B3 AIRPORT AND SURROUNDS GEOLOGY, SOILS AND GROUNDWATER

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3.1 INTRODUCTION

3.1.1 Site description

The Sunshine Coast Airport (SCA) and the Project are located between the coastline at Marcoola and the Sunshine Motorway, south of Mt Coolum and east of the Maroochy River. **Figure 3.1a** shows the location of SCA on a map which also shows local relief.

This chapter comprises the following aspects:

- Geotechnical assessment
- Acid sulphate soil (ASS) assessment
- Contaminated land assessment – Stage 1 preliminary site investigation (PSI)
- Erosion assessment
- Land resource assessment
- Groundwater assessment.

The Project is approximately 5 km north of the regional centre of Maroochydore. It occupies approximately 460 ha of relatively flat, low-lying land east and north of the Maroochy River. The majority of the Project site was cleared and cultivated for sugar cane farming, although none of the area has been productively farmed in the last 10 years. Uncleared areas of the site consist of a mosaic of thickly vegetated natural remnants including melaleuca species, wallum sedges and heathland surrounded by open grassland of native and improved grasses with tree re-growth to approximately 10 m high in places.

The Project is within a moderate rainfall area (approx. 1,465 mm/y), with the majority of rainfall occurring in summer. On-site observations indicate that the site is moderately well-drained, owing to the presence of predominantly sandy surface soil across the majority of the site.

Land uses surrounding the project include residential development, national park and farming, as shown in **Figure 3.1b**.

3.1.2 Study area

The Study area for the geology, soils and groundwater assessment is shown in **Figure 3.1c**.

3.1.3 Proposed development

The Project includes construction of a new runway and redevelopment of the existing terminal, and other supporting aviation infrastructure. The Project is proposed to the north-west of the existing airport, as shown in **Figure 3.1d**. The total development area is approximately 230 ha, which includes approximately 30 ha that is currently elevated above the floodplain.

As discussed in the Chapter A4 – Project Description, the new runway has been designed to have immunity from 100-year average recurrence interval (ARI) flood in combination with a 2100 sea level rise scenario of 0.8 m. To achieve this, a fill embankment up to approximately 4 m height will be constructed from sand imported from Moreton Bay. The site is underlain by soft materials at the northwest end of Runway (RWY) 13/31 (refer **Section 3.5**) and surcharge is proposed to address this. The imported sand will be mixed with seawater and pumped to site; to prevent saline water seeping into the underlying fresh groundwater, it is proposed to install a geosynthetic liner in the reclamation area.

Additionally, major drainage would be constructed to the north of RWY 13/31, which has the potential to affect groundwater levels, as discussed in **Section 3.7.6**. To prevent impacts, it is proposed to install a high-density polyethylene (HDPE) cut-off wall. ASS may also be disturbed during construction of the drain, as discussed in **Section 3.5.2**.

A detailed description of the proposal is included in Chapter A4 – Project Description. Potential impacts from the Project and their mitigation is discussed in **Section 3.6**.

Additional detail of the proposed drainage infrastructure is provided in Chapter A4 – Project Description.

3.2 METHODOLOGY

3.2.1 Geotechnical conditions

Geotechnical investigations were undertaken to identify existing site conditions and determine the necessary ground improvements for the proposed runway and associated infrastructure. The results of field investigations previously undertaken in 2010 for the Master Plan Implementation Project were considered in conjunction with the investigations undertaken for the Draft Environmental Impact Statement (EIS).

3.2.1.1 Desktop review

Background information was reviewed to help target fieldwork for the geotechnical investigation and inform the geotechnical model for the site. The following information was reviewed:

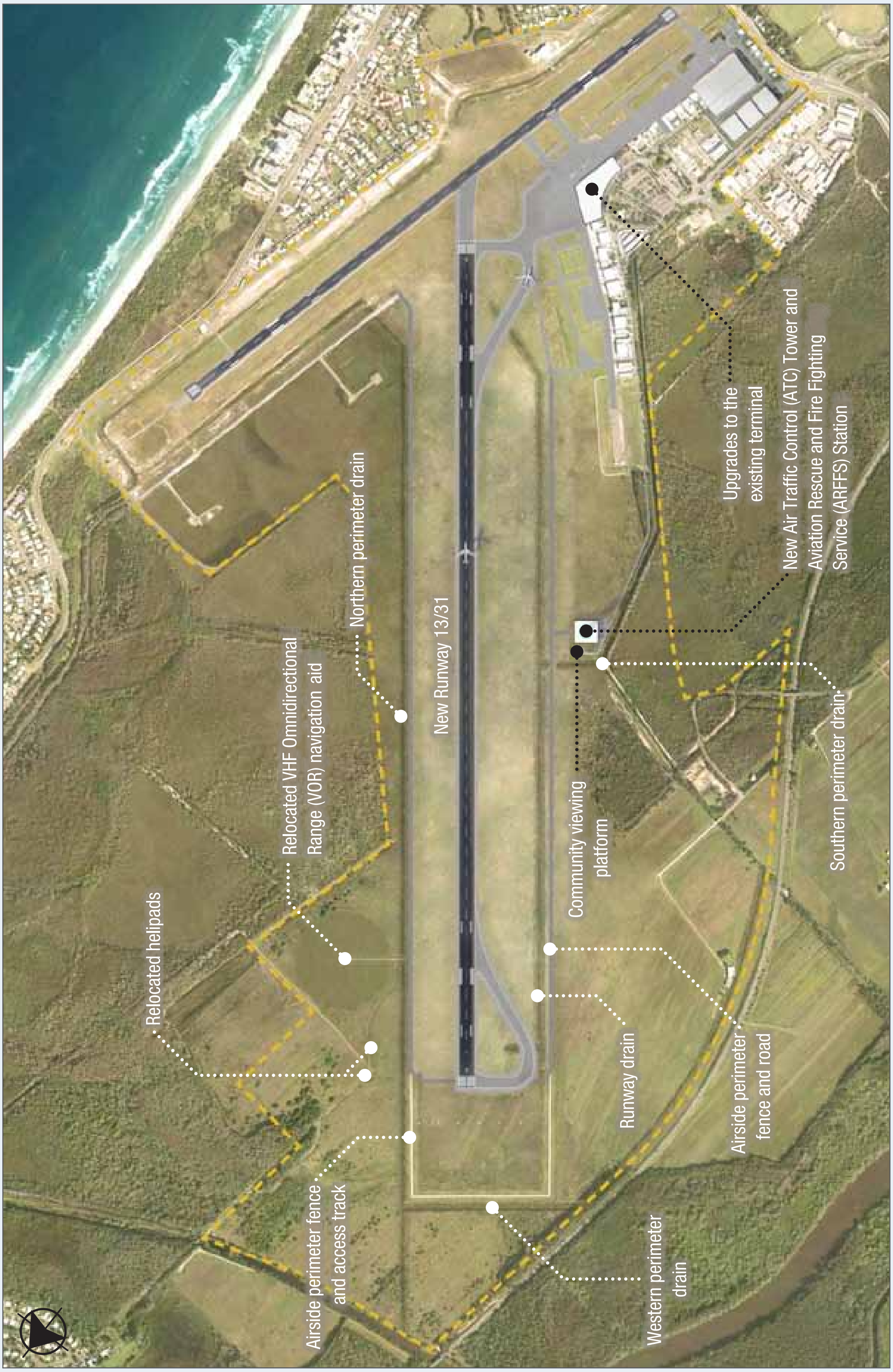
- Nambour Special Sheet 944 and Part 9544, 1:100,000 First Edition 1999 (Cranfield, 1999)
- Geotechnical investigations undertaken by Golder at the SCA site not associated with the Project, including:
  - Preliminary Geotechnical Investigation: Master Plan Implementation Project, Sunshine Coast Airport (ref 107682013) (Golder, 2010)
  - New Bay 5 taxiway and apron between the terminal and south of proposed runway (ref 107682026) (Golder 2010b)

Figure 3.1a: Location of the Sunshine Coast Airport

Figure 3.1b: Surrounding land uses

Figure 3.1c: Geotechnical, soils and groundwater study area

Figure 3.1d: Proposed development



- Extension to lease area on the southern side of the proposed runway and west of existing buildings (ref 097682031) (Golder, 2009)
- Extension to taxiway and hangars (ref 097682008) (Golder, 2009a)
- Jet A1 Facility upgrade within the Shell Aviation compound (ref 05682066) (Golder, 2005)
- Fire station site on the eastern side of the existing runway (ref 04682078) (Golder, 2004).

3.2.1.2 Field investigation

The geotechnical component of the investigation comprised borehole drilling augmented with dynamic cone penetrometer (DCP) testing. Field investigations were undertaken in 2012 and 2013 to inform the EIS and also the preliminary design of the runway.

2012 investigation

Fifteen boreholes (designated BH1/12 to BH17/12) were drilled by means of a four-wheel drive mounted drill rig using solid flight auger techniques (refer **Figure 3.2a**). The boreholes were drilled to depths ranging between 6 m and 8.5 m below ground level (BGL). DCP testing was undertaken adjacent to or within these boreholes.

The boreholes were drilled across the footprint of the proposed new runway and associated infrastructure to the south of the proposed runway. The boreholes were targeted to fill in gaps between borehole locations from the abovementioned previous geotechnical investigations, particularly in the area where very soft/soft clay was previously identified.

An additional nine DCP tests (designated DCP1/12 to DCP7/12, including DCP3b/12 and DCP5b/12) were undertaken in the northern area of the proposed expansion to assist in delineating the extent of soft soils in this area where rough 'boggy' terrain limited access for the drill rig. The DCP tests were undertaken to depths ranging between 1 m and 9.2 m BGL.

Representative disturbed soil samples were recovered from the boreholes, as well as undisturbed (U50 tube) soil samples from suitable cohesive soils, where encountered. Pocket penetrometer testing was carried out on the ends of undisturbed soil samples, as well as on suitable disturbed soil samples.

The fieldwork was undertaken between 27 August and 12 September 2012.

2013 field investigation

Eleven boreholes were drilled across the northern portion of the site in June 2013. These boreholes were designated borehole BH1/13 to BH9/13, BH12/13 and BH13/13. Nine of the boreholes were undertaken on proposed ecological offset areas to the north/north-west of the proposed runway footprint. Two of the boreholes were drilled on the northern portion of the proposed runway footprint.

The boreholes were drilled to depths of 9 m BGL, using a truck-mounted drill rig with auger and/or rotary drilling techniques. All drilling was undertaken in the presence of a geotechnical engineer, who logged the subsurface profile.

A dual-level standpipe piezometer was installed in three of the boreholes on completion of drilling (BH1/13, BH5/13 and BH9/13). The dual-level standpipe comprises a shallow piezometers installed at the top of the indurated sand ('coffee rock'), and a deep piezometer installed through the base of the coffee rock and into the underlying soils.

Borehole and DCP location coordinates were recorded in the field using a handheld GPS unit with +/- 5 m horizontal accuracy. The borehole and DCP locations are shown on **Figure 3.2a**. Test locations from the ASS, contaminated land, erosion & sediment control, agricultural classification, and groundwater investigation are also shown on **Figure 3.2a**.

Reports of the geotechnical boreholes and DCP tests are attached in **Appendix B3:A**, together with explanatory notes.

3.2.1.3 Laboratory testing

Selected soil samples recovered from the boreholes were forwarded to a NATA accredited laboratory for geotechnical laboratory testing.

Bulk soils samples for California bearing ratio (CBR) testing (to provide an indication of the mechanical strength and load bearing capacity of the sub-surface soils) were recovered from test pits excavated as part of the ASS investigation undertaken concurrently with the geotechnical investigation (refer **Section 3.3.2**).

Laboratory testing comprised the following:

- Atterberg limits and percent fines assessments (to confirm visual classifications of the soils)
- Soaked CBR testing (for pavement design parameters)
- Consolidation (oedometer) testing (to confirm soil parameters for refinement of settlement analysis).

3.2.2 Acid sulphate soil

The formation of ASS is most commonly the result of marine or estuarine deposition of sulphate and iron bearing sediments in the presence of an abundant source of readily decomposable organic matter resulting in the deposition of pyrite. This pyrite is stable within the soil so long as anoxic conditions prevail. Oxidation of this material produces acidic conditions and oxidation typically occurs as the material is exposed above the water table by excavation, and by lowering the water table during dewatering processes.

Previous experience and available guidelines indicate that ASS are normally restricted in extent to recent (Holocene to Pleistocene age) soil horizons deposited in a saline environment below RL 5 m, with actual ASS often occurring at the top of the soil profile. ASS commonly occur throughout coastal, eastern and northern Australia and parts of western Australia.

Figure 3.2a: Field investigation locations

In Queensland, ASS assessments are conducted in accordance with requirements of the *State Planning Policy, 2014* and sampling and analysis is planned using the Queensland Department of Natural Resources and Mines (NRM) '*Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland – 1998*', developed by the Queensland Acid Sulfate Soils Investigation Team (QASSIT).

3.2.2.1 Desktop review

The desktop study for ASS was generally based on the methodology recommended in the *Queensland Acid Sulfate Soil Technical Manual* (DNRME, QASSIT, 2004). This included a review of published maps and data on the occurrence of ASS in eastern Australia (in particular the immediate site and surrounds).

Assessment of the following criteria was undertaken:

- Site topography and height above sea level (Australian height datum [AHD])
- Proposed construction methods and design of the project
- Published maps of ASS distribution in South East Queensland
- Regional geology and indicative soil types and their origins
- The findings of previous ASS investigations conducted within the site area.

Preliminary ASS investigations were undertaken at the site as part of the Master Plan Implementation Project (Golder, 2010a). The results from the preliminary assessment were used in the current assessment and in developing a liming regime for the site.

The 2010 assessment included field investigations comprising 12 boreholes from which 96 samples were collected for laboratory testing (Golder, 2010a).

3.2.2.2 Field investigation

Given the ASS investigation and assessment was undertaken for an EIS a reduced sampling density was adopted due to being in the early preliminary planning stages of the proposed development. Further detailed investigations would be required to be undertaken to meet the sampling and analysis requirements as prescribed in the Guidelines once detailed design is complete and the final extent of filling and excavations in areas below 5 m AHD are confirmed.

Twenty-eight boreholes were distributed across the expansion site during the current investigation. Thirteen boreholes were located along the proposed northern perimeter drain alignment at 350 m intervals (ASS 7 to ASS 16, ASS 18 to ASS 20) except between ASS 16 and ASS 18 where access could not be achieved. Boreholes were extended to 1 m below the proposed depth of excavation (estimated at 1 m), to satisfy the SSP2/02 guidelines.

Fifteen boreholes (BH1/12, BH3/12 to BH7/12, BH9/12 to BH17/12) drilled for the geotechnical investigation were sampled for ASS. Samples for ASS analysis were collected to A depth of 2 m. Of these boreholes, 21 were located towards the northern end of the development and six in the southern end of the development. These boreholes supplemented the 12 boreholes completed during the 2010 investigation.

Borehole locations from the current and previous investigations are shown on **Figure 3.2a**.

Boreholes from the current investigation were drilled using a 4WD-mounted solid flight auger rig (using push tube sample techniques to recover undisturbed soil samples where possible). ASS boreholes 15 and 16 were drilled using a hand auger to compensate for access issues. The fieldwork was carried out in the presence of experienced environmental scientists between 27 August 2012 and 31 August 2012.

Soil samples for ASS analysis were recovered from the boreholes at approximately 0.25 m intervals to a depth of 2 m. ASS sampling protocols in the field were observed to minimise oxidation before laboratory testing in accordance with Ahern et al. (1998).

The approximate location of each borehole from the current investigation was recorded using a handheld GPS unit with a differential correction signal, having an accuracy of ± 3 m. Borehole coordinates are presented on the Reports of Boreholes in **Appendix B3:H** together with explanatory notes.

Groundwater was not assessed as part of the ASS investigation; they are reported separately as part of this EIS chapter.

3.2.2.3 Laboratory testing

A total of 227 soil samples were screened at an accredited laboratory to assess field pH (pH_F) and pH after oxidation (pH_{FOX}) using 30 per cent hydrogen solution buffered to pH 4.5 to pH 5.5. This supplemented the 96 samples screened in the previous (2010) investigation.

The pH_F/pH_{FOX} screening method consists of two steps. In the first step, the field pH of a 1:5 soil/water suspension is measured (pH_F). In the second step, a 30 per cent hydrogen peroxide solution is added to the sample, which is then heated to accelerate the oxidation. The pH after oxidation (pH_{FOX}) is then measured. A significant drop in pH between the pH_F and the pH_{FOX} indicates potential acidity. The test simulates extreme natural conditions and drops in pH may not be entirely attributable to pyrite oxidation.

Based upon the results of these screening tests, 56 samples (typically one per meter of soil profile per borehole) were selected and dispatched to Australian Laboratory Services Pty Ltd (ALS) to undergo quantitative analysis by the Chromium suite in accordance with ASS Method 23F and 22B laboratory procedures.

Samples selected for quantitative testing were selected from screening tests that exhibited probable or possible indications of actual/ potential ASS (AASS/PASS respectively) with distribution throughout the soil profile. Twenty-four samples were submitted for quantitative analysis by the Chromium suite method in the 2010 investigation.

The 'full' Chromium suite has been adopted by QASSIT for testing ASS in Queensland. This method includes analysis of the following:

- Actual acidity (as Titratable Actual Acidity [TAA])
- Potential acidity (as Peroxide Oxidisable Sulfur [SPOS])
- Acid Neutralising Capacity (ANC) quantification of naturally occurring alkaline materials (i.e. calcite, coral debris, fine shell fragments)
- Retained acidity (as Net Acid Soluble Sulfur [SNAS]) which includes sulfur held in largely insoluble compounds such as jarosite and other iron and aluminium sulfate minerals).

An overall acid-base accounting method was used to calculate a 'net acidity' value which is then used to calculate liming rates. This equation for 'net acidity' is given by:

Net Acidity = Existing Acidity (Actual Acidity [as TAA] + Retained Acidity [as SNAS]) + Potential Acidity (as SPOS) - insitu Acid Neutralising Capacity (ANC).

The ALS certificates of analysis, chain of custody and laboratory quality control document are attached in **Appendix B3:B** and the results are summarised in **Tables A1** and **A2** (**Appendix B3:B**). ALS is NATA accredited for this analysis method conducted.

3.2.3 Contaminated land

The process of a site contamination land assessment in Queensland is conducted in a staged approach in accordance with the Guideline for Contaminated Land Professionals (DEHP, 2012), which comprises the following:

- Stage 1 – Preliminary Site Investigation (PSI)
- Stage 2 – Detailed site investigation
- Stage 3 – Health and environmental risk assessment and development of Remediation Action Plan (RAP)
- Stage 4 – Implementation of RAP and preparation of validation report.

The requirements for Stages 2, 3 and 4, if any, are dependent on the findings of Stage 1.

This assessment has been prepared to provide site history information (to identify potential contamination sources) and limited, targeted sampling to evaluate the possible presence of contamination in line with the requirements of:

- A Stage 1 PSI as outlined in the Guideline for Contaminated Land Professionals (DEHP, 2012)
- Standard Advice Sheet: Reconfiguration of Lot Applications and Material Change of Use Applications Involving Contaminated Land Issues published by the SCC (SCC, 2009)

3.2.3.1 Desktop review

The site history was reviewed based on the following information sources:

- Current and historical title searches
- Review of available Council and Queensland Department of Environment and Heritage Protection (DEHP) records
- A review of available historical aerial photographs of the site
- Discussions with land owners and stakeholders (previous and current as relevant) as available
- A walkover inspection of the site by an Environmental Scientist.

3.2.3.2 Field investigation

A limited field investigation was undertaken:

- Investigation locations were selected based on particular areas of concern identified within the expansion area - former night soil depot, farm maintenance sheds and the cane fields. The investigation consisted of a total of 13 boreholes (BH1 to BH13) to a depth of 1 m BGL as shown on **Figure 3.2a**
- Selected soil samples were collected and analysed for the Potential Contaminants of Concern (refer **Section 3.5.3**). Laboratory results are provided in **Appendix B3:K**
- A quality assurance/quality control program was implemented and results for the field and laboratory program are summarised in **Appendix B3:L**.

3.2.4 Erosion and sediment control

An erosion hazard assessment (EHA) was undertaken to identify the nature and degree of any constraints or opportunities, relevant to the Project and runway.

The site was assessed for erosion hazard based on the procedures published in the IECA Best Practice Erosion and Sediment Control (IECA, 2008) publication.

Assessment of erosive hazard potential of the site and development included the following:

- Determining site soil characteristics including, but not limited to:
  - Presence of dispersive soils
  - Presence of hard setting and surface sealing soils
  - Extremes of soil pH and fertility (i.e. their ability to sustain vegetative cover)
  - Presence of non-cohesive soils
- Assessing the topography of the site before and after development

- Assessing climatic factors (rainfall and wind)
- Identification of waterways and drainage lines
- Conducting soil loss estimates using the Revised Unified Soil Loss Equation (RUSLE) method
- Determining an erosion hazard rating for the site.

Soil mapping developed and made available by the Geological Survey of Queensland and Sunshine Coast Council was reviewed for the EHA.

3.2.4.1 Field investigation

The assessment used a reduced soil sampling frequency to that recommended by the IECA as existing soil mapping data indicates that there is little variation in soils across the project site, the site generally has adequate vegetation cover and aerial photography did not indicate evidence of surface erosion. Soil sampling and analysis that was undertaken as part of the ASS, Good Quality Agricultural Land (GQAL)/ Strategic Cropping Land (SCL), and geological assessments is considered to be sufficient to develop an understanding of the erosion potential of the site.

The assessment included a site walkover, drilling of auger holes to facilitate collection of soil samples and logging of shallow soils, and was carried out by an experienced environmental scientist. The aim of the walkover was to record surface indicators of soil erosion and to appraise potential erosion hazards and assess the contributing local topography and site drainage. Data from the walkover and subsurface investigations was used to define the predominant soil strata and topographic constraints present at the site. Laboratory testing was then undertaken to determine the particle size and potential dispersivity of the predominant soil types present.

The investigation was also undertaken in accordance with the SCC's *Manual for Erosion and Sediment Control* (SCC, 2008). The *Manual for Erosion and Sediment Control* requires "a single confirmatory composited sub-soil test, for each major geomorphic unit". Sampling of the single geomorphic unit present was carried out in accordance with the Brisbane City Council Soil Sampling and Testing Guideline for Erosion Potential and laboratory analysis carried out by a NATA accredited laboratory.

Fieldwork was carried out between 27 and 31 August 2012, and comprised 23 test pits excavated to depths of 1.1 m to 1.2 m (TP1/12 [south east corner] to TP23/12). The test pits were set out on a modified grid pattern and proposed locations were identified on the MGA94 grid datum. Test pits were spread across the site to attempt to cover variations in soil profiles. Locations were confirmed at the site using a hand held GPS unit with an accuracy of ± 5 m. Final test pit locations are shown on **Figure 3.2a** in **Section 3.2.1.2**.

The soil profile was described and soil samples were collected for field testing and laboratory analysis at depth intervals of 0–0.15 m, 0.25–0.35 m, 0.55–0.65 m, 0.9–1.0 m and 1.1–1.2 m (or 1.0–1.1 m where the test pit was not advanced beyond 1.1 m). Soil samples were labelled and sealed in plastic bags and placed in cooler boxes for transport to the laboratory for analysis.

Reports of test pits are presented in **Appendix B3:C**, together with explanatory notes.

Samples were tested in the field for pH (1:5) and electrical conductivity (EC) (1:5). Selected samples were obtained for preliminary ASS screening by the pH/pH_{FOX} test method. The determination of field pH and EC consisted of making an approximate 1:5 soil/water suspension, and measuring pH and EC using a calibrated portable water quality meter. Selected field screening samples were collected from the same test pits that were undertaken as part of the SCL and GQAL assessment. The pH and EC field test results are recorded on the test pit logs (refer to **Appendix B3:C**).

Specific site details recorded during the fieldwork program comprise:

- Layout of site and site features
- Location of test pits
- Direction and grade of slopes on the site
- Presence of exposed rock and large boulders (none present at this site)
- Extent, condition and type of vegetation cover.

3.2.4.2 Laboratory testing

Selected soil samples were couriered to ALS in Brisbane for determination of baseline soil chemistry. Separate sub-samples collected from five representative locations at the surface and one selected subsurface depth (0.55-0.65 m) were sent to the NATA accredited laboratory for particle size distribution (PSD). The PSD tests were undertaken to confirm the textural classification described in the field and for input into the RUSLE.

Selected samples were also analysed for the following for input into RUSLE:

- Organic content
- Emerson Class Number (This test classifies the behaviour of soil aggregates when immersed, soils are divided into seven classes on the basis of their coherence in water).

3.2.4.3 Assessment of soil erosion and dispersion potential

According to the SCC's Manual for Erosion and Sediment Control, RUSLE is designed to predict the long term, average, annual soil loss from sheet and rill flow. The RUSLE equation is:

A = R x K x LS x P x C

where

A = Computed soil loss (tonnes/ha/yr)

R = Rainfall erosivity factor

K = Soil erodibility factor

LS = Slope length/gradient factor

P = Erosion control factor

C = Ground cover management factor.

The input parameters and values for the above components are discussed below.

Rainfall erosivity factor (R)

The rainfall erosivity factor is a measure of the ability of rainfall to cause erosion.

Soil erodibility factor (K)

Soil erodibility is a measure of the susceptibility of the soil to detachment and transport by rainfall and runoff. The soil erodibilty factor, or K factor, is predominately derived from the soil texture. However, the soil structure, organic matter content and profile permeability also contribute.

Soil profile permeability refers to the rate of infiltration of water into the soil.

The final input to determine the K factor is the measured or estimated content of gravel and rock fragments (> 2 mm) by weight. Gravel and rock fragments, when present in a coarse textured soil profile can reduce infiltration.

The clay content, silt content, very fine and coarser sand contents and gravel content were derived from the PSD reports. The percentage organic matter was determined in the laboratory.

The surface soil structure is generally dependent on the diameter of the soil aggregates, with Grades ranging from 1 (very fine; <1 mm diameter) to 4 (Massive/blocky clay soils).

Topographic factor (LS)

The topographic factor (LS factor), or slope length-gradient factor, describes the combined effect of slope length and slope gradient on soil loss. To calculate the LS factor requires an interpreted slope gradient, slope length and the rill/interill ratio.

The slope length is defined by the distance, measured parallel to the ground surface, from the origin of overland flow to the point where either the slope length decreases enough so that deposition begins or where runoff becomes concentrated in a defined channel (such as an ephemeral gully).

Erosion control factor (P)

The erosion control factor (P factor) is rarely applicable for construction sites and is typically given a nominal value of 1.0 for this application.

Ground cover management factor (C)

The ground cover management factor (C factor) applicable for construction sites referencing **Table A3-3** of **Appendix 3** of the SCC's Manual for Erosion and Sediment Control gives a range of interpretation based on percent grass cover and nature of the surface treatment.

3.2.5 Land resource assessment

The land resource assessment includes:

- Provision of baseline data for inclusion in a site Soil Management Plan and to provide data required to develop soil treatment strategies for rehabilitation works
- Desk based review of the site in terms of whether it is considered strategic cropping land as per *Regional Planning Interests Act 2014*
- Classification of land resources in terms of the existing Queensland Planning Guidelines: The Identification of GQAL, January 1993; which is understood will remain in force to some extent as part of the adopted strategic cropping land legislation, or at least until the SCL legislation is formalised.

Note * DERM has been replaced by the current Department of Natural Resources and Mines (NRM) and Department of Environment and Heritage Protection (DEHP), as of March 2012.

An assessment of the land resources and baseline soil chemistry of the site was undertaken. The assessment includes classifying the soil resources in terms of the existing GQAL guidelines. These guidelines are used for planning and development applications in rural areas, and are used to identify and classify land suitable for cropping or animal production with the aim of protection of these landscapes. The GQAL guidelines remain relevant in the EIS process.

3.2.5.1 Desktop review

Australian Soil Resource Information System (ASRIS) (CSIRO, 2013) and DNRM soil mapping overlays were referenced to determine the predominant soil types within the proposed development area.

The Project does not involve resource activities or regulated activities as defined by the *Regional Planning Interests Act 2014*. Further, according to mapping prepared by the Queensland Government, none of the land within the Project site is designated as strategic cropping land. There are areas adjacent to the airport mapped as strategic cropping land or potential strategic cropping land.

The 'Land Resource Area' 1:100,000 map and the 'Land Suitability for Horticulture' 1: 100,000 map in the report Horticulture Land Suitability Study, Sunshine Coast, South-East Queensland (DPI, 1987) were also reviewed as part of the Land Resource Assessment desktop study.

3.2.5.2 Field investigation

For the Coastal Zone, a sampling frequency of one 'detailed location' per 12 ha is required to undertake a fully compliant Strategic Cropping Land assessment. This would require some 39 locations. As the assessment is for an EIS, a reduced inspection and sampling rate was adopted.

A field and laboratory analysis program was adopted based on the GQAL guidelines and with reference to the Strategic Cropping Land (SCL) 'criteria'. Twenty-three observation locations were used for the assessment. This equates to one location per 20 ha which was considered sufficient to characterise the site in line with the GQAL recommended density of at least 1 location per 25 ha; five of these locations were sampled and analysed as detailed description locations. This density of observations and analysis meets the GQAL guidelines, which require 20 per cent of the assessment locations to be analysed.

The SCL Trigger Map S1 for the Toowoomba – Brisbane Region indicates that the site is not classified as Strategic Cropping Land (SCL). The adjacent land immediately to the west is however, indicated as Potential SCL, so to confirm that the site proper does not contain potential SCL, a limited field program, based on the GQAL assessment locations was undertaken, supplemented by a further seven test pits where pH and EC was determined in the laboratory at the appropriate SCL criteria assessment depths. Additionally, soil profiles were logged and reported for all 23 test pit locations using the Australian Soil Classification (ASC) system and in accordance with the relevant SCL assessment protocols.

Fieldwork was carried out between 27 and 31 August 2012, and comprised 23 test pits excavated to depths of 1.1 m to 1.2 m (TP1/12 [south east corner] to TP23/12) in line with the GQAL guideline for sampling. The test pits were set out on a modified grid pattern and proposed locations were identified on the MGA94 grid datum. Test pits were spread across the site to attempt to cover variations in soil profiles. Locations were confirmed at the site using a hand held GPS unit with an accuracy of ± 5 m. Site and test pit location descriptions were collected including of landform, slope, surface conditions, and vegetation in accordance with the Australian Soil Land Survey Field Handbook (McDonald, 1990). Final test pit locations are shown on **Figure 3.2a** in **Section 3.2.1.2**.

The soil profile was described and soil samples were collected for field testing and laboratory analysis at depth intervals of 0–0.15 m, 0.25–0.35 m, 0.55–0.65 m, 0.9–1.0 m and 1.1–1.2 m (or 1.0–1.1 m where the test pit was not advanced beyond 1.1 m). The depths at which soil samples were collected are identified in the test pit logs (refer to **Appendix B3:C**). Soil samples were collected at depths to accommodate the recommendations of the GQAL for soil sampling and so that the soil could also be characterised against the SCL criteria. Soil samples were collected at the depths shown in **Table 3.2a**.

Based on the site and soil profile findings of these 'ground observation' locations, five locations across the site were selected as 'detailed sites' for description and analysis of the component land types. Detailed site descriptions and additional samples were collected at the 'detailed' locations at the nominated depth intervals. Soil sub-samples were labelled and sealed in plastic bags and chilled for transport to the laboratory for analysis. Soil analyses were selected to assess the baseline chemistry, GQAL criteria and the SCL criteria.

Samples from each of the 23 test pits were tested in the field for pH and electrical conductivity (EC). The determination of field pH and EC consisted of making an approximate 1:5 soil/water suspension, and the measurement of pH and EC using a calibrated portable water quality meter. The pH and EC field test results are recorded on the test pit logs.

As the soils encountered were acidic, no calcitic aggregations were observed in the soils sampled, and so carbonate effervescence ('fizz') testing was not undertaken. Fizz testing rates the degree of sample effervescence (fizzing) qualitatively and is adopted as an indicator of the likely presence of carbonates.

3.2.6 Groundwater

A desktop review of available data was undertaken to inform a data gap analysis to identify information requirements for the controlling factors affecting groundwater recharge, discharge, flow and occurrence.

A field investigation program was designed to target gaps in the data and collect baseline data.

Information collated from the desktop study and field investigation was then reviewed as part of the groundwater baseline assessment to produce a conceptual hydrogeological model (CHM) of the site.

A suitable methodology for the groundwater impact assessment was selected based on the CHM. Numerical modelling was carried out to predict potential impacts on groundwater levels and quality as a result of the Project, and to provide design input to the placement of sand fill, drains and tailwater management.

Table 3.2a: Soil sampling depths

Depth	Rationale
0.0-0.15 m	• Surface (topsoil) sample for baseline chemistry and fertility testing • Represents the commonly accepted cultivation depth
~ 0.3 m	• To assess pH, sodicity and salinity against the SCL and the GQAL guidelines
~ 0.6 m	• To assess pH, sodicity and salinity against the SCL and the GQAL guidelines
0.9-1.0 m	• To determine whether soil depth reaches 1.0 m in accordance with the SCL and the GQAL guidelines
1.1-1.2 m	• As required by the GQAL guideline for soil analysis

3.2.6.1 Desktop review

A number of data sources were reviewed to obtain information on groundwater at the site, as listed in **Table 3.2b**.

3.2.6.2 Field investigation

The fieldwork for the groundwater assessment was undertaken to collect data necessary for defining groundwater conditions, and included the following:

- Installing five dual-level standpipe piezometers to observe groundwater levels
- Geological logging of bores during drilling
- Hydraulic testing of bores to investigate the hydraulic properties of the strata (rising head field testing)
- Groundwater level and quality monitoring to assess changes in groundwater levels and chemistry during the observation period
- Surface water level and quality monitoring to identify baseline conditions.

Site investigation works were carried out between 27 September and 12 October 2012.

Drilling and piezometer installation was completed under the surveillance of a field hydrogeologist. Five zones were determined to require groundwater monitoring wells, each requiring monitoring at two different depths. The shallow piezometers were installed at the top of the coffee rock (between 0.9 m and 1.5 m BGL), and the deep piezometers were installed through the base of the coffee rock and into the underlying sand/silty sand (between 6 m and 9 m BGL).

Drilling was undertaken using a dry, solid stem auger down to 2.5 m depth, and wash-boring beyond 2.5 m with a Hydrapower Scout drill rig. Geological logging of samples was performed at each bore, and drilling observations (including loss of circulation, water make, drill penetration rate, etc.) were recorded. More detail is shown in the bore construction logs in **Appendix B3:D**.

Standpipe piezometers (SP) were installed in each bore using 50 mm diameter Class 18 PVC screw jointed blanks and screened sections machine slotted with 0.5 mm aperture size. Screens were covered with a geotextile sock, and an end plug was fixed to the bottom of the well. A filter pack of 2 mm to 3 mm grain sized sand was installed around the screened sections of the PVC, with a bentonite plug (using pellets) above, and back filled to the ground surface using grout-cement. Each SP has approximately 0.5 m stick-up with a securely fixed, protective monument casing. SP installation reports are in **Appendix B3: D. Table 3.2c** summarises the construction details of the SPs.

Each SP was developed by bailing at least three well bore volumes plus any volume of drilling fluid remaining in the borehole. Well development was initiated on 2 October 2012 and was completed on this day for the deep SPs. The shallow SPs became dry before sufficient water was purged, so development was completed during the field testing visit on 12 October 2012.

Groundwater inflow was observed in each borehole during drilling, and depth to groundwater was measured before and after standpipe installation and field testing.

Water quality measurements were taken for pH, temperature, salinity and dissolved oxygen (DO) in each of the deep standpipes and in a number of surface water monitoring locations. The shallow standpipes did not contain sufficient water for water quality testing. The standpipe piezometer and surface water monitoring locations selected are shown in

Table 3.2b: Summary of data used in the desktop groundwater assessment

Data Requirement	Source
Geological (including previous reporting at this site)	• Nambour Special Sheet 944 and Part 9544, 1:100,000 First Edition 1999 (Cranfield, 1999) • Preliminary Geotechnical Investigation: Master Plan Implementation Project, Sunshine Coast Airport (ref 107682013) (Golder, 2010) • New Bay 5 taxiway and apron between the terminal and south of proposed runway (ref 107682026) (Golder, 2010b) • Extension to lease area on the southern side of the proposed runway and west of existing buildings (ref 097682031) (Golder, 2009) • Extension to taxiway and hangars (ref 097682008) (Golder, 2009a) • Jet A1 Facility upgrade within the Shell Aviation compound (ref 05682066) (Golder, 2005) • Fire station site on the eastern side of the existing runway (ref 04682078) (Golder, 2004)
Hydrogeological	Site investigation carried out as part of this scope of works (see following section)
Water Resources/ Environmental Setting	Department of Natural Resources and Mines (DNRM) (previously Department of Environment and Resource Management (DERM)) bore database
Climatic	Australian Bureau of Meteorology (BOM) internet page (BOM, 2013)

Table 3.2c: Standpipe installation summary

Standpipe ID	Easting (m)	Northing (m)	Installation Date	Bottom of Borehole (m BGL)	Stick-Up (m)	Water Level after installation (m BGL)	Top of Screen (m BGL)
Zone 1A	7059728	507788	27 Sep 2012	8.8	0.60	1.30	5.55
Zone 1B	7059728	507789	27 Sep 2012	2	0.65	1.14	0.50
Zone 2A	7058879	508400	28 Sep 2012	5.7	0.70	0.85	2.70
Zone 2B	7058879	508399	28 Sep 2012	1.2	0.73	0.75	0.60
Zone 3A	7058414	805906	27 Sep 2012	7.2	0.75	0.3	3.80
Zone 3B	7058414	508905	27 Sep 2012	0.9	0.60	0.1	0.50
Zone 4A	7058376	507607	2 Oct 2012	8.2	0.74	2.00	5.00
Zone 4B	7058376	507608	2 Oct 2012	1.2	0.70	Dry	0.50
Zone 5A	7058786	507415	28 Sep 2012	8.25	0.68	1.05	5.00
Zone 5B	7058786	507414	28 Sep 2012	1.55	0.60	0.87	0.75

Note: BGL = below ground level

Figure 3.2a in **Section 3.2.1.2** Water quality parameters were measured using a calibrated meter, and a long arm was used for in-situ surface water data collection.

Rising head tests were performed in all standpipes that contained sufficient amounts of water. The tests were then analysed using the Hvorslev approximation (Hvorslev, 1951) to estimate a field saturated hydraulic conductivity of the corresponding formations.

<u>Supplementary field investigations</u>

A supplementary field investigation was undertaken in November 2013 at an area of ecological significance near the southern extremity of the fill area (Wallum Heath Management Area (WHMA).

The investigation was carried out to assess the subsurface conditions in the WHMA, with particular emphasis on the depth to indurated sands, as well as near-surface groundwater levels.

The supplementary field investigation in the WHMA comprised a grid of 10 dynamic cone penetration (DCP) tests[1], designated DCP1 to DCP10. The DCP tests were carried out to depths of between 1.1 m and 1.8 m BGL.

A standpipe piezometer was installed at five of the WHMA DCP locations (DCP3 and DCP7 to DCP10), i.e. a total of five piezometers. The standpipes were installed using hand augering and manual driving techniques, to depths of between 1.3 m and 1.64 m BGL. Each standpipe comprises 3 m of galvanised steel pipe with a perforated tip of 0.3 m length attached to the base. Following installation, the groundwater level in each piezometer was recorded using a dip-meter.

1 *Due to the sensitive nature of the WHMA, invasive ground investigation techniques (e.g. mechanically-augered boreholes and excavator test pits) were not considered viable.*

The fieldwork was carried out by experienced environmental science personnel, who also logged the ground conditions during hand augering for piezometer installation.

In addition, monthly field sampling and observation of groundwater levels from eight standpipes was undertaken in the period from August 2013 to April 2014. The monitoring and sampling consisted of recording groundwater levels, and field testing of pH and electrical conductivity using a calibrated Aqua Read AP-800 water quality analyser (calibration of the Aqua Read is conducted each time before use). Standing water levels (SWL) were measured using a dip metre (Solinst – Interface Meter, Model 122). Data loggers were installed to record temporal changes in standing water levels at two bores (BH1/13, shallow; and BH9/13, deep). Loggers were downloaded on 28 February 2014. Logger data were compensated for barometric pressure changes and converted to meters above Australian Height Datum (Mahd) using the manual measured SWL.

3.3 ASSUMPTIONS AND LIMITATIONS

3.3.1 Geotechnical

The thickness and lateral extent of the soft alluvial clay layer in the north-western portion of the site area will need to be confirmed through additional subsurface investigation.

3.3.2 Acid sulphate soil

The geology at the site comprises a relatively thick layer of indurated sands ('coffee rock') overlain by fine to medium grained alluvial sand deposits, which makes it impractical to obtain a continuous core using hydraulic vibrocoring in the strongly cemented sand materials.

Consequently, a conventional auger drill rig with push tube capabilities was used to advance to the proposed depth of each borehole.

Some areas of the site could not be accessed because of terrain and vegetation cover, and further investigations will be required in these areas before construction commences. In addition, the QASSIT Guidelines require a minimum of 2 test locations per hectare for ASS assessments and a minimum of 1 test location per 50 m of disturbances for linear alignments (e.g. drains, underground service trenches, etc.). Consequently further investigations will be required once detailed design is complete and the final extent of filling and excavations in areas below 5 m AHD are confirmed.

3.3.3 Contaminated land

The area around the existing airport fuel infrastructure was not targeted for field investigation. Historical spills in this area have been the subject of previous soil and groundwater assessments (by other parties). These previous assessments were conducted for the Shell Company of Australia Ltd (Shell) for its internal purposes and are subject to limitations and reliance statements, which have placed some restrictions on the reporting of contamination in these areas in the EIS.

A detailed investigation to determine the extents of possible contamination and/or detailed remediation plans was beyond the scope of the EIS.

3.3.4 Erosion and sediment control

The assessment of erosive characteristics was undertaken using industry accepted methods. Assumptions that inform the assessment were made based on field investigation and observed site characteristics. While the assessment provides an adequate assessment of the erosion potential of the site, it does not reflect localised variations in erosion potential.

3.3.5 Land resources assessment

The DERM Guidelines for applying the SCL criteria indicate a minimum site sampling density of 1 site per 12 ha. However, given the early planning stage of the project and the preliminary findings of the desktop study the adopted sampling density was considered suitable for characterizing the site. For the EIS, 23 test pits were excavated in a general grid pattern across the 460 ha site, as indicated in **Figure 3.2a** in **Section 3.2.1.2** giving an approximate sampling density of 1 site per 20 ha.

The details collected at the 'ground observation' locations are considered sufficient to characterise the locations as 'check sites' as outlined in the SCL Guidelines for applying the proposed strategic cropping land criteria.

There are eight criteria used to define SCL within the proposed guidelines, three of which are based on 'above ground' characteristics with the remainder assessable by a range of field and laboratory tests. The criteria and thresholds for the Coastal Queensland Cropping Zone are outlined in **Table 3.3a**. All the criteria must be met for the location to be classified as SCL.

A Minimum Map Area (for the Coastal Zone) of 2 ha is an additional constraint to a Map Unit being considered SCL.

Table 3.3a: Criteria for identifying SCL in the coastal Queensland cropping zone

Criteria	Threshold (Coastal Queensland Cropping Zone)	Determined By
1 Site slope	≤ 5%	Above ground observations
2 Rockiness	≤ 20% for rocks > 60mm	Above ground observations
3 Gilgai microrelief[1]	< 50% of land with gilgai microrelief of >500 mm depth	Above ground observations
4 Soil depth	≥ 600 mm	Test pit observations
5 Soil wetness	Has favourable drainage[2]	Above ground & test pit observations
6 Soil pH	At 300 mm and 600 mm depth within range 5.1 to 8.9 [3]	Field testing
7 Salinity	EC1:5 <0.56 dS/m within 600 mm of the soil surface	Laboratory analysis
8 Soil water storage	≥ 75 mm to the depth of soil physico-chemical limitation to root growth[4] or 1000 mm, whichever is shallower	Calculation based on soil texture (test pit observations) and laboratory analysis

Notes:

1 *Seen as depressions or mounds relative to the general level of the ground surface*

2 *Favourably drained soil profiles do not contain waterlogged layers (to 1 m depth or the soil depth, whichever is the shallowest)*

3 *For rigid soils – i.e. soils with minimal capacity to shrink and swell with change in soil moisture*

4 *Soil physico-chemical limitations to root growth for Coastal Zone are: EC > 0.56 mS/cm & pH not 51 to 8.9; or exchangeable sodium percentage (ESP) >15 per cent (rigid soils); or calcium to magnesium ratio of 0.1 or less (rigid soils).w*

3.3.6 Groundwater

The assumptions and technical limitations of the groundwater impact assessment include the following:

- The locations and dimensions of filling and the settlement pond, including water volumes and levels, are as described in the Project Description (see Chapter A4 – Project Description and A5 – Project Construction)
- Preliminary reclamation levels for hydraulically placed fill are 7 m AHD in the northwest half and 5 m AHD in the southeast half of the fill area
- The tailwater retention volume is approximately 100,000 to 150,000 m^3 in the tailwater pond
- The general filling sequence will be from east to west, which is the general direction of the slope of the existing ground
- Material properties of the perimeter bund around the settlement pond is unknown so have been estimated for the modelling. The inside of the settlement pond perimeter bunds were assumed to be lined
- While the occurrence of the coffee rock has been investigated with a seemingly representative spatial distribution, it is evident that the coffee rock depth and thickness can change by at least 5 m between two locations separated by less than 250 m. This can have significant localised effects on water levels and ponding above the coffee rock, as well as the fate and transport of solute (salinity in this case) across the coffee rock layer and, therefore, laterally. Additionally, there is potential for groundwater movement to occur through gaps in the coffee rock layer where head differences allow
- It is expected that the ocean and brackish waters in the river mouth are sufficiently far enough from the site for tidal water level fluctuations to not to have a significant impact on site groundwater levels; however, monitoring has shown that the shallow groundwater quality in the north-western part of the site is tidally influenced
- Investigations were undertaken at a site-wide spatial scale, so groundwater level and quality impacts specific to localised areas on site may require additional field and/or modelling investigations and analyses depending on the details required.

3.4 POLICY CONTEXT AND LEGISLATIVE FRAMEWORK

3.4.1 Geotechnical

The geotechnical design has been developed to provide a stable platform for the runway, which has been designed in accordance with MOS 139 as described in Chapter A4 – Project Description.

3.4.2 Acid sulphate soil

The Queensland State Planning Policy SPP2/02 Planning and Managing Development Involving Acid Sulfate Soils (SPP2/02) has, since the commencement of this EIS, been replaced by the single State Planning Policy, 2014. However, given SPP2/02 was in force at the time of undertaking survey work for the EIS, it was used to guide field investigations. The former SPP/02 applied to land, soil and sediment at or below 5 m AHD where the natural ground level is less than 20 m AHD. Within such areas the SPP applies to development involving any of the following:

- Excavating or otherwise removing 100 m^3 or more of soil or sediment; or
- Filling of land involving 500 m^3 or more of material with an average depth of 0.5 m or greater.

The topography of the site ranges between 0m and 5m AHD. Thus, given the proposed excavations and filling activities, SPP2/02 was considered, at the time of survey, applicable to the Project and an assessment of potential disturbance of ASS in these areas was undertaken. State guidelines for sampling density and sampling procedures are provided in the Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1998 (Ahern et al., 1998). Laboratory testing was undertaken in accordance with accepted analytical procedures described in the Queensland Acid Sulfate Soil Laboratory Methods Guidelines (Ahern et al., 2004).

3.4.3 Contaminated land

Contaminated land in Queensland is managed under the framework of the:

- *Environmental Protection Act 1994* (EP Act)
- *Environmental Protection Regulation 1998*
- *Guideline for Contaminated Land Professionals* (DEHP, 2012).

DEHP administers the EP Act, which has an emphasis on managing Queensland's environment within the principles of ecologically sustainable development.

Contaminated land refers to land contaminated by hazardous substances that may pose a risk to human health or the environment. Land contamination can occur from poor environmental management and waste disposal practices or accidental spills in industrial or commercial activities. Activities identified as being likely to cause land contamination are listed as notifiable activities.

It is the owner or occupier's responsibility to notify DEHP of notifiable activities or of known contamination at a site. The owner or occupier must also comply with a notice given under the Act.

3.4.4 Erosion and sediment control

Erosion and sediment control in Queensland is managed under the following legislative framework:

- *Environmental Protection Act 1994*
- *Vegetation Management Act 1999*
- *Environmental Protection (Water) Policy 2009*
- *Manual for Erosion and Sediment Control (Version1.2), Sunshine Coast Regional Council 2008*.

The industry standard for estimate erosion potential and developing appropriate control measures is *Best Practice Erosion and Sediment Control* produced by the International Erosion Control Association, Australasia (IECA, 2008).

3.4.5 Land resource assessment

The documentation and preservation of GQAL and SCL in Queensland is controlled and managed under the following legislative framework:

- *State Planning Policy, July 2014*
- *Sustainable Planning Act, 2009*
- *Regional Planning Interests Act 2014*.

This framework generally seeks to preserve GQAL and SCL for food production or other agricultural purposes.

The previous *Strategic Cropping Land Act 2011* (SCL Act) provided for the:

- Protection of land that is highly suitable for cropping
- Management of the impacts of development on that land
- Preservation of the productive capacity of that land for future generations.

The SCL Act was repealed upon commencement of the *Regional Planning Interests Act 2014* (RPI Act) on 13 June 2014. Under the RPI Act, an approval is required when a resource activity or regulated activity is proposed in an area of regional interest. The RPI Act identifies four areas of regional interest:

- Priority Agricultural Areas
- Priority Living Areas
- Strategic Environmental Areas
- Strategic Cropping Areas (formerly Strategic Cropping Land).

A "regulated activity" for an area of regional interest is an activity likely to have a widespread and irreversible impact on the area of regional interest and be prescribed under a regulation for the area.

Certain regulated activities in some areas of regional interest will be exempt from requiring an approval under the RPI Act, for example, pre-existing regulated activities.

The Project does not involve resource activities or regulated activities as defined by the RPI Act. Further, according to mapping prepared by the Queensland Government, none of the land within the Project site is designated as strategic cropping land. There are areas adjacent to the airport mapped as strategic cropping land or potential strategic cropping land.

3.4.6 Groundwater

The following legislative documents are applicable to the groundwater impact assessment for this project:

- The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) controls actions that may have a significant impact on matters of national environmental significance. A number of Commonwealth listed species that may be affected by groundwater conditions are the site have the potential to occur within the Project site. The potential impacts on these species are discussed in Chapters B7 – Terrestrial Flora and B8 – Terrestrial Fauna
- *Environmental Protection Act 1994* (Qld) defines and outlines environmental values, environmental impacts process, and environmental management plan
- *Water Act 2000* (Qld) provides for the sustainable management of water and other resources and the establishment and operation of water authorities, and for other purposes
- The study area is located within the *Mary Basin Water Resource Plan, 2006*. The plan applies to surface water and sub-artesian water in the Cooloola Sandmass sub-artesian area. As the Project site is located outside the Cooloola Sandmass sub-artesian area, this plan does not apply to groundwater within the Project area
- *Environmental Protection Regulation 2008* (Qld), Subordinate Legislation 2008 No. 370 made under the EP Act
- *Environmental Protection (Water) Policy 2009* (Qld) identifies protected water bodies and water quality objectives for those water bodies. Environmental values of specific waters to be protected or enhanced in the vicinity of the site consist of the following:
  - Values identified in EPP (Water):
    - The Maroochy River to the west of the site is classified as a middle estuary with a management intent of moderately disturbed
    - The canal in Twin Waters to the south of the site is classified as a tidal canal/constructed estuary/ marina/boat harbour with a management intent of moderately disturbed.
  - Groundwater Dependent Ecosystems, which consist of:
    - The wetland areas to the north and south of the site
    - The areas of ecological significance to the north of the site, through the centre of the site, and to the south of the site, as well as along the Maroochy River to the west of the site and along the coast to the east of the site.
  - Existing and other potential groundwater users – interpreted from bore installations on record in the DNRM bore database.

In addition to the legislation and policies listed above, the guidelines below apply:

- The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) provide a management framework and water quality guidelines on fresh and marine water resources in Australia
- Queensland Water Quality Guidelines 2009 (EHP, 2013) provides guidelines on values of water quality indicators specific to the Queensland wetlands, coastal rivers, and drainage channels involved in this project.

3.5 EXISTING CONDITIONS

3.5.1 Geotechnical conditions

3.5.1.1 Overview

The site is underlain by Quaternary (Pleistocene) age "undifferentiated coastal plains", comprising "sands and mud" that is known to also contain "clay/silt (active stream channel and low terraces)". The Quaternary deposits are inferred to be underlain by the older Landsborough Sandstone and/or Nambour Formation (Cranfield, 1999).

The site is low-lying with a relatively topography; the entire site is below 10 m AHD. The site slopes down from the east towards the Maroochy River west of the site. Maximum elevations are along the existing main runway, at approximately 4 m AHD; the lowest parts of the site, near Marcoola drain are at approximately 0.5 m AHD. Given the very shallow slopes on the site, there is no risk of landslip.

The site is not known or likely to contain significant fossil sites, nor does the site display any significant geomorphological features such as lava tubes or karst.

Subsurface conditions at the site generally comprise topsoil over loose to medium dense sandy soils, which become dense to very dense with depth. A layer of dense or very dense indurated sand (known locally as 'coffee rock') is typically present at depths between approximately 0.5 m to 5 m BGL. This indurated sand can have the properties of extremely low strength rock.

The sandy soils are generally underlain by stiff to hard silty/sandy clay from about 14 m BGL to the depth of testing (up to 26.5 m BGL). This soil layer is inferred to be residual[2] to the Landsborough Sandstone and/or Nambour Formation indicated on the available geological mapping.

In the north-western portion of the site however, clays inferred to be of alluvial[3] origin ('marine' clay) were encountered. The thickness of the highly compressible soft/very soft clay layer is shown on **Figure 3.5a** as thickness contours. The clay thickness contours are derived from a combination of Golder's 2009, 2010, 2012 and 2013 investigations (refer **Section 3.5.1**). The results of the other components of the Geology, Soils and Groundwater Consultancy investigation were also used in the assessment of the clay thickness contours.

The zone of soft/very soft clay shown on **Figure 3.5a** is inferred to be approx. 30 ha in surface area. At the deepest points, roughly at the centre of this zone, soft/very soft clay thickness range between 4.5 m up to 8 m BGL (it should be noted that the 8 m thick very soft clay in borehole BH7/12 was encountered to the borehole termination depth). From the centre, soft/very soft clay thickness gradually decreases outwards to the edges of the zone.

Aerial photographs indicate the presence of waterlogged soils in the zone where the soft/very soft alluvial clays were encountered, with two drainage channels feeding into this area from an approximately north-easterly and south-easterly direction. The 'boggy', waterlogged nature of the ground in this zone is also highlighted by the difficult access across this area during the 2012 field investigation, despite no recent significant rainfall events.

The section of the Sunshine Motorway to the west of this zone is also reported to be underlain by deposits of soft clay (in the order of 10 m deep). Settlement of the road embankment can be seen by the change in grade of the roadway in this area (up to approx. 1 m vertical height in places).

Historical aerial photographs from 1967 show the zone of soft/very soft clay being densely vegetated. More recent aerial photography (1997, 2008 and 2011) shows that the north-western portion of the site has been progressively cleared and replaced with crops, although the lower-lying waterlogged zone was not cropped.

The soft/very soft alluvial clays encountered are likely to be associated with this lower-lying waterlogged area and associated drainage channels. It is inferred that in recent past history (in geological terms), meandering creek channels in the north-western part of the site may have resulted in scouring of the upper levels of the indurated sand layer, with subsequent deposition of soft, unconsolidated sediments of alluvial origin ('marine' or 'estuarine' clay). The presence of the two natural drainage lines, as well as the proximity of the Maroochy River immediately to the west of the soft/very soft alluvial clay zone supports this inference.

The geological model indicated by the subsurface investigations is supported by the available geological mapping.

3.5.1.2 Detailed description

The subsurface conditions encountered over the Project site generally consist of:

a) A thin layer of topsoil, underlain by

b) Loose to dense sand with varying silt and/or clay content to depths of 0.15 m to 3.5 m BGL, then

c) Dense to very dense indurated sand from depths of between 0.5 m and 6.1 m BGL, then

2 Residual soil: Soil that has been formed as a result of weathering of bed-rock, and has remained in the place of formation.
3 Alluvial soil: Soil that has been transported through the movement of water.

d) Medium dense to very dense sand to depths of 2.6 m to 14.0 m BGL, with interlayered silt and clay lenses, then

e) Stiff to hard silty and/or sandy clay to the depth of testing (up to 26.5 m BGL).

The dense indurated sand layer is typically encountered as about 1.5 m to 3.0 m thick.

The north-western end of the proposed new runway shows some variation to the generalised subsurface profile above. Subsurface conditions encountered in this area included:

- A thin layer of topsoil, over
- Loose clayey sand and/or firm to stiff sandy clay to 0.7 m BGL, over
- Very soft sandy and/or silty clay ('marine' clay) to 2.7 m to 5.4 m BGL, then
- Dense indurated sand to depths of 8.4 m to 10.6 m BGL, then
- Interbedded medium dense sand/clayey sand and firm to very stiff sandy clay to the depth of testing (i.e. 15 m BGL).

Very soft to stiff clay of varying thickness and depth was encountered in the north-western portion of the site ((refer **Figure 3.5a** and **Figure 3.5d**). The clay is inferred to be of alluvial origin ('marine' clay).

The soil types encountered are discussed in greater detail below.

Topsoil

Topsoil at the site generally comprises fine to medium grained silty or clayey sand, or medium plasticity silty/sandy clay. Some organic material (including rootlets) is present throughout.

The topsoil layer across the site is between approx. 0.1 m and 0.5 m thick. Test locations along the runway alignment indicate topsoil depths typically between 0.2 m and 0.3 m, with some possible localised areas of topsoil depths up to 0.5 m (at the northern end of the runway in the area of BH13/13 and TP22/12).

The depth of topsoil is likely to vary across the site and is expected to be deeper in areas of denser vegetation. Unsuitable material underlying the top organic soils (such as soft, saturated clay) may also be present.

A topsoil stripping depth of 0.3 m will be adopted across the runway footprint (including the surcharge area), with allowance for localised deeper topsoil depths, particularly at the northern end of RWY 13/31.

Indurated sand

A layer of dense (or very dense) indurated sand ('coffee rock') was encountered across the site in all boreholes except BH7/12 north of the runway end. The thickness of the indurated sand layer varies across the site from 0.2 m to 4.6 m.

The indurated sand was encountered as two relatively thin layers, separated by stiff to firm clay, or very loose to very dense silty/clayey sand/sand, in six boreholes located in the north west of the Project site. The depth and thickness of indurated sand encountered at the boreholes is shown in **Table 3.5a**.

Alluvial clay

Boreholes in the north western part of the site (BH5/12, BH7/12, BH9/12 and BH12/13) encountered very soft to stiff clay, inferred to be of alluvial origin ('marine' clay).

The alluvial clay is of medium to high or high plasticity, and generally contains 15 per cent to 30 per cent fine to medium grained sand. The characteristics of the clay layer at each borehole is described below:

- The clay in borehole BH5/12 is contains greater than 30 per cent sand content. In borehole BH5/12 the clay contains traces of organic material. In borehole BH5/12, the alluvial clay was encountered at a depth of 1.0 m to 4.1 m BGL, and is very soft to soft, becoming firm with depth. The clay is underlain by very dense indurated sand.
- Very soft alluvial clay was encountered in borehole BH7/12 from the ground surface to the borehole termination depth at 8.5 m BGL. At BH7/12 the clay contains traces of organic material. A thin layer of very loose silty sand was encountered in the clay at a depth of 0.2 m to 0.5 m BGL. The base of the very soft/soft clay layer was not encountered due to the drilling method employed (solid flight augering).
- In borehole BH9/12, soft to stiff alluvial clay is interbedded with clayey sand, sand, silty sand and indurated sand.
- Borehole BH12/13 encountered a layer of very soft silty sandy clay from 0.5 m to 2.8 m BGL.

This alluvial clay material is expected to be highly compressible, and future fill earthworks is expected to result in consolidation of this layer (refer **Section 3.7.1**).

The inferred very soft to soft alluvial clay thickness contours are shown on **Figure 3.5a**.

Laboratory Testing

Results of the laboratory testing are summarised in **Table 3.5b**. Laboratory test reports are attached in **Appendix B3:F**.

The laboratory test results confirm the field classifications of soil types tested.

Oedometer testing was carried out on undisturbed U50 tube samples taken from the soft/very soft clay layer from borehole BH5/12 and BH7/12 to provide consolidation properties for settlement analysis. The results are provided in **Appendix B3:G**, with a discussion of the settlement analysis detailed in **Section 3.7.1**.

Table 3.5a: Depth and thickness of indurate sand layers

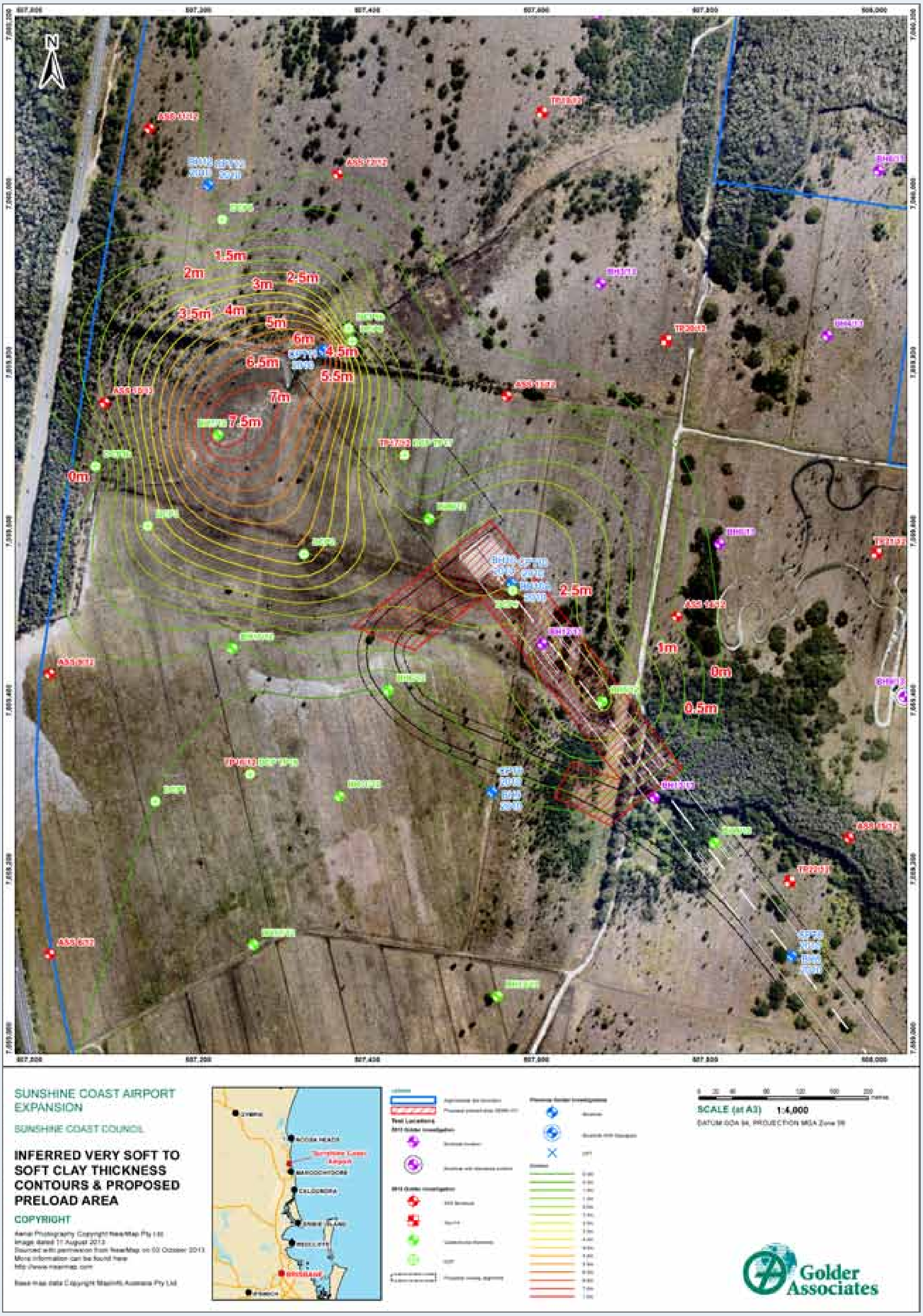
Borehole	Depth of Layer (m BGL)	Thickness (m)
BH1/12	0.8 to 3.0	2.2
BH3/12	0.8 to 4.5	3.7
BH4/12	2.0 to 5.0	3.0
BH5/12	4.1 to 6.0*	1.9
BH6/12	3.5 to 5.5	1.5
BH7/12	Not encountered	
BH9/12	3.0 to 3.6 6.1 to 6.9*	0.6 0.8
BH10/12	2.2 to 2.5 4.3 to 6.0*	0.3 1.7
B11/12	0.9 to 3.5	2.6
BH12/12	0.7 to 3.5	2.8
BH13/12	0.8 to 4.0	3.2
BH14/12	1.0 to 4.0	3.0
BH15/12	1.5 to 2.6	1.1
BH16/12	0.5 to 3.0	2.5
BH17/12	1.0 to 5.2	4.2
BH1/13	1.8 to 3.8	2.0
BH2/13	1.2 to 4.0	2.8
BH3/13	2.9 to 3.3	0.4
BH4/13	1.0 to 2.5	1.5
BH5/13	1.0 to 3.0	2.0
BH6/13	2.0 to 2.7 5.0 to 5.8	0.7 0.8
BH7/13	0.7 to 2.0 1.3	
BH8/13	3.0 to 7.0 4.0	
BH9/13	1.0 to 2.0 8.1 to 8.3	1.0 0.2
BH12/13	4.9 to 5.6 7.0 to 8.3	0.7 1.3
BH13/13	2.0 to 2.5 3.8 to 8.4	0.5 4.6

Table 3.5b: Summary of geotechnical laboratory testing results

Test	Number of Tests Undertaken	Range of Results	Discussion
Atterberg Limits	3	Liquid limit: 26% to 61% Plasticity index: 10 to 34 Percent fines*: 27% to 78%	Results used to confirm field soil classifications
Particle size distribution	12	Percent fines*: 2% to 10%	
California Bearing Ratio	4	4% to 25%	Results used in pavement design criteria
Oedometer	2	m_v: 2.0×10^{-3} to 3.5×10^{-3} kPa^{-1} c_v: 0.13 to 1.45 m^2/y	Results used in settlement assessment

** per cent passing the 0.075 mm sieve size*

Figure 3.5a: Inferred very soft to soft clay thickness contours and proposed preload area



3.5.2 Acid sulphate soil

3.5.2.1 Overview

The site investigations indicate that the Pleistocene age sands and muds on the majority of the site contain low to moderate levels of 'net acidity' (< 50 and 50-300 moles H^+/t, respectively). Acidity is present as actual and potential acidity; however, the latter appears to be limited to depths of generally greater than 1 m. The acidity levels in the Pleistocene sands appear to be distributed uniformly laterally and vertically across the site. **Figure 3.5b** shows the ASS mapping for the Project area.

At the north western end of the runway alignment, the unconsolidated grey clays from 0.5 m BGL contain organic matter and modern accretions of sulfides with resulting very high levels of net acidity (>600 moles H^+/t), which is predominantly present as potential acidity.

In other parts of the site, the indurated sands contain variable levels of net acidity (<300 moles H^+/t) present as both actual and potential acidity.

Groundwater at the site is currently acidic and brackish. The acidity in the groundwater is likely to be due to a combination of actual acidity from the oxidation of sulfides in Holocene and recent Pleistocene sediments and weak organic acids associated with the coffee rock and organic silts. The acidity regimes at each borehole sampled for ASS are indicated on **Figure 3.5c**. The highest actual acidity (represented by TAA) and highest 'net acidity' detected at each location is indicated in moles H^+/ tonne. The TAA and 'net acidity' values are similar at many locations as most samples contain negligible potential acidity. Significant levels of potential acidity are limited to locations towards the northern end of the site (within the Holocene deposits).

Boreholes containing low levels of ASS (net acidity) are surrounded by a green halo, moderate level ASS by a yellow halo, high level ASS by an orange halo and very high level ASS by a red halo (refer **Figure 3.5c**). The 'net acidity' values detected in the soil profile are also depicted on boreholes included in sections AA' and B-B' included on **Figures 3.5d** and **Figure 3.5e**. The inferred extent of moderate to high level PASS is also shown on these figures.

Given that the 'net acidity' values exceed the (former) SPP 2/02 Action Criteria in 75 per cent of samples analysed, management of ASS will be required.

3.5.2.2 Desktop assessment

During the last 6,500 to 10,000 years (the Holocene period) Pyritic soils or ASS, were deposited in coastal zones throughout the world. When drained for development or otherwise disturbed, the iron pyrite in these sediments oxidises producing sulfuric acid which subsequently lowers the pH in runoff and groundwater, leading to the release of toxic aluminium and iron from the sediments into the groundwater.

ASS are only found in soils of alluvial origin and although most common on low lying coastal floodplains in riverine and delta sediments, may also be found at moderate elevations, along the banks of inland creeks and streams. ASS generally occurs below about 5m AHD, but may be found as high as 20 m AHD if Holocene deposits are present.

Sulfidic materials may also occur in parent rock material and their residual weathering products; however, the acidity is bound into the rock matrix and does not readily mobilise. Small amounts or pyrite and significant concentrations of fine organic matter which can form weak organic acids can also accumulate in a matrix of fine sands that cement to form indurated sands, commonly called 'coffee rock'.

The Project site, which occupies some 460 ha, lies below 5m AHD, where it is situated mainly on recent alluvial deposits of Quaternary age (interpreted as being mainly of Pleistocene age) overlying residual geology, predominantly sandstone of the Landsborough Sandstone formation. The entirety of the expansion development site is underlain by 'undifferentiated coastal plain' comprising "sands and mud" that is known to also contain "clay/silt (active stream channel and low terraces)" which include some Holocene age deposits likely to include ASS. Typically ASS occur only in Holocene deposits, although some low level ASS may occur in the more recent of the older Pleistocene deposits.

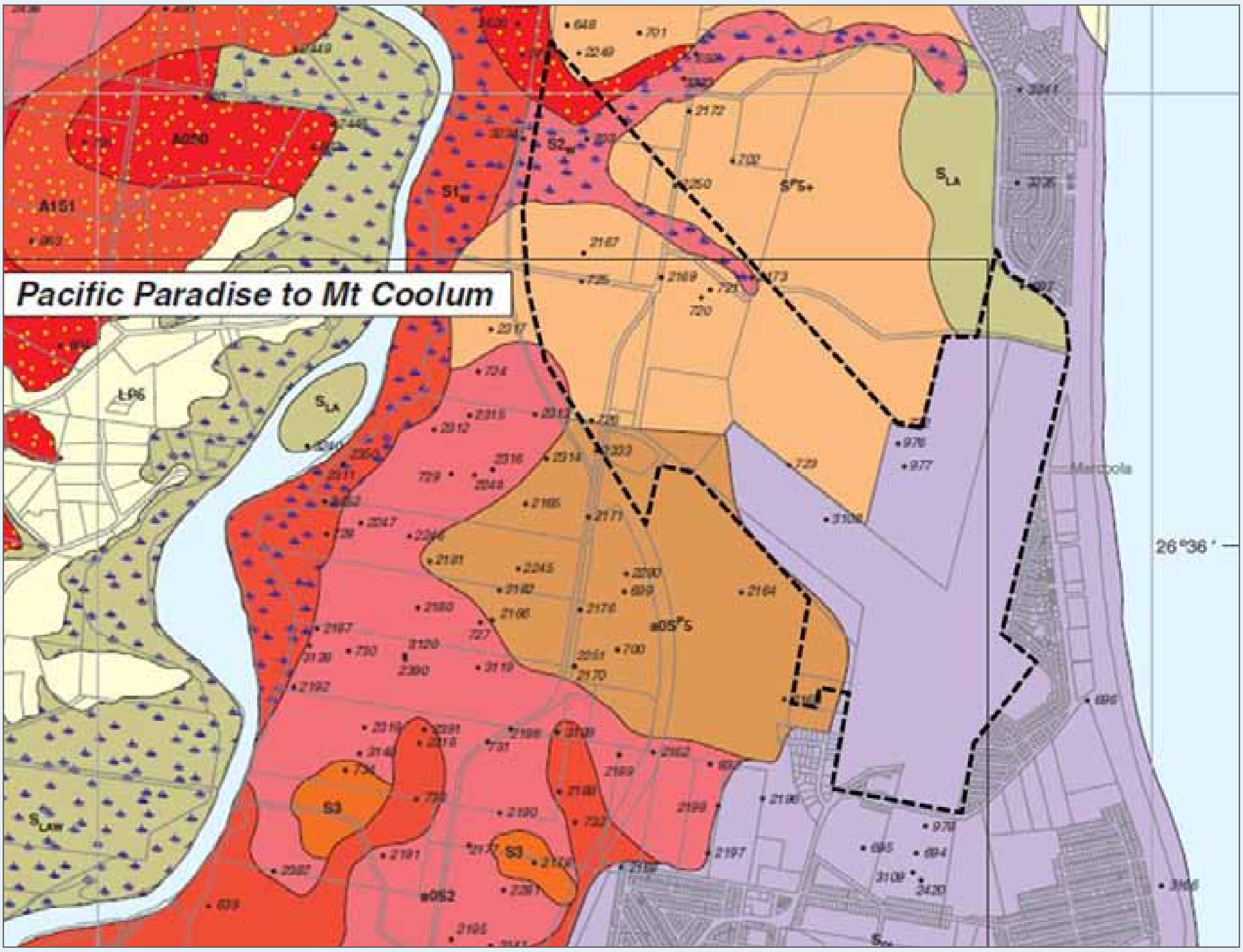
An extract of the Queensland NRM&E 1999 1:100,000 scale ASS – Map 2 'Maroochy – Caloundra' is included in **Figure 3.5b**. The ASS mapping indicates the following:

- **Purple:** The current airport is mapped as SDL, being "Disturbed land, e.g. canal estate, marina, aquaculture, urban or industrial likely to contain ASS (in some cases partial or full treatment may have been undertaken – limited field investigation"
- **Orange:** The majority of the proposed expansion area is mapped as SP 5+ "sulfidic sediments (of Pleistocene age) deeper than 5 m
- **Pink:** A small area in the north western part of the site is mapped as S2W, which is "Areas associated with *Melaleuca* sp. wetlands and occasionally *Casuarina glauca* communities. Oxidisable sulphur per cent in surface layers may be highly variable and often exceeds the 'Action Criteria'. This may include sulphur from organic compounds and modern accretion of sulphides in a wet, organic rich environment. Potential ASS (PASS) from 1 to 2 m depth".

ASRIS and DNRM 1:2,000,000 scale soil mapping indicates that the majority of the soils at the site are classified as Podosols. A small section at the far northwest corner of the site is classified as Hydrosols. Based on the findings of the Land Resources Assessment, undertaken by Golder (refer **Section 3.5.5**) the soils on the site were generally found to be in accordance with the Podosols classification.

Previous ASS investigations were undertaken in June 2010 (Golder, 2010a) as part of the Masterplan Implementation Project. The ASS investigations, which included sampling

Figure 3.5b: Extract of NRM&E ASS mapping for the Project



at 12 locations equally distributed along the extent of the proposed runway (refer to **Figure 3.5c**), indicate that soils underlying the site contain both actual and potential acidity, at least partly from the presence of ASS. Actionable levels of actual acidity were distributed uniformly, laterally and vertically across the proposed runway alignment and surrounding area. Potential acidity was limited to low levels in the indurated sands (below approx. 1 m depth) and at higher levels in silty clays encountered below 0.75 m depth towards the northern end of the site.

Groundwater was encountered during the investigation at depths of between 0.2 m and 3.4 m BGL. Shallow standing water levels were recorded in standpipes installed in BH4b, BH7b, and BH11 (NW end of site) at depths between 0.2 m and 0.8 m BGL. Standing water levels were deeper in the standpipes that were extended to below the cemented sand layers (BH4a and BH7a) at 1.7 m and 1.6 m BGL, respectively.

An assessment of groundwater quality was undertaken at three borehole locations (BH4, BH7 and BH11). The results indicated that the groundwater was moderately acidic (pH 4.6 and 5.3) in southern/central areas of the site and slightly acidic (pH 6.4) with some buffering capacity at the northern end. These results are within the typical pH range for a low-lying coastal environment. Electrical conductivity (EC) values indicated that the groundwater was fresh across the central third of the site and brackish toward the northern end. Dissolved iron and aluminium were detected in groundwater at concentrations above the laboratory limit of reporting.

The soil profiles encountered in the boreholes drilled across the site were generally consistent with those expected based on mapped local geology. The majority of the soils comprised fine to medium alluvial sand that becomes very dense and indurated at depth (i.e. coffee rock). The boreholes at the northern end of the site were generally found to encounter soft high plasticity clay/silt, indicative of Holocene sediments. **Section 3.5.1** describes the subsurface conditions and soils profiles at the site.

ASS sampling locations from 2010 and the EIS are shown in **Figure 3.5c**. The inferred subsurface conditions are presented on graphical cross sections illustrating the subsurface conditions in **Figure 3.5d** and **Figure 3.5e**. Details of the material encountered are provided in borehole reports in **Appendix B3:H**.

Figure 3.5c: ASS sampling locations

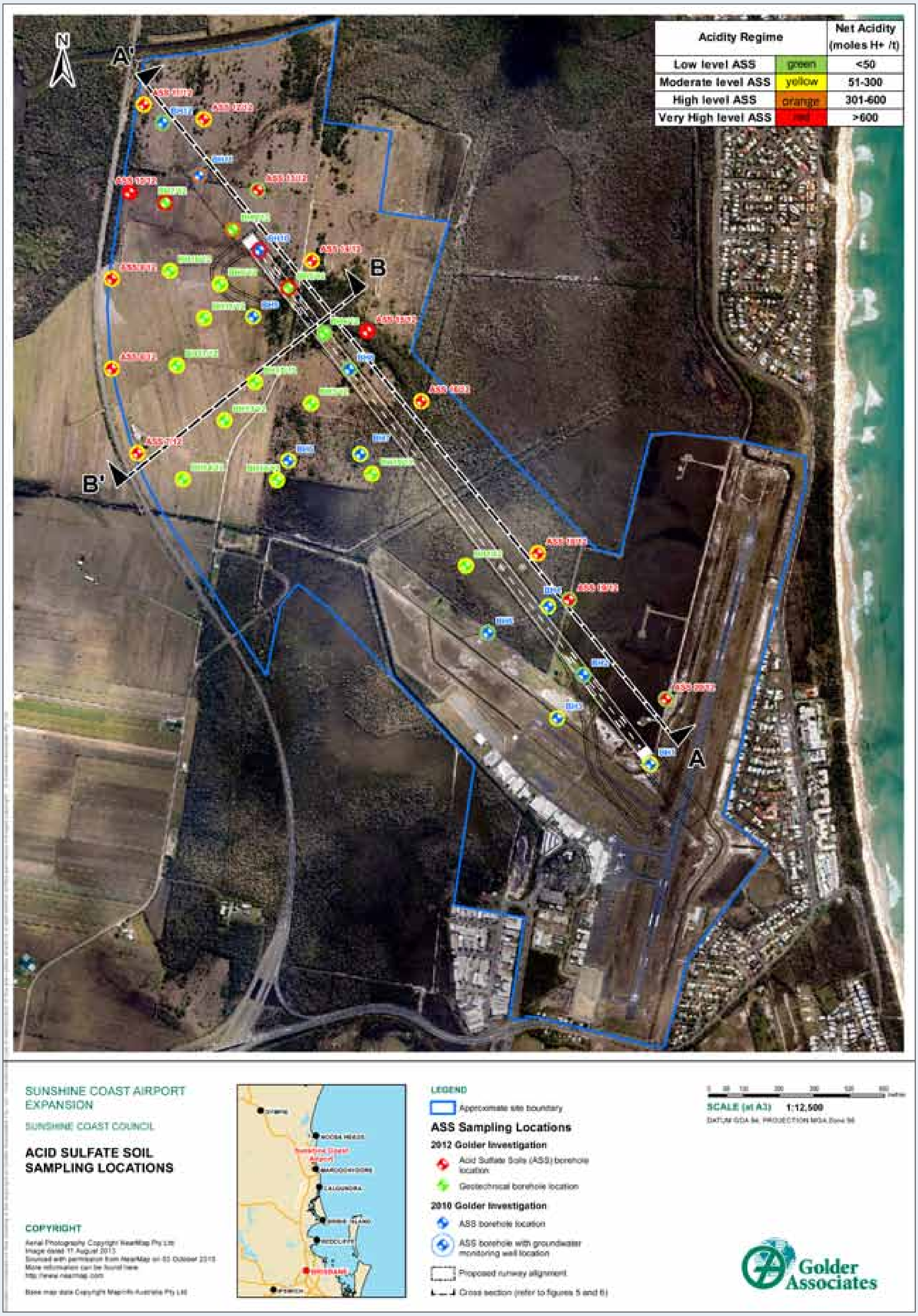


Figure 3.5d: Inferred subsurface cross section for ASS – length of runway

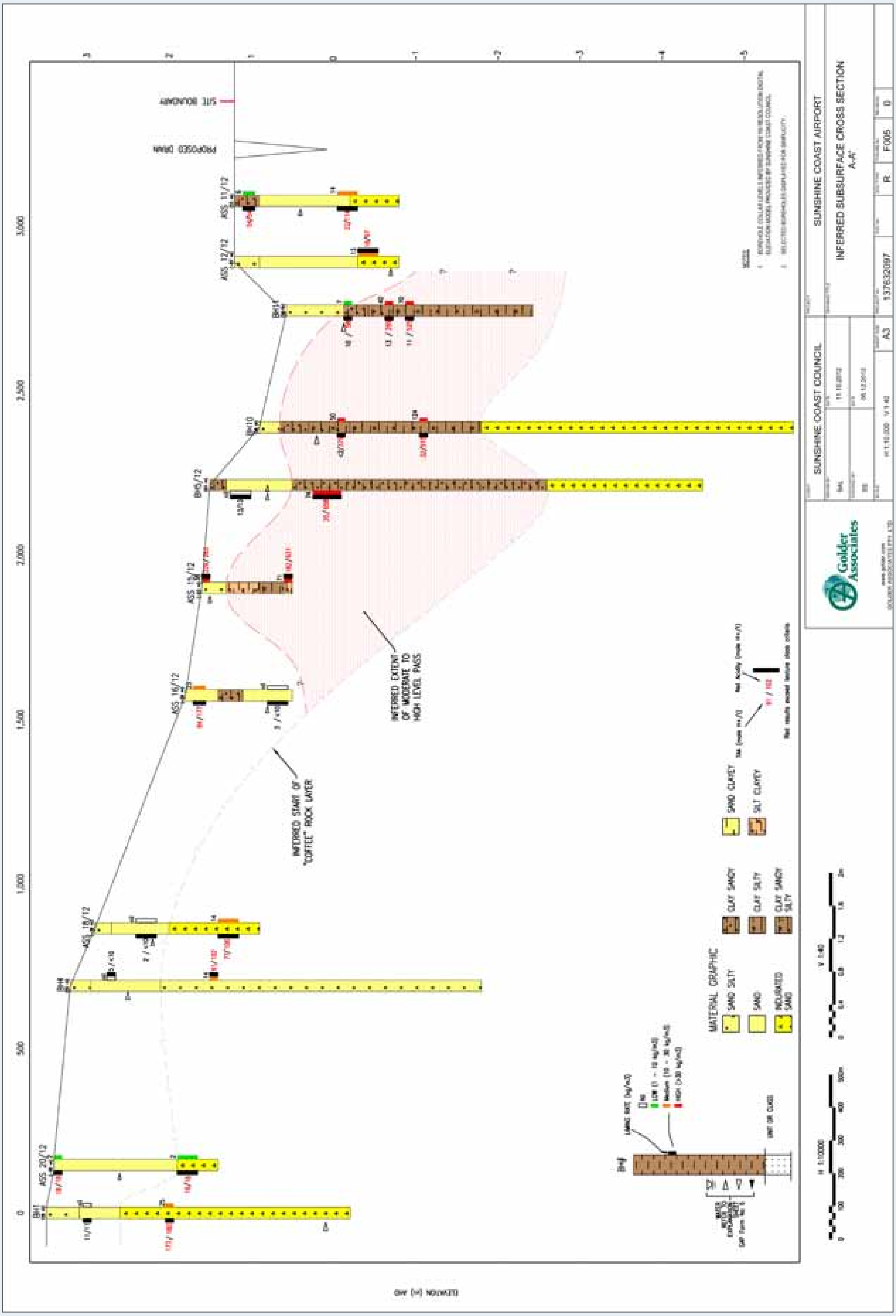
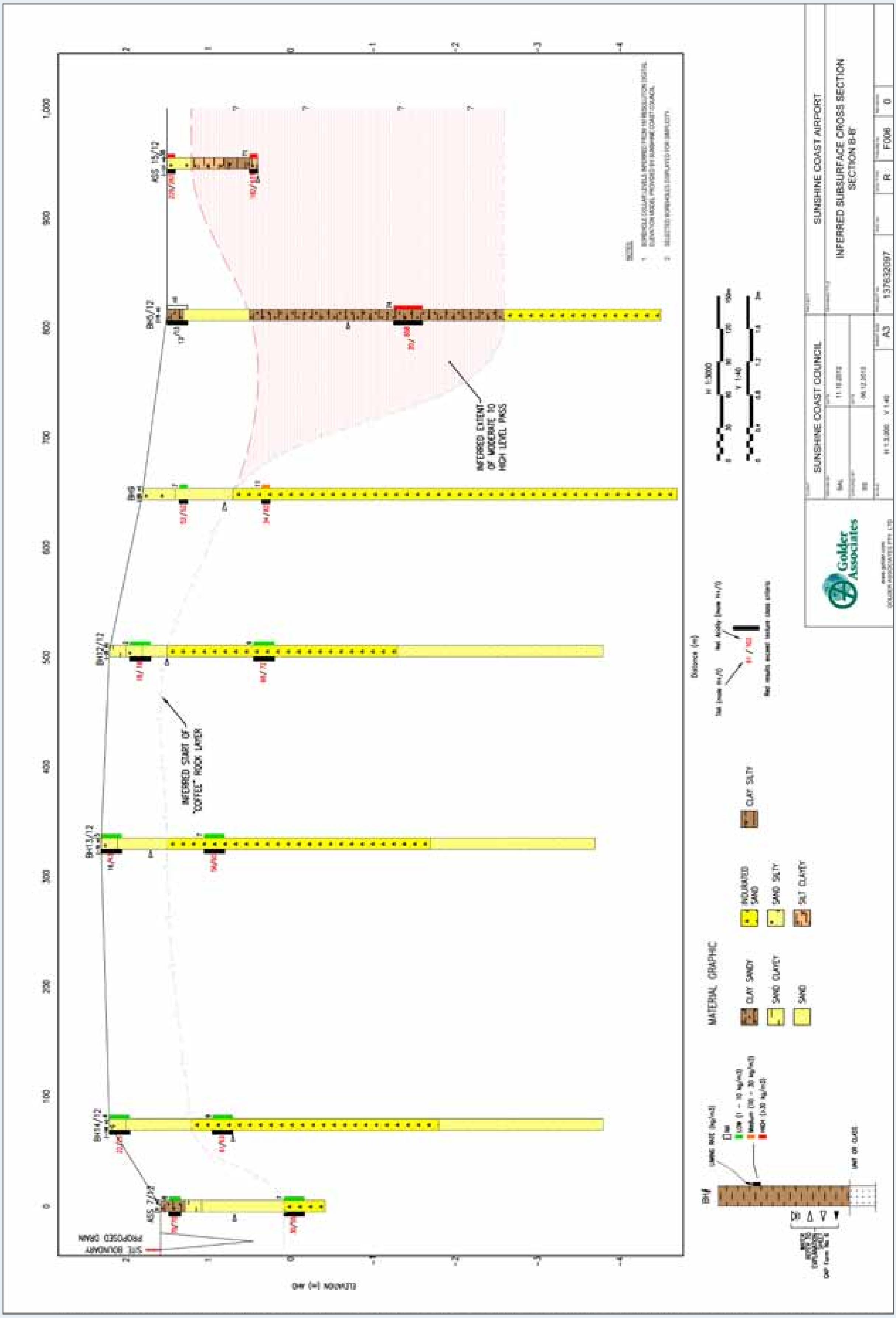


Figure 3.5e: Inferred subsurface cross section for ASS – crossing runway



3.5.2.3 Preliminary screening

Field pH (pH_F) of less than or equal to four may indicate actual ASS are present. The lower the pH_F below 4, the greater the likelihood of actual ASS. Field pH results from the current and previous investigations were found to range between pH 2.7 and pH 6.5. The pH_F results of 25 per cent (82 of 323) of sample was less than or equal to 4.0, indicating the probable presence of actual ASS in these samples.

A pH_{FOX} value of less than three coupled with a difference between pH_F and pH_{FOX} of greater than two may indicate that PASS are present. The pH_{FOX} results from the current and previous investigations ranged from 0.3 to 5.2.

Results of less than three were reported for 88 per cent (285 of 323) of samples with a pH drop of more than two noted for the majority of the samples indicating the probable presence of potential acidity in these samples.

A strong reaction to peroxide in the pH_{FOX} test in combination with other indicators may also indicate PASS. Extreme reaction rates, indicating likely PASS, were recorded in samples from 40 per cent (12 of 30) of boreholes.

The results from the current ASS investigation, geotechnical investigation and previous (2010) investigations are attached in **Appendix B3:B**.

3.5.2.4 Quantitative soils analysis

Quantitative analysis was carried out using the Chromium Reducible Sulfur (S_{CR}) test method, which provides a more accurate indication of ASS where significant amounts of organic matter (and thus organic derived acidity) are present in the soil profile.

Some preliminary screening results returned low pH_{FOX} results and vigorous reactions to addition of peroxide, whereas the quantitative test results generally indicated only low to moderate overall net acidity and little or no potential acidity in these samples. The low screening test results are likely to be due to the presence of weak organic acids, derived from decomposition of organic matter that does not necessarily indicate true ASS.

Standard Queensland ASS action criteria relevant to the Project (>1,000 t of soil disturbed and major filling) are for existing and potential acidity:

- 0.03 equivalent sulphur %S oxidisable (oven dry basis)
- 18 equivalent acid moles H^+/t (oven dry basis).

Results of quantitative analysis carried out for the current and 2010 investigations are summarised in **Appendix B3:B** and discussed below. Laboratory result certificates are included in **Appendix B3:B**.

Actual acidity

Most samples (95 per cent – 76 of 80) samples returned TAA results above the laboratory limit of reporting (2 moles H^+/t) indicating the presence of actual acidity in these samples. Sixty-five per cent (52) of these samples returned TAA results that exceed 18 moles H^+/t and therefore the Action Criteria for 'net acidity'for projects that disturb >1,000 tonnes ASS and major fill projects. Results ranged up to 229 moles H^+/t. Samples exceeding the criteria were from both Holocene and Pleistocene soils.

The actual acidity levels in the samples were generally between 70 per cent and 100 per cent of the 'net acidity', indicating that the majority of the sulfides in the samples had already oxidised. The exception to this trend were clay samples from BH10, BH11, BH5/12 and BH7/12 at the north western end of the site and sands/indurated sands from eight boreholes at depths of greater than 1.5 m, which contained predominantly potential acidity. The ratio of actual to potential acidity generally decreases down the soil profile at these locations as oxygen availability decreased.

Actual acidity was present in soil beneath the observed water table suggesting that the water table fluctuates to depths lower than that observed at the time of sampling.

Retained acidity

Ten samples that returned $pH_{KC}l$ values of less than pH 4.5 and were tested for retained acidity (S_{NAS}). Four returned S_{NAS} values above the laboratory limit of reporting (0.02 per cent) with results ranging from 0.02 per cent to 0.18 per cent. The results indicate there are low levels of retained acidity within only a few samples, suggesting the majority of the pyritic material has previously oxidised as illustrated in the TAA results.

Potential acidity

Thirty-three per cent (26 of 80) of samples analysed returned S_{CR} results above the laboratory limit of reporting (0.005 per cent S for the current investigation and 0.02 per cent S for the 2010 investigation), indicating the presence of potential acidity in these samples. The S_{CR} results indicate that soils with potential acidity are present generally below a depth of 1 m except at four locations in the north western end of the site (BH7/12, BH9/12 and BH13/12 and ASS BH10), where potential acidity is present at shallow depths.

The 26 samples returned S_{CR} results (potential acidity) above 0.03 percent S, which is the adopted Action Criteria for 'net acidity' for projects that disturb >1,000 t of ASS and major fill projects and up to 1.44 per cent.

Four samples returned SCR results greater than 1 per cent. These were samples comprising Holocene silty clay, sandy clay or clay and originated from boreholes located at the north-western end of the runway alignment.

Acid neutralising capacity

One sample from the north western end of the site (BH7/12) returned a $pH_{KC}l$ value of greater than pH 6.5 and was tested for ANC. The sample contained moderate level ANC (109 moles H^+/t). No other sample contained any ANC, so it would appear that ANC is not typically present in the soils at the site. The results indicate that the application of an imported neutralising material will be required to effectively treat and manage the existing and potential acidity identified at the site.

Net acidity Seventy-nine per cent of samples (63 of 80), exceeded 'net acidity' values for the QASSIT 'Action Criteria' for projects that disturb >1,000 tonnes of ASS and major fill projects. The 'net acidity' values ranged from <10 moles H^+/t to 915 moles H^+/t (average of 118 moles H^+/t). The highest individual 'net acidity' values (i.e. > 600 moles H^+/t) were calculated for samples of recent sandy clay and silty clay from boreholes ASS10, ASS15, BH5/12, BH7/12 and BH10, from the northern end of the site.

The stratigraphy of the site and results of screening and quantitative analysis indicate that the north western end of the site, which is underlain by unconsolidated Holocene estuarine sediments from depths of 0.5 m BGL, contain high net acidity levels (up to and >600 moles H^+/t), generally present as potential acidity. Results from the remainder of the site indicate that indurated sands are relatively uniformly distributed laterally and vertically across the site and contain variable levels of net acidity (generally <300 moles H^+/t) present as both actual and potential acidity.

3.5.3 Contaminated land

Property details of the site, including the current airport and expansion area, are summarised in **Table 3.5c**. The relevant current certificates of title and registered plan are presented in **Appendix B3:I**.

Table 3.5c: Site summary

Property Description	Details
Current owners	• The State of Queensland represented by Department of Environment and Resource Management (Lot 59 on CP855985, Lot 99 on SP176239, Lot 844 on SP214352) • The State of Queensland represented by Department of Transport and Main Roads (Lot 58 on CP855985) • Airservices Australia (Lot 898 on CG4782) • Rodger Peters (Trustee Lot 1 on RP133655) • Helena Myers (Lot 4 on RP855987) • Sunshine Coast Regional Council formally known as Council of the Shire of Maroochy/ Maroochy Shire Council (all remaining Lots)
Lot and plan	Project area (15 Lots): • Lot 1106 on SP206556 • Lot 1103 on SP206552 • Lot 5 on CG3622 • Lot 1105 on SP206553 • Lot 5 on RP133655 • Lot 1 on RP133655 • Lot 753 on CG3375 • Lot 4 on RP855987 • Lot 61 on RP855986 • Lot 59 on CP855985 • Lot 58 on CP855985 • Lot 101 on CP883235 • Lot 99 on SP176239 • Lot 844 on SP214352 • Lot 101 on CG6395 Current Airport (4 Lots): • Lot 857on CG4403 • Lot 898 on CG4782 • Lot 98 on SP176239 • Lot 699 on SP214349
Total area	~460 ha
Current zoning	• Special purpose • Sustainable cane lands • Business and industry
Local government	Sunshine Coast Council

The current airport includes:

- The main north/south runway (RWY 18/36), which is 1,797 m long and 30 m wide
- A secondary east/west runway (RWY 12/30), which is 695 m long and 18 m wide)
- Air traffic control tower
- Aviation rescue and fire fighting service (ARFFS) facility
- Terminal building
- Fuel storage/distribution facilities
- Serviced land with concessions and leasing arrangements, used for the storage and maintenance of aircraft and related services.

The expansion area includes undeveloped remnant bush land, sugarcane farm land, one residential property and two properties used for the storage of equipment and machinery.

The eastern boundary of the airport is parallel to the coastline of the Coral Sea. The site is surrounded by a mixture of residential land and national park to the north and south. The Sunshine Coast Motorway, sugarcane farm land and undeveloped remnant bush land lie to the west and north-west. A section of industrial land adjoins the airport's south-western boundary.

3.5.3.1 Site history

The information reviewed to assess the history of the site and the surrounding area included:

- Historical aerial photos
- Historical certificates of title from Department of Natural Resources and Mines
- EMR/CLR searches from DEHP
- Council records search from the Sunshine Coast Council (including Sunshine Coast Airport Celebrating 50 Years August 12, 2011 1961-2011 (Edwards 2011))
- Review of groundwater monitoring information provided by Shell
- Unexploded ordnance (UXO) search from the Department of Defence
- Interviews with Rod Miller (Airport Operations Coordinator) and Evon Peters (wife of landowner Lot 1 on RP133655).

Historical aerial photos from between 1958 and 2008 indicate the current airport and proposed expansion area was historically dominated by a combination of dense native vegetation and cane fields. The airport and associated infrastructure first appear in the 1967 aerial photograph. The only other infrastructure noted in the review was three properties (with farm houses/sheds) in the north-western end of the site, which were constructed between 1972 and 1977. In the 2008 photograph, one of the farm houses/sheds had been removed and a new residential house was noted in the expansion area. Copies of the aerial photographs are provided in **Appendix B3:J**.

Current and historical titles were obtained from DEHP and are presented in **Appendix B3:I**. The following is a summary of current ownership:

- The State of Queensland represented by Department of Environment and Resource Management (Lot 59 on CP855985, Lot 99 on SP176239, Lot 844 on SP214352)
- The State of Queensland represented by Department of Transport and Main Roads (Lot 58 on CP855985)
- Airservices Australia (Lot 898 on CG4782)
- Rodger Peters (Trustee Lot 1 on RP133655)
- Helena Myers (Lot 4 on RP855987)
- Sunshine Coast Regional Council formally known as Council of the Shire of Maroochy/Maroochy Shire Council (all remaining Lots).

The review of historical titles indicates land ownership was historically dominated by the Savimaki family and various Government Departments. The review did not identify possible industrial ownership of the site.

A search of the Environmental Management Register (EMR) and the Contaminated Land Register (CLR) indicates that the only lot listed on the EMR or CLR is Lot 699 on SP214349 (the current airport site), which was listed on the EMR because the following Notifiable Activities were undertaken at the site pursuant to section 374 of the EP Act:

- Petroleum product or oil storage – storing petroleum products or oil, and
- Hazardous contaminant – This site has been subject to a hazardous contaminant.

Copies of the search results from the Queensland DEHP are presented in Appendix B3:I.

Sunshine Coast Council was contacted regarding records held by the Council on the site; no records were provided.

SCA published a book Sunshine Coast Airport Celebrating 50 Years August 12, 2011 1961-2011 (Edwards 2011). The history of the airport obtained from this publication is summarised below:

- 1958: Maroochy Aero Club founded
- 1959: First flight lands at Maroochy Satellite Aerodrome.
- 1961: Airport officially opened under the name 'Maroochy Airport'
- 1962: First hangar built at the airport
- 1979: A new terminal building was constructed
- 1983: Construction commences on air traffic control tower
- 1984: First passenger jet aircraft lands at Maroochy Airport
- 1989: Airport terminal upgraded to include a VIP lounge and increased capacity
- 1997: Current terminal building constructed.

On 11 September 2012, an interview was conducted with Mr Rod Miller (Airport Operations Coordinator), which revealed the following:

- The onsite Underground Storage Tanks (USTs), Above Ground Storage Tanks (ASTs) and associated infrastructure are leased and managed by Shell. The following tanks are located within the area managed by Shell:
  - Two 25 kL ASTs containing Jet A1
  - Two 55 kL ASTs containing Jet A1
  - Two 25 kL USTs containing Avgas
- Aircraft are refuelled using mobile tankers. However, until July 2012, aircraft were refuelled using underground infrastructure that lead to four refuelling pads under the terminal apron. This underground infrastructure has been filled with nitrogen
- One generator is located on the site. It is fuelled using an above ground 300 to 500 L diesel tank located within a bunded area
- A former 'night soil' depot (from around 1970) is reported to be located on the northern boundary of the site.
- A new ARFFS building (constructed in April 2010) is located to the east of the runway. A 5 kL bunded diesel AST and 8 kL bunded Aqueous Film Forming Foam (AFFF) AST is located on the site. Seven 1,000 L containers of AFFF were also located on individual bunds (these were awaiting offsite disposal). Runoff from the site is captured by a triple interceptor trap (maintained by Fox Environmental Systems). It is serviced every three months and pumped out annually. Water is discharged offsite under a trade waste agreement with Unitywater. No firefighting training using accelerants is undertaken on site. AFFF has not been used to fight any onsite fires.

On 13 September 2012, an interview was conducted with Mrs Evon Peters (wife of landowner Lot 1 on RP133655, Rodger Peters). Based on the information provided by Mrs Peters, no areas of potential contamination were identified on the land owned by Rodger Peters.

As Shell lease the fuelling facilities at the site, they were contacted to obtain records in relation to fuel infrastructure on the site. A February 2012 groundwater monitoring report was provided for the EIS. The following general comments are provided on this report:

- During the airport's history several significant spills were reported associated with overfilling of fuel, failure of product hydrant lines and dumping of fuel
- Several soil investigations have been undertaken on the site (reports were not provided)
- Annual groundwater monitoring is undertaken around the fuel infrastructure (only the February 2012 report was provided)
- During the February 2012 monitoring event, free phase product was not detected in any of the monitoring wells. Hydrocarbons were identified above the *Airports Environmental Protection 1997 Freshwater Screening Levels* in four wells. A dissolved phase hydrocarbon plume is present near onsite petroleum related infrastructure and to the north of the bowser (distribution point) beneath the airport apron.

A UXO search of the Department of Defence website indicates the site does not have UXO potential.

A site inspection was conducted by an environmental scientist on 11 September 2012. The following items were noted during the inspection:

Existing Airport:

- Access to the airport terminal is via Airport Drive
- The main and cross runways (RWY 18/36) and (RWY 12/30) dominate the site
- The taxiways and aprons are covered in asphalt. No evidence of significant surface hydrocarbon staining was noted
- The areas surrounding the runway, taxiways and aprons are grassed
- ARFFS was located east of RWY 18/36. The facility is paved with concrete. No evidence of significant surface hydrocarbon staining was noted
- The terminal building, air traffic control tower and public car parking are west of RWY 18/36 at the southern end
- The buildings surrounding the terminal include serviced land with concessions and leasing arrangements, used for the storage and maintenance of aircraft and related services
- Open drainage lines were noted to the south of the RWY 18/36 and to the north of RWY 12/30
- The area identified as the former night soil depot was dominated by dense reeds and grass
- The majority of the airport is clear of vegetation (with the exception of the grassed areas and the wallum heath areas west of RWY 18/36 where the navigation aids are located, and which provides habitat for Ground Parrots).

Expansion area:

The expansion area includes:

- Undeveloped remnant bush land
- Sugarcane farming land
- Two properties used for the storage of equipment and machinery.
- One of the properties used for the storage of equipment and machinery (Lot 1 on RP133655) includes a building used as an office and residential house, and yard used for the storage of machinery (trucks and drill rigs). A septic tank was noted on the property. No signs of significant spills or vegetation stress were noted

- The second property used for the storage of equipment and farming machinery (Lot 1105 on SP206553) has been vacated. However, the maintenance sheds contain abandoned rubbish, including paint, tyres, oil drums and other equipment used to service farm machinery. Significant surface hydrocarbon staining was noted around the oil drums. A septic tank was also present on the property.

3.5.3.2 Potential areas of concern

The site history and inspection identified the following Notifiable Activity pursuant to section 374 of the EP Act for Lot 699 on SP214349 (current airport site):

- Petroleum product or oil storage – storing petroleum products or oil
- Hazardous contaminant – This site has been subject to a hazardous contaminant.

No other Notifiable Activities were noted on the site.

Based on available historical information and site inspection, the potential areas of concern (possible contamination activities) and most commonly associated potential contaminants of concern are listed in **Table 3.5d** and shown in **Figure 3.5f**.

The key areas of concern most relevant to the airport expansion are the potential impacts from the sugarcane fields, farm sheds and night soil depot during construction of the new runway.

The existing fuel storage infrastructure, firefighting activities and aircraft maintenance activities are unlikely to affect the airport expansion, as construction activities are not proposed in these areas.

3.5.3.3 Contamination investigation

A field investigation was conducted to target key areas of concern identified during the site history review. The investigation consisted of 13 boreholes (BH1 to BH13) to a depth of 1 m BGL, as shown on **Figure 3.5f**.

Selected soil samples were collected and analysed for the potential contaminants of concern listed in **Table 3.5d**. Laboratory results are provided in **Appendix B3:K**.

Quality assurance/quality control results for the field and laboratory program are summarised in **Appendix B3:L** and are considered suitable to demonstrate that the laboratory test results are representative and valid.

Assessment criteria to determine levels of contaminants were taken from the following guidelines:

- National Environmental Protection Measures (NEPM) Health Investigation Levels L-F Commercial/Industrial (NEPM HIL-F)
- CRC CARE Pty Ltd 2011 Health Screening Levels – D for Direct Contact (CRC HSL-D)
- NEPM 1999 Ecological Investigation Levels (NEPM EIL)

The subsurface conditions across the site typically include silty sand or sand to depths of up to 1.0 m BGL (maximum depth of investigation).

The findings of the field investigation are summarised in **Table 3.5e**.

3.5.4 Erosion and sediment control

3.5.4.1 Site conditions

A summary of the site conditions is provided below.

Vegetation

A large proportion of the expansion site has been completely cleared and cultivated for sugar cane farming in recent history, although none of the area has been productively farmed in the last 10 years. The site is currently covered by a mix of grasses, planted sugar cane and areas of dense woodland, weeds and stands of native vegetation.

Topography

The ground surface is low lying (below 5 m AHD) and slightly undulating, forming part of the floodplain of the Maroochy River. The surface generally falls towards the north western side of the site and the Maroochy River at a gradual gradient of less than 0.5 per cent to approximately 0 m AHD. Elevated areas with local elevations to 10 m AHD, lie to the north of the site beyond Mt Coolum Creek, and to the east along the ocean frontage. Local gradients across the site vary from 3 per cent to less than 0.5 per cent, with no consistent flow direction.

Table 3.5d: Potential areas of concern and potential contaminants of concern

Potential areas of concern	Potential contaminants of concern
Sugarcane fields	Pesticides and heavy metals
Farm sheds (maintenance of farming equipment/pesticide storage and mixing)	Hydrocarbons, pesticides and heavy metals
Night soil disposal area	Ammonia, nitrogen, *E. coli*, faecal coliforms and heavy metals
Fuel storage at the existing airport	Hydrocarbons and heavy metals
Firefighting activities	ARFF
Aircraft maintenance facilities at the existing airport	Hydrocarbons and solvents

Figure 3.5f: Contaminated land investigation areas of concern and borehole locations

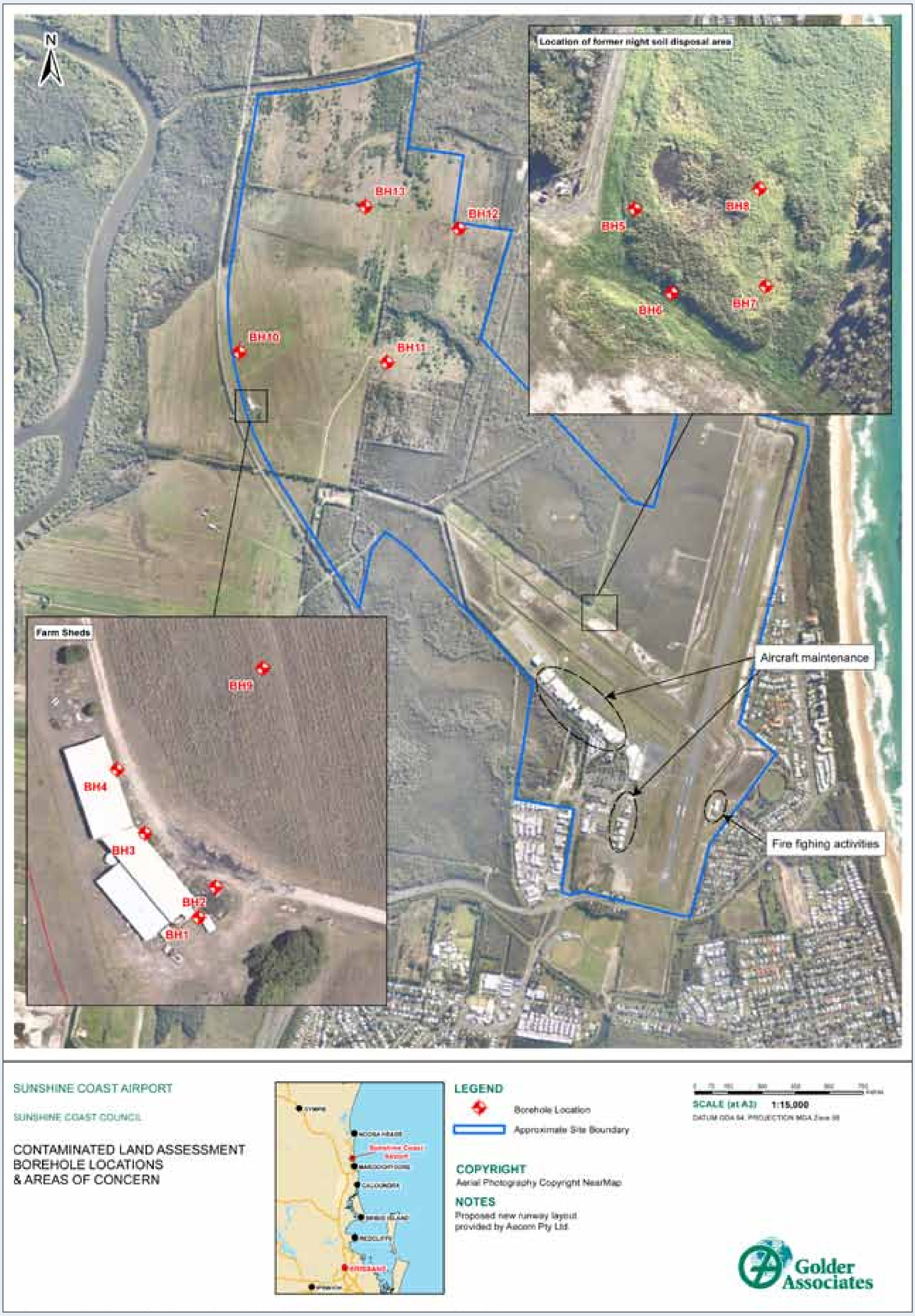


Table 3.5e: Contaminated land investigation findings

Area of Concern	Results
Sugarcane Fields (BH10 – BH13, Figure)	Concentrations of pesticides in the samples were below the laboratory detection limits. Concentrations of heavy metals in the samples were below environmental (NEPM EIL) and health based assessment criteria (NEPM HIL-F).
Farm Sheds (BH1 – BH9, Figure)	Concentrations of pesticides in the samples were below the laboratory detection limits. Concentrations of polyaromatic hydrocarbons (PAH) in the samples were below health based assessment criteria for industrial/commercial land use (NEPM HIL-F and CRC HSL-D). Concentrations of total petroleum hydrocarbons (TPH) in the samples were above health-based assessment criteria for industrial/commercial land use. Concentrations for TPH in the samples exceeded the CRC HSL-D in three samples (BH2-0, BH3-0 and BH4-0). The three exceedances were located at the surface only and TPH C16-C34 concentrations ranged from 33,800 to 66,400 mg/kg, representing levels less than one order of magnitude above the assessment criteria. Concentrations of benzene, toluene, ethylbenzene and xylenes (BTEX) in the samples were below laboratory detection limits. One surface sample had concentrations of lead that exceeded NEPM HIL-F: BH1-0 had a lead concentration of 2,340 mg/kg, representing a level less than one order of magnitude above the adopted assessment criteria. Three soil samples had heavy metal concentrations that exceeded environmental assessment criteria (NEPM EIL): • BH1-0 – arsenic (59 mg/kg), copper (4,920 mg/kg), nickel (77 mg/kg) and zinc (11,000 mg/kg), which represent levels less than one order of magnitude above the adopted assessment criteria for arsenic, greater than one order of magnitude for copper and greater than two orders of magnitude for zinc • BH2-0 – copper (209 mg/kg) and zinc (379 mg/kg) representing a level less one order of magnitude above the adopted assessment criteria for arsenic and zinc • BH4-0 – zinc (395 mg/kg) representing a level less than one order of magnitude above the adopted assessment criteria for zinc.
Night soil disposal area (BH5 – BH8, Figure)	All concentrations of heavy metals in the samples were below environmental and health based assessment criteria Concentrations of ammonia, faecal coliform and *E. coli* in the samples were below laboratory detection limits Nitrogen was detected in all samples and the highest concentration was detected in sample BH6-0 (total nitrogen 2,150 mg/kg), which was located near the former night soil disposal area. Elevated nitrogen concentrations (such as these) are generally considered unlikely to pose environmental or human health risk.

Site drainage

Current surface runoff is expected to follow the ground surface contours and drain as a combination of sheet flow and short directed drainage paths. The Maroochy River situated to the west of the site is the main receiving water body. The confluence of Coolum Creek with the Maroochy River is located to the north-west of the site. Marcoola drain forms the northern boundary of the Project site, and flows into the Maroochy River west of the Sunshine Motorway. The southern perimeter drain traverses the site from the existing terminal, west to the Maroochy River.

Subsurface conditions

The soil profiles encountered in TP1/12 to TP23/12 generally comprised near surface sand alluvium, likely to be Holocene in origin and containing ASS, towards the northern end of the site (i.e. TP17/12 to TP22/12). While the near surface sand alluvium over the remainder of the site is considered to be Pleistocene in origin and also containing ASS, overlying cemented indurated sands ('coffee rock'). **Section 3.5.1** provides more information on soil profiles encountered during the investigation.

3.5.4.2 Laboratory testing

All laboratory documentation is presented in **Appendix B3:E** and **Appendix B3:F**. Textural classifications recorded in the field were confirmed by laboratory testing of PSD. In accordance with Australian Standard AS1289.3.6.3, and size fractions and material descriptions were reported in accordance with AS1726.

The results of the PSD analysis indicate soils across the site are comprised of predominantly sand and clay/sandy loams with the soils in the north west portion of site also displaying low to moderate clay and silt (fines) percentages. **Table 3.5f** summarises the PSD and organic content results.

Table 3.5g summarises the results of laboratory testing for erosion potential determined for each sample. Results of the Emerson class number, exchangeable sodium percentage and dispersion potential analysis indicate that the soils across the site were generally non-dispersive to slightly dispersive.

3.5.4.3 Hydrology and rainfall erosivity

When rain falls on bare soil or disturbed overburden material, it produces sediment in a mix of two primary modes: surface erosion and mass erosion. Surface erosion occurs when rain-induced runoff passes over the soil surface and

Table 3.5f: PSD and organic matter

Location	% Clay (<2 µm)	% Silt (2-60 µm)	% Very fine sand (60-100 µm)	% Sand (100 µm-2 mm)	Textural Description	Topsoil Organic Matter (%)
TP5 0.25–0.35 m	2	4	2	92	Sand	1.1
TP5 0.55–0.65 m	1	1	98	Sand		
TP8 0.25–0.35 m	5	1	94	Sand	7.6	
TP8 0.55–0.65 m	2	2	96	Sand		
TP14 0.25–0.35 m	22	22	3	53	Clay Loam	5.3
TP14 0.55–0.65 m	29	21	1	49	Clay Loam	
TP17 0.25–0.35 m	26	10	7	57	Sandy Loam	6.5
TP17 0.55–0.65 m	12	6	7	75	Sandy Loam	
TP22 0.30–0.40 m	32	17	2	49	Clay Loam	7.2
TP22 0.55–0.65 m	6	10	2	82	Loamy Sand	
Average values	13.2	9.5	2.8	74.5	N/A	5.5

Table 3.5g: Summary of Emerson class number, exchangeable sodium percentage and dispersion potential

Test Pit	Depth (m)	Soil Type	Emerson Class	(ESP (%)	$EC_{1:5}$	Salinity and Dispersion Potential
TP5	0.0-0.15	Sand	Class 5	<0.01	0.008	Non-saline/non-dispersive
TP8	0.0-0.15	Sand	Class 5	3.3	0.017	Non-saline/slightly-dispersive
TP8	0.25–0.35	Sand	–	<0.01	0.006	Non-saline/non-dispersive
TP14	0.55–0.65	Clay Loam	Class 5	7.1	0.022	Slightly saline/slightly dispersive
TP17	0.25–0.35	Sandy Loam	Class 1	11.7	0.565	Saline/highly dispersive
TP18	0.25–0.35	Silty Sand	Class 5	–	0.031*	slightly saline/non-dispersive
TP18	0.55–0.65	Clayey Sand	Class 5	–	0.023*	Slightly saline/non-dispersive
TP22	0.0-0.15	Sand	–	4.1	0.013	Non-saline/slightly dispersive

Note:
* *based on field EC*

dislodges loose particles that are then mobilised in the runoff. As this process occurs, the surface water may begin to concentrate from sheet flow into rivulets with more erosive power. Concentrated flow in rivulets tend to develop into rills and then into a small gully (runnel), with increasing soil removal. If a gully forms, the banks of the gully can give way and provide mass erosion of sediment to the transporting runoff. In many instances when water runs over an edge, such as is the case for much road runoff, there is often a large mass of sediment released. Construction activities remove existing vegetation and disturb the soil, exposing the surface to these processes. The consequences of erosion are numerous and primarily relate to water quality by which flora and fauna may be adversely affected.

The velocity of raindrop impact as rainfall falls on the majority of the site is reduced as it passes through the vegetation cover that dominates the site. Following this, rainfall infiltrates the soil surface. Good vegetation cover acts to reduce overland flow by increasing infiltration, reducing rainfall erosivity and promoting sheet flow. Thus impacts are minimal where vegetation cover remains. The presence of vegetation also acts to replenish soil carbon and organic matter, leading to higher infiltration and therefore less runoff.

Overland flow generated onsite will generally flow as overland flow towards the north west, and locally towards the drain located on the southern part of the site. Drains should be stabilised to resist erosion.

The annual rainfall is approximately 1,465 mm, with the majority of rainfall occurring in summer as reported for the Sunshine Coast Airport weather station. Observations of on-site water infiltration indicate that the site is generally moderately well to well drained with the presence of sand topsoils across the majority of the site. The exception to this is where very shallow groundwater is present.

A number of locations that experience frequent traffic (and compaction) were observed, and there was no evidence of surface water pooling as a result of the compaction. The sandy loam and sand topsoils were commonly found across the site and were generally underlain by moderately dense sand/sandy clay loams or clay loam subsoils, with most areas underlain by cemented indurated sands. It is likely that any rainfall would quickly permeate through the soil profile to depth quite rapidly, so overland flow will be gradual.

Table 3.5h: Rainfall information

Climate averages for station: 040861 Sunshine Coast Airport
Commenced: 1994; Last record: October 2012; Lat: 26.60; Long: 153.09; State: QLD

Element	Mean monthly rainfall (mm)	Mean no. rain days	Highest monthly rainfall (mm)	Lowest monthly rainfall (mm)	Highest recorded daily rainfall (mm)	Mean daily evaporation (mm)	Mean monthly max. temp. (°C)	Mean monthly min. temp. (°C)
Jan	150.4	10.9	557.8	6.6	168.4	–	28.6	21.2
Feb	183.5	10.9	504.8	17.0	160.0	–	28.7	21.3
Mar	161.3	11.3	493.2	37.6	177.0	–	27.6	19.9
Apr	160.3	11.5	353.8	14.2	130.4	–	25.8	17.0
May	164.5	9.8	440.0	22.4	127.0	–	23.3	13.6
Jun	18.5	9.2	286.6	23.0	161.2	–	21.2	11.3
Jul	68.8	6.6	252.6	2.2	73.4	–	20.8	9.5
Aug	76.3	5.6	427.4	0.2	192.2	–	21.8	9.8
Sep	55.8	5.6	427.4	0.2	192.2	–	24.1	12.9
Oct	78.9	7.2	225.6	10.2	95.0	–	25.4	15.6
Nov	87.8	6.8	176.6	16.2	108.0	–	26.8	17.9
Dec	165.0	10.2	588.0	33.0	110.0	–	28	19.8
Annual	1,465.4	105.6	2,599.2	852.8	N/A	1,200–1,400*	25.2	15.8
Record duration (years)	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3

** Monthly site specific statistics not available from BOM; based on BOM mapped evaporation range for Sunshine Coast.*

3.5.4.4 Seasonal weather patterns

The airport is located on the southeast coast of Queensland, which experiences a Sub-Tropical to Tropical climate (based on Koppen Climate Classification), with a dry spring and an early summer, and with the majority of rainfall occurring from January to April. A summary of historical rainfall trends in the region of the site is presented in **Table 3.5h** on the previous page.

Figure 3.5g shows the total annual rainfall for 18 years of monitoring. The data indicates a well-documented long-term regional drought that ended in 2010. The end of the drought was marked by high rainfall across southeast Queensland, where annual total rainfalls for 2010 and 2011 exceeded the long-term average by more than 500 mm. In February 2012, extensive flooding occurred, with 80 per cent of the mean annual rainfall occurring in the three months leading up to the floods. While the recorded highest annual rainfall was more than 2,500 mm in 1999, the majority of the years recorded annual rainfall is less than 1,500 mm.

3.5.4.5 Predicted erosion potential

The revised universal soil loss equation (RUSLE) was used to predict the long-term, average annual soil loss from sheet and rill flow. The RUSLE is:

$$A = R \times K \times LS \times P \times C$$

where

A = Computed soil loss (tonnes/ha/y)

R = Rainfall erosivity factor

K = Soil erodibility factor

LS = Slope length/gradient factor

P = Erosion control factor

C = Ground cover management factor

The input parameters and values for the above components are discussed here.

Rainfall erosivity factor (R factor) is a measure of the ability of rainfall to cause erosion. Rainfall erosivity mapping from Appendix 4 of SCC's Manual for Erosion and Sediment Control indicates the site has an R factor of approximately 5,750.

Soil erodibilty factor (K factor) is a measure of the susceptibility of the soil to detachment and transport by rainfall and runoff, and is predominately derived from the soil texture. However, the soil structure, organic matter content and profile permeability also contribute.

Soil profile permeability refers to the rate of infiltration of water into the soil and is rated into six classes, presented below in **Table 3.5i**. The site is overlain by predominantly structureless sands rated as Class 2.

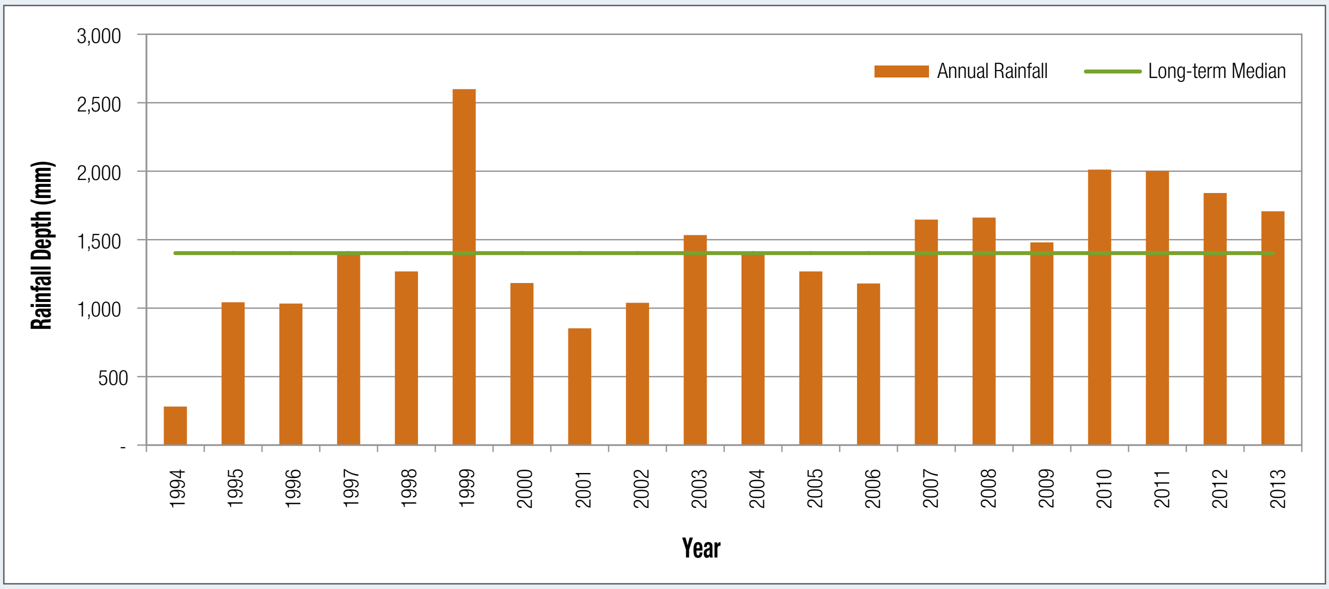
Table 3.5i: Profile permeability classes

Class	Description	Permeability (mm/h)
1	Rapid	>130
2	Moderate to rapid	60–130
3	Moderate	20–60
4	Slow to moderate	5–20
5	Slow	1–5
6	Very slow	<1

The final input to determine the K factor is the measured or estimated content of gravel and rock fragments (>2 mm) by weight. Gravel and rock fragments, when present in a coarse textured soil profile can reduce infiltration. The soil PSD reports were used to derive the gravel content, which is less than 1 per cent.

The clay content, silt content, very fine and coarser sand contents and gravel content were derived from the PSD reports. The percentage organic matter was determined in the laboratory.

Figure 3.5g: Annual rainfall from 1994 to 2013 at Sunshine Coast Airport (station no. 040861)



The surface soil structure is generally dependent on the diameter of the soil aggregates, with Grades ranging from 1 (very fine: <1 mm diameter) to 4 (massive/blocky clay soils). The surface soil structure for the site is classified as Grade 2 (fine granular: 1 mm to 2 mm diameter).

Table 3.5j presents a summary of the site data used to derive the K factor from laboratory data and field observations.

Table 3.5j: K factor inputs

Variable	Average Input	Worst Case Input (TP17/12)
Silt + Very Fine Sand content (%)	12.3	17
Remainder Sand content (%)	74.5	57
Organic matter content (%)	5.5	6.5
Surface soil structure	2	2
Profile permeability	2	3
Gravel Content	0	<1
Computed K factor	0.007	0.008

Topographic Factor (LS Factor), or slope length-gradient factor, describes the combined effect of slope length and slope gradient on soil loss. The LS factor is related to an interpreted slope gradient, slope length and the rill/interill ratio.

The contour mapping for the site indicates the slope gradient is < 0.5 per cent. The slope length is defined by the distance, measured parallel to the ground surface, from the origin of overland flow to the point where either the slope length decreases enough so that deposition begins or where runoff becomes concentrated in a defined channel (such as an ephemeral gully). Although the site is generally fairly level, local flow path lengths vary from approx. 150 m to > 500 m. A nominal slope length of 300 m was adopted; however, using the shortest flow path length of 150 m and gradient of 3 per cent does not alter the overall EHA risk category.

Reference to Table A3-1 of Appendix 3 of the SCC's Manual for Erosion and Sediment Control, for use with construction sites, gives a minimum LS factor of 0.27 for a slope length of 300 m and a gradient of £ 1 per cent, increasing to 0.87 for a slope length of 150 m and a gradient of 3 per cent.

To calculate RUSLE, different LS factors apply to low, moderate and high ratios of rill to interill erosion. The RUSLE input for the rill/interill ratio is selected based on **Table 3.5k**.

Table 3.5k: Rill/interill ratio options

Option	Grade	Description
Option 1	Low	Applies to undisturbed grazing/pasture lands with good cover (e.g. any construction sites before works start).
Option 2	Medium	Applies to moderately consolidated crop lands with little to moderate cover. (Used as the default for construction sites).
Option 3	High	Applies to highly disturbed lands with little or no cover (e.g. most operational construction sites).

Option 1 is applicable for the site in its current state for input into the RUSLE. However, as site works will be considerable, and the majority of the site will be disturbed at one time or another, Option 2 is appropriate for the site during construction.

Table 3.5l presents a summary of inputs for the LS factor into the RUSLE.

Table 3.5l: Summary of LS factor inputs

Variable	Input
Slope gradient	0.5%–3.0 %
Slope length	300 m
Rill/interill ratio	Option 2
Calculated LS factor (as per Table A3-1 of SCC's Manual for Erosion and Sediment Control)	0.27–0.87

Erosion control factor (P factor) is rarely applicable for construction sites and is typically given a nominal value of 1.0 for this application. Table A3-2 of Appendix 3 of the SCC's Manual for Erosion and Sediment Control gives a range of values based on surface treatment during construction. As the site soils are predominantly sands, these do not necessarily apply given the cohesionless nature of the sands, so a mid-range value for the P factor of 1.0 was adopted.

Ground cover management factor (C factor) is applicable for construction sites. Table A3-3 of Appendix 3 of the SCC's Manual for Erosion and Sediment Control gives a range of interpretation based on percent grass cover and nature of the surface treatment. Using this table, the site in its current state with 75 per cent grass cover and undisturbed root mass is given a C factor of 0.02. However, assuming a worst case during construction of 25 per cent grass cover and a disturbed surface, a C factor of 0.35 is applicable.

Based on RUSLE, the annual erosion potential for the site in its current state is less than 1 t/ha/y, which indicates the site is stable and not prone to erosion.

3.5.5 Land resource assessment

ASRIS and DNRM soil mapping show that soil at the site is predominantly classified as Podosols, while the soils in the far north west the site are classified as Hydrosols. These classifications are derived from broad-scale land resources mapping and are not necessarily accurate on a smaller scale (i.e. less than 1:250 000). The land type assessment (**Section 3.5.5**) indicates the area of Hydrosols may be Podosols.

The soil characteristics and chemistry observed on this site were generally found to be in accordance with the Podosols classification. One location (TP18) was mapped as Hydrosols; however, in-field assessment indicated this location is better described as Podosols, with the mapped boundary of Hydrosols to the north of this location. The dominant soil type mapped in the surrounding areas is classified as Hydrosols. Many soil types, including those that might otherwise be classified as Podosols, effectively become classified as Hydrosols if the landform is regularly inundated on a more than episodic basis.

The SCL 'trigger maps' overlays (DERM 2011) for the Brisbane – Toowoomba Region show areas classified as 'potential SCL' near the site. Some of the site (two locations) is indicated as likely SCL.

The site 'Land Resource Area' (LRA) has been mapped at 1:100,000 in the report Horticulture Land Suitability Study, Sunshine Coast, South-East Queensland (Capelin, 1987).

As shown on **Figure 3.5h** the site is mapped as Q1, which is "*Rolling dunes on Holocene windblown sand deposits; podzols with she-oak woodland and Banksia low woodland, level plains on Pleistocene tidal sand deposits; siliceous sands with heathland and gently undulating plains on lagoonal and tidal mud and silt deposits; humic gleys with tea-tree open and closed forest and swamp she-oak woodland; solonchaks with mangrove shrubland, woodland and forest, and saltwater couch*". This assessment is generally consistent with the landform, soils and substrate encountered on the site, which were predominantly Podosols/podzols.

'Land Suitability for Horticulture' was also mapped at 1:100,000 (Capelin, 1987), with the site being mapped as Class 7 (pink shaded area, refer **Figure 3.5i**) and Class 8 (orange shaded area, refer **Figure 3.5i**) which are:

- Class 7: Marginal for all crops with severe limitations, and
- Class 8: Unsuitable lowlands and stream channels.

3.5.5.1 Field investigation

The soil profiles encountered in TP1 to TP23 generally comprised near surface sand alluvium, likely to be Holocene in origin and containing ASS, towards the northern end of the site (i.e. TP17 to TP22). The test locations are shown on **Figure 3.2a**. While the near surface sand alluvium over the remainder of the site is considered to be Pleistocene in origin, and also containing ASS, overlying cemented indurated sands ('coffee rock').

The profiles consisted of:

- A1 Horizon: loose, dark grey to very dark grey/black, moist, medium dense, well sorted loamy sand, sand to depths of 0.1- 0.3 m, overlying
- B1/B2 Horizon: generally sand, (sandy clay loam in TP14, TP16, & TP18. clayey sand in TP17 and light clay in TP22), moist, ranging from light grey to very dark grey, medium dense, well sorted to depths of 0.7 m to depth of excavation; or overlying
- B3 Horizon: medium dense to dense (where indurated), grey to dark grey/black sands. Some locations indicate organic staining and odours within this horizon typical of indurated sand ('coffee rock').

Field soil pH

Soil pH values determined in the field on a 1:5 soil/water suspension are shown in **Table 3.5m**. The majority of the soil profiles were slightly acidic with no significant variation observed laterally across the site. The pH did decrease progressively down the soil profile at some locations, which is likely to be due to increased amounts of decomposed organic matter in the topsoil and upper sub-soil generating weak organic acids. These findings are supported by the results of the ASS assessment at these locations (refer to **Section 3.5.2**). All pH values measured were below 7.0, with the majority being below 5.5 and near surface soils at several locations below 5.0.

SCL criteria use soil pH at depths of 300 mm and 600mm; six of the test locations failed on this criteria because they were too acidic (TP2, TP8, TP11, TP16, TP18 and TP19) (refer **Table 3.5m**). However, SCL assessment is based on laboratory analysis rather than the field indications. The pH results from the laboratory tended to be slightly more acidic at most locations, therefore the number of locations that actually fail the SCL criteria is higher than that identified from the field assessment.

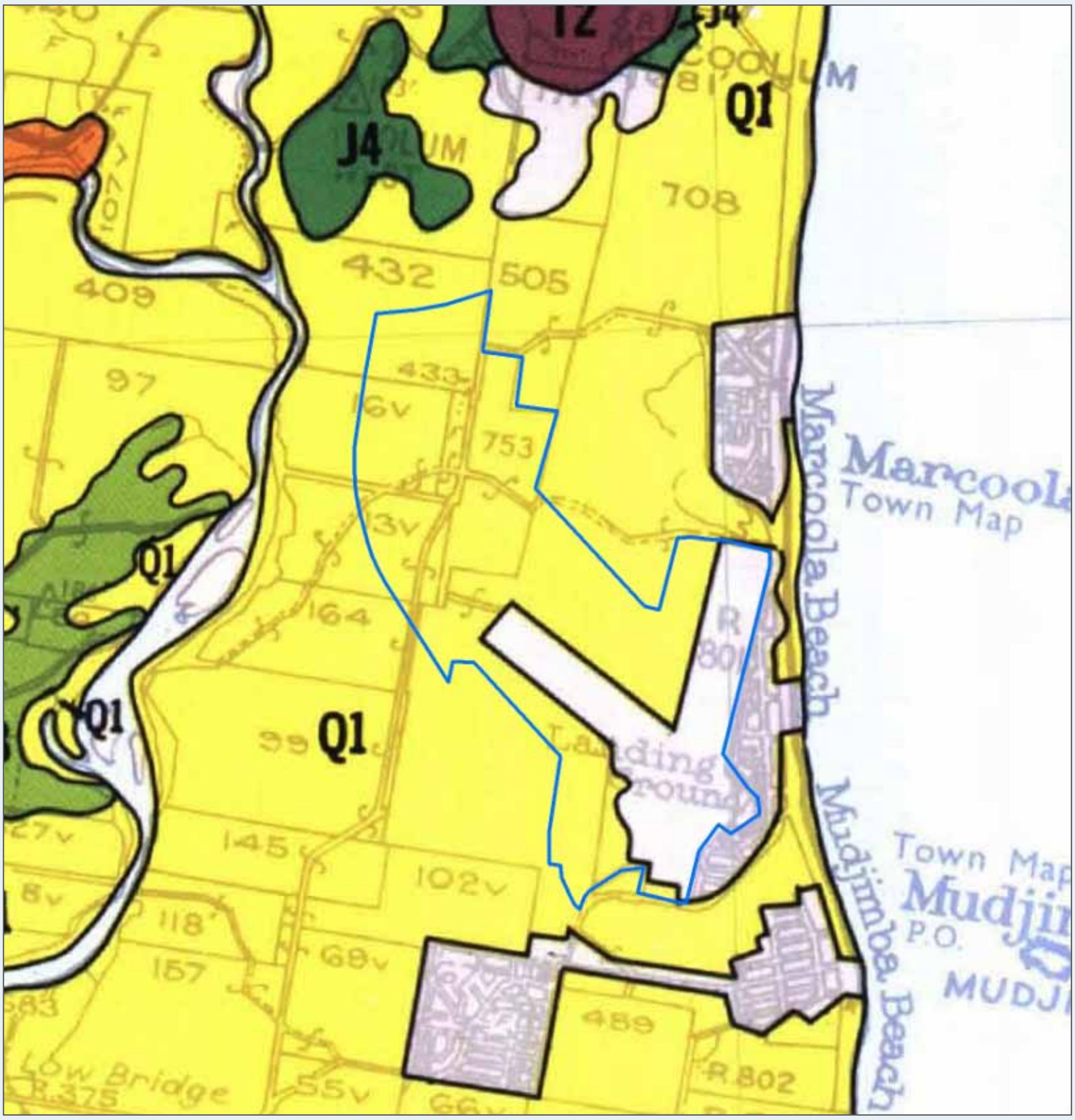
Field conductivity and carbonate tests

Electrical conductivity determined in the field on a 1:5 soil/water suspension, indicate low to moderate salinity in all samples tested (results reported in **Appendix B3:C**). The highest field EC was moderate to high, and was 0.948 mS/cm at TP22 at 1.1–1.2 m depth. The majority of samples returned EC values below 0.03 mS/cm, which is extremely low. The EC values are variable throughout the soil profile, although are generally below the SCL threshold of EC1:5 <0.56 dS/m within 600 mm of the soil surface.

Salinity values above 0.35 mS/cm could be of concern, however, the type and concentration of individual salts within the soil (e.g. soluble chloride and soluble sodium concentrations) need to be considered. For example, the SCL criterion for soil salinity is only based on the EC 1:5 (to a depth of 600 mm). Chloride concentrations and laboratory ECs were determined by the appointed laboratory for the detailed sites.

The EC measurements taken in the field are provided in **Table 3.5n**.

Figure 3.5h: Extract from Land Resource Area, from Horticulture Land Suitability Study, Sunshine Coast, South-East Queensland (Capelin, 1987)



Detailed descriptions

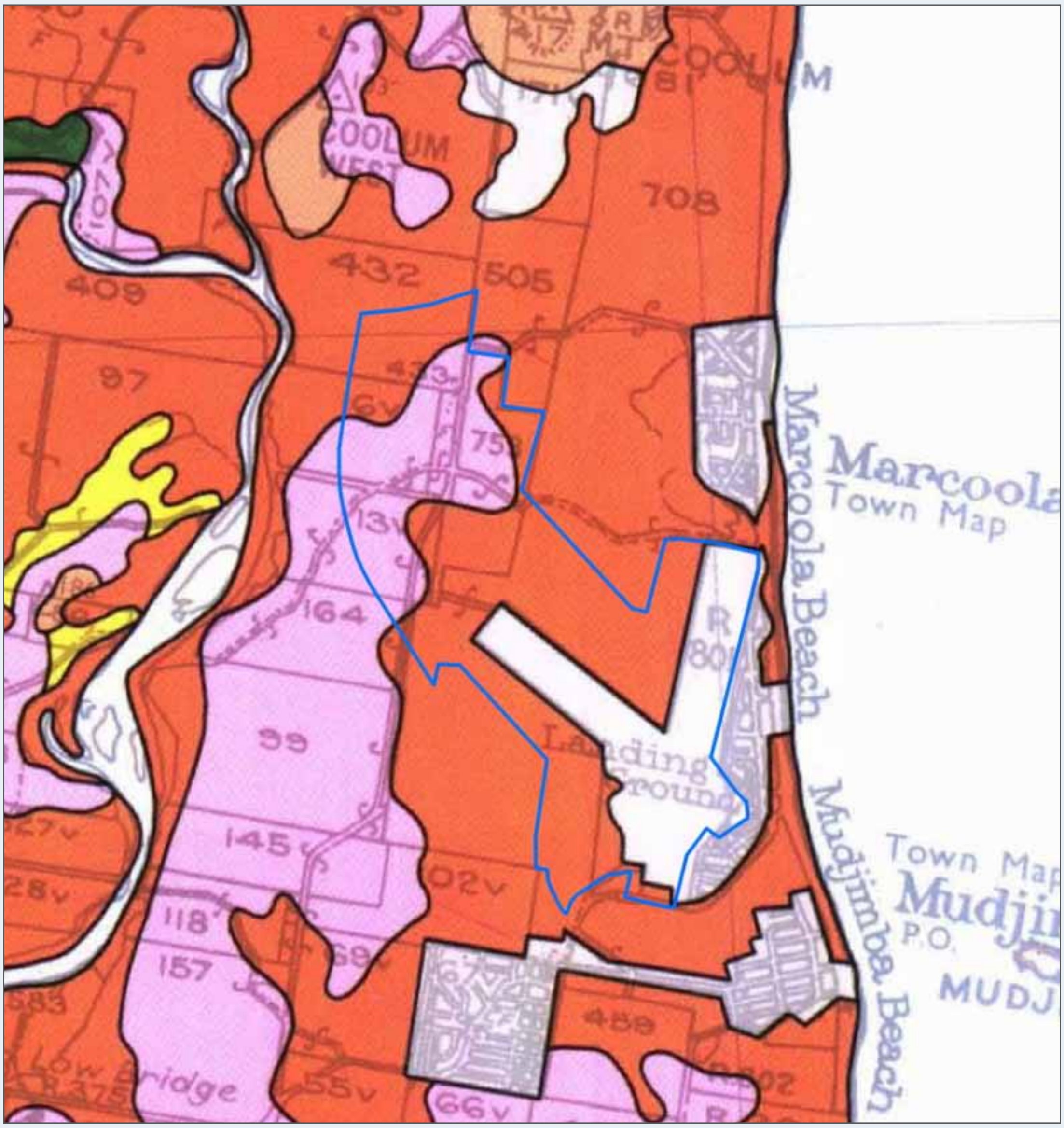
Detailed location descriptions and information gathering, along with laboratory analyses, were carried out at five of the 23 locations assessed. These 'detailed' locations were chosen to represent the majority of the site. The data gathered covers baseline soil chemistry, surface soil fertility, and SCL and GQAL assessments.

The detailed descriptions along with relevant soil data are shown in **Appendix B3:E**. Detailed soil logs are provided in **Appendix B3:C** and laboratory results are provided in **Appendix B3:E**.

Soil sub-samples were couriered to ALS in Brisbane, which is NATA-accredited for the targeted laboratory chemical analysis, comprising baseline soil chemistry, soil fertility on the surface samples, and soil pH, sodicity and salinity on the subsurface samples. In addition to the five detailed sites, samples from another seven sites were analysed for pH and EC only. Results of soil chemical analysis for the five detailed sites are summarised here:

- pH was acidic, and ranged from 4.4 to 6.6
- EC ranged from 0.004 mS/cm to 1,120 mS/cm
- Exchangeable calcium ranged from below the limit of reporting (LOR) to 1.2 meq/100g
- Exchangeable magnesium ranged from below the LOR to 3.1 meq/100g
- Exchangeable potassium ranged from below the LOR to 0.5 meq/100g
- Exchangeable sodium ranged from below the LOR to 0.5 meq/100g
- Exchangeable aluminium ranged from below the LOR to 0.8 meq/100g

Figure 3.5i: Extract from Horticulture Land Suitability Study, Sunshine Coast, South-East Queensland (Capelin, 1987)



- Cation exchange capacity ranged from below the LOR to 4.9 meq/100g
- Exchangeable sodium percentage ranged from below the LOR to 11.7 per cent
- Calcium:magnesium ratio ranged from 0.2 to 2.0
- Soluble chloride ranged from below the LOR to 2,460 mg/kg.

Separate soil sub-samples were collected from each detailed location: at the surface and one selected subsurface depth (0.55–0.65 m). Samples were sent to the NATA accredited laboratory for PSD testing, with the deeper samples also tested for Atterberg limits. The PSD and Atterberg limits tests were undertaken to confirm the field soil classifications. All laboratory documentation, including chains of custody, sample receipt notification, certificates of analysis is presented in **Appendix B3:E** and **Appendix B3:F**.

<u>Particle size distribution</u>

Textural classifications recorded in the field were confirmed by laboratory testing PSD in accordance with Australian Standard AS1289.3.6.3, and size fractions and material descriptions were reported in accordance with AS1726. The laboratory is NATA accredited for these methods. In the Australian Soil Classification (Isbell 1998) and Australian Soil Survey Handbook (McDonald et al. 1990) the international particle size fractions are used, which vary from the AS1726 fractions.

The results of the PSD analysis indicate soils across the site are generally comprised of predominantly sands and clay/sandy loams with the soils in the north west portion of site also displaying low to moderate clay and silt (fines) percentages. **Table 3.5o** shows the corresponding PSD in the International fractions, textural descriptions are also given.

Table 3.5m:Soil pH (1:5) determined in the field

Location	pH (1:5) at soil depth				
	Surface*	300 mm	600 mm	900–1,000 mm*	1,000–1,200 mm*
TP-1	5.5	5.3	5.1	4.7	5.5
TP-2	5.6	5.4	4.8	4.9	4.9
TP-3	5.9	5.8	5.5	6.5	6.9
TP-4	5.3	6.2	7.2	5.5	6.1
TP-5	5.5	5.0	5.2	5.2	5.2
TP-6	4.9	5.4	5.5	5.4	5.1
TP-7	5.7	5.7	5.4	5.7	5.4
TP-8	4.5	4.7	5.2	5.1	5.3
TP-9	5.0	5.3	5.7	6.1	6.1
TP-10	6.8	6.7	6.8	5.0	5.2
TP-11	4.5	4.4	4.9	6.0	6.3
TP-12	5.2	5.5	5.5	5.4	5.7
TP-13	4.9	5.2	5.8	5.8	6.0
TP-14	5.9	5.6	5.7	5.8	5.8
TP-15	5.8	5.9	5.6	5.2	5.2
TP-16	5.0	5.1	4.9	5.7	5.8
TP-17	5.6	5.4	5.7	5.9	5.8
TP-18	4.3	4.8	5.7	5.5	6.0
TP-19	5.7	5.0	5.1	5.4	5.5
TP-20	5.4	5.4	5.4	5.6	5.8
TP-21	5.6	5.6	6.6	6.7	6.5
TP-22	5.7	5.7	6.1	6.2	6.4
TP-23	5.0	5.4	5.6	5.8	5.8

Blue shaded area: SCL pH criteria apply. The SCL pH threshold for rigid soil is pH within the range 5.1 to 8.9 between 300 mm and 600 mm depth. Values in bold fail the SCL pH criteria.

** No SCL criteria applies*

Baseline soil chemistry

A summary of the chemical data is presented in **Appendix B3:E** The baseline soil chemistry suite results will be used to characterise site soil chemistry with the aim of returning the soil to a similar condition upon site reinstatement and rehabilitation after decommissioning of the tailwater pond (refer Chapter A4 – Project Description). The baseline soil chemistry data will be used in the preparation of a Soil Management Plan for the Site and to develop soil treatment strategies for rehabilitation works.

Topsoil pH, as determined in the laboratory, ranged from 4.4 to 5.5 (acidic). The pH results at locations TP5 and TP8 indicate acidic subsoils, which also fail the SCL pH criteria, although pH increases with depth. At TP14, TP17, and TP22 the pH results range between slightly acidic to neutral (pH 4.5 to 6.6). Only TP17 fails the SCL pH criteria at 300 mm with a pH of 4.5.

The soil salinity values, represented by soluble chloride, indicate low levels of salinity in the topsoil at all locations tested, and low to moderate levels in the subsoil. Ideally, the soil EC should be below 0.35 mS/cm with the chloride content below 200 mg/kg. Only at TP17 are the soils highly saline, demonstrated by a high EC (generally above 1.0 mS/cm) and soluble chloride content above 1,500 mg/kg.

Table 3.5n: EC field results

Location	Electrical conductivity (mS/cm) at soil depth				
	Surface	300 mm	600 mm	900–1,000 mm	1,000–1,200 mm
TP1	0.013	0.015	0.009	0.018	0.019
TP2	0.025	0.009	0.014	0.014	0.023
TP3	0.005	0.024	0.004	0.002	0.003
TP4	0.076	0.021	0.015	0.029	0.039
TP5	0.021	0.016	0.013	0.024	0.017
TP6	0.015	0.012	0.009	0.011	0.014
TP7	0.014	0.013	0.014	0.021	0.036
TP8	0.034	0.014	0.006	0.013	0.008
TP9	0.030	0.024	0.039	0.029	0.032
TP10	0.042	0.026	0.011	0.027	0.030
TP11	0.031	0.016	0.016	0.011	0.016
TP12	0.034	0.012	0.010	0.034	0.035
TP13	0.033	0.018	0.012	0.010	0.015
TP14	0.023	0.023	0.020	0.010	0.010
TP15	0.023	0.013	0.010	0.017	0.019
TP16	0.025	0.014	0.038	0.010	0.013
TP17	0.035	0.028	0.015	0.009	0.012
TP18	0.037	0.031	0.023	0.025	0.038
TP19	0.032	0.038	0.025	0.022	0.016
TP20	0.064	0.040	0.028	0.017	0.028
TP21	0.028	0.016	0.019	0.017	0.020
TP22	0.339	0.915	0.844	0.667	0.948
TP23	0.035	0.012	0.009	0.018	0.024

Exchangeable sodium percentage (ESP) below 6 per cent is considered low, with a value greater than 15 per cent indicating highly sodic soil. Soil sodicity can compromise soil structure, leading to poor soil water storage, internal drainage problems, poor soil aeration properties and soil dispersion and erosion issues. The topsoil samples returned low to moderate ESP ranging from less than 0.1 to 11.3 per cent. The subsoil ESP results indicate generally low to moderate sodic soils, (i.e. the ESP ranged from less than 0.1 to 11.7 per cent).

Exchangeable calcium:magnesium ratios can be used to assess soil fertility and structure properties. The ratio should preferably be above 0.5 and ideally above 2.5, with low levels indicating possible soil structure problems. The ratios of the subsoil and topsoils samples tested (0.2 to 2.0) were all low, suggesting that the subsoil structure is compromised in these soils.

Soil fertility

Soil fertility data was collected for the surface soil (topsoil), and this data will be used for the development of soil treatment strategies for topsoil rehabilitation. The Environment Management Plan will incorporate soil management methods including separation, stockpiling and amendment of topsoil ready for the rehabilitation of the site.

Table 3.5o: PSD using international fractions

Location	% Clay (<2 µm)	% Silt (2–20 µm)	% Sand (20–200 µm)	% Gravel (>200 µm)	Textural description
TP5 0–0.15 m	4	95	1	Sand	
TP5 0.25–0.35 m	2	4	94	0	Sand
TP5 0.55–0.65 m	0	1	99	0	Sand
TP8 0–0.15 m	5	94	1	Sand	
TP8 0.25–0.35 m	3	94	1	Sand	
TP8 0.55–0.65 m	2	98	0	Sand	
TP14 0.25–0.35 m	22	22	66	0	Clay Loam
TP14 0.55–0.65 m	29	21	50	0	Clay Loam
TP17 0.25–0.35 m	25	17	58	0	Clay Loam
TP17 0.55–0.65 m	12	10	78	0	Sandy Loam
TP22 0.30–0.40 m	32	17	51	0	Clay Loam
TP22 0.55–0.65 m	6	10	84	0	Loamy Sand
TP23 1.1–1.2 m	2	97	1	Sand	

The soils encountered on the site can generally be characterised into two discrete areas, poor quality soils with negligible nutrients on the eastern side of the site characterised by TP5 and TP8, and soils with low to moderate nutrient levels on the majority of the site, characterised by TP14, TP17 and TP22. Soil quality in the two areas is discussed below.

- **Eastern side of the site (TP5 and TP8):** Plant available phosphorus (extractable phosphorous) concentrations are very low (below laboratory LOR of 2 mg/kg). This concentration is inadequate to support crops or pastures. Soluble sulphate was below laboratory LOR of 10 mg/kg and soluble nitrogen levels are also low at TP5, but adequate at TP8. Available potassium (expressed as exchangeable, acid soluble and water soluble) was also found to be very low (below LOR) in terms of availability to plants. This suggests that the soils at TP5 and TP8 are either leached or have never supported vegetation well.

  Nutrient reserves, as indicated by the total phosphorus, total nitrogen, total potassium and total sulphur were all very low at TP5, with higher nitrogen levels at TP8. Organic matter was also low at TP5, but substantial at TP8 at 7 per cent. The carbon:nitrogen ratio is lower than desirable at TP5, suggesting rapid organic matter breakdown within the soil or an absence of a source of organic matter.

  The diethylene triamine pentacetic acid (DTPA) extractable metals results give an indication of the availability of the important trace metals copper, iron, manganese and zinc. The results indicate probable low concentrations of available copper, zinc and manganese, with adequate levels of plant available iron at TP8. While plant available nutrient levels are low these can be improved by fertiliser applications.

- **Remainder of the site (TP14, TP17 & TP22):** Plant available phosphorus (extractable phosphorous) concentrations are low to moderate over the remainder of the site represented by TP14, TP17 and TP22 (25 to 47 mg/kg). Soluble sulphate levels are generally low, the best being 190 mg/kg at TP17. Soluble nitrogen levels appear adequate, while available potassium (expressed as exchangeable, acid soluble and water soluble) was found to be medium to high in terms of availability to plants.

  Nutrient reserves, as indicated by the total phosphorus, total nitrogen and total potassium range from moderate to high (highest at TP22). However, total sulphur is low at all locations.

  Organic matter was generally found to be high (5.3 to 7.2 per cent), resulting in a relatively high carbon:nitrogen ratio, indicating a good store of organic matter (this is reflected in the presence of organic rich 'coffee rock' underlying parts of the site, which contains remnants of past organic matter break down).

  The DTPA extractable metals results indicate probable low concentrations of available copper, zinc and manganese, with adequate levels of plant available iron. Where plant available nutrient levels are low these can be improved by fertiliser application.

3.5.5.2 SCL assessment

Detailed descriptions and SCL assessment of the total number of locations inspected (23) are presented in **Table 3.5p**. The five locations assessed for GQAL were also analysed against SCL parameters, while a further seven were assessed for pH and EC only. The SCL assessment was undertaken in accordance with the Coastal Queensland zone criteria also included in **Appendix B3:E**.

All locations meet the SCL 'above ground' measures criteria such as slope, rockiness and gilgai microrelief (i.e. none encountered). The site is uniformly located on flat (slope <1 per cent) cleared land, with the Maroochy River to the west. The soil depth is adequate at all locations. At multiple locations groundwater inflow was observed within the test pits within 1.2 m of the surface.

The site appears moderately to well drained, due to the loam soil (clay loam/sandy loam) and the presences of sands throughout the profile; however, there are some indications of imperfect drainage based on soil mottling, potentially caused by the high water table. Nevertheless, soil wetness was found to be favourable at all locations because of their free drainage.

Acidic subsoils at TP2, TP5, TP8, TP11, TP16, TP17, TP18 and TP19 appear to be unfavourable for cropping. Four of the five detailed locations assessed failed the SCL soil pH criteria; furthermore seven sites had samples analysed for pH and EC1.5 at 300 mm and 600 mm depths at the laboratory, and all of these additional sites failed the SCL pH criteria. Subsoil salinity was also unfavourable for the soil type represented by location TP17, with concentrations exceeding the SCL salinity criteria of 0.56 mS/cm.

The available soil water storage was very limited at each of the assessment locations and all failed the SCL soil water storage (SWS) criteria because of the textural classification in addition to physico-chemical limitations at some locations (i.e.TP17). this characterisation is considered representative of the whole site. SWS are shown in **Table 3.5p** for all detailed sites, all of which failed the criteria of 75 mm.

All the assessment locations, which represent soil types across the site fail one or more of the SCL criteria and are not considered potential SCL. A summary SCL assessment for the entire site is presented in **Table 3.5q**.

The site is not classified as SCL as the land types fail SWS criteria. These findings support the current SCL trigger mapping, which indicates that the site is located outside zones of Strategic Cropping Land.

Land types

ASRIS and DNRM soil mapping overlays indicate the soil at the site is predominantly classified as Podosols, while the soils in the far north west the site are classified as Hydrosols. However, the field identified textural and laboratory results indicate that this area resembles the Podosol classification rather than Hydrosols as mapped, mainly as the soils did not appear to be regularly inundated. However, ASS (commonly Hydrosols) were detected in this part of the site, so classification remains tenuous.

Topsoil is relatively uniform across the site and consists of dark grey to black sand to sandy loam soils.

Given the division in the nature of the soil textures and soil chemistry, the assessment area was mapped into four soil types and three soil map units, based on the ground observation points, detailed location descriptions and analytical results.

Distinguishing subsoil properties include pH (field and laboratory determined), salinity, colour and texture as follows:

- Soil Type A in Map Unit 1 - Sand textures, with slightly acidic soils
- Soil Type C in Map Unit 2 – Clay Loam textures
- Soil Type B in Map Unit 3 – Sandy Loam textures
- Soil Type D in Map Unit 3 – high EC vales and acidic soils.

3.5.5.3 GQAL suitability

Detailed location descriptions and the laboratory analysis of the detailed land type locations are presented in **Appendix B3:E**. This data was used to establish land types, determine the suitability of the land and its classification under agricultural land classes.

The observations and results indicate that the site is a uniform flat level plain, with indications of moderate permeability and being moderately well drained. The subsoil is generally acidic. Salinity is generally low with the exception of soils at TP17, where highly saline subsoils were encountered.

A summary of the land types, based on landform, vegetation and soil stratigraphy, are provided in **Table 3.5r**. The soil contains acidic topsoil and subsoil that has developed on a sandstone substrate. The soils at the site generally resemble the soil types described in Horticulture Land Suitability Study, Sunshine Coast, South-East Queensland (Capelin, 1987), i.e. dunes on Holocene deposits (northern most end), and level plains on Pleistocene tidal sand deposits–siliceous sands with heathland. Holocene deposits underlie the northern end of the site where ASS were encountered near TP17, TP18 and TP22.

Table 3.5s outlines the main limitations for land-use, land agricultural suitability and GQAL land class. The land type is similar across the site and is considered as limited to pastoral grazing use. However, there was evidence of the northern half of the site being previously cropped.

Cropping is unlikely to be successful given the subsoil chemical or structural limitations affecting plant root growth and SWS capacity in the southern half of the site (Map Unit 1).

The laboratory analyses show low to moderate topsoil fertility, particularly available nitrogen, phosphorus and sulphur, and slightly acidic subsoils. Organic matter content is good. Exchangeable calcium:magnesium ratios were all extremely low, suggesting, that the subsoil structure is generally compromised in these soils.

Table 3.5p: Soil water storage calculations

Test Pit ID	Horizon start depth (m BGL)	Horizon base depth (m BGL)	Soil texture	Physico chemical limitations	Estimated SWS per 100 mm depth of soil (mm)*	SWS per soil texture (mm)	Total SWS (mm) criteria > 75 mm)
TP1	0	1	S	Nil	4	40	40
TP2	0	1	S	Nil	4	40	40
TP3	0	1	S	Nil	4	40	40
TP4	0	0.8	S	Nil	4	32	
TP4	0.8	1	SCL	Nil	6	12	44
TP5	0	1	S	Nil	4	40	40
TP6	0	1	S	Nil	4	40	40
TP7	0	1	S	Nil	4	40	40
TP8	0	1	S	Nil	4	40	40
TP9	0	1	S	Nil	4	40	40
TP10	0	1	S	Nil	4	40	40
TP11	0	1	S	Nil	4	40	40
TP12	0	1	S	Nil	4	40	40
TP13	0	1	S	Nil	4	40	40
TP14	0	0.35	L	Nil	4	21	61
TP14	0.35	0.7	CL	Nil	8	28	
TP14	0.7	1	S	Nil	4	12	
TP15	0	1	S	Nil	4	40	40
TP16	0	0.4	S	Nil	4	16	44
TP16	0.4	0.6	SCL	Nil	6	12	
TP16	0.6	1	S	Nil	4	16	
TP17	0	0.25	S	pH, EC	4	10	10
TP18	0	0.1	CS	Nil	4	4	46
TP18	0.1	0.5	LS	Nil	4	16	
TP18	0.5	0.8	SCL	Nil	6	18	
TP18	0.8	1	S	Nil	4	8	
TP19	0	0.25	LS	Nil	4	10	40
TP19	0.25	1	S	Nil	4	30	
TP20	0	0.4	LS	Nil	4	16	40
TP20	0.4	1	S	Nil	4	24	
TP21	0	0.35	LS	Nil	4	14	40
TP21	0.35	1	S	Nil	4	26	
TP22	0	0.3	ZCL	Nil	8	24	56
TP22	0.3	0.5	SCL	Nil	6	12	
TP22	0.5	0.85	CS	Nil	4	14	
TP22	0.85	1	S	Nil	4	6	
TP23	0	1	S	Nil	4	40	40

* *From: Department of Environment and Resource Management (2011), Protecting Queensland's strategic cropping land, Proposed criteria for identifying strategic cropping lands; released on 8 September 2011.*

Table 3.5q: Summary of strategic cropping land assessment

CSL map unit umber	Map Unit 1	Map Unit 2	Map Unit 3
Soil map unit name	SOIL A – Dark grey/black sand, overlying acidic grey sand/sandy clay loam on a level plain	SOIL C – Blackloam/silty clay loam, overlying slightly acidic clay loams and sand, on a level plain	SOIL B – Black loamy sand/sand, overlying acidic sandy clay loams and sand, on a developed level plain SOIL D – Black loamy sands/sandy clay loams overlying clay loams/sand, on a level plain
Sites per dominant soil group	14 (TP1–13, TP23)	2 (TP1, TP22)	7 (TP7–TP21)
SCL status of soil-using criteria	Not SCL	Not SCL	Not SCL
Failure criteria	pH and SWS	SWS	pH, EC and SWS
Area of soil map unit	325 ha	50 ha	100 ha
Soil map unit rules			
Final SCL status of soil map unit	Not SCL	Not SCL	Not SCL

Table 3.5r: Summary of GQAL land types

	Slope			
Land Type	Range	Landform	Dominant vegetation	Soils
Map Unit 1, Soil A	<1.0%	Level plain	Cleared, some areas with open woodland	SOIL A – Dark grey/black sand, overlying acidic grey sand/sandy clay loam on a level plain
Map Unit 2, Soil C	<1.0%	Level plain	Cleared, grass	SOIL C – Black loam/silty clay loam, overlying slightly acidic clay loams and Sand, on a level plain
Map Unit 3, Soils B & D	<1.0 %	Level plain	Cleared, grass	SOIL B – Black loamy sand/sand, overlying acidic sandy clay loams and sand, on a developed level plain SOIL D – Black loamy sands/sandy clay loams overlying clay loams/sand, on a level plain

Table 3.5s: Summary of GQAL limitations, suitability and land classes for each land type

Land Type	Important limitations	Agricultural suitability	Agricultural land classes
Map Unit 1, Soil A	Soil water storage, chemical limitations (subsoil acidity)	Suitable for pasture grazing (only)	No better than Class C – Pasture Land
Map Unit 2, Soil C	Soil water storage, chemical limitations (subsoil acidity)	Suitable for pasture grazing (only)	No better than Class C – Pasture Land
Map Unit 3, Soil B	Soil water storage, chemical limitations (subsoil acidity)	Suitable for pasture grazing (only)	No better than Class C – Pasture Land
Map Unit 3, Soil D	Soil water storage, chemical limitations (subsoil acidity and EC)	Suitable for pasture grazing (only)	No better than Class C – Pasture Land

3.5.6 Groundwater

3.5.6.1 Topography and drainage

The Project site has a very shallow slop down towards the north and west, with a very low gradient. The Maroochy River flows from north to south approximately 350 m to the west of the site, ultimately discharging into the ocean. Marcoola drain, a manmade drainage channel, drains the northern part of the site and flows west to the Maroochy River. A small number of cane drains were established at the site to facilitate cane farming in the 1960's; these have very shallow gradients and many contain standing water. The ocean is located within approximately 170 m of the eastern boundary of the site; however there is no direct surface water flow from the site east to the ocean.

3.5.6.2 Climate

The airport is located on the southeast coast of Queensland, which experiences a sub-tropical to tropical climate, with a dry spring and an early wet summer. A summary of climate in the region is presented in **Section 3.5.4.4**.

3.5.6.3 Nearby groundwater bores

The DNRM borehole database indicates a number of groundwater bores near the Project. The three closest bores are located approximately 1.65 km, 3 km, and 5 km from the northern site boundary, north of Mt Coolum Creek. They are located in sandstone and are screened between 13-31 m, 23-41 m, and 22-46 m depth respectively. Eight other standpipes are recorded within 5 km of the Project site, all of which are located on either the western or southern side of the Maroochy River.

No available groundwater level or water quality data exists for these bores.

3.5.6.4 Groundwater and surface water monitoring

Forty-two groundwater level observations from piezometers have been made at the site between 1995 and 2013, which range from 0.1 to 2.1 m BGL, with a geometric mean of 0.9 m BGL. These records were corroborated by the groundwater observations made during geotechnical drilling and test pitting at the site, which have 146 groundwater level observations ranging from 0.2 m to 3.4 m BGL, also with a geometric mean of 0.9 m BGL. Groundwater observed in boreholes during drilling, and depth to groundwater measured before and after standpipe installation and field testing are summarised in **Table 3.5t**.

Initial water quality measurements were taken for pH, temperature, salinity and dissolved oxygen (DO) in each of the deep standpipes and at five surface water monitoring locations. The shallow standpipes did not contain sufficient water for water quality testing. The surface water monitoring locations (SW1 to SW5) are shown in **Figure 3.2a** in **Section 3.2.1.2**.

All drains in which surface water was monitored were highly vegetated, with apparently stagnant channel flows, with the exception of visible low flows at SW4 located in Marcoola drain. Water quality parameters were measured using a calibrated meter, and a long arm was used for surface water sample collection. Results are listed in **Table 3.5w**.

Additional pH and electrical conductivity monitoring was undertaken for the groundwater wells monthly for five months from September 2013 to January 2014. The results of this monitoring are summarised in **Table 3.5x**.

Table 3.5t: Water level (WL) observations during drilling and well installation

SP ID	Depth of WL observed during drilling (m BGL)	WL before installation (m BGL)	WL after installation (m BGL)	WL before testing (m BGL)	WL after testing (m BGL)	Bore Depth (m BGL)	Comment
Zone 1A	0.8	N/A*	1.3	1.33	1.37	8.8	Deep bore
Zone 1B	0.8	1.28	1.14	1.175	N/A+	2.0	Shallow bore
Zone 2A	0.8	NA*	0.85	1.48	1.49	8.7	Deep bore
Zone 2B	0.8	0.85	0.75	0.85	NA+	1.2	Shallow bore
Zone 3A	0.4	N/A*	0.3	1.66	1.71	7.2	Deep bore
Zone 3B	0.4	0.4	0.1	0.41	N/A+	0.9	Shallow bore
Zone 4A	2.1	N/A*	2	1.745	1.75	8.2	Deep bore
Zone 4B	Dry	dry	dry	0.97	dry	1.2	Shallow bore
Zone 5A	1.5	N/A*	1.05	1.8	1.82	8.5	Deep bore
Zone 5B	1.5	1.55	0.87	1	0.97	1.6	Shallow bore

N/A = not applicable; borehole filled with drilling mud*

NA+= not applicable; no testing performed

WL = water level

3.5.6.5 Field testing

Rising head tests were performed in all standpipes that contained sufficient water. The tests were analysed using the Hvorslev approximation (Hvorslev, 1951) to estimate a field saturated hydraulic conductivity of the corresponding formations. Results of rising head tests are summarised in **Table 3.5u**.

The test results are considered representative for the screened soils and are in agreement with the range of values published in literature for this type of soils and values reported for other studies conducted at similar sites.

3.5.6.6 Conceptual hydrogeological model

A Conceptual Hydrogeological Model (CHM) is a non-mathematical presentation of the hydrogeology of an area or region. The model provides information about:

- Water-saturated and permeable sediments (aquifers) that can yield groundwater when intersected by a drainage line, and less permeable sediment beds that impede groundwater flow (aquitards and aquicludes), their characteristics and interactions
- Groundwater occurrence and flow within and between aquifers and surface water bodies
- Geological and anthropogenic influences on the groundwater systems.

The purpose of the CHM is to provide a simplified description of the hydrogeological system. Assembly of the CHM forms the basis of the background groundwater conditions, which can then be used to assess potential impacts. Geological cross sections and contour maps of hydrostratigraphic units are generally used to visualise a CHM. The sections and maps identify the locations, depth and thickness of each formation where possible, salinity, and the direction of groundwater flow.

Hydrogeological maps illustrating the hydraulic heads and salinity data were created where sufficient water heads and salinity data were available. Groundwater sources and discharge locations are also required for the development of the CHM.

The conceptual hydrogeological model is shown in **Figure 3.5j** and discussed below.

Hydrostratigraphy

Subsurface investigations identified two key lithological types that form a shallow aquifer system across the site:

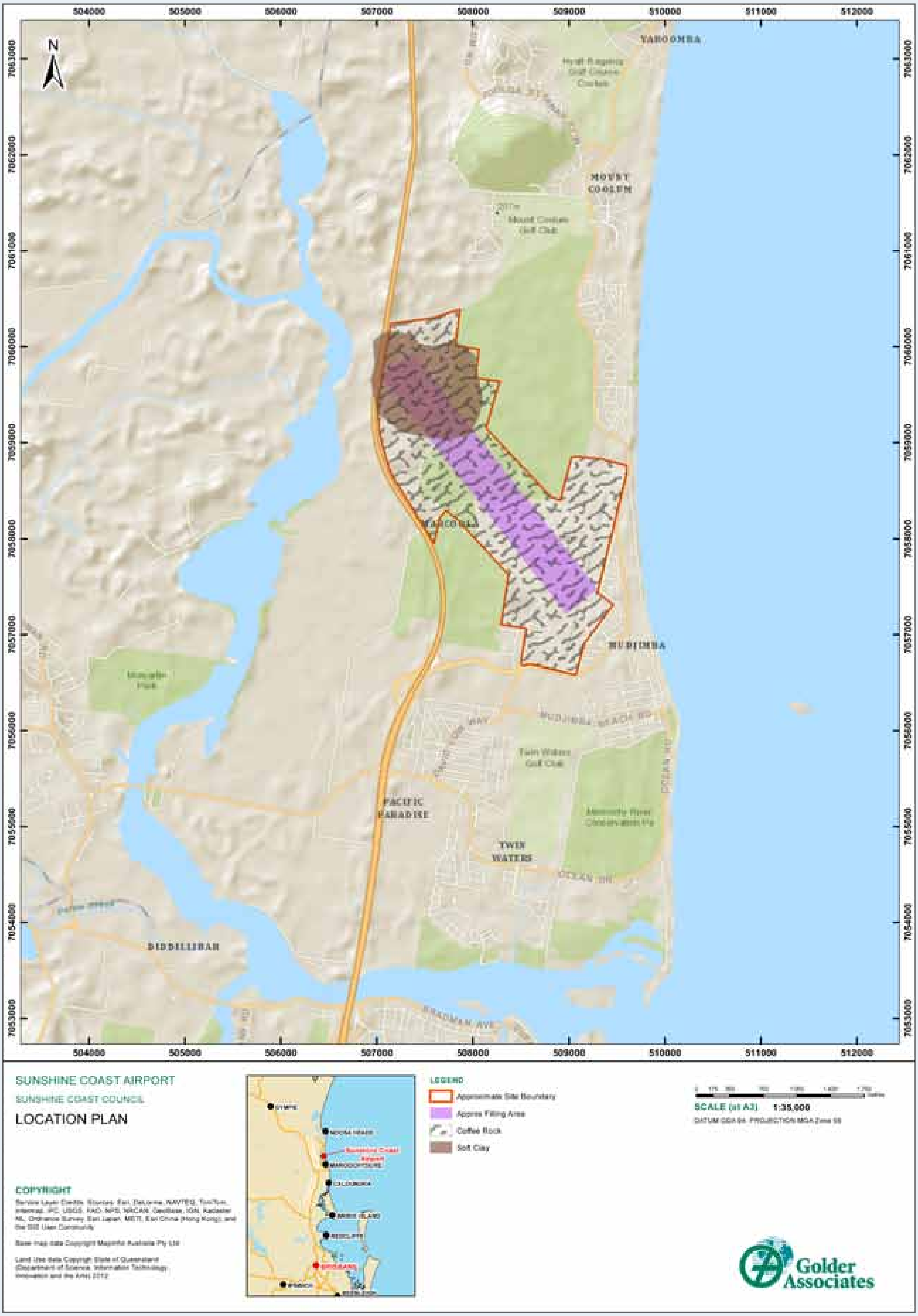
- **Unconsolidated alluvial sediments:** The shallow hydrostratigraphy comprises a predominantly sandy unit with intermixed sand and silt lenses, or laterally discontinuous layers. The sediments do not have distinct strata, and generally act as one hydrostratigraphic unit because of the laterally discontinuous nature of the sediments. Groundwater levels across the site (ranging from 0.2 m to 3.4 m BGL) are similar and generally reflect one shallow groundwater system across the various sediment types.

Table 3.5u: Summary of results from rising head tests

Bore	Bore type	Hydraulic conductivity (m/d)	Static depth to ground-water (m BGL)	Screened soil	Tested interval (m BGL)	Coffee rock		
						Top (m BGL)	Bottom (m BGL)	Thickness (m)
Zone 1	Deep	0.2	1.33	Silty SAND trace clay	5.45 to 8.80	1.5	4.4	2.9
	Shallow	N/A*	1.18	SAND, trace silt just above weak coffee rock	N/A*			
Zone 2	Deep	0.29	1.48	SAND trace silt	2.70 to 5.70	1.0	2.7	1.7
	Shallow	N/A*	0.85	SAND, trace silt just above weak coffee rock	N/A*			
Zone 3	Deep	0.4	1.66	SAND	3.5 to 7.2	0.4	2.0	1.6
	Shallow	N/A*	0.41	SAND, trace silt just above weak coffee rock	N/A*			
Zone 4	Deep	1.65	1.375	SAND, trace silt	4.3 to 8.0	0.8	4.3	3.5
	Shallow	N/A*	0.97	SAND, trace silt just above weak coffee rock	N/A*			
Zone 5	Deep	0.56	1.8	SAND	4.7 to 8.5	0.7	4.0	3.3
	Shallow	1.5	1.0	Silty SAND	0.7 to 1.5			

* *Groundwater level too shallow for test*

Figure 3.5j: Conceptual hydrogeological model



- **Indurated sand (coffee rock):** The coffee rock layers encountered within the shallow aquifer are expected to have a relatively low permeability compared to the overlying and underlying alluvial sands and clays. Borehole logs indicate the depth to coffee rock ranges from approximately 0.4 m to 7.8 m. The groundwater above the coffee rock is likely to be semi-perched.

Coffee rock has previously been described (Farmer et. al. 1983) as a distinctive Podosol B horizon, characterised by accumulated humus, low-iron content and frequent hard cementation. It is described as developing at the water table in quartz sands on coastal plains in sub-tropical and tropical climates.

Thompson et al. (1996) commented on the limited pore space and low permeability, and observed that during the wet season, shallow groundwater may be perched above the coffee rock.

Because coffee rock has low permeability, it is expected to play an important role in the existing hydrogeological processes, which, within coastal plain aquifers, can be a significant factor in the relationship between fresh and saline groundwater (Cox et al., 2000).

The low permeability of the coffee rock suggests it could act as a barrier to groundwater flow. However, it is likely to be hydraulically connected at the catchment scale to the shallow aquifer, and it would therefore act as a semi-confining layer.

The coffee rock at the site is variable in depth to ground level, thickness and degree of cementation (refer to Table 3.5u). During site investigations, it was observed that coffee rock depth and thickness can change by at least 5 m across a horizontal distance of less than 250 m. Experience also suggests that the indurated sand typically contains voids and weaknesses across relatively small distances.

Hydraulic conductivity

Representative values for hydraulic conductivity were taken from site investigations, published values and other studies conducted at similar sites, as summarised in **Table 3.5v.**

Groundwater table and head conditions

It is difficult to define the groundwater table at the site, as regular water level data has not been acquired over an extended time. The groundwater table at the site is relatively flat, with groundwater elevations generally consistent across the site.

However, the topography is lower towards the north-western part of the site, and consequently the water table is closer to the ground surface in that area. Figure 3.5k conceptually shows how the depth to groundwater changes according to the site topography.

Groundwater above the coffee rock is likely to be semi-perched. Given the variability in the coffee rock across relatively small areas, the semi-perched groundwater is likely to be influenced by the coffee rock at a localised scale (i.e.

Figure 3.5k: Conceptual diagram showing variation in depth to groundwater across the site

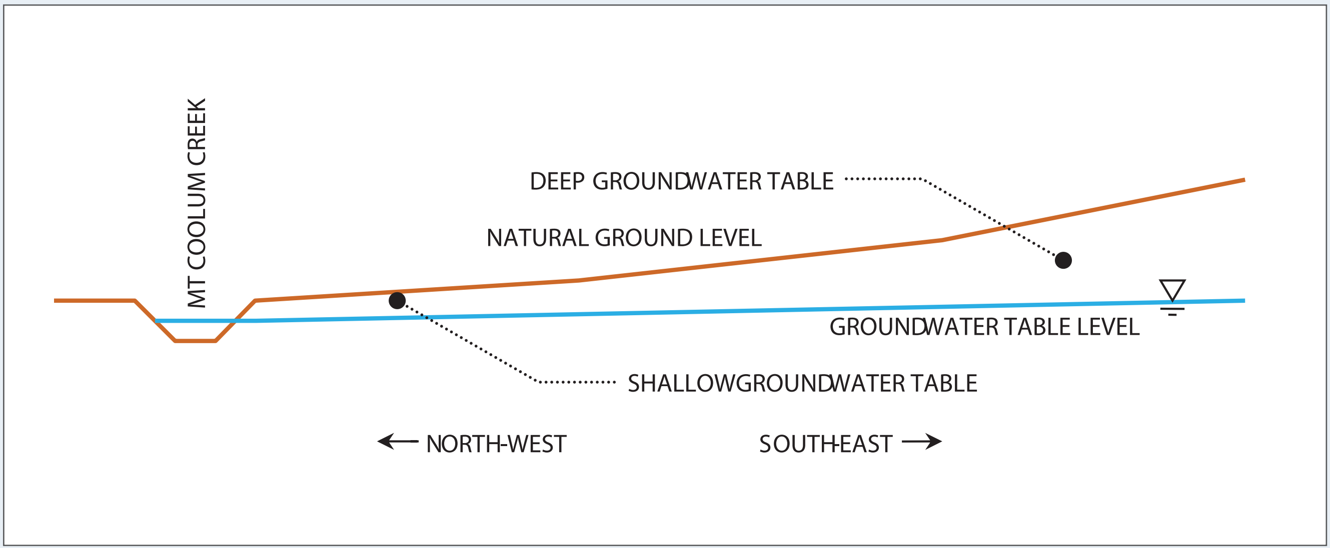


Table 3.5v: Representative hydraulic parameters for the stratigraphy at the site

	Hydraulic conductivity (m/d)			
Strata	**Minimum**	**Maximum**	**Mean**	**No. of Field Tests**
SAND trace silt (above coffee rock)	0.61	2.0	1.47	4
Coffee rock (indurated sand)	0.31	0.40	0.35	2
SAND, trace silt (below coffee rock)	0.67	15.0	3.46	15

only on a site-wide not regional level), and closely linked to the hydrogeologic nature of the coffee rock across relatively small areas.

The local shallow aquifer is partly confined by the coffee rock, however, groundwater may flow from the shallow perched water table above the coffee rock to the aquifer below (dependent upon the relative head relationship). This flow is expected to occur preferentially through weaknesses and voids in the coffee rock. Additionally, groundwater may also migrate upwards through the coffee rock where hydrogeologic conditions permit, such as in areas of confined groundwater.

Aquifer recharge and discharge

Monitoring indicates that groundwater is generally fresher than brackish in both the perched and semi-confined aquifers. This suggests there is groundwater connectivity with the tidal Maroochy River and the sea, and that salt levels in the groundwater are diluted by moderate to high rainfall in the area. This is likely to be due to the permeable nature of the alluvial sediments combined with relatively flat topography.

Infiltration resulting from storm events directly recharges the perched aquifer, and dissipates horizontally to low lying ground and drainage lines, with slight downward leakage across the coffee rock. During dry weather, groundwater may move up through the coffee rock through capillary suction and plant uptake, which results in a discharge from evaporation and evapotranspiration. On an annual basis, a small percentage (1 to 5 per cent) of precipitation is expected to infiltrate and recharge the groundwater table.

Figures 3.5l to **3.5n** show a time-series comparison from August 2013 to April 2014 of groundwater depth and tide height or rainfall for:

- BH9/13, a deep well approximately 1,000 m from Marcoola drain and
- BH1/13, a shallow well approximately 50 m from Marcoola drain.

The hydrographs reflect the generally dry 2013/2014 summer with water elevations decreasing over the monitoring period. It also indicates a direct response in the shallow aquifer to rainfall and a smaller response to tidal variation in Marcoola drain. The deeper aquifer at BH9/13 did not show such correlations.

The current surface water drains generally follow the relatively flat topography with extremely small gradients (less than 0.1 per cent in the existing southern perimeter drain), resulting in relatively stagnant channel flows and, therefore, insignificant discharge rates of groundwater.

Water levels in the existing drains are influenced by tidal fluctuations.

Groundwater quality

Groundwater quality monitoring indicates groundwater and surface water across the site is generally acidic, salinity levels are fresh (< 700 mg/L), and dissolved oxygen (DO) is relatively low. Surface water is also acidic and fresh across most of the site, although some brackish results were reported in the north-western part of the site. DO is generally low in the minor drains within the site, and higher in Marcoola drain and the southern perimeter drain.

Groundwater across the site is typically acidic, with pH ranging between 4.5 and 6.0, and no significant spatial variation. Generally, surface water is slightly more acidic than the underlying groundwater. This is probably because the drains are connected to the shallow, more acidic soils above the coffee rock and most groundwater samples were taken from the less acidic soils below the coffee rock.

Water in Marcoola drain is less acidic (pH 6.16) because of the tidal influence from the Maroochy River. Water samples from the southern perimeter drain (SW5) were also less acidic (pH 5.96), which suggests the water in this drain is influence by tidal flows from the Maroochy River and runoff from upstream developed areas, which have slightly less acidic soils.

The higher acidity measured at SW1, SW2, and SW3 indicates that these drains are not directly connected to Maroochy River, which suggests that drainage from the site is restricted. Additionally, the low DO readings in all standpipes and surface water locations (with the exceptions of SW4 and SW5) indicate stagnant water.

The average groundwater salinity is approximately 450 mg/L, indicating little ingress of seawater and the potential for a fresh water lens to have developed on saline groundwater. Salinity varies across the site and with time. While groundwater in the Wallum Heath Management Area was not measured above 300 mg/L, groundwater in the lower-lying areas of the site to the north and west were measured above 500 mg/L on a number of occasions.

While the average surface water salinity is higher, it shows much greater spatial variation as follows:

- SW1 (4,500 mg/L) is located in a very shallow and vegetated channel, which would cause accumulation of salts as water is evaporated. Although SW1 is located relatively close to the Maroochy River, the drain is so shallow and discontinuous that it is unlikely to have tidal influence.
- SW2 (90 mg/L) and SW3 (70 mg/L) have a very low average salinity, which is lower than the salinity of the groundwater. This is most likely due to inflows of freshwater runoff, the isolation from marine influences, and lower evaporation rates from vegetation coverage.
- SW4 (2,900 mg/L) is tidal so has brackish water
- SW5 (380 mg/L) may also be tidal, but is more likely to be affected by runoff from upstream developed areas.

The results of monthly groundwater level, pH and electrical conductivity monitoring of the eight standpipes monitored from August 2013 to January 2014 are shown in the Appendices. A summary of the results is provided in **Table 3.5x**.

Table 3.5w: Initial water quality results

Location ID	Water Quality Parameter			
	pH	Temperature (°C)	Salinity (mg/L)	DO (%)
Groundwater				
Zone 1A	4.9	20.28	470	34.1
Zone 1A	4.89	20.52	470	33.6
Zone 1A	4.91	20.4	470	36.3
Zone 2A	4.95	19.2	540	25.5
Zone 2A	4.99	19.23	540	27.7
Zone 2A	5.00	19.21	540	29.1
Zone 3A	4.52	20.76	310	14.5
Zone 3A	4.24	21.04	260	19.9
Zone 3A	4.24	21.15	210	36.4
Zone 4A	4.63	22.96	440	25.4
Zone 4A	4.65	22.94	640	25.2
Zone 4A	4.63	22.95	670	14.6
Zone 5A	4.35	21.32	430	9.5
Zone 5A	4.3	21.26	410	12.1
Zone 5A	4.32	21.27	360	6.5
Surface water				
SW 1*	3.33	17.27	4,500	29.8
SW 2	3.71	19.6	90	42.5
SW 3	4.07	19.67	70	21.1
SW 4	6.16	24.28	2,900	114.7
SW 5	5.96	21.74	380	75.7

Notes:

Samples in bore tested at first 20 L, 40 L, and 60 L of pumping.

* *Water in drain approximately 0.1 m deep.*

Table 3.5x: Summary of monthly water quality monitoring from June 2012, and September 2013 to January 2014

General Site Location	Location ID	Water Quality Parameter	
		pH	Salinity (µS/cm)
North west end of proposed Northern Perimeter Drain	Zone 1A	4.90–5.81	755–970
	Zone 1B	4.34–5.65	150–1,020
	SW 1* (one record)	3.33	8,200
Central part of the proposed Northern Perimeter Drain, near the National Park	Zone 2A	4.80–5.78	300–1,130
	Zone 2B (one record)	5.88	621
	SW 2 (one record)	3.71	~165
	SW 3 (one record)	4.07	~130
Wallum Heath Management Area	Zone 3A	4.50–5.77	267–517
	Zone 3B (one record)	5.71	490
South of the Southern Perimeter Drain	Zone 4A	5.22–5.93	199–1,270
	Zone 4B	4.50–5.81	142–390
	SW 5	5.96	~690
South western part of site in cane land	Zone 5A	5.25–5.99	561–710
	Zone 5B	5.21–6.12	300–541
Marcoola drain	SW 4	6.16	~5,270

Figure 3.3l: Groundwater depth at deep well BH9-13 and recorded rainfaill

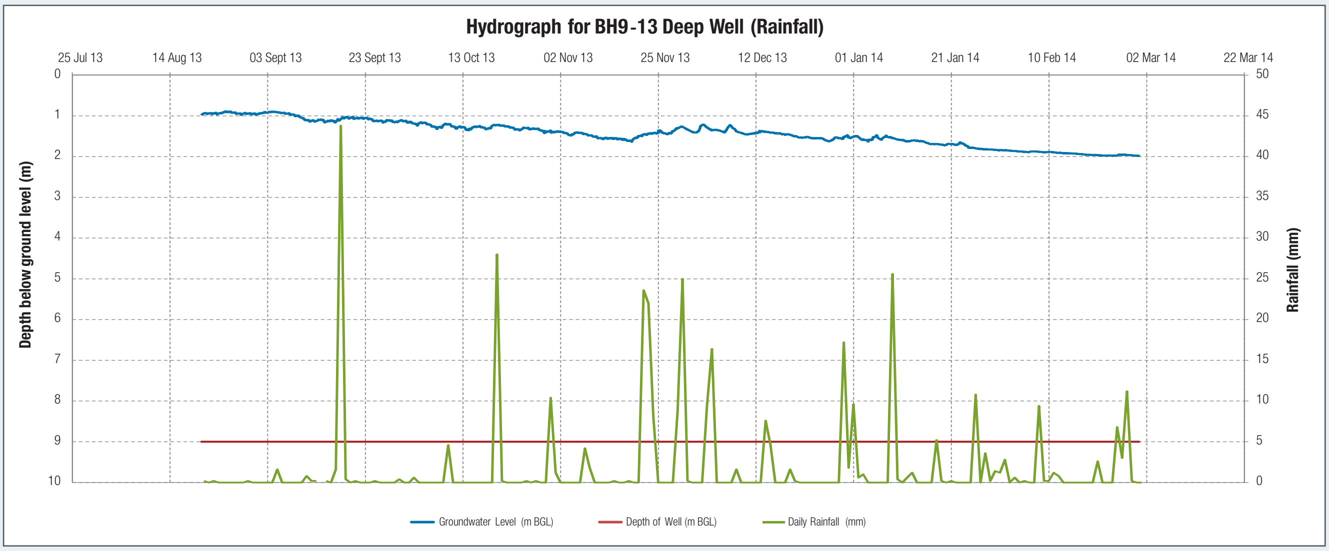


Figure 3.5m: Groundwater depth at shallow well BH1-13 and recorded tide heights

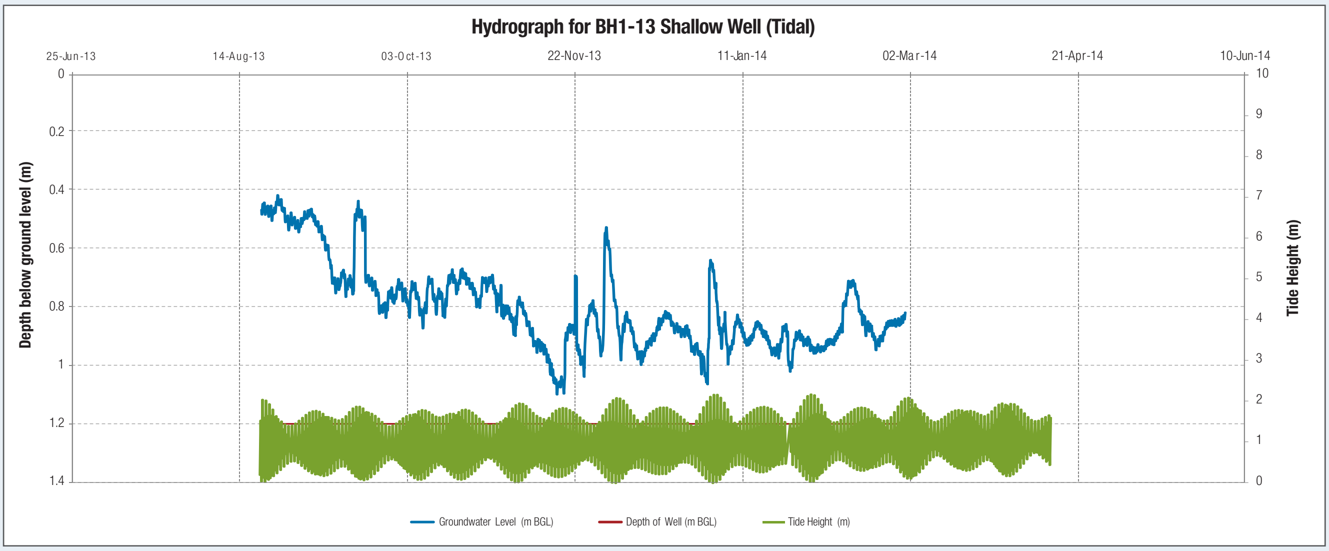
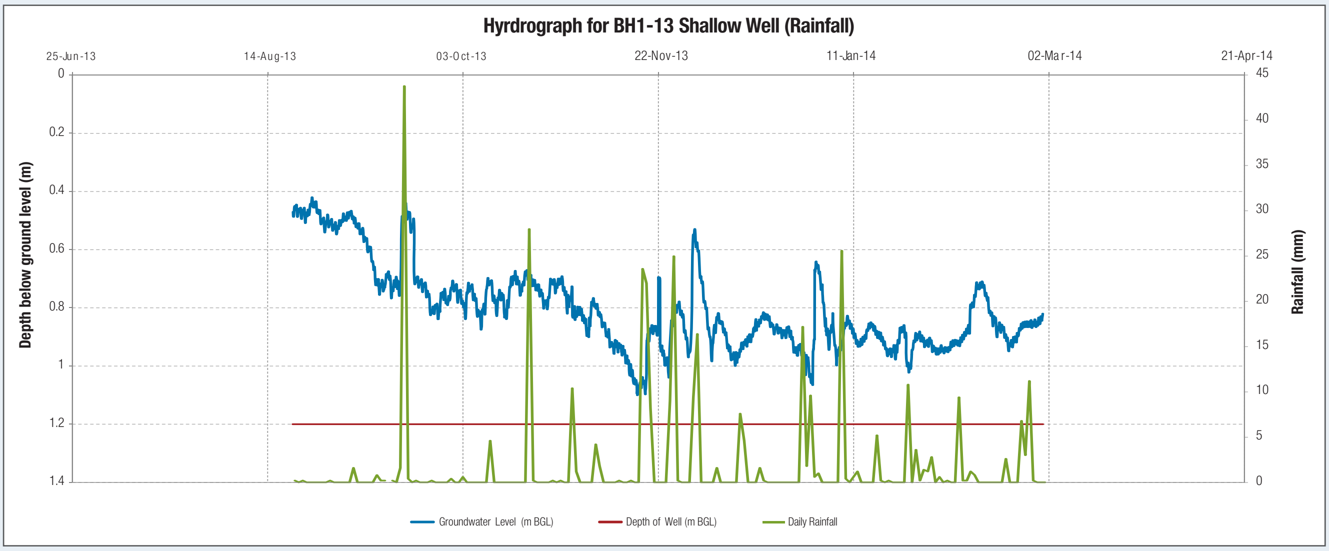


Figure 3.5n: Groundwater depth at shallow well BH1-13 and recorded rainfall



3.6 ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION MEASURES

3.6.1 Description of impact assessment criteria

The geotechnical, soils and groundwater assessment considers potential changes to existing conditions caused by the project. The Project involves the hydraulic placement of approx. 1.1 M m^3 of sand to compress underlying unconsolidated material, which has the potential to affect the surrounding geotechnical and groundwater conditions. The Project also includes major excavation for drain construction, which has the potential to disturb ASS and contaminated soils; major drains also may cause groundwater drawdown.

To assess the impacts, a risk assessment approach was adopted. By considering the combination of the significance of the impact and likelihood of that impact occurring, it is possible to obtain an overall risk rating for the activity.

The impact significance criteria shown in **Table 3.6a** were applied to the impact assessment reported herein. Standard likelihood criteria were adopted for the assessment.

The risk assessment matrix adopted for the environmental impact statement (EIS) is shown in **Table 3.6b**.

3.6.2 Items requiring risk evaluation

The following sections have been evaluated as part of the Geology, Soils and Groundwater risk assessment:

1) Geotechnical
2) Acid sulphate soils
3) Soil contamination
4) Erosion hazard
5) Land resource
6) Groundwater

3.6.2.1 Geotechnical

The north-western portion of the proposed runway is underlain by very soft to soft alluvial clay, with an estimated thickness of up to 2.5 m. Field and laboratory testing indicates that the very soft/soft clay layer is 'normally consolidated', suggesting that any fill loading on this layer will cause significant settlement.

Filling to the required site levels is expected to result in settlement of surficial very loose/loose sandy soils (immediate settlement) and settlement of very soft/soft clay (comprising primary or shorter term consolidation settlement and secondary or long term creep settlement).

The following potential environmental impacts were assessed:

- Consolidation of underlying soft materials
- Slope stability of the fill embankment.

3.6.2.2 Acid sulphate soils

The ASS investigation indicates the presence of low to moderate levels of 'net acidity' in soils at the site. Net acidity is present as both actual and potential acidity; however, the latter appears to be limited to depths of generally greater than 1 m. The potential impacts to the quality of groundwater and receiving waters from excavations and fill placement can be minimised with the implementation of an ASS Management Plan.

The following potential environmental impacts were assessed:

- Acidification of groundwater caused by ASS settling beneath the groundwater table during surcharge
- Mobilisation of actual acidity in soils at the surface of the soil profile following placement of saturated fill materials
- Disturbance of actual and potential ASS during excavations for drain construction

Standard control measures incorporated into the assessment include:

- The ASS risk associated with excavation of the major drains and any areas of unsuitable material will need to be managed on site. Excavated material will be tested, treated on site and stockpiled for use in construction.
- Construction of ASS Treatment Pads for management ASS soils on site. The ASS treatment pads will be bunded and have a low-permeability compacted base to prevent runoff leaching into the underlying groundwater. Each pad covers approximately 1ha (100 m x 100 m) and is expected to have adequate capacity to treat 3,000 m^3 per week. The treatment rate would vary depending on the moisture of the soil to be treated and the prevailing weather conditions. The provision of multiple ASS treatment pads allows for flexibility in managing the ASS material and reduces the haulage distance between the excavation site and treatment area. It is anticipated that a minimum of three treatment areas would be required for the project (see also Chapter A5 – Project Construction). Treated soils will be stockpiled as either fill material or topsoil.
- Preparation and implementation of an ASS Management Plan, including lime treatment of ASS soils, exposed excavation surfaces and monitoring. The ASS Management Plan will need to take into consideration the naturally acidic environment, which is an important habitat feature for some species at the site.

Table 3.6a: Significance criteria for flood impact assessment

Impact Significance	Description of Significance
Very high	• The impact is considered critical to the decision-making process • Impacts tend to be permanent or irreversible, or otherwise long term • Impacts can occur over large scale areas.
High	• The impact is considered likely to be important to decision-making • Impacts tend to be permanent or irreversible or otherwise long to medium term • Impacts can occur over large or medium scale areas.
Moderate	• The impact is relevant to decision-making • Impacts can range from long term to short term in duration • Impacts can occur over medium scale areas, or otherwise represent a significant impact at a local scale.
Minor	• The impact is unlikely to be of importance in the decision-making process • Impacts tend to be short term or temporary and/or occur at local scale.
Negligible	• Minimal change to the existing situation, e.g. impacts that are within the normal bounds of variation.

Table 3.6b: Risk assessment matrix adopted for the EIS

	Significance				
Likelihood	**Negligible**	**Minor**	**Moderate**	**High**	**Very High**
Highly Unlikely	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Negligible	Medium	High	Extreme	Extreme

3.6.2.3 Soil contamination

Contaminated soils were identified at the farm sheds in the western part of the site and may be within the footprint of the construction compound. It is expected that the proposed western perimeter drain would require the removal of these sheds, and the excavation of some or all soils beneath them. There may also be some soil disturbance during establishment of the construction compound. Consequently, the hydrocarbon and heavy metal contamination identified at the site would need to be managed.

Before construction commences, it would be necessary to undertake a detailed contaminated land assessment to define the area of contamination and determine suitable remediation or management measures. The remediation would be undertaken through the implementation of a specific Contamination Management Plan by an approved contractor as part of the early civil works for the Project. Once the Project is complete, the area would be within an operational airport, and the site would remain on the Environmental Management Register.

The disturbance of other contaminated soils during construction was assessed as a potential environmental impact. The assessment incorporates standard control measures, including a Contamination Management Plan, which would be implemented in the event that contaminated soils were identified on site.

3.6.2.4 Erosion hazard

The overall Erosion Hazard for the site during construction is very low. The potential hydrological impacts to waterways and ecosystems as a consequence of increased runoff during clearing and construction can be minimised with strict compliance to ESC measures developed for the site, which would need to be detailed in a suitable site ESC Plan and EMP.

The following potential environmental impacts were assessed:

- Disturbance of sandy soils across the site
- Disturbance of highly dispersive soils at TP17 (at the northern end of the site).

Standard control measures incorporated into the assessment includes preparation and implementation of an Erosion and Sediment Control Plan (ESCP), which would include provisions for:

- Staging clearing and other soils disturbing activities
- Stormwater management during construction
- Stockpile management
- Soil stabilisation and protection, including soil amelioration if required to improve fertility
- Sediment control infrastructure.

3.6.2.5 Land resource

The Project site is not Strategic Cropping Land or Good Quality Agricultural Land, and the proposal is unlikely to have an impact on those values in the surrounding areas. Consequently, no risk assessment was undertaken for land resources.

3.6.2.6 Groundwater

Groundwater at the site is shallow and fresh, and supports a variety of species and ecosystems within the neighbouring Mt Coolum National Park and Wallum Heath Management Area.

The following potential environmental impacts were assessed:

- Increased groundwater levels caused by tailwater infiltration beneath the reclamation area
- Increased groundwater salinity caused by tailwater infiltration beneath the reclamation area
- Reduced groundwater level caused by drawdown from the northern perimeter drain.

Control measures that have been incorporated into the assessment include:

- Installation of a very high quality HDPE liner beneath the reclamation area
- Installation of an HDPE cut off wall on the northern side of the northern perimeter drain.

3.7 DESCRIPTION OF IMPACT

3.7.1 Geotechnical

The majority of the proposed runway footprint is underlain by topsoil over loose to medium dense sand and dense indurated sand, then interbedded layers of stiff (or stiffer) clay and medium dense (or denser) sand/clayey sand. Construction of the runway is expected to cause settlement in these areas of less than 50 mm, under design load of about 60 Pa (i.e. 2 m to 3.5 m of fill), over the design life of 100 years.

The north-western portion of the proposed runway is underlain by very soft to soft alluvial clay, with an estimated thickness of up to 2.5 m. An area of very thick soft cohesive soils is located to the northwest of the proposed runway footprint. Field and laboratory testing indicates that the very soft/soft clay layer is 'normally consolidated', suggesting that any fill loading on this layer will cause significant settlement.

Filling to the required runway level is expected cause settlement of surficial very loose/loose sandy soils (immediate settlement) and settlement of very soft/soft clay (comprising primary or shorter-term consolidation settlement and secondary or long-term creep settlement).

3.7.1.1 Consolidation

In the areas where the proposed runway is underlain by 2.5 m of soft clay, two options are available for construction to address consolidation of the underlying soft material:

1) No surcharge: Filling to the design level, allowing consolidation to occur, then topping up to the final design level, or
2) Surcharge: Filling above the design level, allowing consolidation to occur, then removing any surplus fill.

The following settlement levels and durations are predicted if no surcharge is used:

- Primary settlement: 550 mm to 600 mm over 12 months
- Long term settlement: 70 mm to 90 mm over 100 years.

The following settlement levels and durations are predicted if 1 m of surcharge is used:

- Primary settlement: 600 mm to 700 mm over 12 months
- Long term settlement: < 50 mm over 100 years.
- To minimise the potential for changes in runway grade caused by long term settlement, surcharge has been selected as the preferred construction methodology. The recommend surcharge area for the runway is shown in **Figure 3.5a** in **Section 3.5.1**.

The surcharge will be placed over the proposed runway pavement area plus an additional 10 m beyond the edge of the runway shoulders. The filling will be carried out using dredging, and consequently the surcharge will comprise material that will be suitably compacted and can be retained as the structural fill after completion of the estimated settlement. The overall construction of the runway, including placement of sand in the surcharge area, is described in Chapter A5.

3.7.1.2 Embankment stability

Placing tall or steep embankment over soft materials can sometimes lead to embankment failures. An embankment stability assessment was undertaken for the proposed surcharge area to ensure that appropriate factors of safety are incorporated into the design.

The thickest identified zone of very soft clay underlying the edges of the proposed fill embankment is 2.5 m (refer **Figure 3.5a**). Slope stability analyses were carried out to assess the requirements for slope batters at areas underlain by 2 m to 4.5 m of very soft clay.

In the areas underlain by 2.5 m or less of very soft clay, the fill embankment edges will be battered at a maximum slope of 1 vertical: 4 horizontal (1V:4H). The slope stability analyses indicates that a slope of 1V:4H or shallower would be stable, and no buttressing of the preload batters would be required in areas underlain by 2.5 m or less of very soft clay.

3.7.2 Acid sulphate soils

When actual and potential ASS are disturbed, for example during excavation activities, it has the potential to cause acidification of groundwater and downstream surface water, and increased levels of dissolved metals such as iron and aluminium. A number of construction activities required for the new runway have the potential to disturb ASS and are described below.

It is proposed to fill the north-western part of the site to approx. 2.0 m to 3.5 m above existing ground levels. Settlement of the natural surface of up to 600 mm is expected following placement of fill (refer **Section 3.7.1.1**), which will cause the compression of the deep soft clay layer. Subsequently, the currently shallow unsaturated soils at the surface will settle and remain below the water table. Actual acidity present in this normally unsaturated layer may be mobilised into the groundwater system. Without appropriate management, the proposed filling could affect local receiving waters.

Should groundwater draw down occur during earthworks activities, such as excavation of the northern perimeter drain, it will be necessary to manage groundwater to neutralise any acidity and manage any iron flocs that may form. Nevertheless, the potential impacts are somewhat tempered by the existing groundwater acidity and the low levels of oxygen in the groundwater, which reduces the potential for oxidation of ASS.

Soils at the site contain low to high levels of net acidity, present as both actual and potential acidity. Excavating these soils during drain construction is likely to cause oxidation of potential ASS and mobilisation of acidity. Given the depths of the proposed drains (approximately 1.5 m BGL), there is a moderate risk of affecting the surrounding environment. However, the proposed cut-off wall to be located on the northern side of the northern perimeter drain mitigates this risk to surrounding environments.

Construction is regularly undertaken in Acid Sulphate Soils and management of the potential impacts has been incorporated into standard construction practices in coastal areas. Consequently, the overall risk to the surrounding environment would be addressed through additional ASS testing during detailed design, the use of treatment pads as described in **Section 3.6.2.2**, the proposed cut off wall and the adoption of an ASS management plan during construction.

3.7.3 Contaminated land

Contaminated soil was identified at farm sheds west of the proposed expansion area. The contamination does not present an immediate risk to human health or the environment under the current land use.

Construction activities will not directly affect these areas, and therefore disturbance of the contaminated areas is not expected to occur. Should a change be required to the construction methodology that does require disturbance of these areas, the contaminated sites would be remediated as part of construction.

Within the existing airport, construction activities are limited to expansion of the apron near the existing baggage handling area and expansion of the terminal building. Contamination is not known to occur in either of these areas and therefore disturbance of contaminated soils is not expected.

At the location of the former nightsoil disposal area, concentrations of heavy metals in the samples were below environmental and health based assessment criteria. Concentrations of ammonia, faecal coliform and *E. coli* in the samples were below laboratory detection limits. Nitrogen was detected in all samples and the highest concentration was detected near the former night soil disposal area. These concentrations are generally considered unlikely to pose environmental or human health risk.

3.7.4 Erosion and sediment control

Disturbance of the site vegetation and soils during construction has the potential to lead to erosion and subsequent sedimentation in downstream areas. Potential erosion hazards that are likely to occur during construction of the Project include:

- Exposed soils on waterway banks, most notably for the northern and western perimeter drains
- Steep slopes, particularly on drain banks and the reclamation area bunds and sand embankment.

Potential erosion impacts during construction are somewhat lessened by the site soils, which are predominantly sand and contain few non-dispersive soil fines, with the exception of a small area of clayey soils identified at TP17/12.

On completion of the project, there may be erosion risks associated with increased runoff from impermeable surface such as the runway pavement. However, the potential for erosion will be significantly reduced by very shallow grades (< 5 per cent) and the establishment of vegetation (grass) around the proposed runway.

3.7.4.1 Predicted erosion potential

The RUSLE factors identified for the site, refer **Section 3.5.4.5**, were used to estimate the erosion potential of the site during construction. This indicates that, during construction, the erosion potential will increase to approximately 14 t/ha/y. A soil loss rate of 14 t/ha/y is considered to have a very low erosion hazard based on the SCC Erosion Control Manual, as indicated in **Table 3.7a**.

Across the entire project construction area, the predicted soil loss is approximately 1,120 t/y. However, the duration of disturbance in any particular area is likely to be significantly less than 1 year and erosion and sediment control procedures will be implemented to reduce the potential erosion rates further.

Table 3.7a: Soil loss classes

Soil loss class	Calculated soil loss (tonnes/ha/yr)	Erosion hazard
1	0 to 150	Very low
2	151 to 225	Low
3	226 to 350	Low-moderate
4	351 to 500	Moderate
5	501 to 750	High
6	751 to 1,500	Very high
7	>1,500	Extremely high

3.7.4.2 Soil dispersion potential

The presence of the following soil characteristics can increase soil dispersion potential:

- Dispersive soils
- Hard setting and surface sealing soils
- Extremes of soil pH and fertility (their ability to sustain vegetative cover)
- Non-cohesive soils.

The dispersion potential of the natural subsoil was estimated based on Emerson class tests and ESP analysis. The screening identified slightly dispersive soils (Emerson Class 5) in subsurface soils, which indicates that some dispersion of fines is likely to occur if the soil is exposed to water for an extended time.

Dispersive Index testing returned a percent dispersion of 13. The dispersive fines percentage (the clay fraction plus fine silt fraction, multiplied by percent dispersion) is 6.4 per cent, which is considered non-dispersive (< 10 per cent).

Hard setting soils were not observed on site.

While surface soils are acidic, amendment with small amounts of lime will improve soil fertility. Additionally, a layer of topsoil will be applied to the final earthworks profile to ensure good coverage of grass around the runway.

3.7.5 Land resource assessment impacts

3.7.5.1 Strategic cropping land impacts

The Project site is not within an area mapped as Strategic Cropping Land, although potential SCL is mapped nearby. Field investigations supported the conclusion that the site is not SCL.

Consequently, the proposed development should not affect the value of the site as SCL within the Coastal Queensland Zone.

3.7.5.2 Good quality agricultural land impacts

The Project site was assessed as having limited potential for agricultural uses, being suited to pastoral grazing use at best, although there was evidence of the north half of the site being previously cropped. Cropping is unlikely to be successful because of the subsoil chemical and structural limitations that affect plant root growth and soil water storage capacity in the southern half of the site.

Consequently, the proposed development unlikely to have an impact on the agricultural values of the immediate and surrounding areas.

3.7.6 Groundwater

Potential groundwater impacts were assessed using conceptual and numerical modelling. Key potential impacts associated with the Project are:

- Infiltration of seawater from the hydraulic delivery of sand to the site has the potential to increase groundwater levels and salinity concentrations
- Increased groundwater levels from increased pore pressure in the water caused by compression of subsurface soils from construction of the new runway
- The proposed northern perimeter drain may cause drawdown (reduced levels) of groundwater in the neighbouring national park, which provides habitat for groundwater dependent ecosystems.

3.7.6.1 Potential impacts from reclamation

Figure 3.7a shows the conceptual hydrogeological model of tailwater infiltration from hydraulically delivered sand. The solid red arrows indicate tailwater movement, and the dashed arrows indicate potential pathways into the surrounding environment, the faded arrows indicate less tailwater infiltration further from the reclamation area. Although not shown in **Figure 3.7d**, the potentiometric surface (which is an imaginary surface that defines the level to which water in a confined aquifer would rise were it completely pierced with wells) for the hydraulic head in the semi-confined unit is below the perched water table level in the upper most stratigraphic unit.

The proposed northern perimeter drain would intercept and drain away saline tailwater infiltration in the upper layers of the aquifer between the reclamation area and the drain. However, tailwater infiltration is also expected to occur in the lower levels of the aquifer. While the coffee rock layer is likely to act as a partial barrier to tailwater infiltration into the lower aquifer, investigations indicate that the coffee rock is discontinuous, allowing some interaction between the upper and lower layers of the aquifer. Consequently, the lower permeability layer of coffee rock cannot be relied upon to contain tailwater infiltration in the upper layers of the aquifer where it would be intercepted by the northern perimeter drain.

Given the sensitivity of the neighbouring Mt Coolum national park to potential groundwater impacts, mitigation of groundwater level and salinity impacts was considered necessary for the project. Consequently, the design includes a high quality liner within the base of the reclamation area to minimise infiltration of seawater into the underlying groundwater. **Figure 3.7b** shows the conceptual hydrogeological model of tailwater infiltration with a liner, indicating an expected reduced infiltration rate and therefore lower salinity concentration in groundwater.

Figure 3.7a: Hydrogeological conceptualisation of tailwater infiltration with no mitigation

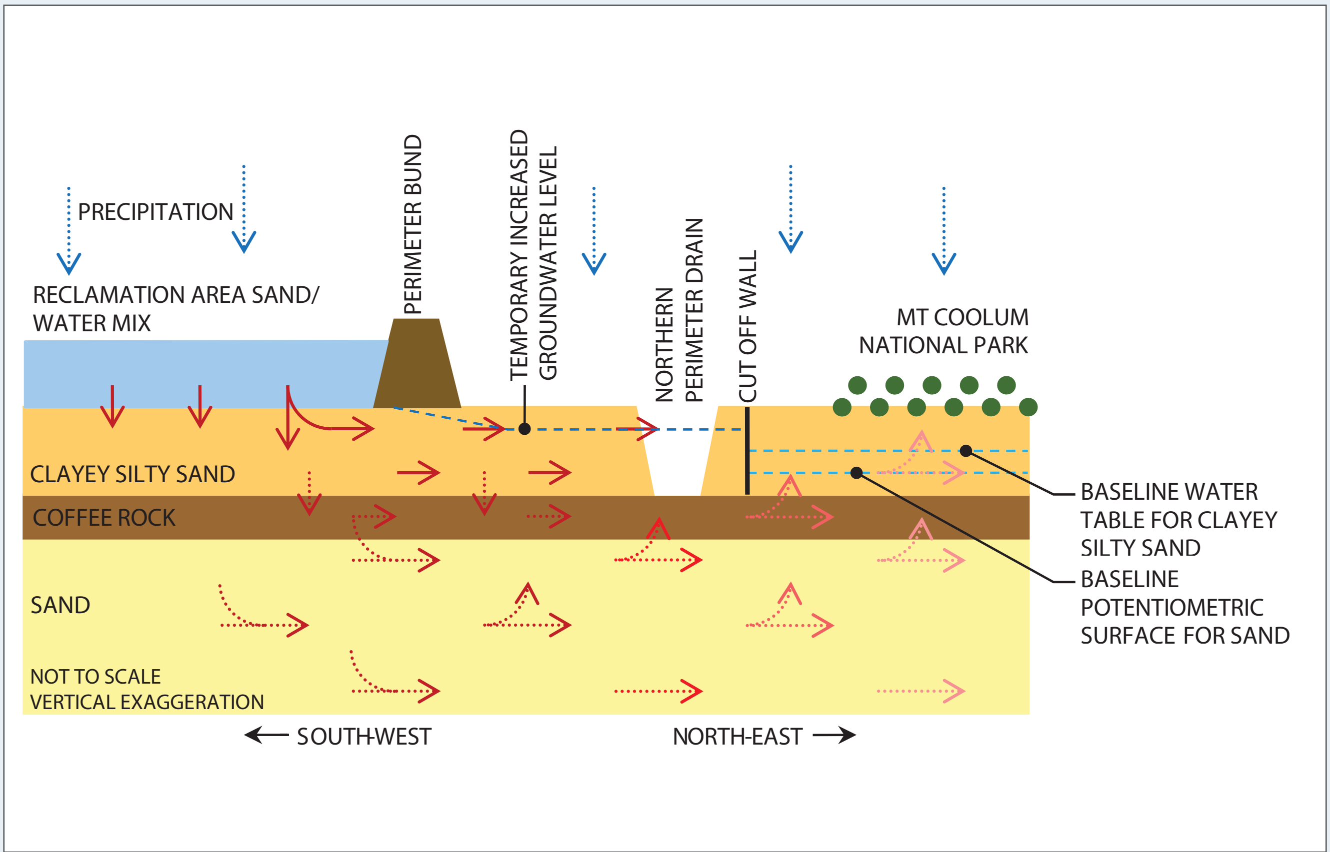
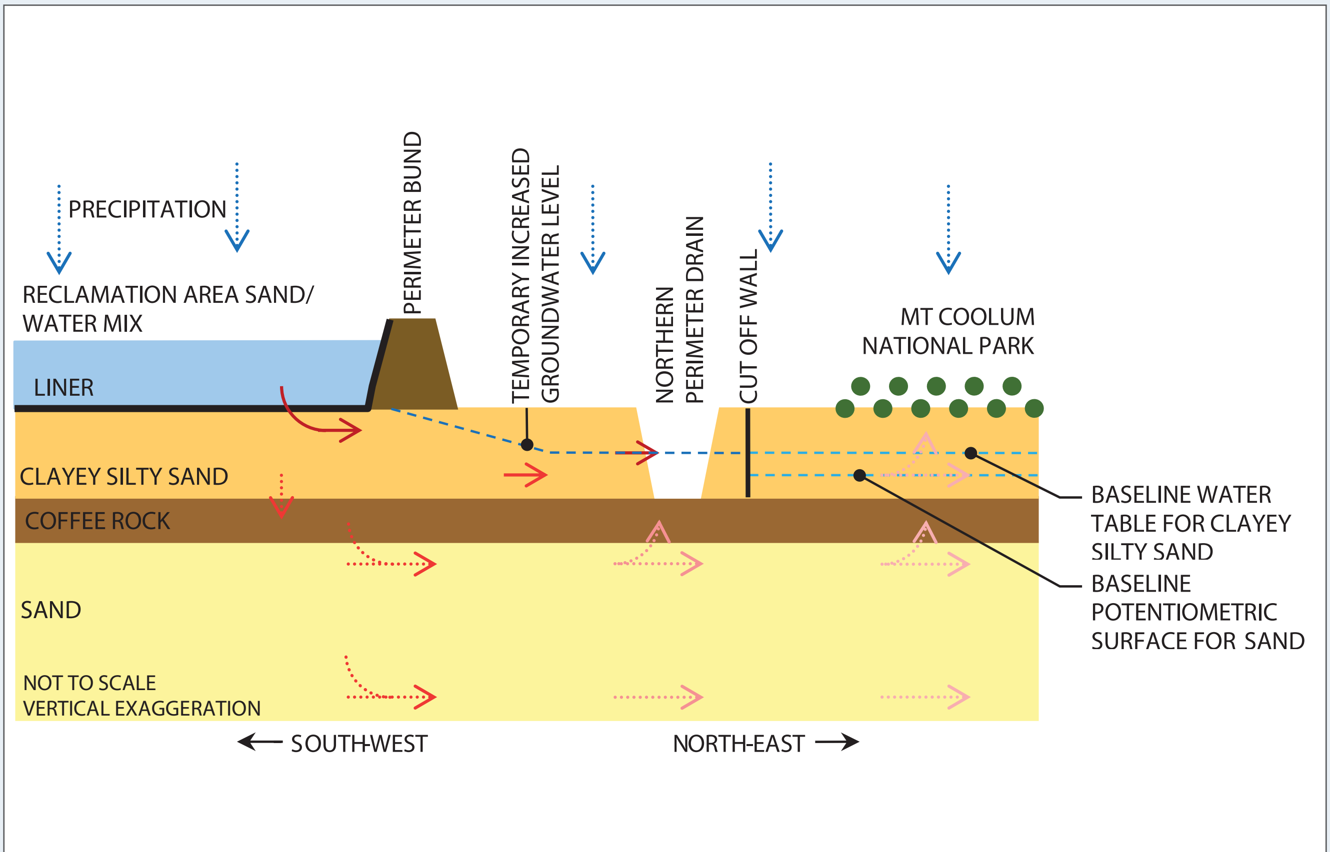


Figure 3.7b: Hydrogeological conceptualisation of tailwater infiltration with a high quality liner indicating reduced infiltration



A three-dimensional numerical model was prepared for the project to assess and quantify potential impacts associated with the construction of the new runway. The model was established to estimate groundwater levels and salinity concentrations before, during and after delivery of sand to site for construction of the runway. As the site is characterised by relatively flat topography and groundwater gradients, a three dimensional flow model with depth-averaged material parameters was adopted to provide an appropriate representation of groundwater flow conditions.

Modelling was undertaken using MODFLOW Version 2000 (groundwater flow) and MT3D (chemical transport) packages within the Groundwater Vistas Version 6.26 software interface. MODFLOW uses a finite difference solver capable of solving mass (water and solute) transport in groundwater flow systems.

Assumptions adopted in the modelling include:

- The reclamation would be undertaken as described in the construction methodology (refer Chapter A5)
- The perimeter bund would be approx. 1 m to 2.5 m above surface level and the polishing pond embankment would be approx. 3.75 m AHD
- The maximum filling level was assumed at 3.3 m AHD
- The polishing pond would be unlined, as it is underlain by a thick layer of naturally occurring clay material, which acts as a barrier to tailwater infiltration
- The bunds and fill area are lined by a very high quality high-density polyethylene (HDPE) liner
- Although the underlying soils across the site are stratified, most notably by a low permeability coffee rock layer, site investigations indicate the movement of groundwater across these strata and therefore weighted horizontal and vertical hydraulic conductivities were adopted for the coffee rock layer
- Weighted vertical and horizontal hydraulic conductivity were assigned to areas with soft clay, similar to that for the coffee rock
- A base layer of sand extending to -15 m AHD was assumed beneath the coffee rock layer
- A value of 1 per cent has been adopted for net recharge. Subsequent field investigations have indicated that net recharge could be closer to 5 per cent. Model results for salinity impacts may therefore be considered conservative.

Parameters and boundary conditions adopted in the modelling are summarised in **Table 3.7b** and **Table 3.7c**.

The model process was divided into the three phases:

1) Steady state simulation to define baseline groundwater level and salinity conditions of the transient model
2) Transient simulation of changes in water and solute concentration and flow regimes caused by a 90 day filling period within the lined reclamation area
3) Transient simulation for 300 years to simulate water level recovery for the post-filling period.

The model parameters for hydraulic filling into the lined reclamation area are summarised in **Table 3.7d**. Under these assumptions, the predicted seepage through the liner during the reclamation period is approximately 860 m^3/day. The estimated leakage rate through the liner is 3×10^{-3} m/d. The calculation of estimated leakance is considered to be 'flow restricted' by underlying sand within the filling area.

The predicted seepage was used to predict the potential groundwater elevation and salinity impacts from the reclamation activities. The model results are illustrated in **Figure 3.7c** and **Figure 3.7d**.

Figure 3.7c shows the contours of the predicted 0.1 m increase in groundwater head at the end of filling and 1 year after filling is complete. A head increase of 0.1 m was selected as the impact indicator, as changes less than 0.1 m would be indiscernible from natural variation.

The modelling indicates that the 0.1 m increase in groundwater head is not expected to extend beyond approximately 250 m from the reclamation area, or approximately 80 m into the northern section of the national park.

Figure 3.7d shows the contours of 1,000 mg/L salinity concentration in the groundwater. The modelling indicates the 1,000 mg/L contour is unlikely to cross the SCA property boundary within 100 years from the completion of filling. Modelling over a 300-year period indicates the following:

- salinity concentrations 50 m from the northern perimeter drain (approximately the national park boundary) are predicted to peak at 1,000 mg/L approximately 200 years after filling is complete and
- salinity concentrations 150 m from the northern perimeter drain are not predicted to exceed 500 mg/L over 300 years.

The south-western side of the site is predicted to have groundwater impacts of negligible significance because the sub-regional groundwater flows from the fill area to the east and north-east towards the coast and because flow to the south-west would be intercepted by a perimeter drain along the south-western edge of the fill area.

The potential ecological impacts associated with the predicted groundwater impacts are discussed in Chapters B7, Terrestrial Flora and B8, Terrestrial Fauna. Generally, the vegetation at the site is expected to tolerate the predicted changes in groundwater salinity and potential impacts to fauna are considered to be localised and unlikely to occur.

3.7.6.2 Potential impacts from the northern perimeter drain

The potential drawdown effect from the northern perimeter drain was modelled to assess variation in water levels in the adjacent hydrological/hydrogeological systems. The northern perimeter drain extends from the new runway's junction with RWY 18/36 to Marcoola drain, near the Sunshine Motorway.

Table 3.7b: Model parameters

Material zone	Sand only zone	Sand-coffee rock zone	Sand-soft-clay zone
Horizontal conductivity	3.5 m/d	2.7 m/d	3.1 m/d
Vertical conductivity	0.35 m/d	0.1 m/d	0.0009 m/d
Longitudinal dispersivity		2.5 m	
Transverse dispersivity		0.5 m	
Diffusion		0.001 m^2/d	

Table 3.7c: Model boundaries

	Modelling Component	
Model boundary	MODFLOW groundwater flow model	MT3D solute transport model
Domain boundary – East (coastline)	Constant head at 0 m AHD	Constant concentration of 35,000 mg/L
Domain boundary – West (Maroochy River)	Constant head at 0 m AHD	Constant concentration of 1,590 mg/L
Domain boundary – South (Maroochy River)	Constant head at 0 m AHD	Constant concentration of 1,590 mg/L
Domain boundary – North (elevated ground)	'no flow' boundary	Not applicable
Northern perimeter drain (invert level above 0 m AHD)	Drainage cells, base of cells at 1.5 m BGL	Not applicable
Northern perimeter drain (invert level below 0 m AHD)	River cells	
Southern perimeter drain	Drainage cells, base of cells at 1.0 m BGL	Not applicable
Proposed fill area	Transient general head boundary	Constant concentration of 35,000 mg/L
Rainfall recharge	4.0×10^{-5} (Zone 1) 2.0×10^{-5} (Zone 2)	Constant concentration of 0 mg/L

** *The filling area was divided into 46 sectors and an approximate time interval was calculated to fill each sector by 0.1 m height increments assuming approximate saltwater inflow due to filling is 78,000 m^3/day and assuming the approximate height of the proposed perimeter bund for the east and west ends is 1 m and 2.5 m above surface level, respectively.*

Table 3.7d: Model parameters and predicted seepage rate for the reclamation area with a very high quality liner

Liner		Model parameters	
Description	Defect density	Hydraulic	Solute
Very high quality liner	< 3 punctures/ha	Recharge: 1% Porosity: 25% Conductivity: 0.003 m/day	Diffusion: 0.001 m^2/d Longitudinal dispersivity: 2.5 m Transverse dispersivity: 0.5 m

Figure 3.7c: Contours for predicted 0.1 m increase in groundwater head during and after reclamation

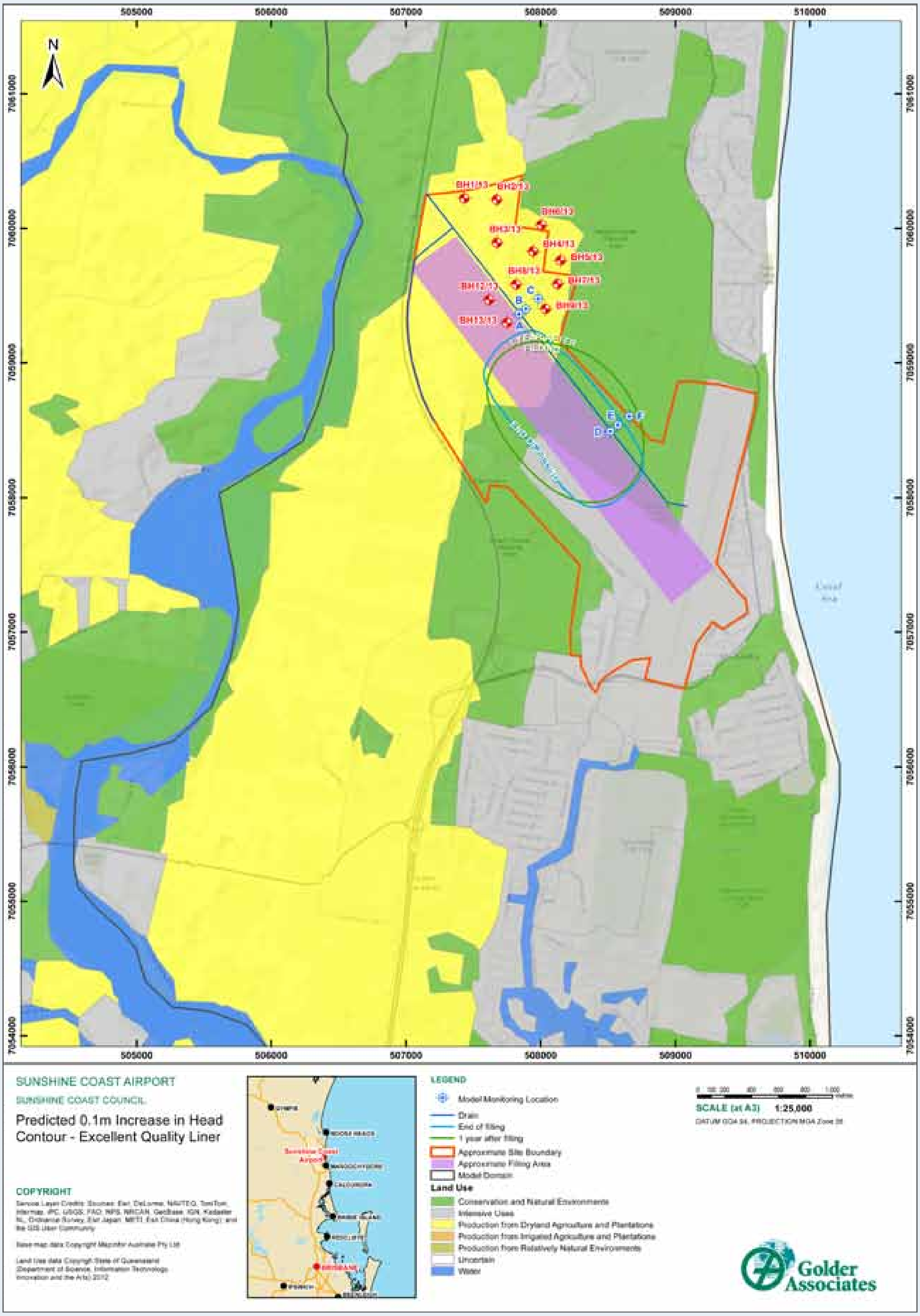
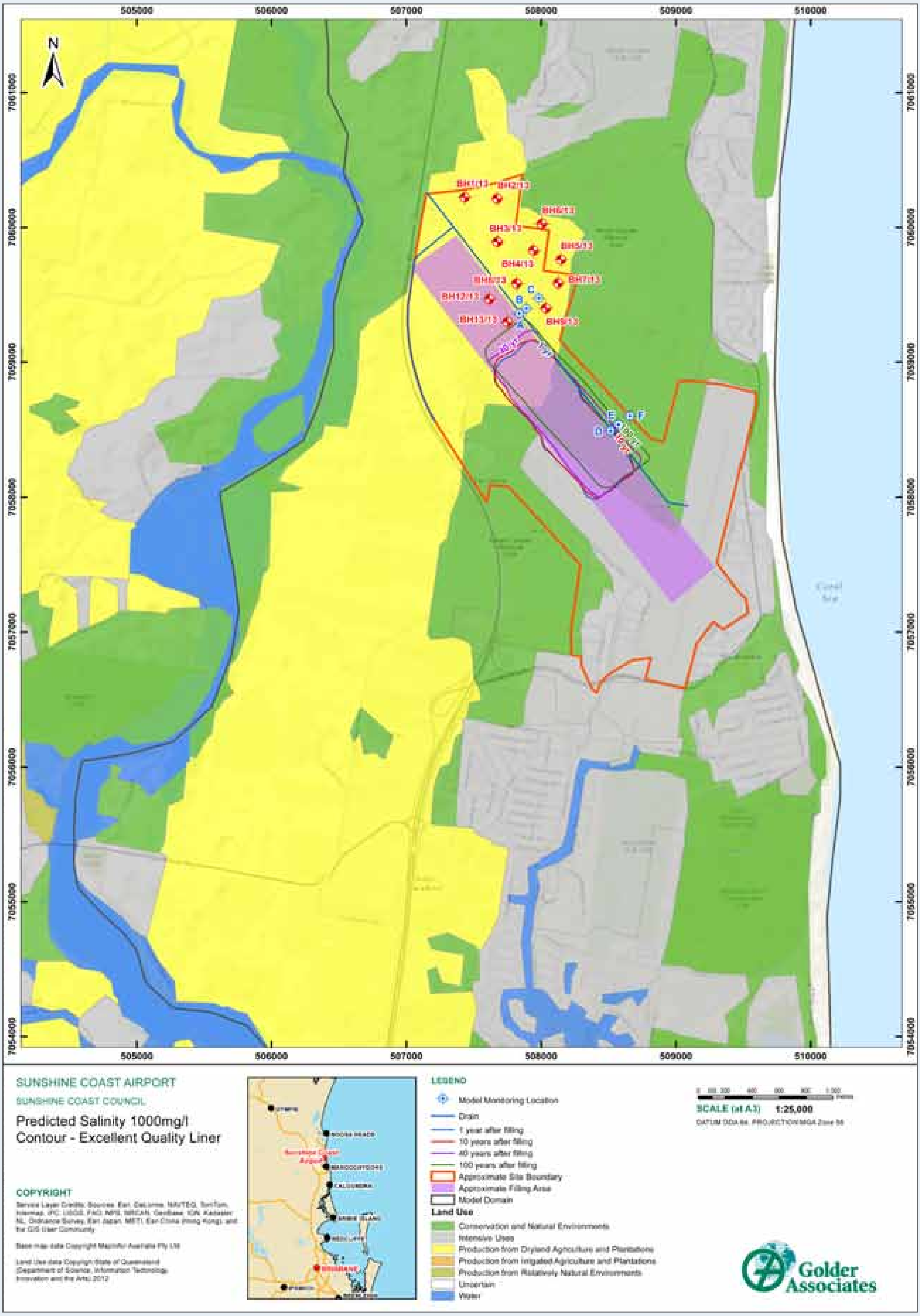


Figure 3.7d: Contours for predicted 1,000 mg/L salinity concentration in groundwater during and after reclamation



The drain would have a base width of 10 m and be approximately 1.5 m deep. Hydraulic conductivity of the surrounding soils was estimated at 2.7 m/day and the rainfall recharge to the system was estimated at 0.00004 m/day.

The drawdown assessment was undertaken for dry and wet weather conditions. For the dry weather condition, the northern perimeter drain was assumed to be dry, with the only inflow from groundwater. The modelled wet weather condition was a 2 y ARI rainfall event, which is representative of a local rainfall event, and groundwater inflow.

The dry weather scenario is the worst-case for groundwater drawdown, as indicated conceptually in **Figure 3.7e**.

Modelling indicates that without mitigation a 0.1 m drawdown for dry weather conditions would extend between 200 m and 300 m from northern perimeter drain. As the modelled drawdown from the drain extends into the national park, a low-permeability cut-off wall is proposed on the northern side of the drain to intercept groundwater flows and prevent draw down. The effect of the installation of the cut-off wall is shown diagrammatically in **Figure 3.7f**.

As indicated in **Figure 3.7f**, drawdown of the groundwater table is expected to occur only between the drain and cut-off wall; this distance would be minimised, taking into account the stability of the drain. It is proposed to install a plastic (HDPE) sheet pile wall, which would significantly reduce the potential for flow into the northern perimeter drain and address potential drawdown impacts in the national park.

It is expected that such a sheet pile barrier is likely to reduce drawdown to the extent well below natural random or climatic driven fluctuations of the current water table. The overall effective permeability of the sheet pile barrier would have to be well below the permeability of the sand and the sheet piles would have to be founded into coffee rock or to be installed at greater depth if coffee rock is absent.

3.7.7 Mitigation

Mitigation measures to be incorporated into the Project are discussed next.

3.7.7.1 ASS mitigation measures and recommendations

Given the size of the proposed development, management of existing and potential acidity at this site would be classified as extremely high level treatment in accordance with the (former) SPP 2/02 Guideline – Table 4, that is more than 25 t of aglime would be used for neutralisation. Consequently, the (former) SPP 2/02 Guidelines requires that an ASS Environmental Management Plan (EMP) must be prepared. Measures to be included in the ASS EMP are discussed here.

The fieldwork program and sampling intensity conduced for the EIS does not fully meet the requirements of SPP 2/02, and detailed investigations will be undertaken subject to discussions with DEHP before commencing bulk earthworks.

Lime treatment will be carried out on constructed pads. The earthworks staging will be planned so that a sufficient number of pads of appropriate size are available to enable spreading, drying and incorporation/mixing of the lime into the soil and verification testing. The earthworks staging plan will allow adequate time to complete the treatment and verification process before placing the next layer.

Soil liming rates

Liming rates for excavated soil were calculated using a factor of safety (fineness factor) of 1.5 and an assumed bulk density of 1.8 tonne/m^3 for sands and 1.5 tonne/m^3 for clays. Liming rates are summarised in **Table 3.7e**, and are to be applied in all instances where soils are disturbed.

Excavation for the proposed drains is likely to extend to a maximum of 1.5 m BGL, with liming rates varying from 6 kg $CaCO_3$/m^3 to 92 kg $CaCO_3$/m^3 depending on the type of soil excavated. Any excavations deeper than 1 m that encounter grey clay will require treatment at 124 kg $CaCO_3$/m^3, based on the results of the investigations to date.

Lime application to surface drains

A guard layer of lime will be placed within sections of the proposed drains to intercept and neutralise any acidity mobilised from normally unsaturated actual ASS that settles beneath the water table. Along the proposed perimeter drain, between BH10 and ASS 11/12 on **Figure 3.5c** in **Section 3.5.2**, lime should be applied to the surface at a rate of 100 kg $CaCO_3$/m along the length of drain. Additionally, between locations ASS 11/12 and ASS 8/12, lime should be placed at a rate of 120 kg $CaCO_3$/m along the length of drain. This corresponds to rates of 40 kg $CaCO_3$/m^2 and 50 kg $CaCO_3$/m^2 for the two sections of drain respectively.

These liming rates are based on the requirement to neutralise 100 per cent of the average actual acidity present in the upper 0.8 m of the soil profile (the normally unsaturated zone) assuming that 50 per cent of the resulting groundwater flow will be propagated towards the east and south (i.e. towards existing waterways).

Liming rates will be refined when further assessment is undertaken. Final rates will be adjusted for the neutralising value of the lime used once this is known. Soil liming rates will also take into consideration the acid tolerant nature of some species in the immediate receiving environment

Groundwater

Given the environmental sensitivity of the receiving environment, a monitoring program for receiving waters and groundwater is proposed for the site. Potential risks associated with the management of groundwater at the site may be reduced by undertaking baseline monitoring of dissolved iron and aluminium, acidity, alkalinity, total chloride and total sulphate concentrations. This will allow better definition of the current groundwater chemistry and assist with developing effective management measures. Several monitoring rounds will be required to establish a representative baseline and to enable development of management measures for potential iron floc formation and to limit the risk of potential environmental impacts.

Figure 3.7e: Conceptual diagram indicating drawdown scenarios in dry and wet weather conditions.

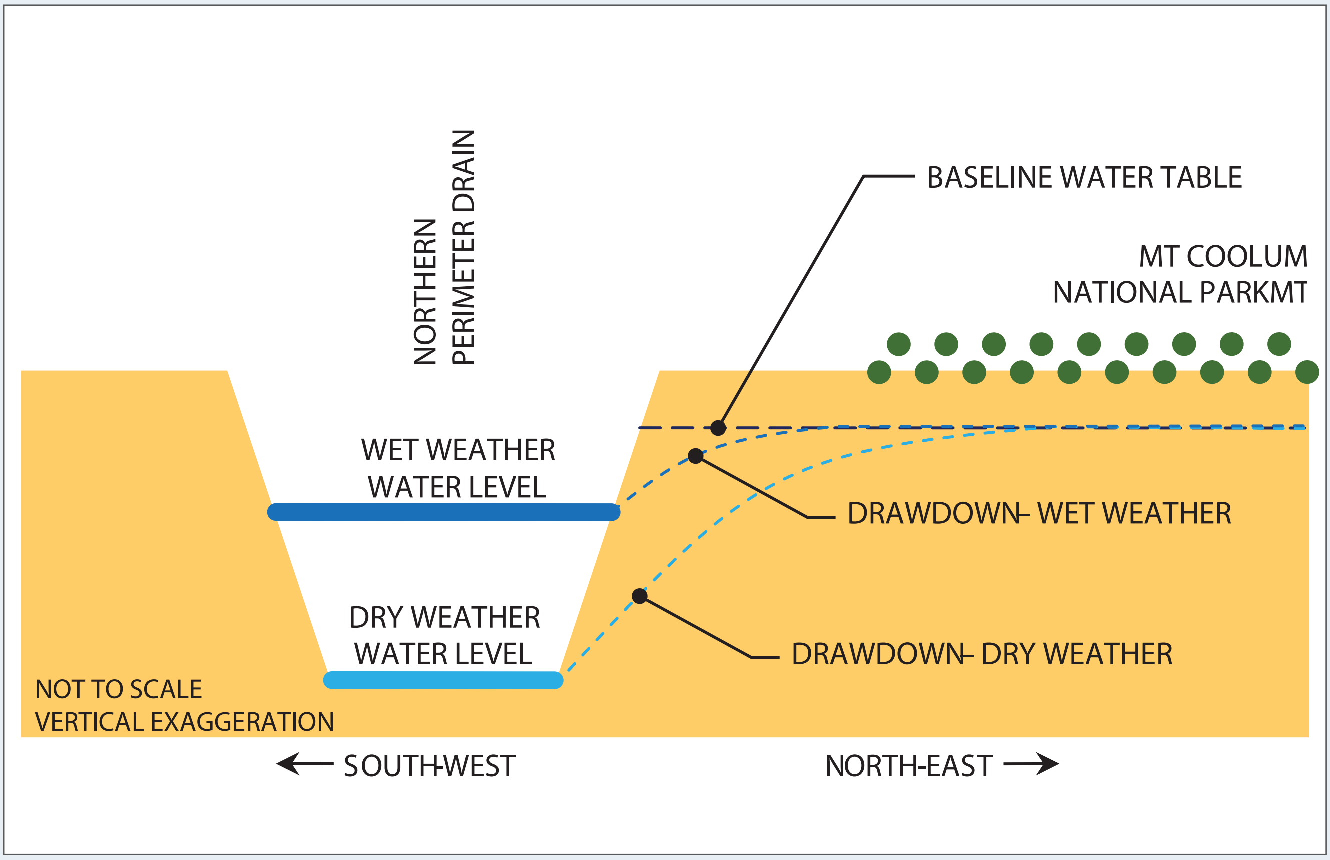


Figure 3.7f: Installation and action of the cut-off wall

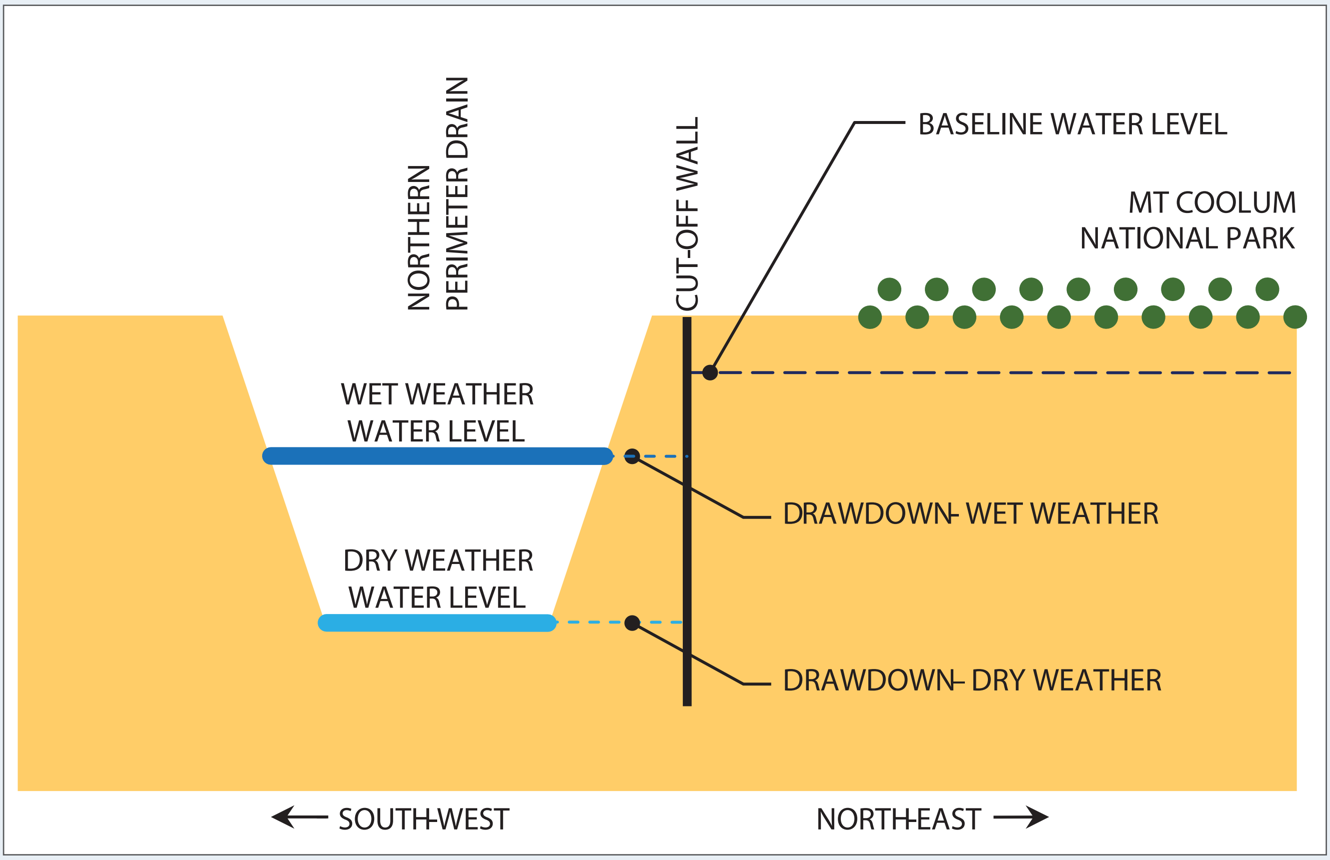


Table 3.7e: Liming rates for excavated soils

Soil type	Treatment rate
Surficial sands	Up to 76kg $CaCO_3/m^3$ (average is 7 kg/m^3)
Indurated sand 'coffee rock'	Up to 25 kg $CaCO_3/m^3$ (average is 9 kg/m^3)
Silty clays to 1 m depth (BH10, BH11, BH 11/12, BH7/12, BH6/12, ASS 7, ASS 8, ASS 9, ASS 10) Generally of soft to firm consistency and grey in colour	Up to 92 kg $CaCO_3/m^3$ (average is 17 kg/m^3)
Silty clays below 1 m depth (BH10, BH11, ASS 10, ASS 15, BH5/12, BH7/12) Generally of soft to firm consistency and grey in colour	Up to 124 kg $CaCO_3/m^3$ (average is 44 kg/m^3)

Future site management

Recommendations for strategies to be included (as a minimum) in an ASS EMP include:

- Good quality agricultural lime, to be thoroughly mixed with the spoil according to the liming rates described in in this section. Any lime treatment should be carried out in accordance with Queensland Acid Sulphate Soil Technical Manual, Soil Management Guidelines (Ver 3.8) (Dear et al., 2002) with consideration given to the acid tolerant nature of some species in the immediate receiving environment
- Agricultural lime to be applied to sections of drains as described in this section
- Agricultural lime 'guard layers' to be placed beneath the down gradient edge (nominally 5 m to 10 m wide) of all fill embankments at a rate of 5 kg/m^3
- Verification sampling and analysis is to be carried out on the treated spoil to confirm that appropriate amounts of the neutralising agent have been incorporated into the soil
- Baseline and regular ongoing groundwater quality monitoring to be undertaken for the project and specified in any ASS EMP
- Monitoring of surface water and any extracted groundwater from wick drains, prior to discharge.

3.7.7.2 Groundwater mitigation measures

Key mitigation measures for groundwater impacts are the installation of a very high quality liner beneath the area of hydraulically placed fill and a low-permeability cut-off wall on the northern side of the northern perimeter drain.

Ongoing baseline monitoring is currently being undertaken to better understand the groundwater dynamics at the site and inform the construction phase monitoring and mitigation measures.

3.8 RISK ASSESSMENT

The risk assessment of geotechnical, soils and groundwater is presented in **Table 3.8a**. As no high risks were identified, additional mitigation is not required.

Table 3.8a: Risk assessment for potential geotechnical, soils and groundwater impacts

Category	Impact	Description
Geotechnical Conditions	Consolidation effects may extend beyond the Project area and affect neighbouring infrastructure (e.g. the Sunshine Motorway)	Consolidation effects are not expected to extend more than 20 m from the surcharge area.
Geotechnical	Failure of the fill embankment or reclamation bund, which could cause safety risks and project delays	The slope stability assessment for the embankments indicate a factor of safety of >1 for slopes of 1V:4H and shallower.
ASS	Acidification of groundwater caused by ASS settling beneath the groundwater table during surcharge	ASS soils at the northern end of the runway are likely to consolidate beneath the shallow groundwater in that area; however, impacts are not expected to extend beyond the project footprint.
ASS	Mobilisation of actual acidity in soils at the surface of the soil profile following placement of saturated fill materials	The liner will minimise tailwater moving through the soil beneath the reclamation.
ASS	Disturbance of actual and potential ASS during excavations for drain construction	Excavation of drains will be addressed through implementation of the ASS MP, including lime stabilising excavated materials and exposed cuts
Contaminated Land	Disturbance of contaminated sites causing a hazard to human and environmental health	The known contaminated sites are not within the construction footprint and are unlikely to be disturbed. Should contamination be identified during construction, a Contamination Management Plan would be implemented.
Erosion Hazard	Disturbance during constriction may lead to increased erosion and downstream sedimentation	The erosion hazard assessment indicates that the erosion hazard across most of the site is very low, and will be adequately addressed through a standard ESCP.
		The erosion hazard assessment indicates a relatively high risk of erosion and sedimentation at the northwest end of the new runway, which will require specific ESCP measures.
Groundwater	Infiltration of groundwater could increase surrounding groundwater levels.	Modelling indicates that with the inclusion of a very high quality liner, an increase in groundwater head of 0.1 m is not expected to extend more than 200 m beyond the reclamation area.
Groundwater	Infiltration of groundwater could increase groundwater salinity levels.	Modelling indicates that with the inclusion of a very high quality liner, salinity concentrations are not expected to exceed 1,000 mg/L in the northern section of the national park.
Groundwater	Drawdown of shallow surface aquifer from the northern perimeter drain	The installation of a low-permeability cut-off wall will significantly reduce the drawdown of groundwater by the drain

Inherent Mitigation	Likelihood	Consequence	Risk Level	Monitoring
Surcharge designed to minimise consolidation outside the project area	Unlikely	Minor	Low	Settlement monitoring of the surcharge area and any nearby sensitive infrastructure
Design includes embankments not steeper than 1V:4H	Unlikely	Moderate	Low	Regular inspections and stability assessments during the reclamation phase
–	Likely	Minor	Medium	Water quality monitoring in the northern perimeter drain and groundwater monitoring wells
Very high quality liner beneath the reclamation area	Possible	Moderate	Medium	Water quality monitoring in the northern perimeter drain and groundwater monitoring wells
ASS Management Plan	Likely	Minor	Medium	Water quality monitoring in the northern perimeter drain, other drains and groundwater monitoring wells pH testing of treated soils before use on site
No known contaminated sites within the project footprint Contamination Management Plan during construction	Unlikely	Minor	Low	Observations during construction to identify unknown contaminated site Contamination testing in accordance with the Contamination Management Plan if contamination is identified
Erosion and Sediment Control Plan during construction	Unlikely	Minor	Low	Regular inspection of ESC infrastructure Water quality monitoring in the perimeter drains
	Possible	Minor	Low	
Very high quality liner beneath the reclamation area	Almost Certain	Minor	Medium	Groundwater level monitoring at the property boundary with the national park
Very high quality liner beneath the reclamation area	Almost Certain	Minor	Medium	Groundwater quality monitoring at the property boundary with the national park
Low-permeability cut-off wall	Likely	Minor	Low	Groundwater level monitoring at the property boundary with the national park

3.9 SUMMARY AND CONCLUSIONS

3.9.1 Geotechnical

Subsurface conditions at the site generally comprise topsoil over loose to very dense sandy soils. A layer of dense or very dense indurated sand ('coffee rock') is typically present at depths between approximately 0.5 m to 5 m BGL. The sandy soils are generally underlain by stiff to hard silty/sandy clay from about 14 m BGL to the depth of testing (up to 26.5 m BGL). In the north-western portion of the site, highly compressible soft/very soft clays, inferred to be of alluvial origin, range from 0.2 m to 8 m thick.

Up to 600 mm primary settlement and up to 90 mm long term settlement are predicted at the north western end of the runway where it is underlain by approx. 2.5 m of soft clay. It is proposed to apply 1 m of additional surcharge for 12 months to accelerate the primary settlement and minimise long term settlement.

3.9.2 Acid sulphate soil

Acid sulphate soils are present across the site, although sulphides in the majority of surface soils have already oxidised. Soils at depths greater than 1.5 m contain predominantly potential acidity (PASS). The ratio of actual to potential acidity generally decreases down the soil profile as oxygen availability decreases.

Disturbance of soils during excavation of the drains is likely to cause the oxidation of potential ASS and mobilisation of acidity. Given the relatively shallow nature of the proposed drains, the risk of impact to the surrounding environment would be considered as a medium risk level. The potential environmental risk will be significantly reduced by conducting additional ASS investigations to satisfy the SPP 2/02 and implementing a site specific ASS EMP the project.

3.9.3 Contaminated land

A number of contaminated sites were identified within the Project area, most notably two farm sheds at the western end of the site that showed hydrocarbon contamination. While the construction footprint does not include these areas, it is possible that other previously unidentified areas of contamination will be identified during construction. To address this risk, a Contamination Management Plan will be prepared for implementation during construction.

3.9.4 Erosion

An erosion hazard assessment indicates that the risk of erosion for the site in its current condition and during construction is relatively low, as the site is characterised by sandy non-dispersive soils. The potential impacts associated with erosion and downstream sedimentation will be addressed through a project-specific Erosion and Sediment Control Plan.

3.9.5 Land resource assessment

The site does not meet the requirements to be classified as Strategic Cropping Land or Good Quality Agricultural Land. The soils across the site are classed as Podosols and are acidic; the soils fail the SCL criteria for pH and water storage capacity. At best, the land types at the site are considered suitable for pasture grazing (Class C).

The Project is not expected to have off-site impacts on SCL or GQAL. Consequently, the development of the new runway will not affect the land resource values of the site or neighbouring areas.

3.9.6 Groundwater

The groundwater aquifer in the Project area is influenced by the stratified geology, including a discontinuous 'coffee rock' layer that provides a partial barrier to groundwater movement between the deeper aquifer beneath the coffee rock layer and shallow semi-perched surface aquifer. Groundwater quality at the site is generally fresh and acidic.

A very high quality liner is proposed beneath the reclamation area to minimise the infiltration of tailwater, which was identified as having the potential to increase groundwater levels and salinity concentrations. The installation of the liner limits potential increases in groundwater head to 0.1 m at approx. 200 m from the reclamation area 1 year after filling, and salinity to 1,000 mg/L approx. 50 m from the northern perimeter drain approx. 200 years after filling.

A low-permeability cut-off wall is proposed on the northern side of the northern perimeter drain to mitigate potential drawdown of the shallow surface aquifer.

Potential ecological impacts of the groundwater changes are discussed in Chapter B7 – Terrestrial Flora and Chapter B8 – Terrestrial Fauna.

A baseline groundwater monitoring program is being implemented to provide greater certainty of the characteristics of the groundwater system at the site and inform mitigation and monitoring regimes accordingly.

3.10
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