B3

VOLUME B: AIRPORT AND SURROUNDS

Geology, Soils and Groundwater

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GLOSSARY OF ABBREVIATIONS

ABA Acid-Base Accounting

AD Airport Datum

AHD Australian Height Datum

ANC Acid Neutralising Capacity

ANZECC Australia and New Zealand Environment Conservation Council

ASS Acid Sulfate Soil

BAC Brisbane Airport Corporation

BTEX Organic volatiles which are benzene, O-xylene, M-xylene and P-xylene.

EC Electrical Conductivity

EIL Environmental Investigation Limits (QLD EPA)

EIS Environmental Impact Statement

EP Environmental Protection

EMP Environmental Management Plan

FAFA Future Aviation Facility Area

HIL Health based Investigation Limits

LOR Level of Reporting

NEPC National Environment Protection Council

NEPM National Environment Protection Measure

NOx Nitrates and nitrites

NTU Nephelometric Turbidity Unit

OC Organochlorine [Pesticides]

OP Organophosphorus [Pesticides]

PAH Polycyclic Aromatic Hydrocarbon

PASS Potential Acid Sulfate Soil

pHox pH after oxidation

PSD Particle Size Distribution

PSI Preliminary Site Investigation

QASSIT Queensland Acid Sulfate Soils Investigation Team

SPOCAS Suspension Peroxide Oxidised Combined Acidity and Sulfide (method)

SS Suspended Solids

SCr Chromium Reducible Sulfur

SPOS Percent Oxidisable Sulfur

SNAS Net Acid Soluble Sulfur

TAA Total Actual Acidity

TBT Tributyl-tins

TDS Total dissolved solids

TOC Total Organic Carbon

TPA Total Potential Acidity

TPH Total Petroleum Hydrocarbons

TSA Total Sulfidic acidity

USTs Underground Storage Tanks

WQOs Water Quality Objectives

WWTP Waste Water Treatment Plant

SUMMARY OF KEY FINDINGS

Geology and Geotechnical Stability

Baseline Conditions

- The runway site contains recent alluvial deposits of Quaternary age (i.e. younger than 10,000 years) and includes areas of 'undifferentiated flood plain' and 'tidal flats'.
- The sediments are Holocene and comprise an upper layer laid down during the most recent rise in sea level which are highly compressible and will settle relatively rapidly.
- The upper layer is underlain by a deeper layer which extends to significant depths. This layer is highly compressible and will consolidate more slowly, taking years to complete consolidation.
- The Holocene sediments are underlain by relatively stable Pleistocene soils.

Impacts

- The proposed filling of the runway area will result in considerable settlements and compression of the underlying soft alluvium. Geotechnical investigations indicate expected settlements (combined primary and secondary) for the expected loads, of the order of 300 mm near the middle third of the runway to 1,850 mm for the 'worst case' towards the northern end. Staged, controlled engineered filling with shallow, stable batters of flatter than 1V:4H will be required to prevent lateral displacement of soft soils.
- Across the site, surcharge loading will be used to accelerate settlements in the deeper alluvium.
- Specialised vacuum settlement techniques can be utilised to further speed up settlement and limit lateral displacement where the alluvium layer is deepest.
- In the excavations planned, stability of the excavation sides will be achieved by use of shallow side batters for drains and permanent diaphragm walls for the tunnel excavation.

Erosion Potential

Baseline Conditions

- The Brisbane Airport is situated on the low lying floodplain of the greater Brisbane River system, in an area of Holocene estuarine sediments. Near surface soils comprise a mix of fine grained soils (clays and silts) and coarse grained, cohesionless soils (predominantly sands).

Impacts

- Sands and silts have little cohesion and will be prone to erosion on significant slopes.
- Cohesive soils are capable of standing at steeper slopes, but may erode as 'blocks' or crumble if dispersive soil fines are present. However no dispersive soils were identified at the site.
- Drains are to be located in tidal areas and exposed surfaces will be in periodic contact with salt water and treated with agricultural lime as part of Acid Sulfate Soils (ASS) management measures. Salinity and the lime both act to buffer against dispersion potential. Erosion will be prevented by use of shallow side batters and stabilisation by other methods.

Acid Sulfate Soils (ASS)

Baseline Conditions

- Pyritic soils or Acid Sulfate Soils (ASS), were deposited in coastal zones throughout the world during the last 6,500 to 10,000 years. When disturbed these sediments oxidise producing sulfuric acid.
- The predominant soil landscapes on the runway site are the Woongoolba and Mudflats landscapes, which include recent Holocene soils including – humic gleys, peaty gleys, solonchaks and saline muds. Such soil profiles contain pyritic material and fine organic matter which contribute to acid conditions.
- The site is situated in an area mapped by the Queensland Department of Natural Resources and Water (DNRW) as likely to contain ASS.
- Findings of a staged ASS investigation of the site indicated the presence of several 'hot spots' of potential ASS and low levels of actual ASS in near surface soils over most of the parallel runway site.

Impacts

- The filling of the runway area will result in compression of soft alluvium, and actual ASS in near surface soils may be mobilised into the rising water table. Due to settlement of the alluvium the existing surface will become waterlogged and remain below the water table.
- Because of the proximity of the site to local waterways, a lime filled interception trench will be placed on the Kedron Brook side of the fill platform to neutralise any acidic groundwater mobilised by the filling.
- Results of soils analysis indicate high levels of net acidity in soils that will be subject to excavation. Excavation of these soils pose a high risk to the receiving environment unless carefully managed.
- Detailed ASS management measures have been prepared to limit environmental risk. Measures mainly rely on lime neutralisation of ASS in 4 purpose-built, bunded treatment areas on-site. Limed spoil will be tested to verify neutralisation before being used elsewhere on-site.
- Strategic reburial of high risk ASS/Potential Acid Sulfate Soils (PASS) spoil in a bunded creek area on the northern half of the site is to be used for material that is unsuitable for use as fill. The burial area will be filled later and covered by more than 2 m of sand.
- Some minor drawdown of the water table may occur along the immediate flanks of the proposed drain systems, but this will only occur for 2-3 months during the wet season. Soil test results indicate that partial oxidation in this zone of potential drawdown has occurred in the past. Lime guard layers will be applied to the banks of the drains in areas where ASS will be exposed and a surface barrier constructed using sacrificial hessian bags filled with agricultural lime chips.
- Careful management of excavations and lime treatment operations will minimise the risk of adverse impacts to off-site water quality. If required, lime dosing of surface water accumulated in excavations will be undertaken during construction.
- The largest of the drains is to be constructed in 100 m sections to limit groundwater drawdown and to ensure acid sulfate soil impacts are managed.
- Regular monitoring of water quality in the drains will be undertaken during and after construction.

Contaminated Soils

Baseline Conditions

- There is an area at the northern end of the proposed runway, near which a former bus depot and a former local rubbish dump were located. Both sites are declared as inactive under BAC's contaminated site register.
- There is a reported site of minor illegal dumping of rubbish on the surface in the Future Aviation Facility Area (FAFA).
- There is a former dredge spoil handling area used in the 1980s to hold spoil from construction of the Kedron Brook Floodway, situated near the centre of the proposed parallel runway.

Impacts

- The former bus depot area has since been filled to a depth of at least 2 m. No disturbance of soil from these locations will occur, however, groundwater will be extracted during vacuum consolidation. The water will be held on-site and screened for possible contamination before discharge.
- Any refuse found during clearing of the site will be separated and disposed of by a licensed waste disposal contactor.
- Results of analysis undertaken on the former dredge spoil indicate some elevated levels of some heavy metals and one occurrence of petroleum hydrocarbons. The affected material will be excavated and reburied in a bunded creek area on the northern half of the development site. This area will be capped and later filled over with more than 2 m of sand fill.

3.1 Introduction

3.1.1 Proposed Development

The New Parallel Runway (NPR) requires construction of a number of key items of infrastructure, the purpose of these is discussed in Chapter A4 of this Draft Environmental Impact Statement and Major Development Plan (EIS/MDP). Following is a brief description of the main components of the NPR and associated infrastructure and dredge pump-out facility that may have an effect on geology, soils or groundwater:

- Construction of a New Parallel Runway and linked taxiway and associated infrastructure;
- pgrading of the existing cross runway to form a high capacity taxiway;
- Construction of the high intensity approach lighting structure(s);
- Construction of a tunnel under the linked taxiway connecting to the Future Aviation Facilities Area;
- Construction of approximately 3,250 m of new major surface drainage systems;
- Construction of temporary above ground sediment retention basins/ponds on the site;
- Construction of a temporary dredge pipeline and associated pump-out facility in the Brisbane River Estuary at Luggage Point.

The project can be broadly characterised from a geology and soils perspective as predominantly a reclamation fill exercise with some discreet major drainage excavations. Consequently, the major potential effects to the environment concerning soils includes:

- Potential erosion and stability issues;
- Acid Sulfate Soils (ASS) and associated water quality issues;
- Groundwater behaviour and quality; and
- Contaminated land issues.

3.1.2 Limitations and Assumptions

Investigations undertaken for this report were limited to the proposed development area(s) indicated by the Brisbane Airport Corporation (BAC). Developments in other areas of the Brisbane Airport are not included within the scope of this document. Testing regimes for ASS were developed in consultation with the Queensland Acid Sulfate Soils Investigation Team (QASSIT) from the Department of Natural Resources and Water (DNRW).

3.1.3 Consultation

The Queensland Acid Sulfate Soils Investigation Team (QASSIT) from the Department of Natural Resources and Water (DNRW) were consulted regarding the findings of the initial (Stage 1) ASS investigations and scoping of the subsequent (Stage 2) investigations and to address the requirements of the EIS/MDP. Consultation with QASSIT and DNRW has been ongoing through the working group process.

3.1.4 Policies and Guidelines

The current Queensland Government (QASSIT) Guidelines for sampling and testing of Acid Sulfate Soils in Queensland – 1998 and the State Planning Policy 2/02 Guideline (SPP 2/02) were referenced when scoping ASS investigations.

The Queensland Environmental Protection Agency (EPA) Draft Guidelines for Assessment and Management of Contaminated Land, May 1998 and the Airport Environment Protection (Environment Protection) Regulations, 1997 (AEPR), were referenced when preparing the Stage 1 Preliminary Site Investigation (PSI) (appended to this report) and choosing analysis for soil samples.

Schedule 3 of the AEPR was referenced when determining Investigation Limits.

The National Environment Protection Councils (NEPC) National Environment Protection Measure, 1999 (NEPM) Groundwater Guideline Investigation Levels were referenced during baseline investigations. The NEPM Guidelines are based on the Australian and New Zealand Guideline for Fresh and Marine Water Quality (2000) Volume 2 (ANZECC Guidelines).

Schedule 2 of the AEPR, was referenced for Water Quality Limits.

3.2 Existing Environment of Runway Site – Geology and Soils

3.2.1 Investigation Methodology

Investigations were conducted in the area of the NPR and all associated on-airport infrastructure, with the following aims:

- Identifying and describing existing geology, geomorphology, stability, and description of soil types and characteristics. Copies of all borehole records are presented in **Appendix A** of this document;
- Describing general topography, important landforms and topographic features;
- Reporting on acid sulfate soils investigations conducted on-airport to identify the extent of Actual and Potential Acid Sulfate Soil (ASS/PASS) conditions existing in soil strata within areas of the site proposed for development. Investigations comprised sampling and analysis of fill and natural soils and groundwater and mapping the results of soil surveys;
- Reporting on geotechnical investigations to assess soil stability and suitability for construction of proposed runway, taxiways and infrastructure (including erosion potential and soil-chemistry);
- Undertaking a Preliminary Site Investigation (PSI) of the site, consistent with Qld EPA Draft Guidelines for Assessment and Management of Contaminated Land, May 1998, (reported in detail as **Appendix C** to this Chapter) and summarised in this Chapter, any contaminated sites and their history;
- For any contaminated sites identified and for the new Kedron Brook Floodway Drain (KBF Drain) and the tunnel under the link taxiway, identifying and describing the nature of materials to be disturbed, including reference to any contaminants of concern that might cause environmental harm.

The geology and soils investigation approach has been to address the range of soil related issues on the basis of the following divisions:

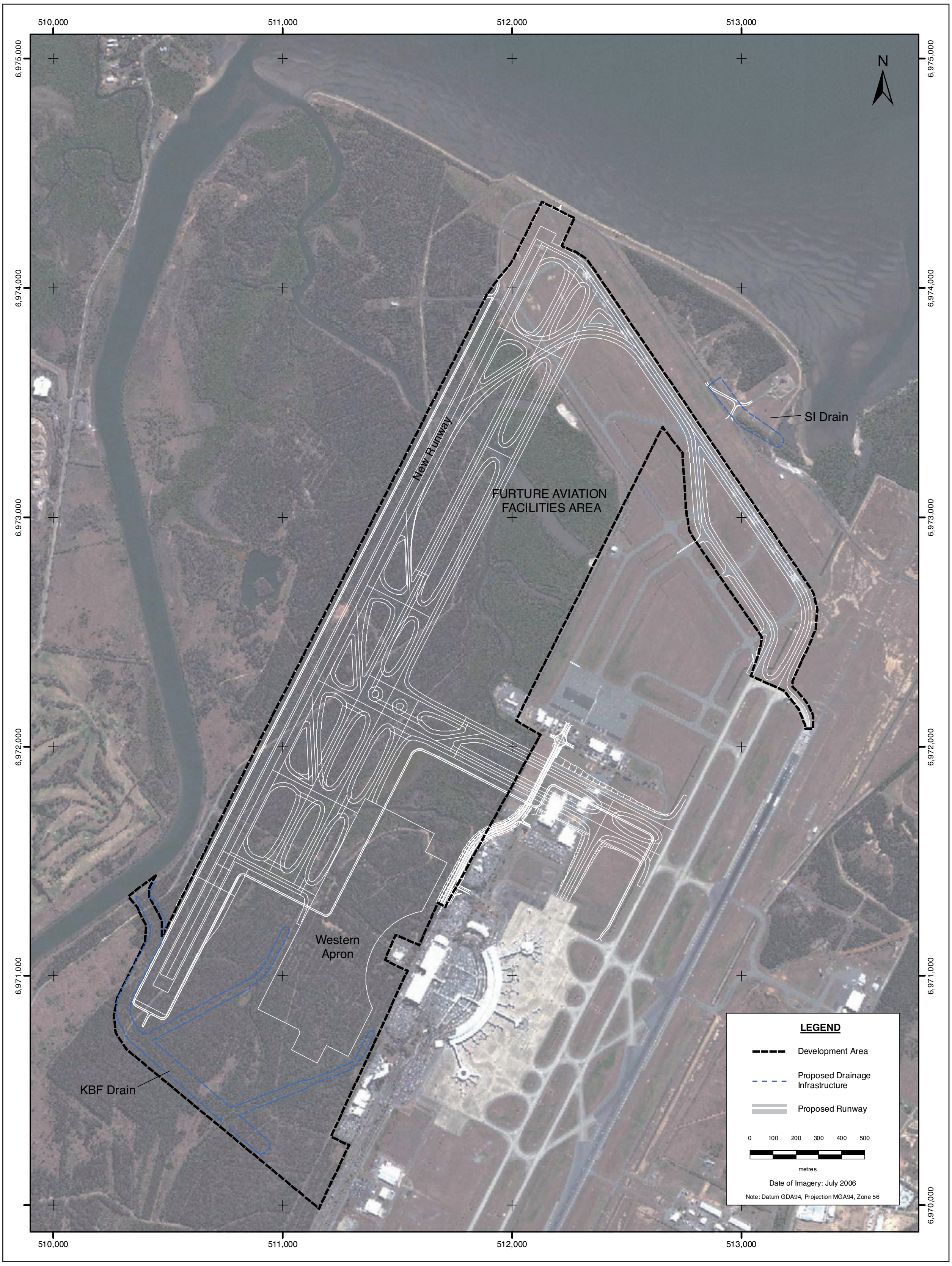
- NPR and linked taxiway system footprint;
- Future Aviation Facilities Area;
- Kedron Brook Floodway (KBF) Drain and associated Connector Drains;
- Serpentine Inlet (SI) Drain;
- Cross Taxiway Tunnel; and
- The Dredge Pipeline and Pump-out Facility.

The places and features listed above are shown on **Figure 3.2a** and within the figures contained in Chapter A4.

Physical subsurface investigations have been undertaken at the following locations:

- A 3,600 m long (400 m wide) area of land which is to be developed into the new runway and will be subject to clearing and placement of fill;
- A 60 ha area of land on the north-eastern side of the proposed runway, designated the Future Aviation Facility Area (FAFA), which is to be developed in the future and at this stage will be subject to clearing and placement of fill only;
- A 70 ha area of land on the south-eastern side of the proposed runway, designated the Western Apron, which is to be developed in the future and will be cleared and filled;
- The proposed route of a new 1,450 m drain (the KBF drain) to be excavated at the southern end of the new runway and two connecting cross channels with an additional combined length of 1,500 m;
- A 200 m shallow drain (the SI drain) at the northern end of the existing cross runway;
- Minor drainage lines through the FAFA and Western Apron area;
- A 100 m long cross taxiway tunnel adjoining the existing Airport; and
- The location for the proposed pipeline and dredge pump-out site at Luggage Point in the Brisbane River estuary.

Figure 3.2a: *Site Plan Showing Main Construction Locations.*



A tabulation of approximate earthworks quantities affecting ASS areas is included in the ASS Management Plan, appended to the EMF in Chapter B14.

3.2.2 Site Description

3.2.2.1 Setting

The NPR is located in an area immediately west of the existing runway at the Brisbane Airport. The whole site is situated in a low lying estuarine flood plain (below about 1–3 m AHD) between Kedron Brook Floodway (to the west) and the remnant sections of old Serpentine Creek. The proposed runway and Western Apron sites are situated in an area of casuarinas plantation, backing onto mangroves on the eastern side (between the existing Airport and the proposed runway site). The proposed KBF Drain will join the Kedron Brook Floodway with two cross connections to Landers Pocket Drain and the new runway area.

3.2.2.2 Physiography

As discussed in Chapter A4, the Brisbane Airport and surrounds consist of low lying coastal and estuarine floodplain situated below 5 m AHD, within the floodplain of the greater Brisbane River system, in an area of recent alluvium (estuarine sediments).

The Brisbane River forms a delta that is prograding into Moreton Bay. The delta front and levee sediments have formed an embankment at the mouth of the river which has been reworked by tidal and low energy wave action and interfingers with other estuarine, marshland and tidal-flat sedimentary processes. The result is the low-lying, flat area on which the Airport has been developed. Fisherman Islands and Bulwer Island are (now modified) interdistributary islands.

Before the Airport was constructed the area was largely a marshland in a delta backswamp area, covered by salt marsh vegetation with fringing mangroves along tidal creeks and estuaries. Farming activities were carried out in the salt marsh areas. Creeks such as Kedron Brook, Serpentine Creek and Boggy Creek meandered across the salt marsh area, and drains discharging to these creeks were used to lower the water table in farming land.

The Kedron Brook Floodway was created during construction of the Airport in the 1980s.

The topography of the proposed new runway area is relatively flat at approximately 1.5 to 3 m AD (Airport Datum). The land is more elevated adjacent to Kedron Brook Floodway and falls slightly towards Serpentine Creek that occupies the lowest elevations in the area. Access tracks have been built up and may be 0.5 m above surrounding ground. Dredge spoil from the construction of Kedron Brook Floodway has been dumped in an area at about the mid-point of the proposed runway (refer **Figure 3.2l** for the location of the spoil area in relation to the runway). At the highest point, the spoil dump has an elevation of around 6 m AD. Mangroves are present along the creeks and drains in this area, and the remainder of the area is covered in casuarina trees which were planted during the development of the Airport in the 1980s.

The area of the existing Airport development, located to the east of the proposed runway, has been reclaimed using sediment dredged from Moreton Bay. The surface levels in this area vary between approximately 2.75 m AD and 4.5 m AD.

A quarry from which basalt was recovered is present towards the west, between the new runway area and Kedron Brook Floodway. The quarry void is now full of water.

Local runoff from the runway site and Western Apron area enters the Kedron Brook Floodway (to the west) and Landers Pocket Drain. The proposed FAFA area is mostly water logged mangrove wetland, and is crossed by three small branches of the old Serpentine Creek. This area drains directly into the estuary of Jacksons Creek and Kedron Brook Floodway, with tidal interchange to nearby Moreton Bay. Following filling of the NPR project site, the extension of Serpentine Creek and minor tributaries will be filled in, but overland flow will remain towards Kedron Brook Floodway and Jacksons Channel/Creek.

3.2.2.3 Geological Setting

Descriptions of the sediments that underlie this area given in DNR&M (2002), which list the following sedimentary environments:

- Undifferentiated coastal plains; mud and sand, with channels or thin cover of clay, silt, and sand deposited by active stream channels, ox bows and low terraces;
- Sand, and shelley sand deposited in beach ridges; and
- Sand, and mud that has accumulated in tidal flats that grades offshore into fringing sublabile sand, muddy sand and sandy mud deposited by shore and delta processes.

Subsurface investigations carried out at the site have encountered primarily fine grained materials described as clays, silts, organic or black clays, with occasional fine sand lenses or laminations, or as mixtures of these materials. Shell fragments and thin peat lenses have been recorded in the geotechnical logs and in acid sulfate investigation. Acid sulfate investigations record high potential and actual acidity, being evidence of the existence of sulfide minerals. Parts of the site are buffered by quantities of (calcareous) shell fragments (and possibly by finer carbonate sediments), and by salinity.

The sediments have been deposited onto a pre-existing landform that developed during a time when the sea level was much lower. The pre-existing hilly topography is reflected in the variable depth and thickness of the sediments. The sediments can be divided into two layers with distinct geotechnical and hydrogeological properties. In this document these layers are referred to as the Upper Holocene alluvia and the Lower Holocene alluvia.

The Upper Holocene alluvia were laid down during the most recent rise in sea level, in shallow fluctuating water bodies, and comprise inter-layered clays, silts and sands, sometimes with peaty inclusions. They are present from ground surface (or from the base of any site fill) and are around 4–12 m thick across the Airport area.

The Lower Holocene alluvia were laid down in deeper water, either off-shore or in deeper stream channels. They tend to be silty clays with very few sandy layers and extend to significant depths, in excess of 30 m in places. They are underlain by Pleistocene soils comprising stiff to hard clayey and medium dense to very dense sandy/gravelly materials. Their upper profile was a former land surface, shaped by erosion and stream cutting when sea levels were lower. The buried landscape was probably similar to present-day landscapes further upstream. **Figure 3.2b** depicts contours of the base of the Holocene alluvium.

3.2.2.4 Soil Landscapes

Reference to the Soil Landscapes of Brisbane and South-Eastern Environs, Queensland, CSIRO 1:100,000 scale Map Sheet indicates that the southern end of the proposed runway site, the Western Apron area and the area proposed for the KBF Drain are situated mainly within the alluvial Woongoolba landscape. The low lying northern end of the runway site are underlain by the Mudflats landscape.

The predominant soil landscapes present on the site are described below:

Woongoolba – Wo

Dominant Soil Group: Humic gleys, peaty gleys and solonchaks.

Landscape and Parent Geology: Low (coastal) plains of alluvium and narrow depressions.

Such soil profiles are young alluvium and frequently contain moderate to high concentrations of pyritic material and fine organic matter, which contribute to acid conditions.

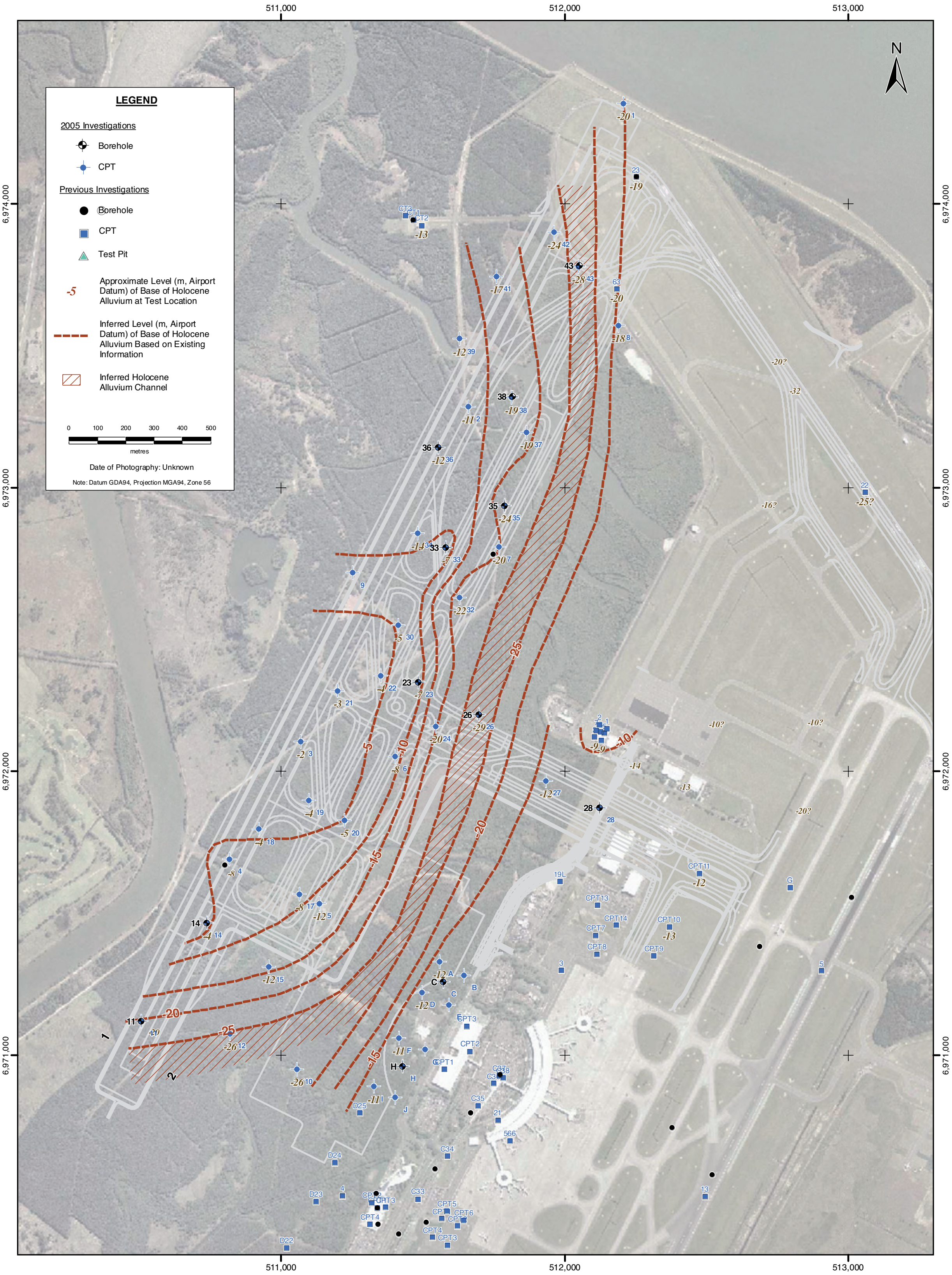
Mudflats – M

Dominant Soil Group: Saline mud.

Landscape and Parent Geology: Tidal flats of estuarine muds.

These soils comprise young alluvium with no profile development and frequently contain very high concentrations of pyritic material, which contribute to acid conditions where not buffered by calcareous material such as shell grit or coral debris.

Figure 3.2b: *Base of the Compressible Holocene Materials at Test Locations.*



3.2.3 Assessment of Acid Sulfate Soils (ASS)

3.2.3.1 Origins of ASS

Pyritic soils or ASS, were deposited in coastal zones throughout the world during the last 6,500 to 10,000 years. 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 (in soluble form) aluminium and iron from the sediments. Acidic water introduced into coastal streams can cause fish kills, alterations to ecosystems and corrosion of civil structures. The source of the acid is naturally occurring pyrite (FeS_2). Environmental degradation occurs when this pyrite oxidises and sulfuric acid is produced and discharged into receiving waters. If receiving waters in ASS areas are saline and subject to tidal exchange, low level acidity naturally generated is often adequately buffered by the salinity.

Potential ASS are soils that contain oxidisable sulfur (in iron pyrite), these soils occur naturally in coastal environments all over the world and are not acidic as long as they remain in an anoxic environment. Actual ASS are formed when potential ASS are allowed to oxidise and form sulfuric acid.

3.2.3.2 Existing Mapping of ASS

Reference to the Department of Natural Resources and Water (DNRW), 1:100, 000 scale Map 1 Acid Sulfate Soils – Tweed Heads to Redcliffe, indicates the site is situated in an area mapped as containing:

- DLU_S - Land < 5 m AHD likely to contain ASS. [Lime] Treatment may or may not have been carried out. (Limited field investigation).

The remainder of the site (along the western edge of the proposed runway) is mapped as:

- S_{LA} – Land where ASS occurrence is reasonably probable based on landscape position and geomorphologic interpretation. (Limited or no field assessment involved).

Inspection of the Brisbane City Council (BCC) 1:100,000 scale Map – A Guide to the Likely Location of Acid Sulfate Soils in Brisbane indicates the southern end of the site is mapped as having a Very High hazard rating; while the northern end of the site is mapped as having an Extremely High hazard rating (i.e. categories 6 and 5 respectively, where 6 is the highest hazard category).

3.2.3.3 ASS Field Investigations

Subsurface investigations were conducted in two stages:

- Stage 1 – to characterise the site generally and inform the need for further investigation; and
- Stage 2 – to undertake further investigation as required.

The Stage 1 investigation included sampling and analysis of soils and groundwater and was conducted in all areas of proposed fill and/or disturbance within the new runway project site.

Investigations were located in the proposed runway site and FAFA. Soil samples were taken at 0.25 m intervals and screened by the pH/pH_{FOX} test method. A representative number of samples selected from the screened samples were then subjected to quantitative analyses. In Stage 1, soils were sampled at a frequency of about 1 borehole per 4 hectares to attempt to characterise the greater site, which was then followed by more intense sampling within areas containing identified ASS hot spots and in areas proposed for excavation (i.e. installation of drains, access tunnel etc.). Sampling was undertaken at 27 locations within the runway site and 13 locations within the FAFA area. Boreholes were generally limited to 2 m depth, as the runway development comprises filling (i.e. no planned excavation at depth).

Findings of the Stage 1 indicated the presence of several potential ASS hot spots and low levels of actual ASS over most of the runway site. This was used to develop a Stage 2 investigation program, based around investigating the areas where high levels of PASS had been detected. The scope of the Stage 2 investigation was also extended to include a future Western Apron area and major items of infrastructure.

Boreholes were distributed evenly within the targeted areas at an increased frequency of 1 borehole / ha in previously identified hot spots in fill areas. Sampling along drain alignments was conducted at regular linear intervals, 1 hole / 50 m for the larger drains and 1 hole / 100 m for the smaller drains as discussed with QASSIT representatives.

Adopted Sampling and Testing Methods

Sampling for the investigations was undertaken using a Gemco HC10 drill rig equipped with a 38 mm push tube sampler and a 130/50 mm hollow flight auger system. Both methods produce a semi-continuous undisturbed core of soil for sub-sampling. Sampling within the FAFA site and along water logged parts of the KBF Drain route was undertaken on foot and from a small boat using a hand held 45 mm diameter piston sampler.

All soil samples were screened by the pH/pH_{FOX} test method and a representative number of samples were selected and subjected to SPOCAS or the Chromium Reducible Sulfur (S_{Cr}) test suites.

The S_{Cr} and SPOCAS analysis suites have been adopted by QASSIT for the testing of ASS in Queensland. These methods include analysis and quantification of existing or actual acidity, naturally occurring alkaline materials (i.e. calcite, coral debris, fine shell fragments) and retained acidity which includes sulfur held in stable oxidation minerals such as jarosite (which was previously not included in estimates of potential acidity). An overall acid-base accounting method has been derived to calculate a net acidity value which is used to qualify analytical test results and to calculate liming rates. The equation used is:

- net acidity = actual acidity (as TAA) + retained acidity (as S_{NAS}) + remaining potential acidity (as TSA) - insitu acid neutralising capacity (ANC) / 1.5 (Fines Factor).

The S_{Cr} test method was used on soils that contained obvious organic matter, which could contain sulfur of organic origin and could artificially inflate Percent Oxidisable Sulfur (SPOS) levels determined using the SPOCAS method. This method was used extensively on the soils from water logged areas.

Fieldwork

The Stage 1 investigations were conducted in April, 2005, at 40 test locations. Stage 2 investigations followed in August/September, 2005 over a 4 week period at 113 locations.

Fieldwork undertaken is summarised below. Boreholes in fill areas were drilled to 2.0 m depths and those in areas of planned excavations were deepened accordingly.

Stage 1 Investigations comprised drilling:

- 27 boreholes on the second runway and taxiway (BH11-BH43);
- 13 piston sample holes in the FAFA (BHNDA1-BHNDA13).

Stage 2 Investigations comprised:

- NPR site – 36 boreholes (BH44-BH58, BH86-BH87, BH89-BH105 and BH155-BH156);
- KBF Drain at end of runway site (approximately 1,450 m) – 33 boreholes (BH106-BH120 and BH130-BH147);
- Cross drains connecting to the KBF Drain (approximately 1,500 m) – 15 boreholes (BH88, BH121-BH127 and BH148-BH154);
- Serpentine Inlet (SI) drain (approximately 370 m) – 7 boreholes (BH59-BH65);
- Minor drains in FAFA (approximately 750 m) – 7 boreholes (BH66-BH72);
- Western Apron and Taxiway – 13 boreholes (BH73-BH85);
- Access Tunnel under Taxiway (adjacent to Airport) – 2 boreholes to 5 m (BH128-BH129).

Follow-up investigation of the former 1980s Kedron Brook Floodway construction dredge spoil handling area (within the runway site) included:

- 20 boreholes (BH157-BH176).

Continuous undisturbed soil cores were recovered using a push tube sampler, hollow flight augers or a piston sampler. Soils were sampled at 0.25 m depth intervals (or at changes in soil strata) for visual classification and pH/pH$_{FOX}$ screening. All samples were labelled and sealed in plastic bags and refrigerated, then frozen within 24 hours of sampling, until laboratory analysis was undertaken.

In all investigation stages, a total of 173 locations were sampled. Borehole locations were positioned and recorded by use of a hand held GPS unit (accurate to within approximately 2 to 5 m) and a pre-surveyed AMG 94 coordinate grid system using commercial software.

Groundwater monitoring wells (designated MW1-MW9) were installed in nine of the boreholes and have been used to establish base line water quality parameters for the site. See section 3.3 in this Chapter for further discussion on groundwater baseline.

Borehole locations and the East-North grid are indicated on **Figure 3.2c** (parts 1 and 2). Ground levels at the top of the boreholes were extrapolated from survey data provided for the project by North Surveys Pty Ltd.

3.2.3.4 Soils Laboratory Testing

The laboratory testing program outlined below was carried out to assess actual and potential ASS conditions in areas of the site to be disturbed by the proposed development.

Preliminary Screening

Soil profiles were sampled at 0.25 m intervals (fill and natural soils) and screened using the pH/ pH$_{FOX}$ test method, which consists of two steps – initially determining the field pH of a 1:5 soil/water suspension which gives an indication of actual ASS, followed by the addition of 30 percent Hydrogen Peroxide, allowing the sample time to oxidise, before determining the pH$_{FOX}$ (pH after oxidation) of the reacted sample which gives an indication of potential ASS. The pH meter used was recalibrated after each time a large drop in pH was measured.

Screening of samples of alluvial sediments and fill carried out using the pH/pH$_{FOX}$ test method indicate that most of the alluvial soil profiles tested included one or more potential ASS (PASS) strata. However, at a number of locations results indicated the presence of significant amounts of fine calcareous material that may be sufficient to buffer the potential acidity present (shell grit or coral debris <2mm in size).

Very few (if any) coarse shells were observed. Results indicated that some samples from shallow depths through to 2–3 m depth (and up to 5 m for BH129) possibly contained high levels of PASS materials that were not apparently buffered by alkaline material.

The pH and pH$_{FOX}$ readings in the different areas investigated are summarised below:

- **Proposed Runway Site** – pH$_{FOX}$ ranged from 1.3 to 8.6 (at some locations, high pH$_{FOX}$ results were evident in the upper 1 m or so of the soil profile), and lower, more acidic values (with pH$_{FOX}$ less than 4.0) predominated below this buffered layer. Field pH values ranged from 3.7 to 8.6, but were generally above 6.0 below the water table. Soil pH below 5.5 may indicate the presence of actual ASS in the near surface soils above the water table.
- **FAFA** – pH$_{FOX}$ ranged from 1.2 to 7.6 (at most locations low pH$_{FOX}$ readings were evident from or near the surface, although some buffering is present). Field pH values ranged from 3.9 to 8.6, but were generally above 6.0 (in all water logged areas), indicating very little actual ASS present.
- **Western Apron** – pH$_{FOX}$ ranged from 1.7 to 7.4 (at most locations, low pH$_{FOX}$ readings were evident from or near the surface down through the soil profile). Field pH values ranged from 3.8 to 8.4, but were generally above 6.0 below the water table. Soil pH below 5.5 was present in most boreholes up to 1.0 m depth and indicates the possible presence of actual ASS.

- **KBF Drain and Connecting Drains** – pH_{FOX} ranged from 1.7 to 7.4 (low pH_{FOX} readings were generally from below about 2.0–2.5 m depth). Field pH values ranged from 3.3 to 8.0, but were generally above 6.0 below the water table, with lower values below 5.5 indicating the possible presence of actual ASS limited to the upper 0.75 m of the profile.
- **SI drain** – pH_{FOX} ranged from 1.7 to 7.1. Low pH_{FOX} readings were generally isolated within the soil profile. Field pH values ranged from 7.2 to 8.0, indicating no actual acidity or apparent oxidation to date.
- **Former Dredge Spoil Handling Area (from construction of the KBF in 1980s)** – pH_{FOX} ranged from 2.1 to 7.8. The lower pH_{FOX} readings (less than 3.0–3.5) were limited to the top of the natural soil profile (i.e. not included in the actual dredge spoil). Field pH values ranged from 3.8 to 8.1, indicating the likely presence of actual acidity in this area.

Summaries of all screening and analytical test results are attached in **Appendix B**.

Quantitative Analysis

Based on results of preliminary screening tests, a total of 260 samples of alluvium were selected to undergo laboratory analysis by either the SPOCAS or Chromium Reducible Sulfur (S_{Cr}) test suites.

A breakdown of the site specific testing is as follows:

- Proposed Runway and Cross Taxiway – 131 tests, (including 50 from the Stage 1 investigation);
- The FAFA – 35 tests, (including 24 from the Stage 1 investigation);
- Western Apron – 11 tests;
- KBF Drain and Connecting Drains – 39 and 21 tests, respectively;
- SI drain – 9 tests; and
- Former Dredge Spoil Handling Area (from 1980s) – 38 tests.

Given the staged approach adopted, which concentrated follow up investigation in areas containing identified PASS hot spots and proposed excavations or disturbance, this was considered sufficient analysis to characterise the soil profiles and to predict the extent of ASS/PASS present in the areas of concern. A reduced sampling frequency was adopted in areas where future disturbance will be limited to bulk fill earthworks and where no direct disturbance of natural soils is expected. Samples were mainly chosen from screening tests that exhibited positive, probable or possible indications of ASS/PASS.

Test results indicate that actual and potential acidity present in the samples of alluvium analysed, varies considerably, but is generally high where the acid neutralising capacity (ANC) is not adequate to supply natural buffering capacity. ANC levels were generally in the range 200 to 400 moles/tonne where present, but some higher levels were detected in samples from the FAFA. This occurs across all areas of the runway site, FAFA and Western Apron area, but is less prevalent in areas to the south of the runway site along the proposed alignment of the KBF Drain(s) and in the dredge spoil present in the former 1980s Kedron Brook Floodway construction dredge spoil handling area.

Note that a fineness factor of 1.5 is applied by the analytical laboratory, as part of the determination of net acidity which builds in a factor of conservatism. Results of all laboratory testing undertaken are included in **Appendix B** and summarised in **Tables 3.2a** to **3.2f**. Values shown in bold on the tables exceed the QASSIT texture based Action Criteria for net acidity. It should be noted that common practise in Queensland for disturbances of greater than 1,000 tonnes (i.e. drain and tunnel excavations), is to adopt an action criteria of 18 moles H+/tonne for materials of all textures that are to be disturbed for any purpose.

Figure 3.2c: *Site Plans – Showing Borehole and Groundwater Sampling Locations (note that this is split into two figures).*

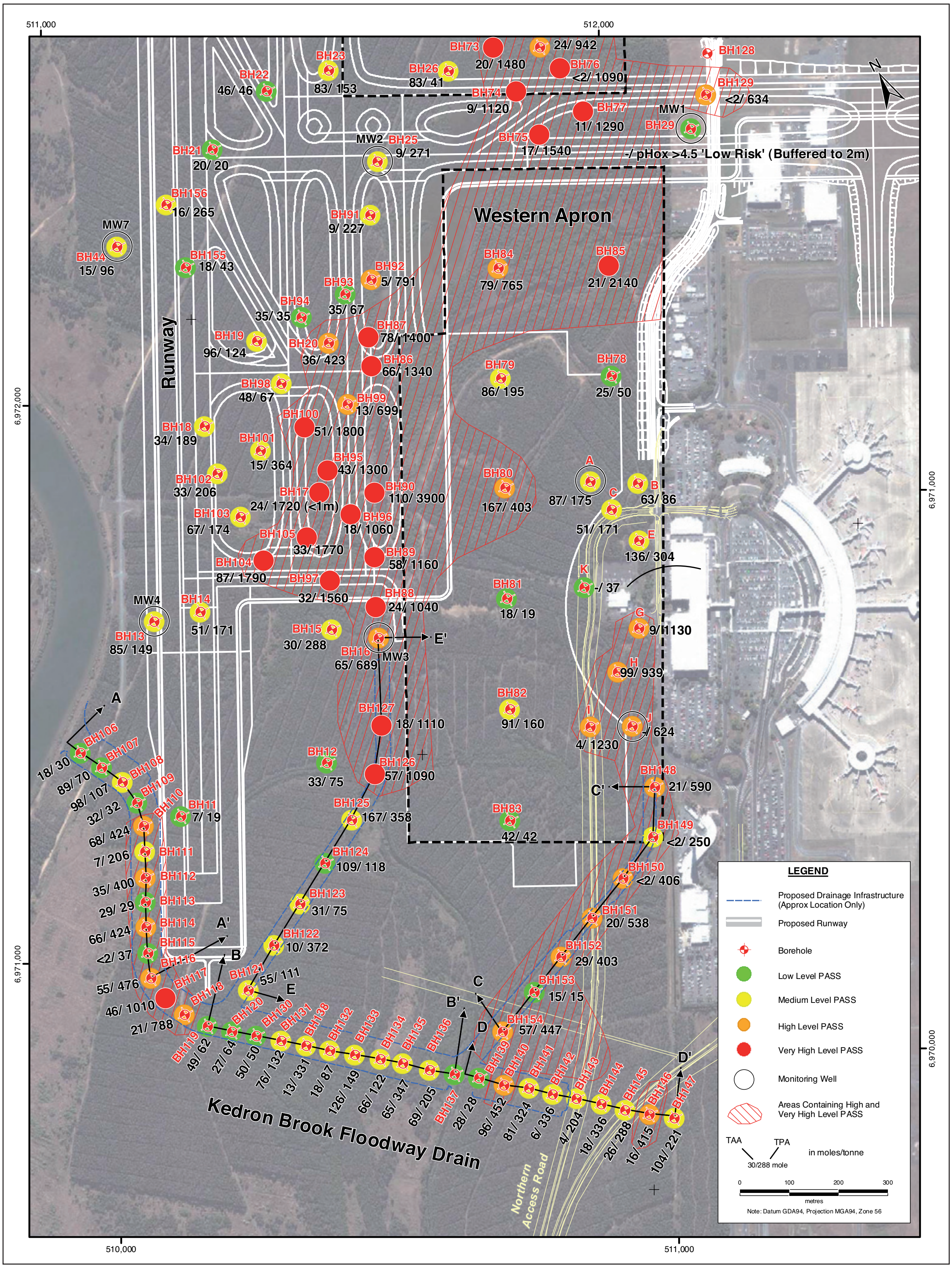


Figure 3.2c: *Site Plans – Showing Borehole and Groundwater Sampling Locations (note that this is split into two figures).*

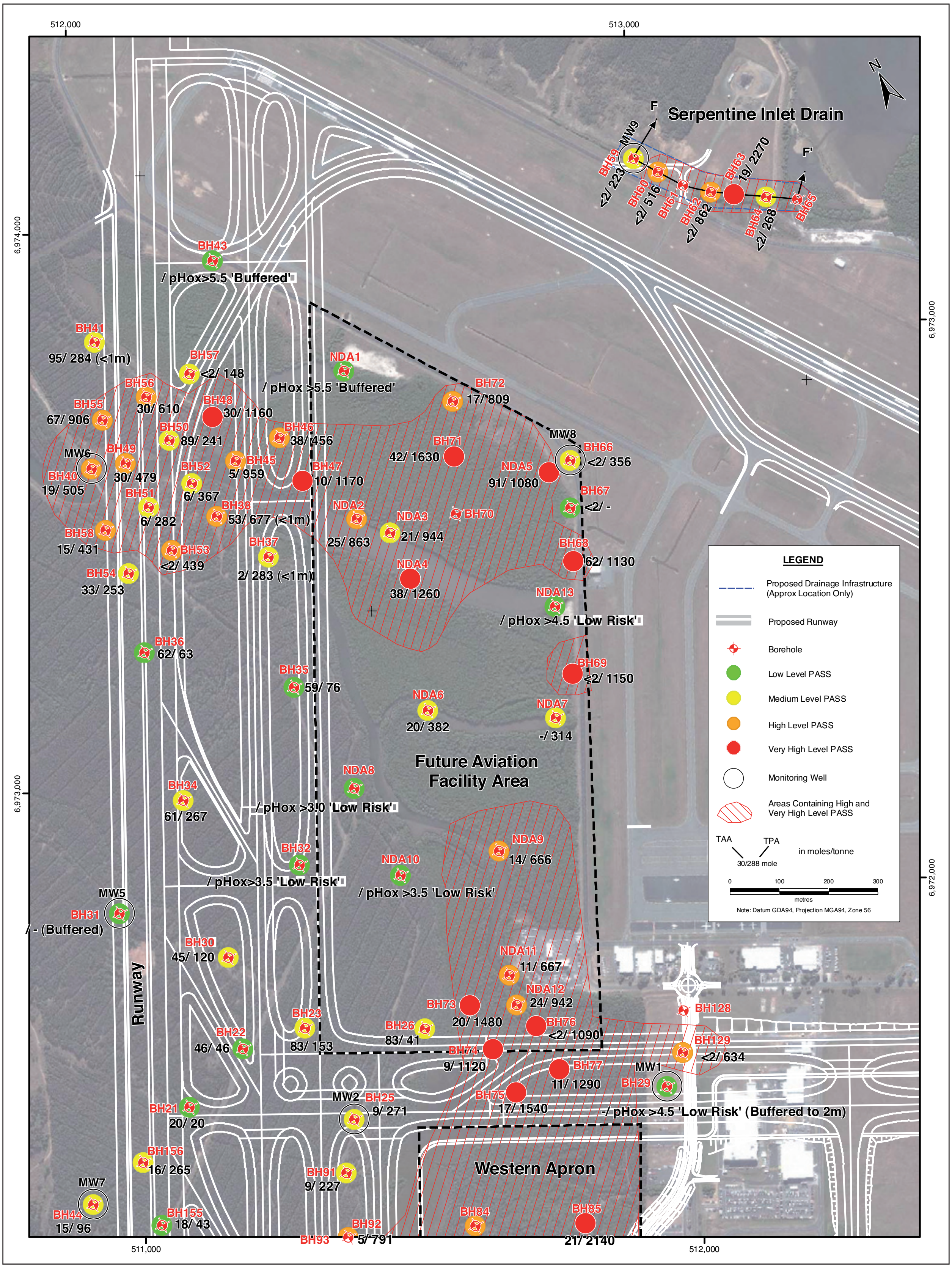


Table 3.2a: Summary of Quantitative Test Results – Runway Area.

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H+/t)	pH_{ox}
BH11 0.75-1.0m	62	7	10	MC, grey/brown	0.02	19	5.1
BH12 0.75-1.0m	36	33	55	CS, grey, fine	<0.02	**75**	3.9
BH12 1.25-1.5m	36	5	6	LC, grey	<0.02	11	5
BH13 0.0-0.25m	62	85	97	MC, brown, silty	0.02	**149**	--
BH13 0.75-1.0m	62	48	<58	LMC, sandy, grey/brown	<0.02	57	--
BH13 1.75-2.0m	62	14	57	LMC, sandy, grey/brown	0.08	**64**	4.1
BH14 0.25-0.5m	62	51	63	MC, grey/brown, organics	0.02	**171**	--
BH14 1.5-1.75m	18	11	51	S, grey	0.08	**61**	3.9
BH15 0.75-1.0m	36	30	231	CS, grey, Fine	0.38	**267**	2.9
BH15 1.5-1.75m	18	14	288	S, dk grey, silt fines	0.44	**288**	--
BH16 1.0-1.25m	62	65	689	MC, dk grey, organics	1.00	**689**	--
BH16 1.25-1.5m	62	<2	131	MC, dk grey, organics	0.21	**131**	--
BH16 1.75-2.0m	62	32	606	MC, dk grey, organics	0.92	**606**	--
BH17 1.0-1.25m	62	6	1,176	HC, grey	1.88	**1,180**	--
BH17 1.25-1.5m	62	6	927	HC, grey	1.78	**1,120**	2.4
BH17 1.5-1.75m	62	24	1,290	HC, grey	2.37	**1,500**	2.0
BH17 2.0-2.25m	62	24	1,510	HC, grey	2.72	**1,720**	1.9
BH18 0.0-0.25m	62	34	53	HC, brown/grey	0.03	**53**	--
BH18 1.5-1.75m	36	8	145	CS, dk grey	0.29	**189**	3.4
BH19 0.0-0.25m	62	96	115	MC, grey/brown	0.03	**124**	--
BH19 0.75-1.0m	62	43	<53	HC, grey/brown	<0.02	43	--
BH20 1.5-1.75m	62	36	323	LMC, sandy, grey	0.62	**423**	2.6
BH21 1.75-2.0m	36	20	<30	CS, grey, orange mottle	<0.02	20	--
BH22 0.0-0.25m	62	46	<56	HC, grey, red mottle	<0.02	46	--
BH23 0.0-0.25m	62	83	<93	MC, sandy, grey and red	<0.02	**153**	--
BH23 1.5-1.75m	62	24	41	MC, sandy, grey/orange	0.02	**36**	4.3
BH25 0.0-0.25m	36	9	<19	SCL, brown/grey	<0.02	<10	--
BH25 1.25-1.5m	62	3	218	MC, sandy, grey mottled	0.43	**271**	2.8
BH26 0.0-0.25m	62	83	102	MC, grey, orange mottled	0.03	**111**	--
BH26 0.75-1.0m	62	16	67	MC, sandy, dark grey	0.11	**85**	3.9
BH26 1.25-1.5m	62	11	65	MC, sandy, dark grey	0.13	**92**	3.8
BH30 0.0-0.25m	36	45	<55	SCL, brown, organics	<0.02	**45**	--
BH30 1.25-1.5m	62	18	120	HC, dk grey, fine sand	0.18	**130**	3.7
BH31 1.0-1.25m	62	<2	<2	HC, sandy, brown, mottle	0.04	<10	6.5
BH34 0.0-0.25m	36	61	80	SCL, brown, organics	0.03	**267**	--
BH35 0.25-0.5m	18	24	<34	S, brown, some silt	<0.02	**24**	--
BH35 0.75-1.0m	62	59	85	HC, grey/ brown	0.02	**76**	4.7
BH35 1.75-2.0m	18	15	18	S, yellow/brown and grey	<0.02	**21**	5.1
BH36 0.0-0.25m	62	58	<68	MC, dk brown	<0.02	**63**	--
BH36 0.75-1.0m	18	8	8	S, brown	<0.02	14	5.5
BH36 1.75-2.0m	18	6	5	S, grey	<0.02	<10	5.4
BH37 1.5-1.75m	62	2	194	MHC, dk grey, trace sand	0.45	**283**	3.1
BH38 0.0-0.25m	36	<2	<2	SCL, brown	0.09	<10	7.3
BH38 1.25-1.5m	62	<2	44	MC, sandy, grey, organic	0.07	<10	--
BH38 1.75-2.0m	62	53	563	MC, sandy, grey, organic	1.00	**677**	2.3
BH40 0.0-0.25m	36	<2	112	CL, dark grey	0.18	<10	--
BH40 1.25-1.5m	36	19	426	CS, fine-med	0.78	**505**	2.5

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H+/t)	pH_{OX}
BH41 0.0-0.25m	62	95	120	MC, sandy, grey/brown	0.04	**134**	--
BH41 1.0-1.25m	62	16	198	HC, sandy, dk grey	0.43	**284**	2.9
BH41 1.75-2.0m	36	19	258	CS, dk grey	0.44	**293**	3.0
BH44 0.25-0.5m	36	15	96	CS, brown	0.13	**96**	--
BH44 1.0-1.25m	62	11	92	MC, black, organics	0.13	**92**	--
BH45 1.0-1.25m	36	5	959	CS, dk grey	1.53	**959**	--
BH46 0.75-1.0m	36	38	456	HC, sandy, dk grey	0.67	**456**	--
BH46 1.5-1.75m	36	15	451	CS, dk grey, tr organics	0.70	**452**	--
BH47 0.0-0.25m	62	<2	<543	HC, dk grey/brown	0.87	**543**	--
BH47 1.0-1.25m	62	6	1,166	HC, sandy, dk grey	1.86	**1,170**	--
BH47 1.75-2.0m	62	10	852	HC, sandy, dk grey	1.35	**852**	--
BH48 0.25-0.5m	62	<2	<1,020	HC, sandy, dk grey	1.64	**787**	--
BH48 1.0-1.25m	62	5	1,155	HC, sandy, dk grey	1.85	**1,160**	--
BH48 1.5-1.75m	62	14	1,054	HC, sandy, dk grey	1.67	**1,060**	--
BH49 0.75-1.0m	36	30	485	HC, sandy, dk grey	0.72	**479**	--
BH50 0.0-0.25m	36	89	108	MHC, brown	0.03	**154**	--
BH50 0.75-1.0m	36	48	241	HC, sandy, dk grey	0.31	**241**	--
BH51 0.5-0.75m	36	<2	223	CS, dk grey	0.64	**282**	2.6
BH51 1.75-2.0m	36	6	152	CS, dk grey	0.21	**137**	2.7
BH52 0.0-0.25m	36	6	131	CS, dk grey	0.2	**131**	--
BH52 1.25-1.5m	36	5	255	CS, dk grey	0.58	**367**	2.7
BH53 0.25-0.5m	36	<2	378	CS, dk grey	0.90	**439**	2.4
BH54 0.0-0.25m	62	33	52	CS, brown/grey, organic	0.03	52	--
BH54 1.5-1.75m	18	16	170	S, grey/brown	0.38	**253**	2.8
BH55 0.5-0.75m	62	53	163	MHC, sand, grey, jarosite	0.19	**279**	2.8
BH55 1.0-1.25m	36	67	729	CS, lt brown/grey	1.3	**906**	2.1
BH56 0.5-0.75m	36	38	181	MC*sandy, grey	0.23	181	--
BH56 0.75-1.0m	36	19	393	MC*sandy, grey,	0.6	393	--
BH56 1.0-1.25m	36	30	610	CS, dk grey	0.93	610	--
BH57 0.5-0.75m	62	<2	212	CS, dk grey, organics	0.34	79	--
BH57 1.25-1.5m	36	<2	306	CS, dk grey, organics	0.49	**148**	--
BH58 0.25-0.5m	62	7	321	CS, dk grey	0.68	**431**	2.4
BH58 0.5-0.75m	36	<2	<195	CS, dk grey	0.31	<10	--
BH58 1.25-1.5m	62	<2	<208	LC, sand, dk grey, organic	0.33	49	--
BH58 1.75-2.0m	36	15	26	CS, dk grey mottled	0.02	27	4.2
BH73 0.25-0.5m	36	20	1,480	MC, dk grey, organics	2.35	**1,480**	--
BH73 1.25-1.5m	36	<2	<445	CS, dk grey	0.71	**443**	--
BH74 0.5-0.75m	36	9	1,129	MC, dk grey, organics	1.80	**1,120**	--
BH74 1.0-1.25m	36	<2	<457	CS, dk grey	0.73	**455**	--
BH75 0.25-0.5m	62	17	1,537	MC, dk grey, organics	2.44	**1,540**	--
BH75 1.5-1.75m	62	9	880	HC, dk grey	1.57	**998**	2.1
BH76 0.0-0.25m	62	<2	<1,202	MC, dk grey, organics	1.92	**1,090**	--
BH76 1.75-2.0m	36	6	322	CS, dk grey	0.61	**386**	2.3
BH77 0.5-0.75m	62	11	1,291	MC, dk grey	2.05	**1,290**	--
BH77 1.75-2.0m	62	11	541	MC, dk grey	0.85	**541**	--
BH86 0.75-1.0m	62	7	612	MC, dk grey	0.97	**612**	--
BH86 1.25-1.5m	36	66	1,346	CS, dk grey, organics	2.05	**1,340**	--
BH87 0.75-1.0m	62	63	1,403	MC, dk grey, organics	2.15	**1,400**	--
BH87 1.5-1.75m	36	78	1,098	CS, dk grey, organics	1.63	**1,090**	--

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H+/t)	pH_{ox}
BH88 0.25-0.5m	62	19	1,039	MC, dk. grey, organics	1.63	**1,040**	--
BH88 1.5-1.75m	62	24	392	MC, dk. grey, tr organics	0.59	**392**	--
BH89 0.75-1.0m	62	9	171	MC, grey, tr organics	<0.02	**171**	--
BH89 1.75-2.0m	36	58	1,158	CS, dk grey	0.09	**1,160**	--
BH90 1.25-1.5m	36	110	3,530	CS, dk grey	6.06	**3,900**	1.7
BH90 1.75-2.0m	36	11	282	CS, dk grey	0.52	**335**	2.3
BH91 1.25-1.5m	36	9	202	SC, grey	0.35	**227**	2.6
BH92 1.0-1.25m	62	9	348	MC, grey	0.60	**383**	2.7
BH92 1.5-1.75m	62	5	652	MC, grey	1.26	**791**	2.2
BH93 0.25-0.5m	36	35	<45	CS, brown	<0.02	**67**	--
BH94 0.25-0.5m	36	35	<45	CS, brown	<0.02	35	--
BH95 0.75-1.0m	62	43	1,303	MC, grey, organics	2.02	**1,300**	--
BH95 1.5-1.75m	36	11	447	CS, grey, organics	0.7	**448**	--
BH96 1.0-1.25m	36	18	957	CS, grey	1.67	**1,060**	2.2
BH96 1.75-2.0m	36	6	315	CS, grey	0.67	**424**	2.5
BH97 1.25-1.5m	62	32	1,562	MC, grey, organics	2.45	**1,560**	--
BH97 1.75-2.0m	36	11	554	CS, grey, organics	0.87	**554**	--
BH98 0.0-0.25m	36	48	67	MHC, sandy, brown	0.03	**67**	--
BH98 0.75-1.0m	36	17	<27	HC, dk grey	<0.02	17	--
BH99 0.25-0.5m	62	13	846	MHC, brown	1.10	**699**	2.3
BH99 1.25-1.5m	36	11	566	CS, dk grey	0.89	**566**	--
BH100 0.25-0.5m	62	51	1,801	HC, dk grey, organics	2.81	**1,800**	--
BH100 1.25-1.5m	62	50	1,670	HC, dk grey, organics	2.60	**1,670**	--
BH101 0.5-0.75m	36	12	41	HC, dk grey	0.03	31	4
BH101 1.0-1.25m	36	15	285	CS, dk grey	0.56	**364**	2.5
BH102 0.25-0.5m	36	33	44	MHC, sandy, brown	<0.02	33	4.1
BH102 1.5-1.75m	36	13	160	MHC, sandy, dk grey	0.31	**206**	2.9
BH103 0.25-0.5m	62	67	<77	MHC, sandy, brown	<0.02	**72**	--
BH103 0.75-1.0m	36	43	174	CS, dk grey	0.21	**174**	--
BH104 0.25-0.5m	62	87	1,207	HC, dk grey, organics	1.80	**1,210**	--
BH104 1.75-2.0m	62	62	1,792	CS, dk grey, organics	2.77	**1,790**	--
BH105 1.0-1.25m	62	33	1,283	HC, dk grey	2.00	**1,280**	--
BH105 1.75-2.0m	62	23	1,773	HC, dk grey	2.80	**1,770**	--
BH129 2.75-3.0m	36	<2	574	CS, dk grey	1.21	**634**	2.1
BH129 4.25-4.5m	36	<2	196	CS, dk grey	0.52	**239**	2.6
BH155 0.0-0.25m	36	18	43	CS, brown, organics	0.04	**43**	--
BH156 1.25-1.5m	36	16	171	CS, dk. grey	0.40	**265**	2.7
Average	**36**	**25**	**481**	**Fine to med material**	**0.75**	**498**	**n/a**

Table 3.2b: Summary of Quantitative Test Results – FAFA.

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H+/t)	pH_{OX}
NDA2 0.0-0.25m	62	2	863	HC, grey	1.38	**863**	--
NDA2 0.75-1.0m	36	25	428	LC*, sandy, grey	0.86	**561**	2.5
NDA2 1.5-1.75m	36	14	162	LC*, sandy, grey	0.32	**214**	3.2
NDA3 0.0-0.25m	62	<2	674	HC, dk grey, organics	1.08	**396**	--
NDA3 1.5-1.75m	62	21	754	HC, dark grey	1.48	**944**	2.3
NDA4 0.0-0.25m	62	4	372	HC, dk grey, organics	0.59	**372**	--
NDA4 0.5-0.75m	62	36	1,256	HC, dk grey, organics	1.96	**1,260**	--
NDA4 1.25-1.5m	62	38	749	HC, sandy, dk grey	1.14	**749**	--
NDA5 0.0-0.25m	62	9	577	HC, dk grey, organics	0.92	**576**	--
NDA5 0.5-0.75m	62	60	1,050	HC, dk grey, organics	1.64	**1,080**	1.9
NDA5 1.0-1.25m	36	91	330	CS, dk grey, organics	0.62	**478**	2.5
NDA6 0.0-0.25m	62	<2	418	LMC, grey/brown	0.67	**234**	--
NDA6 0.25-0.5m	62	20	382	LMC, grey/brown	0.58	**382**	--
NDA7 0.0-0.25m	62	<2	511	MC, dk grey	0.82	**217**	--
NDA7 0.5-0.75m	62	<2	256	MC, dk grey	0.69	**314**	3.2
NDA7 1.25-1.5m	62	<2	5	MC, sandy, dk grey	0.04	12	4.8
NDA9 0.0-0.25m	62	36	666	MC, brown, organics	1.01	**666**	--
NDA9 0.75-1.0m	36	14	149	LC, sandy, grey	0.29	**195**	3.2
NDA9 1.75-2.0m	36	7	151	LC, sandy, grey	0.29	**188**	3.4
NDA11 0.0-0.25m	62	11	179	MHC, brown	0.27	**179**	--
NDA11 0.25-0.5m	62	6	293	MC, dk grey	0.46	**293**	--
NDA11 0.75-1.0m	62	<2	576	MC, dk grey	1.36	**667**	2.4
NDA12 0.0-0.25m	62	<2	287	HC, dk grey	0.46	<10	--
NDA12 0.5-0.75m	62	24	947	MC, dk grey	1.48	**947**	--
BH66 0.25-0.5m	62	<2	<541	MC, sandy, dk grey	0.88	**329**	--
BH66 1.5-1.75m	36	<2	<358	MC, dk grey, tr organic	0.57	**356**	--
BH67 1.25-1.5m	62	<2	<177	MC, dk grey, tr organic	0.28	<10	--
BH68 0.25-0.5m	62	62	1,132	MC, dk grey, tr organic	1.71	**1,130**	--
BH68 1.25-1.5m	36	6	386	MC, dk grey, sand	0.61	**386**	--
BH69 0.5-0.75m	36	<2	1,152	MC, sandy, dk grey	1.84	**1,150**	--
BH69 1.0-1.25m	36	<2	1,042	MC, dk grey, tr organic	1.67	**1,040**	--
BH71 0.25-0.5m	62	42	1,622	MHC, dk grey, organic	2.54	**1,630**	--
BH71 1.25-1.5m	36	7	718	CS, dk grey, organics	1.14	**718**	--
BH72 0.5-0.75m	62	17	809	MC, dk grey, organics	1.27	**809**	--*
BH72 1.25-1.5m	36	12	567	MC, sandy, dk grey	0.89	**567**	--
Average	**62**	**17**	**587**	**Fine to Medium**	**0.97**	**569**	**n/a**

Table 3.2c: Summary of Quantitative Test Results – Western Apron.

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	SPOS (%)	Net Acidity (mole H+/t)	pH_{ox}
BH78 0.75-1.0m	62	25	84	MC, dk. brown	0.04	50	3.4
BH79 0.0-0.25m	62	86	111	MC, brown, organics	0.04	**195**	--
BH80 0.25-0.5m	62	167	<177	HC, dk. brown	<0.02	**303**	--
BH80 1.5-1.75m	36	41	339	CS, dk grey	0.58	**403**	2.4
BH81 0.0-0.25m	18	<2	<21	S, fine, lt brown	0.03	19	--
BH82 0.0-0.25m	62	43	<53	MC, brown, organics	<0.02	43	--
BH82 1.25-1.5m	36	91	397	CS, brown	0.08	**160**	3.1
BH83 0.0-0.25m	36	42	<53	CS, brown, organics	<0.02	**42**	--
BH84 0.25-0.5m	62	4	166	MC, dk grey, organics	0.26	**166**	--
BH84 1.5-1.75m	36	79	802	CS, dk grey, Organics	1.10	**765**	2.3
BH85 1.5-1.75m	36	21	2,050	CS, dk grey	3.39	**2,140**	1.9
Average	**36**	**52**	**387**	**Fine to Medium**	**0.50**	**390**	**n/a**

Table 3.2d: Summary of Quantitative Test Results – KBF Drain and connector channels.

Location	Action Criteria (mole H^+/t)	TAA (mole H^+/t)	TPA (mole H^+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H^+/t)	pH_{ox}
BH106 0.5-0.75m	36	18	30	CS, grey	0.02	30	--
BH106 1.75-2.0m	36	<2	<27	CS, dk grey, organics	0.04	25	--
BH107 0.0-0.25m	62	89	138	MC, brown	0.02	**70**	3.3
BH108 0.0-0.25m	62	98	<108	MC, brown, organics	<0.02	**107**	--
BH109 0.25-0.5m	36	32	<42	CS, grey, organics	<0.02	32	--
BH110 0.25-0.5m	62	68	<78	MC, brown, organics	<0.02	**424**	--
BH111 2.25-2.5m	36	7	126	CS, dk grey	0.32	**206**	2.8
BH112 0.5-0.75m	36	35	48	CS, brown	0.03	**400**	3.3
BH113 0.5-0.75m	36	29	<39	CS, brown, organics	<0.02	29	--
BH114 0.0-0.25m	36	66	<76	CS, brown	<0.02	**424**	--
BH115 2.0-2.25m	36	<2	36	CS, dk, grey	0.06	**37**	3.3
BH116 0.0-0.25m	36	55	<65	MC, grey, mottled	<0.02	**476**	--
BH117 1.5-1.75m	62	46	1,006	MC, grey	1.54	**1,010**	--
BH117 2.0-2.25m	62	32	855	MC, grey	1.32	**855**	--
BH118 2.25-2.5m	62	21	512	MC, grey	1.23	**788**	2.2
BH119 0.25-0.5m	36	49	<59	CS, brown, organics	<0.02	**62**	--
BH120 1.25-1.5m	36	27	52	CS, grey	0.06	**64**	4.2
BH121 0.0-0.25m	36	55	<65	CS, brown, organics	<0.02	**111**	--
BH122 2.25-2.5m	36	10	226	CS, dk grey	0.58	**372**	2.6
BH123 0.25-0.5m	36	109	<119	MC, brown, organics	<0.02	**118**	--
BH124 0.25-0.5m	62	31	75	MC, brown, organics	0.07	**75**	--
BH125 0.0-0.25m	36	167	186	CS, dk brown, organic	0.03	**223**	--
BH125 1.75-2.0m	36	21	273	CS, dk grey	0.54	**358**	2.3
BH126 1.0-1.25m	36	57	1,097	CS, grey	1.66	**1,090**	--
BH126 1.5-1.75m	36	<2	<2	CS, grey	0.06	**37**	4.4
BH127 0.0-0.25m	36	18	1,108	CS, grey, organics	1.75	**1,110**	--
BH130 0.25-0.5m	36	50	<60	CS, grey, organics	<0.02	**50**	--
BH131 2.0-2.25m	36	76	108	CS, grey	0.03	**132**	3.3

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H+/t)	pH_{OX}
BH132 0.0-0.25m	36	18	87	CS, brown, organics	0.11	**87**	--
BH133 1.75-2.0m	36	126	<136	CS, dk grey, organics	<0.02	**149**	--
BH133 2.0-2.25m	36	52	<62	CS, dk grey, organics	<0.02	**89**	--
BH134 0.75-1.0m	36	66	<76	CS, brown, organics	<0.02	**122**	--
BH135 2.25-2.5m	64	65	109	HC, dk grey	0.04	**347**	3.3
BH136 1.25-1.5m	36	69	111	CS, grey	0.03	**92**	3.4
BH136 2.25-2.5m	36	12	138	CS, grey	0.31	**205**	2.7
BH138 1.5-1.75m	36	13	257	CS, grey	0.51	**331**	2.5
BH139 0.25-0.5m	36	28	<38	CS, brown, organics	<0.02	28	--
BH140 0.25-0.5m	36	96	<106	CS, grey	<0.02	**124**	--
BH140 1.75-2.0m	36	16	335	CS, grey	0.70	**452**	2.4
BH141 0.25-0.5m	36	81	<91	CS, brown, organics	<0.02	**324**	--
BH141 0.75-1.0m	36	54	<62	CS, grey	<0.02	**74**	3.8
BH142 0.75-1.0m	36	6	225	CS, brown, organics	0.53	**336**	2.6
BH143 0.25-0.5m	36	4	204	CS, brown, organics	0.32	**204**	--
BH144 0.25-0.5m	36	18	336	CS, brown, organics	0.51	**336**	--
BH145 0.25-0.5m	62	26	288	MC, grey	0.42	**288**	--
BH146 1.5-1.75m	62	16	415	MC, grey, organics	0.64	**415**	--
BH147 0.0-0.25m	62	21	127	MC, dk brown, organic	0.17	**127**	--
BH147 0.5-0.75m	36	104	123	CS, grey	0.03	**221**	--
BH148 0.5-0.75m	36	21	77	CS, dk grey, organics	0.09	**77**	--
BH148 1.5-1.75m	36	16	590	CS, dk grey, organics	0.92	**590**	--
BH149 0.5-0.75m	36	<2	<407	CS, dk grey, organics	0.65	**250**	--
BH150 0.75-1.0m	62	<2	<570	MC, dk grey, organics	0.91	**406**	--
BH151 0.5-0.75m	62	9	477	HC, dk grey, organics	0.75	**477**	--
BH151 1.0-1.25m	62	20	538	CS, dk grey, organics	0.83	**538**	--
BH152 0.5-0.75m	36	29	403	MHC, grey, organics	0.6	**403**	--
BH152 2.25-2.5m	62	2	199	CS, dk grey, organics	0.48	**301**	2.6
BH153 1.25-1.5m	36	15	<25	CS, grey/brown	<0.02	15	--
BH154 1.5-1.75m	36	57	84	CS, dk grey	0.02	**88**	3.6
BH154 2.0-2.25m	36	17	316	CS, dk grey	0.69	**447**	2.3
Average	**36**	**39**	**229**	**Fine to Medium**	**0.33**	**278**	**n/a**

Table 3.2e: Summary of Quantitative Test Results – SI drain

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H+/t)	pH_{OX}
BH59 2.0-2.25m	36	<2	201	S, dk grey	0.43	**223**	2.4
BH60 0.0-0.25m	36	<2	491	CS, dk. Gray	0.91	**516**	2.3
BH60 1.5-1.75m	36	<2	105	HC, dk. Brown	0.49	**172**	3.1
BH62 0.75-1.0m	36	<2	807	CS, grey	1.56	**862**	2.2
BH62 1.25-1.5m	62	<2	1,060	HC, organics	1.70	**711**	--
BH63 1.0-1.25m	36	19	2,130	CS, brown	3.61	**2,270**	1.8
BH63 2.25-2.5m	36	<2	395	CS, brown	1.10	**492**	2.4
BH64 1.25-1.5m	36	<2	196	CS, dk. Brown	0.49	**268**	2.5
Average	**36**	**<2**	**465***	**Fine to Medium**	**1.29**	**463***	**n/a**

*Note: * Excludes BH63 1.0-1.25m*

Table 3.2f: Summary of Quantitative Test Results – Former 1980s Kedron Brook Floodway Construction Dredge Spoil Handling Area.

Location	Action Criteria (mole H+/t)	TAA (mole H+/t)	TPA (mole H+/t)	Texture Description	S_{POS} (%)	Net Acidity (mole H+/t)	pH_{OX}
BH157 0.75-1.0m	36	**41**	**60**	LC, sand, dk brown	0.03	**92**	--
BH157 1.25-1.5m	36	16	<26	CS, grey-brown	<0.02	16	--
BH158 0.25-0.5m	36	5	<15	LC, sandy, red-brown and grey	<0.02	<10	--
BH158 0.75-1.0m	36	**41**	**37**	LC, sand, grey and brown	0.02	**82**	4.8
BH159 0.25-0.5m	62	37	**267**	HC, grey and red-brown	**0.14**	**124**	3.1
BH159 1.5-1.75m	36	5	<2	CS, grey and dk grey	0.02	17	6.3
BH159 1.75-2.0m	36	5	**61**	LS, dk grey	**0.09**	**61**	--
BH160 0.25-0.5m	62	58	56	LMC, grey	0.05	**89**	5.0
BH160 1.0-1.2m	62	**88**	**344**	LMC, dk grey	0.08	**147**	3.7
BH161 0.25-0.5m	62	**75**	**109**	LMC, brown	0.05	**125**	4.5
BH161 0.75-1.0m	62	**102**	**114**	MC, dk grey-brown	0.02	**138**	--
BH161 1.25-1.5m	62	**75**	**947**	MC, dk grey	**1.64**	**1,100**	2.1
BH162 0.25-0.5m	62	53	**65**	HC, brown	0.02	**75**	--
BH162 1.75-2.0m	36	**94**	**154**	CS, grey	0.04	**128**	3.5
BH163 0.75-1.0m	36	**97**	**141**	L, dk grey, organic	0.07	**141**	--
BH163 1.25-1.5m	36	**43**	**68**	L, dk grey, organic	0.04	**68**	--
BH164 0.5-0.75m	36	<2	<2	CS, grey-brown	<0.02	<10	7.4
BH165 0.5-0.75m	62	<2	<2	HC, red-brown and grey	<0.02	<10	8.6
BH165 1.75-2.0m	62	<2	<2	HC, red-brown and grey	0.02	<10	8.0
BH166 0.25-0.5m	62	11	5	HC, red and grey	0.02	23	4.4
BH167 0.75-1.0m	36	<2	<2	SCL, brown, organics	0.04	<10	7.0
BH167 1.75-2.0m	62	36	50	MC, grey and brown	<0.02	47	3.9
BH168 0.25-0.5m	62	32	42	LMC, sand, brown	0.03	60	4.2
BH168 0.75-1.0m	62	19	20	LMC, sand, brown	0.02	31	4.4
BH169 0.25-0.5m	62	23	11	HC, grey and brown	0.03	42	5.3
BH169 1.0-1.2m	62	31	**84**	HC, grey and brown	**0.10**	**93**	4.7
BH170 0.25-0.5m	62	**118**	**110**	HC, brown	**0.22**	**358**	3.8
BH170 0.5-0.75m	62	58	**87**	HC, grey and brown	0.12	**142**	4
BH171 0.0-0.2m	62	<2	<10	MC, brown	<0.02	<10	--
BH171 0.75-1.0m	62	53	**65**	HC, brown	0.02	**108**	--
BH172 0.0-0.2m	62	9	<19	LMC, brown	<0.02	<10	--
BH173 0.25-0.5m	62	**41**	51	HC, brown	0.02	58	4.2
BH174 0.25-0.5m	62	**80**	**97**	MC, brown	<0.02	**86**	3.9
BH174 0.5-0.75m	62	**88**	**123**	MC, brown	0.04	**174**	3.6
BH174 1.25-1.5m	62	37	55	LMC, brown	<0.02	43	4.1
BH175 0.75-1.0m	62	17	<27	LMC, brown	<0.02	17	--
BH176 0.25-0.5m	62	**77**	**89**	HC, grey and brown	0.02	**118**	--
BH176 0.75-1.0m	62	51	**82**	MC, grey and brown	0.02	**68**	3.7
Averages	62	43	**67**	**Fine Textured**	0.04	**76**	n/a

NOTE: BH161 1.25-1.5m is the top of the natural surface (and is excluded from averages)

A summary of soil acidity at each site investigated is given below:

Proposed Runway and Cross Taxiway

Test results returned net acidity values ranging from <10 up to 3,900 moles of acid/tonne. Of the 129 samples of analysed, PASS levels exceeded the adopted Action Criteria for bulk excavations (i.e. 18 moles of acid/tonne) in all but nine samples. Actual acidity levels were of the order of 10 to 60 moles of acid/tonne, which indicates only partial oxidation of sulfidic fines had occurred to about 1.5 m depth. Results of Percent Oxidisable Sulfur (S_{POS}) tests, indicate oxidisable sulfur (sulfides) of up to 6.06 percent which is equivalent to approximately 300 kg of sulfuric acid / cubic metre of PASS).

Future Aviation Facility Area (FAFA)

Test results returned net acidity values ranging from <10 up to 1,630 moles of acid/tonne. The actual acidity levels were in most cases of the order of 10 to 30 moles of acid/tonne, which indicates only very slight oxidation of sulfidic fines had occurred, generally in the upper 0.5–1.0 m of the sediment profile. Of the 35 samples of alluvium analysed, PASS levels in 32 exceeded the adopted Action Criteria. Results of Percent Oxidisable Sulfur (S_{POS}) tests, indicate that the level of oxidisable sulfur (sulfides) present in the alluvium is consistently high, with some very high levels (up to 2.54 percent).

Western Apron

Test results returned net acidity values ranging from 19 up to 2,140 moles of acid/tonne. The actual acidity levels varied considerably, and ranged from <2 to 167 moles of acid/tonne, which indicates a varying degree of oxidation of sulfidic fines had occurred throughout the 2.0 m profile. In all of the 11 samples analysed, PASS levels exceeded the adopted Action Criteria. Results of Percent Oxidisable Sulfur (S_{POS}) tests, indicate that the level of oxidisable sulfur (sulfides) present in the alluvium is variable and ranges from <0.02 percent to 3.39 percent.

Main KBF Drain and Cross Connector Channels

Test results returned net acidity values ranging from <10 up to 1,110 moles of acid/tonne. Of the 60 samples of analysed, PASS levels exceeded the adopted Action Criteria for almost all samples. Actual acidity levels were in most cases of the order of 10 to 60 moles of acid/tonne (with the highest being 167). Actual acidity levels were typically less than 10–15 percent of potential acidity, which indicates some partial oxidation of sulfidic fines had occurred, extending to 2.25 to 2.5 m depth. Results of Percent Oxidisable Sulfur (S_{POS}) tests, indicate that the level of oxidisable sulfur (sulfides) present in the alluvium generally matches potential and net acidity (the highest was 1.75 percent).

SI drain

Test results returned net acidity values ranging from 268 to 2,270 moles of acid/tonne. The actual acidity levels were in most cases <2 moles of acid/tonne which indicates no past oxidation of sulfidic fines. All of the samples of alluvium analysed, returned PASS levels exceeding the adopted Action Criteria.

Results of Percent Oxidisable Sulfur (S_{POS}) tests, indicate that the level of oxidisable sulfur (sulfides) present in the alluvium is consistently high, with some very high levels detected (i.e. up to 3.61 percent with a mean value of 1.29 percent).

Former Dredge Spoil Handling Area (from construction of the KBF in the 1980s)

Test results returned net acidity values ranging from <10 to 1,100 moles of acid/tonne. However the highest PASS levels detected in samples analysed were from the underlying natural alluvium, not from the dredge spoil layer. The highest net acidity detected in the dredge spoil was 358 moles of acid/tonne. Actual acidity was present in most samples, at levels ranging from <10 to 118 moles of acid/tonne, which indicates some past oxidation of sulfidic fines. Of the samples of alluvium analysed, 28 out of 38 returned PASS levels exceeding the adopted Action Criteria. Results of Percent Oxidisable Sulfur (S_{POS}) tests, indicate that the level of oxidisable sulfur (sulfides) present in the actual dredge spoil is consistently low, with an average value of only 0.04 percent.

Linked Taxiway Tunnel

Test results from one of two boreholes drilled at the site of proposed tunnel returned net acidity values of 634 and 239 moles of acid/tonne. Screening of samples from the other borehole did not indicate the presence of any acidity. No actual acidity was detected in the samples tested. PASS levels exceeded the adopted Action Criteria for both samples analysed. Results of Percent Oxidisable Sulfur (S_{POS}) tests, indicate that the level of oxidisable sulfur (sulfides) present is high (i.e. 1.21 percent and 0.52 percent).

3.2.3.5 Extent of ASS/PASS

The highest actual acidity and net acidity encountered at each borehole location (values indicated before and after the slash, respectively) are depicted on **Figure 3.2c** (parts 1 and 2). Locations containing very high levels of net acidity (>1000 moles of acid/tonne) are shown with a red halo. Sample locations containing high levels of net acidity (> 400 moles of acid/tonne) are orange, while other less severe (moderate) levels of net acidity are yellow (i.e. 20–400 moles of acid/tonne). Samples with low or negligible net acidity (i.e. that are adequately buffered or where ASS/PASS are absent) are shown in green. A separate plan showing distribution of ASS/PASS within the former dredge spoil handling area from construction of the KBF in the 1980s, is shown as **Figure 3.2d**. In addition, the vertical extent of ASS/PASS (On-airport) is indicated on a series of vertical transverse sections and specific cross-sections included in **Figures 3.2e-j.**

Appropriate lime treatment rates for the neutralisation of ASS spoil from drain and tunnel excavations have been calculated using a factor of safety of 1.5 and a bulk density of 1.5 tonnes/m^3, and are included in the ASS Management Plan, appended to the EMF (Chapter B14).

3.2.4 Geotechnical Conditions

3.2.4.1 Soil Stratigraphy and Geotechnical Properties

As indicated in section 3.2.2, the sediments present on the site can be divided into two layers with distinct geotechnical properties: the Upper Holocene alluvia and the Lower Holocene alluvia. The relationship between the Upper and Lower Holocene, is demonstrated in **Figure 3.2k**, which illustrates the results of geotechnical investigations along the alignment of the proposed runway.

The Upper Holocene alluvia, comprising inter-layered clays, silts and sands are present from ground surface (or from the base of any site fill) and are around 7–14 m thick in the area of the new runway. A desiccated, stiffer crust is often present at the top of this layer. Apart from the crust, these alluvia are highly compressible but usually settle relatively rapidly. Primary consolidation is often virtually complete within 6–12 months.

The Lower Holocene, comprising silty clays unrelieved by sandy layers are highly compressible, and because they tend not to contain persistent layers of sand, they consolidate relatively slowly, taking years or decades to substantially complete primary consolidation depending on their thickness. The features of dominating importance in terms of site settlement are the infilled former stream channels where thick deposits of compressible Lower Holocene alluvia are present.

Results of geotechnical investigation for the new runway indicate the presence of a relatively broad channel of up to 32 m depth below the current ground surface level, passing beneath the proposed link taxiway, and beneath the northern end of the runway. **Figure 3.2b** illustrates contours of the elevation of the base of the Lower Holocene, which indicates the approximate location of the infilled channel.

The clays in both the Upper and Lower Holocene are slightly overconsolidated through secondary compression following deposition. Clay layers within in the Upper Holocene increase in strength from very soft to soft beneath the crust, to soft to firm towards the base of the layer. Sandy layers within the Upper Holocene are generally very loose to loose. The clay in the Lower Holocene increases in strength with depth from firm to firm to stiff.

3.2.4.2 Erosion Potential

The Brisbane Airport is situated on the low lying floodplain of the greater Brisbane River system, in an area of recent alluvium (estuarine sediments). Natural soils and where present, dredged fill material comprise a mix of fine grained soils (clays and silts) and coarse grained, cohesion-less soils (predominantly fine sands). Sands and silts have little cohesion and are prone to erosion on slopes that exceed their natural angles of repose (which vary from 30–35º). Cohesive soils (clays and sandy clays), are capable of standing at steeper slopes, but may erode as blocks or crumble, where drying of the exposed soil surface occurs. In addition, if soils contain dispersive fines, the soil matrix will disintegrate if subjected to inundation or flowing water.

Soil Dispersion Potential

Laboratory screening was undertaken on a number of samples of the predominant surface and subsurface soil types encountered along the alignment of proposed drainage works (e.g. from the area most prone to erosion). Screening comprised Emerson Class tests and Electrical Conductivity (EC) determined on eight samples of near surface soils.

Results of Emerson Class tests were used to determine dispersion potential of the soils screened. Of the eight samples screened, two were slightly dispersive (Emerson Class 5) and six were non-dispersive (Emerson Class 6 or higher).

The test results indicate that the soils to be disturbed along the KBF Drain alignment do not have any significant dispersion potential, and are unlikely to result in mobilisation of large amounts of fines. In addition, agricultural lime ($CaCO_3$) will be applied to the base and sides of the channel as part of ASS management measures, (the lime will act to buffer to dispersion potential that might be present).

The SI drainage channel is located in a fully tidal environment and exposed surfaces will be in periodic contact with salt water and treated with agricultural lime as part of ASS management measures. Salinity and the lime both act to buffer against dispersion, so the potential for dispersion is very low.

Erosion Potential

The dominant natural subsoils are of two types:

- Clayey/silty sands and low to medium plasticity sandy clays, with low plasticity fines, which are not fine grained (i.e. < 20 percent passing 0.02 mm), but because of their granular nature, have a high potential for erosion if left uncovered on significant gradients (i.e. >5 percent) or exposed to moderate to high velocity flows;
- Clays with medium to high plasticity fines. These soils are fine grained (i.e. 60-90 percent passing 0.02 mm) and are considered to have a low erosion potential if not directly disturbed by development.

In areas where earthworks will be limited to fill (i.e. the main runway and taxiway development area), the potential for erosion of in situ soils is considered to be low. Areas of highest risk to erosion will be exposed cut batters in drainage channel excavations, internal batters of sediment retention basins and perimeter fill batters of the main runway fill platform.

Figure 3.2d: *Plan of Former 1980s Kedron Brook Floodway Construction Dredge Spoil Handling Area – Showing Sampling Locations.*

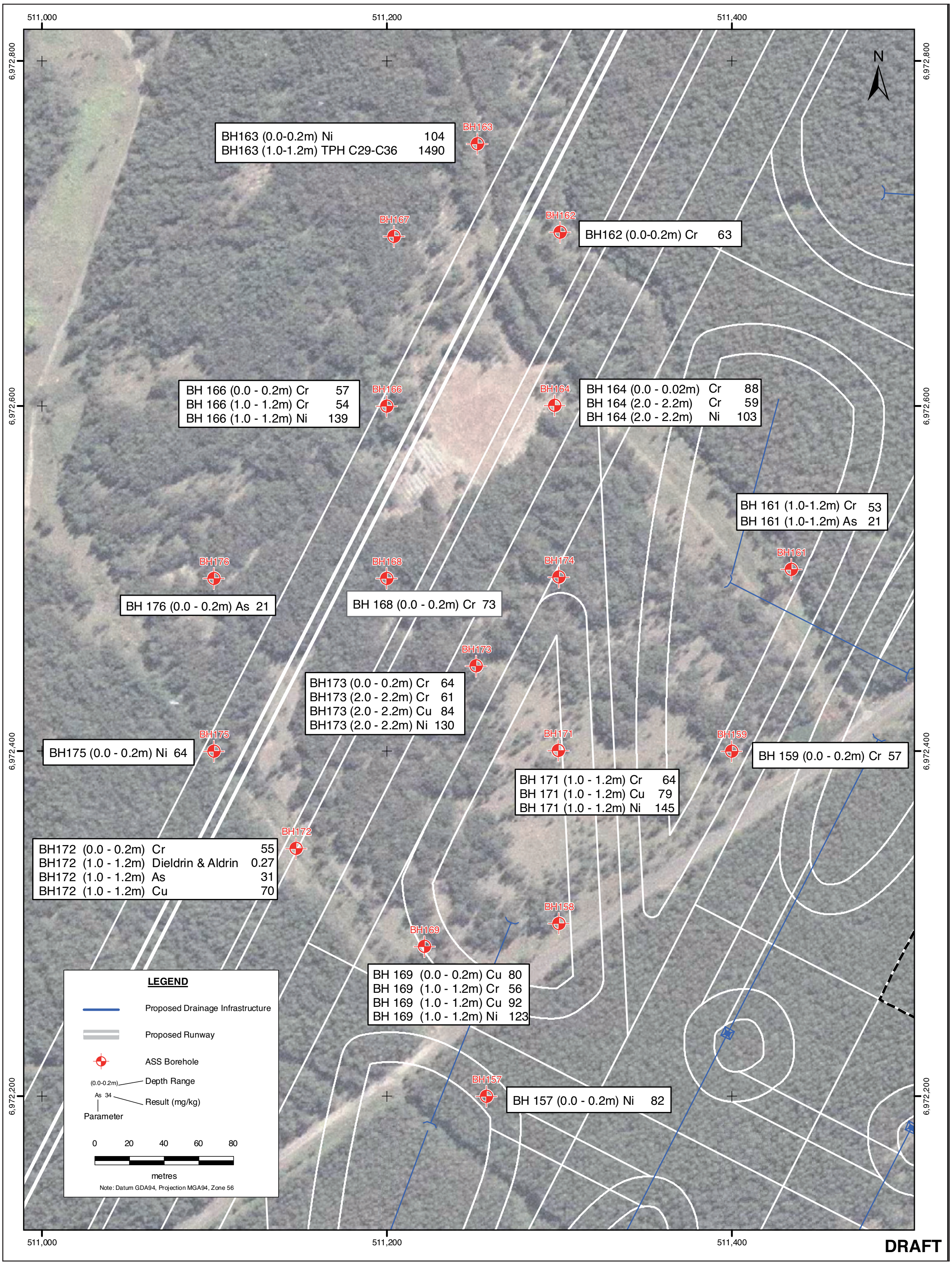


Figure 3.2e: *Vertical Sections – Showing Distribution of ASS/PASS.*

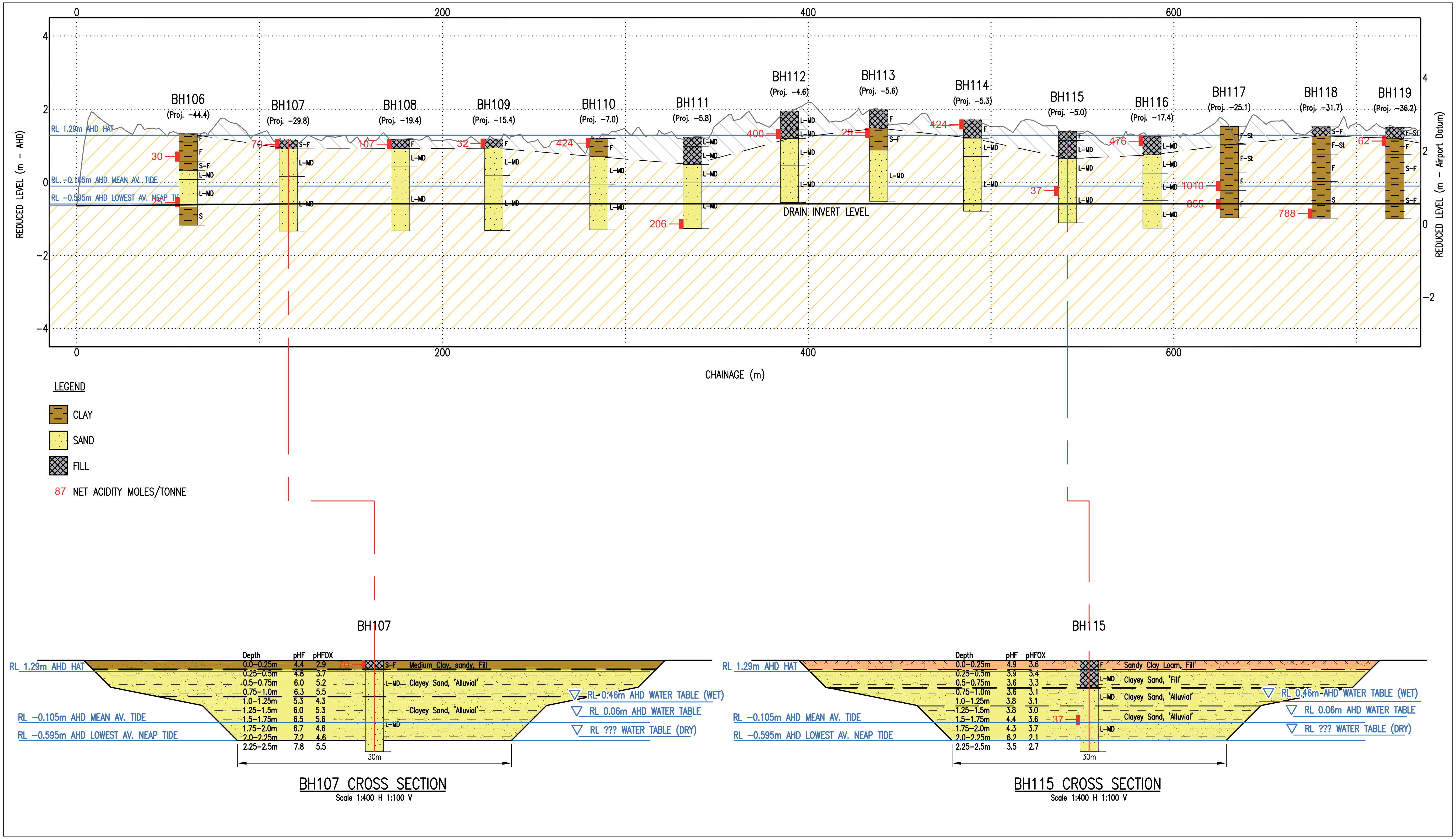
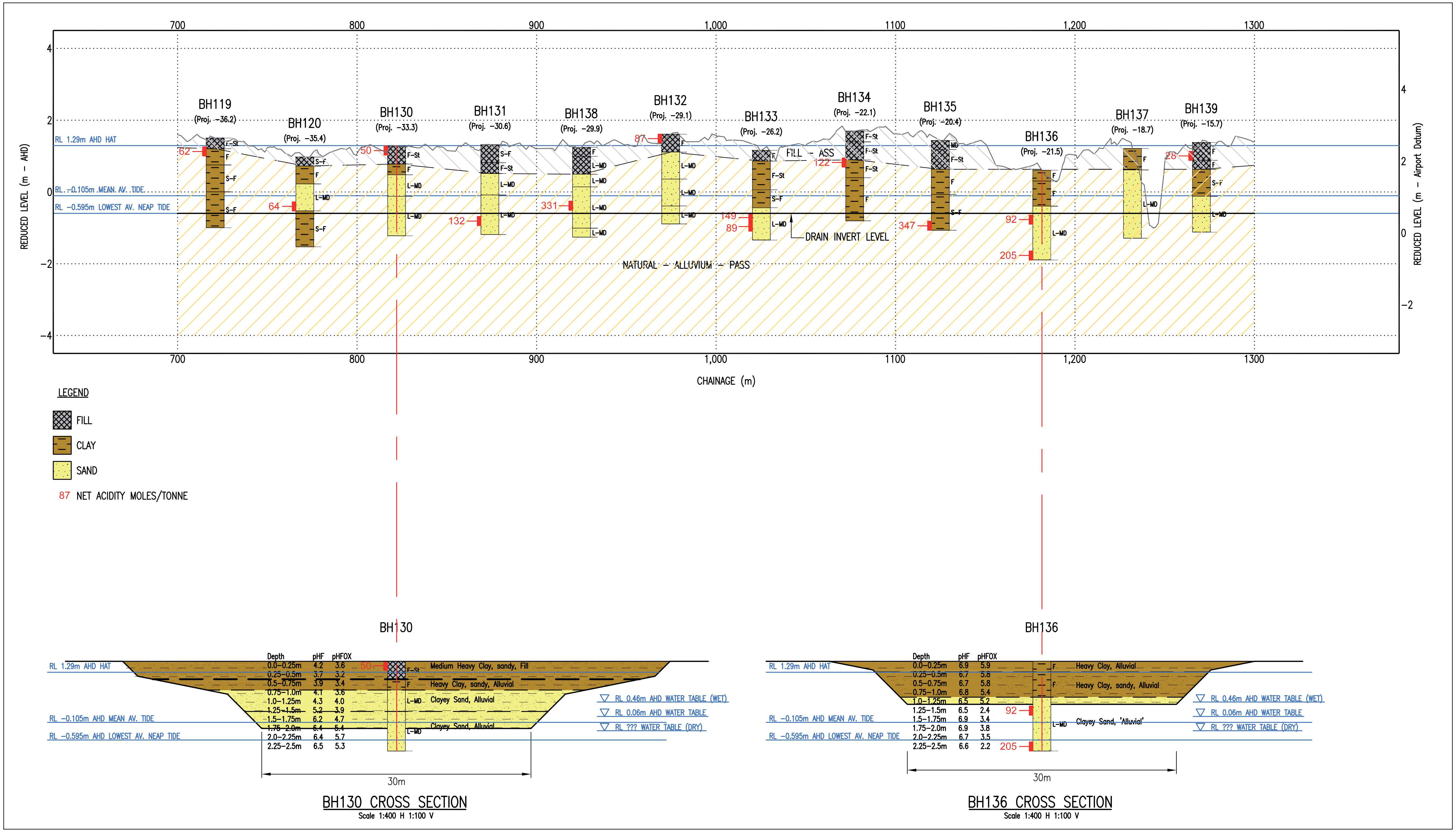
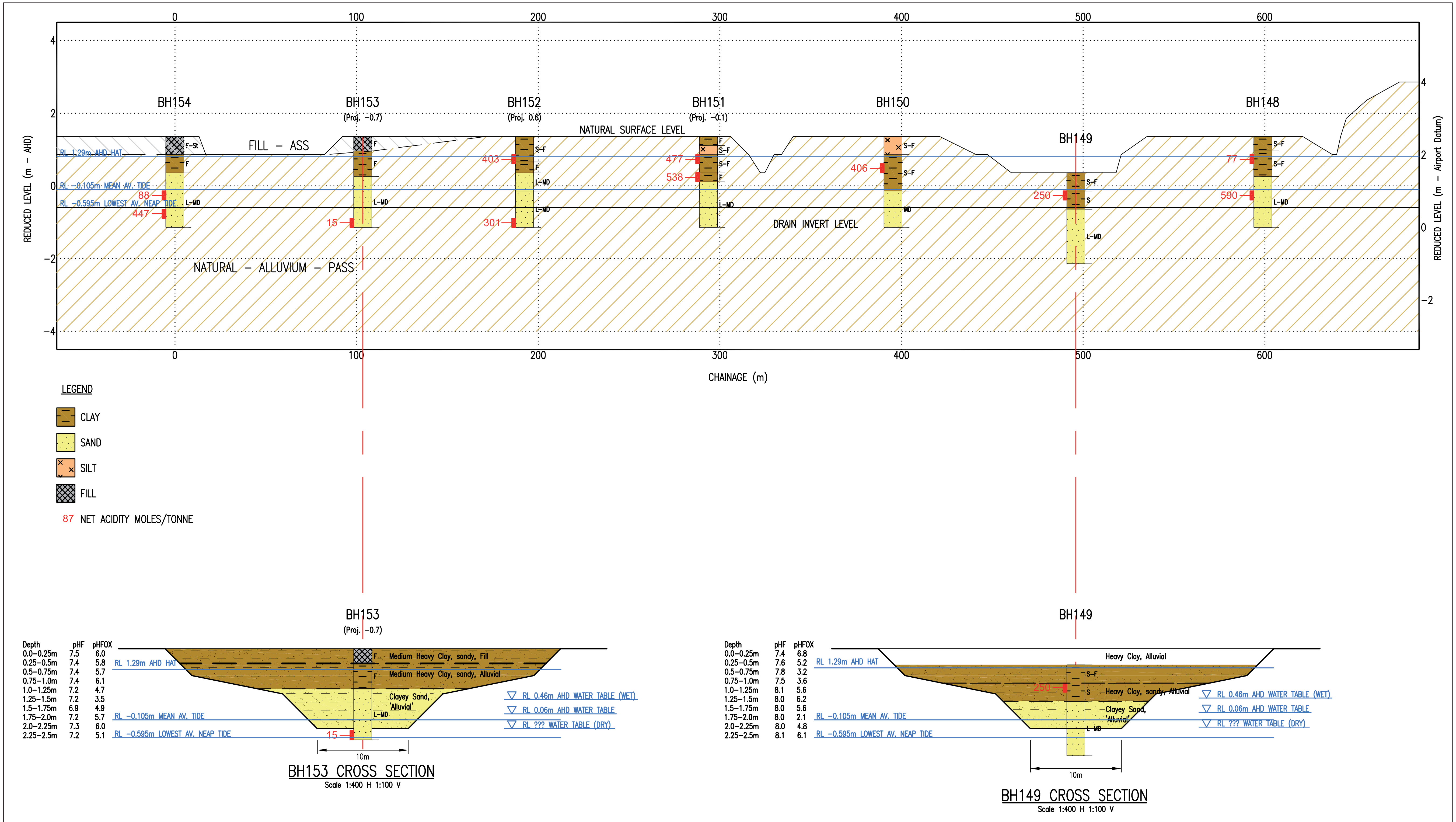


Figure 3.2f: *Vertical Sections – Showing Distribution of ASS/PASS.*



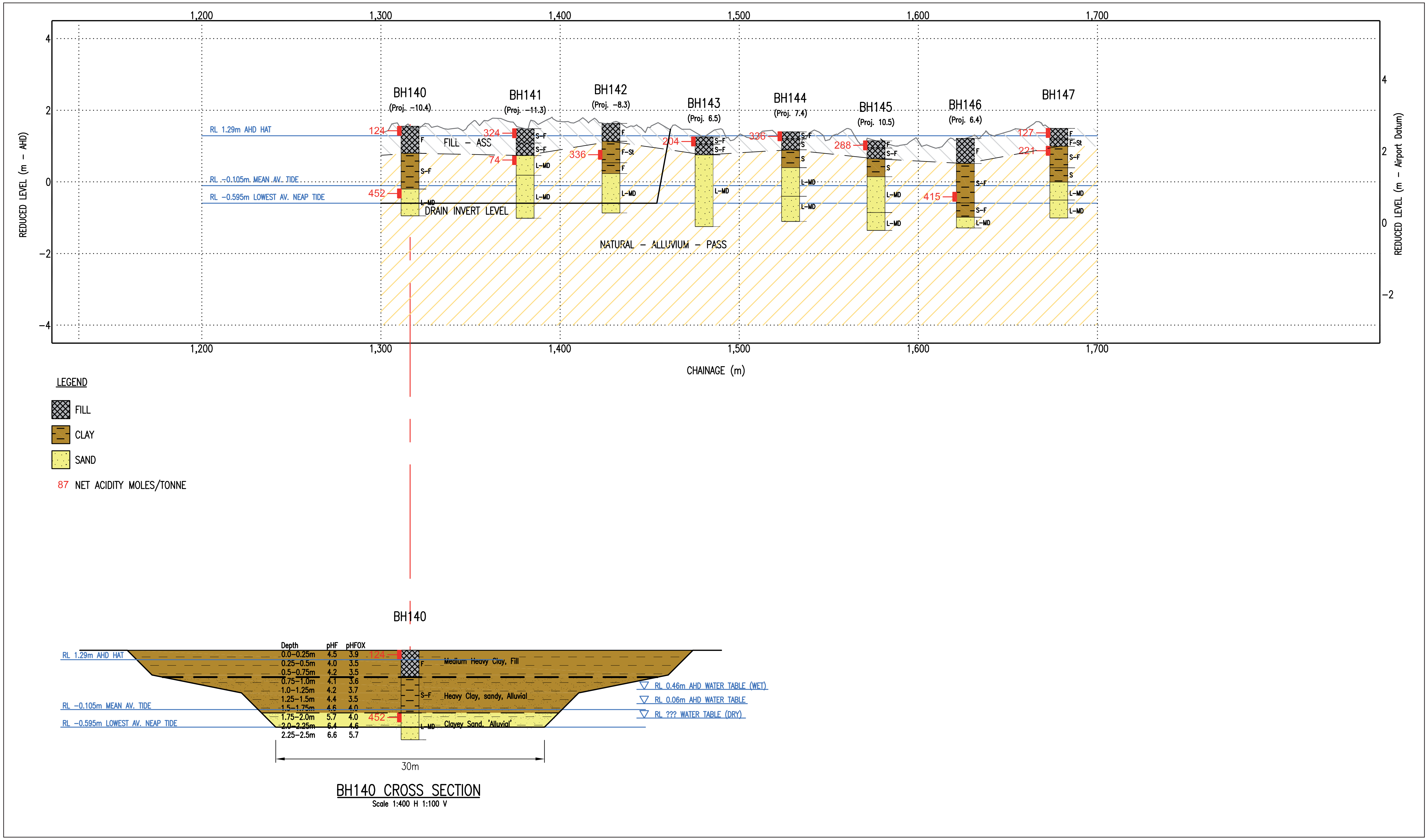
NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

Figure 3.2g: *Vertical Sections – Showing Distribution of ASS/PASS.*



NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

Figure 3.2h: *Vertical Sections – Showing Distribution of ASS/PASS.*



NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

Figure 3.2i: Vertical Sections – Showing Distribution of ASS/PASS.

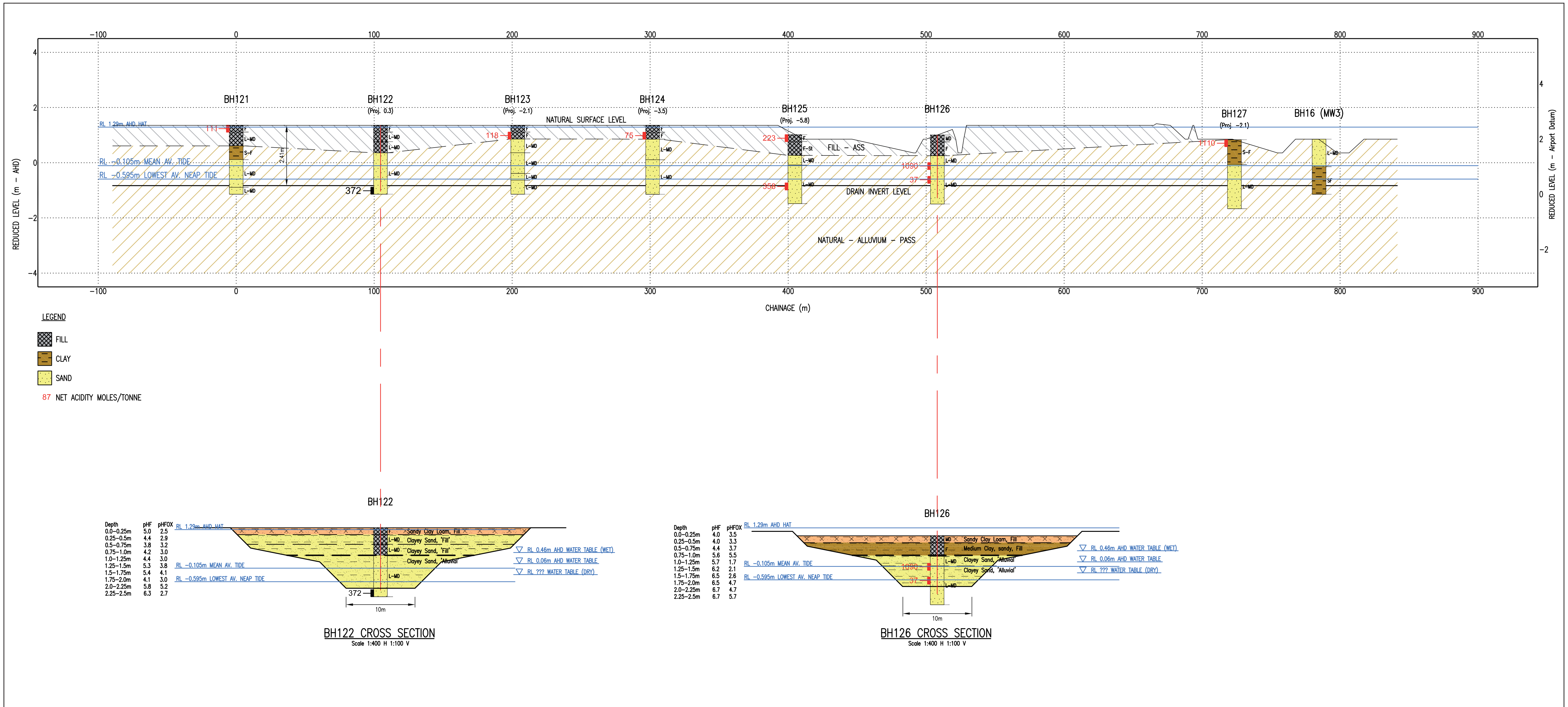
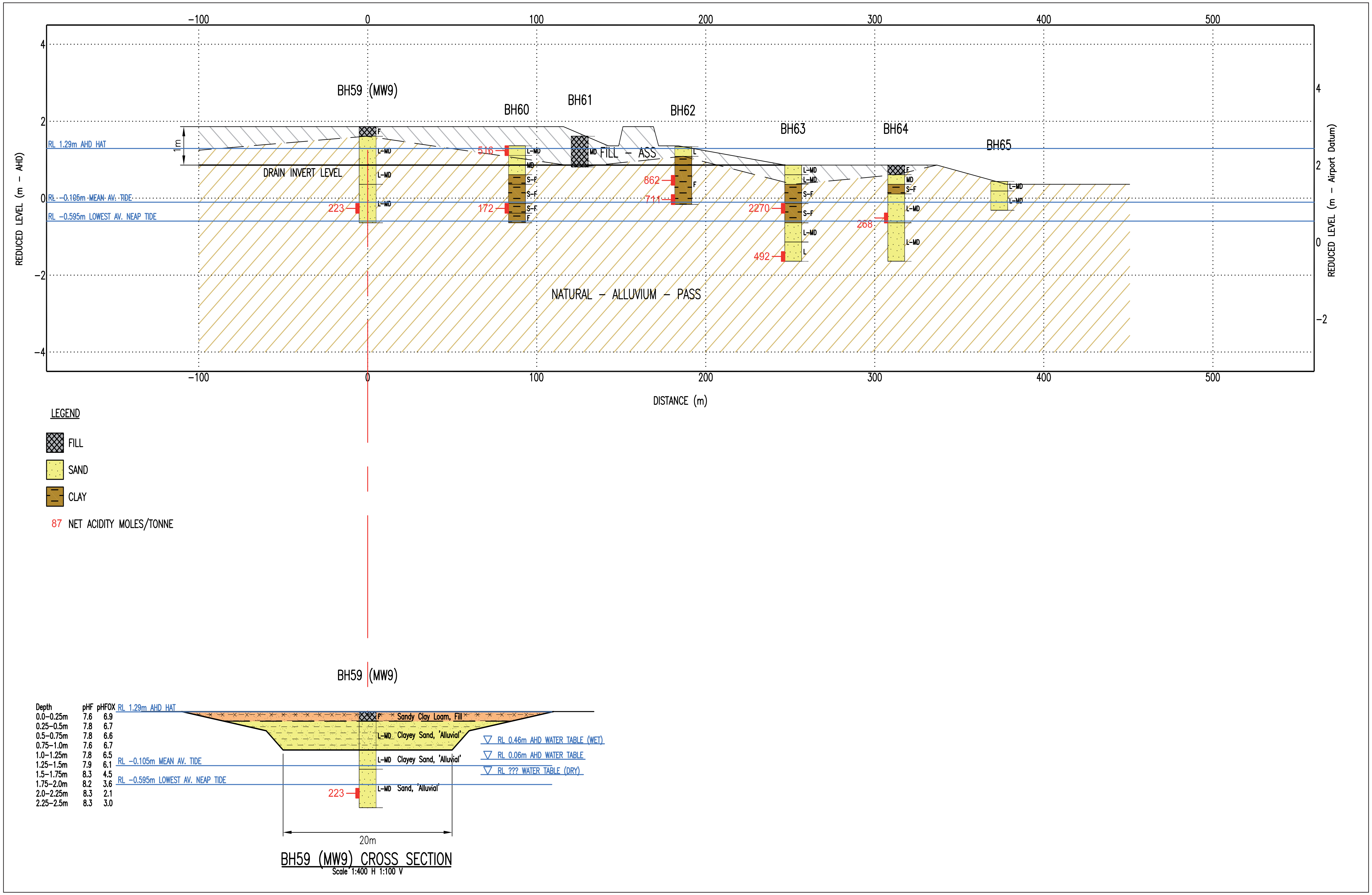
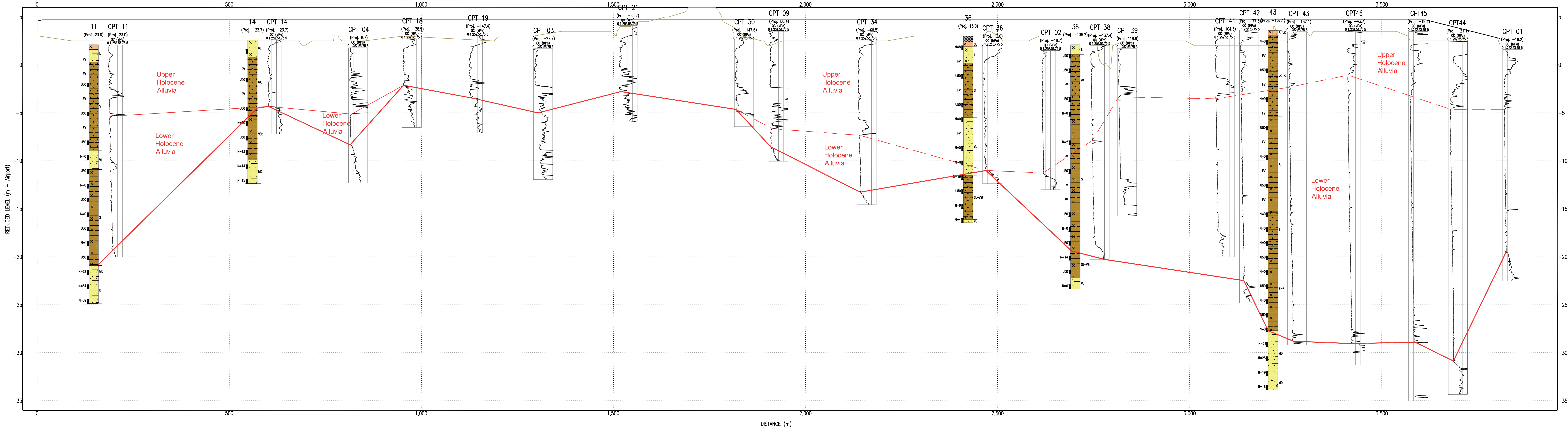


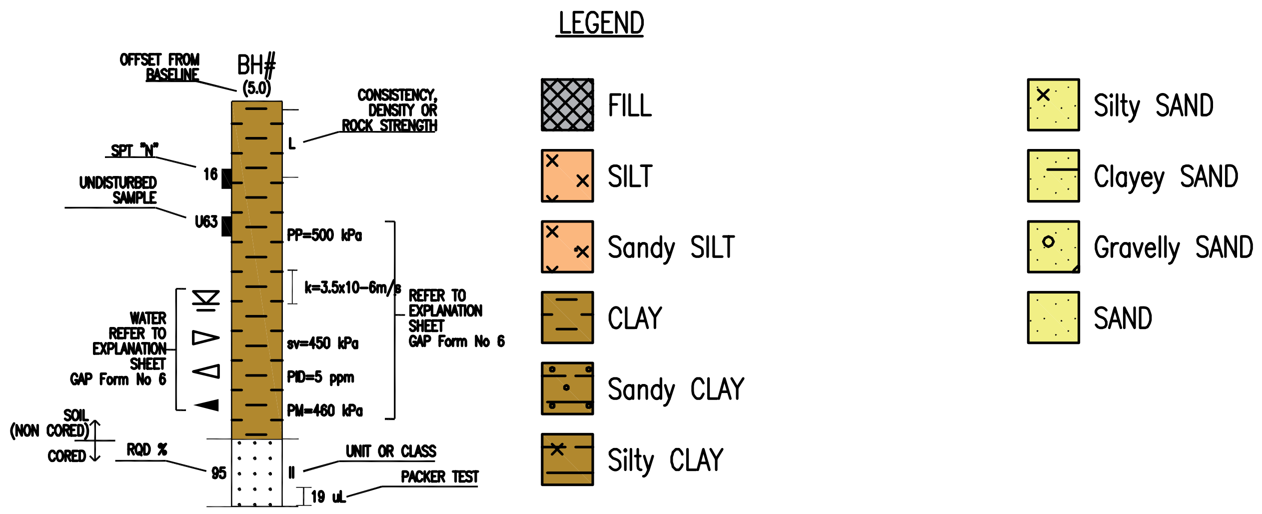
Figure 3.2j: *Vertical Sections – Showing Distribution of ASS/PASS.*



NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

Figure 3.2k: Distribution of Upper and Lower Holocene Alluvium along Runway.





3.2.5 Contaminated Soils

An assessment of potentially contaminated soils was carried out as part of the EIS/MDP process. This included a desktop based Preliminary Site Investigation (PSI) and carrying out specific sampling and analysis programs in areas identified as potentially containing contaminated soil.

3.2.5.1 Preliminary Site Assessment

The PSI, of the proposed development area was conducted as part of the investigation of baseline conditions. The PSI report is included in its entirety in **Appendix C**. The PSI comprised a preliminary document review of existing past and current contaminated sites within the Brisbane Airport.

A review of BAC's Contaminated Sites Register which was initially developed following detailed investigations of the site at the time of the purchase by BAC of the long term operating lease from the Australian Government in 1997 indicated that six sites are located within or in close proximity to the development area (**Figure 3.2l**), these being:

- Site 11 – Northern end of cross runway;
- Site 20 – In the FAFA (Cribb Island);
- Site 23 – Northern end of cross runway;
- Site 26 – East of cross runway;
- Site 31 – Behind domestic terminal; and
- Site 32 – East of the site (edge of Moreton Bay).

According to the Brisbane Airport Contaminated Site Register which is reproduced in the Brisbane Airport Environment Strategy (AES) (2004), **Appendix 3**, the current status of the six mentioned sites is complete, indicating that sufficient work was undertaken to declare the sites inactive prior to the handover of the Airport site to BAC.

In order to ensure these sites would not pose an environmental risk in light of the proposed works further investigation was undertaken. The sites were targeted for detailed document review of the relevant site contamination and site remediation reports. Contaminants of interest which may be associated with the sites include hydrocarbons and general waste.

Site 23, a former Bus Maintenance Depot and Site 11, a former community rubbish dump are situated near the northern end of the proposed runway. The area has been filled over to a depth of approximately 2 m with sand fill. However, the area may be subjected to vacuum settlement treatment and groundwater discharged from this area will need to be monitored for the presence of hydrocarbons and other potential contaminants, temporarily contained, and treated to remove any contamination found to be present (refer to the PSI report in **Appendix C**).

In addition to the sites identified in BAC's Contaminated Site Register, two other sites were considered and targeted for specific sampling and analysis:

- The former dredge spoil handling area for the construction of the Kedron Brook Floodway in the 1980s; and
- Fill materials along the proposed alignment of the KBF Drain.

Field Sampling and Analysis Program

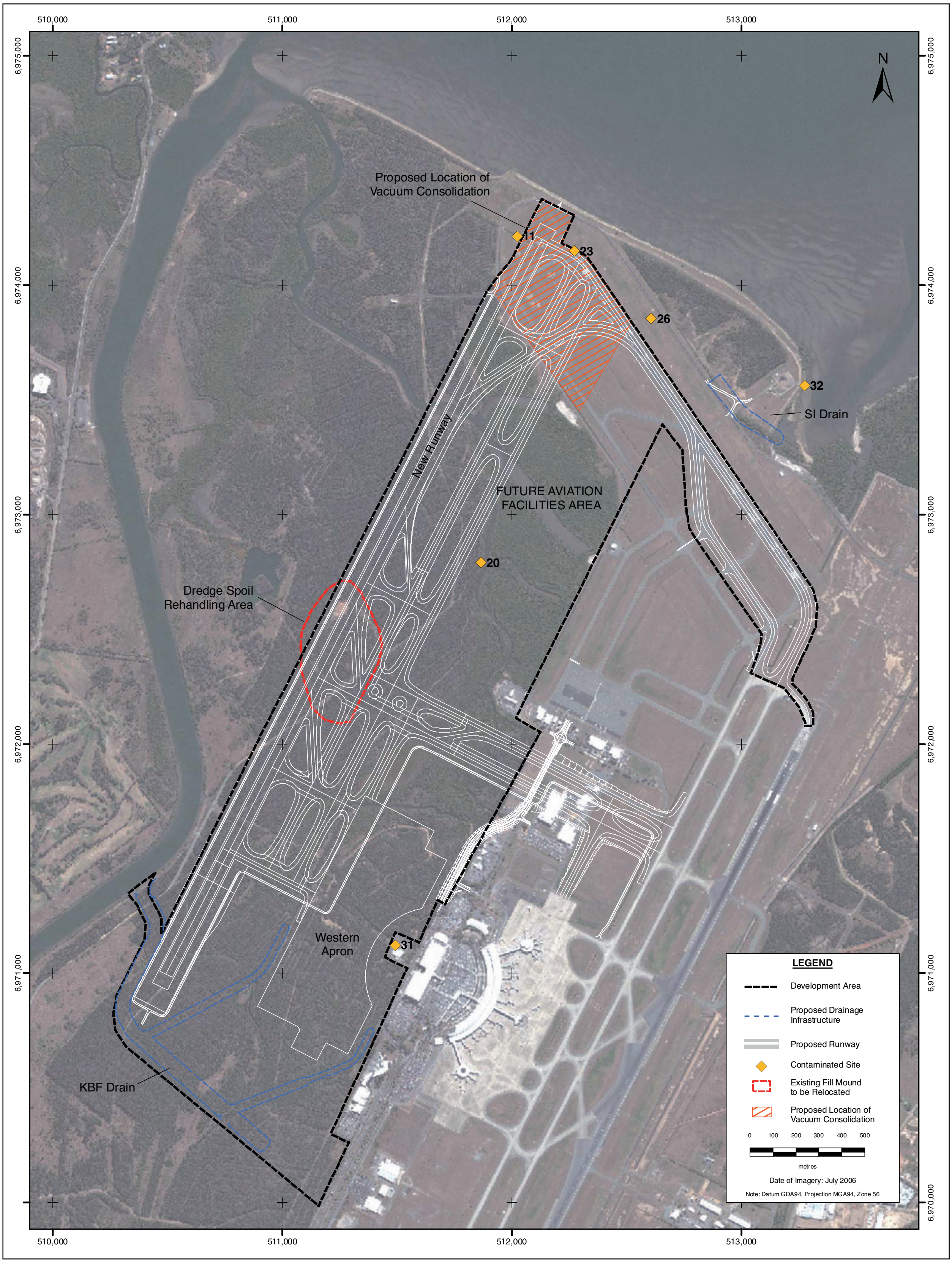
A field sampling plan was developed for the two areas of fill. The aim of the sampling plan was to undertake sufficient sampling and analysis to evaluate, any contamination present in the fill materials of unknown origin(s) and to enable establishment of an appropriate level of protection of ecological values and human health for the proposed land use.

The following sampling and analysis program was carried out by Golder for the initial investigation. Given that no specific sources of contamination were identified. A general screen of possible contaminants of concern was adopted.

Former Dredge Spoil Handling Area

(Samples were recovered from 20 boreholes distributed in an area of approximately 10 ha, containing the fill mound (**Figure 3.2d**). The fill varied from less than 0.5 m to 2.5 m thick.

Figure 3.2l: *Location of Former Contaminated Sites In Development Area.*



Samples were recovered at approximately 0.8–1.0 m intervals through the fill and from the fill and the top of underlying natural strata. On average two or three samples of fill from each location were analysed first and the samples of natural soil retained pending results of analysis. As no high concentrations of the contaminants of concern were detected in the fill, the samples of natural soils were not analysed.

Analysis comprised the follow contaminants of concern:

- Heavy Metals (11 metals including Arsenic and Mercury) – 58 samples;
- OC Pesticides – 58 Samples;
- Organo-Tins (including Tributyl-Tin) – 58 samples; and
- Phenols – 58 samples.

Fill along the KBF Drain Alignment

During ASS sampling along the drain alignment, samples were recovered from all boreholes where fill was detected. Samples were recovered from the fill and the top of underlying natural strata and boreholes were generally spaced at 50 m intervals along the drain alignment.

Fill samples were analysed first and the samples of natural soil retained pending results of analysis. As no high concentrations of the contaminants of concern were detected in the fill, the samples of underlying natural soil were not analysed. In addition to pesticides and metals, analysis for hydrocarbons and BTEX/PAH was included where traces of ash were detected.

Analysis comprised:

- Heavy Metals (eight common metals including Arsenic and Mercury) – 36 samples;
- OC Pesticides – 36 Samples; and
- TPH/BTEX and Polycyclic-Aromatic Hydrocarbons (PAH) – three samples.

3.2.5.2 Results of Contaminated Soils Analysis

Results of all soil analysis undertaken are summarised in **Tables 3.2g** and **3.2h**.

When assessing elevated concentrations of analytes, comparison was made to the following:

- Queensland EPA Environmental and Health-based Investigation Limits (EIL and HIL, respectively). An exposure setting of F which is suitable for industrial/commercial sites with limited opportunity for contact with soils was adopted for the HIL (i.e. HIL F);
- AEPR, Accepted Limits for both Environmentally Sensitive and General Airport Areas.

Former Dredge Spoil Handling Area

Fifty-eight samples of fill (originating from construction of the Kedron Brook Floodway in the 1980s) and some samples of the underlying natural alluvium were analysed for a range of contaminants of concern, including OC/OP Pesticides, heavy metals and Organo-Tin compounds. All samples analysed returned analyte concentrations below HIL-F and AEPR Accepted Limits for General Airport Areas (listed in Schedule 3 – Soil Pollution – Table 1).

Twenty-four samples exceeded the Qld EPAs EIL, but not the AEPR Accepted Limits for "Areas of an Airport Generally"

The highest concentrations of these particular analytes are as follows:

- Arsenic – in BH172 1.0-1.2 m (31 mg/kg);
- Copper – in BH170 1.0-1.2 m (106 mg/kg);
- Chromium – in BH165 0.0-0.2 m (227 mg/kg); and
- Nickel – in BH171 1.0-1.2 m (145 mg/kg).

One sample from BH163 1.0-1.2m contained an elevated concentration of the C29-C36 TPH fraction (1,490 mg/kg) which exceeds the Queensland EPA adopted EIL. There are no AEPR Accepted Limits for this particular TPH fraction, however the total TPH (all fractions) is <2,352 mg/kg and does not exceed the AEPR Accepted Limit of 5,000 mg/kg.

One sample from BH172 (1.0-1.2 m – 0.27 mg/kg) marginally exceeded the Queensland EPAs EIL for Dieldrin and Aldrin (combined).

KBF Drain Fill Area

In total, thirty six samples of fill sampled from along the proposed KBF Drain alignment were analysed for a range of contaminants of concern. All samples returned analyte concentrations below HIL-F and AEPR Accepted Limits for General Airport Areas (listed in Schedule 3 – Soil Pollution – Table 1).

Six samples exceeded the Queensland EPA EIL. These were:

- Arsenic – in BH116 0.0-0.2 m (34 mg/kg);
- Nickel – in BH125 0.0-0.2 m (69 mg/kg); and
- Zinc – in BH144 0.0-0.25 m (254 mg/kg).

EIL and AEPR Accepted Limits for Areas of Environmental Significance have the same exceedence trigger for Arsenic, Nickel and Zinc. Organo-Tins were included in the analyte screen (though not listed in the Queensland EPA Guidelines or AEPR), as the fill in the former dredge spoil handling area may have contained bottom sediments from the Brisbane River or Kedron Brook, that may have contained a build up of Organo-Tin compounds associated with marine anti-fouling surface coatings.

Table 3.2g: Summary of Analytical Testing – Dredge Spoil Rehandling Area.

Sample Location (Depth in m)	Description	TPH				OTC	OC Pesticides				Other Organics			METALS and Other Inorganics											Sample	Date
		C_6-C_9	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}	TBT (µgSn/kg)	Heptachlor*	Dieldrin and Aldrin	DDT	DDE and DDD	PAH* (Total)	B.a.P	Phenol	Al	Sb	As	Cd	Cr	Cu	Pb	Ni	Ag	Zn	Hg	Date	to Lab
DREDGE SPOIL AREA																										
BH157 0.0-0.2	Loamy Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	10,200	<5	<5	<1	28	43	23	**82**	<2	64	<0.1	12/12/2005	15/12/2005
BH157 1.0-1.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	5,470	<5	5	<1	27	6	<5	4	<2	13	<0.1	12/12/2005	15/12/2005
BH157 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,210	<5	<5	<1	21	7	<5	20	<2	41	0.2	12/12/2005	15/12/2005
BH158 0.0-0.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	16,200	<5	14	<1	34	15	12	30	<2	76	<0.1	12/12/2005	15/12/2005
BH158 1.0-1.2	Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	6,940	<5	7	<1	31	6	<5	5	<2	21	<0.1	12/12/2005	15/12/2005
BH158 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	8,560	<5	8	<1	23	9	<5	37	<2	46	<0.1	12/12/2005	15/12/2005
BH159 0.0-0.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	16,800	<5	5	<1	**57**	50	8	46	<2	64	<0.1	12/12/2005	15/12/2005
BH159 1.0-1.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	8,820	<5	11	<1	31	6	6	5	<2	21	<0.1	12/12/2005	15/12/2005
BH159 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,690	<5	6	<1	21	7	<5	23	<2	37	<0.1	12/12/2005	15/12/2005
BH160 0.0-0.2	Loamy Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	0.65	--	--	<0.5	18,800	<5	13	<1	37	43	21	**81**	<2	71	<0.1	12/12/2005	15/12/2005
BH160 1.0-1.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	22,400	<5	17	<1	35	20	15	37	<2	60	<0.1	12/12/2005	15/12/2005
BH160 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	8,320	<5	<5	<1	26	10	<5	4	<2	17	<0.1	12/12/2005	15/12/2005
BH161 0.0-0.2	Loamy Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	10,400	<5	11	<1	33	15	7	20	<2	28	<0.1	12/12/2005	15/12/2005
BH161 1.0-1.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	22,800	<5	**21**	<1	**53**	27	10	20	<2	38	<0.1	12/12/2005	15/12/2005
BH161 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	6,540	<5	<5	<1	32	11	6	3	<2	11	<0.1	12/12/2005	15/12/2005
BH162 0.0-0.2	Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	15,800	<5	7	<1	**63**	51	7	42	<2	62	<0.1	12/12/2005	15/12/2005
BH162 1.0-1.2	Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	13,900	<5	13	<1	45	12	5	8	<2	40	<0.1	12/12/2005	15/12/2005
BH163 0.0-0.2	Loamy Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	11,500	<5	<5	<1	34	40	<5	**104**	<2	58	<0.1	12/12/2005	15/12/2005
BH163 1.0-1.2	Clayey Loam	<2	100	760	**1,490**	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	15,300	<5	11	<1	20	20	17	29	<2	54	<0.1	12/12/2005	15/12/2005
BH163 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	5,930	<5	5	<1	27	6	6	3	<2	12	<0.1	12/12/2005	15/12/2005
BH164 0.0-0.2	Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,000	<5	<5	<1	**88**	30	<5	5	<2	7	<0.1	13/12/2005	15/12/2005
BH164 1.0-1.2	Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,380	<5	<5	<1	26	10	<5	19	<2	31	<0.1	13/12/2005	15/12/2005
BH164 2.0-2.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	23,400	<5	10	<1	**59**	52	8	**103**	<2	86	<0.1	13/12/2005	15/12/2005
BH165 0.0-0.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	6,770	<5	<5	<1	**227**	**84**	<5	40	<2	23	<0.1	13/12/2005	15/12/2005
BH165 1.0-1.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,790	<5	<5	<1	**88**	33	<5	6	<2	10	<0.1	13/12/2005	15/12/2005
BH165 2.0-2.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	9,290	<5	9	<1	24	10	<5	26	<2	69	<0.1	13/12/2005	15/12/2005
BH165 2.75-3.0	Medium Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	17,600	<5	16	<1	35	40	15	22	<2	72	<0.1	13/12/2005	15/12/2005
BH166 0.0-0.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	9,310	<5	<5	<1	**57**	37	<5	39	<2	36	<0.1	13/12/2005	15/12/2005
BH166 1.0-1.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	19,600	<5	16	1	**54**	50	9	**139**	<2	119	<0.1	13/12/2005	15/12/2005
BH166 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	6,660	<5	<5	<1	30	8	<5	4	<2	15	<0.1	13/12/2005	15/12/2005
BH167 0.0-0.2	Loamy Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	5,700	<5	6	<1	20	9	<5	37	<2	27	<0.1	12/12/2005	15/12/2005
BH167 1.0-1.2	Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	9,520	<5	<5	<1	43	53	<5	48	<2	79	<0.1	12/12/2005	15/12/2005
BH168 0.0-0.2	Light Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	10,100	<5	<5	<1	**73**	33	<5	18	<2	35	<0.1	12/12/2005	15/12/2005
BH168 1.0-1.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	8,700	<5	<5	<1	38	18	<5	25	<2	41	<0.1	12/12/2005	15/12/2005
BH169 0.0-0.2	Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	15,400	<5	6	<1	47	**80**	7	59	<2	91	<0.1	13/12/2005	15/12/2005
BH169 1.0-1.2	Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	19,100	<5	7	<1	**56**	**92**	5	**123**	<2	140	<0.1	13/12/2005	15/12/2005
BH169 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,360	<5	<5	<1	22	5	<5	4	<2	16	<0.1	13/12/2005	15/12/2005
BH170 0.0-0.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	17,600	<5	12	<1	**53**	40	9	56	<2	74	<0.1	14/12/2005	15/12/2005
BH170 1.0-1.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	18,200	<5	6	<1	**59**	**106**	5	**75**	<2	116	<0.1	14/12/2005	15/12/2005
BH170 2.0-2.2	Clayey Sand	<2	70	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,700	<5	10	<1	30	11	5	5	<2	19	<0.1	13/12/2005	15/12/2005
BH171 0.0-0.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	13,700	<5	6	<1	48	49	6	50	<2	74	<0.1	14/12/2005	15/12/2005

NEW PARALLEL RUNWAY DRAFT EIS/MDP
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NEW PARALLEL RUNWAY DRAFT EIS/MDP
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Sample Location (Depth in m)	Description	TPH				OTC	OC Pesticides				Other Organics			METALS and Other Inorganics											Sample Date	Date to Lab
		C_{6}-C_{9}	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}	TBT (µgSn/kg)	Heptachlor*	Dieldrin and Aldrin	DDT	DDE and DDD	PAH* (Total)	B.a.P	Phenol	Al	Sb	As	Cd	Cr	Cu	Pb	Ni	Ag	Zn	Hg		
BH171 1.0-1.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	22,300	<5	7	<1	**64**	**79**	5	**145**	<2	159	<0.1	14/12/2005	15/12/2005
BH171 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,750	<5	7	<1	26	7	8	4	<2	14	<0.1	14/12/2005	15/12/2005
BH172 0.0-0.2	Loamy Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	13,300	<5	<5	<1	**55**	49	7	44	<2	58	<0.1	14/12/2005	15/12/2005
BH172 1.0-1.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	**0.27**	<0.2	0.75	--	--	<0.5	13,400	<5	**31**	<1	26	**70**	20	20	<2	58	<0.1	14/12/2005	15/12/2005
BH172 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	6,940	<5	5	<1	22	<5	<5	6	<2	20	<0.1	14/12/2005	15/12/2005
BH173 0.0-0.2	Light Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	10,400	<5	<5	<1	**64**	34	6	18	<2	39	<0.1	14/12/2005	15/12/2005
BH173 1.0-1.2	Light Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	9,120	<5	<5	<1	40	27	<5	23	<2	37	<0.1	14/12/2005	15/12/2005
BH173 2.0-2.2	Light Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	20,200	<5	8	<1	**61**	**84**	5	**130**	<2	155	<0.1	14/12/2005	15/12/2005
BH174 0.0-0.2	Medium Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	11,100	<5	<5	<1	39	24	6	30	<2	40	<0.1	14/12/2005	15/12/2005
BH174 1.0-1.2	Light Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	10,200	<5	<5	<1	44	28	5	32	<2	48	<0.1	14/12/2005	15/12/2005
BH174 2.0-2.2	Heavy Clay	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	1.03	--	--	<0.5	17,000	<5	15	<1	33	39	17	18	<2	63	<0.1	14/12/2005	15/12/2005
BH175 0.0-0.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	14,600	<5	8	<1	43	42	9	**64**	<2	71	0.3	14/12/2005	15/12/2005
BH175 1.0-1.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	5,970	<5	6	<1	27	6	<5	4	<2	20	<0.1	14/12/2005	15/12/2005
BH175 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	7,940	<5	15	<1	25	10	<5	28	<2	57	<0.1	14/12/2005	15/12/2005
BH176 0.0-0.2	Clayey Loam	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	23,400	<5	**21**	<1	29	19	6	48	<2	70	<0.1	14/12/2005	15/12/2005
BH176 1.0-1.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	4,850	<5	8	<1	32	6	<5	3	<2	18	<0.1	14/12/2005	15/12/2005
BH176 2.0-2.2	Clayey Sand	<2	<50	<100	<100	<0.5	<0.05	<0.1	<0.2	<0.1	--	--	<0.5	6,900	<5	5	<1	22	8	<5	22	<2	74	<0.1	14/12/2005	15/12/2005
Environmental Investigation Levels (mg/kg)		100	100	1,000	1,000	--	--	0.2	0.2	--	--	--	--	--	20	20	3	50	60	300	60	--	200	1.0	56 Samples	
Airports (EP) Regulations [AL] - Significant Areas (mg/kg)		100	--	--	--	--	--	0.25	0.97	--	5	--	0.5	--	20	20	3	50	60	300	60	--	200	1.0		
Airports (EP) Regulations [AL] - General Areas (mg/kg)		800	--	--	--	--	50	20	1,000	--	100	5	42,500	--	--	500	100	60%	5,000	1,500	3000	--	35,000	75		
Health Based Investigation Levels 'F' (mg/kg)		100	--	--	--	--	50	50	1,000	--	100	5	42,500	--	--	500	100	60%	5,000	1,500	3000	--	35,000	75		

All Concentrations are expressed in mg/kg (except OTC)
** No EIL listed in EPA Draft Guidelines - denotes EIL adopted by Qld EPA*
*** Denotes currently no Investigation Limits in EPA Draft Guidelines*
(**) Denotes that SVOC/VOC analysis has been untertaken and no detectable concentrations found.
BTEX - Benzene, Toluene, Ethylene and Xylene
TPH - Total Petroleum Hydrocarbons
PAH - Poly-aromatic Hydrocarbonc
B.a.P - Benzo (a) Pyrene (adopted PAH Indicator)
OTC - Organo-tin Compounds

Values in **Bold** exceed the EIL for that substance
Values in **Bold** exceeds Aiprorts (EP) Regulation – Areas of Environmental Significance Acceptable Limits for that substance
Values in **Bold** exceeds Aiprorts (EP) Regulation – General Areas Acceptable Limits for that substance
Values in **Bold** exceed the HIL 'F' for that substance

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Table 3.2h: Summary of Analytical Testing – KBF Drain FIll Area.

Sample Location (Depth in m)	Description	BTEX				TPH				OC Pesticides				Other Organics			METALS and Other Inorganic Substances													Sample Date	Date to Lab
		Benzene	Ethylbenzene	Toluene	Xylene	C_{6}-C_{9}	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}	Heptachlor*	Dieldrin and Aldrin	DDT	DDE and DDD	PAH* (Total)	B.a.P	Phenol	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Mn	Ni	Vn	Zn	Hg		
KEDRON BROOK FLOODWAY FILL AREA																															
BH107 0-0.2	Medium Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	**25**	10	<1	<1	42	4	8	7	24	7	116	30	<0.1	9/6/05	9/9/05
BH108 0-0.2	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	13	30	2	<1	39	15	20	13	<5	38	59	67	<0.1	9/6/05	9/9/05
BH109 0-0.2	Medium Heavy Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	**28**	30	5	<1	40	10	30	15	<5	43	86	56	<0.1	9/6/05	9/9/05
BH111 0-0.2	Loamy Sand - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	7	20	<1	<1	26	12	12	8	174	18	41	37	<0.1	9/6/05	9/9/05
BH111 0.5-0.6	Medium Clay - Fill	<0.2	<0.2	<0.2	<0.4	<2	<50	<100	<100	<0.05	<0.1	<0.2	<0.1	<8	<0.5	- - -	12	160	<1	<1	20	14	21	19	84	26	39	59	<0.1	9/6/05	9/9/05
BH112 0-0.2	Loamy Sand - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	18	40	<1	<1	35	7	15	21	32	18	67	37	<0.1	9/6/05	9/9/05
BH113 0.0-0.2	Medium Heavy Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	11	40	<1	<1	31	15	19	20	488	37	44	51	<0.1	9/6/05	9/9/05
BH114 0.0-0.2	Medium Heavy Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	18	20	<1	<1	26	4	9	37	34	8	48	21	<0.1	9/6/05	9/9/05
BH115 0.0-0.2	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	**24**	20	<1	<1	31	4	8	54	19	8	52	19	<0.1	9/6/05	9/9/05
BH116 0.0-0.2	Clayey Sand - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	**34**	30	<1	<1	33	4	10	78	46	11	58	32	<0.1	9/6/05	9/9/05
BH118 0-0.25	Medium Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	11	20	<1	<1	32	13	16	8	73	23	50	43	<0.1	9/5/05	9/9/05
BH119 0-0.25	Medium Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	7	20	<1	<1	37	10	14	7	151	21	51	37	<0.1	9/5/05	9/9/05
BH120 0-0.25	Sandy Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	8	20	<1	<1	34	23	14	8	416	41	48	50	<0.1	9/5/05	9/9/05
BH121 0-0.2	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	9	40	<1	<1	37	12	16	24	121	24	66	72	<0.1	9/6/05	9/9/05
BH122 0-0.2	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	0.7	- - -	- - -	- - -	15	40	<1	<1	32	10	29	42	73	17	57	57	<0.1	9/6/05	9/9/05
BH123 0.0-0.2	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	0.38	- - -	- - -	- - -	18	40	<1	<1	40	13	22	26	360	26	77	63	<0.1	9/6/05	9/9/05
BH124 0-0.2	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.13	- - -	- - -	- - -	16	20	1	<1	39	13	21	18	82	26	70	62	<0.1	9/6/05	9/9/05
BH125 0.0-0.2	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	8	30	1	<1	33	22	31	12	122	**69**	50	74	<0.1	9/6/05	9/9/05
BH126 0-0.25	Loamy Sand - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	8	10	<1	<1	27	11	12	8	149	15	42	50	<0.1	9/6/05	9/9/05
BH130 0.0-0.25	Medium Heavy Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	12	20	1	<1	34	11	16	16	79	32	64	71	<0.1	9/5/05	9/9/05
BH131 0.0-0.25	Sandy Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	11	20	<1	<1	35	8	13	9	41	17	68	65	<0.1	9/5/05	9/9/05
BH132 0-0.25	Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	7	20	1	<1	23	16	14	20	122	37	37	65	<0.1	9/2/05	9/9/05
BH133 0-0.25	Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	10	30	1	<1	34	13	18	13	112	29	54	54	<0.1	9/1/05	9/9/05
BH134 0-0.25	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	7	20	<1	<1	29	13	13	7	213	21	47	34	<0.1	9/1/05	9/9/05
BH135 0.0-0.25	Clayey Sand - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	6	20	<1	<1	27	11	10	7	129	17	39	31	<0.1	9/1/05	9/9/05
BH138 0-0.25	Sandy Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	<5	10	<1	<1	32	4	6	7	24	8	55	28	<0.1	9/5/05	9/9/05
BH139 0-0.25	Medium Heavy Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	8	30	<1	<1	33	10	15	9	70	16	52	43	<0.1	9/2/05	9/9/05
BH140 0-0.25	Medium Heavy Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	6	30	<1	<1	35	9	18	12	89	19	54	48	1.0	9/2/05	9/9/05
BH141 0.0-0.25	Medium Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	12	50	<1	<1	38	11	22	14	91	22	60	53	<0.1	9/2/05	9/9/05
BH142 0-0.25	Medium Heavy Clay - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	7	40	<1	<1	38	7	9	10	68	12	44	32	<0.1	9/2/05	9/9/05
BH143 0-0.25	Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	12	40	<1	<1	34	14	25	19	134	31	42	63	<0.1	9/2/05	9/9/05
BH144 0-0.25	Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	19	30	1	<1	37	18	14	12	106	26	62	**254**	<0.1	9/2/05	9/9/05
BH146 0-0.25	Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	19	50	4	<1	33	12	30	25	60	56	52	159	<0.1	9/2/05	9/9/05
BH147 0-0.25	Clay Loam - Fill	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	<0.05	<0.1	<0.2	<0.1	- - -	- - -	- - -	13	50	<1	<1	38	11	19	18	40	28	67	54	<0.1	9/2/05	9/9/05
BH128 0-0.25	Sandy Loam - Fill	<0.2	<0.2	<0.2	<0.4	<2	<50	<100	<100	<0.05	<0.1	<0.2	<0.1	<8	<0.5	- - -	<5	30	<1	<1	13	4	14	12	91	6	26	30	<0.1	9/7/05	9/9/05
BH129 0-0.25	Sand - Fill	<0.2	<0.2	<0.2	<0.4	<2	<50	<100	<100	<0.05	<0.1	<0.2	<0.1	<8	<0.5	- - -	<5	10	<1	<1	<2	<2	<5	<5	73	<2	<5	<5	<0.1	9/7/05	9/9/05
Environmental Investigation Levels (mg/kg)		1	--	--	--	100	100	1,000	1,000	--	0.2	0.2	--	--	--	--	20	--	--	3	50	--	60	300	500	60	--	200	1.0	34 Samples	
Airports (EP) Regulations [AL] - Significant Areas (mg/kg)		0.5	5	3	5	100	--	--	--	--	0.25	0.97	--	5	--	0.5	20	200	--	3	50	170	60	300	500	60	--	200	1.0		
Airports (EP) Regulations [AL] - General Areas (mg/kg)		1	50	130	25	800	--	--	--	50	20	1,000	--	100	5	42,500	500	--	100	100	60%	--	5,000	1,500	7,500	3,000	--	35,000	75		
Health Based Investigation Levels 'F' (mg/kg)		--	--	--	--	100	--	--	--	50	50	1,000	--	100	5	42,500	500	--	100	100	60%	--	5,000	1,500	7,500	3,000	--	35,000	75		

All Concentrations are expressed in mg/kg
** No EIL listed in EPA Draft Guidelines - denotes EIL adopted by Qld EPA*
*** Denotes currently no Investigation Limits in EPA Draft Guidelines*
(**) Denotes that SVOC/VOC analysis has been untertaken and no detectable concentrations found.
BTEX - Benzene, Toluene, Ethylene and Xylene
TPH - Total Petroleum Hydrocarbons
PAH - Poly-aromatic Hydrocarbonc
B.a.P - Benzo (a) Pyrene (adopted PAH Indicator)

Values in **Bold** exceed the EIL for that substance

Values in **Bold** exceeds Aiprorts (EP) Regulation – Areas of Environmental Significance Acceptable Limits for that substance

Values in **Bold** exceeds Aiprorts (EP) Regulation – General Areas Acceptable Limits for that substance

Values in **Bold** exceed the HIL 'F' for that substance

3.3 Existing Environment of Runway Site – Groundwater

This section includes a description of existing groundwater system (on-airport), including direction of flow, water quality and depth to water table. Specific investigations have been carried out to characterise the groundwater system, the results of which have been supplemented by geotechnical and ASS investigations for the project. Limited information is available from regional groundwater monitoring that is recorded in the Department of Natural Resources and Water (DNRW) groundwater database.

3.3.1 Investigation Methodology

As part of preliminary ASS investigations, six monitoring wells were installed in March 2005 around the proposed runway site (MW1-MW6). These wells were later supplemented by three additional monitoring wells (MW7-MW9) installed during follow-up ASS investigations in August 2005. Monitoring well MW9 (located airside in the vicinity of the proposed SI Drain) was inadvertently destroyed by airport maintenance personnel in early 2006.

An additional seven monitoring wells (MW9a, MW10-MW15) were installed in July 2007. MW9a was installed as a replacement for MW9. Two extra wells (MW A and MW J) were installed in the Western Apron area in mid-2005 as part of broader investigations of the Airport.

Monitoring well positions are also shown on **Figure 3.2c** (parts 1 and 2) and details of monitoring well construction are provided in **Table 3.3a**. All monitoring wells are shallow wells that are screened in the more permeable Upper Holocene Alluvium, with the screen interval either across or just below the zone of water table fluctuation.

The wells were used for measuring groundwater levels and sampling and analysis of water quality parameters as part of ASS investigations. In situ falling head permeability testing was carried out in a number of wells. Water level dataloggers were installed in seven of the monitoring bores (MW1, MW2, MW3, MW4, MW5, MW6 and MW J), and programmed to record water levels at 15 minute intervals. Results are available for the period from November 2005 to July 2006.

These specific investigations have been supplemented by the information obtained from geotechnical field and laboratory testing for the project, and by information from the ASS investigations.

The details of these investigations are as follow:

- Geotechnical investigations comprised 37 cone penetrometer tests (CPTs) and 10 deep boreholes. These investigations provide information on the stratigraphy of the system, and provided samples of low permeability sediments for laboratory testing. Oedometer testing carried out on 28 such samples provided compressibility and permeability values.
- Previously discussed ASS investigations carried out for the project, comprising a total of 153 shallow boreholes drilled to depths of between 2 m and 4.5 m. These boreholes provide information on shallow stratigraphy, and also provide an indication of the likely range of historical water table fluctuations through measurements of insitu actual and potential acidity.

Information on the stratigraphy in the broader area is available from geotechnical investigations carried out in other areas of the Airport (again, comprising a combination of boreholes, CPTs and laboratory testing). From this previous work, seven CPTs and three boreholes are located in the areas where the new runway developments will interface with the existing Airport development. On a broader scale, stratigraphic information is available from hundreds of CPTs and boreholes.

Since one of the most significant impacts on groundwater as a result of the Airport development will be the increase in pore pressures and consequent groundwater flow as a result of surcharging, an important source of information is monitoring results from other sites which have been surcharged at the Airport. Settlement monitoring data is available from perhaps a dozen sites, which provides indirect data on the rate of pore pressure dissipation. Calibration of consolidation models to the results of settlement monitoring provides values for the parameters which control pore pressure dissipation. More detailed monitoring of pore pressure dissipation as well as settlement was carried out at the International Terminal site, where subsurface conditions are very similar to those found towards the northern end of the runway.

Table 3.3a Monitoring Well Construction Details.

Monitoring Well ID	Easting[1]	Northing	Surface Elevation[2] (m AD)	Slotted Interval (m below surface)
MW1	512074	6971864	3.6	0.4 to 1.9
MW2	511491	6972100	2.9	0.4 to 1.9
MW3	511022	6971251	2.6	0.4 to 1.9
MW4	510635	6971496	2.7	0.4 to 1.9
MW5	511249	6972690	3.5	0.4 to 1.9
MW6	511658	6973545	2.9	0.4 to 2.53
MW7	510973	6972216	3.9	2.5 to 4
MW8	512500	6973085	2.2	0.4 to 1.9
MW9	512872	6973580	2.7	0.4 to 1.9
MW9a	512919	6973548	2.7	1.5 to 4.5
MW10	510811	6971914	3.0	1.5 to 4.5
MW11	511016	6972522	3.0	0.8 to 3.8
MW12	511200	6973080	2.8	1 to 4
MW13	510391	6970851	2.5	1.5 to 4.5
MW14	510704	6970676	2.5	1.5 to 4.5
MW15	510916	6970367	2.9	1.5 to 4.5
MWA	511555	6971329	2.5	1.5 to 4.5
MWJ	511408	6970839	3.1	1.5 to 4.5

Notes

[1] Borehole coordinate geodetic datum is GDA 94 zone 56.

[2] Elevations are to Airport Datum (AD) which is 1.134 m below Australian Height Datum (AHD) (i.e. Airport Datum (m) – 1.134 = mAHD).

3.3.2 Groundwater Levels

The water table across the areas of the site that have not been filled is present in the Upper Holocene sediments, at depths generally ranging between 0.5 m and 1.5 m, with deeper water levels in some areas where the surface level is higher. Along old Serpentine Creek the groundwater level is essentially at the surface.

Water levels across the site are illustrated in **Figures 3.3a**, **3.3b** and **3.3c**, for September 2005, December 2005 and July 2006, respectively. It can be seen that hydraulic gradients are very flat, with no overall regional gradient. Groundwater levels in the new runway area appear to generally reflect the topography, indicating groundwater discharge to the tidal remnant of Serpentine Creek, and to the drains that connect to this creek in the area between the proposed runway and the existing Airport development. Groundwater will also discharge to Kedron Brook to the west of the runway. The low groundwater level in MW11 in July 2006 indicates a local influence on groundwater levels as a result of evaporative losses from the surface water body in the quarry void. Groundwater levels in the existing filled area of the Airport indicate essentially no hydraulic gradient in this area (**Figure 3.3b**), as would be expected in the relatively high permeability sand fill.

The results of water level measurements over the period from the end of November 2005 to the start of July 2006 are illustrated in **Figure 3.3d**, for the standpipes with water level loggers. The effects of the slight variations in density with salinity on the readings of the water level loggers has been taken into account by correction to manual water level readings on the dates when the loggers have been downloaded.

Figure 3.3a: *Groundwater Levels (September 2005).*

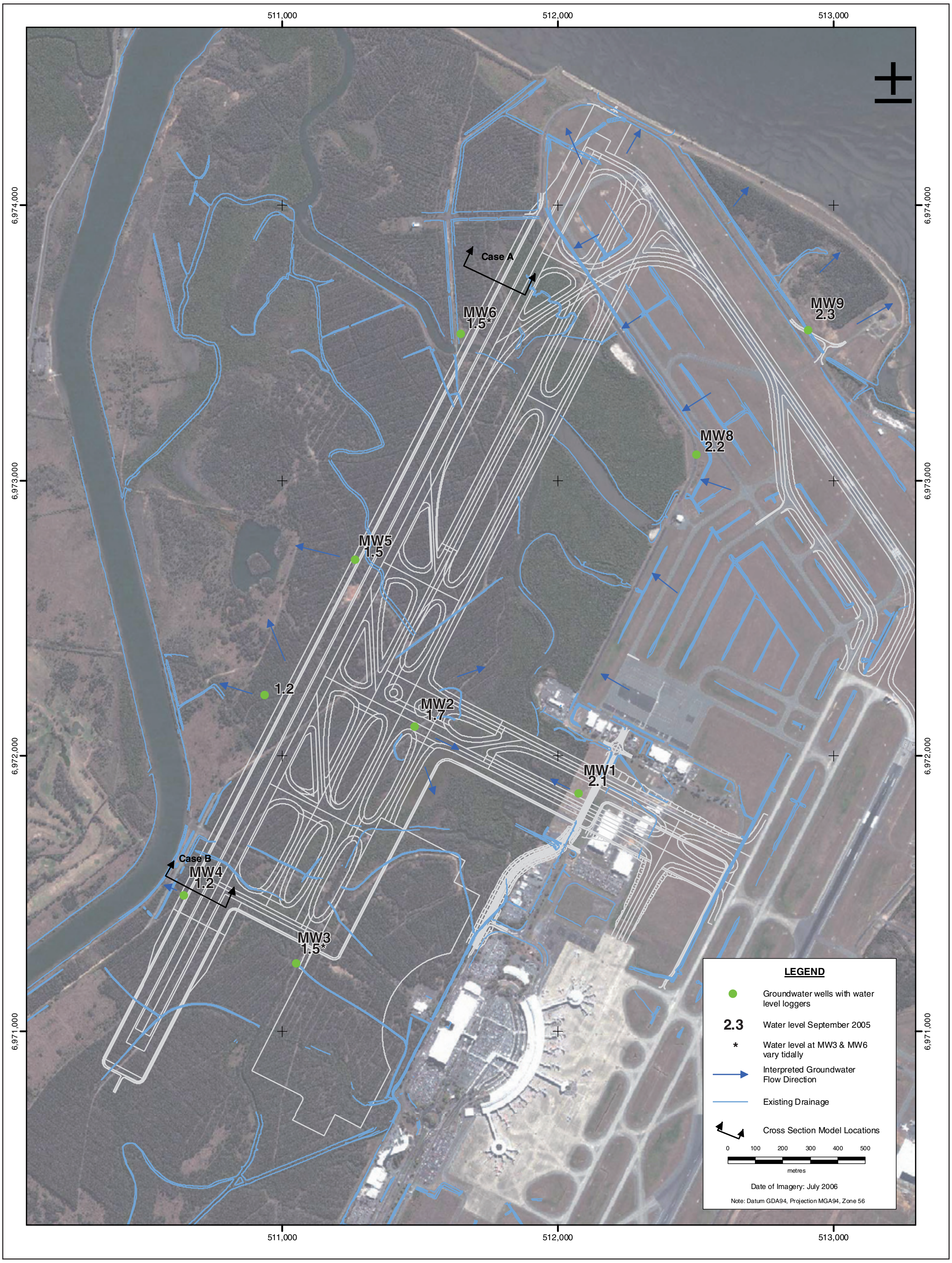


Figure 3.3b: *Groundwater Levels (December 2005).*

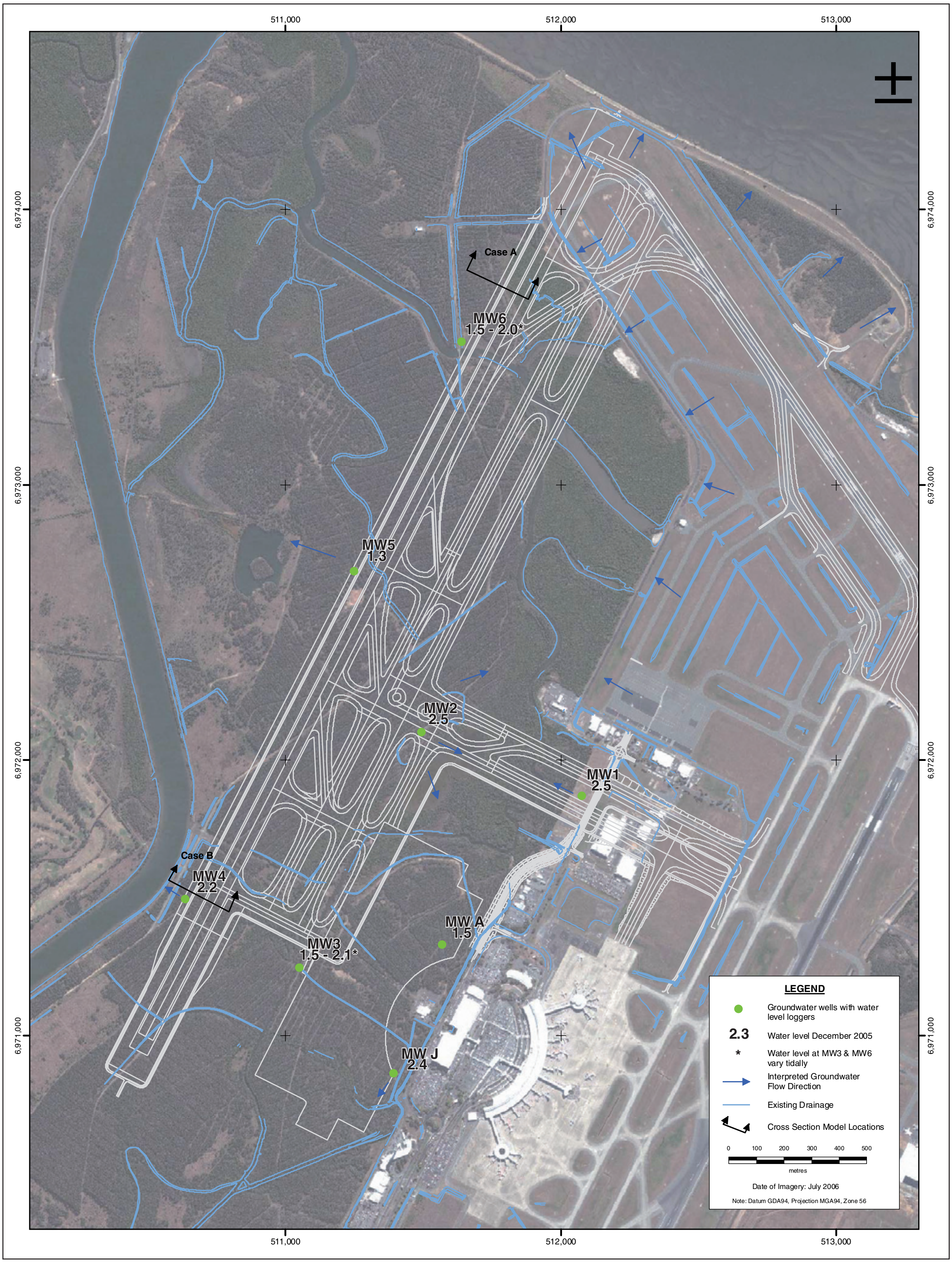
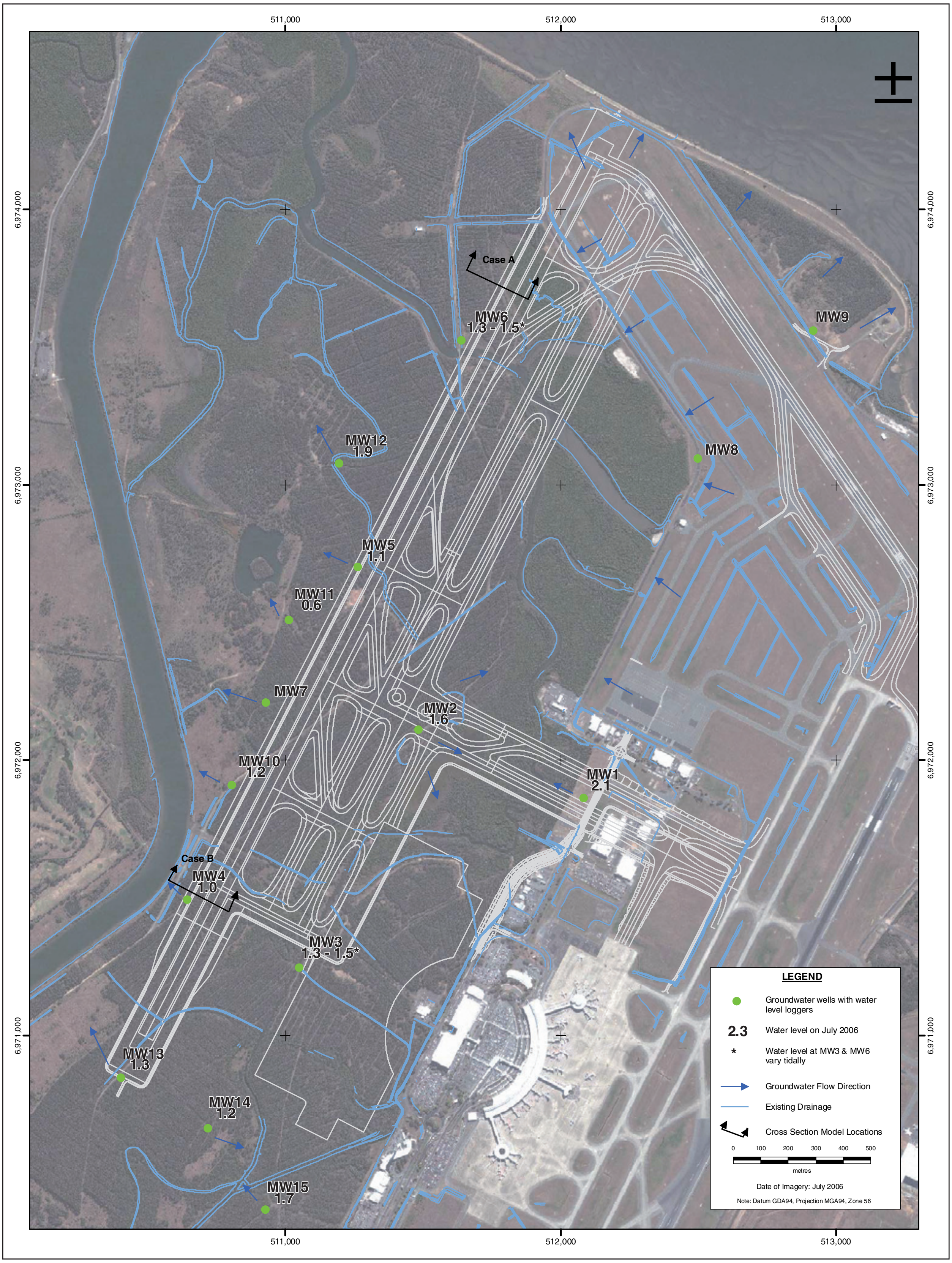


Figure 3.3c: *Groundwater Levels (July 2006).*



In the area of the new runway, groundwater levels at most locations vary over a relatively wide range, in response to individual rainfall events, and between seasons. For example, at MW4 the peak groundwater levels in the 'wet season' period from November 2005 to early March 2006 were approximately 2.3 m AD, while the lowest water levels in this period were in approximately 1.5 m AD between rainfall events. There was little rain between March and early June 2006, and in this time the water level in MW4 dropped to approximately 0.9 m AD before rising slightly after rain. The relatively rapid and large response to individual rainfall events indicates the importance of macroporosity for groundwater flow in the shallow subsurface.

Monitoring wells MW3 and MW6 are located close to tidal drains and creeks (MW3 is located immediately adjacent to a tidal drain, and MW6 is located approximately 30 m from the tidal remnant of Serpentine Creek), and groundwater levels in both these wells demonstrate a strong influence from tidal fluctuations. Groundwater levels in these wells fluctuate within a relatively narrow range (around 0.5 m) over the tidal cycle of approximately 12 hours. The dry season levels in these wells are only marginally lower than the wet season levels, and only a limited response to rainfall can be discerned beyond the tidal fluctuations. The tidal fluctuations that are evident in MW3 and MW6 were not observed at MW4, which is located approximately 100 m from Kedron Brook.

The water levels measured at MW1 (and experience at other locations on the Airport) indicate that groundwater levels in the areas of sand fill are generally located within the fill, at a higher elevation than the groundwater level that would have been present prior to filling. The groundwater levels in the sand fill are thus higher than the groundwater levels in the surrounding areas, and groundwater will discharge from the fill around its perimeter. In most areas, the groundwater discharge from the fill is likely to occur as seepage towards the base of the fill platform during periods of high groundwater levels. Standpipe MW8 is located just outside the sand fill area. Groundwater at this location is very close to the surface, indicating the influence of discharge from the sand fill.

The results of water level monitoring in **Figure 3.3d** indicate that the groundwater levels in MW1 vary seasonally as would be expected, but that the seasonal response and the response to individual rainfall events in MW1 is generally less distinct than the response in the natural clayey soils in the area of the proposed new runway. This is likely due to the significantly higher storage capacity of the sand fill that has been placed in this area, when compared with the natural sediments in the new runway area.

3.3.3 Hydraulic Properties of Sediments

Permeability of the upper Holocene sediments has been assessed by carrying out slug tests (falling head tests) in selected standpipe piezometers. Values of hydraulic conductivity interpreted from the test results are summarized in **Table 3.3b**. For all piezometers, the groundwater level was within the gravel pack at the time of testing, and thus the results all indicate a 'double straight line' response that is typical for slug tests where the initial water table level is within the gravel pack. Hydraulic conductivity values were interpreted from the second straight line in the later part of the test.

No direct measurements have been made of the permeability of the sand fill at the existing Airport. However, recent laboratory measurements of permeability on sand from Middle Banks (the area which was used for dredging for the original Airport development, and which will be used again for the new runway) indicated values of hydraulic conductivity in the range of 1.5×10^{-5} m/s to 4×10^{-5} m/s, over a wide range of density conditions.

For the Lower Holocene sediments, laboratory scale permeability testing indicates hydraulic conductivity values in the range of 1×10^{-10} m/s to 2×10^{-9} m/s. This testing also indicates that the permeability of the clayey deposits in the runway area will reduce by less than half an order of magnitude due to compression under the proposed surcharge loading.

Figure 3.3d: *Groundwater Level Hydrograph (November 2005 – June 2006).*

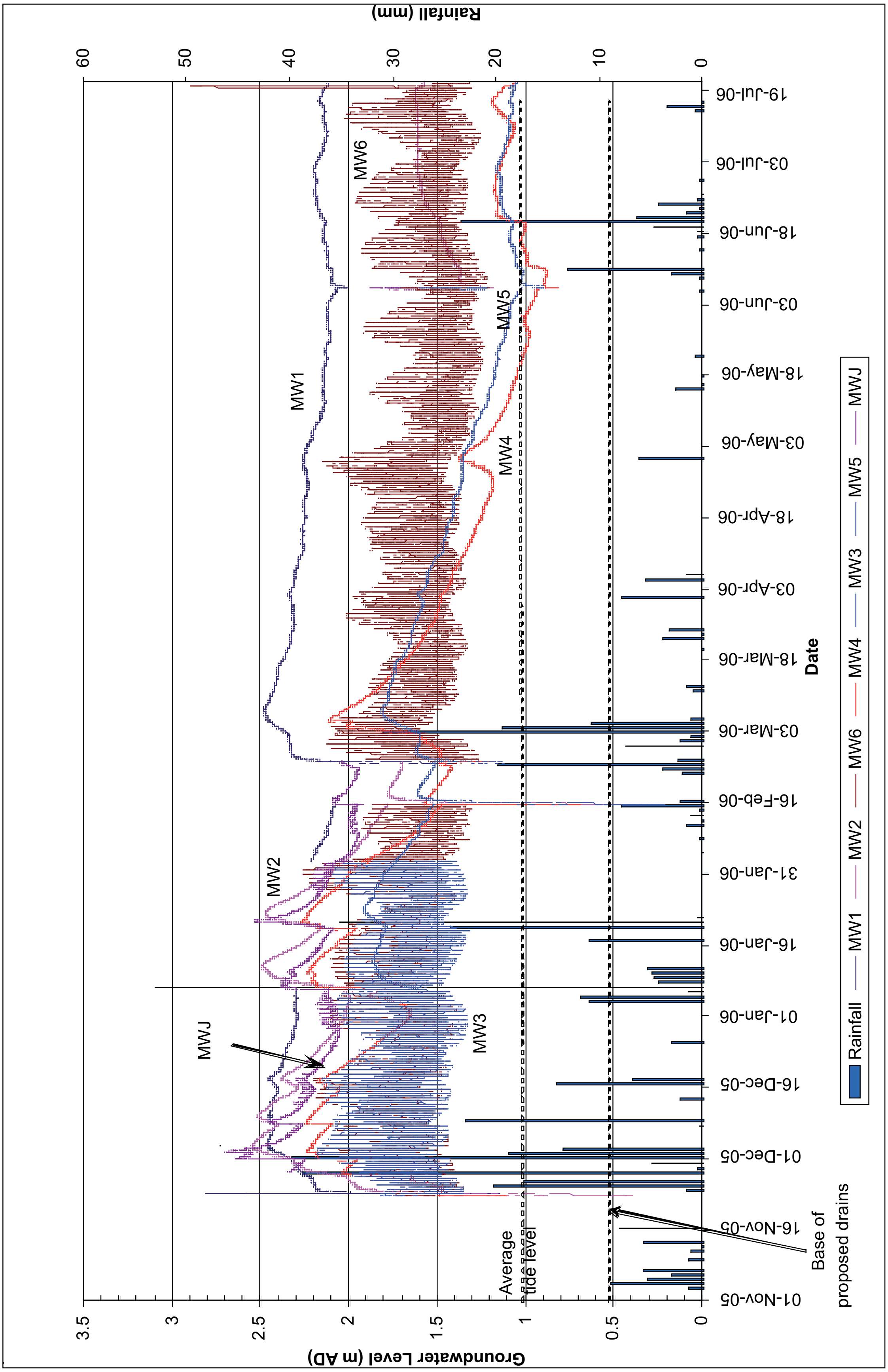


Table 3.3b Values of Hydraulic Conductivity Interpreted from Slug Tests.

Location	Hydraulic Conductivity (m/s)	
	Interpreted using Bouwer and Rice Method	Interpreted using Hvorslev Method
MW2	$1x10^{-8}$	$2x10^{-8}$
MW3	$1x10^{-7}$	$2x10^{-7}$
MW4	$3x10^{-8}$	$4x10^{-8}$
MW5	$2x10^{-8}$	$4x10^{-8}$
MW6	$1x10^{-7}$	$1x10^{-7}$
MW10	$7x10^{-10}$	$4x10^{-9}$
MW11	$4x10^{-8}$	$2x10^{-7}$
MW12	$6x10^{-8}$	$1x10^{-7}$
MW14	$5x10^{-9}$	$8x10^{-9}$
MW15	$4x10^{-8}$	$8x10^{-8}$

3.3.4 Groundwater Quality

Sampling of groundwater from the monitoring wells for laboratory analysis of groundwater quality has been carried out on a number of occasions. The results of three rounds of ASS sampling and two more comprehensive rounds for the contamination baseline study are summarised in **Table 3.3c**.

3.3.4.1 Assessment of ASS Related Parameters

Water quality parameters assessed as part of ASS investigations include: pH, EC, total acidity and alkalinity, concentrations of chloride (Cl^{-}), sulfate ($SO4^{2-}$), aluminium (Al), and iron (Fe).

Where more than one round of analysis has been undertaken, results are generally consistent between rounds. Slight variations in pH between rounds are proportional to changes in salinity and therefore buffering capacity.

The test results indicate that the groundwater salinity (as indicted by EC) is lower in MW1 and MW9 (both located in the sand fill at the existing Airport). This is not unexpected, as the recharge from rainfall is expected to be higher in the area of sand fill than in other areas, and the water sampled from MW1 and MW9 is from within the sand fill. Alkalinity at MW1 is high, this is indicated by a pH above 8, low acidity, low EC and low (but balanced) chloride and sulfate concentrations.

The groundwater chemistry at MW2-MW8, MW A and MW J, is similar, however, slightly acidic conditions are evident where the $Cl:SO_4$ ratio is less than that of sea water (i.e. in MW3, MW7 and MW A). The EC, as an indicator of salinity, was double that of seawater at MW2 and MW6 in one or more tests. This is possibly due to concentration of salt by evaporation in a salt marsh environment.

At MW4, MW6, MW8 and MW9 the water is slightly acidic (and hyper saline at MW6). This is indicated by a near neutral pH, and generally low acidity levels, which are balanced by the concentration of total alkalinity. The higher dissolved sulphur levels are balanced by the high chloride concentrations which buffer the sulfate, and the $Cl:SO_4$ ratio remains close to that of sea water (i.e. 7). MW8 is located in an area with direct tidal connection to Kedron Brook Foodway and water chemistry is similar to that of seawater.

At MW2, MW3, MW5, MW7, MW A and MW J, the water is slightly acidic, and saline (very saline at MW2). This is indicated by a generally lower pH and higher dissolved acidity. However, the acidity is balanced by total alkalinity in all samples, and high EC and chloride concentrations buffer pH change.

The Cl:SO4 ratio is lowest at MW3 (i.e. 3.5, well below that of sea water). The sulfate concentrations are highest in MW3 which indicates that the acidity present is likely to be due to past sulfidic influence (i.e. actual ASS are present).

The concentrations of dissolved iron and aluminium generally vary proportionally with pH as is normally the case and are elevated (when the pH was correspondingly lowest) at MW2, MW3, MW5, MW7 and MW A. Dissolved metal concentrations exceed freshwater NEPC Groundwater Guideline Investigation Levels at these locations (there are no corresponding Investigation Levels for saltwater environments). The NEPC Guidelines are based on the Australian and New Zealand Guideline for Fresh and Marine Water Quality (2000) Volume 2 (ANZECC Guidelines).

Table 3.3c: Results of Groundwater Quality Analysis.

Table 3.3c: Analysis Summary (Groundwater Quality)		pH	Electrical Conductivity (@25°C)	Total Fe	Diss Al	Diss As	Diss Cd	Diss Cr	Diss Cu	Diss Pb	Diss Ni	Diss Se	Diss Zn	Diss Hg	Diss Fe	Cl-	SO_4^{--}	Acidity	Alk	TDS	Turbity	SS	NH3 (NH4+)	NOx	Total N	Total P	Reactive P	Total TPH (C6 - C36)	TPH (C_6 - C_9)	Total BTEX
	Units		(mS/cm)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
MW	Sample Date																													
MW1 (BH29)	22/3/05	7.9	7.01	142,000	<10										90	2,040	290	29												
MW1 (BH29)	15/8/05	8.5	6.50	3,210	30										120	1,670	122	3	809											
MW1 (BH29)	16/9/05	8.1	4.50	11,700	<50										520	1,300	77	<1	787											
MW1 (BH29)	23/11/05	8.6	2.90	580												531	24	<1	603	1,630	11	94	50	160	1,500	1,520	1,590	<220	<20	<7
MW1 (BH29)	15/2/06	8.3	3.50	4,260	20	2	0.1	4	5	2	<1	<10	37	<0.1	130	426	15	2	499	3,200	12	14	118	354	2,600	380	83	<240	<20	<7
MW1 (BH29)	24/2/06		2.44		40	2	<0.1	3	6	2	2	<10	42	<0.1	320															
MW2 (BH25)	22/3/05	6.5	130	42,500	390										14,500	56,000	6,600	173	303											
MW2 (BH25)	15/8/05	7.2	116	38,300	<50										<50	60,300	5,850	100	321											
MW2 (BH25)	16/9/05	6.5	>25	1,900	<50										<50	55,300	6,590	103	306											
MW2 (BH25)	23/11/05	7.6	88.6	<50												51,800	4,540	51	306	76,900	27	98	950	13	3,400	440	11	<220	<20	<7
MW2 (BH25)	15/2/06	7.2	99.1	760	<10	9	<0.1	<1	15	4	43	37	55	<0.1	<50	56,900	5,510	81	298	87,600	6.1	69	670	28	1,100	930	<10	<220	<20	<7
MW2 (BH25)	24/2/06		122		80	<50	<0.5	<5	55	<5	208	170	211	<0.1	<50															
MW3 (BH16)	22/3/05	6.7	52.4	29,200	10										7,550	18,300	5,140	137	373											
MW3 (BH16)	15/8/05	7.2	53.6	111,000	<50										120	21,400	5,240	136	567											
MW3 (BH16)	16/9/05	6.6	>25	3,800	<50										<50	19,600	4,540	88	372											
MW3 (BH16)	23/11/05	7.7	35.8	<50												16,600	4,160	18	357	32,000	50	35	820	1,110	2,600	120	21	<220	<20	<7
MW3 (BH16)	Unaccessable																													
MW3 (BH16)	Unaccessable																													
MW4 (BH13)	22/3/05	7.3	35.7	1,500	<10										< 50	12,900	1,870	56	338											
MW4 (BH13)	15/8/05	7.7	40.3	53,600	< 50										< 50	13,100	2,050	57	471											
MW4 (BH13)	16/9/05	7.1	>25	1,780	< 50										< 50	12,900	1,830	48	345											
MW4 (BH13)	23/11/05	7.8	24.1	50												11,100	1,960	9	308	23,200	12	26	3,600	3,490	7,000	190	20	<220	<20	<7
MW4 (BH13)	15/2/06	7.7	32.1	210	<10	8	0	3	6	<1	9	35	83	<0.1	<50	12,000	1,970	32	316	25,600	1.7	14	498	1,540	5,700	990	79	<220	<20	<7
MW4 (BH13)	24/2/06		36.8		<10	<0.5	<0.2	<0.5	5	<0.2	10	<2	115	<0.1	5															
MW5 (BH31)	22/3/05	6.4	61.2	84,500	<10										35,600	22,700	4,070	251	394											
MW5 (BH31)	15/8/05	7.2	53.8	63,100	<50										130	22,100	3,620	134	384											
MW5 (BH31)	16/9/05	6.8	>25	58,100	<50										5,340	22,700	3,420	128	423											
MW5 (BH31)	23/11/05	7.6	33.5	4,870												20,000	3,510	27	393	36,400	800	159	2,010	70	2,800	310	<10	<220	<20	<7
MW5 (BH31)	15/2/06	7.1	44.0	43,900	<10	<0.5	<0.2	<0.5	5	<0.2	20.7	<2	94	<0.1	800	21,000	3,740	90	392	41,900	220	107	1,800	106	1,800	260	13	<240	<20	<7
MW5 (BH31)	24/2/06		62.5		<10	<0.5	<0.2	<0.5	<1	<0.2	32.3	<2	52	<0.1	7,170															
MW6 (BH40)	22/3/05	7.0	124	5,680	130										< 100	51,600	7,680	96	263											
MW6 (BH40)	15/8/05	7.4	108	148,000	<50										<50	51,800	7,280	83	253											
MW6 (BH40)	16/9/05	7.0	>25	2,420	<50										<50	40,600	8,600	80	263											
MW6 (BH40)	23/11/05	7.6	53.9	2,620												46,800	9,860	42	263	71,300	180	120	6,520	20	6,700	1,660	23	<220	<20	<7
MW6 (BH40)	15/2/06	7.4	89.0	4,820	<10	0.7	<0.2	<0.5	8	<0.2	3.2	<2	54	<0.1	<50	47,300	7,200	58	239	77,400	36	63	3,020	2,770	5,900	90	13	<240	<20	<7
MW6 (BH40)	24/2/06		114		80	0.7	0.6	<0.5	8	<0.2	4.3	103	76	<0.1	120															
MW7 (BH44)	15/8/05	7.1	33.0	262,000	<50										280	10,100	2,840	227	571											
MW7 (BH44)	16/9/05	6.3	>25	68,000	<50										18,600	10,900	2,740	185	546											
MW7 (BH44)	23/11/05	7.6	21.9	24,000												9,150	2,850	27	624	23,100	600	7,230	1,010	<10	3,300	430	22	<220	<20	<7
MW7 (BH44)	15/2/06	6.7	25.1	168,000	<10	1.4	<0.2	<0.5	3	<0.2	208	<2	74	<0.1	51,500	9,200	3,170	230	298	22,600	70	102	5,320	16	9,100	100	76	<320	<20	<7
MW7 (BH44)	24/2/06		31.5		<10	1.4	0.2	<0.5	1	<0.2	246	<2	170	<0.1	66,900															
MW8 (BH66)	16/9/05	6.9	>25	151,000	<50										100	23,400	2,330	166	1,270											
MW8 (BH66)	28/11/05	7.4	37.5	86,000												25,400	1,780	216	1,820	39,100	120	370	30	<10	2,500	700	462	<220	<20	<7
MW8 (BH66)	15/2/06	7.5	45.3	400	<10	8.2	<0.2	2	1	<0.2	3.3	<2	6	<0.1	369	23,800	1,620	262	2,110	45,700	130	244	12	11	3,000	800	377	<400	<200	<60
MW8 (BH66)	24/2/06		59.3		<10	6	<0.2	13	<1	0.2	1.4	<2	<5	<0.1	535															
MW9 (BH59)	16/9/05	6.7	3.10	209,000	<50										120	78,300	21	122	987											
MW9 (BH59)	28/11/05		--	73,600													6			33,000	360	1,790	190	<10	1,200	650	25	<220	<20	<15
MW9 (BH59)	15/2/06	7.6	2.90	166,000	<10	4	<0.1	5	2	<1	2	<10	<5	<0.1	380	851	8	78	858				<10	13	5,700	1,830	16	<630	<20	<18

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Table 3.3c: Analysis Summary (Groundwater Quality)		pH	Electrical Conductivity (@25°C)	Total Fe	Diss Al	Diss As	Diss Cd	Diss Cr	Diss Cu	Diss Pb	Diss Ni	Diss Se	Diss Zn	Diss Hg	Diss Fe	Cl-	SO_4^{++}	Acidity	Alk	TDS	Turbity	SS	NH3 (NH4+)	NOx	Total N	Total P	Reactive P	Total TPH (C6 - C36)	TPH (C_6 - C_9)	Total BTEX
	Units		(mS/cm)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
MW9 (BH59)	24/2/06		3.38		<10	1	<0.1	**6**	**2**	<1	1	<10	7	<0.1	<50															
MW 'A'	29/4/05	6.3	54.2	110,000	3560										61,900	14,600	4,730	159	176											
MW 'A'	15/8/05	7.0	56.1	108,000	<50										290	23100	4,600	52	137											
MW 'A'	28/11/05	4.9	29.3	56,700												20,000	4,300	137	2	36,000	190	425	**2,580**	<10	**2,800**	**220**	**16**	<320	<20	<7
MW 'A'	15/2/06	5.9	44.7	86,300	3200	1.6	0.5	1.4	**4**	2	**148**	<2	**345**	<0.1	33,000	18,200	3,790	90	27	39,500	240	320	**2,960**	**36**	**5,800**	**1,280**	**24**	<220	<20	<7
MW 'A'	24/2/06		57.8		50	0.6	<0.2	0.7	**2**	<0.2	**132**	<2	**141**	<0.1	69,100															
MW 'J'	26/4/05	7.6	59.4	9,040	< 50										< 50	18,600	4,500	113	583											
MW 'J'	15/8/05	7.4	45.1	66,600	<50										140	17,300	3,560	123	634											
MW 'J'	28/11/05	7.1	27.3	36,200												10,900	3,860	103	582	31,000	600	1,150	**1,710**	**150**	**4,100**	**770**	<10	<220	<20	<7
MW 'J'	15/2/06	7.2	39.2	52,900	<10	1.1	<0.2	<0.5	**11**	<0.2	**36.6**	<2	**29**	<0.1	1,100	15,600	3,620	110	638	33,400	400	524	**2,090**	**83**	**2,500**	**1,220**	**21**	<340	<20	<7
MW 'J'	24/2/06		51.1		<10	1.1	<0.2	<0.5	**11**	<0.2	**19.5**	<2	**41**	<0.1	890															
Mean						3	0	4	**8**	2	**59**	**86**	**91**		12,184								**1,798**	**586**	**3,862**	**709**	**161**	<258		<10
95th Percentile						8	1	**10**	**21**	4	**212**	**160**	**231**		65,150								**5,440**	**2,950**	**7,105**	**1,669**	**394**	n/a		n/a
Airports (EP) Regulations - Marine Water Limit (µg/L)		-	-	-	-	50	2	50	5	5	15	70	50	0.1	-	-	-	-	-	-	-	-	-	10	10"	5^^	-	-	-	300**
NEPC Marine Groundwater Investigation Levels (µg/L)		-	-	-	-	50	2	50	5	5	15	70	50	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	300**
ANZECC Marine Trigger Values - 95% Protection (µg/L)		8-8.4e	-	-	-	-	5.5	4.4c	1.3	4.4	70	-	15	0.4	-	-	-	-	-	-	-	-	910	5e	120e	25e	10e	-	-	700**
ANZECC Marine Trigger Values - 90% Protection (µg/L)		8-8.4e	-	-	-	-	14	20c	3	6.6	200	-	23	0.7	-	-	-	-	-	-	-	-	1,200	5e	120e	25e	10e	-	-	900**

All Concentrations are expressed in µg/L
a Value applies provided pH>6.5
b Arsenic (As V)
c Chromium (Cr VI)
d Trigger values for estuarine ecosystem for South East Queensland
TPH – Total Petroleum Hydrocarbons

** BTEX – Benzene and Toluene only – Fresh Waters*
*** BTEX – Benzene only – Fresh and Marine Waters*
^ Phosphorus – River of Stream Waters
^^ Phosphates – Estuarine Waters
' Nitrogen – River or Stream Waters

Values in **Bold** exceeds Aiprorts (EP) Regulation - Accepted Limits of Contamination (Marine Waters)
Values in **Bold** exceed NEPM Marine Investigation Values
Values in **Bold** exceed ANZECC Trigger Values for Marine Waters - 95% Protection
Values in **Bold** exceed ANZECC Trigger Values for Marine Waters - 90% Protection

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3.3.4.2 *Assessment of Baseline Contamination Parameters*

Water quality parameters added to the ASS suite for the baseline study of groundwater included:

- TDS – total dissolved solids (a measure of salinity);
- Turbidity and Total Suspended Solids (TSS);
- Metals – As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Zn;
- Petroleum Hydrocarbons (TPH) and organic volatiles (BTEX); and
- Nutrients, including Total N and P, Ammonia and Combined Nitrates and Nitrites (NO_x).

i) Total Dissolved Solids

Monitoring bores in the new runway area indicate consistently saline conditions, with water quality varying between moderately saline (3,000 mg/L) and hypersaline (66,000 mg/L). TDS concentrations generally conform with EC. Groundwater salinity measured in the shallow DNRW bores in the vicinity of the Airport area varies between fresh (80 mg/L) and hypersaline (70,000 mg/L) with average of 13,000 mg/L.

Schedule 2 of the AEPR indicates that waters with a TDS of less than 1,000 mg/L are to be considered fresh water. Since all TDS values exceed 1,000 mg/L, groundwater at the Airport is not fresh.

ii) Turbidity and Total Suspended Solids

Turbidity and Total Suspended Solids (TSS) are expressions of similar criteria. Turbidity is a measure of the cloudiness of the water and may be due to suspended clay or algae in water. TSS is a measure of suspended matter in turbulent water and will be higher where silt or other coarse material is stirred by turbulence. Generally groundwater is not turbid and does not contain suspended material because the medium through which it moves is a filter that removes suspended matter. Turbidity may be a function of the sampling method (bailing) that agitates the water.

Results indicate that groundwater turbidity varies between monitoring points, but are generally lower in MW1-MW4 at the southern end of the new runway area (i.e. 1.7 – 50 NTU). The turbidity levels elsewhere on the site are higher and range from 180 – 800 NTU. Turbidity can be a function of the saturated material at the monitoring point (it will generally be lowest in clean gravels and sands).

iii) Metals

The initial analysis of most metal ions was subject to interference in saline samples resulting in raised detection limits and level of reporting (LOR). This was the case in samples at sites MW4 (on 24/02/2006), MW5, MW6, MW7, MW8, MW A, and MW J.

These particular samples were re-analysed using an improved analytical method, (Octapole Reaction Cell – ICPMS), which overcomes most of the interference from the salt ions. Hence, some sites have two sets of metals results for each sampling. Only the lowest LOR has been included in summary given in **Table 3.3c**.

Results of analysis indicate elevated concentrations of Copper, Nickel, Selenium and Zinc at several monitoring locations, which exceed the AEPR limits of 5 µg/L, 15 µg/L, 70 µg/L and 50 µg/L, respectively.

Concentrations of Nickel and Zinc also exceed the ANZECC Marine Trigger Values for a 90 percent Protection Limit (i.e. 200 µg/L and 23 µg/L respectively). Concentrations of Chromium exceeds the more stringent ANZECC Marine Trigger Values for a 95 percent Protection Limit (i.e. 4.4 µg/L), in samples from two locations.

These levels are only slightly elevated and not uncommon in estuarine environments. Low lying areas have natural ASS and groundwater can be naturally acidic, under these conditions heavy metals can be mobilised. The metals can occur naturally in the estuarine alluvium.

iv) Organic Substances

There are no specific ANZECC trigger values currently in place for hydrocarbons so these default to toxicological protection values listed in the Australian and New Zealand Guideline for Fresh and Marine Water Quality (2000) Volume 2.

The AEPR – Schedule 3, indicates a limit of 150 µg/L for the TPH C6-C9 fraction and 740 µg/L for combined Benzene and Toluene in freshwater environments (which do not apply as the water is saline), and a limit of 300 µg/L for Benzene (alone) in marine environments.

No BTEX were detected in the samples screened.

Some isolated TPH fractions were detected in some samples, the highest concentration of total TPH was <630 µg/L and <200 µg/l for the C6-C9 fraction (in a sample where the LOR was artificially inflated due to an unspecified influence in the sample run). No specific investigation levels for TPH and BTEX apply for marine environments.

v) Nutrients

There are no specific investigation limits for nutrients in groundwater (under either AEPR or the NEPM Guidelines). However, nutrient values can be compared with WQOs for marine receiving environments, to give a relative indication of potential nutrient loading. Many of the locations monitored are in or adjacent to waterlogged mangrove communities, where high levels of organic matter and anoxic conditions are conducive to production of ammonia and nitrite compounds.

Ammonia (NH^{3+}) was detected at all monitoring locations, at concentrations ranging from 12 to 5,320 µg/L (average values were of the order of 1,800 µg/L). Highest values were detected in areas adjoining mangrove communities away from developed areas. Groundwater from all monitoring location returned detectable concentrations of nitrites and nitrates (NO_x) at concentrations ranging from 11 to 3,490 µg/L, (average values were of the order of 586 µg/L). Total nitrogen levels ranging from 1,100 to 9,100 µg/L, and total phosphorous from 90 to 1,830 µg/L.

All exceeded AEPR Accepted Limits for Marine Waters. However, it must be considered that the baseline conditions represent what would be expected in this type of environment.

3.3.5 Acid Sulfate Soils in the Zone of Water Table Fluctuation

The variation in depth to groundwater between November 2005 and July 2006 is illustrated in **Figure 3.3d** for the standpipes that are located in the new runway area. The range in depth to groundwater at MW4 (the closest standpipe to the drain location) is also shown on **Figure 3.3e**.

The results of Acid Sulfate Soils testing indicate the presence of actual acidity to at least 2.5 m depth, with little evidence of a decrease in actual acidity with depth. These results indicate historical groundwater levels fluctuations down to at least 2.5 m on a relatively regular basis, which is consistent with the results presented in **Figure 3.3d**.

3.3.6 Conceptual Hydrogeological Model

No discrete aquifers are present on the site, in the sense that permeability values are too low for usable quantities of water to be derived.

As indicated in section 3.2.2, however, the natural sediments present on the site can be divided into two layers with distinct hydrogeological properties: the Upper Holocene alluvia and the Lower Holocene alluvia. The differences in these layers are the product of the different depositional environments in which they were formed. The Upper Holocene alluvia were laid down during the most recent rise in sea level, in shallow fluctuating water bodies, whereas the Lower Holocene alluvia were laid down in deeper water, either off-shore or in deeper stream channels.

The Upper Holocene alluvia comprise heterogeneous interlayered clays, silts and sands, and are present to depths between 7 m and 12 m in the new runway area. Results of geotechnical and ASS investigations indicate that sand layers are not continuous. Permeability of this layer is low, but variable (in the range of 10^{-9} m/s to 10^{-7} m/s). The water table is present at shallow depth in the Upper Holocene, and is observed to fluctuate significantly in response to individual rainfall events, as well as seasonally. Groundwater levels are also affected by tidal fluctuations in the vicinity of tidal drains and creeks. Hydraulic gradients are relatively flat, with no distinct regional hydraulic gradient.

Groundwater discharges from the Upper Holocene, to creeks and drains that are present throughout the new runway area, with slightly elevated groundwater levels in areas between drains.

The Lower Holocene alluvia comprise relatively homogenous clays and silts, and are present to depths of up to 32 m in the new runway area. These sediments have consistently very low permeability (10^{-10} to 10^{-9} m/s), and groundwater flow in these sediments would be negligible.

The Upper and Lower Holocene alluvia extend well beyond the area that will be developed for the project. Geotechnical investigations carried out across the Airport site and other sites across the Brisbane River delta indicate similar relationships between the Upper Holocene and Lower Holocene alluvia. The thickness of Upper Holocene alluvia is relatively constant (in the range of 4 m to 12 m), whereas the Lower Holocene varies significantly in thickness (from 0 m to >25 m) as a reflection of the paleo-topography.

The area of the existing Airport development has been reclaimed by filling with fine sand dredged from Moreton Bay. The sand is several orders of magnitude more permeable than the underlying sediments (i.e. typically 10^{-5} m/s). In this area, the water table is present within the sand fill, at an almost constant elevation across the area. Groundwater seepage occurs around the perimeter of the sand fill. Water levels in the sand fill vary seasonally, and the water table response to individual rainfall events is less marked than it is in the Upper Holocene sediments in the new runway area.

The conceptual hydrogeological model described above is illustrated schematically in **Figure 3.3f**.

Figure 3.3e: *Depth to Groundwater (November 2005 – June 2006).*

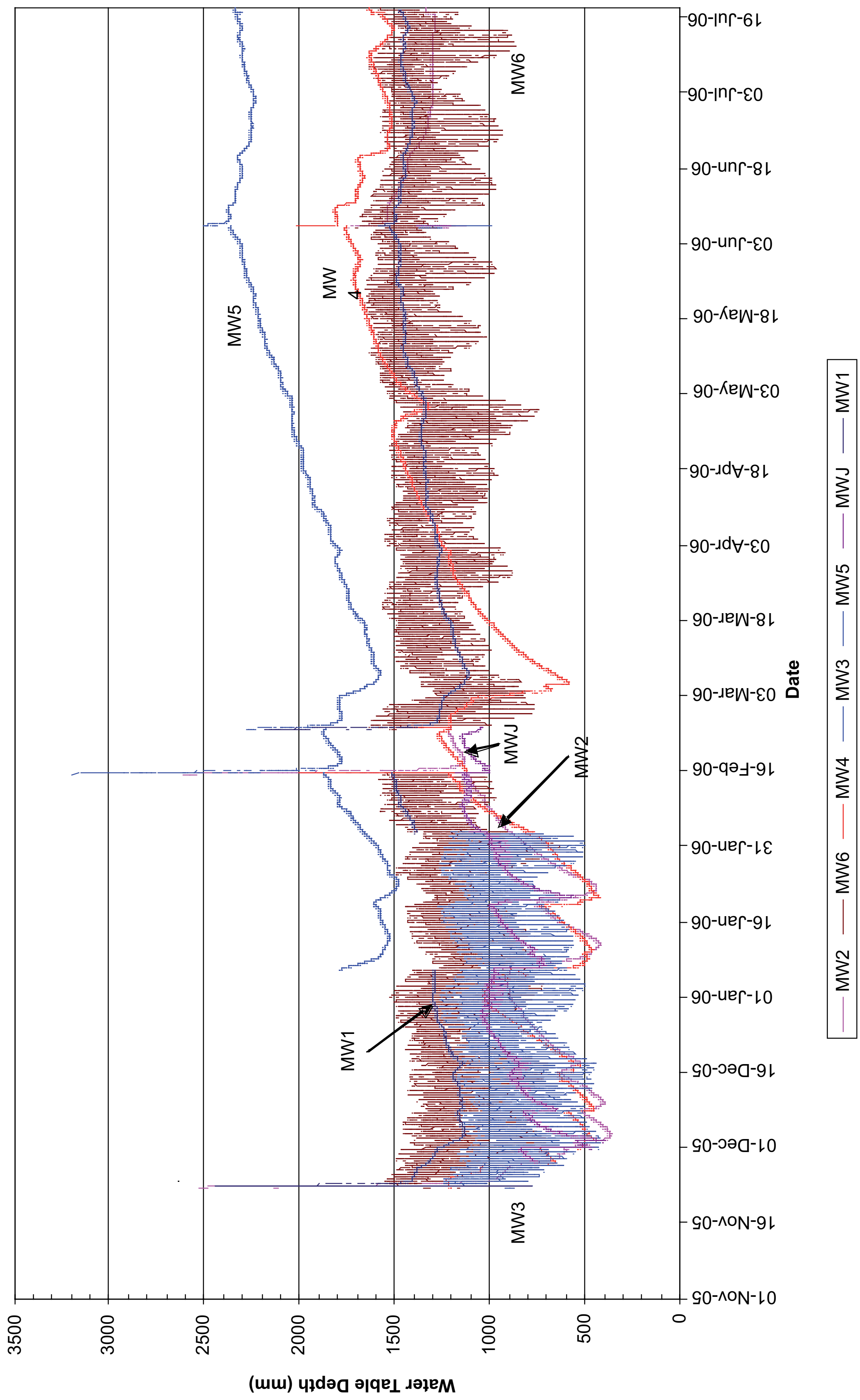
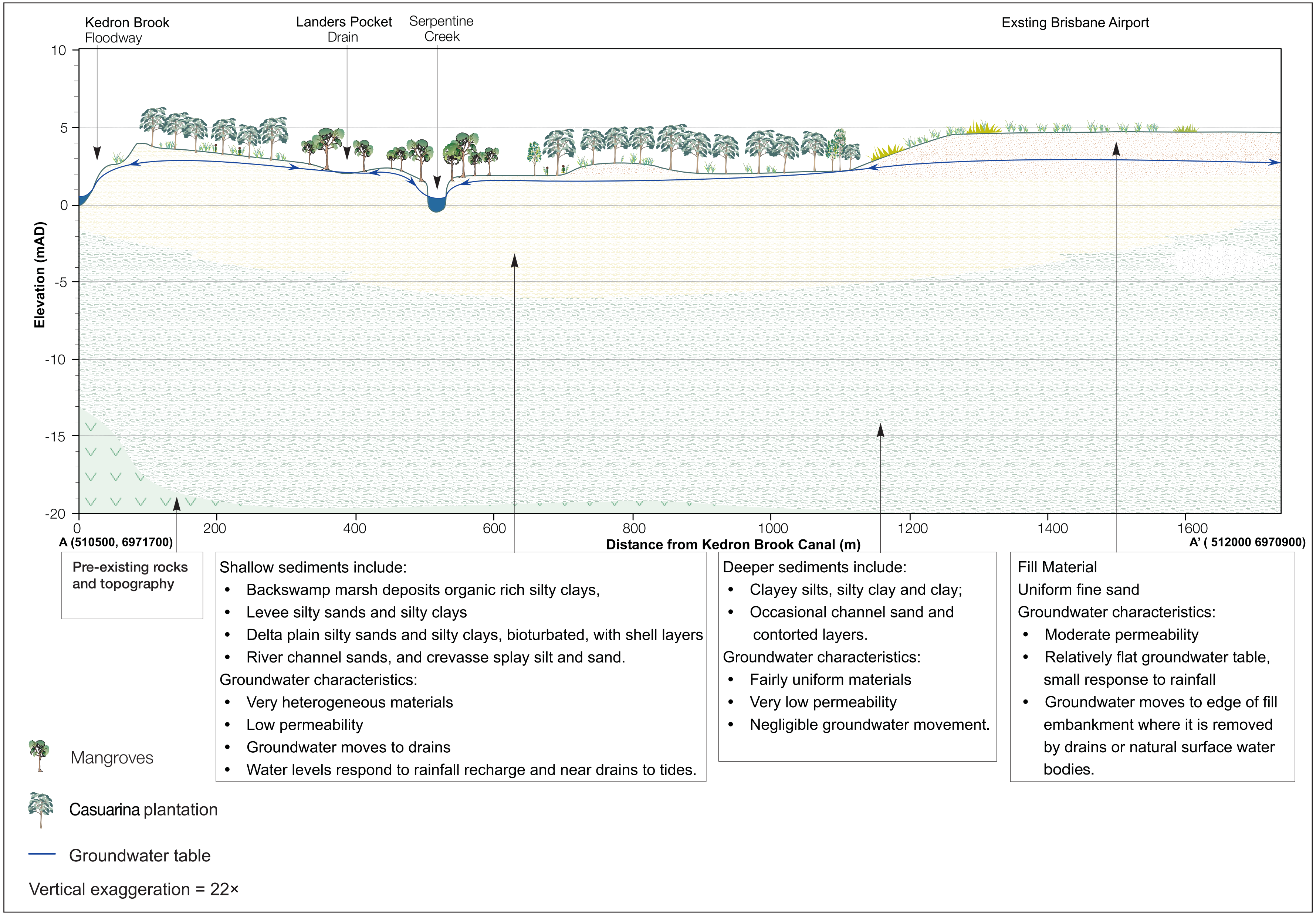


Figure 3.3f: *Conceptual Hydrogeological Model.*



3.4 Existing Environment – Approach Lighting

No specific investigations were undertaken in the area designated for the approach lighting superstructure, which extends approximately 660 m offshore along the centreline of the NPR. Descriptions are limited to published geological survey data. The principal purpose of assessment is to allow confirmation of the preliminary design concept.

Reference to the Geological Survey of Queensland 1:100,000 scale Brisbane Geological map indicates that the site contains alluvial deposits (marine lithofacie), comprising muddy sand, with mud content varying from 10–50 percent. The underlying parent geology is of the Bundamba Group (Woogaroo Sub-group), comprising sandstone, siltstone and shale, which in turn overlies the Ipswich Coal Measures formation at greater depth.

3.5 Existing Environment – Dredge Pipeline and Pump-out Site

3.5.1 Investigation Methodology

Assessment was carried out targeting the western boundary of the Port of Brisbane shipping channel and dredging conditions in the channel bank where construction of the pump-out facility would be required. The work was conducted on the premise that some disturbance of bottom sediments by dredging may have been necessary to establish the dredge vessel mooring berth and each of the four alternative mooring sites (Boggy Creek, Luggage Point, Juno Point and Koopa Channel) as outlined in Chapter B1 were investigated (Refer to **Appendix D**).

Work included PSD analysis and whether the materials contain contaminants or ASS, and sediment consistency and suitability for dredging. Analysis of sediments obtained from vibro-core boreholes also included analysis of the presence of faecal matter and pathogens that may arise from the nearby Luggage Point Wastewater Treatment Plant (WWTP).

In relation to the proposed pipeline alignments, a description of expected soil and sediment conditions along the route of the proposed dredge pump-out pipeline was prepared, sufficient to allow safe location of the pipeline and an adjoining maintenance track.

As outlined in Chapter B1, only the results of the investigations in the Brisbane River at Luggage Point are presented in this Chapter. It should also be acknowledged that dredging is not required to establish the mooring facility for the dredge vessel at the preferred mooring location at Luggage Point, although marine piling will likely be undertaken to establish the dredge mooring structure.

3.5.2 Site Description

3.5.2.1 Setting

The proposed option for location of the dredge pump-out facility is on the western bank of the Brisbane River at Luggage Point at the mouth of the Brisbane River. The site is situated in the low lying estuarine flood plain of the Brisbane River (below the low tide mark).

3.5.2.2 Geology

Reference to the Geological Survey of Queensland 1:100,000 scale Brisbane Geological map indicates that the Luggage Point site is situated on the edge of areas of recent (Holocene) Undifferentiated Coastal Plains comprising mud and sand, and the main deposits of Estuarine Channels and Banks (of the Brisbane River), comprising sandy mud, muddy sand and minor gravel.

3.5.2.3 Soil Landscapes

Reference to the Soil Landscapes of Brisbane and South-Eastern Environs, Queensland, CSIRO 1:100,000 scale Map Sheet indicates that the Luggage Point site is situated in an area containing the Mudflats landscape, described below:

Mudflats – M

- Dominant Soil Group – saline mud; and
- Landscape and Parent Geology – tidal flats of estuarine muds.

These soils comprise young alluvium with no profile development and frequently contain very high concentrations of pyritic material, which contribute to acid conditions where not buffered by calcareous material such as shell grit or coral debris.

3.5.2.4 Stratigraphy

Subsurface investigations were carried out at each proposed location by Geo Coastal Australia (who undertook the survey). A number of continuous soil cores were recovered from each site using a barge mounted vibro-core rig.

Results of investigations indicate Holocene deposits at all locations. The following stratigraphical sequences were encountered for Luggage Point:

BH18 A surface layer of fine to medium grained sand/sediment with increasing mud content, (Deposition is possibly influenced by previous dredging), to approximately 1.4 m depth;

Stratified, fine to medium grained sand and clayey sand layers to 6.8 m; overlying soft to firm, alluvial silty clays to 15.8 m depth.

BH22 Soft, laminated, sandy/silty clay alluvium to approximately 3.5 m depth;

A band of fine to pebble sized alluvial sand, to approximately 4.8 m;

Fine to medium grained alluvial sand, with some thin clay layers, to 10.0 m; overlying soft to firm, alluvial silt/clay to termination at 16.5 m depth.

BH23 A soft, recent layer of clayey silt/silty clay alluvium to approximately 0.5 m depth;

Fine to medium grained, variegated alluvial sands, with some thin clay layers, to 8.0 m; overlying soft to firm, alluvial silty clay to termination at 15.1 m depth.

Detailed stratigraphy is included on Core Log Reports supplied by Geo Coastal Australia, and is presented in **Appendix D**.

3.5.2.5 Ground Conditions Along Pump-out Pipeline Route

The alignment of the dredge pump-out pipeline is to be approximately 10 m wide (including a narrow maintenance track down one side). The proposed route between the dredge spoil pumping/rehandling area at the eastern end of the existing runway and the outfall location at Luggage Point is to be essentially a straight line. Refer to Chapter A4 for details of the pipeline alignment.

The route will transect developed Airport (BAC) land for the first part, comprising engineered fill (pavements and consolidated sands), overlying partly consolidated clays. The route then passes through vegetated tracts of low lying flood plain, containing deep, unconsolidated alluvial layers to similar depths to those encountered on the new runway site (i.e. the order of 20–35 m). Some surface disturbance and localised partial primary consolidation may have occurred in some areas. The route passes close to the Luggage Point Wastewater Treatment Plant on the approach to the banks of the river.

Conditions would be expected to comprise soft to firm near surface soils (frequently inundated soils), with the potential for significant and possible differential settlement, along the eastern half of the route. Lightly loaded, articulated structures or driven piled foundation will be appropriate for the temporary pipeline and outfall structure.

3.5.3 Assessment of ASS

3.5.3.1 Existing Mapping of ASS

Reference to the DNRW, 1:100, 000 scale Map 1 Acid Sulfate Soils – Tweed Heads to Redcliffe, indicates that as the site is actually situated in the Brisbane River (and therefore are not mapped), it adjoins a continuous strip of land along the western bank of the river that is mapped as containing:

- S – Land where ASS occurs within 5 m of the surface.

Inspection of the BCC 1:100,000 scale Map – A Guide to the Likely Location of Acid Sulfate Soils in Brisbane indicates that the site is situated in the Brisbane River and therefore not mapped; it adjoins areas mapped as having High to Extremely High hazard ratings (i.e. categories 4, 5 and 6, where 6 is the highest hazard category).

3.5.3.2 ASS Field Investigations

Adopted Sampling and Testing Methods

A continuous soil core was recovered at the Luggage Point location and kept chilled until sub-sampled for ASS testing and other analysis. Sub-samples were taken at approximately 0.2–0.4 m intervals down to a depth of 4.0 m and then at 0.5 m intervals for the length of the core.

Core recovery depth varied. Some cores were shorter where vibro-coring techniques met with resistance on dense sand or very stiff clay layers. The sub-samples were screened using the pH/pHFOX test method. A representative number of samples selected from the screened samples were then subjected to quantitative analyses (by either the SPOCAS or Chromium Reducible Sulfur test methods).

Fieldwork

Sampling was undertaken at three locations associated with Luggage Point at BH18, BH22 and BH23 as shown in **Appendix D**.

Fieldwork was conducted at Luggage Point in January 2006. A continuous core of sediment was recovered at the location. The cores were chilled until sampling for ASS screening and contaminant testing was carried out, using the pH/pH_{FOX} test method

3.5.3.3 Soils Laboratory Testing

The laboratory testing program outlined below was carried out to assess actual and potential ASS conditions at the dredge pump-out location.

Preliminary Screening

Screening of samples of alluvial sediments carried out using the pH/pH_{FOX} test method indicate that most of the alluvial soil cores screened included one or more potential ASS (PASS) strata. However, at most locations results indicate that the presence of significant amounts of fine calcareous material (shell grit or coral debris) that may be sufficient to buffer the potential acidity present.

At Luggage Point, 107 samples were screened and pH_{FOX} ranged from 4.4 to 7.9 (generally above 6.0), indicating significant buffering through the profile, but less evident in BH22. Field pH values ranged from 7.0 to 8.7 (i.e. alkaline).

Summaries of screening and analytical test results for samples recovered from Luggage point are attached in **Appendix D**.

Quantitative Analysis

Based on results of preliminary screening tests, samples were selected to undergo laboratory analysis by either the SPOCAS or Chromium Reducible Sulfur (S_{Cr}) test suites.

Given that disturbance is likely to be limited (associated with the placement of marine piles) a staged approach to investigation was adopted, the sampling and analysis conducted was considered sufficient to characterise the sediment profile and to predict the extent of ASS/PASS present. By supporting the outfall on driven piles and limiting any agitation of bottom sediments by managing the discharge, such a disturbance could be avoided. Samples were mainly chosen from screening tests that exhibited positive, probable or possible indications of ASS/PASS.

Test results indicate that actual and potential acidity present in the samples of alluvium analysed, varies considerably, but is generally high where the acid neutralising capacity (ANC) is not adequate to supply natural buffering capacity.

Results of all laboratory testing undertaken are summarised in **Appendix D**.

3.5.3.4 Extent of ASS/PASS

Results of investigations confirm the presence of significant layers of PASS alluvium at all locations sampled in the Brisbane River estuary. Significant unbuffered PASS is evident throughout the sediment profiles investigated at the Luggage Point site. Results of screening and analysis indicates isolated layers of high level PASS material at varying depths.

3.5.4 Geotechnical Assessment

3.5.4.1 Particle Size

Results of Particle Size Distribution (PSD) analysis carried out on samples of the fine sediments (clays and silts) are also included in **Appendix D**. The test results indicate quite uniform material types through at least the upper four meters or so of the sediment profile at Luggage Point. Fine sediments comprising mostly silty and sandy clays predominate. Sand where present is finer than about 250 μm.

The iron pyrites present in the fines that cause the ASS which are present, are of the order of sub 10 μm, and will be present in the clay fines fraction, which would be prone to local dispersion when disturbed. However, given the abundance of salt water, the inherent salinity would act to limit the dispersion. Similarly, the low levels of contaminants detected (mainly Organo-Tins) would also be present in the clay fines fraction, and unnecessary mobilisation of the fines is to be avoided.

3.5.4.2 Contaminated Soils

Sediment Sampling Program

The sampling program adopted, comprised sampling of recent, bottom sediments. Samples were recovered from the top of the recent or disturbed sediment layer (where present), and the top of the underlying sediment strata.

Where the recent sediment layer exceeded about 0.4 m depth, a second sample was recovered. In addition, as some locations, a second deeper sample was recovered from the underlying sediment strata for comparison of analytical data.

Samples were taken from the undisturbed core, and mixed to a homogeneous state in a stainless steel bowl. Duplicate samples were then placed in sterile glass jars, refrigerated and dispatched to ALS Brisbane for analysis.

In all, six sediment samples from Luggage Point were analysed for the following analytes:

- Heavy Metals (11 metals including Arsenic and Mercury);
- OC Pesticides;
- Organo-Tins (including Tributyl-Tin);
- Phenols;
- Total Organic Carbon (TOC); and
- Nutrients - Total Nitrogen and Phosphorous, Ammonia, Nitrates and Nitrides (NO_x).

In addition, samples of bottom sediment (top of the recent sediment layer) were recovered from the four locations (Bio Sample #1 – #4) and analysed for the presence of Faecal Coli forms and Total Coli forms. No faecal particles of odours were detected during sampling.

Results of Soils Analysis

Results of contaminant analysis for the four locations initially investigated in the Brisbane River estuary (including Luggage Point) are summarised in **Appendix D**.

All samples analysed returned analyte concentrations below the adopted environmental investigation levels (EIL) and AEPR Accepted Limits for General Airport Areas, listed in Schedule 3 – Soil Pollution – Table 1.

Mercury was detected in a sample from BH18 2.0–2.25 m from Luggage Point, at a concentration that exceeds ANZECC sediment quality guideline trigger values for low effects[1] for heavy metals (i.e. 0.2 mg/kg).

Results of biological pathogen testing did not detect either Faecal Coli forms or Total Coli forms at elevated levels (i.e. results were below detection limits of the adopted test method).

[1] Low effect values as stated in the NOAA listing (Long et al, 1995)

It should be noted that EIL and AEPR Accepted Limits (for Areas of Environmental Significance) have the same exceedence trigger values for Arsenic, Nickel and Zinc, where applicable. Organo-Tins were included in the analyte screen (though not listed in the EPA Guidelines or AEPR), as recent bottom sediments in the estuary of the Brisbane River commonly contain a build up of Organo-Tin compounds associated with marine anti-fouling surface coatings, which may be mobilised as a result of disturbance of the river bottom.

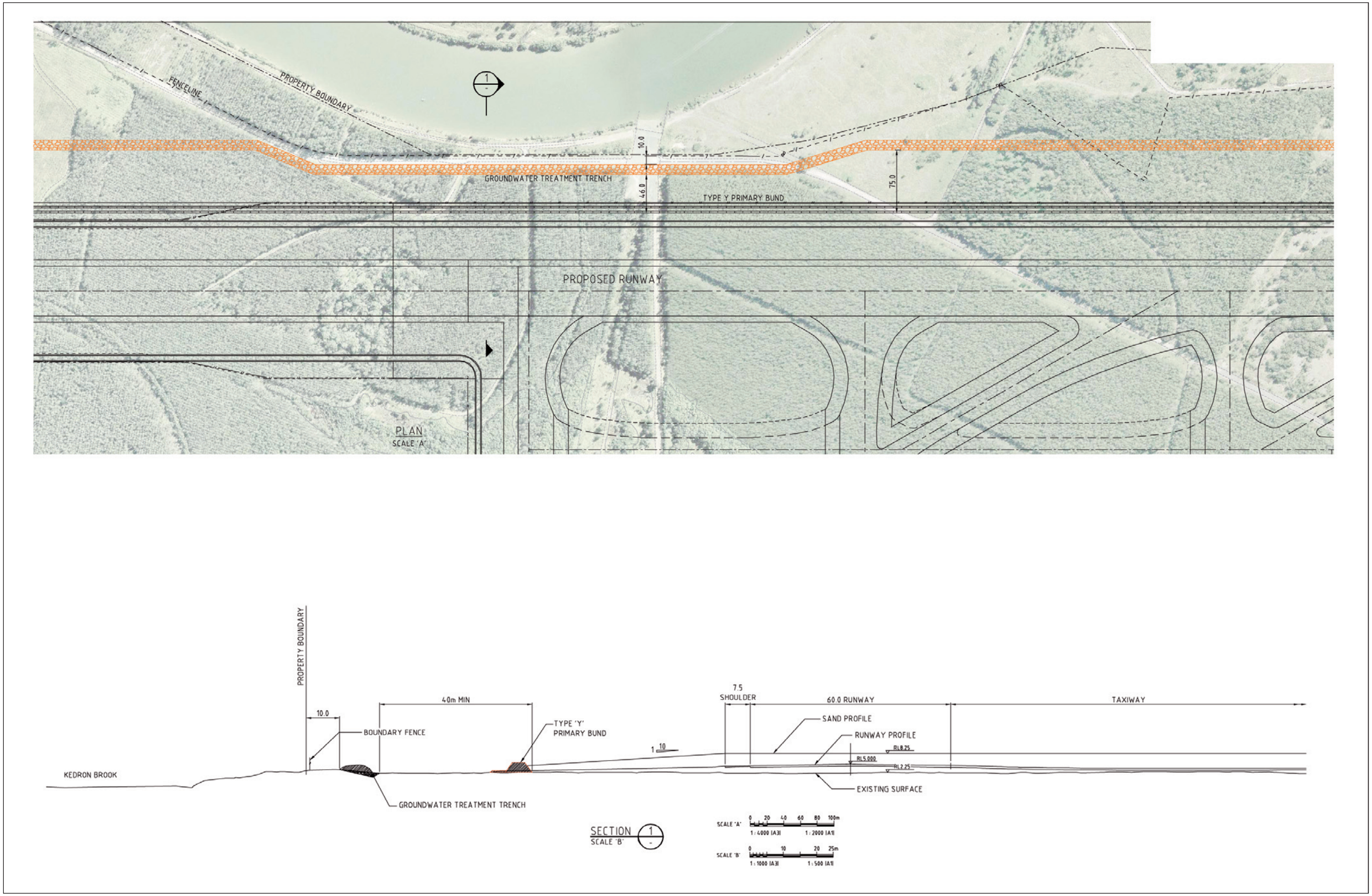
3.6 Potential Impacts – General

3.6.1 Proposed Development and Construction Sequence

Details of the proposed development are provided in Chapter A4, and details of the proposed construction sequence are provided in Chapter A5. In terms of activities that will impact on soil and groundwater, a simplified version of the construction sequence is as follows:

- Undertake limited clearing to establish site access.
- Undertake works to upgrade the existing 14/32 cross runway.
- Construct the under runway culvert and connecting Serpentine Inlet Drain.
- Construct the KBF Drain and eastern cross-connector drain (in 100 m sections, with no connection to Kedron Brook Floodway until ASS management measures are completely implemented).
- Construct the perimeter bund around the area where dredged sand will be placed. The bund will be constructed from the treated material excavated from the KBF drain, and will be lined on the interior face with plastic liner to limit erosion during pumping of the dredged sand. The proposed bund height is 3 m (minimum). The bund will extend across the old Serpentine Creek immediately to the west of where it is crossed by the proposed runway, isolating the portion of the creek to the east of this point, and all the drains that connect into the creek upstream of the bund.
- Construct the proposed groundwater interception/treatment trench between the runway and Kedron Brook. The purpose of the trench is to intercept shallow groundwater flow from the runway area to Kedron Brook, and to treat it to reduce pH and remove metals. Schematic details of the trench are illustrated in **Figure 3.6a**. The need for the trench, and the basis for selecting the location of the trench are discussed in the following.
- Clear vegetation within the bunded area, construct intermediate bunds, and place vertical wick drains in areas where they are required.
- Place dredged sand within the bunded area in a staged program. The thickness of dredged sand to be placed will vary depending on the existing surface topography, and the height of surcharge required.
- After settlements under surcharge are complete on the runway and taxiways, remove surcharge from these areas, and place as additional fill/surcharge in the already filled Western Apron and FAFA.
- Complete construction of pavements, minor surface drainage works and the cross taxiway tunnel.

Figure 3.6a: Schematic – Location and Cross-Section of Lime Interception Trench.



3.6.2 Potential Impacts of Proposed Development

Summary of Physical Impacts

Potential impacts to soils include:

- Potential instability of the fill platform, particularly under surcharge loading;
- Settlement of the fill platform;
- Erosion of proposed drain excavations.

Potential impacts on groundwater include:

- An increase in groundwater levels as a result of clearing of vegetation. This impact will be short-lived, and will be superseded by the subsequent larger impact of surcharging. The temporary rise in groundwater levels within the cleared area will cause increased lateral flow away from the area, to a lesser extent than will occur under surcharge loading.
- The effects of surcharging and filling of the site, that will cause an increase in pore pressures in the underlying alluvial sediments. Dissipation of excess pore pressures will cause groundwater to flow upwards into the sand fill, and laterally through the near surface soils. These effects will last for the duration of the surcharge period (up to approximately four years in some areas), and will be most significant in the early part of the surcharge period when excess pore pressures are highest. It is noted that, based on the results of laboratory testing, surcharging is not likely to lead to a significant decrease in permeability of the alluvial sediments.
- A permanent increase in the groundwater level in the area that will be filled with dredged sand, similar to that currently observed in the existing filled area.
- A lowering of the water table in the vicinity of the proposed drains.

Summary of Geo-Chemical Impacts

Potential impacts to soils include the following (unless adequately managed):

- ASS related impacts arising from the direct disturbance of actual and potential ASS in areas of proposed excavations, including major drainage works for the KBF and SI Drains and connecting drainage channels and the cross taxiway tunnel.
- The use of treated ASS spoil in construction of the perimeter bund and as fill elsewhere on-site.
- The operation of four ASS treatment areas (each at a different time during the construction cycle).
- Placement of potential ASS spoil below the water table in the bunded, redundant section of Serpentine Creek.
- Contamination-related impacts arising from the disturbance and reburial on-site, of fill containing low level contamination.

Potential impacts on groundwater include the following (unless adequately managed):

- ASS related impacts arising from the placement of fill to construct the proposed runway fill platform. The existing actual acidity in the near surface stratum will be permanently inundated following placement of the fill and subsequent settlement of the existing surface, allowing acidity to mobilise in the shallow groundwater.
- ASS related impacts arising from construction of large open drains which expose potential ASS and allow existing shallow actual ASS to come into contact with site runoff and tidal exchange waters.
- Contamination-related impacts arising from the extraction and discharge of potentially contaminated groundwater during vacuum settlement operations for pre-treatment of parts of the runway area.

These impacts are discussed in more detail in the following sections.

3.6.2.1 Fill Platform Stability

The existing alluvial sediments are sensitive to loading and if the initial fill thickness placed is too thick, slope instability and bearing capacity failure within the underlying compressible materials may occur.

Preliminary slope stability analyses undertaken for the strata encountered at the test locations indicates that placement of dredged sand fill to 3.5 m above existing ground surface level (and assuming a 1 m thick natural crust) has a Factor of Safety of 1.2 for batter slopes of 1V:3H. In general, steeper slopes will require a thinner initial fill layer, whilst significantly flatter batters would be required to place fill to a higher level. Note that gentler batter slopes of around 1V:10H have been adopted for the NPR to allow the fill to be placed up to 6.5 m deep.

3.6.2.2 Settlement of the Fill Platform

A batter slope of 1V:3H and a maximum initial dredged sand fill depth of 3.5 m was selected for the settlement analyses. Estimates of construction and post-construction settlement at the test locations have been made using Golder Associates in-house computer program PCON for a variety of surface loadings. This uses a sub-layer formulation of Terzaghi's equation for pore pressure dissipation, to calculate changes in effective stresses with time in response to any nominated sequence of loading and unloading events. Consolidation theory is then used to calculate the accompanying pattern of primary consolidation and secondary compression.

Comparative analyses have been carried out to assess various treatment options (preloading and surcharging for various periods and surcharge heights, with and without wick drains), using most likely parameters based on the results of laboratory testing, and experience at other Airport sites. Based on the results of these analyses, broad treatment areas have been defined, in which a particular treatment scenario will achieve post-construction settlements that are on average less than the tolerable values. Within each of these areas, probabilistic analyses have then been carried out for the chosen treatment scenario, to assess the potential range in settlement (see below).

The settlement analyses have been modelled for a number of treatment options:

1. Preloading for 12–24 months. Preloading involves filling the site to a predetermined level above design level, allowing the site to settle to approximately the nominated design level over a period of time, then undertaking minor reshaping/re-levelling as required.
2. Surcharging. Surcharging involves filling the site to a greater level than the final design level, allowing the surcharge load to remain for a nominated period of time, than cutting back to design level. The following surcharge sequence was adopted:
   - Fill to 3.5 m above the existing surface level;
   - Place an additional 2 m of fill after 6 months; and
   - In selected areas place an extra 1 m of fill after a further 6 months (i.e. 6.5 m total).
3. Wick drains in conjunction with surcharging (using the surcharge sequence above).

Settlement predictions for the options of preloading, surcharging and surcharging with wick drains are presented in **Table 3.6a**. Where tests are located near the edge of ground surface level changes (e.g. near fill crests), analyses have been carried out for both ground profiles with strata levels adjusted accordingly. No abrupt transitions from one extreme to the other would be expected because the compressible soils are relatively deep.

The settlement analyses indicate expected total settlements (combined primary and secondary) ranging from 300 mm in the middle third of the runway where the compressible alluvium is thinnest to 1,850 mm in the area between Serpentine Creek and the existing 14/32 runway, where the compressible alluvium is thickest. Specialised vacuum consolidation settlement acceleration techniques may be utilised at the northern end of the runway, where the target post-construction settlements can not be achieved with surcharge and wick drains. Vacuum consolidation is likely to be used for the 14/32 upgrading works at the western end of the 14/32. In this area the depth of Lower Holocene is deeper than elsewhere on the site, and the settlement period available is less than elsewhere.

Table 3.6a : Construction and Post Construction (Residual) Settlement* Estimates at Test Locations (mm).

CPT	Analysed Surface Level	Fill to RL5		Preload 1 year		Preload 2 years		Surcharge		Surcharge and Wick Drains at 2m centres		Longer Surcharge		Longer Surcharge and Wick Drains at 2m centres		Higher Surcharge		Higher Surcharge and Wick Drains at 2m Centres	
		Depth of Fill	Construction / Residual Settlement	Depth of Fill	Construction / Residual Settlement	Depth of Fill	Construction / Residual Settlement	Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement
1	3.3	1.7	100 / 350	1.9	200/ 300	1.95	250/ 250	3.5/6m, 5.5/18m	600 / 150-200	3.5/6m, 5.5/18m	900 / 0-50	3.5/6m, 5.5/30m	700 / 100-150	3.5/6m, 5.5/30m	1000 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	700 / 150-200	3.5/6m, 5.5/6m, 6.5m/12m	1000 / 0-50
2	3.0	2.0	50 / 450	2.15	150 / 400	2.2	200 / 350	3.5/6m, 5.5/18m	550 / 200-250	3.5/6m, 5.5/18m	950 / 0-50	3.5/6m, 5.5/30m	700 / 150-200	3.5/6m, 5.5/30m	1050 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	600 / 200-250	3.5/6m, 5.5/6m, 6.5m/12m	1050 / 0-50
3	2.7	2.3	50 / 200	2.5	200 / 100	2.55	250 / 100	3.5/6m, 5.5/18m	400 / 0-50		N/a	3.5/6m, 5.5/30m	400 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	400 / 0-50		N/a
4	3.3	1.7	50 / 350	2.0	300 / 150	2.0	300 / 150	3.5/6m, 5.5/18m	700 / 0-50		N/a	3.5/6m, 5.5/30m	750 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	750 / 0-50		N/a
5	2.8	2.2	150 / 400	2.5	300 / 300	2.55	350 / 250	3.5/6m, 5.5/18m	750 / 50-100		N/a	3.5/6m, 5.5/30m	850 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	800 / 50-100		N/a
6	2.9	2.1	100 / 350	2.4	300 / 300	2.55	450 / 250	3.5/6m, 5.5/18m	800 / 0-50		N/a	3.5/6m, 5.5/30m	900 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	900 / 0-50		N/a
7	3.0	2.0	100 / 550	2.3	300 / 400	2.35	350 / 350	3.5/6m, 5.5/18m	600 / 200-250	3.5/6m, 5.5/18m	1050 / 50-100	3.5/6m, 5.5/30m	750 / 200-250	3.5/6m, 5.5/30m	1300 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	700 / 200-250	3.5/6m, 5.5/6m, 6.5m/12m	1200 / 0-50
8	3.2	1.8	100 / 500	2.15	350 / 350	2.2	400 / 300-350	3.5/6m, 5.5/18m	800 / 150-200	3.5/6m, 5.5/18m	1100 / 0-50	3.5/6m, 5.5/30m	850 / 150-200	3.5/6m, 5.5/30m	1200 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	850 / 150-200	3.5/6m, 5.5/6m, 6.5m/12m	1200 / 0- 50
9	3.5	1.5	50 / 350	1.8	300 / 150	1.8	300 / 100-150	3.5/6m, 5.5/18m	950 / 0-50		N/a	3.5/6m, 5.5/30m	1000 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	850 / 0- 50		N/a
10	2.8	2.2	150 / 800	2.75	550 / 500	2.85	650 / 450-500	3.5/6m, 5.5/18m	1200 / 200-250		N/a	3.5/6m, 5.5/30m	1300 / 50-100		N/a	3.5/6m, 5.5/6m, 6.5m/12m	1300 / 150-200		N/a
11	2.4	2.6	150 / 850	3.15	550 / 650	3.2	600 / 600	3.5/6m, 5.5/18m	900 / 450-500	3.5/6m, 5.5/18m	1450 / 150-200	3.5/6m, 5.5/30m	1000 / 400-450	3.5/6m, 5.5/30m	1600 / 100-150	3.5/6m, 5.5/6m, 6.5m/12m	1000 / 450-500	3.5/6m, 5.5/6m, 6.5/12m	1600 / 50-100
12	2.8	2.2	150 / 650	2.65	450 / 550	2.7	500 / 500	3.5/6m, 5.5/18m	900 / 400-450	3.5/6m, 5.5/18m	1600 / 150-200	3.5/6m, 5.5/30m	950 / 350-400	3.5/6m, 5.5/30m	1800 / 50-100	3.5/6m, 5.5/6m, 6.5m/12m	950 / 400-450	3.5/6m, 5.5/6m, 6.5/12m	1900 / 0-50
14	2.6	2.4	200 / 300	2.85	450 / 150	2.9	500 / 100	3.5/6m, 5.5/18m	700 / 0-50		N/a	3.5/6m, 5.5/30m	700 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	700 / 0-50		N/a
15	2.5	2.5	200 / 600	2.95	450 / 400	3.05	550 / 350	3.5/6m, 5.5/18m	900 / 150-200	3.5/6m, 5.5/18m	1100 / 0-50	3.5/6m, 5.5/30m	1000 / 50-100	3.5/6m, 5.5/30m	1200 / 0- 50	3.5/6m, 5.5/6m, 6.5m/12m	1000 / 150-200	3.5/6m, 5.5/6m, 6.5/12m	1200 / 0-50
17	2.2	2.8	200 / 600	3.5	700 / 250	3.6	800 / 200	3.5/6m, 5.5/18m	1000 / 0-50		N/a	3.5/6m, 5.5/30m	1100 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	1100 / 0-50		N/a
18	2.8	2.2	150 / 300	2.6	400 / 100	2.6	400 / 100	3.5/6m, 5.5/18m	650 / 0-50		N/a	3.5/6m, 5.5/30m	700 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	700 / 0-50		N/a
19	3.0	2.0	150 / 250	2.35	350 / 100	2.35	350 / 100	3.5/6m, 5.5/18m	600 / 0-50		N/a	3.5/6m, 5.5/30m	600 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	600 / 0-50		N/a
20	2.8	2.2	100 / 500	2.7	500 / 150	2.75	550 / 150	3.5/6m, 5.5/18m	850 / 0-50		N/a	3.5/6m, 5.5/30m	900 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	950 / 0-50		N/a
21	4.2	0.8	50 / 150	0.9	100 / 100	0.9	100 / 100	3.5/6m, 5.5/18m	550 / 0-50		N/a	3.5/6m, 5.5/30m	550 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	550 / 0-50		N/a
21	3.4	1.6	50 / 250	1.9	300 / 100	1.9	300 / 100	3.5/6m, 5.5/18m	550 / 0-50		N/a	3.5/6m, 5.5/30m	550 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	600 / 0-50		N/a
22	3.2	1.8	100 / 300	2.1	300 / 150	2.15	350 / 100	3.5/6m, 5.5/18m	600 / 0-50		N/a	3.5/6m, 5.5/30m	650 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	650 / 0-50		N/a
22	4.3	0.7	50 / 200	0.8	100 / 150	0.85	150 / 100	3.5/6m, 5.5/18m	600 / 0-50		N/a	3.5/6m, 5.5/30m	600 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	600 / 0-50		N/a
23	2.7	2.3	150 / 500	2.75	450 / 300	2.85	550 / 200	3.5/6m, 5.5/18m	850 / 0-50	3.5/6m, 5.5/18m	900 / 0 - 50	3.5/6m, 5.5/30m	900 / 0-50	3.5/6m, 5.5/30m	950 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	900 / 0-50	3.5/6m, 5.5/6m, 6.5/12m	900 / 0-50
24	3.0	2.0	100 / 650	2.45	450 / 750	2.5	300 / 400	3.5/6m, 5.5/18m	950 / 200-250	3.5/6m, 5.5/18m	1250 / 0-50	3.5/6m, 5.5/30m	1000 / 150 – 200	3.5/6m, 5.5/30m	1350 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	1050 / 150-200	3.5/6m, 5.5/6m, 6.5/12m	1400 / 0-50

CPT	Analysed Surface Level	Fill to RL5		Preload 1 year		Preload 2 years		Surcharge		Surcharge and Wick Drains at 2m centres		Longer Surcharge		Longer Surcharge and Wick Drains at 2m centres		Higher Surcharge		Higher Surcharge and Wick Drains at 2m Centres	
		Depth of Fill	Construction / Residual Settlement	Depth of Fill	Construction / Residual Settlement	Depth of Fill	Construction / Residual Settlement	Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement	Total Depth / Time of Fill	Construction / Residual Settlement
26	2.2	2.8	100 / 1100	3.5	700 / 750	3.7	900 / 650	3.5/6m, 5.5/18m	1150 / 500-550	3.5/6m, 5.5/18m	1850 / 350-400	3.5/6m, 5.5/30m	1250 / 450-500	3.5/6m, 5.5/30m	1950 / 200-250	3.5/6m, 5.5/6m, 6.5m/12m	1300 / 500-550	3.5/6m, 5.5/6m, 6.5/12m	2050 / 200-250
27	2.7	2.3	150 / 700	2.8	500 / 350-400	3.0	700 / 300	3.5/6m, 5.5/18m	1050 / 50-100	3.5/6m, 5.5/18m	1150 / 0-50	3.5/6m, 5.5/30m	1150 / 0-50	3.5/6m, 5.5/30m	1200 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	1150 / 0-50	3.5/6m, 5.5/6m, 6.5/12m	1250 / 0- 50
27	2.1	2.9	200 / 850	3.6	700 / 450	3.75	900 / 300	3.5/6m, 5.5/18m	1150 / 100-150	3.5/6m, 5.5/18m	1200 / 50-100	3.5/6m, 5.5/30m	1250 / 50-100	3.5/6m, 5.5/30m	1300 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	1250 / 50-100	3.5/6m, 5.5/6m, 6.5/12m	1300 / 0-50
28	3.6	1.4	50 / 250	1.55	150 / 150	1.55	150 / 150	3.5/6m, 5.5/18m	600 / 0-50		N/a	3.5/6m, 5.5/30m	600 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	650 / 0-50		N/a
30	2.7	2.3	250 / 250	2.75	450 / 100	2.75	450 / 100	3.5/6m, 5.5/18m	650 / 0-50		N/a	3.5/6m, 5.5/30m	650 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	700 / 0-50		N/a
30	5.0	0.0	10 / 100	0.05	50 / 100	0.05	50 / 100	3.5/6m, 5.5/18m	550 / 0-50		N/a	3.5/6m, 5.5/30m	600 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	600 / 0-50		N/a
32	2.6	2.4	150 / 600	2.85	450 / 500	2.9	500 / 450	3.5/6m, 5.5/18m	650 / 400-450	3.5/6m, 5.5/18m	1400 / 100-150	3.5/6m, 5.5/30m	700 / 350-400	3.5/6m, 5.5/30m	1550 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	700 / 400-450	3.5/6m, 5.5/6m, 6.5/12m	1600 / 50-100
33	2.8	2.2	150 / 350	2.6	400 / 150	2.6	400 / 100	3.5/6m, 5.5/18m	650 / 0-50		N/a	3.5/6m, 5.5/30m	700 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	700 / 0-50		N/a
34	2.7	2.3	100 / 600	2.8	500 / 300	2.9	600 / 250	3.5/6m, 5.5/18m	1000 / 0- 50		N/a	3.5/6m, 5.5/30m	1100 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	1150 / 0-50		N/a
35	2.7	2.3	150 / 600	2.6	150 / 700	2.65	350 / 500	3.5/6m, 5.5/18m	650 / 400-450	3.5/6m, 5.5/18m	1400 / 100-150	3.5/6m, 5.5/30m	750 / 350-400	3.5/6m, 5.5/30m	1550 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	700 / 400-450	3.5/6m, 5.5/6m, 6.5/12m	1600 / 50-100
36	2.5	2.5	150 / 550	3.45	550 / 250	3.1	600 / 150	3.5/6m, 5.5/18m	900 / 0-50		N/a	3.5/6m, 5.5/30m	950 / 0-50		N/a	3.5/6m, 5.5/6m, 6.5m/12m	1000 / 0-50		N/a
37	2.1	2.9	200 / 1000	3.5	600 / 800	3.6	700 / 700	3.5/6m, 5.5/18m	900 / 600-650	3.5/6m, 5.5/18m	1600 / 200-250	3.5/6m, 5.5/30m	1000 / 550-600	3.5/6m, 5.5/30m	1700 / 100-150	3.5/6m, 5.5/6m, 6.5m/12m	900 / 500-550	3.5/6m, 5.5/6m, 6.5/12m	1750 / 150-200
37	3.6	1.4	50 / 550	1.6	200 / 450	1.65	250 / 300	3.5/6m, 5.5/18m	750 / 200-250	3.5/6m, 5.5/18m	1300 / 0-50	3.5/6m, 5.5/30m	800 / 200-250	3.5/6m, 5.5/30m	1400 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	800 / 200-250	3.5/6m, 5.5/6m, 6.5/12m	1400 / 0-50
38	2.0	3.0	200 / 950	3.45	450 / 800-850	3.55	550 / 750-800	3.5/6m, 5.5/18m	750 / 650-700	3.5/6m, 5.5/18m	1500 / 200-250	3.5/6m, 5.5/30m	850 / 550-600	3.5/6m, 5.5/30m	1500 / 200-250	3.5/6m, 5.5/6m, 6.5m/12m	800 / 600-650	3.5/6m, 5.5/6m, 6.5/12m	1650 / 150-200
38	3.4	1.6	100 / 450	1.85	250 / 350	1.9	300 / 350	3.5/6m, 5.5/18m	750 / 250-300	3.5/6m, 5.5/18m	1350 / 0- 50	3.5/6m, 5.5/30m	800 / 200-250	3.5/6m, 5.5/30m	1500 / 0- 50	3.5/6m, 5.5/6m, 6.5m/12m	800 / 250-300	3.5/6m, 5.5/6m, 6.5/12m	1500 / 0-50
39	2.2	2.8	300 / 650	3.4	600 / 450	3.55	750 / 350	3.5/6m, 5.5/18m	1000 / 150-200	3.5/6m, 5.5/18m	1150 / 50-100	3.5/6m, 5.5/30m	1100 / 50-100	3.5/6m, 5.5/30m	1200 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	1100 / 100-150	3.5/6m, 5.5/6m, 6.5/12m	1250 / 0-50
41	2.8	2.2	200 / 550	2.6	400 / 450	2.65	450 / 400	3.5/6m, 5.5/18m	800 / 250-300	3.5/6m, 5.5/18m	1250 / 0-50	3.5/6m, 5.5/30m	900 / 250-300	3.5/6m, 5.5/30m	1350 / 0- 50	3.5/6m, 5.5/6m, 6.5m/12m	900 / 250-300	3.5/6m, 5.5/6m, 6.5/12m	1400 / 0-50
42	2.2	2.8	250 / 900	3.4	650 / 750	3.5	700 / 700	3.5/6m, 5.5/18m	950 / 550-600	3.5/6m, 5.5/18m	1650 / 250-300	3.5/6m, 5.5/30m	1000 / 500-550	3.5/6m, 5.5/30m	1800 / 150-200	3.5/6m, 5.5/6m, 6.5m/12m	1000 / 550-600	3.5/6m, 5.5/6m, 6.5/12m	1800 / 100-150
42	2.8	2.2	200 / 650	2.65	550 / 550	2.7	500 / 500	3.5/6m, 5.5/18m	850 / 400-450	3.5/6m, 5.5/18m	1500 / 50-100	3.5/6m, 5.5/30m	950 / 350-400	3.5/6m, 5.5/30m	1600 / 0-50	3.5/6m, 5.5/6m, 6.5m/12m	900 / 400-450	3.5/6m, 5.5/6m, 6.5/12m	1650 / 0-50
42	3.8	1.2	50 / 500	1.4	200 / 250	1.45	250 / 200	3.5/6m, 5.5/18m	750 / 150-200	3.5/6m, 5.5/18m	1200 / 0-50	3.5/6m, 5.5/30m	800 / 150-200	3.5/6m, 5.5/30m	1350 / 0- 50	3.5/6m, 5.5/6m, 6.5m/12m	800 / 150-200	3.5/6m, 5.5/6m, 6.5/12m	1350 / 0-50
43	3.5	1.5	100 / 350	1.8	300 / 250	1.8	300 / 250	3.5/6m, 5.5/18m	800 / 200-250	3.5/6m, 5.5/18m	1500 / 0-50	3.5/6m, 5.5/30m	850 / 150-200	3.5/6m, 5.5/30m	1600 / 0- 50	3.5/6m, 5.5/6m, 6.5m/12m	850 / 200-250	3.5/6m, 5.5/6m, 6.5/12m	1600 / 0-50
43	2.5	2.5	200 / 700	3.0	500 / 600	3.05	550 / 550	3.5/6m, 5.5/18m	850 / 450-500	3.5/6m, 5.5/18m	1650 / 250-300	3.5/6m, 5.5/30m	900 / 450-500	3.5/6m, 5.5/30m	1750 / 100-150	3.5/6m, 5.5/6m, 6.5m/12m	900 / 450-500	3.5/6m, 5.5/6m, 6.5/12m	1800 / 150-200

NOTES:

1. *Settlements based on average settlement parameters*
2. *Preload/first surcharge lift based on 1 month construction time (assumed dredge pipe placement)*
3. *3.5/6m and 5.5/18m denotes 3.5 m of fill placed for 6 months then additional 2.0 m of fill (for a total of 5.5 m) placed for a further 18 months*
4. *Construction settlement is settlement occurring from start of construction to removal of surcharge or end of preload*
5. *Residual (post-construction) settlement is settlement after 50 years (after end of filling or preloading or surcharging)*
6. *Unit weight of fill 20kN/m3*
7. *N/a – Not analysed*
8. *Predicted Residual Settlement >200mm after 50 years, Predicted Residual Settlement <200mm after 50 years.*

NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

3.6.2.3 Groundwater Impacts from Surcharging

Groundwater modelling has been carried out to assess the potential magnitude of the impact due to site filling. In order to model the impacts of surcharging, it is necessary to use a model that is capable of simulating the generation of pore pressures/hydraulic gradients as a result of mechanical loading, and their subsequent dissipation. Conventional groundwater models (such as MODFLOW) are not capable of modelling the pore pressure generation.

Stress analysis software SIGMA/W (which models the generation of pore pressure due to loading) was used, coupled with SEEP/W (a groundwater flow model). The modelling has been carried using cross-sectional models, which is not considered to be a drawback since the hydraulic gradients induced by surcharging will be primarily vertical, and away from the axis of the runway. Furthermore, modelling of the consolidation using three-dimensional models would be impractical as a result of the relatively fine finite element mesh discretisation that is required to model the steep vertical hydraulic gradients.

The models that have been used are specifically designed to be used in a coupled mode. SEEP/W is used to model variably saturated groundwater flow, and when combined with SIGMA/W to conduct a 'coupled' analysis, can model the transient pore pressure response to loading. This modelling is similar in many ways to consolidation modelling that has been carried out to assess preloading and surcharging requirements for the project, except that it considers lateral flow of groundwater away from the loaded area, and the consequent increase in groundwater level adjacent to the loaded area (consolidation modelling is conventionally carried out using one-dimensional models).

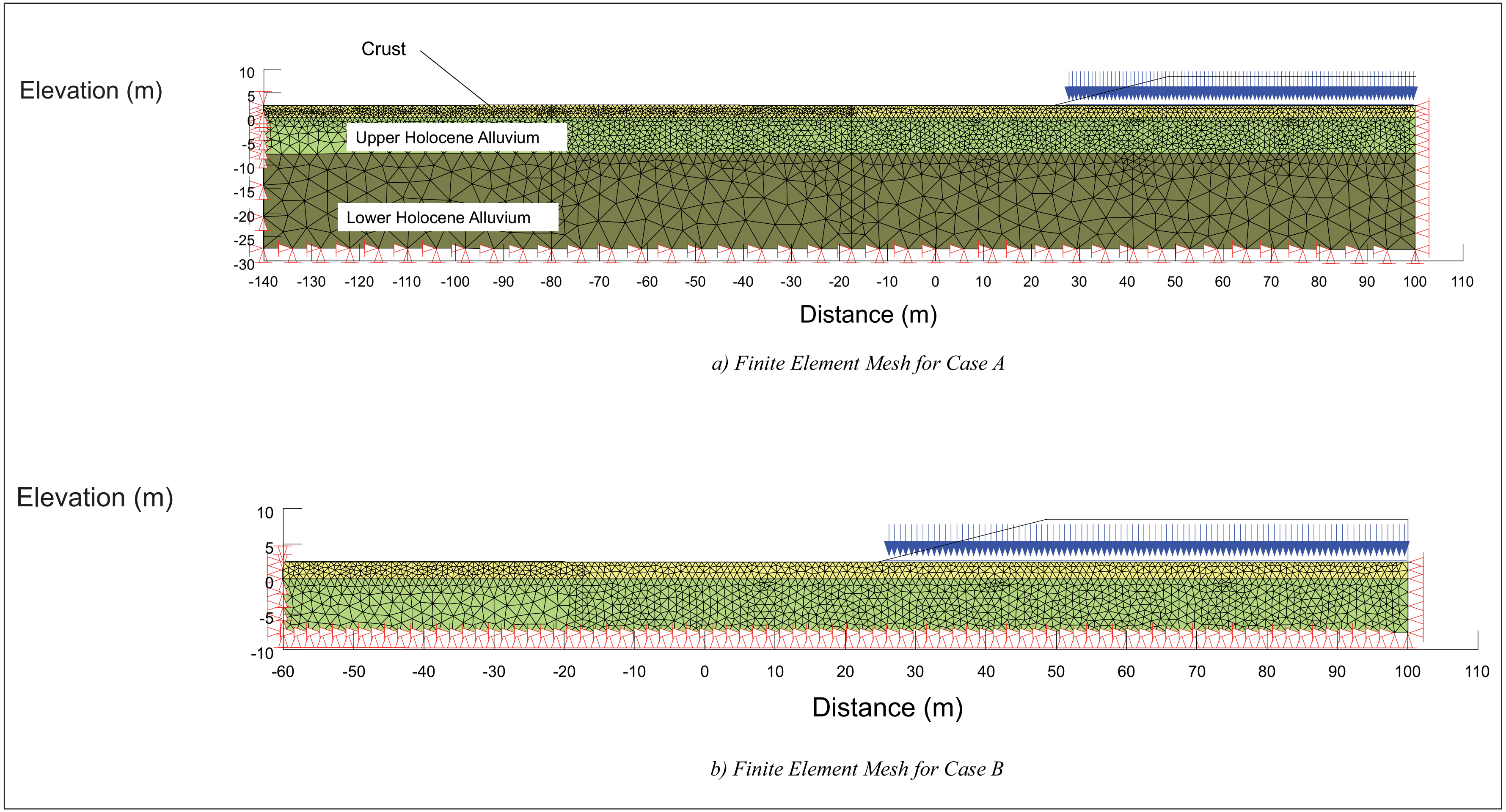
Finite element models have been developed for two conditions:

- Case A: where a significant thickness of Lower Holocene alluvia is present in the subsurface and the runway is a significant distance from Kedron Brook (for example, in the vicinity of monitoring well MW6); and
- Case B: where no Lower Holocene alluvia are present in the subsurface and the runway is close to Kedron Brook (for example, in the vicinity of monitoring well MW4).

The locations of thse cross-sections is illustrated on **Figures 3.3a**, **3.3b** and **3.3c**.

The finite element meshes for these two cases are illustrated in **Figure 3.6b**. The Upper and Lower Holocene alluvia are included in the model, however for Case B there is no Lower Holocene alluvia. Note that for both cases, the sand fill is represented by an applied surface load rather than by directly including it in the finite element mesh, due to numerical instability when the sand was included in the mesh. This is conservative, in that it forces all groundwater to flow laterally away from the filled area, and does not allow for storage of water in the sand fill itself. For Case A, the parameters in the zone directly beneath the embankment were modified to reflect the proposed use of wick drains in this area. This modification requires an increase in the vertical hydraulic conductivity of the Lower Holocene. The horizontal hydraulic conductivity remains unchanged.

Figure 3.6b: *Finite Element Meshes used for Groundwater Modelling.*



Modelling was carried out for an initial water table level at 0.5 m below the surface, which is equal to the highest water levels encountered on the site during the 2005/2006 wet season. Parameters adopted for the modelling were selected to be consistent with parameters used for 1-D consolidation analysis[2].

Parameters for the 1-D modelling have been derived from back-analysis to observed settlement behaviour for a number of surcharges at the Brisbane Airport, over a number of years.

The model results have been used to assess the increase in groundwater level in the area adjacent to the sand fill, in order to select the location for the proposed groundwater interception/treatment trench that will be constructed along the length of the sand fill platform.

In selecting the location of the trench the following factors should be taken into consideration:

- In the current situation, groundwater levels vary significantly on a seasonal basis, and also in response to individual rainfall events. Depending on when the sand fill is placed in relation to the natural fluctuations in groundwater levels, the increase in groundwater levels as a result of the filling may or may not raise the water table above the normal range of fluctuation.
- In any event, the increase in groundwater levels as a result of the filling is not likely lead to generation of additional acid, and may or may not lead to movement of acid groundwater, depending on whether the natural fluctuations in the water table preceding the site filling have led to generation of acid.
- Except in the immediate vicinity of the sand fill where increased infiltration will lead to a permanent rise in groundwater levels, the increase in groundwater level due to site filling will be temporary.

Based on these considerations, it is not intended to use the trench to intercept all groundwater flows to Kedron Brook, which under current conditions will be naturally acidic at times, rather the purpose of the trench is to intercept shallow groundwater that is discharged laterally from the surcharge area itself during pre-loading and construction.

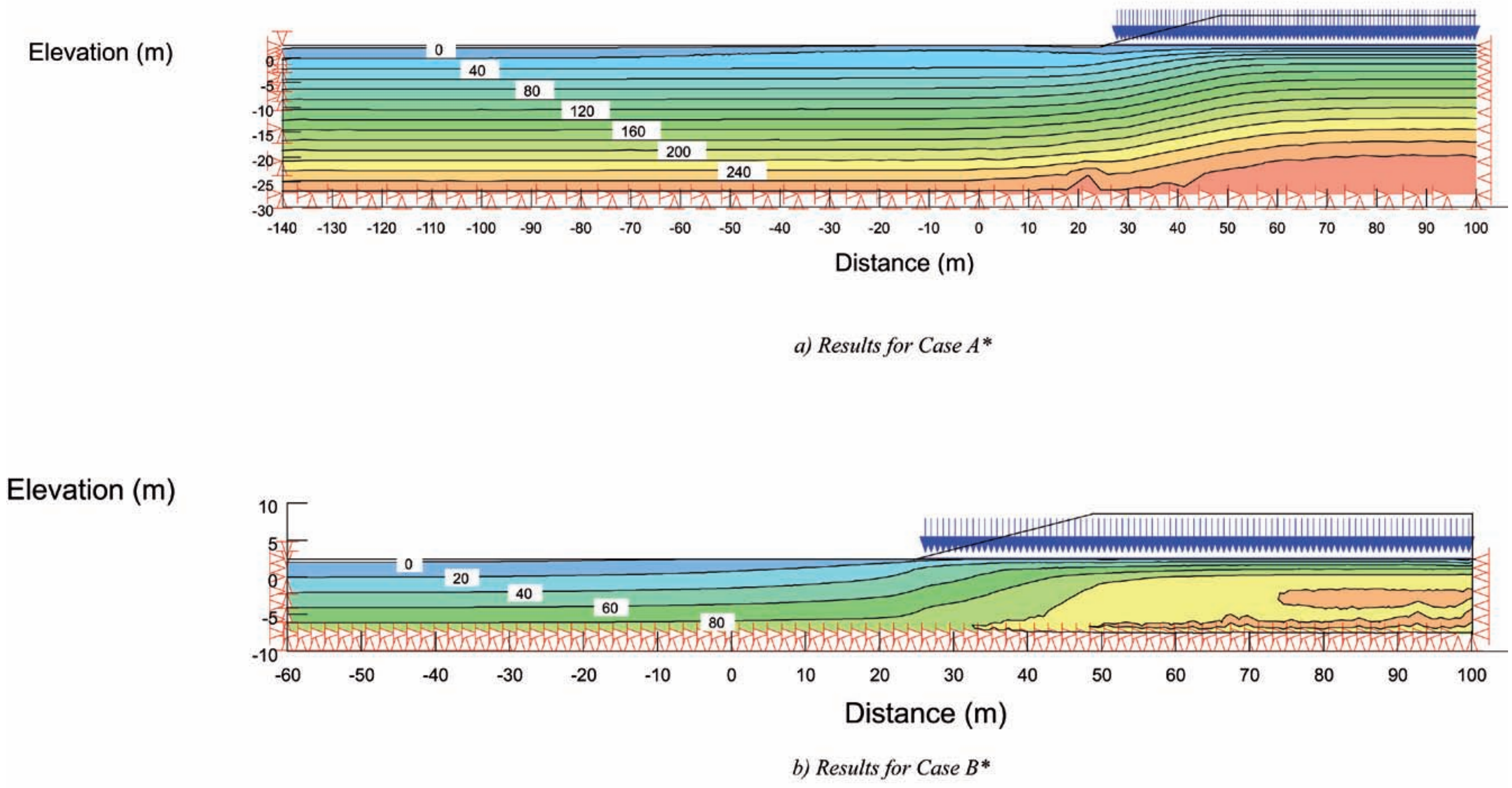
The model results for both cases indicate that the water table will temporarily rise to the surface in the area adjacent to the surcharge. For Case A, the model results indicate that the water table will temporarily rise to the surface up to 50 m away from the toe of the surcharge batter. For Case B, the model indicates a water table rise to the surface up to 25 m from the toe of the batter. Pore pressure contours are illustrated in **Figure 3.6c** for Cases A and B, showing the position of the water table (the zero pressure contour) at the time when the water table rise to the surface extends the maximum distance from the surcharge. Allowing for uncertainties in the modelling and to provide a factor of safety, the groundwater interception trench is to be placed a minimum distance of 40 m from the toe of the surcharge where the runway passes close to Kedron Brook, and a minimum distance of 75 m from the toe of the surcharge in other.

3.6.2.4 Groundwater impacts from Drain Construction

The results of groundwater level monitoring illustrated in **Figure 3.3d** indicate that the construction of the drains will modify the currently occurring fluctuations in groundwater levels, in the vicinity of the drains. The measured groundwater level fluctuations in MW3 and MW6 indicate that in the vicinity of the drains, groundwater levels will fluctuate over a relatively narrow range in response to tidal fluctuations, with a limited influence from seasonal fluctuations.

[2] The coupled analysis and the 1-D consolidation analysis are formulated in different ways and thus the input variables are slightly different, however the critical parameters for the analysis are compressibility, and the parameter(s) defining the rate of consolidation. For the 1-D analysis, compressibility is entered as the Coefficient of Compressibility (Cc/1+e0), and the rate of consolidation is controlled by the Coefficient of Consolidation Cv. For the coupled 2-D analysis, compressibility is defined in Sigma/W by Young's modulus and Poisson's ratio, and in Seep/W by the slope of the Volumetric Water Content function. The rate of consolidation is controlled by the ratio of hydraulic conductivity, and the slope of the Volumetric Water Content function (i.e. the hydraulic diffusivity). Well established theoretical relationships were used to ensure consistency of parameters between the two methods, so that the magnitude and rate of calculated settlement were consistent.

Figure 3.6c: *Pore Pressure Contours.*



* Pore pressure contours are shown for the time at which the water table rise to surface extends the maximum distance from the toe of the surcharge

Within the zone of tidal influence, groundwater levels will fluctuate within a narrower range than the current range of fluctuation in response to rainfall and seasonal effects. Results of monitoring at MW4 indicate that the zone of tidal influence is likely to be limited to within less than 100 m from the drains.

Since water levels in the vicinity of the drain will fluctuate within a narrower range than the current range of fluctuation in response to rainfall and seasonal effects, the drains will not cause a lowering of the water table that will expose currently unoxidised potential ASS. However, groundwater from the zone of actual ASS will discharge to the drains, potentially flushing some acid into the drains. This process will be currently occurring along the drains and remnant tidal creek in the area of the proposed runway.

Inflow rates to the proposed drains that may require treatment of groundwater to raise pH have been estimated based on the following assumptions:

- An average hydraulic gradient towards the drain of 0.02. This is based on the average water level in MW6 in relation to the mean tide level, and the distance from MW6 to Serpentine Creek.
- A hydraulic conductivity of $1x10^{-6}$ m/s for the upper, sandy clay Holocene alluvium (noting that the highest measured value is $2x10^{-7}$ m/s).
- A cross-sectional area for flow of $10m^2$/m length of drain, which is based on a thickness of 10 m for the upper, sandy clay alluvium (the thickness is generally observed to be in the range of 8-10 m in Cone Penetrometer Testing). Adopting this value will lead to an estimate of total inflow to the drain. This is conservative for the purpose of assessing volumes requiring treatment to correct pH, since only a portion of the inflow has the potential to be acidic.

Based on these assumptions, the annual inflow to the drains that would potentially require treatment would be approximately 6,400 L/m length of drain.

3.6.2.5 Long Term Changes to Groundwater Levels

After the completion of consolidation and following the removal of surcharge, groundwater levels in the areas adjacent to site filling will return to levels that are similar to current levels. Temporal fluctuations in response to seasonal and short term fluctuations in rainfall will return to areas where groundwater levels are predicted to rise to the surface between the fill platform and the groundwater interception/treatment trench.

Groundwater levels in the fill platform will remain above the existing levels, at a level that will be within the sand fill itself. This level is likely to be similar to the level in the existing filled area, and the level across the filled area is likely to be effectively constant (similar to the condition observed in the existing filled area). Seepage may occur around the perimeter of the fill, close to the point where it intersects natural ground. Ongoing increased lateral flow will occur towards Kedron Brook as a result of the higher groundwater levels in the fill. Treatment of potential ongoing acidic flows towards Kedron Brook will be provided by the groundwater interception/treatment trench. Note that the volume of lime provided in the trench is sufficient to treat all the actual acidity in the runway area, the FAFA and the Western Apron area.

Long term groundwater levels in the vicinity of the KBF Drain and connector drains will be lowered, although, as discussed above, in the zone of influence of the drains, the groundwater level will continue to fluctuate within the zone where actual acidity has developed as a result of previous groundwater level fluctuations. Ongoing treatment of acidic groundwater inflows will be provided by the lime guard layer that will be placed on the face of the drain.

3.6.2.6 ASS Impacts

The runway development area is low lying and will be filled with up to 6 m of sand fill. The placement of the fill will appreciably impact on the final groundwater level, resulting in a permanent mounding of the local water table within the fill platform.

The existing surface will be subject to settlements of the order of 0.3–1.8 m resulting in permanent inundation of much of the area under the new runway, Western Apron and FAFA. These areas are underlain by soils containing low to moderate levels of actual acidity, and once inundated, the actual acidity will eventually be mobilised in the shallow groundwater. However, management of the mobilised acidity will be achieved using a full length lime interception trench situated between the runway platform and Kedron Brook, filled with sufficient lime to neutralise all of the actual acidity present in the near surface zone. In the long term, much of the actual acidity will be neutralised and the magnitude of acid discharges from the modified flood plain will be much reduced (from what would currently be occurring following rainfall).

In most areas of the development site no actual physical disturbance of ASS or PASS will occur. However, disturbance of ASS and high level PASS soils will occur in drain and tunnel excavations at several discrete locations within the site (at differing times during the construction program). These activities pose a significant risk to the receiving environment unless carefully managed. All ASS/PASS spoil will be treated by the addition of agricultural lime in four purpose built ASS treatment areas. Exposed surfaces along the flanks of open drains will be limed and the lime guard layers maintained in the short term during construction until any actual acidity generated (or otherwise present) has been neutralised. Monitoring and if required lime treatment of surface waters prior to discharge will be carried out during this period. In addition to treatment of short term acidic inflow/runoff during the construction phase, sufficient lime will be provided to treat ongoing groundwater inflows.

3.6.2.7 Contaminated Land Related Impacts

There are few potential impacts arising from the disturbance of potentially contaminated land. For the most part the site will be covered by in excess of 2 m of clean sand fill (up to 6 m in some areas). Former contaminated sites that have already been filled over will eventually remain under even deeper protective 'capping' layers.

The former dredge spoil material from the construction of the Kedron Brook Floodway, which contains low level contamination is currently on the surface and can generate runoff. Following development of the runway site this material will be removed to the redundant (dammed off) section of Serpentine Creek, and capped by a layer of geotextile and more than 2 m of clean fill, in the FAFA, significantly lowering the likelihood of further disturbance.

3.7 Potential Risk and Impacts – Assessment Methodology

A semi-quantitative risk and impact assessment of potential adverse environmental impacts and risks has been undertaken and recommendations made for the management of unavoidable risk. This significance criteria listed in the following tables have been derived with reference to this risk assessment. The various risks identified and mitigation strategies to reduce resulting impacts are discussed in detail in the following sections and summarised in **Table 3.7a** to **3.7d**.

The results of the risk and impact assessments are summarised in **Table 3.12a** in section 3.12.

Table 3.7a: Significance Criteria – Soil Erosion.

Significance	Criteria: Soil Erosion – On-airport
Major Adverse	The uncontrolled mobilisation of sediments resulting from excavations or placement of large volumes of soil, or the exposure of expanses of unstabilised soils on steep slopes or in areas on-site and prone to runoff. Sufficient to cause severe erosion and immediate, large scale impact to local waterways and long term siltation impacts on the receiving environment. Adverse effects of national or international significance would result.
High Adverse	The excavation or placement of substantial quantities of soil on-site, or the exposure of large areas of unstabilised soils on uncovered slopes, or in areas prone to runoff, which results in mobilisation of soil fines. Sufficient to cause detectable erosion and obvious impact on local waterways that can contribute to longer term siltation impacts on the receiving environment. If works are prolonged and not managed, adverse effects of state or national significance would result.
Moderate Adverse	The excavation or placement of significant quantities of soil on-site, or the exposure of areas of soils in areas prone to runoff (at slopes of less than 10 percent). Sufficient to cause localised erosion and limited impact to local waterways and also contribute to the accumulative long term siltation impacts on the receiving environment. Adverse effects of local or state significance may occur if management measures are not correctly implemented.
Minor Adverse	The unmanaged excavation or placement of soil on-site, or the exposure of soils in areas prone to runoff (at slopes of less than 10 percent), resulting from minor works. Sufficient to cause small scale localised erosion. Unlikely to significantly impact on waters within the receiving environment. Adverse effects of local significance may occur if the works are unmanaged or unexpectedly prolonged or repeated
Negligible	The managed excavation or placement of small quantities of soil on-site, or the exposure of small areas of soils in areas not prone to runoff (at slopes of less than 10 percent), not likely to cause measurable impact to local receiving water quality.
Beneficial	Carefully managed works, particularly in areas adjoining drains or local waterways, that result in the stabilisation of soils (i.e. by use of geofabric, rip-rap, mangrove vegetation etc.), that were otherwise be at risk of erosion. Such stabilisation measures result in improved runoff water quality and reduce risk of adverse environmental impact to the receiving environment.

Table 3.7b: Significance Criteria – ASS.

Significance	Criteria: ASS– On-airport
Major Adverse	The uncontrolled direct disturbance of large volumes of ASS having an adverse short and long term effect on-sites of national or international significance. Also possibly causing algal blooms resulting from the discharge of Iron rich runoff. Adverse effects of national or international significance would result.
High Adverse	The disturbance of a substantial volume of ASS or smaller volumes of ASS containing high levels of oxidisable sulfur, having an adverse short and long term effect on-sites of state or national significance if unmanaged. Careful management can mitigate this problem.
Moderate Adverse	The disturbance of a significant volume of ASS (greater than 1,000 m^3) containing high levels of oxidisable sulfur or large scale filling over actual ASS, resulting in short term degradation of the local receiving environment. Careful management of works can mitigate the impacts. Adverse effects of local or state significance may occur if the disturbance is continued.
Minor Adverse	The disturbance of a minor volume of ASS (less than 1,000 m^3) or filling to greater than 0.5 m depth over actual ASS, resulting in generation of periodic or continual low yield acid runoff. Appropriate management can mitigate these impacts.
Negligible	The disturbance of small volumes of ASS (less than 100 m^3) or filling involving less than 500 m3 of fill, over actual ASS, resulting in generation of periodic or continual low yield acid runoff. Degradation of the local receiving environment is not likely and degradation to the greater receiving environment will be imperceptible.
Beneficial	Where disturbance of ASS is minor and the management measures employed result in an improvement of the quality of ecological resources of the local receiving environment. For example, the creation/relocation of mangrove habitats, or introduction of passive, in situ ASS management measures that would achieve improvements in quality off groundwater and/or runoff leaving the site.

Table 3.7c: Significance Criteria – Contaminated Land.

Significance	Criteria: Contaminated Land – On-airport
Major Adverse	The disturbance of large volumes of soil containing high levels of contamination (i.e. exceeding EIL by more than an order of magnitude), or significant volumes of soil containing very high levels of one or more contaminants (i.e. exceeding EIL by several orders of magnitude and/or exceeding health-based limits), which results in mobilisation of the contaminant within the receiving environment. Sufficient to cause immediate, irreversible impact to the local environment and longer term adverse impacts on the receiving environment. Adverse effects of national or international significance would result.
High Adverse	The disturbance of large volumes of soil containing environmentally significant levels of one or more contaminants (i.e. exceeding EIL), or significant volumes of soil containing high levels of one or more contaminants (i.e. exceeding EIL by an order of magnitude) and/or exceeding health-based limits, which results in the mobilisation of the contaminant within the immediate environment. Sufficient to cause adverse impact to the local environment and long term impacts on the receiving environment. Careful management or avoidance can mitigate adverse effects of state or national significance may occur if left unmanaged.
Moderate Adverse	The disturbance of either large volumes of soil containing isolated environmentally significant levels of contamination or smaller volumes containing consistent levels of contamination (i.e. exceeding EIL, but by less than an order of magnitude, but not exceeding health-based limits), which may result in limited mobilisation of contamination within the immediate receiving environment. Implementation of careful management can mitigate the problem. Local ecological and recreational values will be effected if contamination spreads.
Minor Adverse	The disturbance of minor volumes of soil containing isolated occurrences of environmentally significant levels of one or more contaminants (i.e. exceeding EIL, but not exceeding health-based limits), which may result in mobilisation of small amounts of the contaminant within the immediate receiving environment. Appropriate management measures can mitigate any adverse effects of local significance.
Negligible	The disturbance of small volumes of soil containing isolated occurrences of environmentally significant levels of a contaminant (i.e. exceeding EIL, but not exceeding phyto-toxicity thresholds or health-based limits), which may result in mobilisation of small amounts of contaminants within the immediate receiving environment. Degradation of the greater receiving environment is unlikely and degradation to the local receiving environment, imperceptible.
Beneficial	Where the management of the disturbance of small volumes of contaminated soil, results in an improvement of the quality of ecological resources of the receiving environment and or a reduction of risk to human health, (i.e. the placement of contaminated soil that is currently exposed, beneath sealed pavements or capping layers).

Table 3.7d: Significance Criteria – Groundwater Quality.

Significance	Criteria: Geology and Soils – On-airport
Major Adverse	The wide spread degradation of onsite groundwater quality caused by uncontrolled disturbance of ASS or contaminated soil or direct discharge of contaminants into groundwater. Resulting in adverse impact to groundwater quality and surface waters in the local receiving environment and leading to degradation of the receiving environment. Sufficient to cause immediate, irreversible impact to the local environment and long term adverse impacts on the receiving environment. Adverse effects of national or international significance would result.
High Adverse	The degradation of onsite groundwater quality at more than one location, caused by uncontrolled disturbance of ASS or contaminated soil, or direct discharge of contaminants into groundwater. Resulting in adverse impact to groundwater quality and surface waters in some areas within the receiving environment, leading to possible degradation of the immediate receiving environment. Sufficient to cause medium to long term impacts to the local environment and cyclic adverse impacts on the receiving environment. Adverse effects of state or national significance may result if left unmanaged.
Moderate Adverse	The degradation of onsite groundwater quality at one or more locations, caused by uncontrolled disturbance of ASS or contaminated soil, or discharge of contaminants into groundwater. Resulting in elevated contaminant levels with limited adverse impact to groundwater quality and connected surface waters. Careful management can mitigate adverse impacts. Degradation of the immediate receiving environment will occur if management techniques are unsuccessful. Adverse effects of local or state significance may occur if contamination remains unmanaged.
Minor Adverse	Minor, temporary degradation of onsite groundwater quality at one or more locations, caused by 'one off ' disturbance of ASS or contaminated soil. Resulting in slightly elevated contaminant levels. Careful management can mitigate adverse impacts. Adverse effects of local significance may occur if the source of contamination remains unmanaged.
Negligible	Minor, temporary degradation of onsite groundwater quality at a single location, caused by a 'one off ' disturbance of ASS or contaminated soil. Unlikely to cause measurable impact to groundwater or receiving water quality.
Beneficial	Where management of construction involving ASS or contaminated soil results in a reduction of contaminant levels or where groundwater is directly treated to improve quality. The risk of adverse environmental impact will be reduced and the receiving environment enhanced.

3.8 Potential Impacts – Erosion and Stability

3.8.1 New Runway and Linked Taxiway

3.8.1.1 Geotechnical and Seismic Stability

New Runway and Linked Taxiway	Unmitigated Impact – Minor Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible	Low Risk (2)

Fill will placed on the runway area initially as surcharge to induce short term settlement of the deep soft estuarine layers. The fill remaining after removal of surcharge will then be compacted to form subgrade for pavements. Vacuum assisted consolidation is likely to be required where the alluvium is deepest (at the north-eastern end of the new runway).

Potential Impacts

Significant settlement is expected following placement of surcharge, compression within the upper 1.0–1.5 m is not expected to exceed about 50–100 mm with no significant lateral displacement. It is the upper 1.0 m or so that contains actual ASS will be capable of withstanding proposed construction loads without being subject to significant lateral displacement. There will be some instability along the edges of the sand fill platform. If fill batters are constructed too steeply the exposed faces will not be not adequately stabilised. However, gentle 1V:10H batter slopes will be adopted. This will result in geotechnical and seismic stability for the fill platform.

Mitigation Measures

Filling must be carried out in a staged, controlled manner, with fill placed progressively in layers, to prevent instability. Surcharge batters must be constructed at geotechnically stable slopes to limit the risk of slope failure. Geotechnical assessment indicates batter slopes no steeper than 1V:3H will be suitable. Steeper slopes will require a thinner initial fill layer, whilst significantly flatter batters would be required to place fill to a higher level. As a guide, batter slopes of around 1V:6H to 1V:8H would be required to allow fill to be placed to a height of 4.0-4.5 m.

Specialised vacuum settlement techniques are likely to be utilised at the northern end of the runway. This will further limit the lateral displacement of the deep, soft clay layer at that location, where the alluvium is the deepest and settlements will be greatest.

3.8.1.2 Erosion and Dispersion Potential

New Runway and Linked Taxiway	Unmitigated Impact – Major Adverse	Moderate Risk (6)
	Mitigated Impact – Negligible	Low Risk (2)

The proposed development will include a number of major earthworks operations which could increase the risk of erosion and the subsequent migration of soil fines within the site and off-site. These include placement of sand fill over a large area for the initial surcharging and subsequent fill platform for the new runway and taxiways and the stockpiling of excess sand fill, excavated pavement materials and lime treated ASS spoil on-site.

Potential Impacts

Sands, silts and pavement gravels have little cohesion and are prone to erosion on slopes that exceed their natural angles of repose (which vary from about 30–35º). Cohesive soils (clays and sandy clays), are capable of standing at steeper slopes, but may erode as blocks or crumble, where drying of the exposed soil surface occurs. Sand fill material to be used in the runway fill platform and any gravel pavement material that will be disturbed, contain relatively few fines and subsequently are unlikely to pose a significant risk from soil dispersion.

Mitigation Measures

Filling must be carried out in a controlled manner, with fill placed using temporary batter slopes of not steeper than 1V:3H to minimise short term erosion potential. Final surcharge batter slopes are to be no steeper than 1V:4H. In addition, a continuous earth bund at least 2.0 m high is to be constructed around the entire development site prior to commencement of work.

The bund will act to limit wind action on exposed sand fill surfaces and to contain any sand displaced by runoff after heavy rainfall. The bund itself will be stabilised by seeding with grass and kept moist until the grass has taken hold.

Further wind prevention measures will include the use of spray applications of anti-erosive emulsions on exposed areas adjacent to the active runway while the surcharge is in place.

Location of temporary stockpiles, will be limited to designated areas, and will be surrounded by an additional low earth bund to trap local sediment runoff. Stockpiles will be kept moist during dry and windy weather. Exposed batter slopes on the perimeter bund will be stabilised by an application of mulch, until the seeded grass cover takes hold.

Regular inspection of the surface and overall integrity of all bunds will be undertaken.

3.8.2 Future Aviation Facilities Area and Western Apron

The FAFA and Western Apron, like the main runway area are underlain by thick deposits of compressible Holocene alluvium and underlying near surface natural soils are generally firm clays, with some stiff surface crusts. The FAFA is a tidal mangrove community and contains the dead end extension of Serpentine Creek and a number of minor streams. There are some areas of exposed estuarine clay soils. The Western Apron area contains a shallow surface layer of fill to about 0.8 m depth. The deeper underlying alluvium is wet and soft / loose (depending whether clay or sand) and compressible.

It is proposed to bulk fill the FAFA and Western Apron area with more than 2 m of sand fill once surcharging of the New Parallel Runway area is completed.

Filling will be done using the former surcharge material. Some filling will occur during initial site clearance to provide a clean working platform.

3.8.2.1 Geotechnical Stability

FAFA and Western Apron Area	Unmitigated Impact – Minor Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

Some settlement is expected following placement of the fill in both areas. Compression within the upper 1.0–1.5 m is expected to be of the order of 50–100 mm in the FAFA and significantly less in the Western Apron. It is the upper 1.0 m or so that contains actual ASS and will be capable of withstanding the fill load imposed without significantly deforming laterally.

No instability of the sand fill platform is expected, as edges will butt up against the runway fill platform. Several minor surface drains are planned for both areas. Such channels will require to be constructed with sufficiently flat side batter slopes to prevent instability.

Mitigation Measures

No general construction measures are required for the bulk filling operations. When in-filling the former creek and streams, a surface layer (upper 0.5 m) of sand fill would be placed, first underlain by a continuous layer of geofabric to improve local stability and distribute the load of the bulk sand fill that will follow.

Side batters of the open drainage channels are to constructed at geotechnically stable slopes to minimise risk of slope failures. Batter slopes will be no steeper than 1V:4H.

3.8.2.2 Erosion and Dispersion Potential

FAFA and Western Apron Area	Unmitigated Impact – Moderate Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible	Low Risk (2)

In the FAFA and Western Apron, earthworks operations which could increase the risk of erosion and the subsequent migration of soil fines within the site and off-site are limited.

These include placement of sand fill over the whole of both areas and excavation of minor stormwater drainage channels across both sites, connecting to larger drainage channels.

Potential Impacts

The sand fill has little cohesion and is prone to erosion on slopes that exceed their natural angles of repose. However, placement of fill in these areas will be undertaken in staged lifts and no significant fill batters will result.

Minor open drainage channels will be constructed through both sites. The potential exists for erosion of exposed slopes by heavy rainfall. In addition, if soils are dispersive, clay fines can be transported off-site to cause siltation of local waterways. Unabated, such siltation is potentially a moderate adverse impact and may result in accumulative major adverse impacts.

Mitigation Measures

Filling will be carried out in a controlled manner, in even lifts, with fill placed using temporary batter slopes of not steeper than 1V:3H to minimise short term erosion potential. The continuous perimeter earth bund will extend around both sites and will act to limit wind action on exposed sand fill surfaces. The bund itself will be stabilised by seeding with grass and kept moist until the grass has taken hold. Further wind prevention measures will include the use of spray applications of special anti-erosive emulsions on exposed areas of sand until grass cover and pavements are established.

3.8.3 KBF Drain and Cross Connector Channels

Results of the baseline study conducted for the main KBF Drain and connecting channels indicate soil profiles along the drain alignment consist of:

- Shallow fill comprising mainly firm to stiff sandy clay and some clayey sand to 0.0–0.8 m depth along most of the alignment, (with some heavy clay fill towards the eastern end); overlying
- Loose to medium dense clayey sand (saturated below the water table) and soft clay alluvium to the limit of investigation at 2.0–2.5 m depth.

The 1,450m long KBF Drain will be a trapezoidal open channel approximately 30 m wide at the base and 60 m wide at the top and nominally 2.0 m deep. The two smaller connector channels have a combined length of approximately 1,560 m. These will also be of trapezoidal open channel design. There are two nominal cross-sections, both are 10m wide at the base and approximately 30 m wide at the top and are to extend to a depth 2.0 m where they join the main drain, reducing to about 1.7 m further up-reach. Spoil from the excavations will be either lime treated to neutralise ASS and then used elsewhere on the site as fill; or placed below the water table in the redundant sections of Serpentine Creek and Landers Pocket Drain (both of which will be dammed off prior to construction).

3.8.3.1 Geotechnical Stability

KBF Drain and Connector Channels	Unmitigated Impact – Moderate Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

All surface drains and channels are to be constructed in loose and or soft alluvial soils which have a propensity for collapse if side batter slopes are not constructed sufficiently flat to provide geotechnical instability. Localised slope failures would result in erosion and possible ASS related adverse impacts.

Mitigation Measures

Cut batter slopes of no steeper than 1V:4H will be adopted for all drains and channels. Each 100 m long section will be excavated then stabilised as described below, before the adjacent 100 m section is excavated.

In addition, the following construction measures are to adopted to minimise the risk of batter slope failure.

- Batter slopes will be protected by a layer of rock rip-rap in areas prone to inundation and erosion; and
- Local mangroves will be used to revegetate the benched platform in areas not containing rip-rap. Refer to Chapter A4 for further details.

3.8.3.2 Erosion Potential

KBF Drain and Connector Channels	Unmitigated Impact – Moderate Adverse	High Risk (6)
	Mitigated Impact – Beneficial	Low Risk (2)

The dominant natural subsoils are of two types:

- Clayey/silty sands and low to medium plasticity sandy clays, with low plasticity fines, which are not fine grained (i.e. <20 percent passing 0.02 mm), but because of their granular nature, have a high potential for erosion if left uncovered on significant gradients (i.e. >5 percent) or exposed to moderate to high velocity flows;
- Clays with medium to high plasticity fines. These soils are fine grained (i.e. 60–90 percent passing 0.02 mm) and have a low erosion potential if not directly disturbed by development.

Laboratory screening was carried out on a number of samples of the predominant surface and subsurface soil types from areas where excavations for drains are proposed. Results indicate non-dispersive soils predominate.

Potential Impacts

Areas of highest risk to erosion will be exposed cut batters during construction of the drains. Test results indicate that the soils to be disturbed along the KBF Drain alignment do not have a significant dispersion potential, and are unlikely to result in mobilisation of large amounts of fines. In addition, agricultural lime ($CaCO_3$) will be applied to the base and sides of the channel as part of ASS management measures. This lime will act to buffer to dispersion potential that might be present.

Mitigation Measures

Mangroves will be used to stabilise the benched platform in areas not containing rip-rap, and will provide improved erosion resistant conditions to those that currently exist elsewhere in inter-tidal areas of the site. Geotextile held in place by a layer of rip-rap will serve to protect the lower channel sides from erosion during flood events and high tides.

Prior to starting work, a silt curtain will be installed just beyond the mouth of the drain to protect Kedron Brook down stream. During excavations for the main drain this is to be extended to a double curtain to minimise risk of failure of one curtain.

3.8.4 SI Drain

Results of investigations conducted for the proposed SI Drain indicate soil profiles comprising:

- Loose to medium dense sand fill to 0.8 m depth (at the eastern end); overlying
- Mainly soft to firm clay alluvium with some sand layers, to the limit of investigation at 0.75–2.5 m depth.

The drain will have a total length of approximately 200 m, comprising a trapezoidal channel (20 m wide at the base and 0.8–1.0 m deep), connected to Serpentine Inlet.

3.8.4.1 Geotechnical Stability

SI Drain	Unmitigated Impact – Minor Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

The drain is to be constructed in a mix of sand and soft alluvium which have a propensity for collapse if side batter slopes are not constructed sufficiently flat to provide geotechnical instability. Localised slope failures would promote erosion and possible ASS related adverse impacts.

Mitigation Measures

Cut batter slopes of no steeper than 1V:4H will be adopted (realistically much shallower batters will likely be used). The drain will be constructed with shallow side batters (not exceeding 1V:8H).

3.8.4.2 Erosion Potential

SI Drain	Unmitigated Impact – Minor Adverse	Low Risk (2)
	Mitigated Impact – Negligible	Very Low Risk (1)

Dominant natural subsoils are of two types:

- Sands with few fines, that because of their granular nature have a high potential for erosion if left uncovered on significant gradients (i.e. >5 percent) or exposed to moderate to high velocity flows;
- Clays with medium to high plasticity fines. These soils are fine grained (i.e. 60–90 percent passing 0.02 mm) and have a low erosion potential if not directly disturbed by development.

Potential Impacts

Cut batters will be gentle and will pose only a minor adverse impact potential during construction, further reduced after installation of rip-rap.

The drain will remain under tidal inundation once completed. Soils in contact with salt water are not prone to dispersion because of the buffering capacity created by excess salts in the contact zone. Thus the dispersion potential is negligible.

Mitigation Measures

Cut batters on the drain will be protected by rip-rap in the tidal zone and the upper benches stabilised by planting mangroves.

3.8.5 Cross Taxiway Tunnel

The dual carriageway tunnel proposed for beneath the taxiway linking the existing Airport with the FAFA will involve excavation to about 4.0 m into the existing fill and natural profile.

3.8.5.1 Geotechnical Stability

Cross Taxiway Tunnel	Unmitigated Impact – Moderate Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

The proposed tunnel will incorporate earth retaining structures (i.e. the walls and roof) and will be subject to traffic loading during construction and use. Retaining walls, pavements and roof structures will be subject to operational loads and possible inundation during flooding.

Given the location, within the developed part of the Airport, impacts arising from any geotechnical failure during construction of the tunnel would not pose a significant environmental risk. Soils involved are predominantly sands, thus dust generation would be minimal.

Mitigation Measures

The top down construction method to be used involves the installation of deep diaphragm walls to exclude groundwater and retain the surrounding soils prior to excavation. The walls and roof slab will be designed to withstand passive and active earth pressures and construction and operational loading. No significant impact to the local environment is envisaged with this construction technique.

3.8.5.2 Erosion Potential

Cross Taxiway Tunnel (No mitigation required)	Unmitigated Impact – Moderate Adverse	Very Low Risk (1)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

The proposed tunnel will be constructed underground within concrete diaphragm walls and will not pose a significant environmental risk during or after construction.

3.8.6 Dredge Pump Line and Pump-out

The above ground dredge pipeline from the Airport to Luggage Point will require a cleared 10 m wide clear corridor. Minimal disturbance of soil is required for construction of the pipeline and pump-out structure at Luggage Point.

Operational loads for the pipeline are expected to be light and local settlements along the route will be accommodated by the flexibility of the pipeline.

3.8.6.1 Geotechnical Stability

Dredge Line/ Pump-out Facility (No mitigation required)	Unmitigated Impact – Moderate Adverse	Very Low Risk (1)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

Construction of the proposed temporary dredge pipeline and pump-out structures will not result in significant potential for geotechnical instability and poses a negligible potential for adverse impacts along the pipeline route.

3.8.6.2 Erosion Potential

Dredge Line/ Pump-out Facility (No mitigation required)	Unmitigated Impact – Moderate Adverse	Very Low Risk (1)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

The proposed pipeline and pump-out structure will be constructed above ground with no significant earthworks planned and will not pose a significant environmental risk during or after construction.

3.9 Potential Impacts – Acid Sulfate Soils (ASS)

The Appendix to the EMF sets out a management plan that has been prepared for the project to outline construction methods and management measures required to deal with ASS (refer Chapter B14). Four separate ASS treatment areas are to be constructed (during different phases of construction) in different parts of the site to deal with ASS spoil.

3.9.1 New Runway and Linked Taxiway

Results of analysis conducted on soil samples from the new runway and linked taxiway areas returned net acidity values ranging up to 3,900 moles of acid/tonne with actual acidity levels of up to 110 moles of acid/tonne), which indicates slight partial oxidation of sulfidic fines has occurred in soils exposed above the water table.

New Runway and Linked Taxiway	Unmitigated Impact – High Adverse	Moderate Risk (4)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

No direct disturbance of ASS will be required for construction of the runway fill platform. However, significant settlement is expected following placement of this surcharge. Resulting compression within the upper 1.0–1.5 m is expected to be of the order of 100 mm with no significant lateral displacement. It is the upper layer of soils that contain actual ASS which may be mobilised off-site by a rising water table. Due to overall settlement of the alluvium under the load of the proposed sand filling, the existing surface will eventually become water logged (i.e. remain at or near the top of the water table in the long term) and thus allow existing acidity to mobilise in groundwater. Without management the proposed filling of the runway site poses a moderate environmental risk to local receiving waters through mobilisation of actual acidity and associated dissolved metals. Clearing of vegetation and subsequent surcharging of the proposed runway will raise groundwater levels beneath the runway, and will cause increased groundwater flows to Kedron Brook. The result would be a potentially high adverse impact. Section 3.11 discusses changes to the groundwater regime in more detail.

Mitigation Measures

Because of the proximity of the development site to local waterways and the potential for ongoing potential for lateral migration of acidic groundwater away from the proposed fill platform, a lime filled groundwater interception/treatment trench will be placed between the runway and Kedron Brook, prior to clearing of vegetation and placement of fill.

The quantity of lime required for the interception trench has been calculated using a (conservative) factor of safety of 2.0 and is of the order of 400 kg of lime / linear metre of trench. A trench width of 6–12 m is proposed. The surface of the edge of the trench closest to the runway will remain unsealed for a width of 1–2 m to allow capture of surface water and seepage escaping the edges of the fill platform. A surface layer of geotextile over this area, held in place by a sparse layer of coarse gravel (Nom. 50–75 mm dia.) will prevent wash out of the lime. It is planned to excavate the trench to a minimum of 1.2 m deep and may be deepened (sufficient to adequately intercept the water table), should on-going monitoring of groundwater levels indicate lower groundwater levels during and at the end of the dry season. Refer to the western lime trench details included in **Figure 3.6a**.

The required location of the trench in relation to the proposed fill platform has been assessed through modelling of the impacts of surcharging on groundwater levels (which will be more significant than the short term impacts from vegetation clearing, and the long term impact from the increase in water levels beneath the sand fill platform. Modelling has been discussed previously in section 3.6.2. Based on the results of this modelling, the interception trench will be situated approximately 75 m from of the edge of the runway fill platform at the northern end (where the depth of soft alluvium is deepest and the resulting zone of water table influence extends the furthest), and 45 m away at the southern end, where the alluvium is shallower and Kedron Brook is closer.

A total of seven monitoring wells were established along the western side of the runway, between the runway and Kedron Brook Floodway and a further six wells have recently been installed. Monitoring of groundwater quality will be carried during the filling and consolidation period and continued throughout construction of the runway, and extending as part of BAC regular monitoring program following construction.

The use of large quantities of agricultural lime will not result in any adverse impact to either local habitats or the receiving environment (i.e. Moreton Bay). The water quality objectives for tidal Kedron Brook are pH 6.5–8.5, and for Moreton Bay 8.1–8.4. Agricultural lime has pH of approximately 8.4 and the local environment is rich in natural sources of calcium carbonate, with high levels of dissolved alkalinity in the water in Serpentine Creek.

3.9.2 Future Aviation Facilities Area

Results of analysis conducted on soil samples from the FAFA returned net acidity values ranging up to 1,630 moles of acid/tonne with actual acidity levels of the order of 10 to 30 moles of acid/tonne, which indicate only very slight oxidation of sulfidic fines has occurred in the upper 0.5–1.0 m of the sediment profile. High levels of inherent Acid Neutralising Capacity (ANC) were also present in some soil profiles.

Future Aviation Facilities Area	Unmitigated Impact – Minor Adverse	Moderate Risk (4)
	Mitigated Impact – Very Minor Adverse	Very Low Risk (1)

Potential Impacts

During surcharging of the runway, some filling will occur in the FAFA to provide a clean working platform. When the surcharge is removed from the runway, the removed sand will be placed in the FAFA, to a height of 2–2.5 m above the existing levels. This will result in displacement of some groundwater back into the NPR area, and also under the existing Airport development. Actual acidity levels in the FAFA are generally low as the site is currently almost completely water logged, and near surface sediments contain significant natural buffering capacity in the form of fine shell grit. Subsequently, the risk of mobilisation of actual acidity and associated dissolved metals within the FAFA site and potential adverse impact to local receiving waters is low.

Excavations for a 300 m section of drainage channel at the northern end of the FAFA (the component of the Serpentine Inlet drain south of the 1432 cross runway) may intercept the natural surface to about 0.5–1.0 m depth. Direct disturbance of soils poses a potential moderate adverse impact to the local receiving environment.

Mitigation Measures

Spoil from the excavation of this section of the drain will need to be lime treated, at a rate of about 190 kg of lime/m^3. On the basis of current results and for reasons of practicality, it is recommended that this liming rate be adopted for all spoil from the FAFA. However, if further characterisation of spoil is conducted during excavations, the treatment rate may be reduced. Careful management of excavations and lime treatment operations will be necessary to minimise any impacts to off-site water quality. Lime treatment of spoil will be specified in the ASS Management Plan, appended to the EMF (Chapter B14).

Large sediment retention ponds will be constructed in the FAFA to hold and treat supernatant from the deposited dredged sand. These ponds will be constructed above existing ground level using water proof liners and either imported clean fill or lime treated (and verified) ASS spoil from construction of the KBF Drain. No excavations, nor resulting disturbance of ASS will be necessary for construction of the ponds.

3.9.3 Western Apron

Results of analysis conducted on soil samples from the Western Apron area returned net acidity values ranging up to 2,130 moles of acid/tonne with actual acidity levels of up to 167 moles of acid/tonne. This indicates that a varying degree of oxidation of sulfidic fines has occurred throughout the upper 2.0 m of the soil profile.

Western Apron area	Unmitigated Impact – Moderate Adverse	Moderate Risk (4)
	Mitigated Impact – Very Minor Adverse	Very Low Risk (1)

Potential Impacts

Excavations through the sand fill and into the natural surface will be necessary for a minor drain and disturbance of some low level actual ASS and high level PASS will result. There is another minor drain planned along the western edge of this area and excavations may intercept the natural surface to about 0.5–1.0 m depth.

During surcharging of the runway, some filling will occur in the Western Apron area to provide a clean working platform. When the surcharge is removed from the runway, the removed sand will be placed in the Western Apron area, to a height of 2–2.5 m above the existing levels. This will result in displacement of some groundwater back into the NPR area, and also under the existing Airport development. Actual and potential acidity levels in the Western Apron area are generally similar to those encountered on the NPR site. Acidification and mobilisation of heavy metals poses a moderate environmental risk to local receiving waters. A very high level of PASS was detected at one location below 1.5 m depth, and will not be disturbed.

Mitigation Measures

The interception trench to the west of the runway will intercept any potential migration of groundwater from the Western Apron towards Kedron Brook Floodway, however final surcharging of the Western Apron is likely to impact groundwater levels beneath the previously surcharged runway area only.

Excavation for the minor drain planned along the western edge of this area may intercept the natural surface to about 0.5–1.0 m depth. The spoil from the excavation of this section of the drain will need to be lime treated at a rate of up to 130 kg of lime/m^3. A very high level of PASS was detected below 1.5 m depth at this location, and disturbance of this material will be avoided as liming would not be practical (i.e. a rate of 460 kg of lime/m^3 would be needed). Careful management of excavations and lime treatment operations will minimise the risk of adverse impacts to off-site water quality.

3.9.4 KBF Drain and Connector Channels

Results of soils analysis undertaken along the main Kedron Brook Floodway drain alignment indicate net acidity ranging up to 1,110 moles of acid/tonne. Actual acidity levels are mostly of the order of 10 to 60 moles of acid/tonne. The acidity regime along the two smaller connecting drains is similar, with higher potential acidity towards the northern end of the western-most drain where it will abut the proposed runway fill platform). Low level actual acidity is present to 2.0 m and extends to 2.5 m depth at some locations. This is evident of past oxidation of potential ASS due to seasonal water table fluctuations.

KBF Drain and Connector Channels	Unmitigated Impact – High Adverse	Very High Risk (9)
	Mitigated Impact – Minor Adverse	Moderate Risk (3)

Potential Impacts

Disturbance of high level PASS soils will occur in drain excavations along the length of the drain and connector channels. These activities pose a high risk to the receiving environment unless carefully managed (refer to ASS Management Plan, appended to the EMF in Chapter B14). As discussed previously, some long term drawdown of the water table will occur along the immediate flanks of the proposed KBF Drain system associated with a differential between the mean tidal level in the drain and the surrounding groundwater level. Review of ASS test data from along the KBF Drain alignment indicates that while the groundwater level is currently measured at less than 1.0 m below ground level, the incidence of actual acidity occurs throughout the investigated soil profile to approximately 2.5 m depth. Average TAA in the upper 1.0 m of the profile (mostly fill) is 47 moles of acid/tonne, while in the deeper soils it is 36 moles of acid/tonne. These results indicate that past partial oxidation has occurred to below the zone of potential drawdown associated with excavation of the proposed drain system.

Mitigation Measures

Management of exposed PASS will be achieved using the following measures (refer to **Figure 3.9a**):

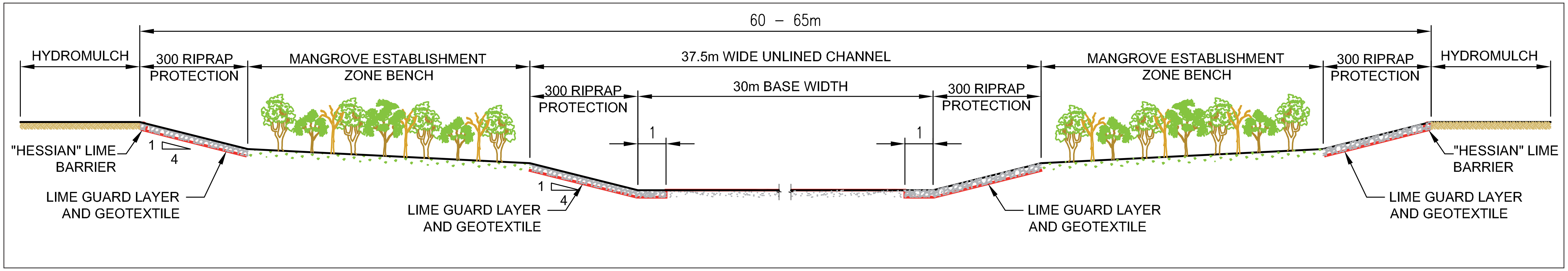
- Benched areas of the main drain banks are to be stabilised by re-establishment of mangroves which prefer slightly acid conditions. A lime guard layer will be applied to exposed banks in areas where re-establishment of mangroves is not planned. The lime guard layer will be protected by geotextile. The lime guard layers will extend for the entire length of the KBF drain at elevations both above and below the bench containing the Mangroves.
- A barrier constructed from sacrificial hessian bags filled with a mix of fine and coarse agricultural lime chips will be placed at the top of the geotextile layer and pinned in place by the upper course of rip-rap. This will act to intercept acidic runoff from elsewhere in the development area during and after construction. Sufficient lime will be used to remain functional for the medium term (until the bags degrade and the lime is used up) and will assist to neutralise acid runoff from beyond the site that enters the main drain on the way to Kedron Brook. The hessian bags will be maintained during the surcharging and construction period, and will be replenished or replaced if they become clogged with a build up of iron floc, until no longer required.

Management of ASS/PASS spoil will be achieved using conventional neutralisation of high level PASS spoil by mixing with agricultural lime, adopting a factor of safety of 1.5, and subsequently undertaking verification testing of the limed spoil using the SPOCAS test method. Lime treatment will be undertaken in purpose built lime treatment areas, to be constructed in accordance with current industry practice (i.e. QASSIT Management Guidelines). The locations of these areas are shown in **Figure 3.9b**.

Approximately 140,000 m^3 of spoil will be managed in this manner. Spoil from the main drain and connecting drains will need to be lime treated at rates of up to 140 kg of lime/m^3 (actual treatment rates are given in the ASS Management Plan, appended to the EMF (Chapter B14). For reasons of practicality a number of liming rates have been adopted for different sections of the excavation(s). Liming rates for each section of the drain(s) are also given in the ASS Management Plan. Where possible high level PASS will be strategically reburied (refer below) and less severe material lime treated and reused on-site.

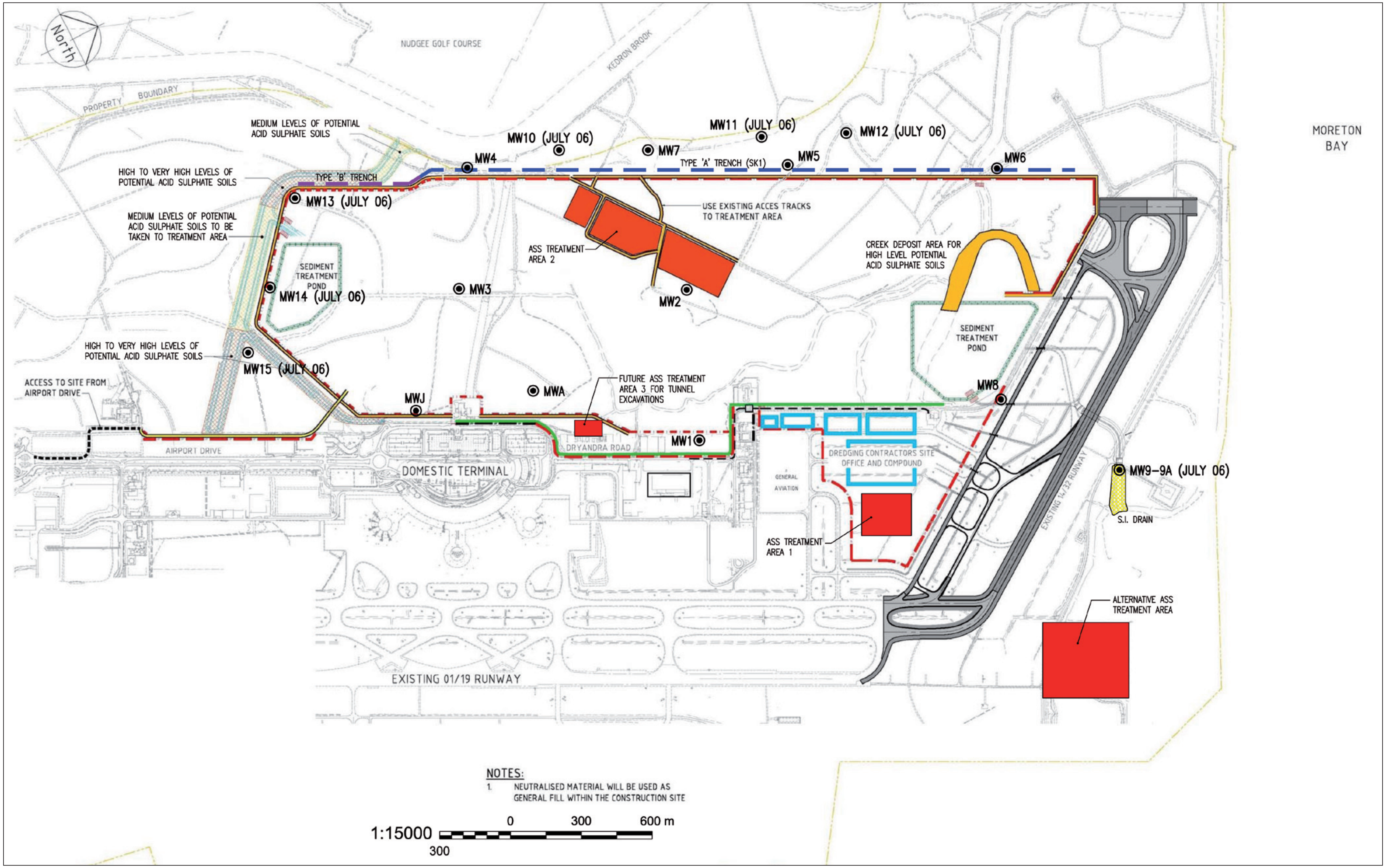
Strategic reburial of high risk ASS/PASS spoil in the isolated portion of old Serpentine Creek located within the FAFA will be utilised for material that is not suitable as fill. The creek is to be permanently dammed and infilled as part of future development of this area. Spoil would be placed promptly (within 12 hrs of excavation), below the existing water level (i.e. an anoxic environment that will prevent oxidation of PASS) and capped with geotextile and 0.3 m of clean sand fill or lime treated and verified ASS. This will be later filled over by at least 2.0 m of sand fill. ASS investigations indicate an abundance of alkaline buffering capacity in the in situ sediments in this area, which will act as a third line of defence to prevent any short term acid generation resulting from disturbance and placement of the spoil. Local alkalinity will be supplemented by placement of a layer of geotextile and a lime guard layer on the surface of the fill (above the water level), which will in turn be covered by sand fill.

Figure 3.9a: Detail of KBF Drain Construction.



NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

Figure 3.9b: *Plan Showing Areas for Remediation and ASS Treatment.*



NEW PARALLEL RUNWAY DRAFT EIS/MDP
FOR PUBLIC COMMENT

Management of any acidic groundwater generated by drawdown of the water table in close proximity to the drain system will be achieved using the following strategy:

- A surface application of agricultural lime is to be applied to the side batters of the drain (and connector channels) above and below the zone of tidal fluctuation. The lime barrier will be applied at a rate of 5 kg/m^2 generally, and at 15 kg/m^2 in the zone of potential drawdown (i.e. for a depth of 0.5 m above the average mean tide level (i.e. above 1.05 m AD). In order to correct pH from 4.0 to 7.0 (recognizing that the lowest pH measured in the monitoring wells to date is 4.9 in MWA and the target pH for discharge is a minimum of 6.5), the theoretical requirement for Aglime is 5 kg per ML of water (refer to SPP 2/02). Assuming that the entire groundwater flow enters the drain through a seepage face extending 0.5 m up the face above the mean tide level, there would be sufficient lime to theoretically treat inflow at pH 4.0 for hundreds of years.

Three groundwater monitoring wells have been installed along the alignment of the KBF Drain to allow real time monitoring of both pH and groundwater level. Data loggers will be installed in these wells to allow semi-continuous monitoring of tidal (and seasonal) fluctuations in groundwater acidity and height over a period of 12 months prior to construction works commencing and will continue as required during construction. During construction additional piezometer standpipes may be installed in addition to these monitoring wells, to provide lines of monitoring wells perpendicular to the KBF Drain alignment. These wells would be used to monitor the lateral extent of drawdown.

The drain will remain isolated from Kedron Brook Floodway (by retaining an earth plug), during the expected 4–6 month construction period. The drain is to be constructed in four stages, with excavations limited to 100 m sections. Active drawdown of the water table will not be required during construction of the drain as dewatering will be from a local sump located in the base of excavations for each 100 m section of the drain. During construction, regular monitoring of inflow rates and water quality in the drain will be undertaken during and after construction.

Should results of the monitoring indicate higher inflow rates, or an increase in water acidity (and a sustained drop in pH), for any unforeseen reason, the lime guard layers on both flanks of the drain and connector channels (in the affected areas) will be recharged with a further application of lime placed among the rip-rap. For further details of the construction methodology refer to A5.

3.9.5 SI Drain

Results of soils analysis in the area of proposed northern drain indicate net acidity values ranging from 268 to 2,270 moles of acid/tonne. High PASS levels were detected in all samples analysed, while actual acidity levels were low or negligible.

SI drain	Unmitigated Impact – Moderate Adverse	High Risk (6)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

Disturbance of high level PASS soils will occur in drain excavations at several discrete locations along the drain alignment. Although the depth of disturbance is shallow (i.e. 0.3–1.0 m), these activities still pose a high risk to the receiving environment unless carefully managed.

Mitigation Measures

All spoil from drain excavations will need to be lime treated at rates of up to 260 kg of lime/m^3. For reasons of practicality a number of different liming rates have been adopted for various discrete sections of the excavations. Liming rates for each section of the drain are included in the ASS Management Plan (refer Chapter B14). In addition, a lime guard layer will be applied to exposed banks (to include any tidal fluctuations). Careful management of excavations and lime treatment operations will be necessary to minimise any adverse impacts to off-site water quality. Monitoring and possible lime dosing of any surface water accumulated in the excavations during construction will also be necessary. Drawdown of the water table will be minimised and avoided if possible during construction of the drain.

The proposed SI drain is much shallower than the KBF Drain, and will not require any prolonged dewatering, only possible short term pump-out of excavations should heavy rainfall occur during construction sufficient to elevate the water table. If this occurs, then any water pumped out shall first be monitored for pH and if necessary have the pH adjusted to within discharge limits before release. The groundwater at this location will also be more saline than at the KBF Drain site and will act to locally buffer acidity generated in the short term.

3.9.6 Cross Taxiway Tunnel

Results of soils analysis from two samples taken at the site of the proposed tunnel returned net acidity values ranging from 634 to 239 moles of acid/tonne, at depths of 2.75 m and 4.25 m, respectively. Screening of other samples did not indicate the presence of potential acidity. No actual acidity was detected in the samples tested.

Cross Taxiway Tunnel	Unmitigated Impact – Minor Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

Disturbance of high level PASS soils will occur during the tunnels excavations. Excavation and disposal of the spoil pose a moderate risk to the receiving environment unless carefully managed. A detailed ASS Management Plan has been prepared for the development (in accordance with **Appendix 4** of the SPP 2/02), and provides management measures to limit environmental risk.

Mitigation Measures

ASS/PASS soils exist within the proposed tunnel alignment below about 2.0 m depth and where disturbed will need to be neutralised by the addition of up to 80 kg of agricultural lime/m^3. Fill material from the upper 2.0 m will not require specific lime treatment. Construction of the tunnel is in the latter part of the development and liming rates will be refined, following further investigations prior to disturbance. It is expected that the tunnel will take approximately 2–3 months to construct.

3.9.7 Dredge Line and Pump-out Facility

The above ground dredge pipeline from the Airport to Luggage Point will pass through low lying areas where ASS may be present. At the Luggage Point pump-out site, significant, unbuffered PASS was evident in bottom sediments sampled from the Brisbane River estuary. Results of screening and analysis indicates isolated layers of high level PASS material at varying depths. Results of preliminary screening indicates the presence of significant amounts of fine calcareous material in some samples. Quantitative testing carried out returned net acidity values ranging up to 374 moles of acid/tonne. No actual acidity was detected, which indicates no oxidation of sulfidic fines.

Review of published ASS maps indicate, areas of very high ASS risk in areas within close proximity of Luggage Point (that will be crossed by the above ground pipeline).

Dredge Line and Pump-out Facility (No mitigation required)	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

The proposed temporary dredge pipeline and pump-out facility will not involve any significant excavation or filling and no dredging of bottom sediments from the river is proposed. Since no actual ASS were detected and no significant quantities of ASS will be disturbed, no specific mitigation is required.

3.10 Potential Impacts – Contaminated Soils

3.10.1 New Runway and Linked Taxiway

3.10.1.1 Former Dredge Spoil Handling Area (from construction of the Kedron Brook Floodway in 1980s)

The new runway development area includes a former dredge spoil handling area dating from the formation of the Kedron Brook Floodway in the 1980s. The fill extends over an area of approximately 15 ha, near the centre of the runway site.

Results of soils analysis undertaken on samples recovered from the fill indicate elevated levels of heavy metals, most commonly nickel (up to 145 mg/kg), chromium (up to 227 mg/kg) and copper (up to 106 mg/kg). 24 samples analysed exceeded the Qld EPA EIL. In addition, one sample also contained an elevated concentration of the C29-C36 TPH fraction (1,490 mg/kg) which exceeds the Qld EPA adopted EIL. There are no AEPR Accepted Limits for this TPH fraction. A second sample marginally exceeded the adopted EIL for Dieldrin and Aldrin (combined).

Former Dredge Spoil Handling Area (1980s)	Unmitigated Impact – Moderate Adverse	High Risk (6)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

The in situ fill material forms a mound and prior to filling and surcharging the runway site some of the fill material (up to 3.0 m deep) will be removed and deposited elsewhere on-site in the FAFA. Some of this material will remain in situ and the area will be filled over by up to 3.5 m of imported sand fill. There are two potential sources of adverse impact, the fill that is removed and the exposed fill that will remain in situ.

The fill that remains in situ will be exposed in the short term before placement of the sand fill/surcharge layer. The concentration of heavy metals present in the fill pose a low risk to the environment and public health. The fill to be removed to the FAFA will be disturbed resulting in a moderate risk to the environment in the short term (while being loaded and transported), due to the heavy metals present.

The isolated occurrence of hydrocarbon and pesticides detected are at sufficiently low concentrations so as to pose a negligible environmental risk. It is possible that the single instance of elevated hydrocarbons was due to the presence of decomposed organic matter, given the sample was a clay loam with significant levels of visible organic matter). With careful management of earthworks the risk can be reduced to a negligible level. The potential adverse impacts are minor.

Mitigation Measures

The fill remaining in situ will be kept moist to avoid dust generation. The extent of the affected areas is to be delineated as a contaminated area and access limited until filled over. Workers will be required to wear Level D Personal Protection Equipment (PPE) during earthworks operations. The fill to be removed, will be placed in the dead end extension of the old Serpentine Creek and covered with a lime guard layer and geofabric, then capped with sand.

3.10.1.2 Former Bus Depot Site

The former bus maintenance depot site is located on the edge of the proposed fill platform at the northern end of the new runway. The depot was demolished and the site filled over in the mid-1980s with approximately 2 m of sand fill.

Former Bus Depot Site (No mitigation required)	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

No direct disturbance of the overlying fill is planned at the location of the former bus depot site at the northern end of the new runway site. The placement of the proposed volume of sand dredged from Moreton Bay will result in an increase in the depth of cover (up to 4.0 m in total) further reducing the risk of any adverse impacts from direct disturbance. Negligible adverse impact will result provided the fill over the site is not disturbed.

3.10.2 Future Aviation Facilities Area

The site of reported dumping of a quantity of domestic/agricultural rubbish located within the FAFA at the edge of Cribb Island Road, on a creek bank. The extent of dumping (documented in BAC records) was minor.

FAFA Fill Area	Unmitigated Impact – Minor Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible Adverse	Low Risk (2)

Potential Impacts

Should any gross contaminants be detected in rubbish found at the site, they will be separated and removed off-site by a licensed contractor.

Mitigation Measures

This area will be capped and isolated prior to any major works commencing. Following development the area will be filled to a depth of at least 2.0 m.

3.10.3 Western Apron

There are no known contaminated sites or potential sources of contamination in the Western Apron area. The site of former underground fuel storage tanks (USTs) located behind the Brisbane Airport Domestic Terminal, is located near the eastern edge of the Western Apron area, but is not within the proposed development area. The tanks were decommissioned and removed and the site validated in 1994 and has since been filled over and paved.

Western Apron Fill Area (No mitigation required)	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

Development of the Western Apron area will not involve disturbance or filling of the former UST site (which has been validated) and no adverse impacts resulting from disturbance of contaminated soils are expected.

3.10.4 KBF Drain and Connector Channels

The PSI conducted, did not reveal any specific records of contaminated sites along the proposed drain alignment. The area was filled during the early 1990s. The source of fill is likely to have been dredge spoil from nearby Kedron Brook.

KBF Drain and Connector Channels	Unmitigated Impact – Minor Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

In total, 36 samples of the fill sampled from along the proposed KBF Drain alignment were analysed for a range of contaminants of concern. All samples returned analyte concentrations below HIL-F and AEPR Accepted Limits for General Airport Areas. Six samples of fill analysed as part of the baseline investigation returned slightly elevated concentrations of Arsenic (3 locations at up to 34 mg/kg); Nickel (1 location at 69 mg/kg) and Zinc (1 location at 254 mg/kg).

The occurrences of elevated metals concentrations do not exceed published background levels given in Table 5-A of the NEPM – 1999 Guidelines (1–50 mg/kg for Arsenic, 5–500 mg/kg for Nickel and 10–300 mg/kg for Zinc). The levels of metals detected do not pose a significant risk to public health.

Provided the excavated fill when disturbed (i.e. the spoil), is not placed in direct contact with any waterways or other areas deemed by the AEPR to be environmentally sensitive, the resulting adverse environmental impact will be low.

Mitigation Measures

All spoil from drain and channel excavations will be treated by the addition of agricultural lime to neutralise any ASS present. This will act to limit the leachability of the heavy metals present. Areas of in situ fill that will remain exposed on the upper surfaces of cut batters along the drains will be covered with geotextile and rip-rap to prevent erosion and mobilisation of soil fines off-site. In addition, a line of hessian bags filled with a mix of fine and coarse agricultural lime chips will be placed at the top of the geotextile layer and pinned in place by the upper course of rip-rap. This will act to intercept any acidic runoff from elsewhere on the site that may pass over the fill layer when entering the drain.

3.10.5 SI Drain

The PSI did not reveal any specific records of contaminated sites along the proposed SI drain alignment. The nearest site (the fire fighting training area) is located approximately 300 m from the development area and some 170 m from the drain alignment.

SI drain (No mitigation required)	Unmitigated Impact – Minor Adverse	Low Risk (2)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

Excavations for the SI drain are relatively shallow, and for the most part occur in natural soils. A shallow layer of sand fill is present over the western part of the drain alignment. All spoil from drain excavations will be treated by the addition of agricultural lime to neutralise any ASS present. This will act to limit the leachability of any heavy metals or other pH sensitive inorganic substances that may be present. There is no basis for supposing contamination from organic substances and the potential for adverse environmental risk is low.

3.10.6 Cross Taxiway Tunnel

The dual carriageway tunnel proposed for beneath the taxiway linking the existing Airport with the new runway will involve excavation to about 4.0 m into the existing soil profile, and will include excavation of approximately 5,000 m^3 of fill material (to 2–2.5 m depth).

Cross Taxiway Tunnel	Unmitigated Impact – Minor Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

Existing ASS test results in the vicinity indicate that the material is benign for ASS. However, as the fill is of unconfirmed origin, a full contaminated land investigation will be required when the tunnel design is further developed.

Mitigation Measures

When the location of the tunnel has been finalised, and prior to commencing excavations, samples of the fill layer will be recovered at a recommended frequency of 1 sample / 100 m^3 of fill (to be disturbed) and analysed for a range of common contaminants including heavy metals, pesticides and petroleum hydrocarbons. Provided the results of the screening program do not indicate significant contamination of the fill, no specific management measures will need to be adopted, and the need to mitigate potential adverse impacts will be negligible. If contaminants are detected (in the fill), then site specific management measures will need to be developed and implemented prior to excavation and disposal of the material.

3.10.7 Dredge Line and Pump-out Facility

The above ground dredge pipeline from the Airport to Luggage Point will pass through low lying areas where some areas of undetected contaminated fill may be present. However, minimal direct disturbance of soils is required for construction of the pipeline. Placement of shallow gravel fill to act as a temporary base for the pipeline will be required in areas where founding conditions are not good.

Results of contaminant testing undertaken on bottom sediments from the Luggage Point site returned slightly elevated levels of Mercury in one sample (i.e. 0.2 mg/kg). Biological pathogen testing undertaken on bottom sediments did not detect Faecal Coli forms or Total Coli forms at elevated levels.

Dredge Line and Pump-out Facility (No mitigation required)	Unmitigated Impact – Minor Adverse	Low Risk (2)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

Construction of the pump-out structure at Luggage Point will not require the direct disturbance of bottom sediments, except through the installation of marine piles which will be driven and will not require excavation of spoil. There is an associated low risk of adverse environmental impact from the re-suspension of bottom sediments during dredge pump-out operations and general operation of the facility.

The level of Mercury detected slightly exceeds the ANZECC Sediment Quality Guideline trigger value for low effects (i.e. 0.15 mg/kg), which represents the lower bound of the potential impact range. The high effects trigger value, which represents the median of the distribution across the range is (1.0 mg/kg) and is not exceeded. This limit is coincident with Queensland EPA's adopted EIL. As mobilisation of bottom sediments is expected to be minimal, the level of Mercury detected poses only a low environmental risk.

3.11 Potential Impacts – Groundwater Levels

3.11.1 New Runway and Linked Taxiway

New Runway and Linked Taxiway (No mitigation required)	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

As discussed in section 3.6.2, impacts on groundwater levels and linked taxiway area will include:

- Short term increase in water level due to clearing of vegetation;
- Medium term increase in water level as a result of surcharging;
- Long term increase in water levels in the area of the proposed site filling.

These changes to groundwater levels have the potential to cause increase lateral flow in the near surface soils, and thus increased flow to Kedron Brook.

Vacuum consolidation settlement acceleration techniques are likely to be employed in the area where soft alluvial deposits are deepest, at the northern end of the new runway site. This treatment is similar to surcharging in that it causes consolidation of the soil, however groundwater expelled in the consolidation process is collected for treatment and there is no increase in water table in the adjacent areas. In the long term, the water levels in this area will be similar to elsewhere in the filled area.

3.11.2 Future Aviation Facilities Area and Western Apron

FAFA and Western Apron Fill Areas (No mitigation required)	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

Final filling of the FAFA and Western Apron areas will occur after the surcharge on the runway is removed. This will likely cause a medium term increase in groundwater levels in the surrounding filled areas, however since the sand fill is so permeable, it will not cause a significant groundwater mound.

Minor drainage works in these areas will be either in fill or involve shallow excavations above the water table with no resulting impact on the water table.

3.11.3 KBF Drain and Connector Channels

The new KBF Drain and two smaller connector channels will be nominally 2.0–2.2 m deep. The drains will be constructed in sections, with each section constructed in the dry by dewatering from a sump.

KBF Drain/ Connector Channels	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

Drawdown caused by dewatering for construction will be short term, and limited to the local area around the section that is under construction at any particular time. In the longer term, the drains will locally lower the groundwater table by approximately 0.5 m, as the mean tide level in the drains will be lower than existing groundwater levels.

Mitigation Measures

The works will be constructed in 100 m lengths, with temporary dewatering where required, will be undertaken from temporary sumps constructed in the base of each 100 m section. The extent of drawdown in this temporary condition will be limited by limiting the size of the active construction zones. Some slight long term local lowering of the groundwater will also occur (particularly during the wet season when the regional groundwater level is highest).

3.11.4 SI Drain

The new 200 m long SI drain will be 0.8–1.0 m deep. The invert level of the drain will be the tidal variation in the area where the drain is to be constructed. No change to groundwater levels will result and dewatering will not be required.

SI drain	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

Exclusion of tidal waters will be required during construction. No appreciable impact to the local or regional hydrogeology will result from construction of the drain or following development.

Mitigation Measures

Construction below high tide level will be carried out during periods of low tide with tidal waters excluded by the use of a temporary check drain.

3.11.5 Cross Taxiway Tunnel

The dual carriageway tunnel proposed for beneath the taxiway linking the existing Airport with the new runway will involve excavation to about 4.0 m into the existing soil profile.

Cross taxiway Tunnel	Unmitigated Impact – Minor Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

The tunnel will most likely be constructed using diaphragm wall techniques, which do not require dewatering to be undertaken. The base of the completed tunnel will be below the existing water table, however, no permanent dewatering will be required (the tunnel will be fully tanked and designed to adequately resist buoyant uplift).

Mitigation Measures

No mitigation is required for the proposed construction method.

3.11.6 Dredge Line and Pump-out Facility

An above ground dredge pipeline from the Airport to Luggage Point is required to deliver the fluidised the material. A dredge mooring facility structure will be constructed at Luggage Point.

Dredge Line and Pump-out Facility	Unmitigated Impact – Negligible	Very Low Risk (1)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts

The proposed temporary dredge pipeline and pump-out facility (at Luggage Point) will not involve any significant excavation or filling. No dewatering will be required along the length of the pipe line. There are no envisaged impacts to groundwater.

3.12 Potential Impacts – Groundwater Quality

3.12.1 New Runway and Linked Taxiway

3.12.1.1 ASS Influences

New Runway and Linked Taxiway	Unmitigated Impact – High Adverse	High Risk (6)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

Resulting impacts from filling of the new runway and cross taxiway will be acidification of the local groundwater when it is brought into contact with actual acidity present in the near surface natural alluvium. Subsequent mobilisation of heavy metals (Iron and Aluminium) is likely to result. Without management, the proposed filling of the runway site will potentially pose a high adverse impact to local receiving waters as impacted groundwater with elevated levels of dissolved metals migrates laterally away from the filled area.

Mitigation Measures

The amount of actual acidity present in the upper 0.5–0.8 m of the soil profile is finite and will be flushed out in the short to medium term. The placement of a 1.2–1.5 m deep lime filled groundwater interception/treatment trench between the runway platform and areas with possible hydraulic connection off-site prior to placement of fill, will act to neutralise the groundwater and minimise the potential impact to receiving waters. Dissolved metals (including Iron) will precipitate out once groundwater is neutralised to around pH 7–8 and the groundwater will no longer contain dissolved metals.

Groundwater extracted by vacuum consolidation techniques will be held in an isolation tank and the pH adjusted to between 7.0 and 8.0 and any red iron precipitate that forms will be removed on a floating layer of absorbent fabric, before the water is discharged (Aluminium gives no visible precipitate when dropped out of solution). The water extracted from vacuum consolidation areas will be required to meet discharge criteria which includes levels of dissolved iron and aluminium (included in the ASS Management Plan, in Chapter B14).

3.12.1.2 Contaminated Land Influences

Findings of a PSI conducted as part of a baseline study of the development site indicated the following potentially contaminated sites present within or in close proximity to the new runway development area:

- The site of a former bus maintenance depot located on the edge of the proposed fill platform at the northern end of the new runway. The depot was demolished and the site filled over in the mid-1980s with approximately 2 m of sand fill. Groundwater from the immediate locality of the former bus depot site may contain traces of hydrocarbon.
- The site of the former Cribb Island community landfill located just beyond the development area, near the western edge of the northern end of the new runway. The former community dump site was filled over (by 1981) with approximately 2 m of sand fill. No specific remediation of the site has been reported prior to filling.
- The existing Kedron Brook Floodway spoil site, near the centre of the new runway site, containing slightly elevated levels of heavy metals. Groundwater samples collected from this area returned elevated levels of nickel (up to 246 µg/l) which exceed the adopted WQO. The concentration, while elevated, is consistent with nickel concentrations in the groundwater at other locations within the development site.

Former Bus Depot and Community Land fill Site	Unmitigated Impact – High Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible	Low Risk (2)
Former Dredge Spoil Handling area (from 1980s)	Unmitigated Impact – High Adverse	Moderate Risk (4)
	Mitigated Impact – Negligible	Low Risk (2)
Nutrients and Salinity	Unmitigated Impact – Minor Adverse	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

No direct disturbance of the existing overlying fill is planned at the locations of the former bus depot and community landfill, however, dewatering of the area will be carried out as part of vacuum consolidation treatment of the underlying soft alluvium. Groundwater from under the nearby landfill site (approximately 50–60 m distant) may also be drawn into the development area by the proposed vacuum consolidation operation and may contain traces of inorganic or organic contaminants including, hydrocarbons, metals and decomposition products such as ammonia. Prior to filling some of the fill material from the dredge spoil handling area, (up to 3.0 m deep) will be removed and placed in the FAFA. Some of the dredge spoil will remain insitu and the area will be filled over by up to 3.5 m of imported sand fill.

Where ammonia and total nutrient concentrations in groundwater are elevated they also pose a risk the receiving environment and have been linked to increases in cyano-bacteria in receiving waters (i.e. algal blooms). Given that the staged filling and subsequent settlement will take several years to occur, the transport off-site of ammonia and other nutrients in the groundwater will be gradual and the short term and accumulative adverse impact to the receiving environment is expected to be low.

Given the receiving environment currently contains mangrove swamps with high levels of organic matter decay, and include areas of stagnant and brackish water (e.g. the truncated section of Serpentine Creek), elevated levels of nutrients would be expected to be very common throughout the area.

The placement of the proposed volume of sand dredged from Moreton Bay will result in an increase in salinity in the fill/soil profile which may eventually leach into the groundwater. However, given the hyper-saline condition of existing soils and the highly saline nature of the local receiving environment, any adverse salinity impacts will be negligible. The sands have little organic matter (less than 0.5 percent) and will not provide an additional source of nutrients.

Mitigation Measures

The vacuum extraction operation will be carried out utilising a number of discrete cells, thus groundwater can be extracted from specific areas separately. If water quality monitoring of groundwater extracted from the former bus depot area indicates elevated levels of TPH above the adopted AEPR limits, the water will be held in an isolation vessel and treated using a layer of floating absorbent media (which will act to draw off any free phase product that is present). Following initial treatment the TPH concentration will be re-determined and the process repeated (if necessary) until water quality limits are met, before discharge of the treated groundwater.

Groundwater extracted will initially be monitored for a range of potential contaminants possibly remaining from the former landfill, including BTEX, heavy metals, ammonia and phenols. If any elevated levels of any contaminants are detected by this monitoring, then regular monitoring for the detected contaminants will be continued for the duration of the groundwater extraction operation. If elevated levels of contaminants detected are above the adopted AEPR limits, the water will be held in an isolation tank and treated. Groundwater treatment for heavy metals would consist of pH adjustment and aeration followed by separation and removal of precipitates using geofabric or a similar sacrificial layer of floating absorbent material. Any free phase organic contaminants identified can be removed with any TPH as described above.

Where ammonia and total nutrient concentrations remain elevated, dilution will be required before release to minimise the risk of creating a nutrient plume in the immediate receiving environment. This will be achieved by mixing the treated groundwater into the tail discharge from the on-going dredging operation. Alternatively, the water may be discharged as irrigation, well away from receiving waters.

The placement of agricultural lime in a groundwater interception trench on the Kedron Brook side of the new runway site prior to placement of fill will minimise further mobilisation of heavy metals and reduce the dissolved concentration of nickel, copper and chromium in the vicinity. The resulting potential for adverse impact on receiving waters is expected to be negligible.

3.12.2 Future Aviation Facilities Area and Western Apron

3.12.2.1 ASS Influences

Once consolidation of the main runway fill platform has been achieved, the 2.0 m of sand surcharge material will be moved into the FAFA site and Western Apron area. This filling will result in displacement of some groundwater back under the new runway site, and under the existing Airport.

FAFA Fill Area (No mitigation required)	Unmitigated Impact – Minor Adverse	Low Risk (2)
	Mitigated Impact – Minor Adverse	Low Risk (2)
Western Apron Fill Area	Unmitigated Impact – Moderate Adverse	Moderate Risk (4)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

Actual acidity levels in the FAFA are generally lower as the site is currently almost completely water logged, and near surface sediments appear to contain significant natural buffering capacity in the form of fine shell grit. Any acidification in this area will be minor.

Actual and potential acidity levels in the Western Apron area are similar or lower to those encountered on the new runway site and some elevated concentrations of heavy metals are present in the groundwater. As is the case for the runway, settlement after filling has the potential to cause an increase in local groundwater acidity through contact with actual acidity currently present in the near surface natural alluvium, and mobilisation of heavy metals (Iron and Aluminium). Without management the proposed filling would pose a moderate adverse impact to local receiving waters as impacted groundwater is forced off the filled area.

Mitigation Measures

Acidity mobilised from the Western Apron has the potential to pass under the NPR site and eventually to Kedron Brook. If this occurs, treatment of this water would be provided by the proposed groundwater interception/treatment trench. As previously discussed, sufficient volume of lime will be provided in the trench neutralise acidic groundwater from both the main runway site and the Western Apron.

3.12.2.2 Contaminated Land Influences

Two former contaminated sites are situated in or near areas to be filled following the surcharging of the runway area.

These are:

- The site of former underground fuel storage tanks (USTs) is located behind the Brisbane Airport Domestic Terminal, at the edge of the Western Apron area, but is not within the proposed development area. The tanks were decommissioned and removed and the site validated in 1994 and has since been filled over and paved;
- The site of reported dumping of a quantity of domestic/agricultural rubbish located within the FAFA at the edge of Cribb Island Road, on a creek bank. The extent of dumping (documented in BAC records) was minor and no putrescible waste was documented. The site is located in an undeveloped tidal estuary, currently supporting a mangrove community, and access is limited.

Groundwater samples collected from monitoring wells in both areas returned elevated concentrations of total nitrogen at 3,000 µg/L (FAFA) and 3,400 µg/L (Western Apron) and Phosphorous at 800 µg/L (FAFA) and 930 µg/L (Western Apron). Both wells are in areas of mangrove swamp where elevated nitrogen levels are not uncommon.

Groundwater EC and dissolved chloride concentrations are very high at some locations within the FAFA and Western Apron areas. This is likely due to concentration of salts by evaporation of near surface groundwater, as is common in some salt marsh environments.

FAFA Fill Area (No mitigation required)	Unmitigated Impact – Minor Adverse	Low Risk (2)
	Mitigated Impact – Minor Adverse	Low Risk (2)
Western Apron Fill Area (No mitigation required)	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)
Nutrients and Salinity	Unmitigated Impact – Minor Adverse	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

Development of the Western Apron area will not involve disturbance or filling of the former UST site (which has been validated) and no adverse impacts on groundwater are likely.

The FAFA site is currently almost completely water logged, and contains a number of tidal streams. It is not likely that any soluble or otherwise readily mobilised contaminants from the dumped wastes would remain in near surface soils and the current risk of adverse impact to groundwater quality is low (i.e. a Minor Adverse impact potential).

Where ammonia and total nutrient concentrations in groundwater are elevated they pose a risk the receiving environment. However, given that the filling and subsequent settlement of these areas will take several years to occur, the transport off-site of ammonia and other nutrients the in groundwater will be gradual, and short term and accumulative adverse impact to the receiving environment will be slight.

The receiving environment currently contains mangrove swamps with high levels of organic matter decay, and include areas of stagnant and brackish water (e.g. the truncated section of Serpentine Creek), elevated levels of nutrients would be expected to be very common throughout. As part of the filling process (in these areas) these stagnant areas will be filled over and the levels of nutrients produced will be reduced over time.

The placement of the proposed volume of sand dredged from Moreton Bay will result in an increase in local salinity in the fill/soil profile which may eventually leach into the groundwater. However, given the hyper-saline condition of existing soils and the highly saline nature of the local receiving environment, any adverse salinity impacts will be negligible.

Mitigation Measures

The former UST site is not situated in the proposed development area and no specific remediation or management measures are required.

Near surface sediments in the FAFA appear to contain significant alkaline buffering capacity in the form of fine shell grit reducing the risk of acidification and mobilisation of heavy metals in the groundwater and no specific remediation or management measures are required to manage potential impacts to groundwater quality. However, during clearing of the FAFA site, prior to filling, any visible gross contamination will be separated out and removed off-site to a licensed landfill.

3.12.3 KBF Drain and Connector Channels

3.12.3.1 ASS Influences

Results of investigations conducted at the site of main KBF Drain and two connecting channels indicate net acidity ranging up to 1,110 moles of acid/tonne, with actual acidity levels of the order of 10 to 60 moles/tonne. Monitoring of groundwater quality in nearby wells indicates neutral to slightly alkaline pH and low dissolved acidity levels with compensating higher alkalinity levels. High sulfate concentrations which indicate the acidity is likely to be due to past sulfidic influence (i.e. actual ASS) are much lower than corresponding chloride concentrations which acts to buffer the sulfate influence.

KBF Drain / Connector Channels	Unmitigated Impact – Moderate Adverse	High Risk (6)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

Actual acidity levels in near surface soils indicate a moderate risk of further acidification and possible mobilisation of heavy metals in the groundwater during construction of the drains if earthworks are not carefully managed.

Seepage through surface soils and infiltration through soils exposed during construction and possible local drawdown of the water table will result in acidification of the local groundwater unless mitigation measures are employed. Given the proximity of Kedron Brook, any adverse impacts to groundwater quality could be transferred to local receiving waters with tidal connection to Moreton Bay.

Mitigation Measures

Construction of the drain and connector channels will be constructed in four stages, each comprising construction in 100 m lengths. Dewatering where required, will be from temporary sumps constructed in the base of each 100 m section, which will also serve to catch seepage and runoff from exposed soil embankments. Drawdown of the water table will be limited (to 100 m sections) and avoided where possible, during construction of the drains.

During construction longitudinal sumps will be excavated into the base of each section to collect ground water seepage and runoff. If required the groundwater can be contained by using two clay bunds at the low end of the current section of works to allow pH adjustment by lime treatment prior to discharge. Sufficient lime will be placed on the face of the drain to neutralise long term groundwater inflow to the drain system, and prohibit of site mobilisation of heavy metals.

3.12.3.2 Contaminated Land Influences

The PSI conducted, did not reveal any specific records of contaminated sites along the proposed drain alignment.

Six samples of fill analysed as part of the baseline investigation contained slightly elevated levels of heavy metals.

Groundwater samples collected from this area also indicated slightly elevated levels of heavy metals. The concentrations, while elevated, are consistent with metals concentrations in the groundwater at other locations within the site.

KBF Drain / Connector Channels	Unmitigated Impact – Moderate Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts and Mitigation Measures

Potential impacts are as described above for ASS influences.

3.12.4 SI Drain

3.12.4.1 ASS Influences

Results of investigations conducted for the SI drain indicate very high levels of net acidity ranging up to 2,270 moles of acid/tonne. Actual acidity levels are negligible. Monitoring of groundwater quality in an adjacent monitoring well indicates near neutral pH and low dissolved acidity levels with compensating much higher alkalinity levels. Sulfate concentrations are much lower than corresponding chloride concentrations which acts to buffer the sulfate influence. Concentrations of naturally occurring dissolved metals (iron and aluminium) are not significantly elevated.

SI drain	Unmitigated Impact – High Adverse	High Risk (6)
	Mitigated Impact – Minor Adverse	Low Risk (2)

Potential Impacts

Actual acid conditions are absent from the site. However, construction will require disturbance of a relatively small volume of soils containing some very high levels of PASS resulting in a high risk of acid generation and short term acidification of groundwater and possible mobilisation of heavy metals if earthworks are not carefully managed.

Given the proximity of the drain to Moreton Bay any adverse impacts to groundwater quality could be readily transferred to receiving waters. However, given the limited depth of disturbance, provided the works are staged and exposed soils are promptly covered, the risk of adverse impact will be minimal.

Mitigation Measures

Construction of the drain will be constructed in two 200 m stages and dewatering will not be necessary. It is planned to apply a layer of coarse lime chips to exposed surfaces for short term management and utilise a concrete fill mattress to seal and stabilise the banks of the drain in the long term. Construction below high tide level will be carried out during periods of low tide with tidal waters excluded by the use of a temporary check drain. Areas below the low tide mark will not be exposed and the risk of acid generation there is negligible.

3.12.4.2 Contaminated Land Influences

The PSI conducted, did not reveal any specific records of contaminated sites along the proposed drain alignment. The nearest site, the Airport fire fighting training area (FFTA) is located approximately 300 m from the development area.

Groundwater samples collected from the adjacent monitoring well returned detectable levels of the TPH (limited to C15-C36 fractions). There are no AEPR limits nor specific ANZECC trigger values set for these hydrocarbon fractions, so a default EIL of 600 mg/l based on the Intervention Value for Mineral Oil in the Dutch Intervention Value – Environmental Quality Objectives in the Netherlands, 2000, was referenced for comparison. The total concentration detected was 560 µg/l which does not exceed this limit (i.e. 600 µg/l).

SI Drain (No mitigation required)	Unmitigated Impact – Negligible	Low Risk (2)
	Mitigated Impact – Negligible	Low Risk (2)

Potential Impacts

Excavation of the SI drain will not involve any significant dewatering during construction and no measurable impact to groundwater quality is expected. No specific mitigation is required.

3.12.5 Cross Taxiway Tunnel

The duel carriageway tunnel proposed for beneath the taxiway linking the existing Airport with the new runway will involve excavation to about 4.0 m into the existing soil profile. No dewatering will be required for construction or operation of the tunnel.

3.12.5.1 ASS Influences

Cross Taxiway Tunnel	Unmitigated Impact – Minor Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts and Mitigation Measures

No impacts on groundwater quality are expected from tunnel construction.

3.12.5.2 Contaminated Land Influences

Cross Taxiway Tunnel	Unmitigated Impact – Minor Adverse	Moderate Risk (3)
	Mitigated Impact – Negligible	Very Low Risk (1)

Potential Impacts and Mitigation Measures

No impacts on groundwater quality are expected from tunnel construction.

3.12.6 Dredge Line and Pump-out Facility

The proposed temporary dredge pipeline and pump-out facility will not involve any significant excavation or filling other than placement of a shallow pad of gravel fill up to 0.3 m thick at some locations. No dewatering will be required and the risk of impact to groundwater quality arising from disturbance of ASS or contaminated soil is negligible. The pump-out structure is to be located in a permanently inundated area (in the Brisbane River), and as such groundwater will not be influenced.

Dredge Line and Pump-out Facility	Unmitigated Impact – Negligible	Very Low Risk (1)
	Mitigated Impact – Negligible	Very Low Risk (1)

Table 3.12a: Summary of Risks (Unmitigated and Mitigated).

		Location	Unmitigated / Mitigated Impact	Risk	Risk
Potential Impacts – Geology and Soils (On-Airport)	Physical Impacts – Geotechnical Stability	New Runway and Linked Taxiway	Unmitigated Impact – Minor Adverse	Moderate Risk	4
			Mitigated Impact – Negligible	Low Risk	2
		NDA and Western Apron Area	Unmitigated Impact – Minor Adverse	Moderate Risk	4
			Mitigated Impact – Negligible	Low Risk	2
		KBF Drain and Connector Channels	Unmitigated Impact – Moderate Adverse	Moderate Risk	4
			Mitigated Impact – Negligible	Low Risk	2
		SI drain	Unmitigated Impact – Minor Adverse	Moderate Risk	3
			Mitigated Impact – Negligible	Very Low Risk	1
		Cross Taxiway Tunnel	Unmitigated Impact – Moderate Adverse	Moderate Risk	3
			Mitigated Impact - Negligible	Very Low Risk	1
	Physical Impacts - Erosion Potential	New Runway and Linked Taxiway	Unmitigated Impact – Major Adverse	High Risk	6
			Mitigated Impact – Negligible	Low Risk	2
		FAFA and Western Apron Area	Unmitigated Impact – Moderate Adverse	Moderate Risk	4
			Mitigated Impact – Negligible	Low Risk	2
		KBF Drain and Connector Channels	Unmitigated Impact – Moderate Adverse	High Risk	6
			Mitigated Impact - Beneficial	Low Risk	2
		SI drain	Unmitigated Impact – Minor Adverse	Low Risk	2
			Mitigated Impact – Negligible	Very Low Risk	1
		Cross Taxiway Tunnel	Unmitigated Impact – Negligible	Very Low Risk	1
			Mitigated Impact – Negligible	Very Low Risk	1
		Dredge Line and Pump-out	Unmitigated Impact – Negligible	Very Low Risk	1
			Mitigated Impact – Negligible	Very Low Risk	1
	ASS Impacts	New Runway and Linked Taxiway	Unmitigated Impact – High Adverse	Moderate Risk	4
			Mitigated Impact – Minor Adverse	Low Risk	2
		Northern Development Area	Unmitigated Impact – Minor Adverse	Moderate Risk	4
			Mitigated Impact – Very Minor Adverse	Very Low Risk	1
		West Apron area	Unmitigated Impact – Moderate Adverse	Moderate Risk	4
			Mitigated Impact – Very Minor Adverse	Very Low Risk	1
		KBF Drain and Connector Channels	Unmitigated Impact – High Adverse	Very High Risk	9
			Mitigated Impact – Minor Adverse	Moderate Risk	3
		SI drain	Unmitigated Impact – Moderate Adverse	High Risk	6
			Mitigated Impact – Minor Adverse	Low Risk	2
		Cross Taxiway Tunnel	Unmitigated Impact – Minor Adverse	Moderate Risk	3
			Mitigated Impact – Negligible	Very Low Risk	1
		Dredge Line and Pump-out	Unmitigated Impact – Negligible	Low Risk	2
			Mitigated Impact – Negligible	Low Risk	2
	Contaminated Soils	New Runway – Former dredge spoil area (1980s)	Unmitigated Impact – Mod Adverse	High Risk	6
			Mitigated Impact – Minor Adverse	Low Risk	2
		New Runway – Former Bus Depot	Unmitigated Impact – Negligible	Low Risk	2
			Mitigated Impact – Negligible	Low Risk	2
		FAFA Fill Area	Unmitigated Impact – Minor Adverse	Moderate Risk	4
			Mitigated Impact – Negligible Adverse	Low Risk	2
		West Apron Fill Area	Unmitigated Impact – Negligible	Low Risk	2
			Mitigated Impact – Negligible	Low Risk	2
		KBF Drain and Connector Channels	Unmitigated Impact – Minor Adverse	Moderate Risk	4
			Mitigated Impact – Negligible	Low Risk	2
		SI drain (No mitigation required)	Unmitigated Impact – Minor Adverse	Low Risk	2
			Mitigated Impact – Minor Adverse	Low Risk	2
		Cross Taxiway Tunnel	Unmitigated Impact – Minor Adverse	Moderate Risk	3
			Mitigated Impact – Negligible	Low Risk	2
		Dredge Line/Pump-out (No mitigation required)	Unmitigated Impact – Minor Adverse	Low Risk	2
			Mitigated Impact – Minor Adverse	Low Risk	2

References

Geo Coastal Australia (2006) Brisbane Airport New Parallel Runway Environmental Impact Statement - Results of Sediment Coring At Middle Banks and Luggage/Juno Point Areas, Moreton bay, Queensland.

Evans, K.G., Stephens, A.W. and Shorten, G.G. (1992) Quaternary sequence stratigraphy of the Brisbane River delta, Moreton Bay, Australia. Marine Geology 107: 61-79

Gourlay, M.R. and Hacker, J.L.F. (1979) Redevelopment of Brisbane International Airport. Sediment Investigations. Comm. Dept. Housing and Construction (Unpub. Report).

Harris, P.T, Pattiaratchi, C.C, Keene, J.B and Cole, A. (1990) Modelling the Evolution of a Linear Sandbank Field, Moreton Bay, Queensland: Report of results obtained during the cruise of A.M. Brolga, July 1989. Ocean Sciences Institute Report No. 41. The University of Sydney.

Harris, P.T and Jones, M.R. (1988) Bedform movement in a marine tidal delta: air photo interpretations. Geological Magazine 125 (1):31-49.

Moreton Bay Marine Park Extractive Industry Strategy Sand Resource Study. (1998) PPK Environment and Infrastructure Pty Ltd, for Dept. Environment and Heritage.

K. H. Head (1982) Manual of Soil Laboratory Testing - Volume2: Permeability, Shear Strength and Compressibility Tests.