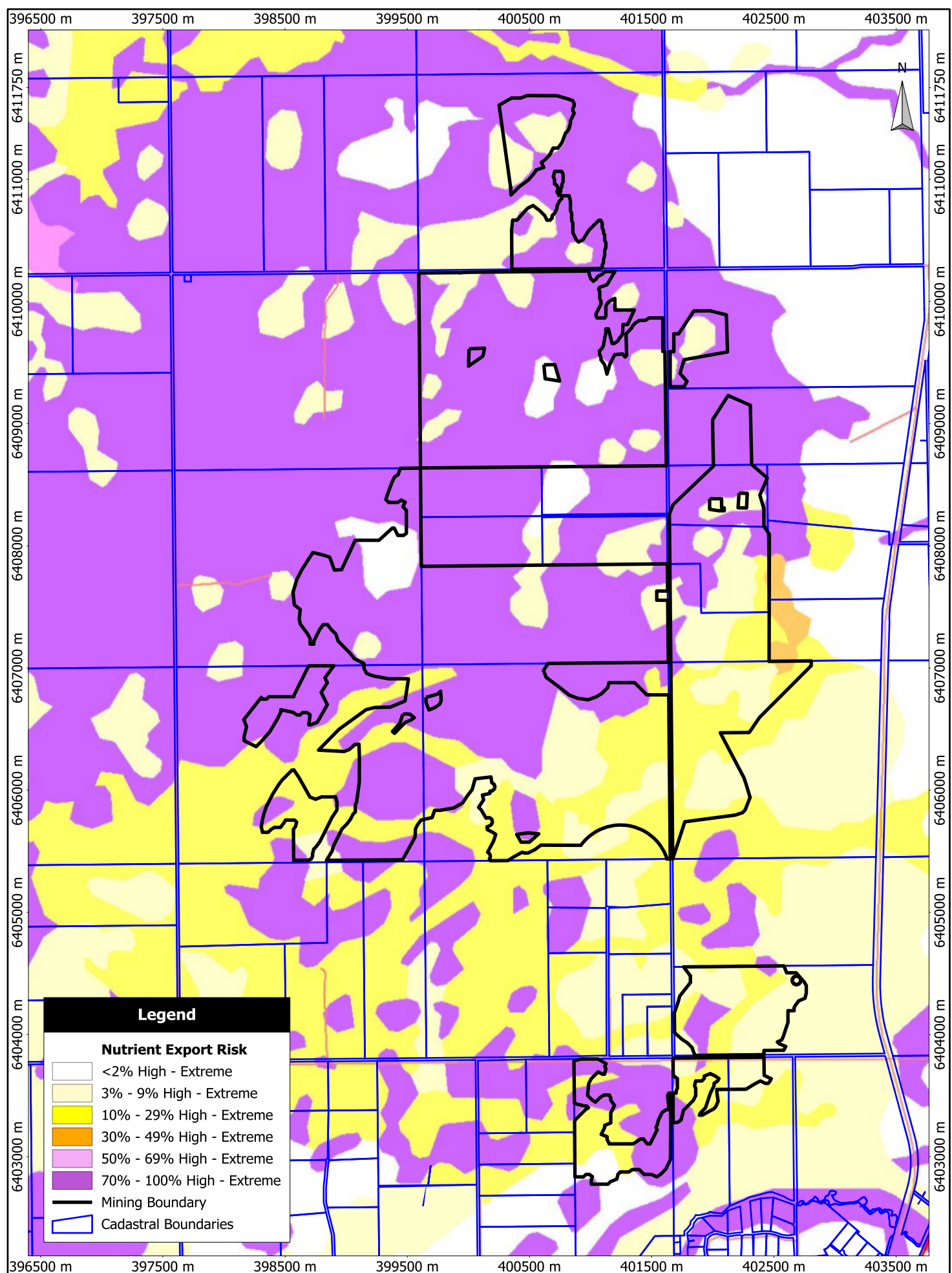
This data is consistent with findings from many studies on the nutrient leaching problems of the sandy coastal plain soils. In summary, these findings are:

- The dominant source of nutrients is from applied agricultural fertilisers.
- The high porosity and poor nutrient retention capability of the sandy soils result in rapid leaching and export of the predominantly water soluble forms of nutrients in fertiliser.
- The majority of this nutrient leaching and transport process occurs in surface water flow and in the surface soil layers.

Sand returned to the mine site after processing will have a higher content of fine particles and iron minerals than the original topsoil as a result of blending with materials from the original B horizon. While this will result in a dilution of nutrients originally stored in the A horizon, the replaced soil will have improved water holding and nutrient retention characteristics. This is expected to increase the production potential for grazing by cattle.

Table 2: Nutrient Analyses of Soils in the Mine Area

Sample Location and Depth (m)	P (total)	(PRI)	P (H ₂ O)	P (CaCl ₂)
	mg/kg	mL/g	mg/kg	mg/kg
H1 0.5	39	2.0	1.5	0.3
H1 1.0	14	3.6	<0.1	0.2
H1 1.5	16	4.6	<0.1	0.2
H1 2.5	18	9.2	0.3	0.2
H1 3.5	19	11	0.1	0.2
H1 Bulk	24	5.3	<0.1	0.2
H2 0.5	22	13	<0.1	0.2
H2 1.0	13	16	<0.1	0.2
H2 Bulk	20	17	<0.1	<0.1
H3 0.5	22	5.7	<0.1	0.2
H3 1.0	17	38	<0.1	0.2
H3 1.5	17	34	<0.1	0.2
H3 Bulk	18	18	<0.1	0.2



4. LAND CLEARING

The Environmental Officer shall be responsible for ensuring the area to be cleared is clearly marked in the field and earthworks operators informed such that only the area proposed for clearing is disturbed.

The Environmental Officer will be responsible for ensuring that a Clearing Register is maintained and that it records:

- The location of all land clearing.
- Total surface area of clearing.
- Type and volume of topsoil removed.
- Dieback status of topsoil removed.
- Location of direct re-application or where topsoil was stockpiled.

The Environmental Officer will be responsible for ensuring that the total area of land cleared is reported in the Annual Environmental Report (AER).

The project will be designed, constructed and operated to minimise the impacts on remnant vegetation and nutrient export by:

- Defining the area to be cleared on maps and supervising clearing activities.
- Ensuring that effective dust control measures are implemented.
- Progressively rehabilitating and monitoring disturbed areas.
- Salvaging millable and firewood timber in Dieback free areas of the site for use prior to land clearing occurring.
- Stockpiling vegetation from Dieback free areas to be cleared not useful for millable or firewood purposes for later use in rehabilitation. Vegetation stockpiles will be located adjacent to cleared areas.
- Stockpiles of vegetation from known Dieback infected areas will be burned and not used for rehabilitation. Phosphorus in the resulting ash is expected to be present in a highly insoluble form. Most of the nitrogen will be volatilised.
- Topsoil will be recovered and stockpiled separately from vegetation areas, or where possible replaced immediately on backfilled areas ready for rehabilitation. The Site Manager shall be responsible for ensuring that topsoil stockpiles are:
 - No greater than two metres high.
 - Located away from water inundation or vehicle traffic.
- A topsoil stockpile register shall be maintained by the Environmental Officer.

5. SOIL AND VEGETATION NUTRIENT MANAGEMENT

The RMP provides a detailed discussion of the rehabilitation process. To summarise, the rehabilitated landform will be similar to pre-mining levels, but not always identical. In most locations, post-mining landforms will be similar to existing (pre-mining) contour levels. In other locations variations in surface levels between active mining areas and backfill locations will mean some difference in post-mining levels. In all cases, the post-mining ground level will re-establish pre-mining regional surface drainage.

Land rehabilitation will consist of landform and soil profile restoration. Restored surfaces will be stabilised with vegetation, in most instances pasture. Rehabilitation will also include protection and enhancement of remnant vegetation as well as the establishment of shelter belt plantings and more complete communities of native vegetation within the mine site.

5.1 LANDFORM RESTORATION

Waste materials from the plant are returned to the mined out areas to reform land for post mining land use. The quartz sand component of the waste (about 90% by volume) is mixed with the thickened clay component from the thickener (about 8% by volume) and pumped to backfill the mined out areas. A proportion of the thickened clay may be pumped into shallow dams on top of the backfilled sand to add extra clay at the surface of the re-contoured area. As a result of the waste material return process, the post mining soil characteristics will have altered and are likely to have increased moisture and nutrient retention characteristics.

Earthworks will be undertaken to return the completed mine area to as close as possible to pre-mining levels, but recognising that some minor changes to existing topography will occur. The restored landforms will be shaped to direct surface drainage towards existing major creek lines running through the mine area. The restored mine landform will not create drainage barriers that result in localised flooding in areas not previously subjected to water inundation.

Where necessary, temporary erosion control measures will be implemented to minimise water erosion of restored landforms prior to establishment of a stabilising vegetative cover. This may include construction of shallow contour banks, sumps and drains in the first year of rehabilitation to prevent scouring and release of suspended sediments and associated nutrients to natural waterways. With the stabilisation of the landform by pasture species or native vegetation after the first year, these temporary structures will be removed during the second year's pasture reseeding process.

Risk of wind erosion will be reduced by scheduling earthmoving for landform restoration, as far as is practically possible, to periods when the soil is moist. Cover crops, binding agents or mulches will be used where necessary to minimise dust emissions until more favourable conditions prevail for vegetation establishment.

5.2 REVEGETATION

Land access and compensation agreements are required in order for Matilda Zircon to conduct mining operations on each property. Matilda Zircon may also purchase properties in the mine area. Individual landowners have agreed on the rehabilitation strategy for their property.

Although several types of vegetation will be established during rehabilitation, the majority of the land disturbed by mining activities will be returned to pasture. Methods of establishing and assessing success of rehabilitation will vary with vegetation types. These are described in further detail below. Wherever possible, revegetation with native species will be focused on the deeper Bassendean sands, while restoration to grazed pasture will be more successful on the duplex sandy soils of the Pinjarra Plain.

5.2.1 Pasture

Topsoil from agricultural lands affected by mining operations consists mainly of a thin organic rich A-horizon over deep grey sand in Bassendean sand or sandy clay loam B-horizons in the Pinjarra Plain duplex soils. These areas will be rehabilitated to pasture. Pasture will be sown mechanically into the restored landforms using standard agricultural machinery. Consultation will occur with the landowner and the Department of Agriculture and Food (DAF) on the appropriate pasture species in particular areas, seeding rates, fertiliser types and application rates.

The use of fertilisers on agricultural land on the Swan Coastal Plain is expected to become highly regulated when the Fertiliser Action Plan (FAP) is implemented by the Western Australian Government in the near future. This NMP adopts the principles of the FAP as summarised below:

- Selection of appropriate fertilisers and application rates will be based on results from soil testing.
- No fertiliser will be applied if the pH of the soil (as measured by extraction in 0.01 M CaCl₂) is below 4.5. If it is decided to grow pastures on such acidic soils, application of two tonnes of agricultural lime per hectare will be required to increase the pH above 4.5.
- Recommendations for application rates of phosphatic fertilisers will be based on use of a recognised calibrated soil test for plant-available phosphorus (such as the Colwell, Olsen or Mehlich-3 tests) and a measure of phosphate adsorption capacity of the soil. Recognised tests for phosphate adsorption capacity by commercial soil testing laboratories in Western Australia are the Phosphorus Retention Index (PRI) and Phosphorus Buffering Index (PBI).
- Recommendations for application rates of nitrogenous fertilisers will be based on use of recognised Decision Support Systems developed in Western Australia. Decision Support Systems based on soil test results typically require analysis of the soil for organic carbon and mineral forms of nitrogen (ammonium and nitrate forms of extractable nitrogen).
- All soil samples will be tested for plant-available potassium and sulphur to determine if these nutrients need to be supplied by fertilisers.
- Fertiliser application rates based on soil testing will be calculated by recognised Decision Support Systems developed in Western Australia for low production livestock grazing enterprises.
- If application of phosphatic fertilisers is indicated, preference will be given to 'slow release' formulations rather than water-soluble fertilisers such as superphosphate.
- Fertilisers will only be applied in autumn, preferably before the onset of winter rainfall.

- Symptoms of nutrient deficiencies, toxicities or imbalances in pastures or native plants will be confirmed by tissue testing for major and minor nutrients (nitrogen, phosphorus, potassium, calcium, magnesium, sodium, sulphur, boron, copper, iron, manganese, molybdenum and zinc).

Grazing of re-established pastures will be minimised during the first and second years to allow plant establishment and seed set. Reseeding will also occur in the second year to ensure full establishment of pasture to sustain grazing and be self-sustaining by natural seeding.

It is anticipated that pasture areas will be fully returned to the landowner for recommencement of normal grazing activities after the two year reseeded process.

It has been demonstrated in other mineral sand mines operating in sandy soils that recombine clay, which has been separated during the process, back into the top of the soil profile improves the water and nutrient retention ability of the soil, overcomes the problem of non-wetting (hydrophobic) soils and reduces the potential for erosion. This improves the quality of pasture on the completed mine areas. The Environmental Officer will ensure that any clay materials used for soil amendment (that is, clay contained within the shallow dams) will be tested for acidity (pH) and the presence of any acid producing sulphide minerals such as pyrite.

Apart from the use of clay residues produced by the project, there is no requirement for application of other soil amendment materials such as bauxite residue ('red mud'), compost or animal manures.

5.2.2 Native Vegetation

Nutrient requirements of native vegetation are significantly lower than those of pasture for grazing by livestock. However, revegetation by native plants may be accelerated by application of low rates of fertilisers or liming materials, especially on impoverished sandy soils following disturbance of topsoil, blending with subsoil materials during processing or clearing of vegetation.

The Environmental Officer is responsible for ensuring soil testing is undertaken prior to revegetation of areas using native plant species. If required, application rates of fertiliser or agricultural lime will be determined using the procedures described in Section 5.2.1.

5.3 GRAZING PROTECTION FOR REHABILITATED AREAS

The Environmental Officer is responsible for ensuring that rehabilitation areas planted with native vegetation and riparian zones are fenced to prevent access by stock and associated transport of nutrients in faeces and urine.

6. OTHER NUTRIENT SOURCES

6.1 PROCESS CHEMICALS

The beneficiation process uses gravity separation as the means to extract the heavy mineral concentrate from the quartz sand. The only chemical used in the process is a flocculant to remove suspended clays from process water. The flocculant used in the process is a polyacrylamide, which contains some nitrogen. Nitrogen in polyacrylamide polymers is very stable and can only become mobilised by microbial degradation. The contribution of nitrogen from flocculants to the total soil nitrogen pool is insignificant.

6.2 WASTE WATER AND SEWAGE

The Environmental Officer will ensure that a biocycle sewerage system is used for the processing plant site and administration office ablutions. This will be designed, located and operated in compliance with the requirements of the Health Department of Western Australia and the local Shire. The system treats sewage effluent before discharging treated water to a contained area, which will be elevated to ensure a minimum two metre separation distance to the water table is maintained.

The proposed waste treatment system has been specifically designed with consideration of potential of nutrient leaching in sandy soils with shallow water tables. The system contains an amended soil with a high capacity for removing phosphate by surface adsorption.

Discharge of treated water will be conducted in accordance with Water Quality Protection Note 22 (WQPN22) provided by the Department of Water (DoW, 2008). According to Table 1 of WQPN22, the Risk Category based on soil type and location is Category A. This restricts the annual application loadings of inorganic nitrogen and reactive phosphorus to 140 kilograms of nitrogen per hectare per year and 10 kilograms of phosphorus per hectare per year.

7. MONITORING

7.1 LOCATIONS FOR SOIL AND WATER MONITORING

7.1.1 Water Quality Monitoring

Regular monitoring will be required to demonstrate that mining operations do not adversely affect groundwater and surface water quality.

The Environmental Officer will be responsible for ensuring that regular water samples are collected from shallow groundwater monitoring bores and surface draining lines as shown in Figure 4 and Figure 5. Descriptions of these sampling locations, testing frequency and quality parameters are presented in the Water Management Plan for the project.

Nitrate-nitrogen, soluble phosphorus and total phosphorus will be included as quality parameters for water samples collected from these sites as indicators of nutrient export.

7.1.2 Soil Quality Monitoring

The Environmental Officer will be responsible for ensuring soil samples are taken from areas where landform restoration for return to pasture has occurred prior to any revegetation works proceeding. The soil samples will be analysed to determine whether fertiliser or other soil amendments are required and, if so, suitable application rates. The analysis required for such samples is as described in Section 5.2.1.

The Environmental Officer will be responsible for ensuring soil samples taken for the purposes of determining the need for soil amendments prior to revegetation are also analysed for the standard contaminated sites suite of elements (DEC, 2010). This typically includes antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, tin and zinc.

7.2 TRIGGER VALUES

7.2.1 Water Quality

A target set by Peel-Harvey Water Quality Improvement Plan (EPA 2008) is to reduce the median winter concentration of total phosphorus in major rivers and drains with the Peel-Harvey catchment below 0.1 milligrams per litre. Matilda Zircon will adopt this value as an interim 'trigger value' for monitoring the effectiveness of nutrient management within the project area.

It is recognised that total phosphorus concentrations may exceed 0.1 milligrams per litre at upstream boundary of the project area as a result of nutrient management practices adopted by other land managers in the catchment area. For this reason, Matilda Zircon will compare water quality for upstream and downstream boundary monitoring locations. Management responses will be triggered under the following circumstances:

- Phosphorus concentrations at the downstream boundary surface monitoring location exceed the corresponding upstream locations by more than 10%.
- Phosphorus concentrations at the downstream boundary groundwater monitoring location exceed the previous result at that location by more than 10%.

The Australian and New Zealand Guidelines for Fresh and Marine Quality (ANZECC 2000) provide three potential ‘trigger values’ that may be appropriate for this particular project and environment. They are:

- The Australian Drinking Water Guideline (ADWG) value of 50 milligrams per litre as nitrate (NO_3).
- Protection of natural freshwater ecosystems in southwest Australia (lowland). The ‘trigger value’ is 150 micrograms per litre as nitrate-nitrogen ($\text{NO}_3\text{-N}$).
- The livestock drinking water quality guideline of 400 milligrams per litre as nitrate (NO_3).

As the surface and groundwater at the project site does not constitute a ‘natural freshwater ecosystem’ and nitrate concentrations at the ADWG or livestock drinking water quality guideline are much higher than levels required for algal blooms, these ‘trigger values’ were not considered appropriate. For this reason, Matilda Zircon will compare water quality for upstream and downstream boundary monitoring locations. Management responses will be triggered under the following circumstances:

- Total nitrogen and nitrate-nitrogen concentrations at the downstream boundary surface monitoring location exceed the corresponding upstream locations by more than 10%.
- Total nitrogen and nitrate-nitrogen concentrations at the downstream boundary groundwater monitoring location exceed the previous result at that location by more than 10%.

Water quality and groundwater level Trigger Levels and Contaminant Limits are presented in Appendix 3 of the Water Management Plan.

7.2.2 Soil Quality

The Environmental Officer will be responsible for comparing soil results with the relevant reference materials listed in Section 5.2.1 to determine the need for fertiliser or other soil amendment application.

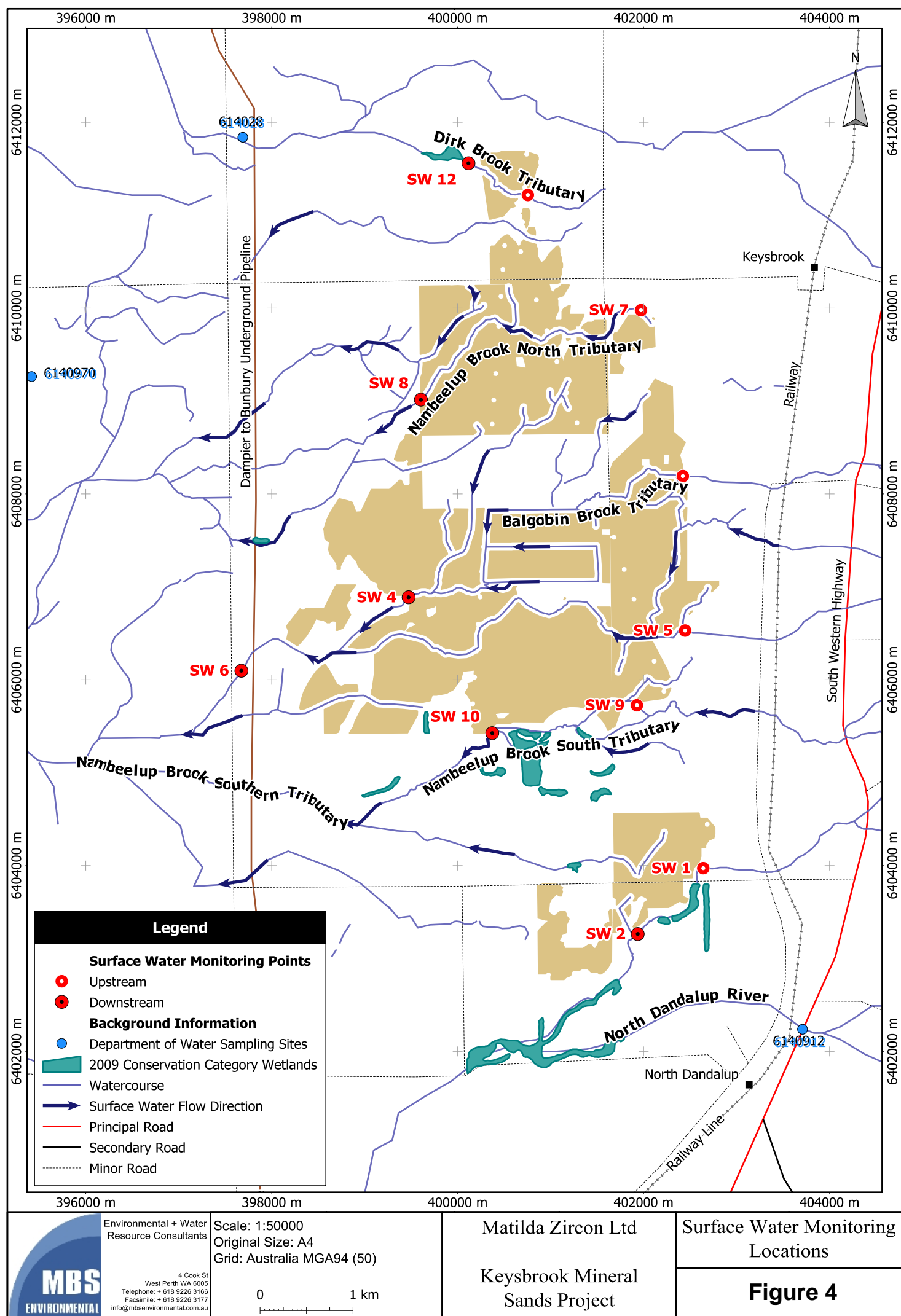
Soil from the designated irrigation site for disposal of treated water from the biocycle sewerage system will be sampled annually and analysed for total nitrogen and phosphorus by a NATA accredited laboratory. The sampling depth will be 0 to 100 millimetres.

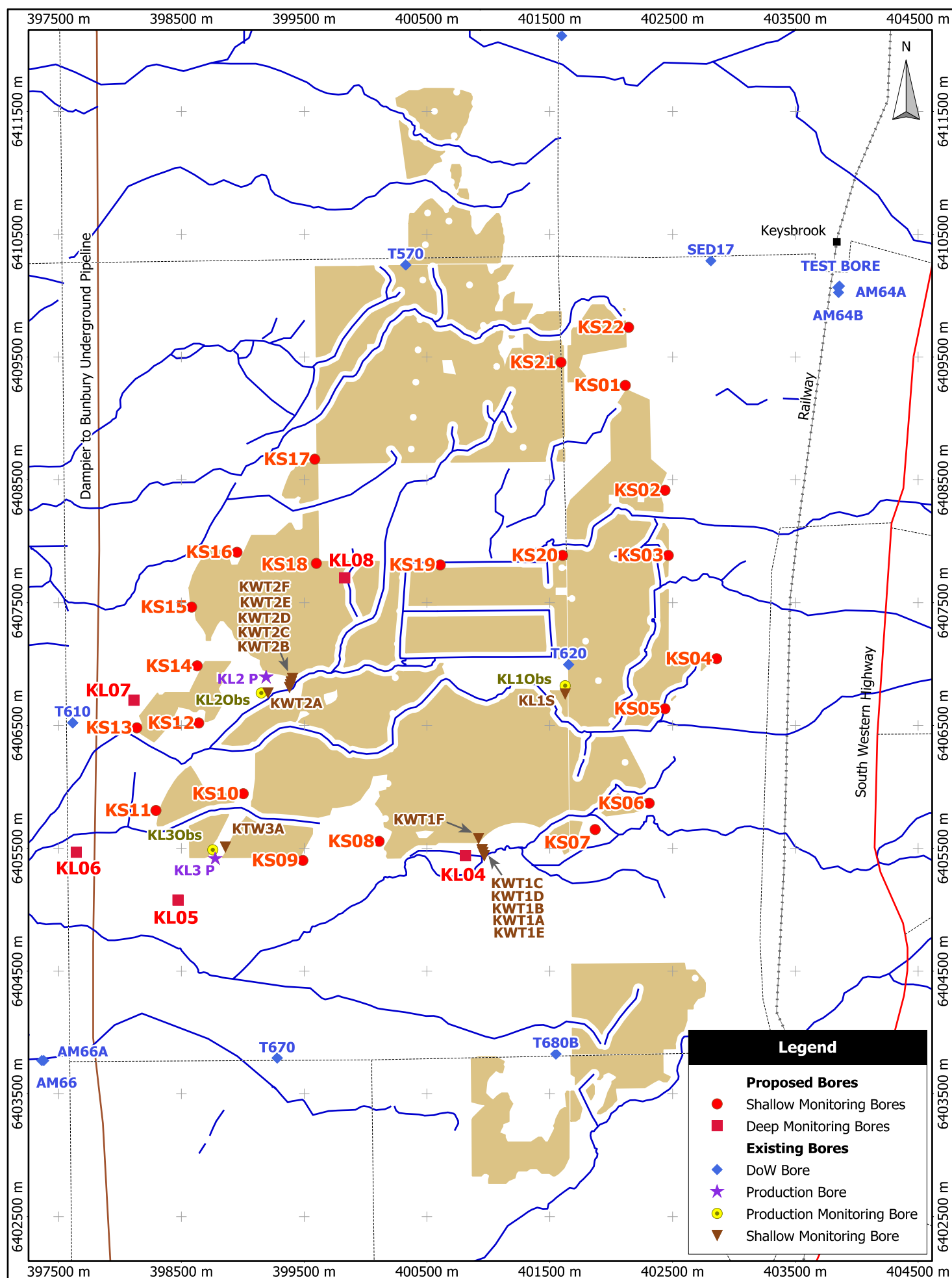
The Environmental Officer will be responsible for comparing the soil analysis results with the Environmental Investigation Limits (EIL) contained in the Department of Environment and Conservation Contaminated Lands Series information (DEC, 2010).

7.3 MANAGEMENT ACTIONS

If a water quality trigger value for nutrients (Appendix C of Water Management Plan) or soil metal concentrations is exceeded, the Environmental Officer will be responsible for ensuring the following actions are taken:

- The Site Manager is advised.
- Confirming the test results by collecting additional samples from locations at which the trigger values were exceeded and where relevant corresponding upstream locations.
- If the results from the additional analyses confirm exceedance of the trigger values, then:
 - Reviewing any recent mining or rehabilitation activities that may be responsible for nutrient mobilisation or elevated metal concentrations.
 - Checking fencing to ensure animals have no access to waterways.
 - Checking stockpiles of soil or mulched organic material to ensure they are stable.
 - Undertaking additional soil and water testing to identify the source of excess nutrients or elevated soil metals.





8. RECORDS, REVIEW AND REPORTING

The Environmental Officer is responsible for recording the results of water and nutrient monitoring conducted on site. In addition to management items specified in the WMP and RMP, records will need to be maintained for the following activities to ensure compliance with the NMP:

- Laboratory soil test reports.
- Reports provided by suitably trained agronomists for fertiliser application rates.
- Any fertiliser or soil ameliorant applied.

The Environmental Officer is responsible for ensuring that the NMP is reviewed annually and amended if necessary to ensure that it remains relevant, practical and effective.

The Environmental Officer is responsible for ensuring that all results for soil and groundwater monitoring undertaken in the year are included in Matilda Zircon's Annual Environmental Report (AER) for DEC. The AER will also present the findings from any related investigations resulting from exceeding relevant trigger levels. The report will propose any amendments to the NMP.

9. RESPONSIBILITIES

9.1 SITE MANAGER

The Site Manager is responsible for ensuring topsoil stockpiles are no greater than two metres high and are located away from water inundation or vehicle traffic.

9.2 ENVIRONMENTAL OFFICER

The Environmental Officer is responsible for:

- Ensuring the area to be cleared is clearly marked in the field and earthworks operators informed such that only the area proposed for clearing is disturbed.
- Ensuring that a Clearing Register is maintained and that it records:
 - The location of all land clearing.
 - Total surface area of clearing.
 - Type and volume of topsoil removed.
 - Dieback status of topsoil removed.
 - Location of direct re-application or where topsoil was stockpiled.
- Reporting the total area of land cleared in the Annual Environmental Report (AER).
- Maintaining a topsoil stockpile register.
- Testing any clay materials used for soil amendment for acidity (pH) and the presence of any acid producing sulphide minerals such as pyrite.
- Ensuring soil testing is undertaken prior to revegetation of areas using native plant species.
- Ensuring that rehabilitation areas planted with native vegetation and riparian zones are fenced to prevent access by stock and associated transport of nutrients in faeces and urine.
- Ensuring soil samples are taken for areas to be revegetated to pasture prior to any revegetation works taking place. The soil samples are required to be tested for a range of nutrients and metals as described in Section 7.1.2.
- Ensuring that regular water samples are collected from existing shallow groundwater monitoring bores and surface draining lines. The sampling frequency for nutrient testing is identical to that for other water quality parameters listed in the WMP.
- Ensuring soil samples are collected from the treated waste water irrigation area.

- Undertaking the following actions if a water quality trigger value for nutrients (Appendix C of Water Management Plan) or soil EIL is exceeded:
 - The Site Manager is advised.
 - Confirming the test results by collecting additional samples from locations at which the trigger values were exceeded and where relevant the corresponding upstream locations.
 - If the results from the additional analyses confirm exceedance of the trigger values, then:
 - Reviewing any recent mining or rehabilitation activities that may be responsible for nutrient mobilisation or elevated metal concentrations.
 - Checking fencing to ensure animals have no access to waterways.
 - Checking stockpiles of soil or mulched organic material to ensure they are stable.
 - Undertaking additional soil and water testing to identify the source of excess nutrients.
- Undertake annual review of the NMP.

10. REFERENCES

ANZECC 2000. National Water Quality Management Strategy. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council. Agriculture and Resource Management Council of Australia and New Zealand.

Department of Environment and Conservation (DEC). 2010. *Assessment Levels for Soil, Sediment and Water*. Contaminated Sites Management Series. Government of Western Australia. Perth.

EPA. 2008. Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System - Phosphorus Management. Environmental Protection Authority, Perth, Western Australia.