21. Geology, soils and contamination

21.1 Overview

This section summarises the geological conditions and soil profile which exist in the study area and the effects of the project on existing site conditions with respect to erosion potential, site contamination and acid sulfate soils. Management of these issues during the planning, design, construction and operational phases of the project are also addressed.

Current conditions were established through a combination of desktop analyses and site walkover as well as a review of previous reports relevant to the study area. A large scale intrusive geotechnical investigation and assessment will be undertaken in the area of the project and a detailed contamination assessment is planned for the medium and high risk sites where relevant.

21.2 Methodology

The assessment of geology, soils and site contamination in the region has been based on:

- review of published soils and geological literature, including the information from the Department of Water, Land and Biodiversity Conservation web-based Drill Hole Enquiry System
- review of a previous preliminary desktop report *North–South Corridor: Port River Expressway to Grand Junction Road, Preliminary Geotechnical Assessment* Ref GSO 1277/1, dated December 2008
- review of a previous preliminary geotechnical investigation report *North–South Corridor: Port River Expressway to Grand Junction Road, Preliminary Geotechnical Investigation* Ref GSO 1277/2 dated April 2009
- a source-pathway-receptor model was applied to high risk sites identified in previous reports which involved acid assessing the potential for migration of contaminants onto the site. Further work to assess the medium and high risk sites and local road network is currently being undertaken.

21.3 Legislative and policy requirements

21.3.1 Commonwealth and state legislation

Table 21.1 summarises key Commonwealth and state legislation relevant to site contamination issues associated with the project.

Table 21.1 Commonwealth and state legislation

Legislation	Description	Relevance to project
Environment Protection Act 1993 (SA) and *Environment Protection (Site Contamination) Amendment Act 2007* (SA)	This Act is the overarching environmental legislation that deals with the protection of the environment and environmental offences. The Act is administered and enforced by the South Australian Environmental Protection Authority. In relation to pollution the Act requires a 'duty of care' in relation to polluting activities and states that breaches include: *Causing serious or material environmental harm or an environmental nuisance by polluting the environment'* and *failing to inform the Environmental Protection Authority of an incident that has caused, or threatens to cause serious or material environmental harm as soon as reasonably practicable.*	Construction and operation of the proposed road network must comply with the Act. This includes the prevention of environmental harm as detailed in Part 4 Section 25 of the Act. The Amendment Act assigns responsibility for site contamination, establishes a statutory audit system for South Australia and gives the Environment Protection Authority (EPA) powers to deal with site contamination.
Development Act 1993 and *Planning Advisory Notice 20/02 (PAN 20)*	This Act covers planning processes for sites. A key responsibility of the planning authority is to ensure that a site is suitable for its intended use and does not pose an unacceptable risk to human health or the environment, taking into account the proposed use of the site.	Development must be undertaken in accordance with the Planning Act which requires suitable land use and the advisory notice of 2001 which reminds planning authorities of their responsibilities in relation to addressing site contamination through the Development Plan Amendment process
National Environmental Protection (Assessment of Site Contamination) Measure (NEPM) (Australia)	This Measure provides a national approach to site contamination assessment *and forms an Environment Protection Policy under the Environment Protection Act.*	Assessment of site contamination will require comparison to NEPM guidelines to determine the contamination status.
Stormwater Pollution Prevention Code of Practice for Local, State and Commonwealth Government	The Stormwater Pollution Prevention Code of Practice for Local, State and Commonwealth Government (EPA 1998) is intended to inform government agencies and their contractors of their 'general environmental duty' with respect to stormwater under the Environment Protection Act 1993. The code provides for the preparation of a soil erosion and drainage management plan (SEDMP) where there is a risk of significant sediment pollution to adjoining lands or receiving waters.	Construction and operation of the proposed road network must comply with the Code. The preparation of an SEDMP may be required to address any significant sediment pollution.

21.4 Existing conditions

21.4.1 Physical environment

The proposed road corridor consists of approximately 4.8 kilometres length of South Road from the Port River Expressway to Regency Road, with a number of modifications to the local road network. The proposed road improvement solution includes a elevated roadway that will be raised above the existing alignment of South Road. The study area is predominantly industrialised between Port River Expressway and Days Road, with an east to west running Australian Rail Track Corporation (ARTC) rail line positioned to the south of South Terrace. Between Days Road and Regency Road, a golf course bounds the Site to the west, with more industrial type buildings positioned to the east.

The land surface where the South Road Superway will be constructed slopes gradually from approximately four metres Australian Height Datum (AHD) at Regency Road to two metres AHD where it connects with the Port River Expressway and Salisbury Highway.

Two differing geomorphic zones have been identified in the area between the Port River Expressway and Regency Road.

North of Grand Junction Road, the South Road Superway lies in the Coastal Plain geomorphic unit, which is characterised by low lying land underlain by marine and estuarine soils. The sub-surface profile is expected to contain shallow, saline groundwater and to include coastal acid sulfate soils.
The Coastal Plain encompasses inter-tidal mangrove flats and supra-tidal samphire flats. The western limit of the Coastal Plain is bounded by Gulf St Vincent and the northern limit of the Coastal Plain, with respect to the Site, is bounded by the North Arm. The eastern and southern limits of the Coastal Plain are approximately defined by the 6 metres AHD contour. The Coastal Plain is near flat (typical surface gradients of less than 0.2 %) and is subject to periodic stream and marine flooding where the land is not protected by levee banks.

In the general area of the study area, a significant proportion of the original land in the Coastal Plain has been altered by drainage, filling and/or levee bank construction to allow for industrial development. Prime examples of this adjacent to the northern end of the South Road Superway are the Cheetham Salt crystallisation pans and the Barker Inlet Wetlands.

From around Grand Junction Road and southward, the South Road Superway lies in the Lower Alluvial Plain geomorphic unit, which is characterised by land that is slightly more elevated than the land to the north, and which is underlain by alluvial soils representing outwash fan deposits from the major stream lines. Groundwater is expected to be deeper and less saline than for the land to the north, and coastal acid sulfate soils are not generally expected to be present.

The Lower Alluvial Plain is bounded by the Coastal Plain to the west and north and by the Para Fault Zone to the east. The Lower Alluvial Plain is quite flat (typical surface gradients of 0.2 to 0.4 %). Much of the land in the Lower Alluvial Plain has been developed for industrial use, with industrial lots present on each side of South Road.

The South Road Superway does not cross any major drainage lines, but its northern end terminates near the Barker Inlet Wetland and North Arm Creek. In addition, an open drain runs north along the side of the South Road Superway and discharges into the Barker Inlet Wetlands. This drain is present on the west side of the South Road Superway between Salisbury Highway and Senna Road and is present on the east side of the corridor south of Senna Road to Grand Junction Road. South of Grand Junction Road the open drain is absent and stormwater drainage is provided by a large buried culvert. It is known that the existing formed open drain was originally a natural drainage line, and that its alignment has shifted westwards several times in the past to accommodate the existing South Road construction.

21.5 Geology and regional soils

21.5.1 Geology

A summary of the expected geologic conditions in the Coastal Plain and Lower Alluvial Plain geomorphic zones are presented in **Table 21.2**. The project area geology is shown on **Figure 21.1**, which is based on geological maps of 1:50,000 scale published by the Department for Primary Industries and Resources, South Australia.

According to the geological map, two differing surficial geological types are expected. To the north of Grand Junction Road, Holocene aged St Kilda Formation soils are expected, whilst at Grand Junction Road and southwards, Pleistocene aged Pooraka Formation soils are expected.

Table 21.2. Summary of expected geological conditions

North of Grand Junction Road (coastal plain)	Grand Junction Road and southwards (lower alluvial plain)
St Kilda Formation	Pooraka Formation
Glanville Formation	
Hindmarsh Clay	

The Holocene aged St Kilda Formation consists of a variety of sedimentary materials derived from marine beach, coastal dune, estuarine and backbarrier lagoonal environments of deposition. The St Kilda Formation sediments in the project area were deposited in an estuarine environment and are highly variable. They range from silts, clays and muds to variants rich in organics, shell and sand. The main facies expected to underlie the South Road Superway are the estuarine and lagoonal facies. The soil types forming these facies are black to grey to blue-green in colour, and in composition they range from silts and clays to organic layers including peat and fibrous beds, shelly layers and sands. The soils are soft where clayey, loose where sandy, and highly compressible. Shallow saline groundwater is associated with these soils, which also have a fetid odour and acid sulfate potential. The total thickness of St Kilda Formation may vary from less than 1 metre to nearly 10 metres.

- Study Area
- South Road Superway
- Qhc, Saint Kilda Formation
- Q, Undifferentiated Quaternary aeolian sediments
- Qp, Undifferentiated Pleistocene calcrete
- Qpa, Pooraka Formation

Regional Geology

Figure 21.1

The Glanville Formation consists of marine, grey shelly sand, varying to sandy marl and sandy clay and underlies the St Kilda Formation. The sands are generally loose and uncemented, but the upper portion is often calcreted (or lime impregnated) and oxidised to a variable degree due to its exposure as a land surface during the low sea levels of the last glaciation. Usually the thickness of the Glanville Formation is not more than several metres. The soils generally have low strength except where cemented. The groundwater system present in the Glanville Formation is only partially confined and thus has a similar phreatic surface to the groundwater system in the overlying St Kilda Formation.

Underlying the Glanville Formation is the Pleistocene aged Hindmarsh Clay. This material is predominantly mottled red brown, yellow brown and grey clay but is often sandy, silty, micaceous or gravelly, and it contains lenses of these materials where fluvial influences have been pronounced. The clay layers are generally stiff to hard, but often have lower strength near the top of the unit due to weathering and/or the presence of a watertable in the overlying sediments. Relict soil horizonation and cyclic layers of carbonate segregations (containing pisoliths, nodules and concretions) are common in the upper 1–3 m, probably indicating past surficial pedogenic processes. West of the Para Fault, in the area of the project, the Hindmarsh Clay exceeds 50 metres in thickness. Alluvial units, consisting of sand, gravel and boulder lenses, strings and zones, are common in the Hindmarsh Clay, with ephemeral and permanent aquifers limited to these units.

From Grand Junction Road and southwards, sediments of the Pooraka Formation are present. The Pooraka Formation is a typical piedmont slope deposit of alluvial origin, consisting of sandy clay and clayey to sandy silt, with interbeds and layers of clay, sand, gravel, pebbles, cobbles and boulders. The clayey strata in the unit are typically stiff. Numerous layers rich in carbonate silt and carbonate segregations also occur in the Pooraka Formation. The material has been dissected by Holocene erosion and therefore exhibits variable thickness. However, in general terms the Pooraka Formation ranges from less than 0.1 metres to about 8 metres thick. The Pooraka Formation includes clays of low to extreme plasticity, silty materials of low to very high plasticity, well sorted and gap-graded sand and gravels and cyclic mixes of the these materials. The presence of sandy lenses means that sharp changes in soil lithology over short distances can occur in the Pooraka Formation. Perched watertables are known to occur in the Pooraka Formation and may yield large quantities of potable to brackish water. These are associated with sandy and gravelly lenses representing former, now buried drainage lines.

Except for the northern fringe of the Lower Alluvial Plain where the Glanville Formation may be present, the Pooraka Formation directly overlies the Hindmarsh Clay.

21.5.2 Regional soils

The soils in the study area consist of two distinct formations. North of Grand Junction Road is predominately surficial fill underlain by loose sands and soft to medium dense clays and silt of the St. Kilda Formation with groundwater considered to be shallow (less than two metres below ground surface (mbgs)) at the northern end of the corridor near the Salisbury Wetland. South of Grand Junction Road is predominately surficial fill underlain by silty/sandy clay of the Pooraka Formation with groundwater found at the base of the deposited fill material (less than 10 mbgs) further south.

An identifiable soil profile is associated with each of the St Kilda Formation and Pooraka Formation surficial geological units. **Figure 21.2** illustrates that to the north of Grand Junction Road, the soil profile type is known to comprise estuarine muds and sands (EMS). At Grand Junction Road and southwards, the soil profile is known to comprise Red Brown Earth type RB6-RB7.

The EMS type soil profile can be described as a belt of silty to sandy deposits containing organic accumulations. The formation is generally sandy below 1 metre depth and is typically grey, dark grey or mottled with a tendency to be bluish below the watertable indicating reducing conditions.

The Red-Brown Earth soils are the most extensive of the Great Soil Groups occurring in the Adelaide region and are formed mostly on the transported sediments of the outwash plain. Type RB6-RB7 soil profile typically comprises brown loamy topsoil, over red brown to brown sandy clay soil with low carbonate content overlying light brown sandy clay, clayey sand and sand below 1–2 metre depth.

21.5.3 Results of previous geotechnical investigations

The ground conditions encountered by previous intrusive geotechnical investigations at and around the site of the project generally showed good agreement with the geology and soils information that is presented above. The main points from the review are:

- fill was encountered in all boreholes. For the DTEI boreholes, BH1 to BH4, the depth of fill was 1.3–4.2 m and generally comprising grey black sandy clays
- the log for DTEI borehole BH2 illustrates the presence of up to 4.2 m depth of fill near the ARTC corridor at the eastern side of South Road. The borehole noted that the fill had significant thicknesses of refuse (plastic bags, metal lids, sand and clay). Diesel, organic and 'very bad' odours were reported to emanate from the fill in DTEI boreholes BH1 and BH2
- an 'upper clays' unit for the DTEI boreholes BH1 to BH4 was proposed by DTEI, comprising soft to stiff, low to medium plasticity clay, sandy clay and sand. This unit is interpreted to include St Kilda Formation, Glanville Formation and Pooraka Formation sediments
- a 'lower clays' unit for the DTEI boreholes BH1 to BH4 was also proposed by DTEI, comprising mottled, medium or high plasticity clay and sandy clay of very stiff to hard consistency. This unit is interpreted to comprise Hindmarsh Clay
- groundwater was encountered around 3.6 m depth below existing ground level, in the DTEI boreholes. Standing groundwater levels from other boreholes ranged from about +1.5 m AHD at Grand Junction Road to about +0.6 m AHD at South Terrace.

Study Area
South Road Superway
EMS Estuarine Muds and Sands
RB6-RB7 Red Brown Earths

Regional Soils

Figure 21.2

21.6 Erosion potential

Erosion of soil may be caused by the following mechanisms:

- wind erosion of exposed soil surfaces
- physical erosion of exposed soil surfaces by surface water runoff, either by sheet flow or, especially, flow lines
- dispersion of soil surfaces and sub surfaces, cause by surface water runoff and/or sub-surface seepage for soils that have an inherent lack of coherence in the presence of water.

The South Road Superway Project will follow the alignment of the existing South Road. This means that no significant erosion issues are present in the project site, because most of the ground surface is sealed with road pavement.

Wind erosion is unlikely to be an issue for unsealed areas, unless they have been stripped of vegetation or otherwise disturbed, because of the significant shielding provided by existing industrial buildings.

Erosion by surface water runoff is unlikely to be an issue because of the flat topography and well defined channelised drainage lines. The open stormwater drain may be subject to stream erosion during periods of heavy flow, but the gradient of the drain is very flat and the drain base and sides are generally well vegetated, which would limit the extent and severity of any stream erosion that might occur.

Erosion by dispersion of soils does not appear to be a significant problem for the soils for the South Road Superway Project. However, no test results for the site soils are yet available to allow their dispersion potentials to be assessed.

21.7 Site contamination

Based on past and present land uses across the study area, a number of potentially contaminating activities, leading to potential site contamination have been identified. Typical contaminating activities, potential contaminants and likely significance are outlined in **Table 21.3.** From a due diligence perspective, a number of other sites may need to be investigated for potential or actual site contamination prior to construction.

Buried waste materials have also been identified in a portion of the South Road Superway Project study area. It is known that fill that may be from contaminated sites has been bought in over time and due to the low-lying nature of the land north of Grand Junction Road there exists the potential for soil and / or groundwater contamination.

The regional groundwater flow direction is believed to be generally in a northwesterly direction towards the coastal wetlands which are the closest surface water body to the study area. However it is noted that the aquifer is located in generally discontinuous sand lenses resulting in local variability in the groundwater flow direction, Localised groundwater contamination may be present as a result of previous site activities in the South Road Superway Project.

The current and previous land use in the study area may provide source of potential contaminants, presented in **Table 21.3**.

Table 21.3 Land use that may provide source of potential contaminants

Activity	Potential Contaminants
Weed control (verges)	Pesticides/Herbicides – Arsenic, lead, organochlorines, organophosphates, sodium tetraborate, carbamates, sulfur, synthetic pyrethroids, ammonium thiocyanate, mercury, triazines.
Transformers	Polychlorinated biphenyls (PCBs), solvents, tin, lead, copper, mercury
Imported fill	Heavy metals, PAHs, Asbestos
Service station sites	TPH's (Total petroleum hydrocarbons), BTEX (benzene, toluene, ethylbenzene, xylene), Lead, heavy metals, volatile organic compounds, phenols
Road activities (e.g. traffic, spills)	TPH's, BTEX, lead, heavy metals

21.8 Acid sulfate soils

Acid sulfate soils are saline soils which, in their natural state, are saturated and contain pyrite (iron sulfide). Upon exposure of the soil to air via soil drainage or excavation, the pyrite becomes oxidised and sulfuric acid is produced. Potential acid sulfate soils are saturated pyritic soils that have not yet oxidised because they have not been disturbed. Actual acid sulfate soils are soils that are naturally pyritic but which have been disturbed by dewatering and/or excavation, such that sulfuric acid has been generated. Acid sulfate soils are widespread in coastal areas in South Australia, especially where mangroves are present.

The soils in the study area are inland and therefore have yet to be classified in relation to risk or potential risk of acid sulfate soils.

The web based atlas for South Australia (www.atlas.sa.gov.au) shows that the landward extent of acid sulfate soil mapping appears to have been limited to the eastern edge of the coastal plain geomorphic unit, which is also the eastern edge of the distribution of the St. Kilda Formation soils. This means that none of the South Road Superway project will be lies in the extent of the coastal acid sulfate soil mapping.

The limited amount of acid sulfate soil sampling and testing that was undertaken as part of the geotechnical investigations for the possible future project, Northern Connector, to the north of the South Road Superway suggests that potential acid sulfate soils are present but not actual acid sulfate soils.

The areas associated with the large natural drainage line that ran north along the approximate route of South Road to North Arm, prior to South Road being constructed.

The area north of Grand Junction Road is expected to be an area of potential acid sulfate soils, corresponding to the extent of the former samphire marsh that has since been reclaimed for industrial development by extensive filling.

The area south of Grand Junction Road has not been mapped for acid sulfate soils.

21.9 Effects of the project

21.9.1 Erosion potential

The project is unlikely to have any significant effect on the erosion potential of the site soils. This is because the elevated roadway proposed for the South Road Superway will not involve large scale bulk earthworks in the form of either excavations or fills. Rather, earthworks for the project will be essentially limited to the following elements:

- excavations to form the pile caps to the group of pile footings below each pier
- excavations to form the piles, if a replacement pile type such as a continuous flight auger is selected for this purpose

- fills to form embankments to the on and off ramps to the South Road Superway Project.

Wind erosion is unlikely to be a significant issue for the project. Dry, loose, fine sand and friable silt soils are most susceptible to wind erosion. These soil types and states are not generally present in the surficial fill and natural soil layers, which tend to be clayey in nature. Wind erosion is more likely to occur where the natural surficial soil is of a susceptible type and the soil structure is disturbed, such as by removal of vegetation. Wind erosion is also more likely to occur where loosely heaped stockpiles of soil of a susceptible type are present, or where fill of a susceptible type is placed and spread but is not immediately densified by compaction. None of these circumstances is relevant to the project.

The main effects of wind erosion are loss of the eroded material, the generation of excessive dust, and the dirtying of downstream areas when the dust is eventually deposited as a blanket.

Erosion of soil by surface water runoff is also unlikely to be a significant issue for the South Road Superway Project. This is because there would not be significant areas of unprotected earthworks during the construction phase in the form of stripped ground surfaces or excavated or filled slopes. Drainage lines are the locations of greatest risk. These are, by their very nature, associated with concentrated flow and hence are more susceptible to gullying. However, the project is unlikely to cause any significant increase in stormwater runoff volume or velocity because the catchment for the existing earth drain that runs alongside South Road is already mostly developed and hence sealed.

The main effects of soil erosion by surface water runoff are loss of material from along the route of the runoff and siltation of downstream receiving environments, in particular surface waterbodies. Rill and gully formation in earth slopes, and local reduction in slope stability, may also develop.

Dispersion of surface and sub-surface soils may be an issue wherever dispersive soils are present and surface water or sub-surface seepage are also present. The results of simple tests for soil dispersion potential that were undertaken for the geotechnical investigations of the possible future project, Northern Connector, (located to the north of the South Road Superway Project study area) showed that some of the soils tested are partly dispersive. Most of the other soils tested contain calcium (mainly in the form of lime) and hence are also potentially erodible.

The main effects of erosion of dispersive soils are rilling and gullying of the soil surface, and piping through the soils along seepage lines. This may lead to local slope instability and sinkhole formation. Once the South Road Superway has been constructed, the potential for erosion would be greatly reduced. This is because the surface area of susceptible soils that is exposed would be greatly reduced once the earthworks and elevated roadway construction have been completed.

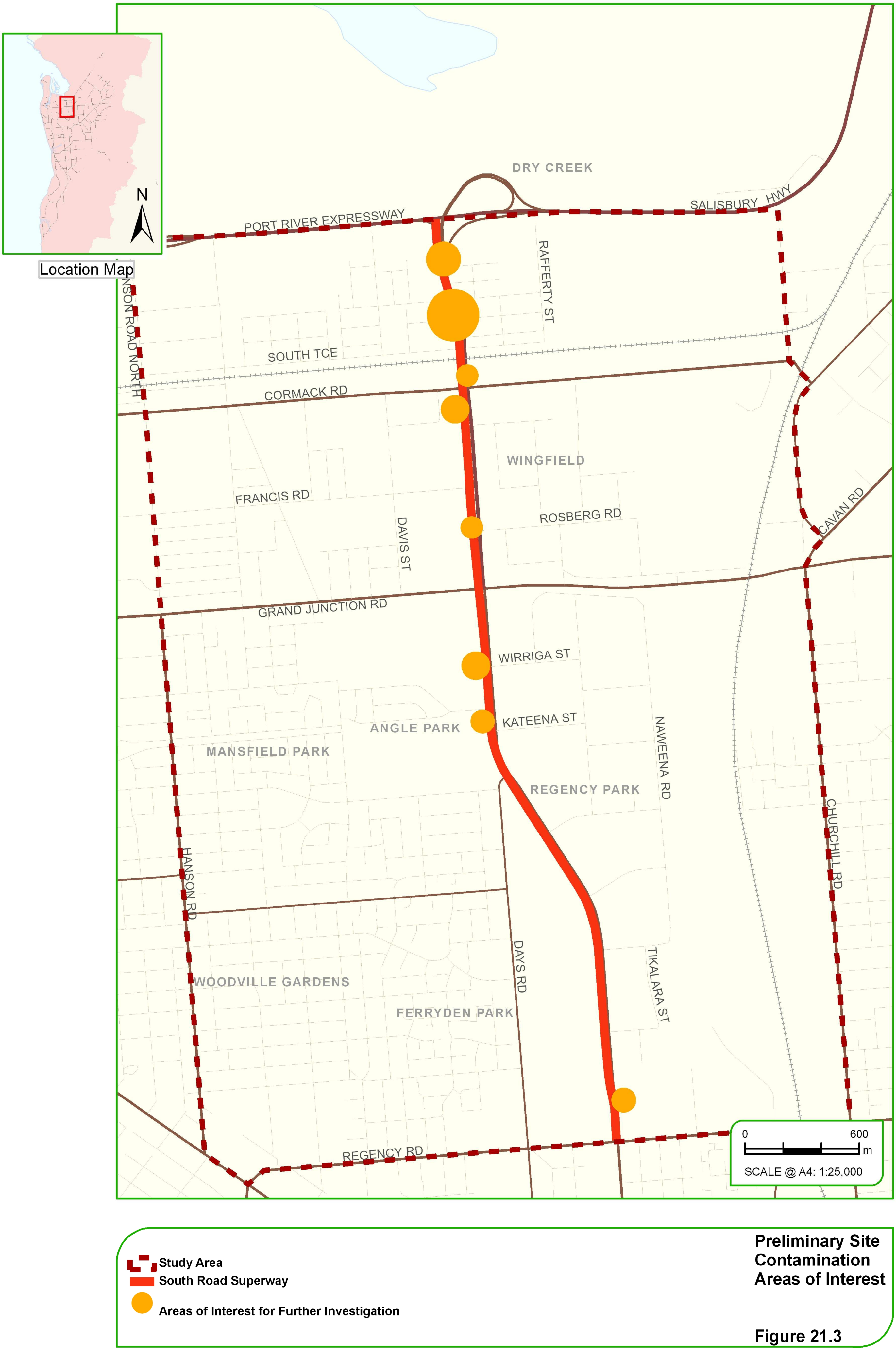
However, the project is not expected to have any adverse effect on the dispersion potential of the existing site soils.

21.9.2 Site contamination

As a result of the geology and hydrogeology, it is considered that contamination will generally migrate faster and further in the St Kilda Formation with a higher chance of groundwater contamination than in the Pooraka Formation. Therefore properties west at and south of Grand Junction Road in the Pooraka Formation would present a lower risk of contamination migrating than properties north of Grand Junction Road in the St Kilda Formation.

The identified buried waste in the South Road Superway Project study area indicates the presence of some plastic bags, aluminium and construction and household materials as well as a diesel odour and a pungent odour of unknown origin. Borehole 1 was located on the northeastern portion of South Road and contained less household rubbish and more construction materials. The fill material is present to 4 mbgs at Borehole 2 on the southwestern side of South Road in ARTC property. Groundwater is expected to be close to or within this depth and is a potential pathway for contaminant migration. The potential contaminants are road base, construction material, discarded paints, solvents or chemical drums as well as a variety of hard rubbish and the contaminants of concerns predominately include asbestos, aliphatic and aromatic hydrocarbons, halogenated hydrocarbons and metals.

The preliminary site contamination areas of interest are illustrated in **Figure 21.3.**



Preliminary Site Contamination Areas of Interest

Figure 21.3

21.10 Acid sulfate soils (naturally occurring)

The presence of potential acid sulfate soil does not present a problem if the soil is not disturbed, because potential acid sulfate soil is largely benign in its natural state. However, the presence of actual acid sulfate soil, and the disturbance of potential acid sulfate soil, is highly undesirable. This is because the associated sulfuric acid is very likely to have significant adverse effects on both the environment and on any surface and sub-surface infrastructure made of steel or concrete that may be present. These effects are by virtue of the acidity itself and by the leaching and mobilisation of heavy metals that have hitherto been sorbed to the soil.

Adverse effects are likely to occur if potential acid sulfate soils become actual acid sulfate soils. Disturbance exposes potential acid sulfate soils to oxygen in the presence of water, which facilitates the formation of sulfuric acid and the subsequent release of other toxic products, including nutrients and heavy metals (particularly arsenic, aluminium and iron) that were held in the soil matrix. When these products are transported to adjacent waterways following rainfall events, adverse environmental impacts can occur, impacting aquatic ecosystems. Economic effects associated with acid sulfate soil disturbance include concrete attack, corrosion of steel infrastructure and subsidence of foundations.

Common indicators of acid sulfate soil include:

- the presence of particular vegetation species, such as mangroves, saltwater couch, tea-trees and she-oaks
- fish kills
- iron staining through the oxidation of acid sulfate soil
- concrete attack or destruction of infrastructure
- water colour – clear blue-green water can indicate the presence of aluminium. Toxic quantities of aluminium in water bodies have been associated with increased fish mortality, chronic illness in aquatic organisms and potential health affects in animals or humans using the affected water body as a drinking supply (ASSS 2005)
- low pH of water, as sulfuric acid moves into a water body. Acidity can have significant impacts on vegetation and aquatic ecosystems
- hydrogen sulfide odour.

The risk based mapping of coastal acid sulfate soil by CSIRO Land and Water (**Figure 21.4)**, identifies that no actual acid sulfate soil is present even in the mangrove areas fringing the North Arm Creek. However, potential acid sulfate soil is present in this area and is also expected to be present for that part of South Road Superway Project study area north of Grand Junction Road.

Notwithstanding that no coastal acid sulfate soil mapping of the land south of the North Arm Creek was undertaken by CSIRO Land and Water, the level of risk associated with the Lower Alluvial Plain at and south of Grand Junction Road is likely to be very low at most. This is because acid sulfate soils are strongly associated with the St Kilda Formation, and this geological unit is confined to the Coastal Plain.

The construction of the project could result in acid sulfate soil impacts, by possibly disturbing potential acid sulfate soils and causing them to become actual acid sulfate soils. This may occur as a result of the activities, among others:

- excavation of soil from below the groundwater table, for example spoil from the construction of replacement type piles footings to piers
- dewatering of the groundwater table to facilitate construction work, such as excavation and formation of pile caps to pile footing groups below piers.

Any such acid sulfate soil impacts would be expected to be confined to that part of the South Road Superway north of Grand Junction Road, because that is the expected extent of potential acid sulfate soils.

Once the South Road Superway has been constructed, no new acid sulfate soil impacts would be expected to be associated with the operation of the corridor because no new disturbance of the existing ground profile is likely during the service life of the corridor.

Rather, any impacts during the operation phase would be mainly in the form of legacy impacts on the environment and infrastructure from any acidic soil and groundwater that is generated by disturbance of potential acid sulfate soils during the construction phase.

- South Road Superway
- Major Freight Corridors
- Northern Connector (Possible Future Project)
- Northern Expressway (Under Construction)
- Railway
- Potential ASS (mangrove)
- Potential ASS (tidal stream)
- Potential ASS (intertidal)
- Potential ASS (supratidal)
- Actual ASS (disturbed)
- Marine Soils
- Other Soils

Acid Sulfate Soil Risk

Figure 21.4

21.11 Mitigation measures to minimise effects

21.11.1 Principles and measures to minimise effects during planning and design

A construction environmental management plan (CEMP) will be required to document environmental controls and measures to be implemented during the construction phase of the project. The issues to be addressed in the CEMP include:

- topsoil management
- soil erosion management
- contaminated land management
- hazardous materials management
- acid sulfate soil management.

Prior to construction, a comprehensive geotechnical investigation will be undertaken along the length of the project. This will include boreholes, in situ testing and laboratory geotechnical testing. Assessment of the results will allow a better understanding of the effects on the project of the site soils and groundwater.

Where is it considered possible that a site has been impacted upon by contaminating activities, an appropriate soil testing program will be undertaken to determine the extent of these potential risks.

21.11.2 Erosion potential

Although the effects of erosion are mainly associated with the construction phase and in any case are unlikely to be significant for the project, there are a number of measures that can be implemented during the planning and design phase to minimise construction phase erosion impacts. These measures would include:

- specifying that dispersive materials are not to be used in earthworks
- designing permanent surface water drainage systems of adequate hydraulic capacity and with suitable scour protection along flow paths
- minimising flow path gradients and the lengths of any steeply graded flow paths over unsealed surface
- designing suitable surface protection measures to any earth slopes, such as a quick growing vegetative cover or a geosynthetic erosion protection product.

21.11.3 Site contamination

Where it is considered possible that a site has been affected upon by contaminating activities, an appropriate soil testing program will be undertaken to delineate these potential risks.

21.11.4 Acid sulfate soils

There is a preferred hierarchy of management measures to deal with the risks posed by acid sulfate soils. These are set out in the Coast Protection Board document no. 33 (January 2003). The two most preferred management measures are best implemented during the planning and design phase of the project:

- avoidance – leave the coastal acid sulfate soils in an undisturbed state
- minimisation of disturbance – minimise the opportunity for oxidation of potential acid sulfate soil by minimising excavation and/or dewatering of such soil.

DTEI will implement these management measures by virtue of:

- adoption of an elevated roadway scheme for the South Road Superway project which would minimise earthworks and dewatering
- design of pile caps and pile types to minimise excavation below the groundwater table and minimise the extent of dewatering.

A thorough acid sulfate soil investigation and risk assessment, would also need to be undertaken to provide a basis for consideration of acid sulfate soil issues in the design phase for the project and during construction.

21.12 Specific actions to minimise effects during construction

21.12.1 Erosion potential

Prior to the commencement of construction, the contractor would develop an SEDMP. During construction the contractor would implement and maintain the plan as part of their CEMP. The SEDMP would be developed in accordance with the *Stormwater Pollution Prevention Code of Practice for Local, State and Commonwealth Government*.

It would be the responsibility of the contractor to design, construct, operate and maintain drainage and temporary erosion control measures. This would require the contractor to:

- plan and carry out the whole of the construction works to minimise the effects of runoff and erosion on the site and downstream areas. The contractor would be required to avoid unnecessary ground disturbance and provide for the proper control of stormwater runoff at every stage
- ensure that all required runoff, erosion and sediment control measures are in place and comply with their SEDMP prior to the commencement of earthworks
- establish sediment control structures around all areas prone to erosion including stockpiles, batters and drainage lines. The location of stockpiles should be away from drainage lines and least susceptible to wind erosion. Existing stockpile sites are to be utilised where available.

Immediately after the completion of earthworks areas (including any batters, drains, cut or fill areas), or if earthworks areas are to remain essentially the same for 2 days or more, the contractor would be required to install temporary measures to prevent erosion and/or control sediment. All proposed temporary erosion and sediment control measures would need to be documented in the SEDMP.

Where necessary, erosion control measures would include:

- staging of excavation operations
- diversion drains or catch drains to divert concentrated flows to points where they can pass through the works without damage
- rehabilitation of disturbed areas during the contract period.

Sediment collection structures may include:

- straw bales
- hessian bags
- silt fences
- sediment traps.

To minimise wind erosion and dust generation from disturbed sites in the construction area, the contractor would be required to implement the following measures:

- stabilisation of soil to be stockpiled for longer than a period of one month by grass seeding, covering or other appropriate means
- watering of unsealed work areas by use of a water cart that is available on site full time
- avoidance or minimisation of dust generating activities during dry and windy conditions
- minimisation of the extent of exposed, stripped ground surface until covered with appropriate fill material.

21.12.2 Site contamination

Site contamination management

For contamination identified during the site investigations and where there exists a potential risk to human or environmental receptors, a construction environmental management plan (CEMP) will be implemented to manage these risks. The CEMP will be based on the DTEI specification for managing environmental issues during construction activities, which is in turn based upon the *Environment Protection Authority Guidelines for Environmental Management of On-Site Remediation*.

Where significant site contamination is identified, it is intended to develop the CEMP with the EPA to ensure the management strategy adopted is consistent with environmental protection standards.

Typically the CEMP will be required to address:

- management of dust resulting from excavation, dumping and placement of excavated soils
- management of potentially odorous emissions from wastes or contaminated soil
- Occupational Health and Safety requirements for workers directly involved in excavation of contaminated soils
- erosion control including provision of adequate bunding
- management of any stockpiled soils and contaminated materials, taking care not to cross-contaminate nearby clean soils, and locating stockpiles in areas of least disturbance to flora
- provisions to ensure that contaminated soil is not transported offsite
- surface water drainage controls to ensure that contaminants are not mobilised off site and surface water resources are protected
- consideration of potential adverse impacts to groundwater quality
- handling and possible disposal of potentially hazardous waste materials
- off-site disposal of contaminated soil to licensed waste repositories
- access to the site during excavation activities that may expose people to contaminated soils.

Hazardous materials management

All potentially contaminating materials used on site will be listed in a Hazardous Materials Register, including storage location details and requirements, proper usage, safe handling procedures and appropriate disposal procedures. All chemical and fuel storage areas and bund facilities will be designed to comply with relevant Australian Standards. Fuels or other chemicals used during construction will be handled in accordance with these standards and accepted industry practice so as to minimise the risk of spills. Appropriate spill response and containment equipment will be kept at the site in close proximity to storage and handling areas. Spills and leaks will be cleaned up and remediated promptly.

21.12.3 Acid sulfate soils

Any acid sulfate soils identified during road assessment will be appropriately managed to ensure no adverse effects on the local environment. If acid sulfate soils are encountered, the mitigation and management measures for controlling impacts will be developed in accordance with the *Acid Sulfate Soil Manual* (Stone et al. 1998), and will include best practice in management and monitoring to ensure potential environmental impacts are minimised and controlled.

Where avoidance is not possible and some disturbance of acid sulfate soils occurs, measures to manage the associated risks would be necessary. These would be set out in the CEMP, which would have been prepared before construction begins. The acid sulfate soil component of the CEMP would include proposed management strategies as well as monitoring requirements and verification testing requirements, for the short term and for the long term.

The construction phase measures for managing acid sulfate soil impacts are likely to include the following:

- stockpiling excavated spoil in such a manner that the generation and spread of acidity is minimised, by directing surface runoff around stockpile areas, collecting runoff from the stockpiles and not allowing it to discharge, covering the stockpiles with plastic sheeting or similar to minimise contact with the air, and not moving the excavated material further once it has been stockpiled
- neutralising the excavated material, by mixing in a sufficient amount of a reducing agent such as agricultural lime, or by mixing in other excavated soil containing lime or fine shells
- strategically reburying disturbed material below the watertable.

21.12.4 Specific actions to minimise effects during post-construction

Erosion potential

Measures to minimise erosion effects during operation of the South Road Superway Project would include:

- regular inspection and maintenance of any formal unsealed drainage paths and any earth slopes
- replacement of any degraded slope protection surfacings such as vegetative covers and geosynthetic products.

Site contamination

Any site contamination identified in the corridor post construction will require ongoing management and will be included in the operational specification for the road.

Acid sulfate soils

No adverse effects from acid sulfate soils are expected as a result of the operation of the project. Therefore, the only measure that is likely to be required during the operation phase is ongoing monitoring of adjacent drainage lines in areas north of Grand Junction Road. This in order to ensure that any acid sulfate soil effects arising from construction phase activities are properly managed in the operation phase.

21.13 Conclusion

The project extends over two main physical (in a geomorphic sense) environments, and two main geological and soil profiles.

North of Grand Junction Rood, the South Road Superway Project lies in the Coastal Plain, which is characterised by low lying land underlain by marine and estuarine soils. These soils comprise mixtures of clays, silts, sands, shell beds and organic zones. This sub-surface profile is generally of low strength and high compressibility, and is expected to contain shallow, saline groundwater and coastal acid sulfate soils.

At Grand Junction Road and southwards, the corridor lies in the Lower Alluvial Plain which is characterised by land that is slightly more elevated than the land to the south, and which is underlain by alluvial soils representing outwash fan deposits from the major stream lines. These soils comprise sandy clays and clayey sands, with some sandy lenses representing buried stream lines. This sub-surface profile is generally of moderate strength and compressibility. Groundwater is typically deeper (except where perched water is present in sandy lenses) and less saline than for the land to the south, and coastal acid sulfate soils are not generally expected to be present.

Fill generally overlies the natural soil profile along the corridor, especially for this part of the corridor north of Grand Junction Road. The fill is associated with alteration of the natural low lying topography for the purposes of industrial development and stormwater drainage.

Coastal acid sulfate soil mapping of the Gillman-Barker Inlet-St Kilda area by CSIRO Land and Water suggests that around North Arm Creek, acid sulfate soils are present. However, these soils are currently only potential acid sulfate soils and are not actual acid sulfate soils. Potential acid sulfate soils are also expected to be present between North Arm Creek and Grand Junction Road. From Grand Junction Road and southwards, the absence of estuarine soils would suggest that acid sulfate soils are unlikely to be present, though the CSIRO mapping did not encompass the land south of North Arm Creek.

The main soil and geological hazards that may give rise to effects as a result of the South Road Superway Project proceeding are erosion and acid sulfate soils. In both cases, the great majority of the impacts will be associated with the construction phase of the South Road Superway Project, rather than with the planning and design phase or the operation phase.

Erosion may occur at locations of exposed (unprotected) soil surfaces, and may be in the form of wind erosion, erosion by surface water runoff, or surface water runoff or sub-surface seepage for dispersive soils. In each case the effects comprise loss of material and potential slope instability at the erosion site, and 'dirtying' of the receiving environment by deposition of the eroded material.

However, soil erosion is unlikely to be a significant issue for the project because no large scale excavation or fill earthworks are associated with the elevated roadway that is proposed for the South Road Superway . Any erosion related effects may be controlled by the following means:

- use of erosion resistant materials in earthworks, and avoiding erosion prone materials such as dispersive soils, silts and fine sands
- provision of adequate surface protection to soil surfaces otherwise exposed to erosive actions, for example a vegetative cover
- minimising the extent and degree of disturbance of existing soil surfaces
- minimising contact time and/or area between the erosive agent and the soil surface, such as by careful design of surface water drainage paths
- provision of control structures or measures for eroded material, such as silt fences to intercept sediment laden runoff and using water trucks to minimise dust generation from work areas

Many of these control measures will be addressed in the SEDMP, which will form part of the CEMP and will be prepared by the contractor prior to the commencement of any earthworks on site.

Acid sulfate soil impacts will only arise if the existing potential acid sulfate soils are disturbed by excavation or dewatering, such that it is exposed to the atmosphere and becomes oxidised to form actual acid sulfate soil. For the South Road Superway Project, the risk of encountering acid sulfate soils or potential acid sulfate soils along the corridor is considered low and would only be expected to occur if a replacement pile type was used to support pier loads or if pile cap excavations or excavations of services extend below about 3.5 m depth below ground surface. The resultant generation of sulfuric acid and leaching of heavy metals from the soil matrix would have significant adverse effects on the environment, and on any surface or subsurface steel or concrete infrastructure. The CSIRO mapping of coastal acid sulfate soils suggests that the risks associated with the acid sulfate soils varies with location, from no or very low risk at Grand Junction Road and southwards, through to high risk. High risk areas are those where mangroves are or were present, namely the northern end of South Road Superway.

Where avoidance is not possible and some disturbance of acid sulfate soils occurs, measures to manage the associated risks would be necessary.