11. Ground conditions

11.1 Introduction

Understanding the natural environment such as the topography, geomorphology, geology and soil is essential when examining the overall impacts of a major public transport infrastructure project on an area and the impact of the existing environment on the CoastConnect — Caloundra to Maroochydore project.

It is important for engineers to know whether the properties of the soils and rocks (geology) and/or the general topography and geomorphology (i.e. watercourses, erosion, etc.) could adversely affect a project's design, construction and operation. Considering the potential interaction between the existing environment and the project during the design process can reduce the risk of negative environmental impact.

The potential issues surrounding topography, geomorphology, geology and geotechnical properties that could hinder or enhance the successful implementation of the CoastConnect — Caloundra to Maroochydore project therefore need to be considered in this Concept Design and Impact Management Plan (CDIMP). This chapter includes but is not limited to the following considerations:

- the properties of rocks and soils of the wider area affecting the environment during construction and operation
- the properties of rocks and soils of the wider area affecting geotechnical conditions for design and construction
- the topography and geomorphology which could influence design to optimise layout of proposed structures and selection of engineering solutions
- the presence of ASS.

11.2 Methodology

A desktop study to assess the existing physical environment, including the presence or absence of ASS, along the transport corridor was undertaken. This comprised a review of available published geology and spatial system data.

Information reviewed or referred to includes:

- aerial photography
- topographic maps
- the Caboolture to Maroochydore Corridor Study (CAMCOS)
- various reports and maps sourced from government departments.

11.3 Preliminary analysis

11.3.1 Existing physical environment

Corridor-wide considerations

Topography

The topography of the project area is shown in Figure 11-1 and comprises the following terrain elements:

- Southern topographic high area at Battery Hill/Caloundra with surface levels (RL) up to 30 m Australian height datum (AHD) in Caloundra and up to about 20 m AHD in Battery Hill. Slopes are generally gently to moderately inclined with the steepest slopes in the central portion of Caloundra, along the eastern loop portion of the proposed corridor. The western loop portion of the corridor crosses the topographic high at approximate RL of 10 m to 20 m AHD. The transition from the higher ground to the coastal plain near Golden Beach in the south-west and at Currimundi in the north is generally gradual.
- The central coastal plain portion of the proposed corridor is on flat, low-lying, swampy terrain between Currimundi and Mooloolaba. Prior to urban development, this area was subject to frequent flooding and was poorly drained. Laterally extensive but shallow filling is anticipated in this area. RL of the coastal plain before filling was generally about 1.5 m to 2.5 m AHD.
- Northern topographic high area along the proposed corridor is at Alexandra Headland. The RL along the eastern loop portion of the corridor is about 5 m to 15 m AHD along Mooloolaba Esplanade and up to 25 m AHD along Alexandra Parade. The western loop of the corridor in the north crosses a topographic high near Sugar Road.

Drainage of the area is generally to the east and north, except the area in the south-western portion of Caloundra, which drains to the south.

Geology

Reference to the Queensland Department of Natural Resources and Water interactive resource and tenure maps (http://www.webgis.nrm.gov.au–IRTM v4.2 accessed on the 19 November 2007) indicates that the proposed CoastConnect corridor is underlain by the following geological units:

- Landsborough Sandstone — Jurassic age sedimentary rocks comprising sandstone, shale and siltstone.
- Tertiary age poorly consolidated sediments comprising quartzose to sublabile sandstone, claystone, conglomerate and minor olivine basalt.
- Quaternary — Pleistocene and Holocene age alluvial deposits comprising, clay, silt, sand and gravel, floodplain alluvium.
- Quaternary — Pleistocene and Holocene age estuarine and tidal delta sediments comprising, sandy mud and muddy sand.

The lateral extent of the various geological units along the proposed CoastConnect corridor is shown on Figure 11-2 and described below.

Soils

Soils along the proposed corridor have been determined from borehole data in the 2002 QASSIT report on ASS soil mapping and from the *Maroochydore station corridor study geotechnical assessment report* (PB 2007). Soil/landscape units are described in Figure 11-3.

Along the corridor soils are expected to be dominantly deep non-cracking, acidic grey friable clays with associated pale and yellow duplex soils. Small areas of other non-calcareous gradational soils may occur on stream levees and terraces — some with clay D horizons below the solum. Yellow duplex soil is anticipated to occur on the sandstone areas such as in the Battery Hill/Caloundra and Alexandra Headland areas. Other than the yellow duplex soils, all other described soils are associated with flat to very gently undulating coastal plains and low sandstone hills.

Predominantly podsolic soils with minor Vertosol and Hydrosols are anticipated along the corridor. Podosols with possible multiple layers of hard coffee rock several metres thick are expected at depths from around 1.0 m owing to the continual burying and later cementation of iron rich subsoils. According to previous geotechnical investigations (PB 2008) topsoil in the area is generally absent, as the corridor alignment covers only previously disturbed and urbanised area.

Acid Sulfate Soils (ASS)

Results of regional ASS mapping in and around the project area conducted by Department of Natural Resources and Water are shown on Figure 11-4. A description and definition of the ASS categories is shown in Table 11-1 below.

Table 11-1: Description of ASS categories shown on Figure 11-4

Code	Description
S1	Indicates PASS[1] at 0.5 m to 1.0 m depth
S2	Indicates PASS at 1.0 m to 2.0 m depth
S3	Indicates PASS at 2.0 m to 3.0 m depth
SDL	Disturbed land, e.g. Canal estate, marina, aquaculture, quarry, urban, industrial likely to contain ASS
LP	Low probability of ASS occurrence. Limited field assessment
a0S2	AASS[2] with field pH between 4 and 5 from surface to 2.0 m overlying PASS
a0LP[3]	Surficial acid soil layer which may or may not be ASS, in an area with low probability of ASS occurring
SLA	Limited field assessment but occurs in a landscape position where there is a reasonable probability of ASS occurring.
SLAW[3]	Land mapped at 1:100 000 scale where ASS occurs within 5 m of surface, limited field assessment, with Melaleuca or Casuarina wetlands
a0S2[3]	AASS with field pH between 4 and 5 from surface to 2.0 m overlying PASS and associated with Melaleuca wetlands
a1S3[3]	AASS with field pH between 4 and 5 from surface to 3.0 m overlying PASS
a0SP[3]	AASS with field pH between 4 and 5 from surface to >5 m overlying PASS

Notes: 1: PASS — potential Acid Sulfate Soils; 2: AASS — actual Acid Sulfate Soils; 3 — No earthworks are proposed in areas covered by these units

Figure 11-4 and Table 11-1 indicate that the project area is likely to contain both Actual Acid Sulfate Soils (AASS) and Potential Acid Sulfate Soils (PASS). A potential exists for ASS in the Mooloolaba Road to Battery Hill corridor section owing to the presence of estuarine/tidal delta sediments. Refer to the specific sections below for potential of different sections.

Potentially economically significant mineral, energy and extractive material resources

A review of the Department of Mines and Energy interactive resource and tenure maps (http://www.dme.qld.gov.au/mines/tenure_maps.cfm, accessed on 21 April 2009), showed no significant resources along or surrounding the alignment.

Sections 1 and 2 — Caloundra to Currimundi

Topography and geomorphology

Sections 1 and 2 of the alignment covers the southern topographic high area at Battery Hill/Caloundra with surface levels (RL) up to 30 m AHD in Caloundra and up to about 20 m AHD in Battery Hill (see Figure 11-1) Slopes are generally gently to moderately inclined with the steepest slopes in the central portion of Caloundra, along the eastern loop portion of the proposed corridor. The western loop portion of the corridor crosses the topographic high at approximate RL of 10 m to 20 m AHD.

The transition from the higher ground to the coastal plain in the south-west and at Currimundi in the north-east is generally gradual. Drainage of the area is generally to the east and north, except the area in the south-western portion of Caloundra, which drains to the south.

The alignment of the corridor is not anticipated to be affected by coastal erosion.

Geology

The topographic highs described above are due to the presence of the Landsborough Sandstone which underlies all of Section 1 and most of Section 2. It is expected that at surface and at the depth of excavations mainly residual soils developed on Landsborough Sandstone will be present. It appears that erosion of the slopes is most pronounced on the seaward margins.

A small part of Section 2 in the north-east, surrounding the Coondibah Creek, is indicated on the published geological data to comprise Pleistocene age beach ridges and sandy swamp sediments.

Lateral extent of the various geological units along the proposed corridor is shown on Figure 11-2.

Acid Sulfate Soils

In Section 2, in the area north of Battery Hill, the proposed alignment is at the boundary of sandy coastal swamp sediments with ASS potential. Figure 11-4 shows the lateral extent of ASS potential along this portion of the alignment.

Section 3 and 4 — Nicklin Way and Kawana Town Centre

Topography and geomorphology

Sections 3 and 4 contain the central coastal plain portion of the proposed corridor on a flat, low-lying, swampy terrain between Currimundi and Mooloolaba. Prior to urban development, this area was subject to frequent flooding and was poorly drained. Extensive filling has occurred in this area. Drainage of the area is generally to the east and north.

This topographic low area is likely to be underlain by estuarine and lagoonal sediments with thin, surficial alluvial layers adjacent to current or former stream lines.

Geology

Estuarine/tidal delta sediments are expected to occur at the surface along these sections of the corridor, together with anthropogenic fill. Pleistocene and Holocene age estuarine and tidal delta sediments present comprise, sandy mud and muddy sand. The fill generally comprises the same sandy soil types. Lateral extent of the various geological units along the proposed corridor is shown on Figure 11-2.

Acid Sulfate Soils

The corridor section from Mooloolaba River in the north to Battery Hill in the south has been mapped as disturbed land likely to contain ASS (mapped as SDL). A narrow east-west band at the intersection of Lake Kawana Boulevard and Nicklin Way is the exception. This band was mapped as S2 land, with PASS anticipated from about 2 m depth. It is anticipated that most of the area in SDL portion of the corridor will be underlain by PASS from between 1.0 m and 3.0 m depths.

An area around the proposed Kawana Town Centre loop of the proposed corridor is anticipated to have AASS from a depth of about 0.5 m to 1 m and possibly from as deep as 2.5 m.

The lateral extent of ASS is related to the low-lying Pleistocene and Holocene age estuarine sediments but they may be present in the tidal delta sediments. These sediments are anticipated to be present in the central portion of the proposed corridor on the low-lying coastal plains. Figure 11-4 shows the lateral extent of ASS potential along the alignment.

Section 5 — Mooloolaba

Planning and delivery of Section 5 is being lead by the Sunshine Coast Regional Council.

Section 6 — Alexandra Parade

Topography and geomorphology

Section 6 contains the northern topographic high area along the proposed corridor at Alexandra Headland. The RL along Mooloolaba Esplanade is about 15 m AHD and up to 25 m AHD along Alexandra Parade. Drainage of the area is generally to the east along the coast and to the north-west behind the near coast ridges. The original drainage pattern is disturbed by urban development and few distinct gully lines remain. The northernmost portion of this corridor section is along coastal plain before turning north-west along Aerodrome Road.

Geology

The southern portion of this section along Mooloolaba Esplanade and Alexandra Parade is underlain by Tertiary sediments and Landsborough Sandstone. The Jurassic age Landsborough Sandstone comprises sandstone, shale and siltstone. In the northern portion of Section 6 Pleistocene and Holocene age sandy coastal plain sediments along the shoreline grade into the overlying alluvial deposits comprising, clay, silt, sand and gravel. These alluvial floodplain sediments are anticipated to be present intermittently with estuarine sediments along Aerodrome Road. The lateral extent of the various geological units along the proposed corridor is shown on Figure 11-2.

Acid Sulfate Soils

Disturbed ground likely to be underlain by PASS (mapped as SDL) is anticipated in the northern, topographically lower area in Section 6. Only estuarine soils are anticipated to contain ASS, the alluvial sediments are considered non-ASS. The lateral extent of ASS along the alignment is shown on Figure 11-4.

Section 7 — Maroochydore

Topography and geomorphology

Section 7 of the proposed corridor is located predominantly on flat terrain through Maroochydore. Drainage of the area is generally to the north-west and north but original drainage paths are generally altered by urbanisation.

Geology

Section 7 contains Pleistocene and Holocene age alluvial sediments comprising, clay, silt, sand and gravel, intermittent, or underlain by estuarine sediments and remnant tidal delta sediments. The lateral extent of the various geological units along the proposed corridor is shown on Figure 11-2.

Acid Sulfate Soils

The presence of ASS in Section 7 is related to the low-lying Pleistocene and Holocene age estuarine sediments but they may be present in the tidal delta sediments. These sediments are anticipated to be more likely to occur in the northern part of the section. The lateral extent of ASS along the alignment is shown on Figure 11-4.

11.3.2 Potential impacts and typical mitigation measures

Corridor-wide considerations

Potential impacts

- **Topography and geomorphology**

Disturbance of existing topography could change drainage patterns, slopes and subsurface moisture regime, and impact on the current geomorphologic processes. Owing to relative flat terrain across the corridor (other than the southern and northern topographic highs, sealed surfaces and trained surface runoff) the potential impacts on the current geomorphic processes are anticipated to be insignificant. Detailed discussion in relation to water runoff patterns is provided in the Hydraulics and Hydrology chapter of the CDIMP. The corridor is proposed to cross areas previously disturbed and therefore topographic changes will be minimised.

- **Soils/soil erosion**

Soil erosion is likely to occur in any location where soils are exposed through clearance of vegetation and/or removal of hard surfaces. Erosion potential of soils during construction is generally increased owing to the clearing of vegetation, unless appropriate erosion control measures are considered and implemented at the design and construction phase.

Sandy and loamy Podosols, Hydrosols and similar duplex sandy soils encountered along the corridor will have the greatest erosion potential. Surface soils with low cohesion are generally held together by the rootlets of grasses. Once vegetation is removed or disturbed, surface soils are prone to erosion by both flowing water and wind.

These soils are also prone to erosion when spread on new earth structures and before re-establishment of vegetation. Vertosols and other clayey soils are less prone to erosion when disturbed. They generally have low workability and trafficability when wet.

However, owing to the construction of infrastructure for this project being predominantly on previously disturbed and urbanised areas, the potential for encountering topsoil is low and therefore the impact on soil and soil erosion is likely to be minimal. Areas that may be impacted would include new set down areas or production areas, although these areas would probably also be areas previously disturbed and the impact is likely to be low.

- **Acid Sulfate Soils**

Oxidation of ASS and acid formation mainly occurs when ASS is excavated or the groundwater level is lowered. When structures are built over ASS (but the structures do not penetrate into the ASS and the groundwater regime is not affected), the ASS are not impacted. In this case there is no impact from the proposed structures on ASS.

Earthworks for the proposed bus corridor are anticipated to comprise mainly shallow excavations and placement of fill and pavement materials, mainly in already disturbed/filled areas.

There is the potential for interference with ASS in the low-lying areas of the corridor, especially at locations of auxiliary structures such as light poles and similar that may require deep excavations. This however is extremely unlikely and, if occurs, is able to be mitigated. The proposed works are not anticipated to impact on the groundwater regime in such a way as to expose existing PASS or drain AASS.

- **Geotechnical constraints**

Based on a review of available data, key geotechnical constraints relevant to the bus corridor alignment which may influence or impact on construction and operation of the project include:

- potential interference with ASS in low-lying areas of the corridor (very low risk)
- widening of the Parrearra Island bridge, is anticipated to require widening of the existing road. Detailed geotechnical investigation will be required at this location to define subsurface conditions
- excavation of continuous coffee rock, if encountered, could be difficult.

Typical mitigation measures

- **Soil/soil erosion**

According to previous geotechnical investigations (PB 2008) topsoil in the area is mainly absent as the corridor alignment crosses previously disturbed and urbanised area. Erosion and sediment control will need to be implemented where subsoils will be exposed during construction.

Department of Natural Resources, Mines and Energy (1974) investigation found that soils in the vicinity of the alignment have negligible to moderate susceptibility to erosion. The risk of soil erosion is higher on steeper slopes such as occur in Sections 1, 2, 6 and 7.

As noted above, however, topsoil in the area is mainly absent therefore erosion potential even in these steeper areas is likely to be low.

Runoff management of disturbed sites will need to ensure that no surface runoff is channelled into areas outside of actual earthworks, where it could have a negative impact, including increased erosion potential and/or slope instability.

An assessment of soil properties and topsoil depth may need to be undertaken should a previously undisturbed area be used for construction-related activities, such as lay-down area or construction camp.

- **Acid Sulfate Soils**

Should excavations more than about 0.5 m deep are required in either the Mooloolaba to Battery Hill, Kawana Town Centre loop, north-eastern portion of Section 6 or Section 7, then detailed ASS investigations at these locations will have to be carried out. The localised detailed investigations should determine the lateral extent and severity of the ASS.

Extent and severity of ASS may have implications for infrastructure foundations (e.g. station buildings, bridges etc) and may require specific design considerations. Preparation of an ASS management plan is not likely to be required owing to the expected relative low volume of excavated soils at each individual location.

Disposal and/or treatment of excavated ASS at each location will have to be managed to reduce the risk of environmental harm. The appropriate management techniques can only be assessed after detailed site assessment determined the extent and characteristics of the ASS at those locations.

- **Geotechnical constraints**

Further geotechnical investigations should be undertaken to determine the properties of rocks and soils around canal bridges and to determine the presence and extent of continuous coffee rock within the alignment area especially surrounding Currimundi Lake.

Sections 1 and 2 — Caloundra to Currimundi

Sections 1 and 2 mainly cross urbanised, topographic high areas where environmental impacts of the project are anticipated to be negligible.

Potential impacts

- **Geotechnical constraints**

Based on the information sources reviewed, key geotechnical constraints relevant to the bus corridor alignment which may influence or impact on construction and operation of the project include:

- potential interference with ASS (very low risk)
- excavation of weathered rock with poorly developed discontinuities may be difficult if encountered at location of auxiliary structures.

- **Acid Sulfate Soils**

Earthworks for the proposed bus corridor are anticipated to comprise mainly shallow excavations and placement of fill and pavement materials, mainly in already disturbed/filled areas. No ASS are anticipated to be impacted by these works. Should service trenches be excavated below the exiting fill, site-specific ASS investigations should be carried out to confirm the presence or absence of ASS.

The proposed works are not anticipated to impact on the groundwater regime in such a way as to allow the oxidation of the existing ASS.

Typical mitigation measures

The potential for intercepting ASS is very low. However if in the future an impact is perceived, mitigation measures are described in this chapter.

Further geotechnical investigations will be undertaken to determine the excavation properties of rocks at specific structures.

Section 3 and 4 — Nicklin Way and Kawana Town Centre

Sections 3 and 4 mainly cross urbanised, flat areas with existing road network where environmental impacts of the project are anticipated to be negligible.

Potential impacts

- **Geotechnical constraints**

Based on the information sources reviewed, key geotechnical constraints relevant to the bus corridor alignment which may influence or impact on construction and operation of the project include:

- potential interference with ASS at locations of auxiliary structures
- deep excavations for potential auxiliary structures are anticipated to require support of excavations and dewatering. Dewatering may impact locally on the groundwater regime and management of ASS will be required
- construction of new pavements in a high traffic flow areas will be difficult and may require work outside peak traffic volume times.

- **Acid Sulfate Soils**

As mentioned above, it is anticipated that most of the area in SDL, S2 and S3 portions of the corridor will be underlain by PASS from between 1.0 m and 3.0 m depths. Therefore, PASS are anticipated to be encountered at these depths in Section 3 and 4. In Section 4, AASS is likely be encountered from a depth of about 0.5 m to 1 m and possibly from as deep as 2.5 m in some areas.

Typical mitigation measures

- **Geotechnical constraints**

Excavations in saturated sandy and soft clayey soils are anticipated to require shoring to reduce the risk of trench wall collapse. Further geotechnical investigations should be undertaken to determine the excavation characteristics of potentially saturated soils, together with groundwater conditions to determine best construction methods.

- **Acid Sulfate Soils**

Should excavations more than about 0.5 m deep be required in these sections, then detailed ASS investigations at these locations will have to be carried out. The localised detailed investigations should determine the lateral extent and severity of the ASS. Extent and severity of ASS may have implications for infrastructure foundations (e.g. station buildings, bridges etc) and may require specific design considerations. Preparation of an ASS management plan is not likely to be required owing to the expected relative low volume of excavated soils at each individual location.

Disposal and/or treatment of excavated ASS at each location will have to be managed to reduce the risk of environmental harm. The appropriate management techniques can only be assessed after detailed site assessment determined the extent and characteristics of the ASS at those locations.

Section 5 — Mooloolaba

Planning and delivery of this section is being lead by the Sunshine Coast Regional Council.

Section 6 — Alexandra Headland

Section 6 mainly crosses urbanised, topographic high areas together with a transition to flat, low-lying terrain, where environmental impacts of the project are anticipated to be negligible.

Potential impacts

- **Acid Sulfate Soils**

As mentioned above, it is anticipated that most of this section is in SDL category and are likely to contain ASS and will be underlain by PASS below a depth of 0.5 m. Therefore, PASS and possibly ASS are anticipated to be encountered if excavations are deeper than 0.5 m.

Typical mitigation measures

- **Acid Sulfate Soils**

Should excavations more than about 0.5 m deep be required in this section, then detailed ASS investigations at these locations will have to be carried out. The localised detailed investigations should determine the lateral extent and severity of the ASS. Extent and severity of ASS may have implications for infrastructure foundations (e.g. station buildings, bridges etc) and may require specific design considerations.

Preparation of an ASS management plan is not likely to be required owing to the expected relative low volume of excavated soils at each individual location.

Disposal and/or treatment of excavated ASS at each location will have to be managed to reduce the risk of environmental harm. The appropriate management techniques can only be assessed after detailed site assessment determined the extent and characteristics of the ASS at those locations.

- **Geotechnical constraints**

Based on the information sources reviewed key geotechnical constraints relevant to the bus corridor alignment which may influence or impact on construction and operation of the project in Section 6 include:

- potential interference with ASS
- potential excavation of cuts along Alexandra Parade may require soil/rock support systems. Suitable engineering solutions are available and will be considered during design
- global slope stability of areas between the existing road network and the shoreline cliffs is anticipated to require assessment before increased traffic loading is allowed. Should the assessment indicate potential for slope instability, the engineering design would consider appropriate slope stabilisation methods
- construction activities in high traffic areas and/or close to residential areas may need to be managed to lower potential impact on users/occupiers. A traffic management plan is anticipated to be developed so as to minimise impact on road users.

Section 7 — Maroochydore

Section 7 mainly crosses urbanised, topographic low areas where environmental impacts of the project are anticipated to be negligible.

Potential impacts

- **Acid Sulfate Soils**

As mentioned above, it is anticipated that most of this section is in SDL and S3 categories and are likely to contain ASS and will be underlain by PASS between a depth of 2.0 m and 3.0 m. Therefore, ASS are anticipated to be encountered if excavations are deeper than 0.5 m and PASS below 2.0 m.

Typical mitigation measures

- **Acid Sulfate Soils**

Should excavations more than about 0.5 m deep be required in this section, then detailed ASS investigations at these locations will have to be carried out. The localised detailed investigations should determine the lateral extent and severity of the ASS. Extent and severity of ASS may have implications for infrastructure foundations (e.g. station buildings, bridges etc) and may require specific design considerations. Preparation of an ASS management plan is not likely to be required owing to the expected relative low volume of excavated soils at each individual location.

Disposal and/or treatment of excavated ASS at each location will have to be managed to reduce the risk of environmental harm. The appropriate management techniques can only be assessed after detailed site assessment determined the extent and characteristics of the ASS at those locations.

- **Geotechnical constraints**

Based on the information sources reviewed key geotechnical constraints relevant to the bus corridor alignment which may influence or impact on construction and operation of the project in Section 7 include:

- potential interference with ASS
- construction activities in high traffic areas and/or close to residential areas may need to be managed to lower potential impact on users/occupiers.

11.4 Future investigations

If ASS are likely to be disturbed at any location during the construction of the CoastConnect – Caloundra to Maroochydore project, a detailed ASS investigation should be undertaken at those locations. As described in Section 11.4.2 above, the localised detailed investigations should determine the lateral extent and severity of the ASS. Extent and severity of ASS may have implications for infrastructure foundations (e.g. station buildings, bridges etc) and may require specific design considerations.

Should this investigation go ahead, it should be undertaken consistently with State Planning Policy 2/02 and the Department of Environment and Resource Management should be contacted to discuss parameters for an ASS investigation. Preparation of an ASS management plan is to be produced following this ASS investigation if applicable.

11.5 References

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