
# Williamtown SAP

B3.2G Final Geotechnical Report

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# Glossary

| Abbreviation | Term |
|---|---|
| PFAS | Per and Polyfluoroalkyl Substances |
| RAAF | Royal Australian Air Force |
| SAPs | Special Activation Precincts |
| WAP | Williamtown Aerospace Park (Precinct) |
| Wiliamtown SAP | Williamtown Special Activation Precinct |
| DPE | Department of Planning and Environment |
| JSF | Joint Strike Fighter |
| DAREZ | Defence and Aerospace Related Employment Zone |
| TfNSW | Transport for New South Wales |
| ASS | Acid Sulphate Soils |
| R&D | Research and Development |
| CPT | Cone Penetrometer Testing |
| GCL | Geosynthetic Clay Liner |
| CBR | California Bearing Ratio |

# Executive Summary

The Williamtown SAP presents an opportunity for employment and investment opportunities associated with its strategic location to the WAP.

The Geotechnical Report presents the Baseline assessment (Stage 1), the Scenarios assessments (Stage 2) and the structure plan assessment (Stage 3). The Baseline assessment discusses the constraints and opportunities for the entire proposed Williamtown SAP area. The Scenarios Report focuses on the constraints and opportunities for the proposed sub land uses while applying them to different scenarios captured during the Preliminary Enquiry by Design (EBD) workshop on the 10th and 11th of February 2021. The structure plan report focuses on the constraints and opportunities for the sub precincts captured during the second Enquiry by Design workshop held on the 27th to 30th of April 2021.

A constraint ranking method was then used to provide the reader with an interpretation of the challenges associated with the structure plan, and in turn an evaluation of the potential geotechnical challenges associated with the structure plan are provided in this report to inform the workshop as follows:

- Identification and evaluation of the strengths and weaknesses associated with the geological conditions in the structure plan area
- Identification and evaluation of the constraints and opportunities associated with the geological conditions in the structure plan area.
- Provision of recommendations associated with the different constraints and opportunities highlighted across the structure plan area

The comparative analysis of the scenarios was completed using the following testing criteria:

- NSW Statewide Seamless Geology Dataset (Colquhoun et al., 2019)
- The Soil Landscape Map: Newcastle 1:100,000 Geological Sheet 9132 (Gobert V and Chestnut W, 1975)
- Topographic Maps from the publicly available LIDAR survey data
- Acid Sulphate Soils Risk Map (State Government of NSW and Department of Planning, Industry and Environment 1998)

Aside from the geotechnical challenges associated with the above, there are also some PFAS contamination and high ground water level constraints that are expected to present challenges to development.

PFAS contamination is one focus area that requires careful consideration. Referencing the *B.3.2AB PFAS & non-PFAS Contamination Report*, 2022, PFAS has been identified in specific areas around the RAAF base and has been heavily investigated over the years. It is understood that the handling and disposal of the PFAS impacted soils is actively being managed, the excavation of these soils is expected to have cost implications additional to more typical earthworks.

Flooding associated with the Williamtown SAP location and typically high ground water levels is a major constraint to the developable area. The flooding and water sensitive urban design management measures included under a separate report (*B.3.2E Flooding and Water Cycle Management Report, 2022*) include a combination of strategies to manage flooding and water quality across the Williamtown SAP. The anticipated earthworks and fill placement required to mitigate flooding may cause excessive total or differential settlements in the underlying soft soils. This settlement will require engineering control to ensure the required performance criteria are achievable. In addition, road pavements, sub base materials and underlying fill embankments –are susceptible to damage if not adequately drained or protected from the effects of flood water inundation.

A review of the existing information available show there is a significant volume of information in the northern section of the structure plan but little to no information to inform design in the area extending south from the central biodiversity area. We have used publicly available data as well as the following reports as inputs for a preliminary ground model for each of the precinct areas.:

- Environmental Site Assessment for the RAAF Base Williamtown Stage 2B Environmental Investigation (AECOM, December 2017) and
- Report on Geotechnical Investigation for the Williamtown Aerospace Park Williamtown (Douglas Partners, May 2009).

An issue with the majority of the information available is that as the scope of the previous investigations was predominantly groundwater, PFAS and contamination focussed. As such, there is limited geotechnical specific information recorded such as:

- AS1726:2017 soil descriptions
- no in situ testing recorded in the logs
- no geotechnical laboratory testing (such as particle size distribution, consolidation testing maximum dry density etc.),

However, the Environmental Site Assessment (2017) Report by AECOM provides geological cross sections of the area which have been used to understand the soil profile and estimate associated geotechnical properties for the  Structure plan boundary.

Therefore, geotechnical investigations are considered necessary during subsequent stages of design to confirm the extent and location of the soils present within the structure plan. Investigations should characterise the full ground profile for total and differential settlements, as well as allow for insitu testing and sampling, followed by laboratory testing.

The following measures are therefore recommended :

- Early investment in geotechnical investigations to allow concept design and cost estimates to be developed with more certainty of ground conditions. Investigations would be expected to be mainly comprise:
  - Cone Penetrometer Testing (CPT) – to profile the alluvial soils and any layering. Also permeability data for settlement assessments.
  - Boreholes - to verify CPT data and retrieve samples.
  - Test pitting – excavator pits in areas of potential material reuse to allow bulk sampling.
  - Installation and monitoring of groundwater standpipes in selected boreholes

Other additional recommendations and opportunities are presented:

- Referencing the *B.3.2E Flooding and Water Cycle Management Report*, 2022, Early investment in fill placement and preloading to reduce construction stage settlement management. If fill material becomes available from local highway improvement projects in the Hunter region, then this fill may be acquired for more cost-effective rates and could be used in early pre-release flood management land improvement work.
- Monitoring of settlements associated with preloading by using remote sensing and interferometry, installation of survey targets on the fill surface for better accuracy. This could reduce the need for extensometers and other installations through PFAS barriers.
- Levee design – lining channels with suitable impermeable and non-dispersive fill over locally sourced fill may reduce the volumes required for import.
- Investment in collation and organisation of the various sources of geotechnical data currently held by third parties. If a central Williamtown SAP geotechnical database was developed then all subsequent stages of design and planning and any individual developments could benefit from this record of previous work and site geological conditions.

# 1 Introduction

## 1.1 Purpose

This geotechnical provides an assessment and presents a summary of the geological  setting within the Williamtown SAP study area and presents opportunities and constraints for the structure plan.

This study has been based on publicly available records together with existing information including borehole logs and laboratory test certificates, no site new investigations have been undertaken.

### 1.1.1 Scope of Works

This geotechnical report has been developed to provide the New South Wales Department of Planning and Environment (DPE) with a geotechnical assessment of the structure plan of the Williamtown SAP area, including:

- Identifying the strengths and weaknesses of the options by review of the existing record and data.
- A review of the existing geotechnical data including identifying constraints and recommending key areas for further investigation.
- A geotechnical assessment for a better understanding of the sub surface geological profile and hydrogeological conditions and identify potential opportunities and constraints associated with the geotechnical assessment with the consideration of options that will not disturb, expose or drain acid sulphate soils.
- Identify and develop innovative solutions that could be implemented across the precinct to achieve the precinct vision, which may include new/emerging industries and advancements in technology and renewable energies.
- Demonstrate that future development and land use types within the precinct will preserve the operational and safety needs of the Williamtown RAAF Base and Newcastle Airport
- Undertake any further modelling required to support each scenario.
- Include spatial mapping for each scenario.

### 1.1.2 Limitations

The limitations associated with this assessment are outlined below:

- This assessment has been limited to publicly accessible data; Aurecon data and DPE data.
- No geotechnical or hydrogeological modelling has been undertaken for the purpose of this assessment.
- No impacts on the community assessment has been undertaken as part of this geotechnical assessment.
- No development options analysis has been undertaken as part of geotechnical assessment.
- No geotechnical investigations were carried out for this assessment.
- No site walkover was carried out for this assessment

## 1.2 Background Context

### 1.2.1 Williamtown SAP Background

On 28 May 2020, the Deputy Premier announced Williamtown as regional NSW's fifth Special Activation Precinct (SAP). This follows other SAPs at Parkes, Wagga Wagga, Moree and Snowy Mountains. The focus for all SAPs is a 20-year vision for job creation and regional economic development.

The Williamtown SAP is focused on leveraging employment and investment opportunities associated with its strategic location to the Williamtown Aerospace Precinct (WAP) including the RAAF Base Williamtown, Newcastle Airport and The Defence and Aerospace Related Employment Zone (DAREZ).

The Department of Planning, Industry and Environment (DPE) and Regional Growth NSW Development Corporation's establishment of Special Activation Precincts (SAPs) is a joint Government Agency and innovative approach to plan and deliver infrastructure projects in strategic regional locations in NSW.

Investment in these specific areas of Regional NSW 'activate' State or regionally significant economic development and jobs creation as part of the 20-Year Economic Vision. A strategic need from a land use demand and supply perspective, is that there is limited long term availability of readily developable land. The Williamtown SAP will seek to resolve environmental, drainage and other development constraints in a coordinated precinct scale approach as opposed to a site by site basis.

The Williamtown SAP's vision is based on six key visions as shown in Figure 1. The strategic need for growth in the Hunter Region involves:

- **The Place** – leveraging the vicinity of the RAAF and civil aviation operators attract local employment and commercial investment;
- **Economy and Industry** - facilitate development of additional employment land for Defence and aerospace industries;
- **Environment and Sustainability**– regionally coordinated approach to flooding, water cycle management and contamination while preserving and enhancing the natural environment;
- **Infrastructure and Connectivity** – providing infrastructure to resolve development constraints to reduce investment barriers to entry and enable effective connections to nearby Hunter Region infrastructure;
- **Connection to Country** – To preserve, respect and integrate Aboriginal cultural heritage, particularly the Worimi people; and
- **Social and Community Infrastructure** – Enabling high skill employment, innovation, education and skill training opportunities.


**Figure 1 – Williamtown SAP Visions**

### 1.2.2 Williamtown SAP Location

Williamtown is located approximately 30 km east of the Newcastle CBD in New South Wales.

The Hunter Region has the largest share of both regional population growth and regional employment and is in the state's fastest growing corridor (Sydney to Newcastle). Greater Newcastle is the centrepiece of the Hunter Region with 95% of residents living within 30 minutes of the strategic centre.

Newcastle Airport and the Port of Newcastle are recognised as global gateways targeted to enable the region and the state to satisfy the demand from growing Asian economies for products and services associated with education, health agriculture, resources and tourism (Hunter Regional Plan, 2036). The Hunter Regional Plan 2036 identifies that the region's ongoing economic prosperity will depend on its ability to capitalise on its global gateway assets and as such cites a need to expand the capacity of Newcastle Airport and the Port of Newcastle.

The Williamtown SAP study area covers an area of approximately 11,408ha and is low-lying coastal land on the edge of Fullerton Cove and Stockton Beach of land within Port Stephens local government area in the Hunter Region and Greater Newcastle area of NSW. It is centred around the Williamtown Aerospace Precinct (WAP).

The Williamtown SAP is focused on leveraging employment and investment opportunities associated with its strategic location to the Williamtown Aerospace Precinct (WAP) which includes:

- RAAF Base Williamtown which F35 Australia Joint Strike Fighter (JSF) fleet is based in. The area has also been affected by Per- and Polyfluoroalkyl Substances (PFAS) contamination associated with past activities conducted at the Williamtown RAAF Base;
- Newcastle Airport which is jointly owned by Port Stephens Council and Newcastle City Council, leased from the Department of Defence and shares their airport runway with RAAF Base Williamtown;

- The Defence and Aerospace Related Employment Zone (DAREZ) which is intended for the development of aerospace and defence specific industries in close proximity to the adjoining Newcastle Airport;
- Bushland vegetation is prominent in the area with some areas containing threatened flora and fauna species as well as important wetland areas;
- Rural and agricultural lands;
- Small rural and low density residential clusters including the township of Salt Ash, Williamtown and Fullerton Cove;
- Commercial and light industrial clusters associated with the airport and RAAF Base alongkey road corridors;
- The Tillgery State Conservation Area;
- The Grahamstown Lake is located to the north of Fullerton Cove; and
- The study area and structure plan is also crossed by several transport infrastructure assets including roadways.

The study area and structure plan are presented in Figure 2 – Williamtown SAP Study Area and structure plan.

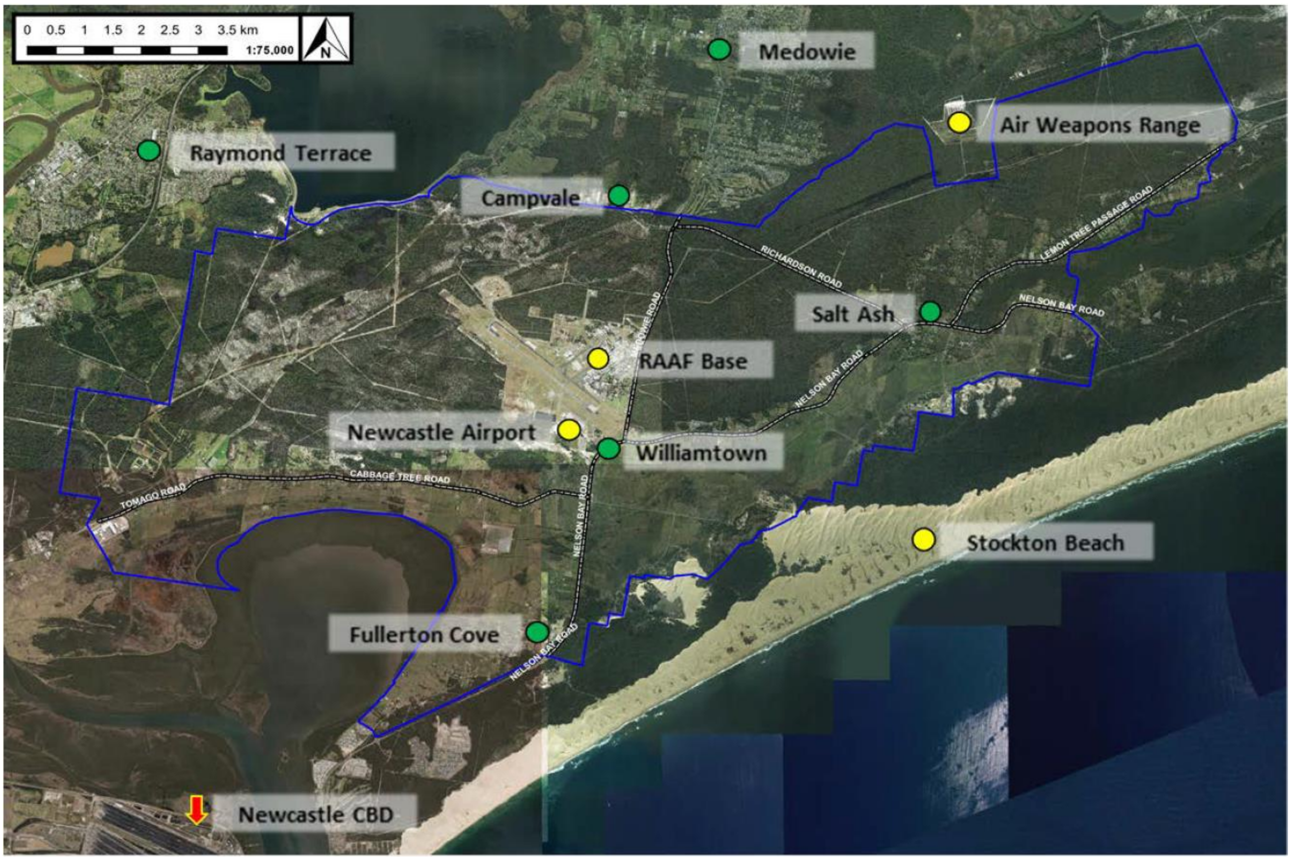


**Figure 2 – Williamtown SAP Study Area and structure plan**

### 1.2.3 Williamtown Geotechnical Context

The opportunities for building development at Williamtown SAP will include light industrial buildings such as warehousing, laboratories and office buildings for use by advanced manufacturing and logistics companies associated with the RAAF base and airport. These would then require associated transport and utilities links.

Typically, such developments include predominantly lightweight buildings, which are commonly founded on shallow strip or pad foundations or slab on ground foundations.

The buildings will require service access for transport as well as vehicle car parking facilities and roads for access.  Earthworks associated with such developments typically include filling to create levelled areas or fill placement to raise formation levels to improve flood immunity and drainage of properties.

This report discusses the limitation and opportunities to development that exist in geological and geotechnical terms for the following:

- The Baseline Assessment for the Williamtown SAP study area
- The scenario testing and
- The structure plan.

# 2 Baseline Assessment

## 2.1 Regional Geological setting

The extent of the Williamtown SAP study area is covered by a range of published mapping sources as listed below:

- Newcastle 1:100 000 Geological Series Sheet (9232) & explanatory notes
- Nelson Bay 1:100 000 Geological Series Sheet (9332) & explanatory notes
- Newcastle 1:250 000 Geological Series Sheet (SI56-2) & explanatory notes
- NSW Statewide Seamless Geology dataset (Colquhoun, et al., 2019)
- Newcastle Coalfield Regional Geology Map 1:100000 & explanatory notes
- Nelson Bay 1:100 000 and 1:25 000 Coastal Quaternary Geological Series Sheet & accompanying report

The Williamtown SAP study area and structure plan are shown overlying the NSW Seamless Geology map in Figure 3.

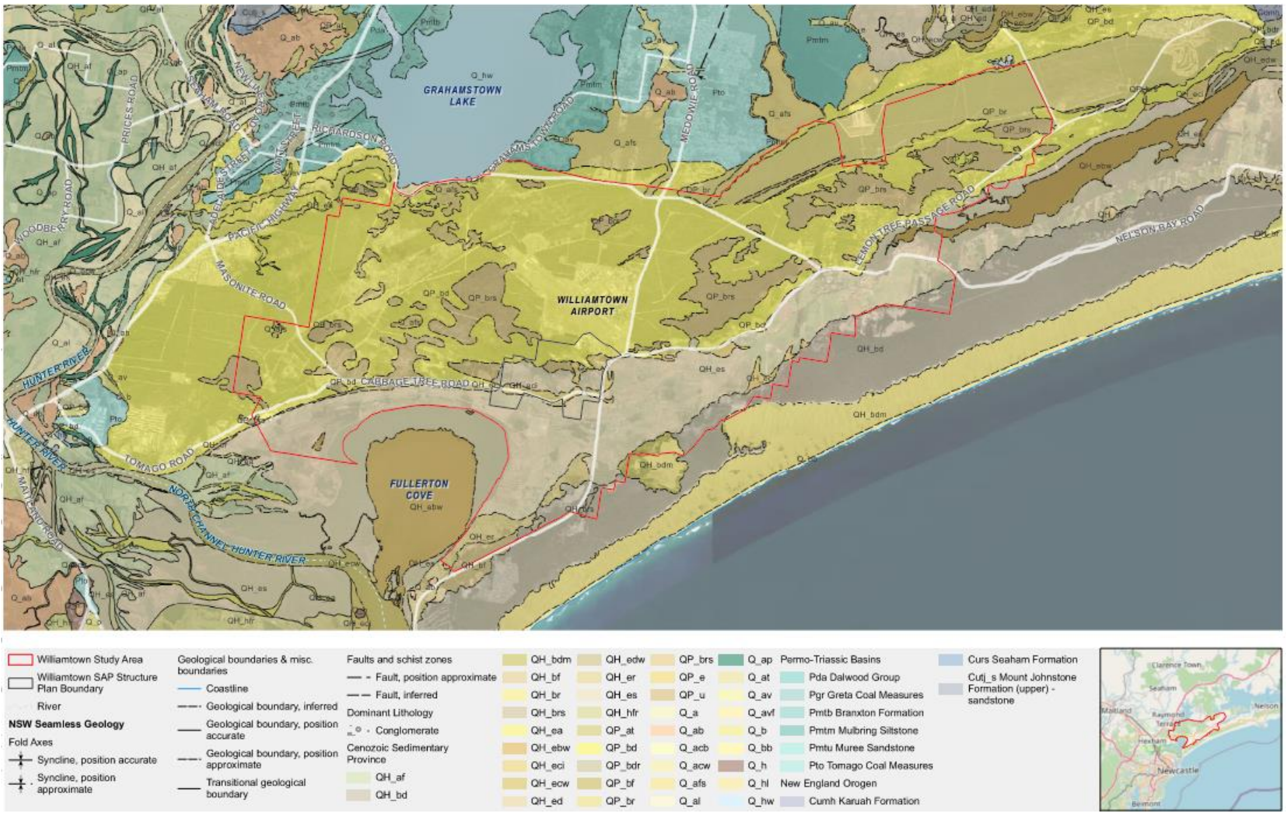


**Figure 3 – Regional Geology, digital copy displayed as part of the NSW Seamless Geology Dataset.**

In general terms, the Hunter river 'delta' (river mouth and floodplain area), in which the Williamtown SAP study area is located, is dominated by a sedimentary basin structure or bedrock palaeovalley that extends up to 35km inland. This basin is a low point in the rockhead, eroded into the underlying Permian and Triassic rocks which are also controlled by folding and faulting, into which sediments have since been deposited. These sediments are relatively recent in age and have not yet lithified into rock, they are unconsolidated and reach thickness of at least 90m.

The folding and faulting in the basin rocks includes large scale regional structures such as the Hunter – Mooki Thrust system. Below the Williamtown SAP study area at depth the rocks are folded and form the Medowie Syncline.

Given the depth of the sediments it is considered highly unlikely that the types of developments that would be considered in the Williamtown SAP will interact with the bedrock. However, the faulting is considered to be active and the Newcastle earthquake of 28 December 1989 is testament to this.

Of the maps listed above the NSW Statewide Seamless Geology map and Nelson Bay Coastal Quaternary map have been used to prepare the figures in Appendix B and Appendix C respectively.

The summary of the geology mapped in the Williamtown SAP study area and structure plan is summarised in Table 1 below.

**Table 1. Summary of Geology**

| Geology Type | Name | Description | Period | Ref. |
|---|---|---|---|---|
| Cenozoic Sedimentary Province | Coastal Deposits | Comprises sand, beach ridges and low-level windblown dunes | Quaternary | QP_bd |
| Cenozoic Sedimentary Province | Coastal Deposits | Comprises sand and dunes | Quaternary Pleistocene | QP_brs |
| Cenozoic Sedimentary Province | Alluvial Floodplain Deposits | Comprises Clay | Quaternary | Q_afs |
| Cenozoic Sedimentary Province | Estuarine swamp | Comprises very compressible organic rich sediment | Quaternary Holocene | QH_es |
| Permo-Triassic basins | Tomago Coal Measures | Sandstone | Lopingian | Pto |
| Permo-Triassic basins | Dalwood Group | Sandstone | Permian | Pda |
| Permo-Triassic basins | Mulbring Siltstone | Siltstone | Guadalupian | Pmtm |
| New England Orogen | Ungrouped Carboniferous Units | Sandstone | Carboniferous | Cus |

Sections 2.1.1, 2.1.2 and 2.1.3 discuss the characteristics of the geology summarised in relation to the Williamtown SAP study area.

### 2.1.1 Cenozoic Sedimentary Province

#### Coastal Deposits

Majority of the Williamtown SAP study area comprises Coastal deposits. These Pleistocene sedimentary deposits comprise aeolian sand sheets and low dunes composed of quartz sands interbedded with lenses of clay. The characteristics of this geology type are:

- Highly permeable sandy soils - difficult excavation conditions. Dewatering and shoring costs could be prohibitive.

- High water table - Water management controls may be more expensive in areas with this geology.
- Dunes – low hills in sand with poor slope stability and not typically suitable for founding without earthworks to create levelled areas or densify them. Dunes are formed by the wind and are prone to movement so constant management of material is required.
- Salts in the sands can cause durability issues with concrete. Local sand quarries complete ‘double washing’ process to refine for use as aggregate.

#### Estuarine Deposits

Within the Williamtown SAP study area this geology runs from Tillagerys creek to Fullerton cove. Holocene estuarine mud deposits consist of silt and clay. In the Hunter delta, these deposits are underlain by Holocene tidal delta sands (Roy1993). The characteristics of this geology type are:

- Highly compressible organic matter – these soils can cause significant total and differential settlements that can be challenging and costly to control.
- High water table – Water management controls may be more expensive or impractical.
- Highly Reactive soils – movements associated with moisture content in such soils can require additional considerations for foundation design such as replacing part of the underlying soil, improve it with chemical or mechanical means or controlling ground water and potential moisture content variations around the foundations. The figure in Appendix C shows this area clearly between Tilligerry creek and Fullerton Cove.
- Seasonal Waterlogging – changes in strength of the soils as well as volume with moisture levels can lead to defects and failures if not adequately managed in design.

#### Alluvial Floodplain deposits

Within the Williamtown SAP study area there is a small area of Alluvial Floodplain deposits located to the west and east of Masonite road. The alluvial floodplain deposits have been formed as part of the Cenozoic Sedimentary Province consisting of silt and clay. The characteristics of this geology type are:

- Highly Reactive soils – movements associated with moisture content require additional considerations in foundation design.
- High water table – Water management controls may be more expensive or impractical. This can also lead to potential impacts on adjacent areas.
- Seasonal waterlogging – changes in strength of the soils as well as volume with moisture levels can lead to defects and failures if not adequately managed in design.

### 2.1.2 Permo-Triassic Basins

Bedrock across the Williamtown SAP study area is only exposed at the surface in limited areas in the north east where the siltstone of the Mulbring formation outcrops to the east of Grahamstown dam.

The sediments associated with the Hunter River floodplain and the coastal dunes cover the rock across the rest of the Williamtown SAP study area to depths of over 40m.

The following bedrock units are recorded below the Williamtown SAP study area.

#### Mulbring Siltstone

This rock unit consists predominantly of siltstone with minor claystone and sandstone lenses. Mulbring siltstone is 330 metres thick in its type section near Mulbring. Based on our experience with the unit the following should be noted:

- Residual soil profiles vary from 2-4m of relatively easy to excavate material; and

- Residual soils can be reused for earthworks as the CBR values are typically greater than 3%.

The following rock units are at depths below the site and are not expected to be encountered by foundations or excavations:

#### Tomago Coal Measures

Reference to the Newcastle Coalfield Regional Geology Map 1:100000 explanatory notes, indicates this rock unit lies below the area where the Medowie road runs from north to south through the Williamtown SAP study area, and is constrained by the Medowie syncline. The Measures are divided into three formations:

- Wallis Creek is the basal formation which consists of sandstone, siltstone, claystone and thin coal seams.
- Four Mile Creek is the principal coal bearing interval in the Tomago Coal measures which consists of siltstone, claystone, sandstone and coal. Four Mile creek Formation is approximately 77m thick and is known to exceed 450m at its maximum development in the Williamtown area
- Dempsey Formations is the uppermost formation which consists of siltstone, claystone, sandstone and thin coal seams. Fullerton Cove Seam is 110m thick.

#### Dalwood Group

Referencing the Newcastle Coalfield Regional Geology Map 1:100000 explanatory notes, the Dalwood Group is divided into the:

- Lochinvar Formation consists of poorly fossiliferous siltstone, claystone and sandstone and interbedded basalt flows.
- Allandale Formation consists of lithic sandstone and conglomerate containing abundant invertebrate.
- Rutherford Formation consists of siltstone and minor sandstone with thin limestone and marl horizons occurring in the Pokolbin area.
- Farley Formations consists of fossiliferous silty sandstone.

### 2.1.3 New England Orogen

Beneath the Permian and Triassic rocks lies a basement of carboniferous consisting of sandstones, siltstones and claystones. The depth of these means there are highly unlikely to be encountered in any works in the Williamtown SAP study area.

## 2.2 Soil Landscapes

A review of the Newcastle 1:100,000 Geological Sheet 9132 (Gorbert V and Chestnut W, 1975) indicates the Williamtown SAP study area and structure plan are underlain by five soil landscape units.

An extract of the soil landscapes map is shown below in Figure 4 and a more detailed figure is presented in Appendix D. The typical characteristics of each landscape mapped in the Williamtown SAP study area and structure plan are summarised in Table 2 and further described in Section 2.2.1.

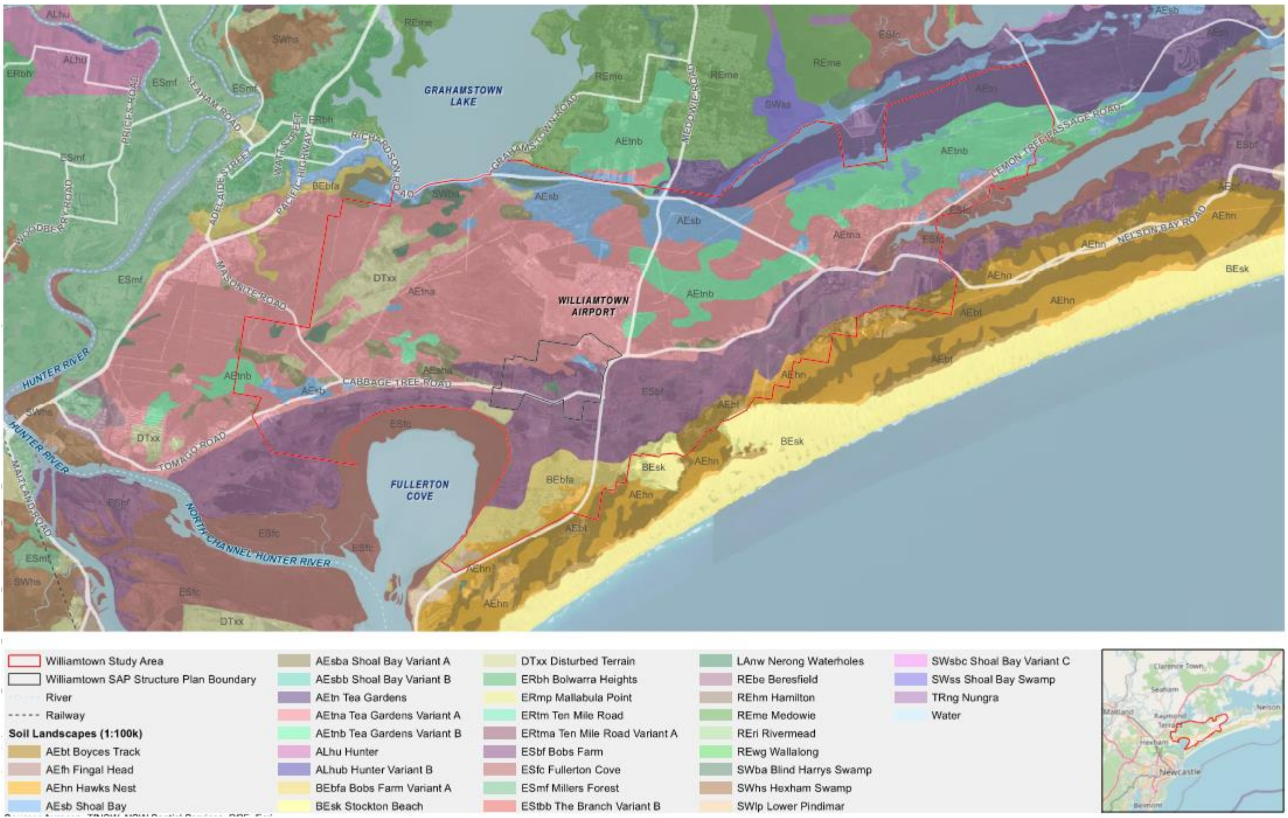


**Figure 4 – Soil Landscapes present within the Williamtown SAP study area and structure plan.**

**Table 2. Soil Landscapes**

| Soil Landscape | Ref. |
|---|---|
| Tea Gardens Variant A | AEtna |
| Tea Gardens Variant B | AEtnb |
| Bobs Farm | ESbf |
| Shoal Bay | AEsb |
| Disturbed Terrain | DTxx |

## 2.2.1 Soil Landscape Descriptions

### Tea Gardens Variant A and Variant B (AEtna and AEtnb)

Tea gardens Variant A (Aetna) is an Aeolian landscape and is located north of Cabbage Tree Road and Lemon Tree Passage Road.

The soil landscape typically comprises beach ridges on the Tomago Coastal Plain. Hills and slopes are typically less than 1m in height and with slopes with less than 5% grade.

The elevation within this landscape varies between 5m to 8 m RL.

Both variants are typically found to the North of Cabbage Tree Road and Lemon Tree Passage Road. Variant A is more extensive throughout the Williamtown SAP study area whilst Variant B (AEtnb) is located in isolated areas north of Fullerton Cove and on the eastern end of the Williamtown SAP study area and structure plan.

Whilst these soils are recorded as windblown (Aeolian soils) and are typically sands, they also include areas of poorly drained deep organic soils in swales and swamps. Such areas are challenging to develop in and are discussed in later sections.

### Bobs Farm (ESbf)

This is an Estuarine landscape and is limited to a narrow corridor that runs parallel to Nelson Bay Road and Cabbage Tree Road. This extends the full length of the Williamtown SAP study area from east to west, widening towards the west and surrounding Fullerton Cove.

Local relief consisting of hills and slopes of less than 3 m in low lying land, with slopes of less than 1% grade.

The Estuarine soils are deep, very poorly drained clayey soils (Humic Gleys) with low bearing capacity and high compressibility (I.e. subject to excessive settlements).

### Shoal Bay (AEsb)

This is an Aeolian landscape and is located in small concentrated areas between Williamtown RAAF base and Medowie. Small isolated pockets are also recorded near the intersection where Tomago Road becomes Cabbage Tree road to the Northwest of Fullerton Cove.

This landscape is characterised by sandsheets and low dunes on the Tomago Coastal Plain. Local relief consisting of hills and slopes of less than 15 m, with slopes of less than 15% grade.

The aeolian soils are deep, well-drained quartz rich sands in the low-lying hills. However, they are poorly drained in flats and depressions.

### Disturbed Terrain (DTxx)

Disturbed terrain includes areas of fill or excavated, and reworked material created by human activity.

The landscape is described with local relief and slope gradings that are highly variable, landfill consisting of soil, rock, building and waste materials with original vegetation completely cleared and replaced with turf or grassland.

## 2.3 Site Topography

The Williamtown SAP study area is found in generally low-lying land characterised by low sand dunes and sand sheets.

To the north of Lemon Tree Passage Road and Cabbage Tree Road the Williamtown SAP study area is characterised by elevation of generally 5m to 8m with slope gradients of less than 5%.

To the south of Lemon Tree Passage Road and Cabbage Tree Road the Williamtown SAP study area is characterised by elevation of 1m to 3m with slope gradients of less than 1%. To the north of Tomago Road the Williamtown SAP study area is characterised by elevation of less than 15m with slope gradients of less than 15%.

The publicly available LiDAR data is presented in Figure 5 and a more detailed map is shown in Appendix E.

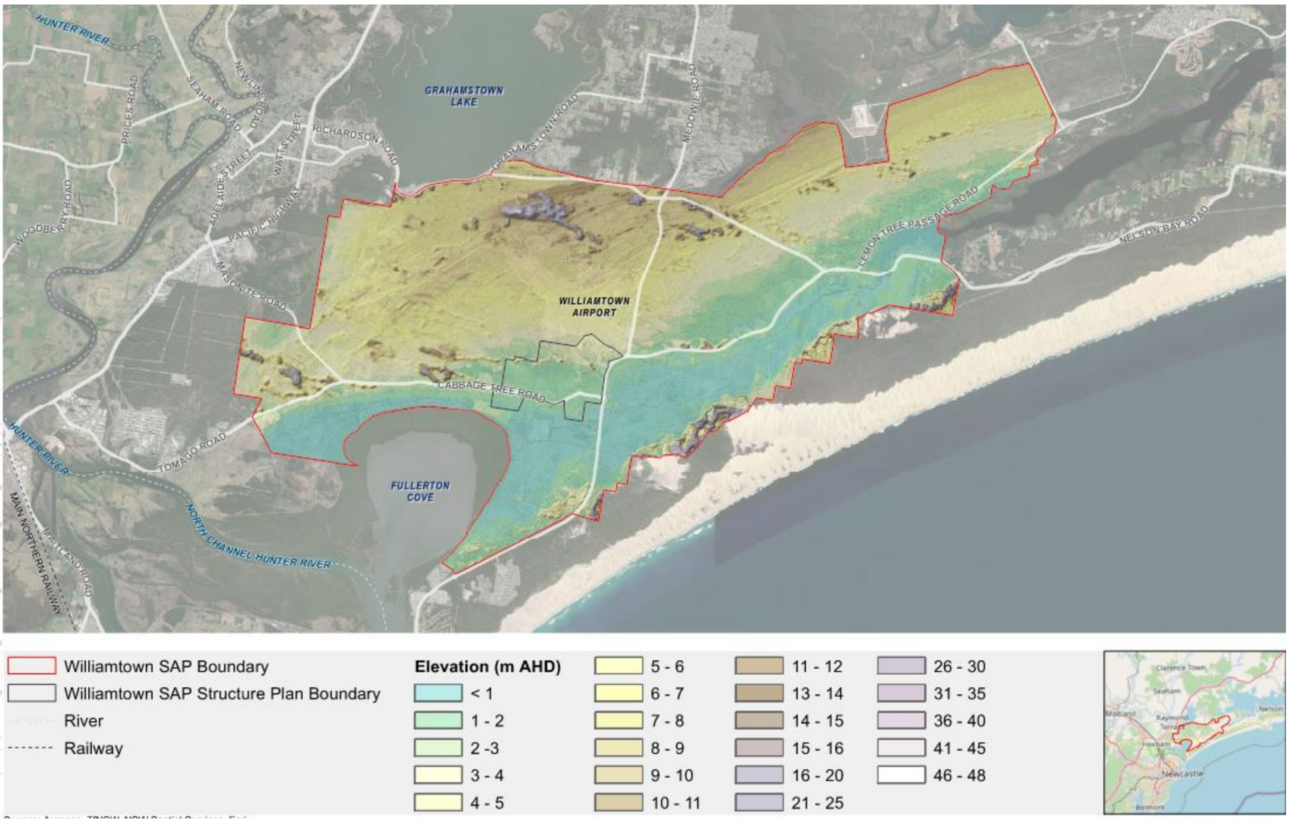


Figure 5. Map showing Site Topography.

## 2.4 River & creek systems

Several creeks are mapped in close proximity to and/or crossing sections of the Williamtown SAP study area shown in Figure 6 below. These areas may be associated with localised and channelised alluvial floodplain deposits associated with soft to firm clays, silts and loose sand as indicated in the geological mapping. The thickness of these materials is expected to be highly variable. The features and their locations are summarised below:

- Tilligerry Creek which runs parallel to Lemon Tree Passage Road and runs through half the Williamtown SAP study area.
- Dawsons Drain which runs parallel to cabbage tree road and runs through Fullerton Cove.
- Mofats Creek runs perpendicular to Richardson Road.
- Grahamstown Lake and Dam is located between Medowie Road and the Pacific Highway.

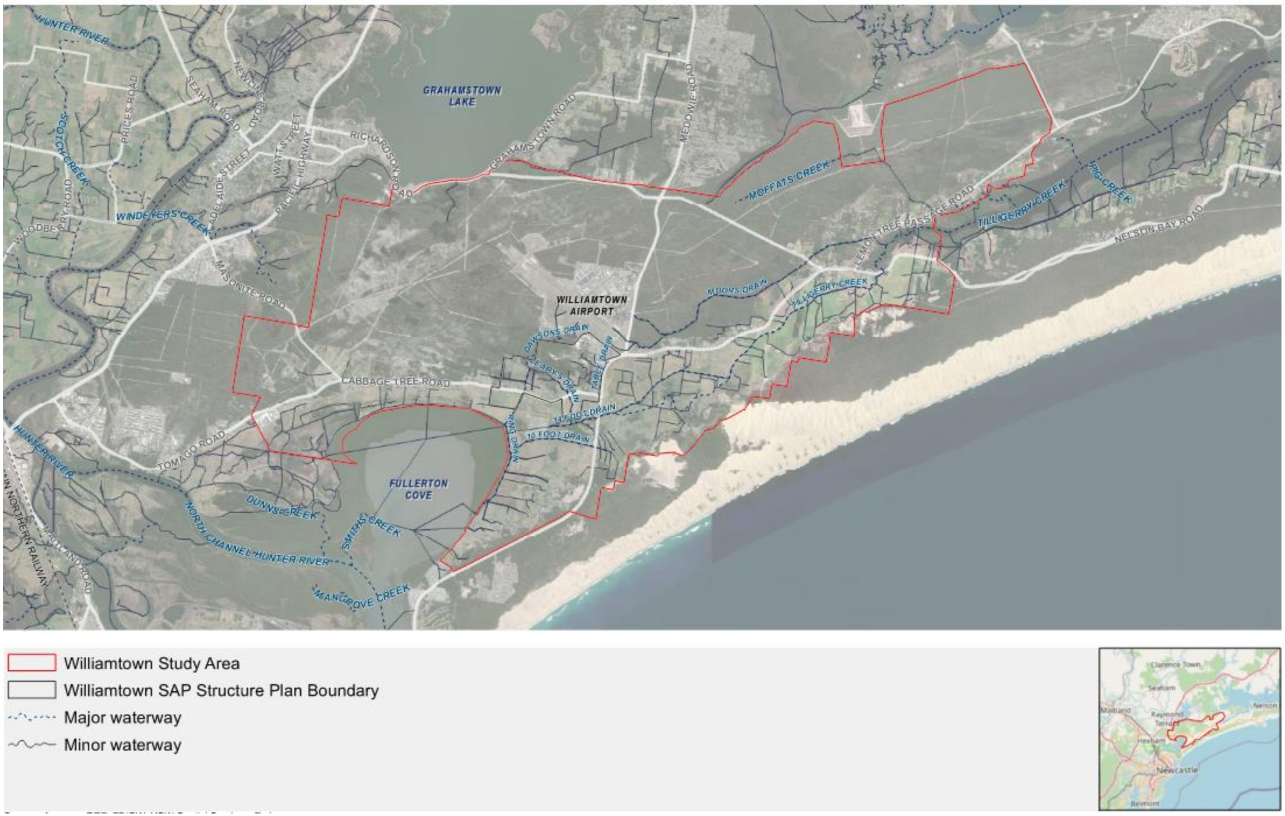


Figure 6 – Creeks Mapped in Area

## 2.5 Seismicity

In accordance with the Australian Standard AS1170.4-2007, The study areas have a hazard design factor (Z) of 0.11 and a range of site sub-soil classes. The likely subsoil classes to be encountered at the Williamtown SAP study area may be shallow soil (Ce). Investigations are required to confirm the indicative sub-soil class. The hazard factor indicates that the Williamtown SAP study area is in a low seismicity risk area.

## 2.6 Salinity

There are small areas of high salinity potential scattered across the western end of the Williamtown SAP study area only. It is noted that the salinity risk mapping only indicates potential in Williamtown NSW and does not guarantee that salinity will not develop in the proposed area of study. The map shows potential at a 1:100 000 scale and should not be relied upon at a property scale. Appropriate investigation should be undertaken on a site-specific basis, as the map is not a substitute for on-site investigation.

## 2.7 Acid Sulphate Soils

Acid Sulphate soils are natural sediments that contain iron sulphides. Left undisturbed they do not present any risk but when disturbed or exposed to air these soils can cause environmental harm through exposure of iron sulphides to oxygen and water, forming iron compounds and sulphuric acid.

This can potentially impact the durability of buried concrete and other foundations types. In addition, the costs associated with safe management of excavations and removal of construction spoil is significantly increased if ASS are present.

An extract of the Acid Sulphate soil map is shown in Figure 7.

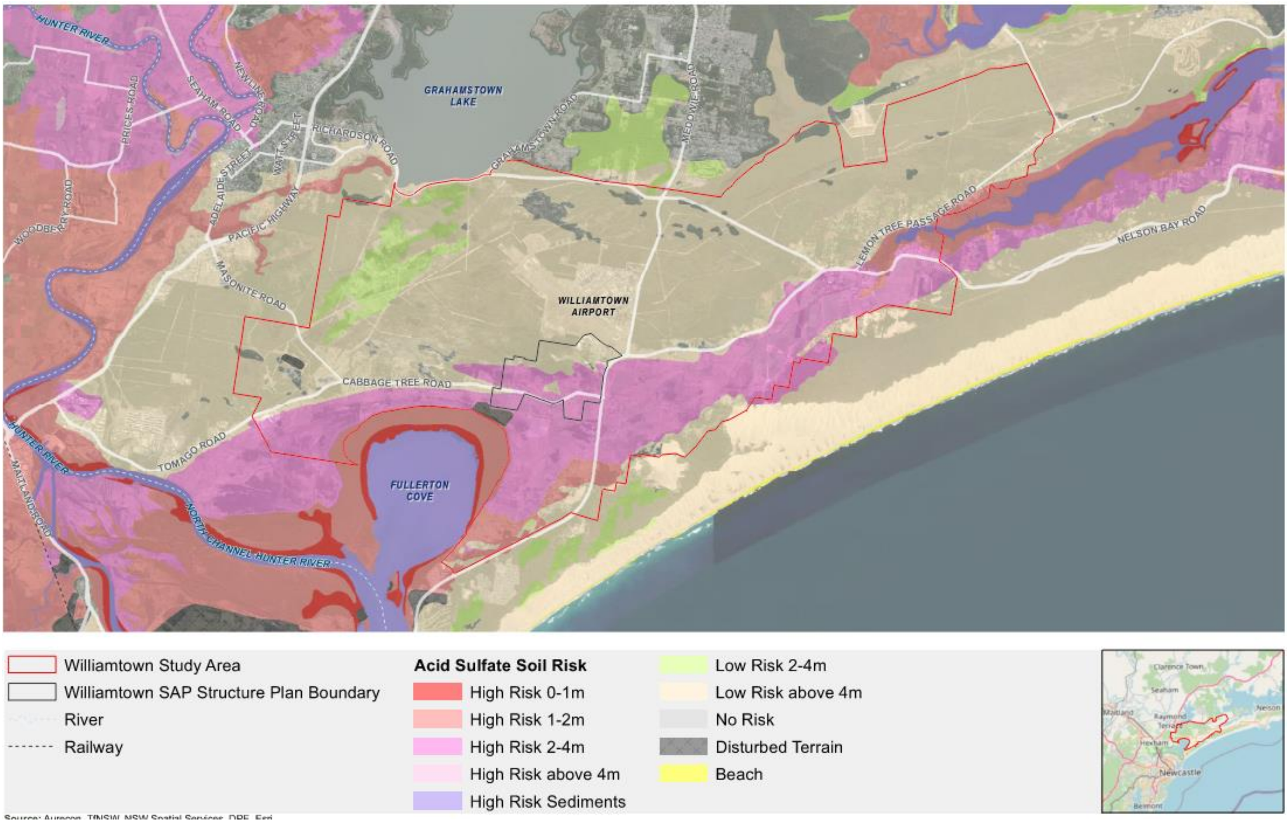


**Figure 7 – Acid Sulphate Soils Risk Map Extract.**

Figure 7 shows the locations in which ASS are likely to be found and the level of risk. The map has nine risk classes:

- High Risk 0-1m – High probability of Acid Sulphate Soils <1m below the ground surface.
- High Risk 1-2m - High probability of Acid Sulphate Soils between 1m – 2m below the ground surface.
- High Risk 2-4m - High probability of Acid Sulphate Soils 2m – 4m below the ground surface.
- High Risk above 4m - High probability of Acid Sulphate Soils >4m below the ground surface.
- High Risk Sediments – Presence of high-risk sediments.
- Low Risk 2-4m – Low probability of Acid Sulphate Soils 2m – 4m below the ground surface.
- Low Risk above 4m – Low probability of Acid Sulphate Soils >4m below the ground surface.
- No Risk – No risk of Acid Sulphate Soils.

The Acid Sulphate Soils map shows a relatively well-defined corridor from Tilligerry creek to Fullerton cove that presents a high probability of encountering acid sulphate soils. This risk diminishes further away from the creek line in the north-east to south-west. To the North of the Lemon Tree Passage Road and Cabbage Tree Road there is a low risk of encountering acid sulphate soils.

Appendix F contains the ASS mapping and further information on ASS and PFAS is presented in *B.3.2AB PFAS & non-PFAS Contamination Report*, 2022

## 2.8 Groundwater

Groundwater is shallow across the floodplain and the Williamtown SAP study area in general. A separate report has been prepared on this topic and is presented as *B.3.2F Hydrogeology Report.* A site plan showing the available groundwater bores is shown in Appendix G.

## 2.9 Mining

The publicly available information held by the NSW Government Subsidence Advisory indicates that the proposed infrastructure is not within a mine subsidence district (NSWG, 2019a).

## 2.10 Quarries

The Williamtown SAP study area has several quarries in the surrounding region. The closest of these are sand mines, and several rock quarries in the Port Stephens area, these are summarised together with their publicly available products in Table 3 below.

**Table 3. Summary of Local Quarries and Products.**

| Quarry Name and Address | Products |
|---|---|
| Hunter Quarries,<br>61 Blue Rock Cl, Karuah NSW 2324<br>https://hunterquarries.com.au/ | ▪ asphalt aggregates<br>▪ concrete aggregates<br>▪ manufactured sand<br>▪ crusher dust<br>▪ road bases<br>▪ gabion rock<br>▪ rock<br>▪ rhyolite |
| Redisand, 7 Janet Parade, Salt Ash, NSW, 2318<br>https://redisand.com.au/ | 'Brown' Sand<br>double washed sand for:<br>Premixed Concrete<br>Fine Aggregate<br>Concrete Sand<br>Mortar<br>Pipe Installations<br>Asphalt<br>Grout<br>Manufacturing Processes |
| Boral Quarries Seaham,<br>139 Italia Road, Balickera NSW 2324<br>https://www.boral.com.au/locations/boral-quarries-seaham-balickera | ▪ Hard Rock Aggregate |
| Boral Quarries Stockton (Fullerton Cove)<br>32 Coxs Lane<br>Fullerton Cove NSW 2295<br>https://www.boral.com.au/locations/boral-quarries-stockton-fullerton-cove | ▪ Fine Sand |

| Quarry Name and Address | Products |
|---|---|
| Anna Bay Sand & Earthmoving<br>41 Gan Gan Rd<br>Anna Bay, NSW 2316<br>https://www.annabaysands.com.au/ | ▪ Beach Sand<br>▪ Washed Sand |
| Newcastle Sand<br>398 Cabbage Tree Rd, Williamtown NSW<br>https://www.newcastlesand.com.au/ | ▪ Concrete & Asphalt Sand<br>▪ White / Industrial Sand<br>▪ Landscape Sand |

## 2.11 Depth of Soil and Regolith Dataset

Reference to the Soil and Landscape Grid National Soil Attribute Maps - Soil Depth as published by CSIRO on the Minview website shows the surface soils range from 0.75m to 1.5m. This reflects the shallow soils of the present-day landform.

A review of the depth of regolith layer from the same dataset suggests that the depth of regolith increases towards and around Fullerton Cove from Tilligerry creek in the east – west direction. The depth is greater than 30m. These figures are in Appendix H.

## 2.12 Available Geotechnical Records

Appendix I presents the locations of records available at the time of writing this report these have been taken from the sources summarised in the following sections.

### 2.12.1 NSW Public works

NSW Public Works reports are now published online via MinView. The available reports all lie outside of the Williamtown SAP study boundary and as such have been referenced for information only. The locations of the relevant reports are shown in Figure 8 below. The reports included:

- Groundwater was encountered during geotechnical investigations
- The geology encountered in the area was Quaternary formations compromising of marine and freshwater deposits: gravel, sand, silt and clay.
- Borehole logs for borehole drilled in the area which indicated the presence of alluvial, aeolian soil deposits and residual soils

The above information broadly agrees with the publicly available mapping information as discussed in sections 2.1, 2.2, 2.7 and 2.8.


**Figure 8 – Historical investigation Locations from Public Works database**

### 2.12.2 Aurecon held records

Aurecon has conducted a series of geotechnical investigations at the Williamtown RAAF Base for the Department of Defence. The works included mainly borehole drilling and suggest that:

- The area below the RAAF base is typically underlain by fine to medium grained sands deposits (alluvial and aeolian soil deposits)
- The sands ranged from loose to medium dense typically
- Groundwater was encountered at depths varying from 1.5 to 4 m at the time of readings.

### 2.12.3 Other Reports

#### DAREZ Volume Three – Background Reports Part 1 to Part 4

GHD prepared a series of reports for the Defence and Airport Related Employment Zone (DAREZ) for the NSW Department of Planning. The reports included:

- The geology encountered in the area was Quaternary formations compromising of marine and freshwater deposits: gravel, sand, silt and clay
- Constraints and Risks associated with each soil landscape
- Groundwater was encountered at depths varying from 0 to 5 m.

#### Environmental Site Assessment December 2017, RAAF Base Williamtown Stage 2B Environmental Investigation – AECOM

AECOM prepared this report for the Department of Defence which is primarily focused on groundwater and PFAS in the Williamtown Area and contains limited geotechnical information. However, the report includes five (5) interpreted geological cross sections which are shown in Figure 9. Two of these cross sections are presented in Figure 10 and Figure 11 below

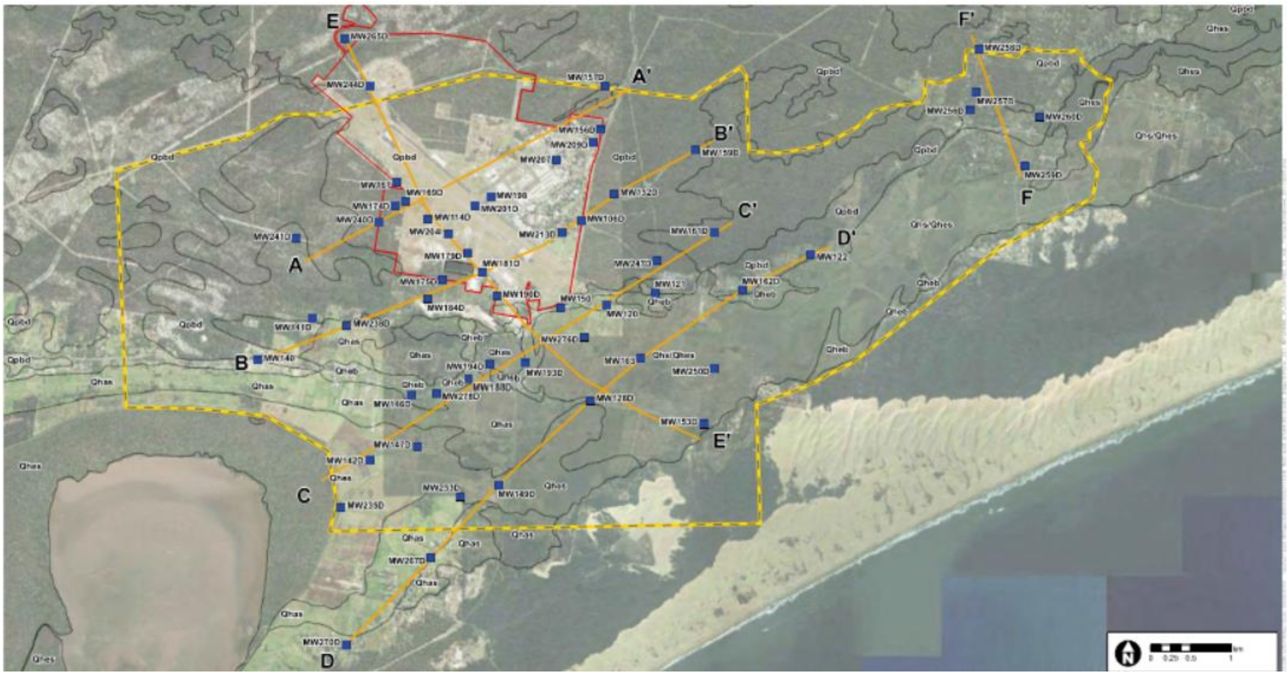

**Figure 9. Location of Cross sections (A-E) as developed by AECOM.**

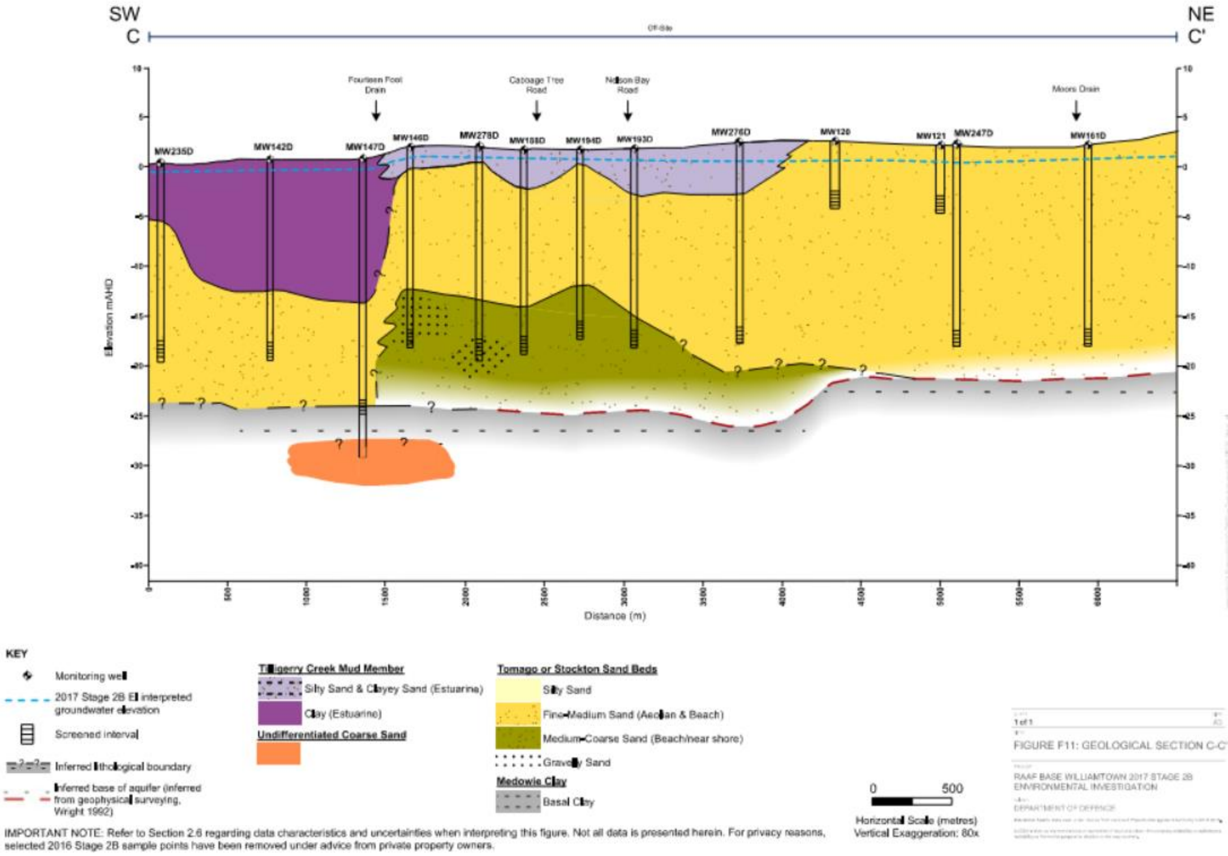


**Figure 10. Geological Cross Section C-C'**

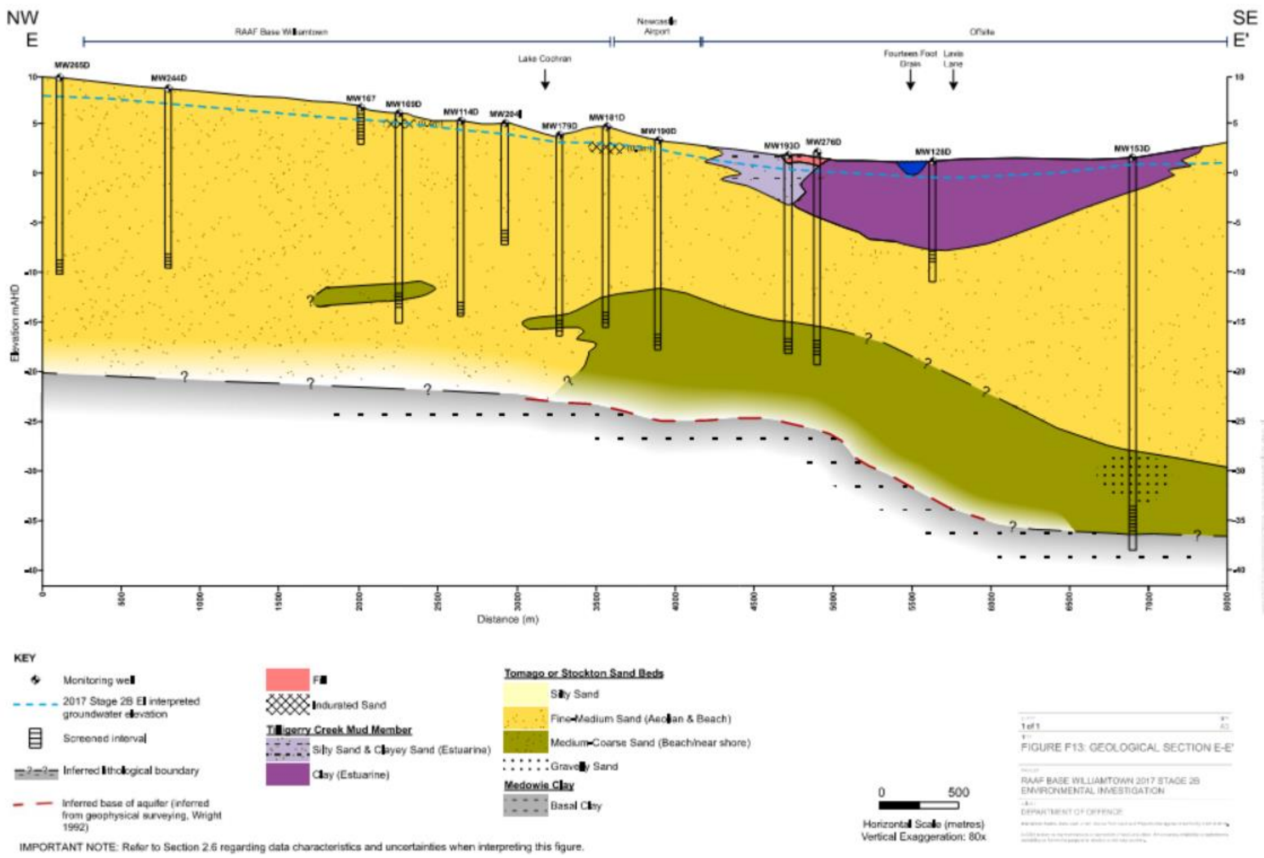


**Figure 11. Geological Cross Section E-E'**

These cross sections indicate the following:

- Depth of soils (sediments) is inferred to be 15 m to 20 m deep.
- Soils are predominantly fine to medium sands with lenses of clay.
- The depth of overlying softer 'Estuarine' deposits increase to the southeast from the airport towards Fullerton Cove.
- The Estuarine deposits are also constrained to a paleochannel formed between Tiligerry Creek and Fullerton cove.
- Groundwater is inferred to be 1 m to 2 m depth typically but locally deeper or shallower.
- Section C-C' shows estuarine clay near Fullerton Cove of 10 m to 15 m below ground level
- Estuarine silty sand and clayey sand of up to 5 m thickness overlies fine to medium sands in the western half of section C-C' between the Williamtown runway and Fullerton Cove.
- Depth to top of rock typically increases to the south and south west.

## Cabbage Tree Road Sand Quarry Williamtown NSW, Maximum extraction Depth Management Plan, (by Water shed HydroGeo, May 2019)

Water shed HydroGeo prepared this report for the Williamtown Sand Syndicate for proposed further quarrying to the north of cabbage tree road near Barrie close.

The quarry is planned to excavate sand from two low lying hills (up to 23 m high) in this area.

Available information in the report suggests:

- Tomago Sand Beds exhibit high hydraulic conductivity of greater than 10m/d and up to 55m/d

- Tilligerry Mud member measure permeability of 0.1 to 1 m/d
- Within the Tomago aquifer localised variations can include coffee rock and indurated sand
- Table 3.1 of this report includes maximum groundwater levels ranging from 1.6 to 4.2 mAHD.

# 3 Summary of Baseline Constraints

The various soils and rocks described in the preceding sections of this report have associated challenges to overcome when planning or designing infrastructure. There are also unique opportunities to consider how best to capitalise on these from the outset.

This section is intended to provide a summary and discussion of these for the Williamtown SAP study area to inform master planning decisions.

In order to present the reader with a graphical interpretation of where these areas exist, we have prepared a constraints map, which is presented in Appendix J This map was developed from the data held in the following primary sources:

- NSW Statewide Seamless Geology Dataset (Colquhoun et al., 2019)
- The Soil Landscape Map: Newcastle 1:100,000 Geological Sheet 9132 (Gobert V and Chestnut W, 1975)
- Topographic Maps from the publicly available LIDAR survey data
- Acid Sulphate Soils Risk Map (State Government of NSW and Department of Planning, Industry and Environment 1998)

The information from these maps was reviewed and the units ranked in terms of associated limitations to development. The mapped units and resultant rankings are presented in Table 5.

We would note that Acid sulphate soils are already ranked based on risk and this ranking was not altered for the purposes of this study. Three ranking levels were selected, and they are Low, Moderate and High. The definitions of these categories are shown in Table 4.

Once the rankings were assigned a Multicriteria Analysis was completed using ARCGIS software. This process takes each ranking and assigns it a number 1, 2 or 3, with equal weighting, (e.g. 1 = Low, 2= Moderate, 3= High) and completes a function of overlaying the separate GIS layers and colour coding (Also in Table 4) them according to total score. The higher the score, the more challenging ground conditions are for development.

Figure 12, Figure 13 and Figure 14 show the individual constraints maps and the final combined figure is presented as Figure 15. The detailed maps are shown in Appendix J.

**Table 4. Definition of Constraint Rankings.**

| Ranking | Description | Examples | Colour |
|---|---|---|---|
| Low | Minimal limitations to development | Sandy soils with no organic or clay content<br>Low Risk of ASS<br>Low Salinity<br>No disturbed terrain recorded | Green |
| Moderate | Some limitations to development | Combination of Low and High-risk soil units that may affect development | Yellow |
| High | Multiple limitations to development | High Risk of ASS<br>Organic soils (Peat)<br>Soft or clayey soils | Orange |

From Figure 15 it is clear where areas exist that will encounter challenges when designing and constructing infrastructure. The dominant constraints are all as shown in orange or red in the Williamtown SAP study area:

- Disturbed material
- ASS
- 'Estuarine' soils - organic or clayey soils

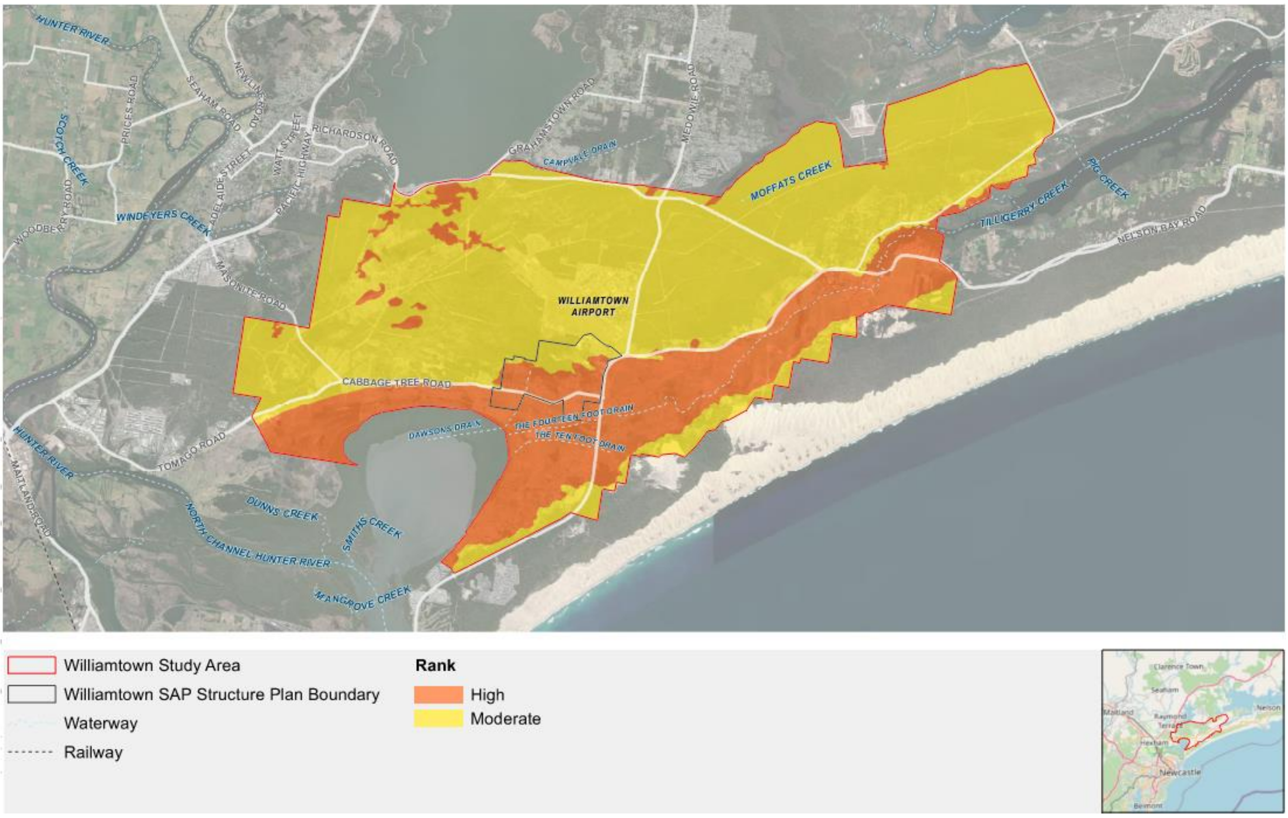


**Figure 12. Constraints for Geology**

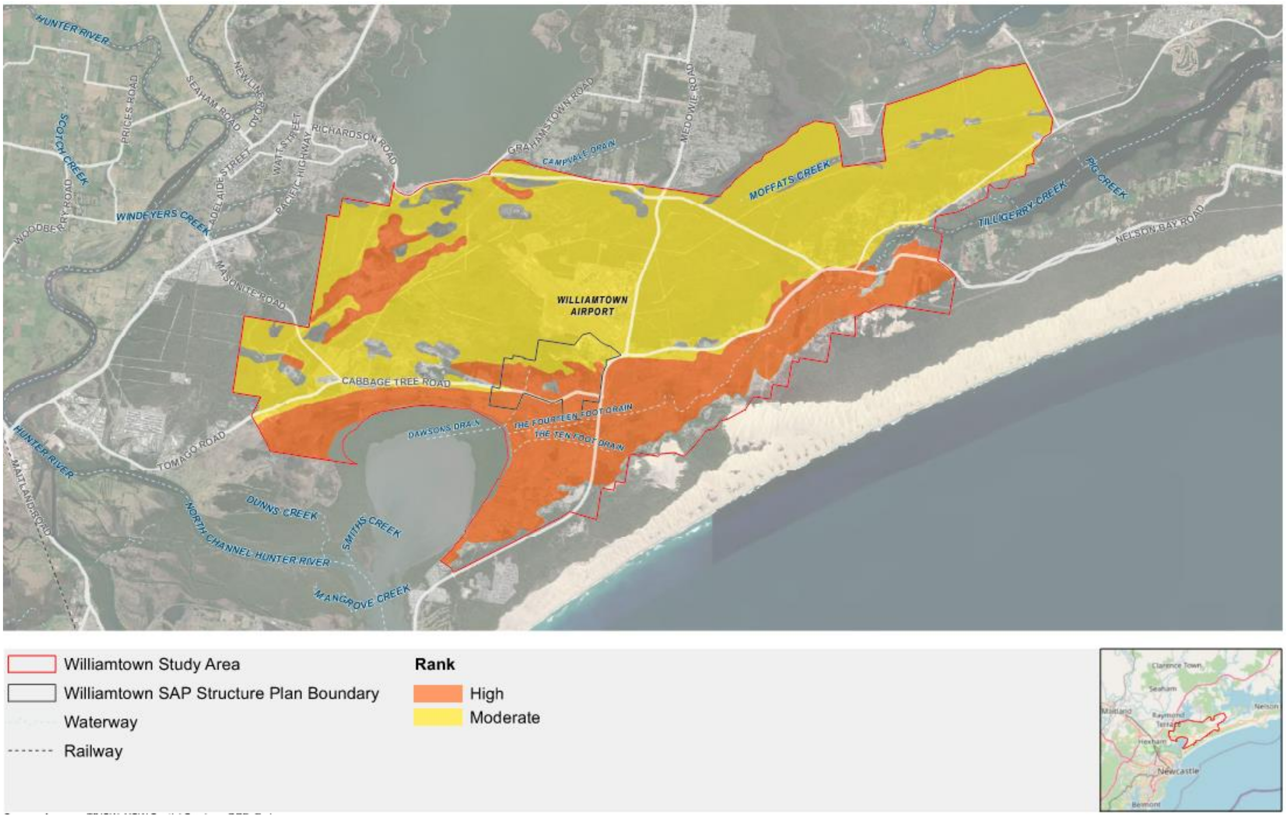


**Figure 13. Constraints for Soil Landscapes.**


Source: Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

**Figure 14. Constraints for ASS.**

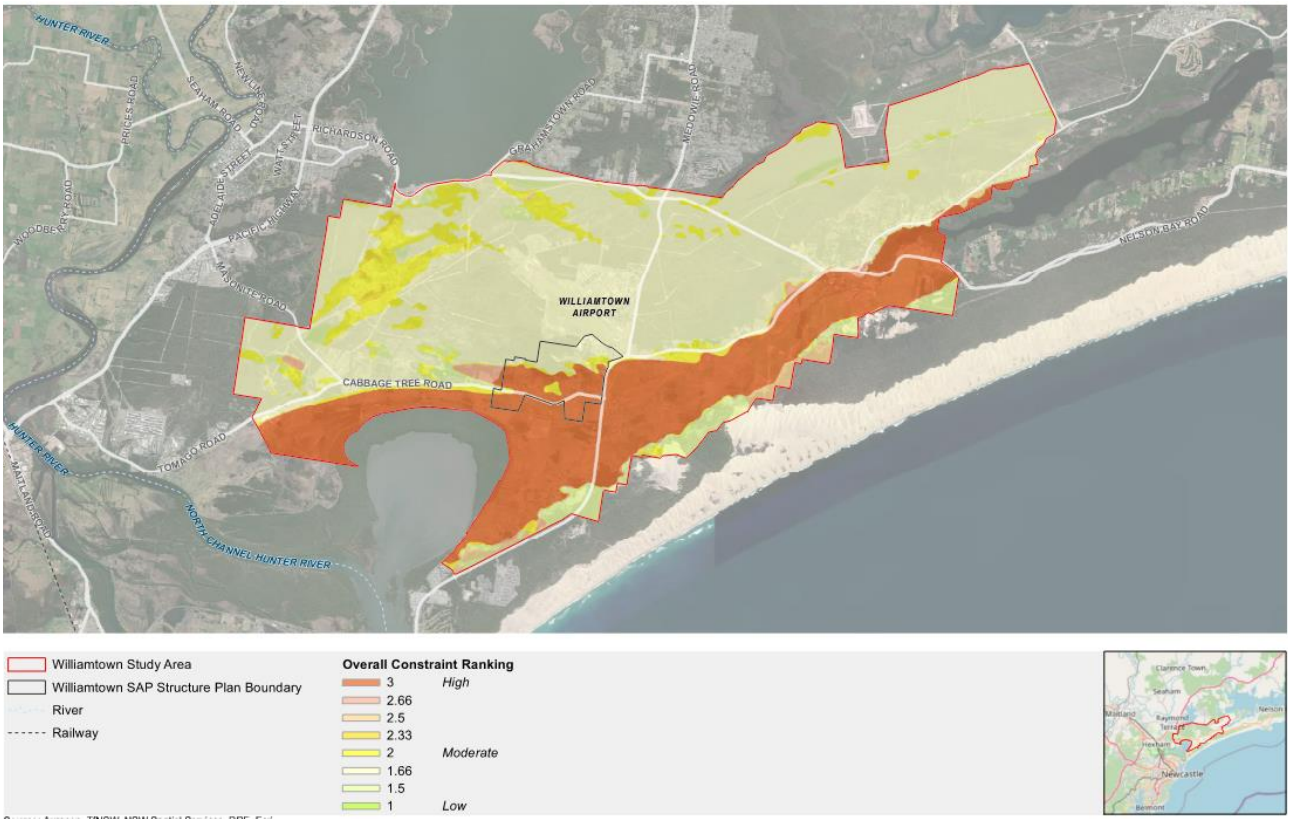


**Figure 15. Overall Constraints.**

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**Table 5.Constraints based on the Soil Landscapes and the Overall Limitation to Development**

| Unit Name | Data source | Soil Type | Acid Sulphate Soil Risk | Foundations | Earthworks | Excavations | Overall limitation to development |
|---|---|---|---|---|---|---|---|
| Shoal Bay | Soil Landscape | Sandy soils and low to high Sand dunes | Low | High Foundation Hazard on steeper slopes, swampy areas and waterlogged swales.<br>Shallow foundations - Potential for excessive total and differential settlement.<br>Deep foundations – challenges with shallow ground water and limited construction options | Sandy soils could present difficulties for earthworks operations especially in silty strata | Highly pervious soil materials which are unstable sandy soils could present difficult hence shoring would be required. | Moderate |
| Disturbed Terrain | Soil Landscape | Highly variable soil types.<br>Landfill includes soil, rock, building and waste materials. | Low | Highly variable conditions depending on the materials and degree of compaction and site limitations need further characterisation before design compared with other soil types<br>Shallow foundations - Potential for excessive or uncontrolled total and differential settlement.<br>Requirement for Preloading<br>Deep foundations – depths may need to increase to allow for fill in upper portion. Potential for obstructions to excavation | Potential for uncontrolled fill placement to need removal and / or rework. | Excavations in Fill can present unknown conditions as it is highly variable, with potential obstructions also present. | High |
| Tea Gardens | Soil Landscape | Sandy Soils | Low | High Foundation Hazard in waterlogged swales<br>Shallow foundations - Potential for excessive or uncontrolled total and differential settlement.<br>Requirement for preloading<br>Deep foundations – challenges with shallow ground water and limited construction options | Sandy soils could present difficulties for earthworks operations especially in silty strata | Highly pervious soil materials which are unstable sandy soils could present difficult hence shoring and groundwater management would be required. | Moderate |

| Unit Name | Data source | Soil Type | Acid Sulphate Soil Risk | Foundations | Earthworks | Excavations | Overall limitation to development |
|---|---|---|---|---|---|---|---|
| Bobs Farm | Soil Landscape | Deep Estuarine soils of poorly drained Humic Clay | High (at shallow depths) | Organic clays of high plasticity do not provide suitable foundation material due to potential of compressibility of organic matter and High potential for differential settlement as a result of shrink swell movement, therefore special considerations must be made to improve the ground/ manage groundwater or adopt deep foundation options.<br>High Foundation Hazard due to High water tables and seasonal waterlogging<br>Deep foundations – depths may become not practical to reach a bearing stratum.<br>Saline subsoils may be aggressive to deep foundations | High hazard due to high water tables and high plasticity and potentially reactive subsoils | Need for ground improvements such as preloading to manage settlement risks.<br>Embankments required to manage flood risk. Preloading required for embankments<br>Instability risk<br>Support / shoring requirements may be uneconomic or impractical.<br>Potential high cost of ground treatments to achieve standard performance criteria for infrastructure. | High |
| Coastal Deposits | Geology | Sandsheets and low dunes composed of quartz sands interbedded with lenses of clay. | Low | High foundation hazard on steeper slopes and swampy area.<br>High foundation hazard in waterlogged swales and high wind erosion hazard linked to extremely acid sandy non cohesive soils.<br>Earthworks may be required if ground profile needs to be raised. Preloading be required in localised small low-lying areas. | Sandy soils could present difficulties for earthworks operations especially in silty strata | Highly pervious soil materials which are unstable sandy soils could present difficult hence shoring may be required.<br>Preloading be required in localised small low-lying areas. | Moderate |

| Unit Name | Data source | Soil Type | Acid Sulphate Soil Risk | Foundations | Earthworks | Excavations | Overall limitation to development |
|---|---|---|---|---|---|---|---|
| Alluvial Floodplain Deposits | Geology | Consists of silt and clay | Low | Organic clays of high plasticity do not provide suitable foundation material due to potential of high compressibility of organic matter and High potential for total and differential settlements as a result of shrink-swell movement.<br>High Foundation Hazard due to High water tables, seasonal waterlogging. | Saturated and organic soils are typically not suitable<br>Removal and replacement would be required<br>Potentially reactive subsoils | Instability risk<br>Support / shoring requirements may be uneconomic or impractical | High |
| Estuarine Swamp | Geology | Holocene estuarine mud deposits consist of silt and clay | High | Organic clays of high plasticity do not provide suitable foundation material due to potential of compressibility of organic matter and High potential for differential settlement as a result of shrink-swell movement.<br>High Foundation Hazard due to High water tables, seasonal waterlogging. | Saturated and organic soils are typically not suitable<br>Removal and replacement would be required<br>potentially reactive subsoils | Instability risk<br>Support / shoring requirements may be uneconomic or impractical | High |

| Unit Name | Data source | Soil Type | Acid Sulphate Soil Risk | Foundations | Earthworks | Excavations | Overall limitation to development |
|---|---|---|---|---|---|---|---|
| Tomago Coal Measures | Geology | Consists of sandstone, siltstone, claystone and thin coal seams | Low | Residual soil profile could provide good founding medium for shallow foundations<br>Possibility of high shrinkage soil – shallow foundations would require to be sited below zone of influence.<br>Deep foundations – rock excavations in medium to high strength rock<br>Coal seams would be unsuitable founding materials | Residual soils expected to relatively easy to excavate<br>Rock may require heavier plant or ripping<br>Coal and some reactive soil may limit reuse options. Rock may not be suitable for some uses due to low expected durability. | Relatively simple shallow excavations in Residual soil material | Low |
| Dalwood Group | Geology | fossiliferous siltstone, claystone and sandstone and interbedded basalt flows | Low | Residual soil profile could provide good founding medium for shallow foundations<br>Basalt – high strength rock good for founding on but may be impersistent and hard to excavate into.<br>Possibility of high shrinkage soil – shallow foundations would require to be sited below zone of influence.<br>Deep foundations – rock excavations in medium to high strength rock | Residual soils expected to relatively easy to excavate<br>Rock may require heavier plant or ripping. Basalt especially.<br>Coal and some reactive soil may limit reuse options. Rock may not be suitable for some uses due to low expected durability | Relatively simple shallow excavations in Residual soil material<br>Basalt would be time consuming and costly to excavate if high strength | Low |

| Unit Name | Data source | Soil Type | Acid Sulphate Soil Risk | Foundations | Earthworks | Excavations | Overall limitation to development |
|---|---|---|---|---|---|---|---|
| Mulbring siltstone | Geology | Siltstone with minor claystone and sandstone lenses | Low | Residual soil profile could provide good founding medium for shallow foundations<br>Possibility of high shrinkage soil – shallow foundations would require to be sited below zone of influence.<br>Deep foundations – rock excavations in medium to high strength rock | Residual soils expected to relatively easy to excavate<br>Rock may require heavier plant or ripping<br>Coal and some reactive soil may limit reuse options. Rock may not be suitable for some uses due to low expected durability | Relatively simple shallow excavations in Residual soil material | Low |
| Ungrouped carboniferous Units | Geology | Sandstones, mudstones, siltstone, and claystone | Low to High | Residual soil profile could provide good founding medium for shallow foundations<br>Possibility of high shrinkage soil – shallow foundations would require to be sited below zone of influence.<br>Deep foundations – rock excavations in medium to high strength rock | Residual soils expected to relatively easy to excavate<br>Rock may require heavier plant or ripping<br>Coal and some reactive soil may limit reuse options. Rock may not be suitable for some uses due to low expected durability | Relatively simple shallow excavations in Residual soil material | Low |

# 4 Land Use Scenarios

Section 5 of the report provides a summary of the scenario development during the first Enquiry by Design workshop held on 10 and 11 February 2021 which involved implementing visions and concepts, identifying challenges and developing innovative solutions at a precinct-wide level across all technical streams. Scenarios were developed and refined by Roberts Day for the Williamtown SAP Structure plan boundary. They considered land use, transport, infrastructure, PFAS, environmental, social, aboriginal heritage and economic matters in conjunction with the Williamtown SAP vision.

Each of the scenarios tested identifies the development limitations, constraints management and required infrastructure that would be required to support the respective structure plan's proposed development. This information was subsequently used at the second Enquiry by Design workshop to inform the structure plan.

## 4.1 Key Scenario Findings

As part of the scenario testing the methodology described in Section 3 was used to assess each option. Acid sulphate soils were not specifically included in the development of the scenario maps as they are limited to the Estuarine Swamp soil unit and as such only the soil unit is included in the multicriteria analysis.

From a geotechnical perspective the scenarios were relatively comparable based on the testing criteria used in Section 5.1.

In general,  one key finding from the scenario testing phase was that it would be less costly to develop land to the north of Cabbage Tree Road and to the north and west of Nelson Bay Road due to the mapped extent of organic estuarine soils and the high Acid Sulphate soil potential to the south of Cabbage Tree Road which may be more costly to develop on and is a consistent threat to development.

In addition to the organic estuarine soils, scenario testing was based on limited data across the Williamtown SAP structure plan boundary. Due to the limited information available across the scenarios, further geotechnical investigation may be required prior to or during subsequent stages of the Williamtown SAP process to confirm the extent and location of the soils present within each scenario area.

The land is relatively low lying which has may have cost implications on the energy corridor land use i.e. for solar farms.

# 5 Structure Plan

## 5.1 Methodology and Approach

Section **Error! Reference source not found.** of the report provides a summary of the scenario development during t he second Enquiry by Design workshop held on the 27th to 30th of April 2021. This workshop involved the further testing of the previously prepared scenarios and development of the draft Williamtown SAP structure plan. Like in the previous Enquiry by Design workshop, the structure plan considers land use, transport, infrastructure, PFAS, environmental, social, aboriginal heritage and economic matters in conjunction with the Williamtown SAP vision.

Figure 16 provides an outline of the key principles which were incorporated into the masterplan.

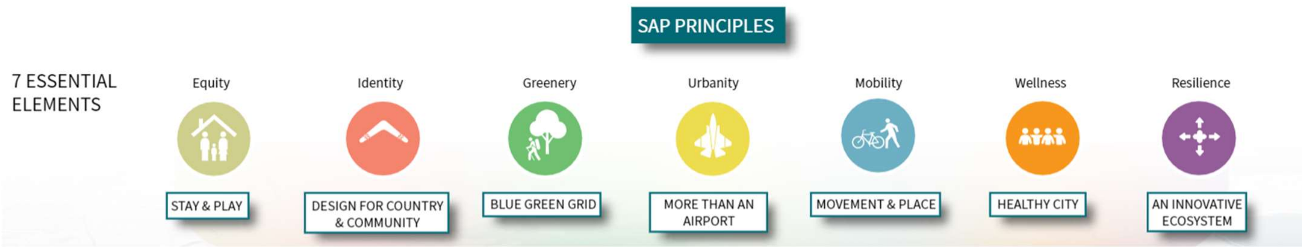


**Figure 16.The 7 SAP Principles which governed the master plan.**

The structure plan leverages the preferred elements of all the scenarios developed, further explores the items under investigation and avoids the earmarked no-go zones. The previously identified strengths and opportunities of each scenario were pursed while weaknesses and threats mitigated. This approach was taken to maximise the positive development outcomes rather than considering the previous scenarios as options and adopting one as the structure plan.

## 5.2 Proposed structure plan

The Structure Plan refined by Roberts Day is centred around the existing Williamtown Airport Precinct, which includes Newcastle Airport, Williamtown RAAF base and Astra Aerolab. The precinct incorporates a core development area south of the existing airport. Initial stages of the Williamtown SAP development are to incorporate aerospace and defence contractor industries around the southern airside boundary of the airport. The land uses within the Williamtown SAP's northern precinct focuses on defence and aerospace, commercial centres, freight and logistics and research and development industries. The later stages of the Williamtown SAP, which includes the Western and Eastern precincts, focus on a more flexible land use application which focuses on complimentary industries such as commercial centres, advanced manufacturing, light industry and research and development. The plan shown in Figure 17 adheres to the existing drainage and flooding characteristics and incorporates the inclusion of the Dawson's and Leary's drain reserve. Additionally, it maintains hydrological regime for the biodiversity corridor, facilitates controlled flooding throughout the Williamtown SAP and utilises floodplains South of Cabbage Tree Road to offset impacts.

Based on the findings from section 5.2 the majority of the development is proposed north of Cabbage Tree Road to reduce the extent of the area that will lie on the soft soils of the Estuarine swamp soil type.

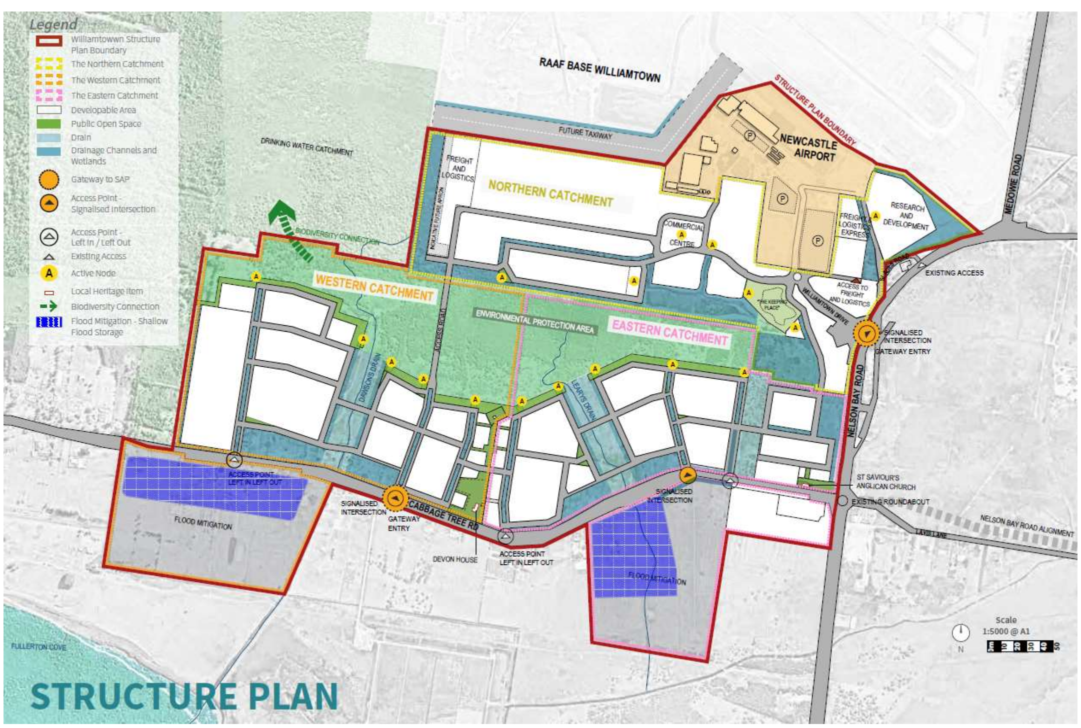


**Figure 17 – Williamtown SAP Structure Plan**

## 5.3 Geotechnical assessment of structure plan

### 5.3.1 Constraint Ranking

Our interpretation of the challenges associated with developing the structure plan are presented in the form of a constraints map. This has been developed using the same multi criteria analysis as described in Section 3 using the following key geotechnical data sources:

- NSW Statewide Seamless Geology Dataset (Colquhoun et al., 2019)
- The Soil Landscape Map: Newcastle 1:100,000 Geological Sheet 9132 (Gobert V and Chestnut W, 1975)
- Topographic Maps from the publicly available LIDAR survey data
- Acid Sulphate Soils Risk Map (State Government of NSW and Department of Planning, Industry and Environment 1998)

The area was subdivided in to three precinct areas that have indicative land uses related to each. These are presented in Table 6 below with our understanding of the probable associated building and infrastructure types for each.

**Table 6. The structural characteristics for each precinct in the structure plan.**

| Precinct | Land Use | Structural characteristics |
| --- | --- | --- |
| Northern precinct:<br>Freight and Logistics | Refer to Mecone Statutory Report for Permissible Land Uses within each sub-precinct | Shallow foundations in engineered fill typically, with possibly some deeper piles foundations for heavier load areas.<br>Building heights –2 storey buildings expected.<br>Significant live loads e.g. heavy trucks such a loaded B-Double trailers |
| Northern precinct:<br>Defence and Aerospace/ Airside | | Buildings might have height limitations.<br>Potentially heavier loads for Airside pavement access. |
| All precincts:<br>Commercial Centre | | Light industrial developments – warehousing and office space |
| Western and Eastern Precinct:<br>Light Industrial | | Light industrial developments – warehousing and office space<br>Building heights between 1 to 5 storeys for Hi-tech company offices.<br>Retail and entertainment building heights of 1 to 2 storeys maximum. |
| Western and Eastern Precinct:<br>Advanced Manufacturing | | Light industrial developments – warehousing and office space |
| All precincts:<br>R&D | | Light industrial developments – warehousing and office space<br>Between 1 to 5 storeys for Hi-tech company offices<br>Education or research facility building heights of 1 to 2 storeys maximum. |

The overall constraints map associated with each precinct in the Williamtown SAP structure plan is presented in Figure 18 and a more detailed map is presented in Appendix K.

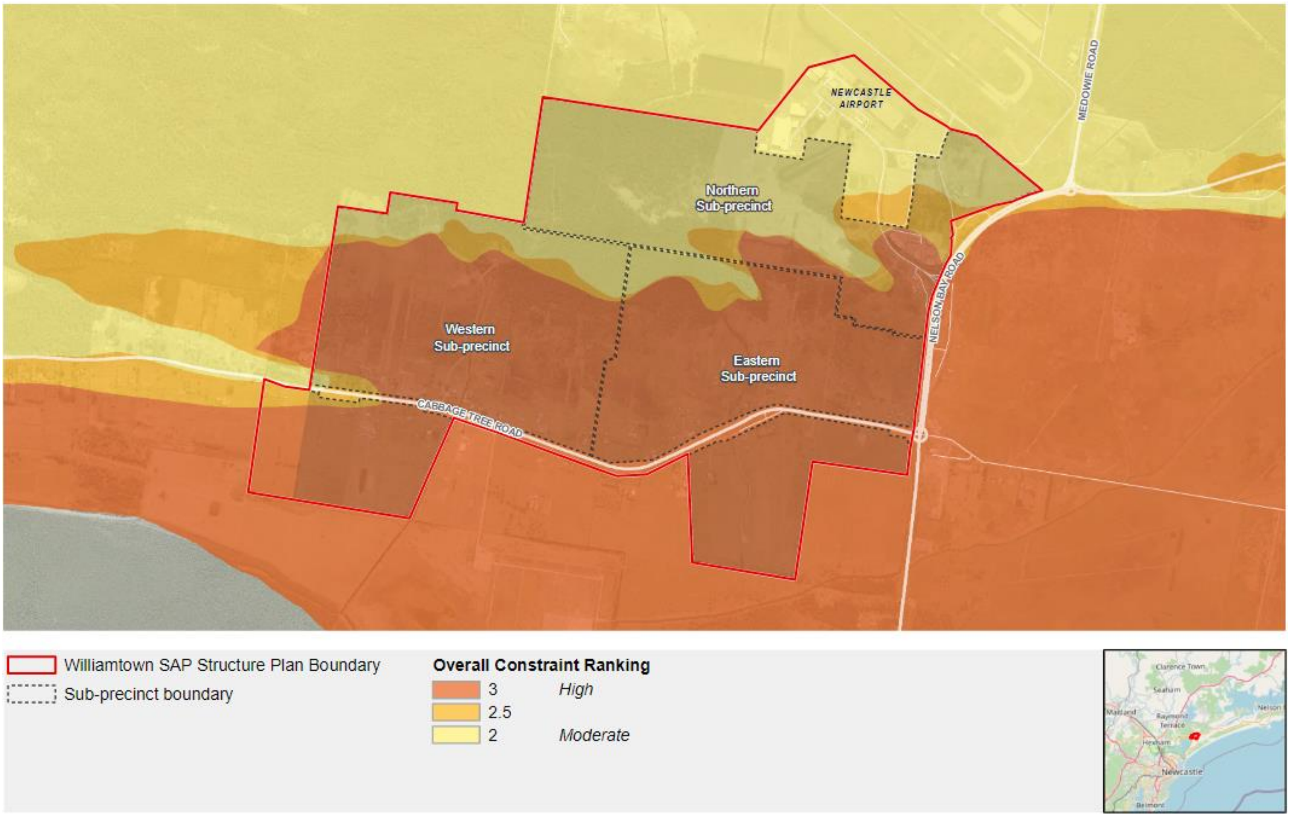


Figure 18. Overall constraints map for the structure plan

### 5.3.2 Limitations of Existing Data

The available geotechnical information within the Williamtown SAP structure plan area has been collated and is presented for reference as Figure 19 below a more detailed map is shown in Appendix L.

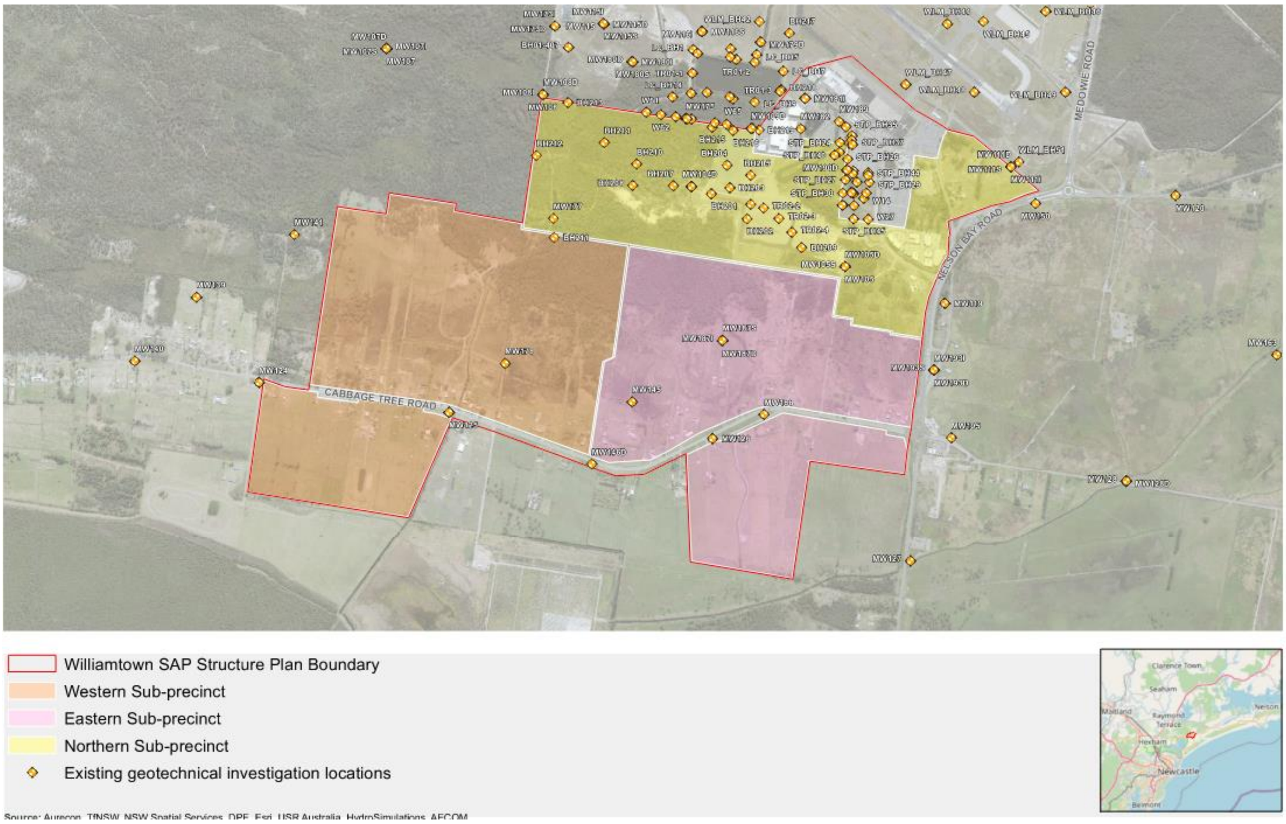


**Figure 19. Available geotechnical information in the structure plan area.**

It is clear from this figure (Figure 19) that there is limited to no available geotechnical information in the western and eastern precincts.

The reports used in the development of the subsurface profiles for each sub precinct have the following limitations:

- There are no density and consistency descriptions for the SAND and CLAY soils in Environmental Site Assessment (2017) Report by AECOM. This limits the possibilities of assigning typical geotechnical properties for more detail evaluations.
- No indication of consolidation testing conducted on soil samples which will in turn help determine the short- and long-term stability of the anticipated infrastructure in both the Report by AECOM (2017) and the Report by Douglas Partners (2009). In areas of thick estuarine soils, this information is important for the assessment of settlements and ground improvement requirements.
- There is no indication of the strength of the soils in the area in both the Report by AECOM (2017) and the Report by Douglas Partners (2009).
- The Environmental Site Assessment (2017) Report by AECOM only provides geological cross sections of the area which have limited details on the soil profile properties for the sub precincts.

Due to the presence of limited information available across the structure plan, further geotechnical investigation may be required in the southern part of the site prior to or during concept design to confirm the extent and location of the soils present.

### 5.3.3 Subsurface profiles for each Precinct

Figure 20 shows the geological mapping with the Williamtown SAP structure plan overlain and a more detailed map is shown in Appendix M.

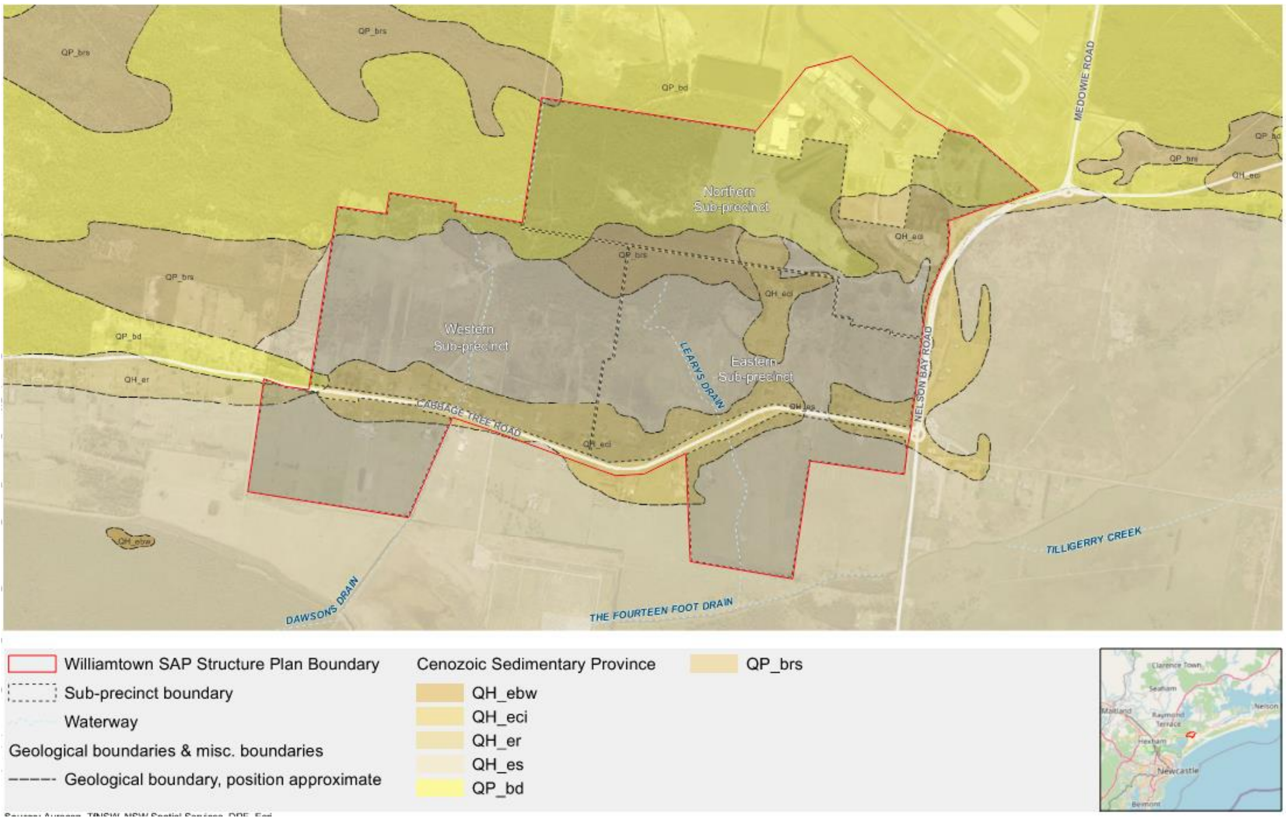


**Figure 20. Geology in structure plan area**

A preliminary ground, model for each of the precinct areas has been developed based on the published information as well as the following reports:

- Environmental Site Assessment for the RAAF Base Williamtown Stage 2B Environmental Investigation (AECOM, December 2017) and
- Report on Geotechnical Investigation for the Williamtown Aerospace Park Williamtown (Douglas Partners, May 2009).

The AECOM report contains predominantly groundwater wells with soil log records but limited geotechnical information on the consistency of the soils and other materials.

The Douglas partners report contains records of Cone Penetrometer Testing (CPT) across the Astro Aerolab site in the northern half of the Williamtown SAP structure plan area.

No site-specific investigation data is available in the southern half of the Williamtown SAP structure plan area.

The preliminary ground model profiles for each precinct area are presented in the Table 7 to 9. Descriptions of soil names are presented as reported in the source documents.

**Table 7.The Northern Precinct Subsurface Profile.**

| The Northern Precinct | | |
|---|---|---|
| **Depth** | **Soil Name** | **Notes** |
| 0 – 5 m | Fine to medium grained SAND (Aeolian and Beach) | No description on the density of sand |
| 5 m– 10 m | Fine to medium grained SAND (Aeolian and Beach) | No description on the density of sand |
| >15 m | Rock | No name and description of the rock |
| Groundwater Level | No information available | |

**Table 8. The Western Precinct subsurface profile.**

| The Western Precinct | | |
|---|---|---|
| **Depth** | **Soil Name** | **Notes** |
| 0 – 13 m | CLAY (Estuarine) | No description on the consistency of clay |
| 13 m – 24 m | Fine to medium grained SAND | No description on the density of sand |
| 24 m – 27 m | Basal CLAY | No description on the consistency of clay |
| 27 m – 31 m | Coarse undifferentiated SAND | No description on the density of sand |
| >31 m | Rock | No name and description of the rock |
| Groundwater Level | No information available | |

**Table 9. The Eastern Precinct subsurface profile.**

| The Eastern Precinct | | |
|---|---|---|
| **Depth** | **Soil Name** | **Notes** |
| 0 m – 2.5 m/4 m | Silty SAND and Clayey SAND (Estuarine) | No description on the density of sand. |
| 2.5 m/4 m – 15 m | Fine to medium SAND (Aeolian and Beach) | No description on the density of sand |
| 15 m – 24 m | Medium to coarse Gravelly SAND (Beach/Near shore) | No description on the density of sand |
| 24 m – 27 m | Basal CLAY | No description on the consistency of clay |
| >31 m | Rock | No name and description of the rock |
| Groundwater Level | No information available | |

### 5.3.4 Assessment of development requirements

It is understood that in order to meet the required flood immunity for the structure plan area, a significant amount of fill material will need to be imported to achieve this.

In order to inform subsequent planning and business development the Table 10Table  has been developed to provide a preliminary indication of the anticipated total settlements that would be expected. No guidance on differential settlement is possible at this stage.

Also presented are indicative estimates for preloading the fill, in order to achieve the majority of total settlements in the sub-precinct areas.

The anticipated preliminary total settlement values presented are based on the subsurface profiles developed in Section 5.3.3.

It is to be noted that the values presented in the table are preliminary only at this stage and a range has been provided based solely on experience. It is difficult to provide a reasonable estimate of expected settlements and times for preloading in the absence of relevant soil properties information. The design criterion for a surcharge is usually to build out sufficient settlement during construction that would include both the primary and secondary settlement to be expected over the design life of the structure if a surcharge were not applied. The requirements will depend both on the ground conditions and the expected development. These estimates can be refined once the fill levels and stages have been established in the *B3.2E Flooding and Water Cycle Management Report* and further refined once site-specific investigation results become available. Extrapolations can be made for anticipated settlement depths and durations for fill heights beyond the estimated range.

**Table 10. Assumed fill heights based on experience.**

| Precinct | Fill height scenario for flood protection* (m) | Anticipated Settlement (mm) | Estimated Primary Settlement duration (months) | Preload duration (months) |
|---|---|---|---|---|
| **Northern Precinct**:<br>Freight & Logistics<br>Defence & Aerospace<br>Defence & Aerospace (Direct Airside Access)<br>Commercial Centre<br>Research & Development | 2 | 50 | 2 | Not anticipated |
| | 3 | 60 | 2 | |
| | 4 | 80 | 3 | |
| **Western and Eastern Precinct:**<br>Advanced Manufacturing<br>Commercial Centre<br>Research & Development<br>Light Industrial | 2 | 40 - 60 | 12 | 4 – 6 |
| | 3 | 60 - 100 | 18 | 5 - 8 |
| | 4 | 100 - 150 | 24 | 6 - 10 |
| *The three fill height scenarios (2, 3 or 4m) are illustrative only and are based on preliminary discussions. | | | | |

### 5.3.5 Assumptions

The following assumptions have been made:

- The fill heights presented in Table 10 are indicative only at this stage and based on an interpretation of the available information which is limited to the Environmental Site Assessment for the RAAF Base Williamtown Stage 2B Environmental Investigation report (2017) and the Geotechnical Investigation for the Williamtown Aerospace Park Williamtown report (2009) therefore the soil profiles may vary from the actual soil profiles in each precinct area.
- The preloading durations assume that the magnitude of the preload is equivalent to the required fill heights for flood immunity. It is possible to place additional fill to reduce the time required to achieve a target consolidation settlement.

## 5.4 Constructability

The following section discusses the implication for construction and planning associated each with each precinct.

## PFAS Management

PFAS is non-volatile however it is known to migrate with groundwater fluctuations. Fill placement is therefore subject to protection from PFAS migration. Referencing the *B.3.2AB PFAS & non-PFAS Contamination Report*, 2022 the following notes have been made.

- Excavation of PFAS impacted soils can incur additional costs for testing management and disposal
- Protection of newly placed fill typically requires the inclusion of an impermeable layer prior to placement of fill. This impermeable layer can either be a clay capping layer, Geosynthetic Clay Liners (GCLs) or other combination of sheeting product.
- Management of settlement of newly placed fill with such an impermeable layer incorporated could prove challenging and require additional detailed design and experienced contractors to deliver.
- Typically, preloading or other additional fill is controlled by monitoring and this often includes boreholes drilled into the foundation with extensometers, piezometers and other methods. These would pass though the impermeable layer and careful control and preinstallation may be required to avoid damage to the layer or allowing PFAS to migrate upwards.

**A key consideration** – any PFAS or other contaminant mitigation measure may limit the potential development options for a given development area or lot.

As such, the end use developments should be determined as far as possible before designing and building the infrastructure. For example: It may prove impractical  to develop infrastructure that requires piled foundations as these would need careful planning and construction if the lot has an impermeable liner included in the fill platform.

## Flood Management

- Filling to mitigate flooding may cause excessive total or differential settlements in the underlying soft clays soils present in the following sub precincts: Advanced Manufacturing, Commercial Centre and the Research and Development. The risks associated with this are ongoing settlement, shallow foundations and program delays due to the preloading of the soft clay soils. However, early works can include ground improvement solutions to prepare the ground for future development. Geotechnical instrumentation and monitoring will assist in the control of this process (in many cases following an observational method approach). It is difficult to predict a timeframe for the early works due to the limited information regarding compressibility and consolidation properties present within the structure plan area. However, techniques such as wick drains may aid in acceleration of this process. It should also be noted that there may be opportunities to increase the amount of preload to reduce the settlement timeframes. However, this technique may also have cost implications.

  Geotechnical and instrumentation data from pre-loading projects in the area can assist in better defining the time frame for ground improvement early works. Notional advice from the Astra Aerolab team has indicated that approximately 8 months of preloading was experienced in their works with settlements of up to 400mm, whist this is not applicable to the entire Williamtown SAP, it does provide an indication and reference point of approximate time frame for settlement.
- Designs that incorporate flood resilience, such as ground floor car parking and first floor offices will reduce damage and the need for inspections and repair after flood events.
- Road base materials / fill embankments – road pavements are susceptible to damage if not adequately drained or protected from the effects of flood water inundation. Drainage ditches are a common feature of the Williamtown area and should be included in designs to allow shallow groundwater to drain away from the pavement subgrade. Fill embankments should be suitably specified to use free draining materials, adequate erosion control measures to avoid fines washout, or incorporate draining base layers. The same is applicable to associated structures such as bridge abutments or retaining walls.
- There are four nearby existing sand quarries that could be used as sources of fill material if on site sources are limited. This would be used for road embankments and landscaping to raise this

infrastructure above design flood levels to provide fill to locally raise the ground and improve flood resilience.

- Sources of fill material could potentially be won from ongoing large infrastructure projects (tunnelling or highway) located in Sydney or Newcastle. This could reduce the total cost of importing fill material. Testing would need to be completed to confirm suitability of material in terms of both contamination and earthwork requirements.
- Levees along the proposed or existing drainage channel typically need to be constructed using clay rich fill or other less permeable soil material as liner material. Such materials aren't extensively available within the Williamtown site and are expected to be imported. A combination design including local fill and imported clay lining would reduce the volume of clay fill required. The thicknesses of such liners would depend on the geometry of the levee in question.

Earthworks completed in the Structure plan area are to be designed and constructed in accordance with the following standards:

- AS1726.2017 Geotechnical Site Investigations
- AS 3798-2007 guidelines on Earthworks for Commercial and Residential sites
- R44 Earthworks Specification (where roads are proposed)
- AS2870 residential slabs and footings

Other standards may also be applicable depending on design progress.

## Shallow Foundations

Shallow foundations associated with the sub precinct: Defence and Aerospace Advanced Manufacturing, Commercial Centre and Research and Development may have to consider the following:

- Given the shallow groundwater across the structure plan area, designs that incorporate shallow foundations as far as possible will have reduced geotechnical challenges. Founding at an appropriate depth above the normal groundwater levels will reduce the need for temporary excavations support and dewatering, as well as costs associated with PFAS management.
- The risk of differential and total settlements under new structures needs to be understood and addressed during the design stage. This may include surcharge preloading of proposed footprints to improve the underlying soil sand to support fill pads. Preloading is also effective in reducing long-term creep movements under embankments. The specific requirements for preloading of any given area will depend on the proposed infrastructure and the soils beneath. Typically, cohesive soils (clays) will take longer to consolidate than free draining ones such as sands. Where a mixture of soil types is recorded the treatment will likely need to be adapted to suit this.
- The surcharge time required to achieve adequate conditions to comply with standard serviceability requirements depends on the thickness of the soft/compressible clay deposits and the amount of preloading. Time can be reduced by increasing the surcharge, but care must be taken that the increased load does not give rise to instability (due to the soft nature of such deposits). Preload times can vary between 3 to18 months, but specific studies are required. Vertical drains can be installed to speed up the consolidation process. The use of lightweight fills, together with surcharge, is also an accepted construction option. Depending of final levels, non-engineered fill can be used for surcharge material above the required grade levels.
- For light industrial buildings such as warehousing and offices the use of shallow foundations is expected to be sufficient. However, point load structures within warehouses such as gantry cranes would require deep foundations.

### Deep foundations

- It is recommended that designs of heavy buildings that require deep foundations such as basement car parks which may be associated with the land uses: Defence and Aerospace, Commercial Centre use driven piles and CFA solutions as these methods minimise the amount of excavated soil and groundwater material treatment required compared to bored piles.
- Pile Foundations will need to be designed for uplifting during flooding. Potential effects of negative friction in consolidating soils also need to be considered.

### Utilities

Utilities associated with Advanced Manufacturing, Commercial Centre and Defence and Aerospace may have to consider the following:

- In ground utilities are typically constructed in trench excavations. The shallow groundwater, together with ASS and PFAS, could lead to expensive constructions costs.
- Most shallow excavations such as trenches are expected to require shoring and dewatering.
- Excavation plant would typically only need to be appropriately sized for the excavation and the sediments are expected to be easy to excavate, except in the limited rock areas in the area north of Cabbage Tree road.
- Above ground utilities such as overhead power lines may require deep foundations to prevent differential settlement issues.

### Pavements and Roads

- The mapped sediments across the area will have low CBR (soil strength measure) for the most part. The majority of the road network in the area is raised above the surrounding land to mitigate against impacts from flooding events.
- The organic soil areas and highly reactive clays will likely need careful consideration and testing during design. Removal and replacement, or ground improvement may be required and if fill embankments are proposed these may require some form of preloading/ basal reinforcement to allow for settlement associated with longer term consolidation of those soils.

### Acid Sulphate Soils

- In addition to the ASS considerations for PFAS and flood management, shallow foundations, deep foundations, utilities, pavement and road constructability noted above, the higher risk of Acid Sulphate soils for the Western and Eastern precincts will require ASS testing as part of any investigation work and ASS management plans would be expected to be required for construction also.

## 5.5 Conclusion and Recommendations

The eastern and western sub precincts within the structure plan contain little to no available geotechnical information. As such it is highly recommended that these sub precincts be subject to geotechnical investigation work to inform any further planning.

This investigation would be expected to comprise:

- Cone Penetrometer Testing (CPT) – to profile the alluvial soils and any layering. Also permeability data for settlement assessments.
- Boreholes - to verify CPT data and retrieve samples.
- Test pitting – excavator pits in areas of potential material reuse to allow bulk sampling.

– Installation and monitoring of groundwater standpipes in selected boreholes

CPT testing also produces less soil arisings to dispose of than Boreholes so the costs of removing PFAS impacted drilling mud is reduced in this approach. CPTs should be at 250 m spacing which would indicatively require 50 CPTs in the structure plan area. The CPTs will give a continuous soil profile, dissipation test results, permeability and groundwater information.

Boreholes should be completed at wider spacing and used in verifying the CPT results. Boreholes also would allow for the installation of groundwater instrumentation in order to monitor the groundwater levels. We estimate approximately 20 boreholes would be sufficient.

Shallow bulk samples collected from the boreholes will help inform pavement design.

All geotechnical investigations should be completed in accordance with AS1726.2017 Geotechnical Site Investigations.

Following the collation and review of this data, several additional tasks are recommended in order to inform the subsequent design and planning phases:

- A consolidated database of the geotechnical and groundwater information
- A 3D geological model
- Approval for use and reliance on any additional geotechnical information that may exist – such as Department of Defence records.

### Opportunities

- Early investment in geotechnical investigations to allow concept design and cost estimates to be developed with more certainty
- Combining any further Investigations with contamination and other soil testing for cost effectiveness.
- Monitoring of settlements associated with preloading by using remote sensing and interferometry, installation of survey targets on the fill surface for better accuracy. There is still a need for extensometers and other installations thought PFAS barriers.
- Collation and organisation of the various sources of geotechnical data currently held by third parties. If a central Williamtown SAP geotechnical database is developed then all developments will benefit from this streamlined data for design and planning.
- Flood water management – lining channels and basins with suitable impermeable and non-dispersive fill to address the risks of PFAS migration in impacted areas.
- Early placement of fill to allow settlements to occur prior to development of other infrastructure such as roads, drainage and utilities
- If preloading does form part of the development approach, then the fill used could be moved across into subsequent earthworks lots to improve staging costs and additional value form the final fill volumes.
- If fill material becomes available from local projects in the Hunter region then this fill may be acquired for more cost-effective rates and could be used in early pre-release flood management land improvement work.

# 6 References


- Australian Standard AS1170.4-2007
- Acid Sulphate Soils Risk Map, State Government of NSW and Department of Planning, Industry and Environment 1998

- Acid Sulphate Soil Management Plan Astra Aerolab Stage 1 Williamtown Drive Williamtown, Douglas Partners, 2019
- Cabbage Tree Road Sand Quarry Williamtown NSW, Maximum extraction Depth Management Plan, Water shed HydroGeo, 2019
- Defence and Airport Related Employment Zone – Williamtown, Stage 1 – Selection Report Part 1 to Part 4, 2008
- Environmental Site Assessment, RAAF Base Williamtown Stage 2B Environmental Investigation, AECOM, 2017
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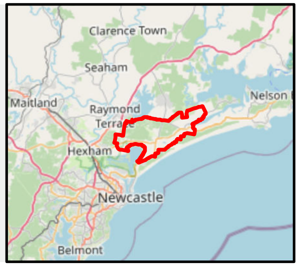
- Report on Geotechnical Investigation Medowie – Telstra Mobile Network, Aurecon Australia Pty LTD, 2010
- Report on Geotechnical Investigation Medowie – Telstra Mobile Network, Aurecon Australia Pty LTD, 2010
- Newcastle 1:100 000 Geological Series Sheet (9232) & explanatory notes
- Nelson Bay 1:100 000 Geological Series Sheet (9332) & explanatory notes
- Newcastle 1:250 000 Geological Series Sheet (SI56-2) & explanatory notes
- NSW Statewide Seamless Geology dataset, Colquhoun, et al., 2019
- Newcastle Coalfield Regional Geology Map 1:100000 & explanatory notes
- Nelson Bay 1:100 000 and 1:25 000 Coastal Quaternary Geological Series Sheet & accompanying report
- NSW Statewide Seamless Geology Dataset, Colquhoun et al, 2019
- RAAF Williamtown Building Works Geotechnical Investigation Report, , Aurecon Australasia Pty LTD, 2018
- RAAF Williamtown AEWSCPO Carpark Works Geotechnical and Contamination Investigation Report, , Aurecon Australasia Pty LTD, 2019
- Report on Geotechnical Investigation Williamtown Aerospace Park Williamtown, Douglas Partners, 2009
- The Soil Landscape Map: Newcastle 1:100,000 Geological Sheet 9132, Gobert V and Chestnut W, 1975
- Williamtown RAAF Airport – Optus Mobile Network Australia, Aurecon Australia Pty LTD, 2009
- Williamtown Special Activation Precinct Statutory Planning Considerations Paper, Prepared for the NSW Department of Planning and Environment, Mecone, 2021

# Appendix A – Site Setting

aurecon


Williamtown Study Area
Williamtown SAP Structure Plan Boundary
River
Railway
National Parks and Reserves

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**Source:** Aurecon, TfNSW, NSW Spatial Services, Esri

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**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE:** Site Location

# Appendix B – Geology – Seamless


- Williamtown Study Area
- Williamtown SAP Structure Plan Boundary
- River

**NSW Seamless Geology**

Fold Axes

- Syncline, position accurate
- Syncline, position approximate

Geological boundaries & misc. boundaries

- Coastline
- Geological boundary, inferred
- Geological boundary, position accurate
- Geological boundary, position approximate
- Transitional geological boundary

Faults and schist zones

- Fault, position approximate
- Fault, inferred

Dominant Lithology

- Conglomerate

Cenozoic Sedimentary Province

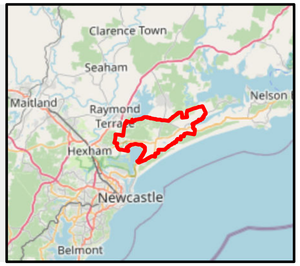
- QH_af
- QH_bd
- QH_bdm
- QH_bf
- QH_br
- QH_brs
- QH_ea
- QH_ebw
- QH_eci
- QH_ecw
- QH_ed
- QH_edw
- QH_er
- QH_es
- QH_hfr
- QP_at
- QP_bd
- QP_bdr
- QP_bf
- QP_br
- QP_brs
- QP_e
- QP_u
- Q_a
- Q_ab
- Q_acb
- Q_acw
- Q_afs
- Q_al
- Q_ap
- Q_at
- Q_av
- Q_avf
- Q_b
- Q_bb
- Q_h
- Q_hl
- Q_hw

Permo-Triassic Basins

- Pda Dalwood Group
- Pgr Greta Coal Measures
- Pmtb Branxton Formation
- Pmtm Mulbring Siltstone
- Pmtu Muree Sandstone
- Pto Tomago Coal Measures

New England Orogen

- Cumh Karuah Formation
- Curs Seaham Formation
- Cutj_s Mount Johnstone Formation (upper) - sandstone




**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

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**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE:** NSW Seamless Geology

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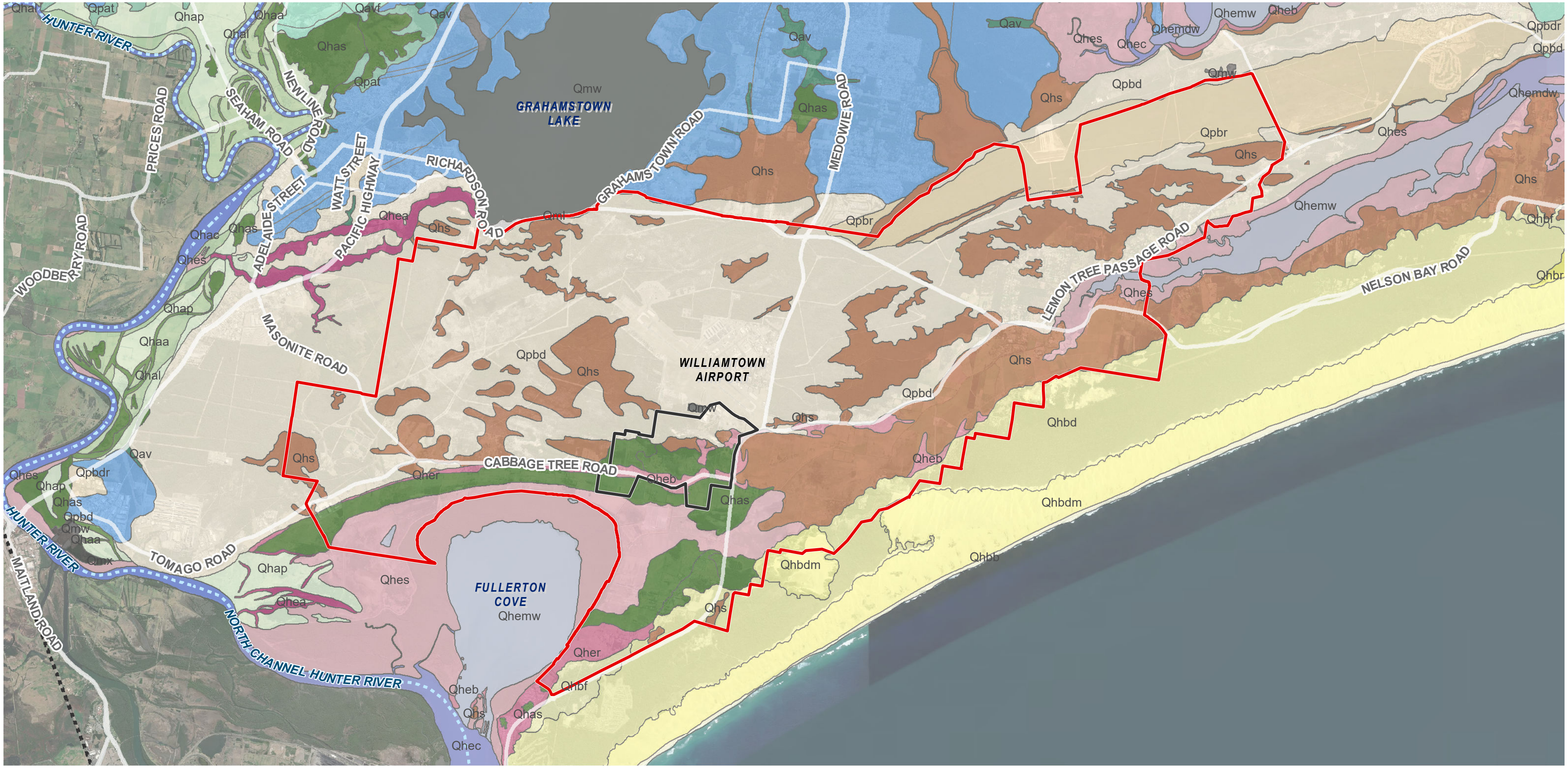
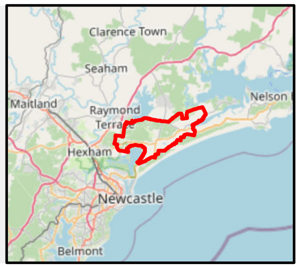
# Appendix C – Geology – Coastal Quaternary




| | | | |
|---|---|---|---|
| Williamtown Study Area | Qav - Quaternary undifferentiated valley fill | *Estuarine Plain System* | Qhemw - Holocene estuarine basin and bay |
| Williamtown SAP Structure Plan Boundary | Qavf - Quaternary undifferentiated alluvial and colluvial fan | Qhes - Holocene saline swamp | *Anthropogenic* |
| River | *Coastal Barrier System* | Qheb - Holocene estuarine in-channel bar and beach | Qml - Modern breakwaters, embankments and artificial levees |
| Railway | Qhbb - Holocene sandy beach | Qher - Holocene estuarine shoreline ridge and dune | Qmw - Modern stored water, pondage, reservoirs, canals |
| **Quaternary surface geology** | Qhbf - Holocene backbarrier flat | Qhea - Holocene estuarine paleochannel fill | Qmx - Modern disturbed land |
| *Alluvial Plain System* | Qhbd - Holocene dune | *Undifferentiated* | **Bedrock Geological Systems 1** |
| Qhap - Holocene floodplain | Qhbdm - Holocene mobile dune | Qhs - Holocene freshwater swamp | Arc/forearc |
| Qhal - Holocene levee | Qhbr - Holocene beach ridge and associated strandplain | *Subaqueous* | Sydney Basin |
| Qhaa - Holocene alluvial palaeochannel fill and inter-levee swale | Qpbd - Pleistocene dune | Qhac - Holocene alluvial channel | |
| Qhas - Holocene backswamp | Qpbdr - Pleistocene bedrock-mantling dune | Qhec - Holocene estuarine channel | |
| Qpat - Pleistocene terrace | Qpbr - Pleistocene beach ridges and associated strandplain | Qhemdw - Holocene fluvial delta front | |

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

1:120,000 @ A4

0 2 4km

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE:** Coastal Quarternary Geology (North Coast NSW)

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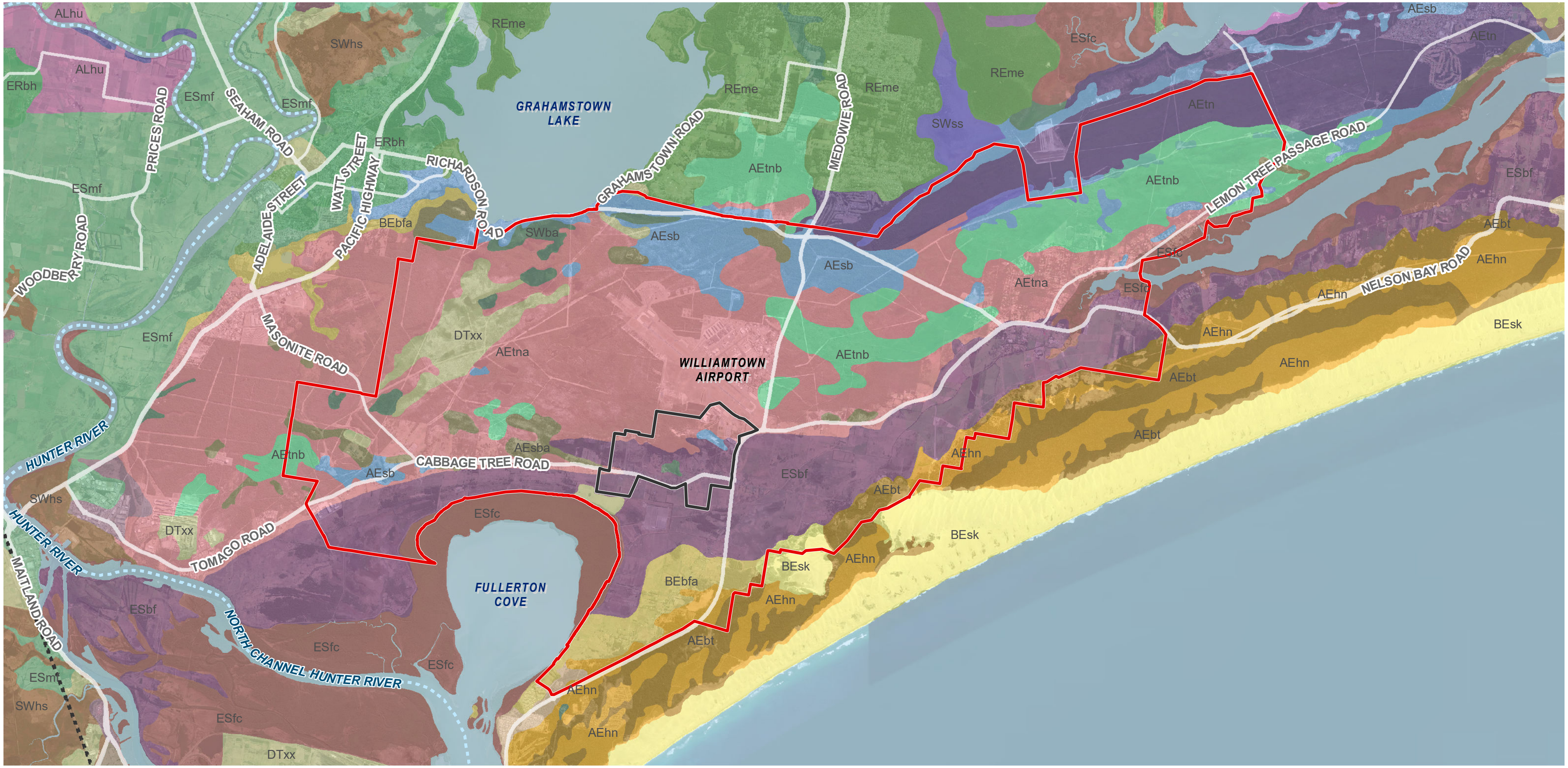
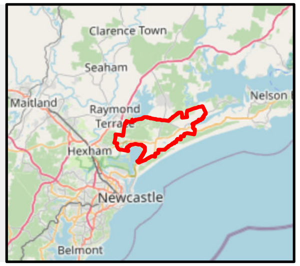
# Appendix D – Soil Landscapes




| | |
|---|---|
| Williamtown Study Area | |
| Williamtown SAP Structure Plan Boundary | |
| River | |
| Railway | |

**Soil Landscapes (1:100k)**

AEbt Boyces Track
AEfh Fingal Head
AEhn Hawks Nest
AEsb Shoal Bay
AEsba Shoal Bay Variant A
AEsbb Shoal Bay Variant B
AEtn Tea Gardens
AEtna Tea Gardens Variant A
AEtnb Tea Gardens Variant B
ALhu Hunter
ALhub Hunter Variant B
BEbfa Bobs Farm Variant A
BEsk Stockton Beach
DTxx Disturbed Terrain
ERbh Bolwarra Heights
ERmp Mallabula Point
ERtm Ten Mile Road
ERtma Ten Mile Road Variant A
ESbf Bobs Farm
ESfc Fullerton Cove
ESmf Millers Forest
EStbb The Branch Variant B
LAnw Nerong Waterholes
REbe Beresfield
REhm Hamilton
REme Medowie
REri Rivermead
REwg Wallalong
SWba Blind Harrys Swamp
SWhs Hexham Swamp
SWlp Lower Pindimar
SWsbc Shoal Bay Variant C
SWss Shoal Bay Swamp
TRng Nungra
Water




**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

1:120,000 @ A4

0 2 4km

**Projection:** GDA 1994 MGA Zone 56

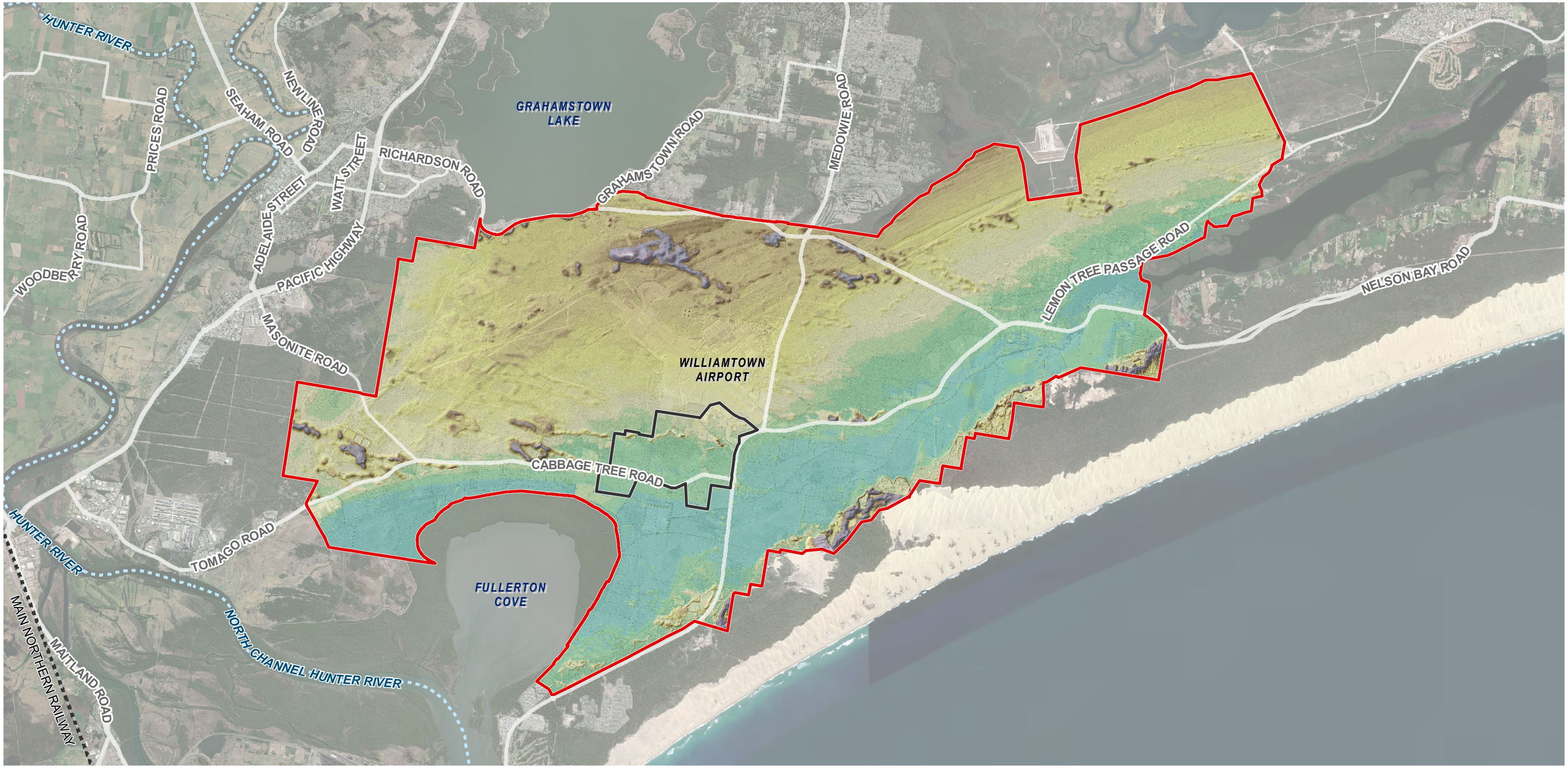
Williamtown SAP Geotech

**FIGURE:** Soil Landscapes

P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_SoilLandscape.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

# Appendix E – Local Topography

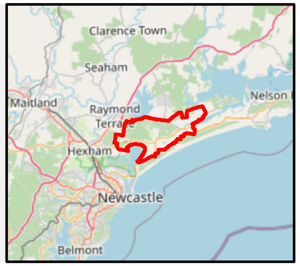
aurecon




| | |
|---|---|
| Williamtown SAP Boundary | |
| Williamtown SAP Structure Plan Boundary | |
| River | |
| Railway | |

**Elevation (m AHD)**

< 1, 1 - 2, 2 -3, 3 - 4, 4 - 5, 5 - 6, 6 - 7, 7 - 8, 8 - 9, 9 - 10, 10 - 11, 11 - 12, 13 - 14, 14 - 15, 15 - 16, 16 - 20, 21 - 25, 26 - 30, 31 - 35, 36 - 40, 41 - 45, 46 - 48




**Source:** Aurecon, TfNSW, NSW Spatial Services, Esri

1:120,000 @ A4

0 2 4km

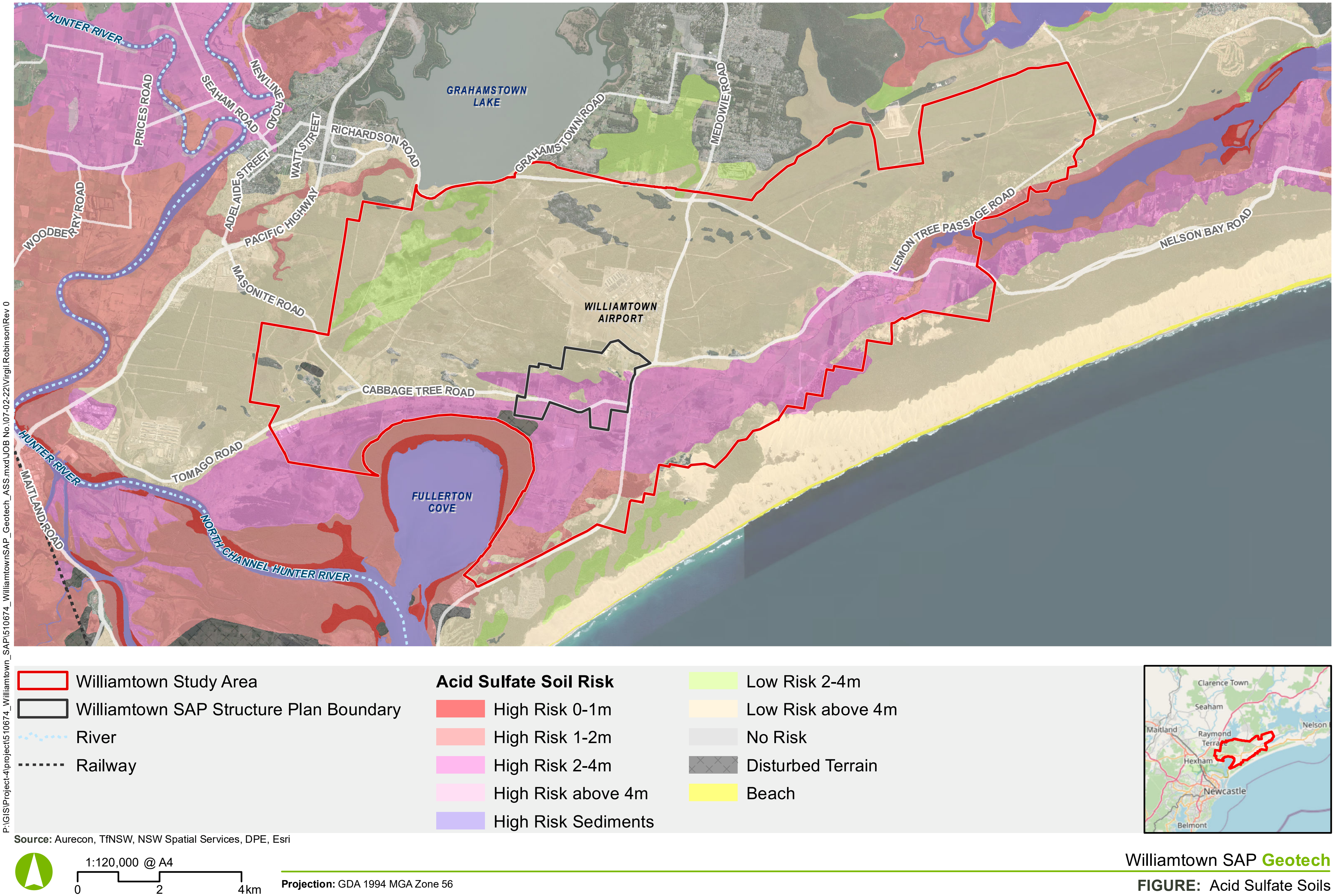
**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP Geotech

**FIGURE:** Local topography

P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_LocalTopography.mxd\JOB No.\09-02-22\Virgil.Robinson\Rev 0

# Appendix F – Acid Sulphate Soils




**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP Geotech

**FIGURE:** Acid Sulfate Soils

# Appendix G – Groundwater Bores (NOW)


P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_GroundwaterBores.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

**Projection:** GDA 1994 MGA Zone 56

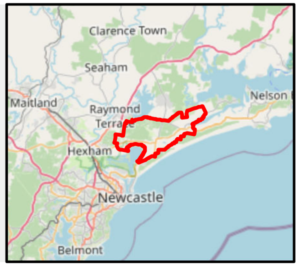
Williamtown SAP Geotech

**FIGURE:** Groundwater Bore

# Appendix H – Depth of Soil and Regolith


Williamtown Study Area
Williamtown SAP Structure Plan Boundary
River
Railway

**Depth of soil (m)**
0.75 - 1
1 - 1.25
1.25 - 1.5




P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_SoilDepth.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, CSIRO, Esri

1:120,000 @ A4

0 2 4km

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE:** Soil Depth


P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_SoilRegolithDepth.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

| | | |
|---|---|---|
| Williamtown SAP Boundary | **Depth of regolith (m)** | 10 - 20 |
| Williamtown SAP Structure Plan Boundary | 1 - 2 | 20 - 30 |
| River | 2 - 3 | 30 - 40 |
| Railway | 3 - 10 | >40 |

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, CSIRO, Esri

1:120,000 @ A4

0 2 4km

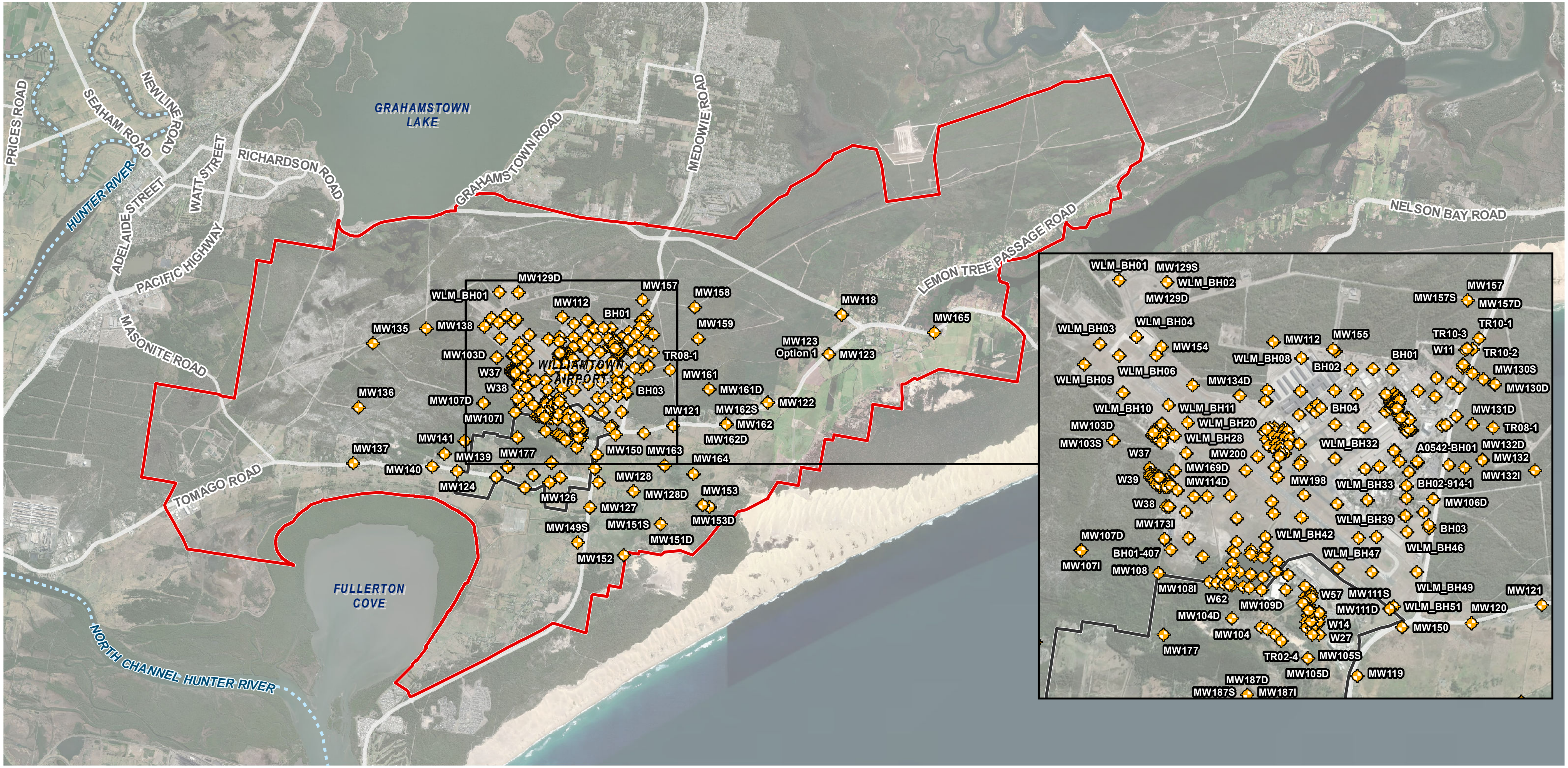
**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE:** Soil Regolith Depth

# Appendix I – Available Geotechnical Information

aurecon



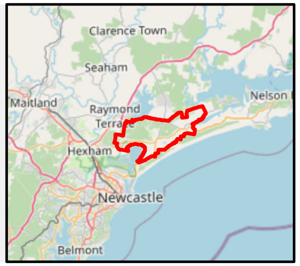

Williamtown Study Area

Williamtown SAP Structure Plan Boundary

River

Railway

Existing geotechnical investigation locations




P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_Available geotech information.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri, USR Australia, HydroSimulations, AECOM

1:120,000 @ A4

0 2 4km

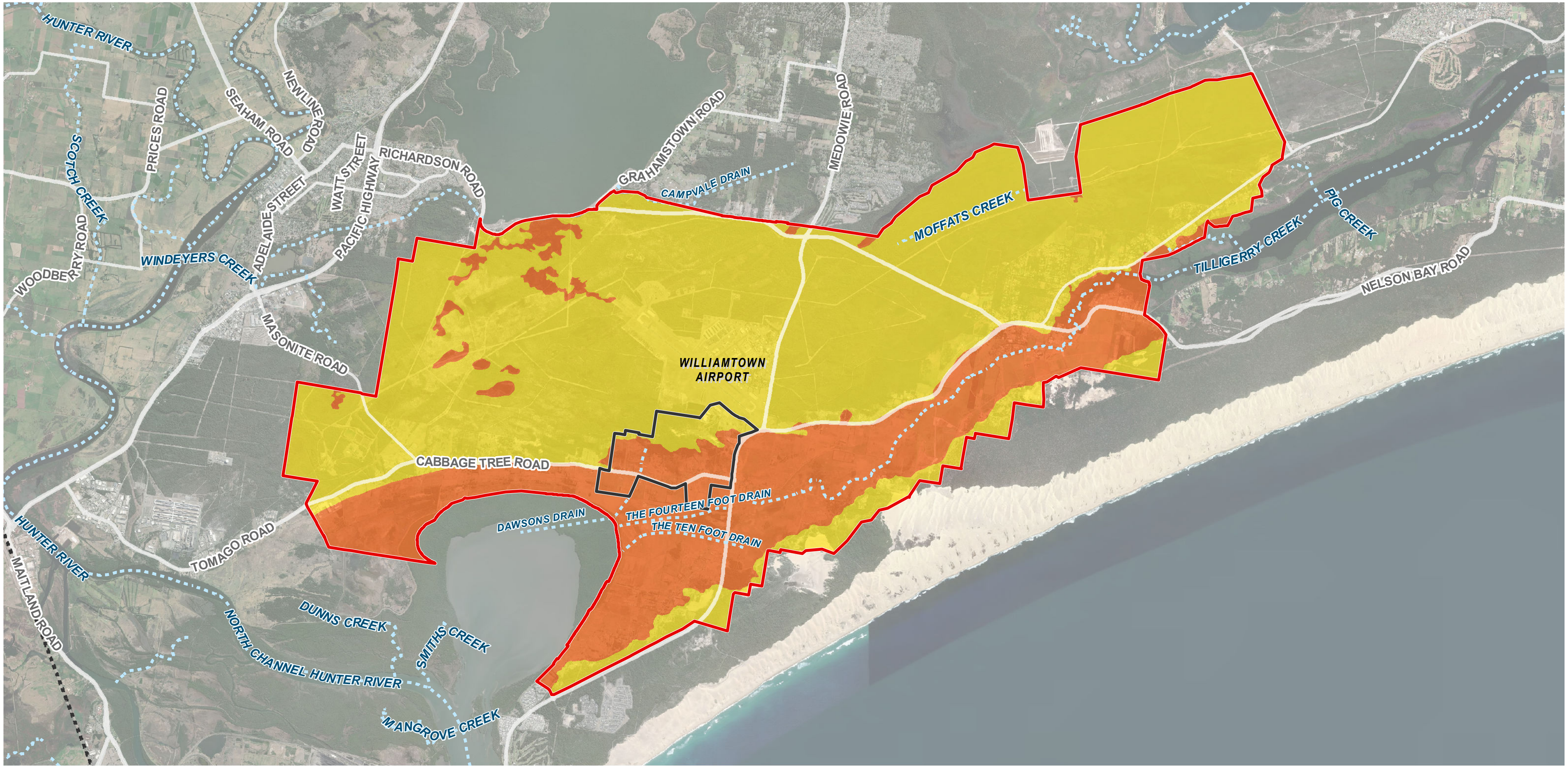
**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP Geotech

**FIGURE:** Available Geotechnical Information

# Appendix J – Constraints Maps

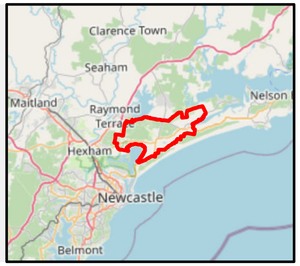
aurecon




| | |
|---|---|
| Williamtown Study Area | |
| Williamtown SAP Structure Plan Boundary | |
| Waterway | |
| Railway | |

**Rank**

- High
- Moderate




P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_Constraints_Geo.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

1:120,000 @ A4

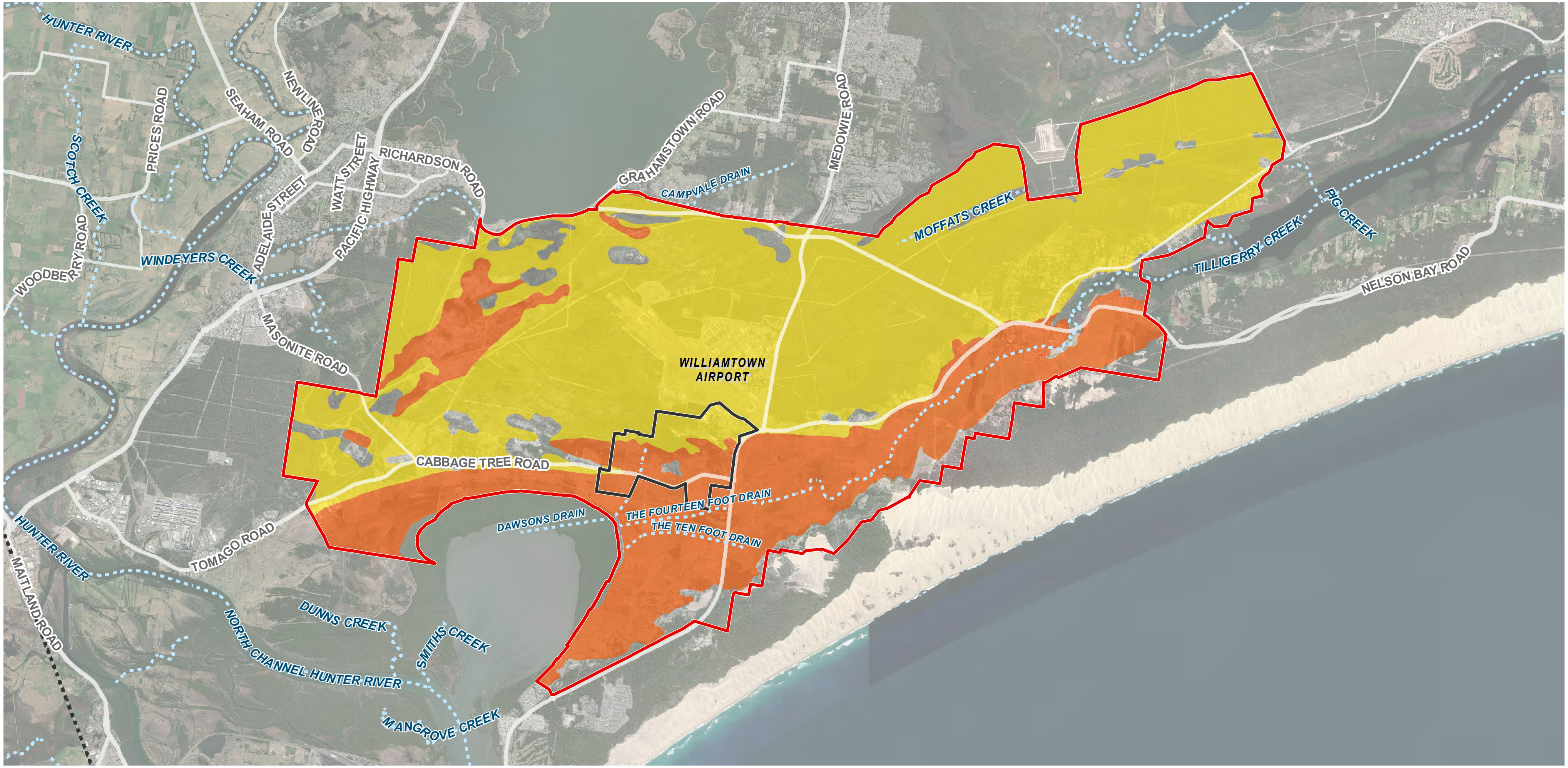
0 2 4km

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

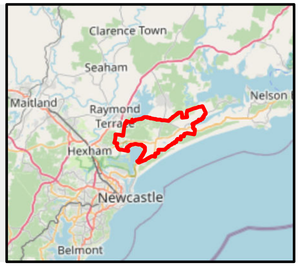
**FIGURE:** Constraints - Geology

aurecon




Williamtown Study Area
Williamtown SAP Structure Plan Boundary
Waterway
Railway

**Rank**
High
Moderate




P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_Constraints_Soil.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

1:120,000 @ A4

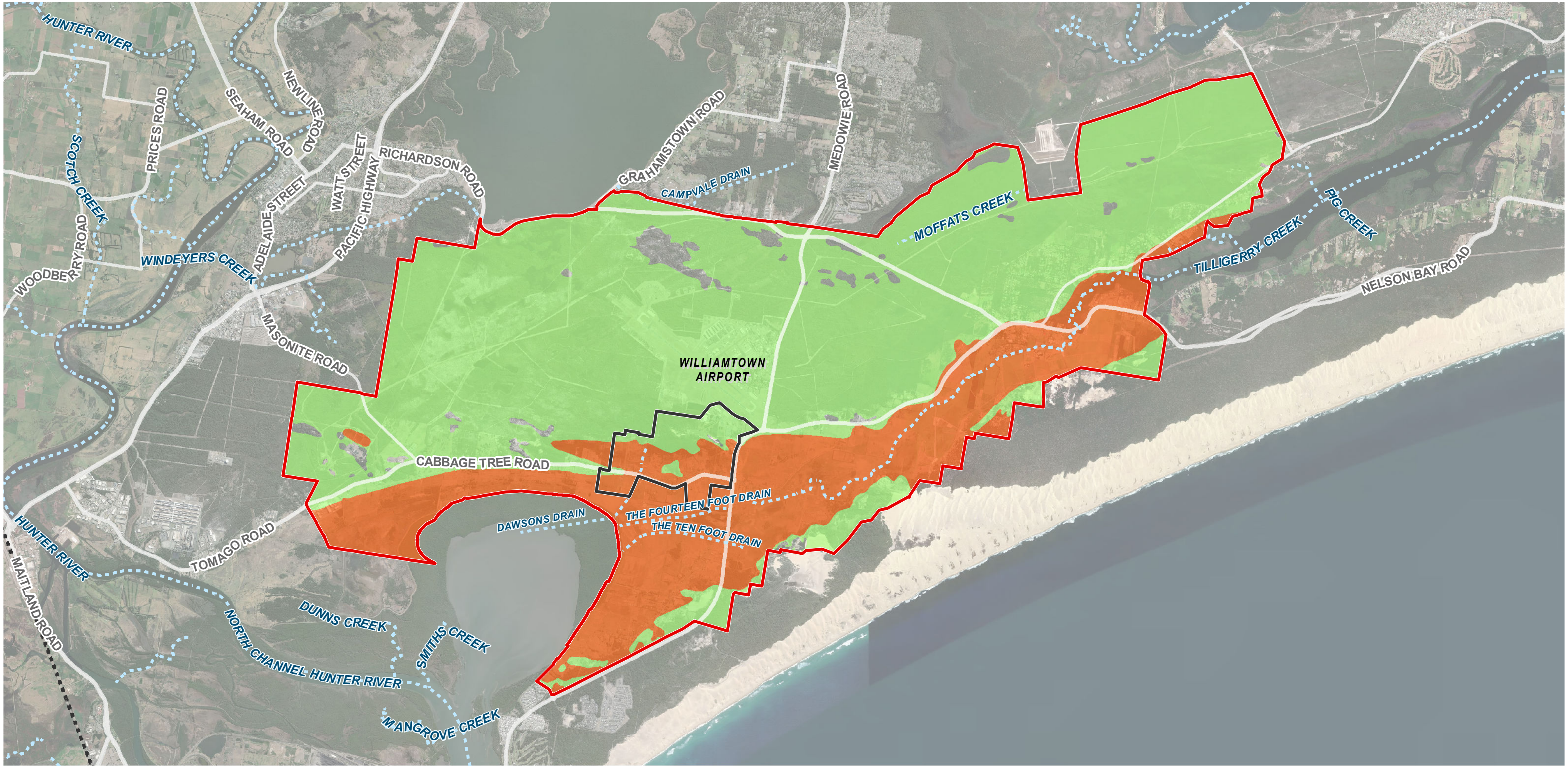
0 2 4km

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

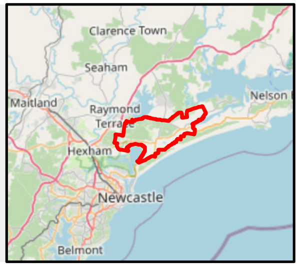
**FIGURE:** Constraints - Soil

aurecon




Williamtown Study Area
Williamtown SAP Structure Plan Boundary
Waterway
Railway

**Rank**
High
Low




P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_Constraints_ASS.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

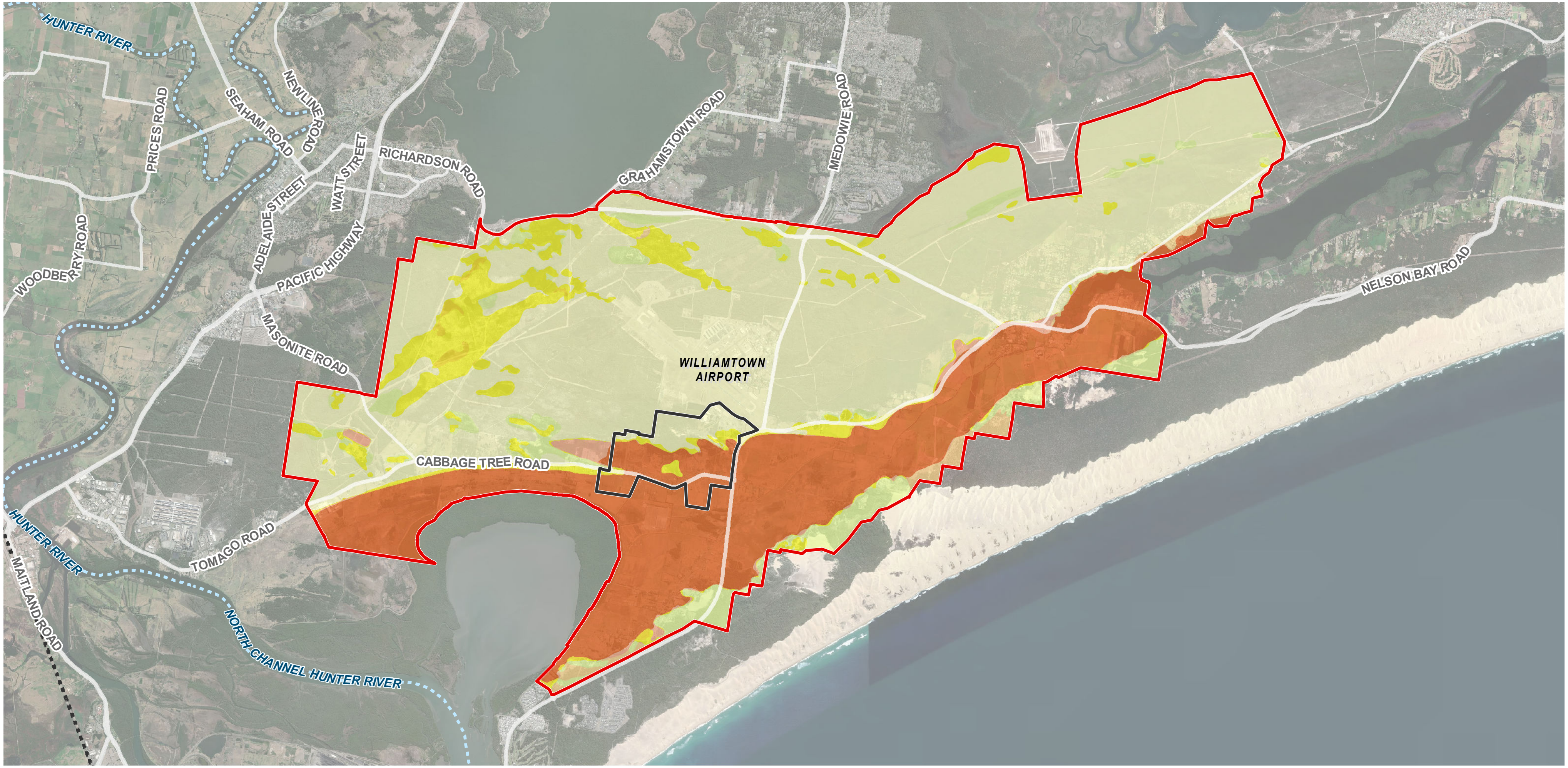
1:120,000 @ A4
0 2 4km

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE:** Constraints - Acid Sulfate Soils

aurecon




Williamtown Study Area

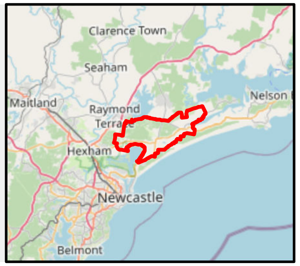
Williamtown SAP Structure Plan Boundary

River

Railway

**Overall Constraint Ranking**

| | |
|---|---|
| 3 | *High* |
| 2.66 | |
| 2.5 | |
| 2.33 | |
| 2 | *Moderate* |
| 1.66 | |
| 1.5 | |
| 1 | *Low* |




**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

1:120,000 @ A4

0 2 4km

**Projection:** GDA 1994 MGA Zone 56

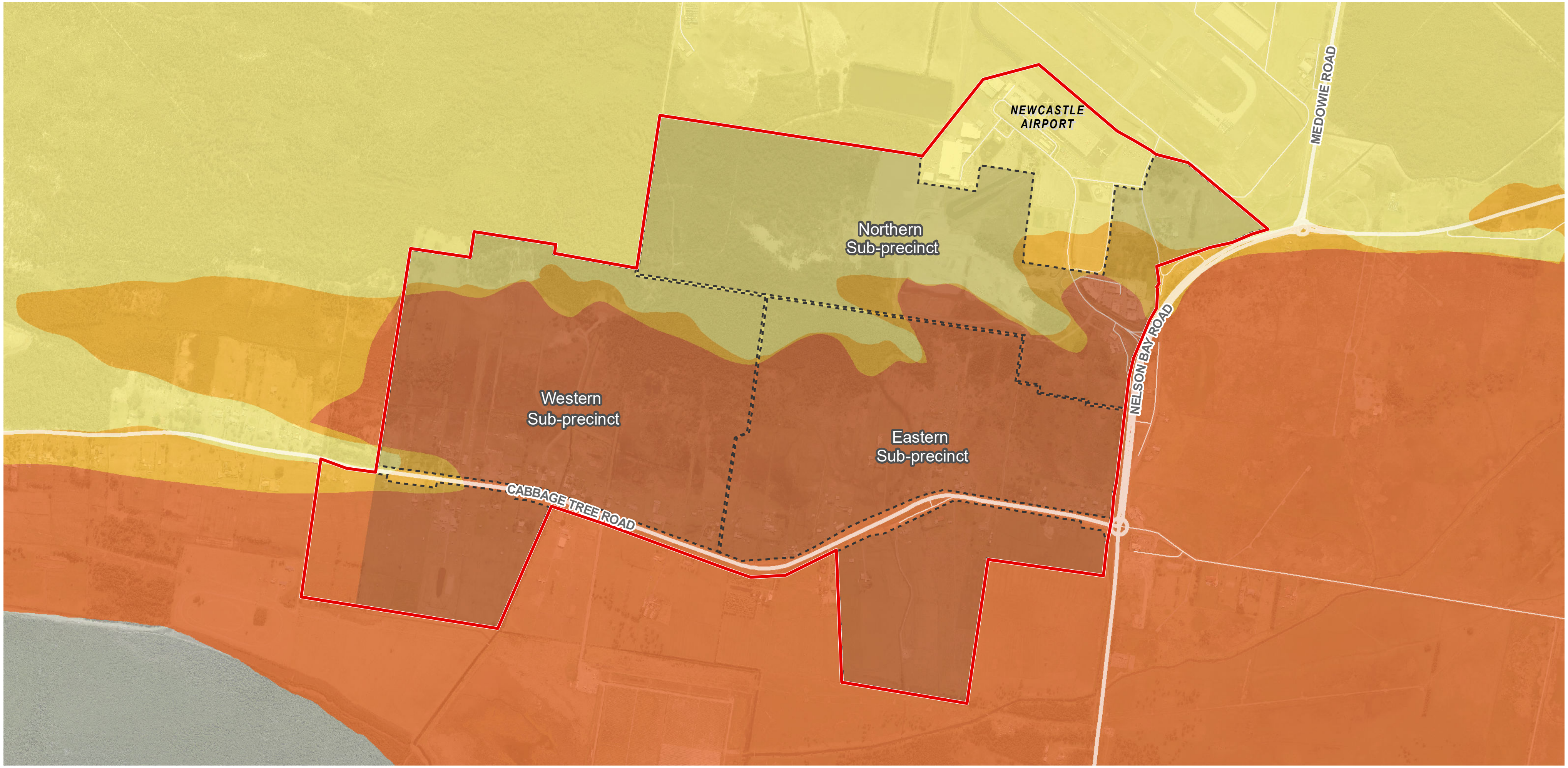
Williamtown SAP **Geotech**

**FIGURE:** Constraints - Overall

P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_Geotech_Constraints_Overall.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

# Appendix K – Overall Constraints Map for Structure Plan

aurecon

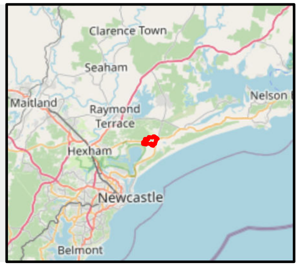



Williamtown SAP Structure Plan Boundary

Sub-precinct boundary

**Overall Constraint Ranking**

| | | |
|---|---|---|
| 3 | | *High* |
| 2.5 | | |
| 2 | | *Moderate* |




P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_STAGE3_Geotech_Constraints_Overall.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Aerometrex, Esri

1:20,000 @ A4

0 200 400 m

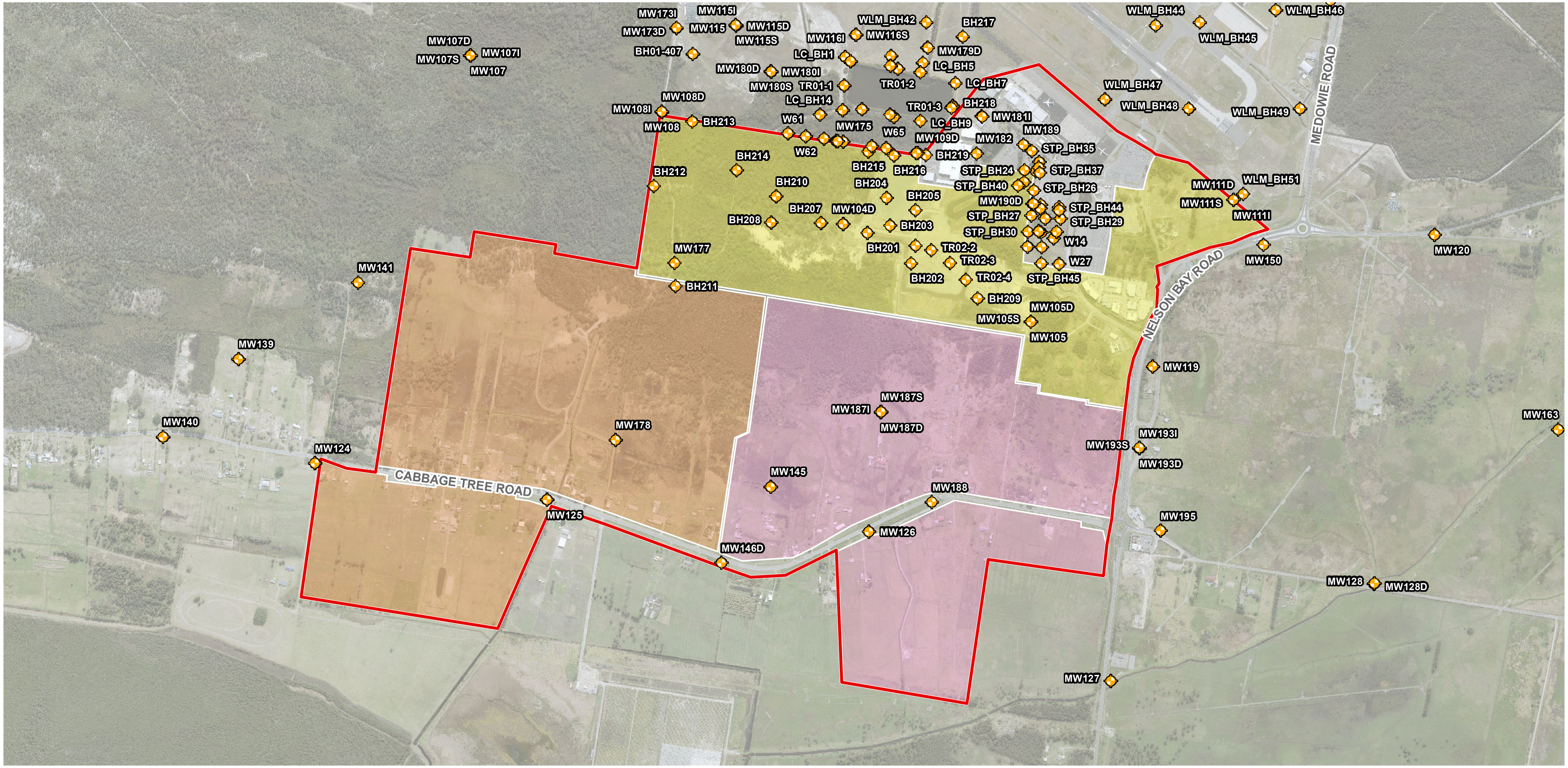
**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

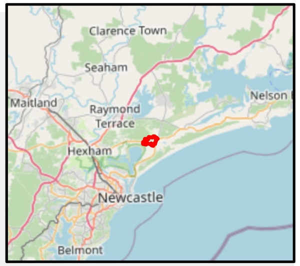
**FIGURE:** Constraints - Overall | Structure Plan

# Appendix L – Available Information in the Structure Plan Area

aurecon




| | |
|---|---|
| | Williamtown SAP Structure Plan Boundary |
| | Western Sub-precinct |
| | Eastern Sub-precinct |
| | Northern Sub-precinct |
| | Existing geotechnical investigation locations |




P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_STAGE3_Geotech_Available geotech information.mxd\JOB No.\07-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri, USR Australia, HydroSimulations, AECOM

1:20,000 @ A4

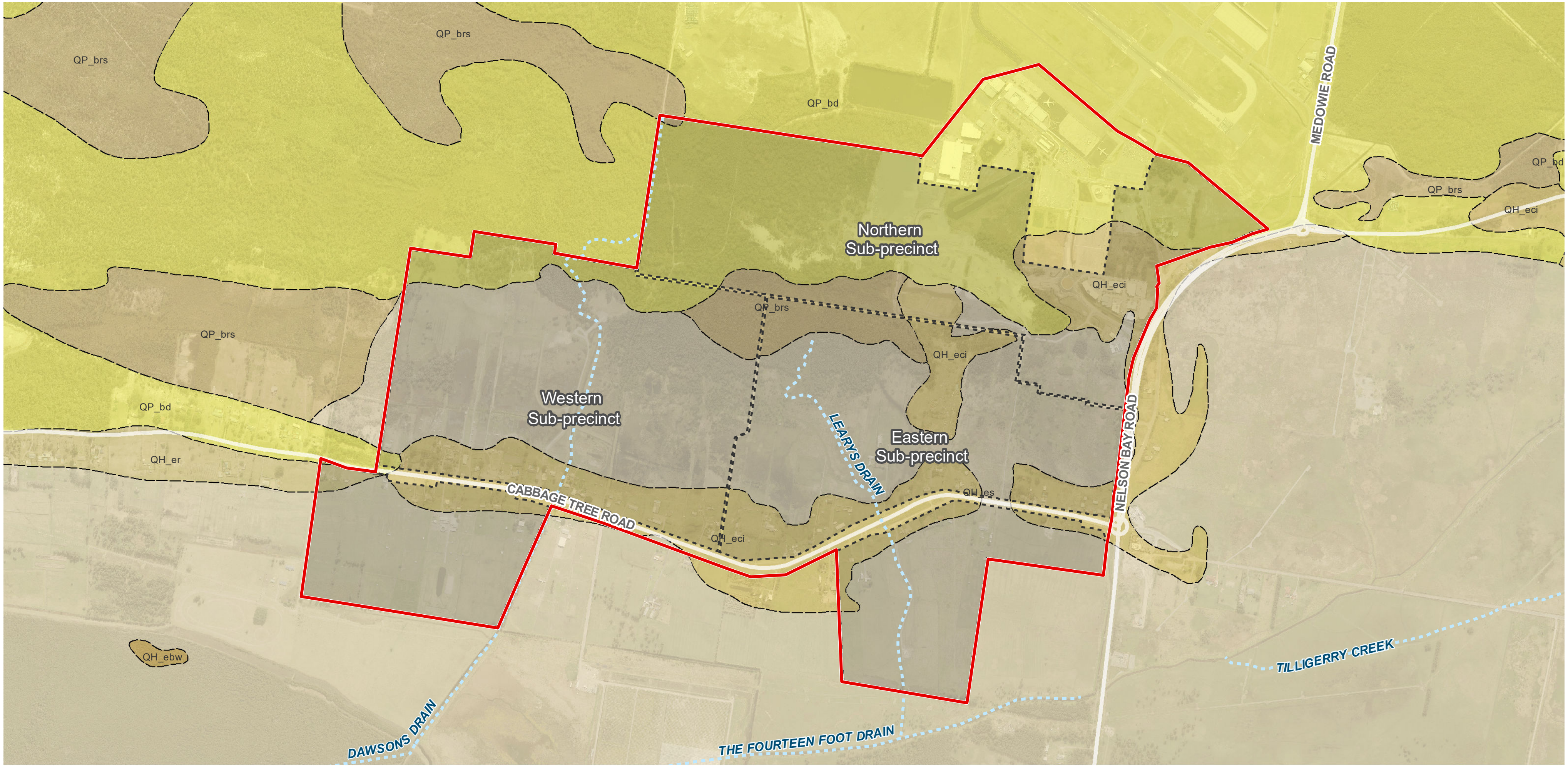
0 200 400 m

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE:** Available Geotechnical Information

# Appendix M – Geological Mapping for the Structure Plan




Williamtown SAP Structure Plan Boundary

Sub-precinct boundary

Waterway

Geological boundaries & misc. boundaries

Geological boundary, position approximate

Cenozoic Sedimentary Province

QH_ebw

QH_eci

QH_er

QH_es

QP_bd

QP_brs

P:\GIS\Project-4\project\510674_Williamtown_SAP\510674_WilliamtownSAP_STAGE3_ContamGW_Geology_Superficial_rev1.mxd\JOB No.\09-02-22\Virgil.Robinson\Rev 0

**Source:** Aurecon, TfNSW, NSW Spatial Services, DPE, Esri

1:20,000 @ A4

0 200 400 Meters

**Projection:** GDA 1994 MGA Zone 56

Williamtown SAP **Geotech**

**FIGURE :** Geology (Superficial)

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**W** aurecongroup.com