Williamtown SAP

B3.2F Hydrogeology Report

Department of Planning and Environment

Reference: 510674

Revision: 3

2022-03-18

aurecon

Bringing ideas to life

Document control record

Document prepared by:

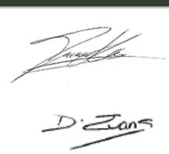
Aurecon Australasia Pty Ltd

ABN 54 005 139 873

23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W aurecongroup.com

Document control						
Report title		B3.2F Hydrogeology Report				
Document code		B.3.2F	**Project number**		510674	
File path		**https://aurecongroup.sharepoint.com/:b:/r/sites/510674/5%20Deliver%20Design/501%20Engineering/Contamination/Reporting/Stage%203/GW%20Report/Stage%203%20Draft_Final/B3.2F%20Hydrogeology%20Report%2020220318.pdf?csf=1&web=1&e=8I1OgK**				
Client		Department of Planning and Environment				
Client contact		Caitlin Elliot	**Client reference**			
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
0	2021-05-26	Draft for client comment	DH	DE	DE	
1	2021-12-02	Draft for client comment	DE	DE		GL
2	2022-02-17	Draft addressing agency comments	DE	GH		
3	2022-03-18	Minor updates	MM	AL		
Current revision		**3**				

Approval			
Author signature		Approver signature	
Name	David Harris / Dan Evans	Name	Greg Lee
Title	Senior Hydrogeologist / Director Environment & Planning	Title	Practice Leader, Infrastructure Advisory

Executive Summary

The hydrogeological baseline analysis, preliminary Enquiry by Design Workshop and a framework to analyse and assess development scenarios was designed using a comparative matrix table with key hydrogeological characteristics as well as constraints and opportunities. This process informed a Final Enquiry by Design Workshop where a preferred precinct plan was developed.

The key testing criteria adopted for the purpose of this hydrogeological assessment included:

- Potential impacts on **Groundwater Levels**
- Potential impacts to and from **Groundwater Flooding**
- Potential impacts to and from **Groundwater Quality**
- Potential impacts to annual demand and available **Groundwater Supply**
- Potential impacts to **Groundwater Dependent Ecosystems**
- Potential Impacts to perviousness affecting **Groundwater Recharge** to aquifers

The Williamtown preferred precinct plan is centred around the existing Williamtown Airport Precinct, which includes Newcastle Airport, Williamtown RAAF base and Astra Aerolab. The final structure plan leverages the preferred elements of preliminary scenarios, explores the Strength, Weakness, Opportunity and Threat Analysis and where possible avoids the identified higher impact zones. The identified strengths and opportunities were pursued in developing the final structure plan while weaknesses and threats were mitigated. This approach was taken to maximise the positive development outcomes and adopting the Structure Plan.

The SAP is underlain be a sequence Quaternary aged unconsolidated sediments consisting of estuarine, beach, dune and swamp deposits that is collectively known as the Tomago Sandbeds. Groundwater within the Tomago Sandbeds is shallow and typically less than four metres below ground level. The groundwater is of good quality and is a major water resource for Hunter Water. Groundwater flow within the SAP is southerly discharging directly into local waterways and within and around Fullerton Cove. Areas of shallow groundwater may be prone to groundwater flooding following significant rainfall events that may form significant constraints to the development of the SAP. The development may result in minor changes to groundwater levels beneath and down-gradient of the SAP, however this is unlikely to affect the Tomago Aquifer's resource potential but could have the potential to expose acid sulfate soils. There are several terrestrial and aquatic Groundwater Dependent Ecosystems (GDEs) mapped within the SAP, that are highly sensitive to changes in groundwater conditions, however the potential impact on the GDEs is not considered to be significant since there are no high priority ecosystems and the SAP footprint is not located in conservation areas.

A comparative analysis found that the Williamtown SAP Structure Plan poses a 'medium-low' risk to groundwater and hydrogeology. This may be reduced to an overall 'Low' risk categorization with implementation of appropriate management measures and the development of a Groundwater Management Plan (GMP) during construction and ongoing use of the SAP. The GMP would include measures to be implemented during construction (including dewatering and discharge, acid sulphate soils and inflow to excavations) and ongoing use (including groundwater quality, GDEs and groundwater levels).

Recommendations for managing risk have been explored and discussed in **Section 7** of this report, including further investigations to be implemented during Concept Design, State Environment Planning Policy and Delivery Planning to refine potential mitigation measures. This should include the development of a groundwater model to simulate potential impacts of development on groundwater levels and flow paths. In addition, drains could be used to remove poor quality stormwater from entering the groundwater and rainfall harvesting used to mitigate for losses in recharge.

Overall a key objective of the development is that it should not result in significant changes to groundwater recharge and flows; cause a lowering of the beneficial use category of the groundwater source beyond 40 m from area of disturbance; or affect high priority GDEs in accordance with the Aquifer Interference Policy. These specific issues are considered to be low risk in the context of the proposed development; however, if these conditions are not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of groundwater dependent ecosystems, significant sites or any affected water supply works.

Contents

Appendices

Figures

Tables

Glossary

Abbreviation	Term
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018
DPE	Department of Planning and Environment
GDEs	Groundwater Dependant Ecosystems
HEV	High Ecological Value
HEVAE	High Ecological Value Aquatic Ecosystems
mAHD	Metres above Australian Height Datum
mbgl	Metres below ground level
mg/L	Milligrams per litre
ML	Megalitres
ML/a	Megalitres per annum
PFAS	Per- and Polyfluoroalkyl Substances
SAPs	Special Activation Precincts
SWOT	Strength-Weakness-Opportunity-Threat
Williamtown SAP	Williamtown Special Activation Precinct

1 Introduction

1.1 Background Context

1.1.1 Williamtown SAP Background

The Department of Planning and Environment (DPE), Department of Regional NSW and Regional Growth NSW Development Corporation's establishment of Special Activation Precincts (SAPs) is an 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 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
- Social and Community Infrastructure – Enabling high skill employment, innovation, education and skill training opportunities.

Figure 1 Williamtown SAP Visions

1.1.2 Williamtown SAP Location

Williamtown is located approximately 30 km north 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 area covers 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.

1.1.3 Williamtown hydrogeology and groundwater strategic context

Groundwater within the Williamtown SAP is managed under three principal water sharing plans, namely:

- Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Sources 2009
- Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources, 2016 (incorporates and consolidates Tomago Groundwater Source and Stockton Groundwater Source)
- Water Sharing Plan for the Hunter Unregulated and Alluvial Sources, 2009

Under the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources, 2016, the Tomago Groundwater Source is divided into 5 'Management Zones' (Zones 1-5). The Preferred Precinct Plan lies within Zone 3 managed under the Tomago Groundwater Source.

The Tomago Sandbeds fall under Hunter Water owned land and the Tilligerry State Conservation Area which is known as a ‘Special Area’ in the *Hunter Water Act, 1991*, with all activities within the area regulated under Part 2 of the Hunter Water Regulation 2015. The reserve is jointly managed by NSW National Parks and Wildlife Service and Hunter Water and is closed to the public in order to protect groundwater quality and water extraction infrastructure.

Groundwater within the Tomago Coastal Sands aquifers is used for urban water supply by the Hunter Water Corporation. The sandbeds are strategically important for both ongoing and backup water supply (Hunter Water, 2020). The ongoing supply from the sandbeds reduces the load on surface water sources and thereby allows greater overall yield from the total water supply system.

The Tomago Sandbeds are an important and significant water source within the Lower Hunter region and provide approximately 20 percent of the Lower Hunter drinking water, with an accessible volume of up to 60,000 megalitres (ML) for potable water supply (Hunter Water, 2020). The groundwater extraction and treatment infrastructure for the Tomago Sandbeds is managed by the Hunter Water Corporation, and is central to the supply of potable groundwater within the Williamtown SAP.

The Tomago Sandbeds, and its importance as a water resource are discussed further in Section 3, along with further detail on the management and supply of groundwater extracted from the Tomago Sandbeds by Hunter Water Corporation.

Large areas of high potential terrestrial Groundwater Dependant Ecosystems (GDEs) and smaller areas of moderate and low potential terrestrial GDEs are present within the northern portion of the SAP and overlying the Tomago Sandbeds aquifer. Terrestrial GDEs are also present over limited areas within the southern portion of the SAP, overlying the Stockton Sandbeds aquifer. A number of terrestrial GDEs are present within and around Fullerton Cove, which is classified over a large area as both a wetland and Ramsar listed wetland.

GDE’s are discussed further in Section 3. The extent of terrestrial and aquatic GDEs within the SAP are presented in **Appendix A**. The figure includes High Ecological Value Aquatic Ecosystems (HEVAE) classified by NSW DoI Water (June 2020). High priority GDE’s as classified under the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources 2016 – Tomago Groundwater Source are also presented in **Appendix A.**

1.1.4 Regulatory framework and guidelines

The regulatory framework and guidelines relevant to development within the SAP in the context of aquifers and groundwaters are summarised below.

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)
- *Hunter Water Act 1991*
- Hunter Water Guidelines for developments in the drinking water catchments (2017)
- Hunter Water Regulation (2015)
- NSW Aquifer Interference Policy (2012)
- NSW Groundwater Dependent Ecosystems Policy (1998)
- NSW Groundwater Quality Protection Policy (1998)
- NSW Groundwater Quantity Management Policy (1998)
- *Water Management Act 2000*
- Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources (2016)

Further detail on these guidelines, including key considerations relevant to development of the SAP were presented during the optioneering stage.

2 Summary of regional baseline hydrogeology assessment

Review of the SAP topography shows that the southern portion of the SAP area is characterised by a broad and relatively flat open plain, with surface elevations typically between <1 to 2 m Australian Height Datum (AHD). The open plain is prone to both surface water and groundwater flooding (Aurecon 2020b).

Topography rises steeply to the south from Tilligerry Creek up to around 35 m AHD along the Stockton Sand Dunes (NSW Government, 2013). The northern portion of the SAP is characterised by large open areas with elevations of between 6 and 10 m AHD. A local ridge comprising a topographic high is located to the north of RAAF Base Williamtown.

As a result of the topography, the Williamtown SAP can be divided into three key drainage catchments:

- Hunter River catchment - drains surface runoff from the western portion of the SAP area into Fullerton Cove and the Hunter River Estuary
- Port Stephens catchment - drains surface runoff from the north east portion of the SAP area towards Oyster Cove
- Tilligerry Creek catchment - drains surface runoff from the eastern portion of the SAP area into Tilligerry Creek

The seamless geology data set shows the project area is underlain by a number of Quaternary Age superficial geological units, which can broadly be classified into three categories (Colquhoun, 2019), comprising:

- Alluvial floodplain deposits
- Coastal deposits
- Estuarine deposits

The bedrock geology of the SAP area comprises three key geological units associated with the Permo-Triassic Sydney Basin, as part of the Hunter-Bowen Cycle (approximately 300-252 Ma) including:

- Dalwood
- Mulbring Siltstone
- Tomago Coal Measures

The hydrostratigraphy of the SAP area comprises upper sequences of unconsolidated gravels, sands, silts and clays (associated with the Quaternary age coastal, estuarine and alluvial deposits), overlying a basement of weathered and fresh consolidated sequences of the Permo-Triassic Sydney basin. The most important parts of the Newcastle Formation, in relation to the storage of groundwater, are the three sand members, namely the Tomago Sand Member, the Stockton Sand Member, and the Tomaree Sand Member. which form two key aquifers:

- The Stockton Sandbeds (Dunes)
- The Tomago Sandbeds

Recharge of the Tomago Sandbeds and Stockton Sandbeds has been estimated at approximately 30% of the mean annual rainfall (GHD, 2013), equivalent to approximately 36,000 megalitres per annum (ML/a) and 21,000 ML/a, respectively. The Tomago Sandbeds form part of the North Coast Coastal Sands Groundwater Sources (2016), which are classified as highly productive groundwater sources under the NSW Aquifer Interference Policy (2012). Superficial aquifers such as these (e.g. shallow water table with little or no protective cover), are the most vulnerable to pollution. The Tomago Sandbeds fall under Hunter Water owned land and the Tilligerry State Conservation Area which is known as a 'Special Area' in the *Hunter Water Act, 1991*, with all activities within the area regulated under the Hunter Water Regulation (2015). They require the maximum degree of protection, as contaminants entering the aquifer through these areas could spread widely through the aquifer; furthermore, recharge rates could be seriously impaired if the areas are not properly managed.

Groundwater levels within the superficial aquifers of the SAP are typically within 1.3 m of the surface but range from 4.8 m AHD to 0 m AHD and temporarily artesian conditions in locations around Fullerton Cove (AECOM, 2017).

Groundwater levels within the Tomago aquifer are variably sensitive to the climatic drivers that exert controls on recharge of groundwater. Groundwater levels in the Tomago Sandbeds fall from approximately 8 m AHD north of RAAF Base Williamtown (South of Lake Cochran) to approximately 0.5 m AHD immediately north of Fullerton Cove, Fourteen Foot Drain and Tilligerry Creek and contour mapping indicates that groundwater generally flows from north to south within the SAP area and discharges directly into local waterways within and around Fullerton Cove.

The Tomago sandbeds are strategically important for both ongoing and backup water supply (Hunter Water, 2020). Groundwater within the Tomago Coastal Sands aquifer is used for urban water supply by the Hunter Water Corporation. The ongoing supply from the sandbeds, providing approximately 20 percent of the Lower Hunter drinking water, reduces the load on surface water sources (principally the Grahamstown Dam and Chichester Dam) and thereby allows greater overall yield from the total water supply system.

Water requirements for the Tomago groundwater source include 421 ML/a for basic landholder rights, 25,300 ML/a for major utility access licences (i.e. Hunter Water Town Water Supply), and 790 ML/a for all other licensed entitlements. Water requirements for the Stockton groundwater source include 254 ML/a for basic landholder rights, and 1,009 ML/a for all other uses.

The long-term average annual extraction limit for the Tomago groundwater source is 25,000 ML/a (69% of annual recharge). The long-term average annual extraction limit for the Stockton groundwater source is 14,000 ML/a (66% of annual recharge). A review of the National Groundwater Information System database has identified a total of 537 registered groundwater bores within the Williamtown SAP. A significant portion (approximately 83%) of the bores are of ‘unknown’ purpose and 2.5% are registered for ‘water supply’ (including boreholes and spear points). The baseline assessment found low salinity Sodium-Chloride type groundwaters typically associated with boreholes screened through shallow and intermediate sections of the aquifer, with deeper boreholes showing a trend of increasing salinity and shift in hydrogeochemical facies towards higher salinity Sodium-Bicarbonate-Chloride type groundwater and Calcium-Magnesium-Bicarbonate type groundwater. Groundwater salinity is generally fresh to the north and south of Tilligerry Creek within the Tomago and Stockton aquifers, respectively. Groundwater becomes increasingly saline with depth and in low lying areas beneath the flood gated area between Fullerton Cove and Tilligerry Creek, and along the estuarine influenced drainage line of Tilligerry Creek. Water pumped from the Tomago aquifer system by Hunter Water is of low salinity in both total and individual ions. Total dissolved solids (a surrogate for salinity) is typically in the range of 60 mg/L to 200 mg/L (Woolley *et al*., 1995) and well below both the Australian Drinking Water Guidelines v3.6 2011 ‘good quality drinking water’ limit of 600 mg/L and the World Health Organisation limits for drinking water quality (500 – 1,000 mg/L). Several aspects of the groundwater however are less satisfactory, including low pH (pH 4-6), elevated carbon dioxide (100 – 240 mg/L) and elevated hydrogen sulphide (0.5 – 1.0 mg/L) (Woolley *et al*., 1995).

Large areas of high potential terrestrial Groundwater Dependant Ecosystems (GDEs), 'ecosystems where the species composition or natural functions depend on the availability of groundwater', and smaller areas of moderate and low potential terrestrial GDEs are present within the northern portion of the SAP and overlying the Tomago Sandbeds aquifer. Terrestrial GDEs are also present over limited areas within the southern portion of the SAP, overlying the Stockton Sandbeds aquifer. A number of terrestrial GDEs are present within and around Fullerton Cove, which is classified over a large area as both a wetland and Ramsar listed wetland. A limited number of discrete areas comprising known and potential aquatic GDEs are present within the study area, including a number of areas to the north-west of the RAAF Base Williamtown., which are also mapped as High priority (high ecological value) GDEs under the North Coast Coastal Sands Groundwater Sources Water Sharing Plan. Along Tilligerry Creek and along the north channel of the Hunter River, land subject to tidal inundation supports mangrove and saltmarsh wetlands, as well as extensive mud flats. The dominant hydrological influence on these wetlands is the tidal estuarine water and the influence of groundwater is considered to be limited (Woolley *et al*., 1995).

The information reviewed in this section has been used to develop a hydrogeological conceptual model cross-section of the Williamtown SAP area (**Figure 2**).

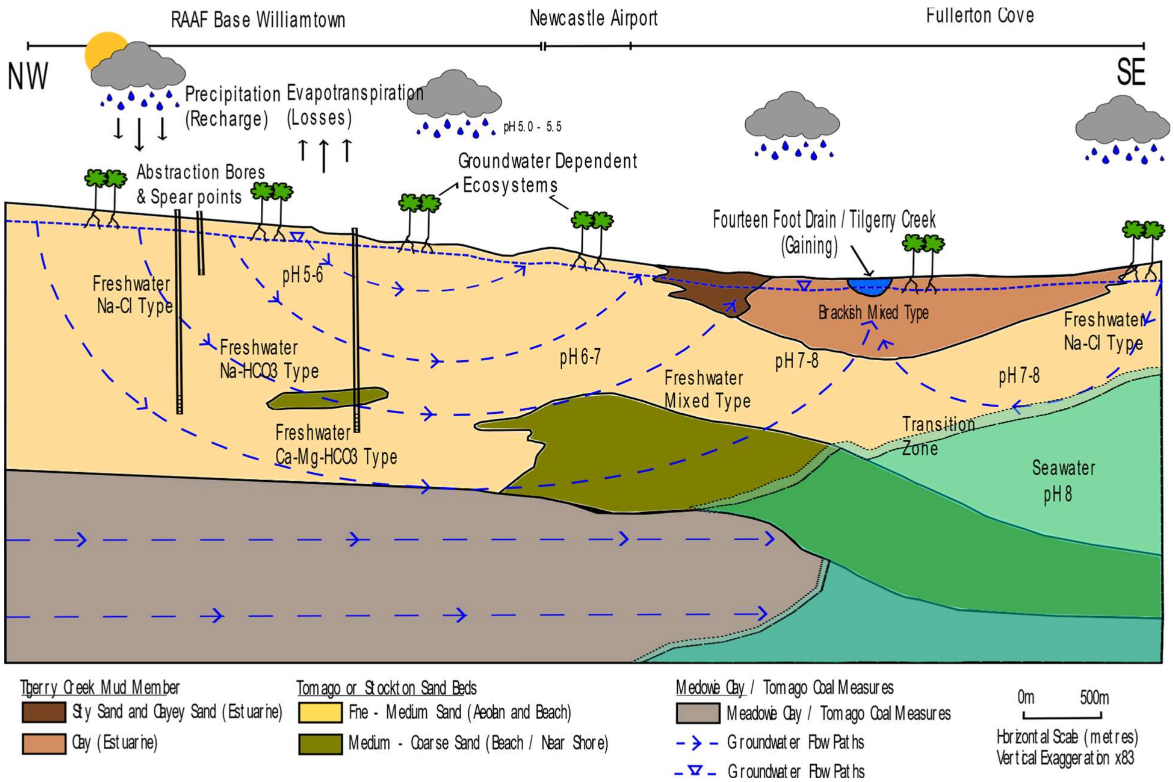


Figure 2 Hydrogeological conceptual cross section: Williamtown SAP

The key variables and interactions associated with groundwater within the Williamtown SAP include groundwater recharge and losses, evolution of groundwater chemistry, presence of GDEs and abstraction points, groundwater levels and flow paths, mixing of groundwaters and discharge to local waterways.

3 Precinct vision

The Williamtown SAP will be Australia's first 'Innovation Precinct' at scale defined by symbiosis of Newcastle Airport and Defence Land and creative infrastructure solutions. It will be achieved through a place- led approach to aerospace, defence, advanced manufacturing, emerging industries, community, connection to country and ecological urbanism and day and night activation. It will lead and empower meaningful partnerships, tenant curation, co-design, innovation through collaboration, circular economy and resilience design and policy.

The key SAP principles include 7 essential elements, including:

- Equity – Stay and Play
- Greenery – Blue Green Grid
- Identity - Designing for Country & Community
- Mobility – Movement & Place
- Resilience – An Innovative Ecosystem
- Urbanity – More Than an Airport
- Wellness – Healthy City

In the Williamtown SAP design development process, all existing constraints identified in the baseline assessment were holistically evaluated to identify preferred elements which should be included in the structure plan, areas for further investigation and no-go zones. This included:

Scenario specific

- The likely demand for water for each of the scenarios
- The required water quality
- Groundwater pollution risk
- Location with respect to available water resources
- Location with respect to groundwater vulnerability / pollution risk

Relevant to all scenarios

- Key attributes of the Tomago and Stockton Coastal Sands aquifers as groundwater resources for the SAP.
- Assessment of potential supply of the limited amount of water that may be available from the Tomago and Stockton Coastal Sands aquifers
- Assessment of water supply infrastructure required for the SAP and who might operate that infrastructure.
- Assessment of limitations to SAP development in the context of the relevant regulatory frameworks identified in **Section 1.1.3, Section 1.1.4, and Section 2**.

These baseline investigations resulted in the development of a range of structure plan scenarios based on holistic themes which aimed to maximise certain regional opportunities. As part of the subsequent scenario testing phase of the Williamtown SAP, comparative assessments were conducted to explore the strengths, weaknesses, risk and opportunities of each development scenario from a hydrogeological perspective.

The hydrogeology assessment was based on specific testing criteria shown in **Table 1**. The testing criteria provided ratings of 'Low', 'Medium', or 'High' potential impact based on both qualitative and quantitative criteria.

Table 1 Hydrogeology and groundwater testing criteria: Williamtown SAP

Rating	Category	Criteria
High	Groundwater supply	Annual water demand likely to cause annual average water demand for catchment to exceed available water supply, increasing pressure on Tomago aquifer and reducing drought resilience. Loss or significant impact to Hunter Water groundwater assets.
	Groundwater recharge	Reduces groundwater recharge to Tomago aquifer over both High Ecological Value (HEV) and Non-HEV areas. Reduction in groundwater recharge may result in catchment exceeding available water supply under average conditions. Reduction in groundwater recharge equal to, or greater than, 5% of annual average recharge to Tomago Aquifer.
	Groundwater levels	Likely to cause unacceptable drawdown of water levels at reference bores. Likely to cause unacceptable drawdown of water levels and affect long-term viability of water resource.
	Groundwater quality and pollution	Unacceptable impacts to groundwater quality that cannot be mitigated through environmental controls.
	Groundwater dependent ecosystems	Existing GDEs likely to be adversely impacted over large areas, including high priority GDEs.
	Groundwater flooding	Development likely to result in adverse groundwater flooding directly or indirectly over large areas.
Medium	Groundwater supply	Annual water demand likely to cause annual average water demand for catchment to increase close to supply limits pressuring on Tomago aquifer and reducing drought resilience. Potential for limited impacts to Hunter Water groundwater monitoring and supply assets that can be managed with environmental controls.
	Groundwater recharge	Reduces groundwater recharge to Tomago aquifer in Non-HEV recharge areas Reduction in groundwater recharge likely to occur but unlikely to result in catchment exceeding available water supply under average conditions Reduction in groundwater recharge equal to, or less than, 5% of annual average recharge to Tomago Aquifer.
	Groundwater levels	Likely to require level 2 impact assessment under Aquifer Interference Policy.
	Groundwater quality and pollution	Potential impacts to groundwater quality if not managed appropriately, but can be mitigated through environmental controls.
	Groundwater dependent ecosystems	Limited impacts to existing GDEs, not including high priority GDEs.
	Groundwater flooding	Development likely to directly or indirectly result in limited groundwater flooding events over small low sensitivity areas .
Low	Groundwater supply	Annual water demand likely to cause annual average water demand for catchment to increase marginally, with limited additional pressure on Tomago aquifer and drought resilience. No impacts to Hunter Water groundwater supply and monitoring assets.
	Groundwater recharge	No loss of recharge to Tomago aquifer.
	Groundwater levels	Level 1 impact outcome under the Aquifer Interference Policy.
	Groundwater quality and pollution	Neutral or beneficial effect on groundwater quality.
	Groundwater dependent ecosystems	No impact to / potential for enhancement of existing GDEs.
	Groundwater flooding	Development unlikely to directly or indirectly result in groundwater flooding events.

The criteria presented in **Table 1** addressed the regulatory framework, guidelines and the baseline conditions presented in **Section 1** and **Section 2** for the SAP scenarios. Following the individual specific technical assessments, several rounds of stakeholder review and multi-disciplinary workshops were conducted to explore all the technical findings, provide a holistically balanced approach to managing constraints and develop the Williamtown SAP Structure Plan.

4 Structure Plan

4.1 Methodology and Approach

Section 3 of this report provides a summary of the scenario development during the 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 Williamtown SAP Structure Plan. The Structure Plan considered land use, transport, infrastructure, Per-and Polyfluoroalkyl Substances (PFAS), environmental, social, aboriginal heritage and economic matters in conjunction with the SAP vision.

Figure 3 provides an outline of the key principles which were incorporated into the masterplan.

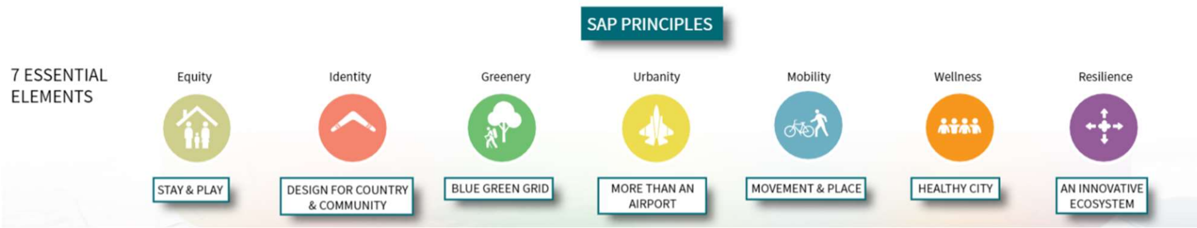


Figure 3 The 7 SAP Principles which governed the masterplan

The Structure Plan leveraged 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.

4.2 Structure Plan Location and Land Uses

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 SAP development are to incorporate aerospace and defence contractor industries around the southern airside boundary of the airport. The land uses within the SAP's northern precinct focuses on defence and aerospace, commercial centres, freight and logistics and research and development industries. The later stages of the 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 4** adheres to the existing drainage and flooding characteristics and incorporates the inclusion of the Dawsons Drain and Learys Drain reserve. Additionally, it maintains the hydrological regime for the biodiversity corridor, facilitates controlled flooding throughout the SAP precinct and utilises floodplains South of Cabbage Tree Road to offset impacts.

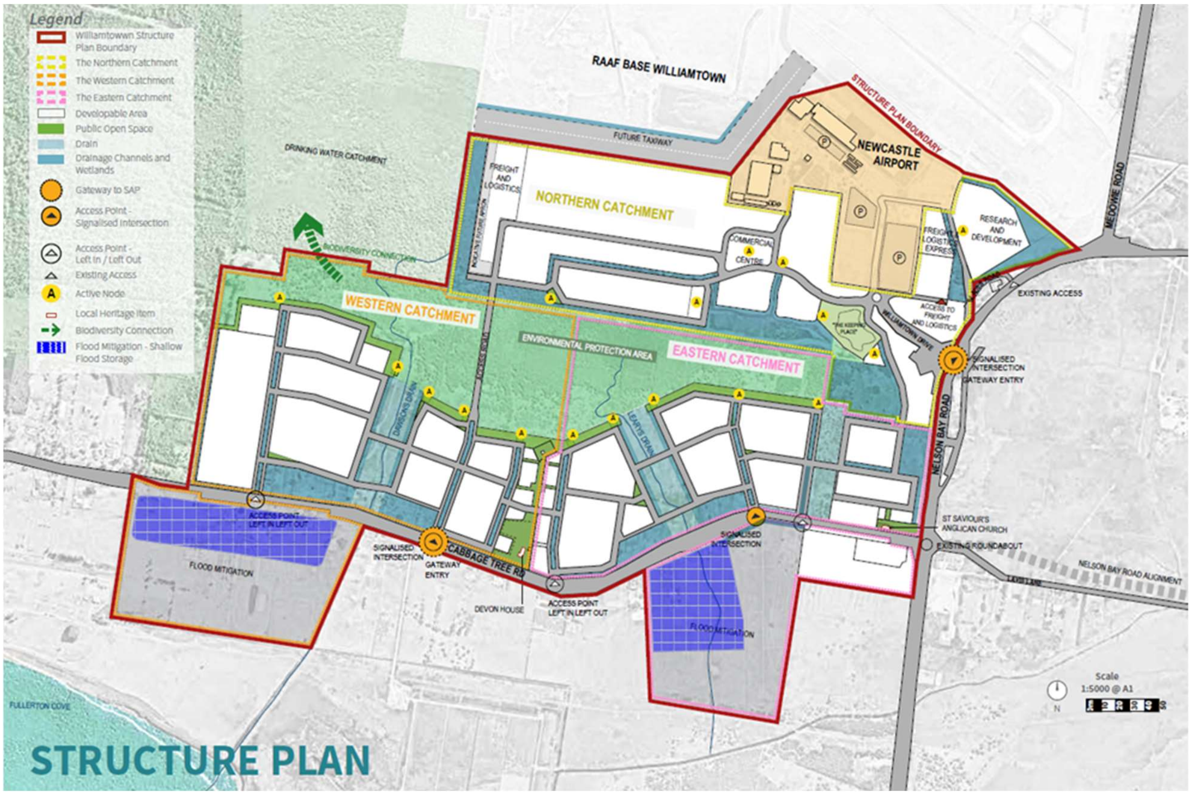


Figure 4 – Williamtown SAP Structure Plan (Source: Hatch Roberts Day (2021) Williamtown SAP - Structure Plan)

Table 2 shows the descriptors that are used to describe sub-precincts for the Williamtown SAP Structure Plan along with the typical and indicative land use activities that may occur in each of these sub-precincts.

Table 2 Overview of Williamtown Structure Plan sub-precincts and land uses

Precinct	Land Use	Structural characteristics
Northern Precinct: 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. Building heights –2 storey buildings expected. Significant live loads e.g. heavy trucks such a loaded B-Double trailers
Northern Precinct: Defence and Aerospace/ Airside		Buildings might have height limitations. Potentially heavier loads for Airside pavement access.
All precincts: Commercial Centre		Light industrial developments – warehousing and office space
Western and Eastern Precinct: Light Industrial		Light industrial developments – warehousing and office space Building heights between 1 to 5 storeys for Hi-tech company offices. Retail and entertainment building heights of 1 to 2 storeys maximum.
Western and Eastern Precinct: Advanced Manufacturing		Light industrial developments – warehousing and office space
All precincts: R&D		Light industrial developments – warehousing and office space Between 1 to 5 storeys for Hi-tech company offices Education or research facility building heights of 1 to 2 storeys maximum.

5 Baseline local conditions assessment

A regional review of hydrogeological conditions was summarised in **Section 2**. This section focusses on the local hydrogeological conditions underlying the Preferred Precinct Plan area.

5.1 Geology

The geology of the SAP is covered by the Newcastle 1:100 000 Geological Sheet. The site plan is shown with respect to the local geology map as provided in the NSW Statewide Seamless Geology dataset (Colquhoun, 2019). Further detailed discussion on geology and the implications for the SAP are provided in the Stage 3 Geotechnical Baseline Analysis (Aurecon, 2021).

The seamless geology data set shows the Preferred Precinct Area is underlain several Cenozoic - Quaternary Age superficial geological units, shown on **Figure 5 (Appendix A),** including:

- Estuarine in-channel bar and beach deposits – comprising fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell, gravel.
- Coastal beach-ridge swale and dune-deflation hollow deposits – comprising fine- to medium-grained quartz-lithic-carbonate (marine-deposited) sand, organic-rich mud, peat.
- Coastal dune facies deposits – comprising marine-deposited and aeolian-reworked coastal sand dunes; partially consolidated.
- Estuarine swamp deposits – comprising organic-rich mud, peat, clay, silt, very fine- to fine-grained sand (marine-deposited), fine- to medium-grained sand (fluvially deposited).

Further information on the local groundwater conditions associated with these geological units is presented in the following sections.

5.2 Groundwater levels and flow paths

Groundwater levels within the Tomago aquifer are variably sensitive to the climatic drivers that exert controls on recharge of groundwater.

Figure 6 (**Appendix A**) presents groundwater elevations for the Williamtown SAP Structure Plan area derived from level-monitoring of 145 monitoring wells within the Williamtown SAP area (AECOM, 2017).

The mapping shows groundwater levels in the Tomago Sandbeds across the SAP falling from approximately 3.0 m AHD in the north of the SAP to approximately 0.5 m AHD immediately north of Fullerton Cove, Fourteen Foot Drain and Tilligerry Creek.

Groundwater in the Tomago aquifer generally flows from north to south within the SAP and discharges directly into local waterways within and around Fullerton Cove. To the south, in the Stockton Sandbeds groundwater flow is to the north towards Fullerton Cove and Tilligerry Creek.

Owing to variations in topography, groundwater levels may be relatively shallow in places across the Structure Plan. **Figure 7** (**Appendix A**) presents the calculated depth to groundwater across the Structure Plan based on results from groundwater monitoring (AECOM, 2017), and show calculated groundwater depths of between >4.0 m bgl and <0.5 m bgl across the SAP.

Areas of shallow groundwater may be prone to groundwater flooding and formation of springs following significant rainfall events. Areas of shallow groundwater may form significant constraints to the development of the SAP.

It is likely that reductions in recharge may result in minor changes to groundwater levels beneath and down-gradient of the SAP, however this is unlikely to affect the Tomago Aquifer's resource potential. Overall, development of the SAP is considered unlikely to significantly affect groundwater levels or flow paths as changes to groundwater recharge are not considered to be significant against the overall recharge rates to groundwater for the Tomago Aquifer (discussed further in **Section 5.5**).

Local declines in groundwater levels have the potential to expose acid sulfate soils, which are classed as high potential across the Structure Plan SAP. The potential for exposure of acid sulfate soils should be further investigated as part of future geotechnical and contaminated land investigations to profile risks and identify suitable management measures. Management measures are documented in Aurecon (2021a).

5.3 Groundwater quality

Major ion chemistry within the Williamtown SAP aquifers has been reviewed as part of baseline assessment for the SAP. The baseline assessment found low salinity Sodium-Chloride type groundwaters typically associated with boreholes screened through shallow and intermediate sections of the aquifer, with deeper boreholes showing a trend of increasing salinity and shift in hydrogeochemical facies towards higher salinity Sodium-Bicarbonate-Chloride type groundwater and Calcium-Magnesium-Bicarbonate type groundwater.

Groundwater salinity is generally fresh to the north and south of Tilligerry Creek within the Tomago and Stockton aquifers, respectively. Groundwater becomes increasingly saline with depth and in low lying areas beneath the flood gated area between Fullerton Cove and Tilligerry Creek, and along the estuarine influenced drainage line of Tilligerry Creek.

Groundwater across the Williamtown SAP Structure Plan is generally fresh <2,000 μs/cm and has slightly acidic to neutral pH (pH 5.0 – 7.0). Low pH and elevated concentrations of carbon dioxide / hydrogen sulphide causes the water to be relatively corrosive, which can be managed through aeration and pH balancing. The concentration of dissolved iron is also frequently high, which is commonly the key water quality issue associated with the Tomago aquifer and Newcastle Formation (Wooley *et al*., 1995).

Geotechnical design will need to consider the salinity and pH characteristics of groundwater beneath the SAP in undertaking SAP development if foundations or structures are planned to intersect groundwater. This may include special provisions for corrosion and pH resistant materials including cements and in-ground infrastructure.

Groundwater quality across the SAP is also affected by both PFAS and non-PFAS contamination. Further information on the groundwater quality impacts associated with PFAS and non-PFAS contamination is discussed in the Stage 3 Contamination Assessment Report for the Williamtown SAP Structure Plan (Aurecon, 2021a). PFAS contamination is a significant constraint affecting the use and management of groundwater beneath the Structure Plan.

5.4 Groundwater dependent ecosystems

Figure 8 (**Appendix A**) presents the locations and relative potential of terrestrial and aquatic GDE's within the Williamtown SAP.

The GDE map shows that there are several high potential terrestrial GDE's across the development area of Williamtown Structure Plan SAP, including:

- Fern-leaf Banksia / Prickly-leaved Paperbark / Tantoon / *Leptocarpus tenax* wet heath on coastal sands
- Scribbly gum / Wallum banksia / Prickly-leaved Paperbark heathy coastal woodland on coastal lowlands
- Parramatta red gum / Fern-leaved banksia / *Melaleuca sieberi* swamp woodland of the Tomaree Peninsula
- Broad-leaved Paperbark / Swamp Mahogany / Swamp Oak / Saw Sedge swamp forest of the Central Coast

These ecosystems will be highly sensitive to changes in groundwater conditions. Further information on the nature, distribution and sensitivty of these ecosystems is provided in the Stage 3 SAP Biodiversity Report (ERM, 2021).

There are no mapped high priority GDE's within the Williamtown SAP Structure Plan that are referenced by the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources (2016). One (1) HEVAE GDE has been identified by the NSW Department of Industry (DoI) Water, and is located within the environmental protection sub-precinct, with small portions overlapping into the Western Sub-precinct and Eastern Sub-precinct. The HEVAE is shown on **Figure 8 (Appendix A).**

SAP development will involve the disturbance or impact of high potential GDEs located within the Northern Sub-precinct; however, the presence of GDEs within the Structure Plan is not considered to have significant implications on SAP development as:

- There are no high priority ecosystems within the SAP development footprint (as mapped by the North Coast Coastal Sands Groundwater Sources (NSW Department of Primary Industries, 2016).
- The GDEs present within the SAP development footprint are not located within areas classed as conservation areas of HEV for the North Coast Coastal Sands Groundwater Sources (NSW Department of Primary Industries, 2016).
- The GDEs classed as HEVAE by DoI Water are contained within the Environmental Protection sub-precinct (with the exception of a small area overlapping into the Western and Eastern sub-precincts).

5.5 Aquifer vulnerability

The Tomago Sandbeds form part of the North Coast Coastal Sands Groundwater Sources (2016), which are classified as highly productive groundwater sources under the NSW Aquifer Interference Policy (2012).

Wooley *et al*., (1995) undertook an assessment of aquifer vulnerability for the Tomago Tomaree Stockton Groundwater Source. The assessment included classification and mapping of zones for vulnerability for the Tomago, Tomaree and Stockton aquifers. The vulnerability map is reproduced in **Figure 9 (Appendix A)** for the Williamtown SAP Structure Plan.

A review of the available aquifer vulnerability mapping shows that the Northern Sub-precinct and a small area of the Eastern Sub-precinct of the SAP partially overlie an area of the Tomago aquifer that is classified as an A1 vulnerability area (high level recharge and high vulnerability). The Western Sub-precinct and the majority of the Eastern Sub-precinct of the SAP is located outside the extent of mapped aquifer vulnerability (suggesting a negligible vulnerability rating).

The portion of the SAP located within the A1 zone will be highly vulnerable to groundwater pollution and changes in groundwater recharge with significant impacts to groundwater resource if groundwater quality or recharge are compromised.

Despite the high vulnerability of this portion of the SAP, it is noted that the current condition of the Tomago sandbeds in this portion of the SAP is highly degraded as a result of PFAS contamination. As such, additional management measures should be considered that are reflective of the existing PFAS contamination issues (Aurecon, 2021a), including appropriate measures to restrict groundwater abstraction and limit activities (including dewatering) which may cause the mobilisation and migration of PFAS impacted groundwater into unaffected portions of the Tomago Aquifer and/or local receiving waterways. The following section provides further discussion on groundwater resource protection associated with the Structure Plan.

5.6 Groundwater resource protection

Groundwater recharge to the Tomago aquifer occurs primarily via direct rainfall and infiltration, with an approximate recharge rate of 36,000 ML/a (equivalent to 31% of annual rainfall).

The Tomago groundwater source is protected by provisions under the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources (2016), which include environmental water provisions, long-term annual extraction limits, share components for water access licences, rules for granting access licences, and rules for granting or amending water supply work approvals.

Water requirements for the Tomago groundwater source include 421 ML/a for basic landholder rights, 25,300 ML/a for major utility access licences (i.e. Hunter Water Town Water Supply), and 790 ML/a for all other licensed entitlements.

The Hunter Water Corporation operates a network of over 500 individual bores as borefields with associated pumping stations within the Tomago Sandbeds, reaching from Lemon Tree Passage west to Tomago. Water is extracted from the Tomago Sandbeds via a network of bores and vacuum stations. There are 67 groundwater monitoring wells screened within the Tomago aquifer.

The potable water supply bores and associated monitoring bores within the Tomago Sandbeds, along with other National Groundwater Information System registered groundwater bores within and around the Williamtown SAP Structure Plan are shown in **Figure 10 (Appendix A)**. The mapping shows that there are no Hunter Water operated extraction or monitoring bores within the SAP development area. Four National Groundwater Information System registered bores are located within the SAP development area, including one registered monitoring bore (GW080079.1.1) located in the Eastern Sub-precinct alongside Nelson Bay Road; one registered water supply bore (GW067175.1.1) located in the Eastern Sub-precinct close to the Cabbage Tree Road Signalised Intersection; and two dewatering bores (GW203979.1.0, GW203251.1.1) located in the Northern Sub-precinct on Williamtown Drive close to the Gateway Entry. In addition, a monitoring bore (GW079448.1.1) lies in the Flood Mitigation Zone to the south of the Western Sub-Precinct.

The planning assumptions associated with the SAP development include calculations for percentage impervious areas for the various sub-precinct land use categories. Detailed water balance calculations associated with development of the Williamtown SAP Structure Plan are presented in the SAP Flooding and Water Cycle Management Report (Aurecon, 2021b). The results of the assessment show reductions in local groundwater recharge for sandy soils to a minimum of 80% of predevelopment mean annual recharge volume. Where development occurs within existing E1 and E2 land zonings or in bushland areas of SP1 land in the Drinking Water Catchment, it may not be feasible to meet the 80% groundwater recharge target. These reductions in recharge, however, are considered unlikely to result in significant degradation of the Tomago aquifer resource, both with and without consideration of the underlying impacts from PFAS that already affect groundwater resource potential within and around the northern portion of the Structure Plan.

The calculated potable water demand for the Structure Plan is equivalent to approximately 3.73 ML/day or 1,361 ML/ year (Aurecon, 2021c). This annual water demand does not increase average demand (69,400 ML/a) above available supply (75,000 ML/a) for Hunter Water's available water supply resources.

Due to local PFAS impacts, it is recommended that no groundwater is extracted locally from the Tomago sandbeds underlying the Structure Plan. All water should be supplied and managed by Hunter Water directly for both potable and non-potable supply, with the exception of locally captured stormwater that could be reused for the latter purpose (Aurecon, 2021a).

All rainfall-runoff from developed (i.e. urbanised) portions of the Structure Plan should be diverted away from recharging the Tomago sandbeds unless NorBE criteria can be achieved. In addition, special measures for in-ground infrastructure may be required to protect groundwater quality in the Tomago Aquifer, including special measures to mitigate potential for leaks or spills of chemicals and wastewaters associated with the various SAP land uses.

Further discussion on water cycle management with respect to both groundwater recharge, surface water management, and water supply demand can be found in the SAP Flooding and Water Cycle Management Report (Aurecon, 2021a).

6 SWOT and comparative analysis

6.1 SWOT analysis

Table 3 presents an analysis of the Strength-Weakness-Opportunity-Threat (SWOT) for the Williamtown Structure Plan.

Table 3 Structure Plan SWOT analysis – hydrogeology

SWOT Descriptor	Comments
Strengths	▪ There are no high priority GDEs within the area of disturbance for the Structure Plan development area. ▪ The Structure Plan protects large areas of land classified as high potential groundwater dependent ecosystems. ▪ No development in HEV areas. ▪ Development is unlikely to result in significant reductions in groundwater levels with the potential to affect high priority GDEs as a result of reduced recharge. ▪ Annual potable water demand (1,361 ML/a) does not increase average demand (69,400 ML/a) above available supply (75,000 ML/a) for Hunter Water’s available water supply resources. ▪ SAP sub-precincts do not impact on Hunter Water reference bores for Water Sharing Plan. ▪ SAP sub-precincts do not impact on Hunter Water monitoring or water supply bores. ▪ No disturbance of state park conservation areas. ▪ With appropriate management SAP development is unlikely to affect the beneficial use category of groundwater within the immediate area of the SAP when accounting for existing impacts from PFAS and non-PFAS contamination. ▪ SAP development is unlikely to significantly impact groundwater levels at existing water supply works. ▪ Natural patterns of groundwater recharge and flow are unlikely to be significantly affected by SAP development. ▪ Structure Plan likely to result in Level 1 impact outcome under the Aquifer Interference Policy. ▪ Structure Plan reduces potential for waterlogging within SAP through emplacement of bulk fill materials.
Weaknesses	▪ Due to the presence of PFAS contamination in groundwater, groundwater abstraction licences within the SAP development area should be restricted to avoid potential impacts to human health and the environment. ▪ Development will result in disturbance / direct impacts of habitat classed as high potential GDEs. This may contravene provisions under the Groundwater Quality Protection Policy and Groundwater Dependent Ecosystem Policy on protection of vulnerable and valuable ecosystems. ▪ Any dewatering activities required for SAP development will require special measures to ensure that dewatering does not result in significant drawdown impacts within the Tomago aquifer. ▪ Any dewatering activities required for SAP development will require special measures to ensure that dewatering activities do not result in migration of PFAS / non-PFAS contamination into unaffected portions of the Tomago aquifer or receiving waterways. ▪ Any dewatering activities required for SAP development will require special measures to ensure that dewatering does not result in compaction and land subsidence.
Opportunities	▪ Opportunity to actively manage and improve habitat conditions within environmental protection corridor in the Structure Plan ▪ Opportunity to improve water quality of downstream receiving waterways through treatment and discharge of treated rainfall runoff into receiving waterways

SWOT Descriptor	Comments
Threats	▪ Wastes generated on the SAP including effluent / wastewater, solvents, oils, heavy metals, toxic organics, toxic inorganics, PCBs, and acids have the potential to leach to groundwater from leaks / spills resulting in further deterioration of Tomago aquifer groundwater resource. ▪ Development of SAP over drinking water catchment may contravene provisions under the NSW Groundwater Quality Protection Policy on protection of water supplies against contamination if not appropriately managed through adequate protection measures. ▪ Shallow groundwater levels may result in significant geotechnical constraints to SAP development requiring special measures. ▪ SAP development has the potential to result in localised groundwater flooding or formation of springs as a result of compaction by ground preparation and emplacement of bulk fill materials, resulting in potential geotechnical and environmental impacts. ▪ Shallow groundwater levels in portions of the SAP may result in significant risks of groundwater flooding, resulting in potential geotechnical and environmental risks. ▪ Lowering of groundwater tables during dewatering activities may expose acid sulfate soils resulting in generation of acidic leachate causing environmental and geotechnical impacts. ▪ Lowering of groundwater tables as a result of reduced recharge from SAP development may expose acid sulfate soils resulting in generation of acidic leachate causing environmental and geotechnical impacts.

6.2 Comparative analysis

A comparative analysis has been undertaken for the purpose of comparing and contrasting the SWOT for the Williamtown SAP Structure Plan against the testing criteria identified in **Section 3**. The comparative analysis summarised in **Table 4** includes an absolute rating (Low, Medium, High) for the Williamtown SAP Structure Plan.

Table 4 Comparative Risk Analysis

Testing criteria	Williamtown SAP Structure Plan
Groundwater supply	Low
Groundwater recharge	Medium
Groundwater levels	Low
Groundwater quality and pollution	Medium
GDEs	Medium
Groundwater flooding	Low
Overall	Medium-Low

The comparative analysis has found that the Williamtown SAP Structure Plan poses an overall ‘medium-low’ risk to groundwater and hydrogeology. In summary, the development incorporates the following risks:

- ‘Low’ risk for groundwater supply groundwater levels, and groundwater flooding.
- ‘Medium’ risk for groundwater recharge, groundwater quality and pollution, and GDEs.

It should be noted that the overall risk framework adopts a conservative measure for consideration of ‘Low’ impact due to the vulnerability and strategic importance of the Tomago aquifer as a water supply resource for both anthropogenic and environmental uses.

Risk categorisation for the Williamtown SAP Structure Plan may decrease to ‘Low’ risk with the introduction of appropriate management measures during construction and ongoing use of the SAP. Consistent with reducing the risk to ‘Low’ it is recommended that a Groundwater Management Plan is developed as part of the Concept Design as outlined in **Section 7.27**.

7 Recommendations

7.1 Key recommendations linked to testing criteria

Table 5 summarises some of the key issues identified as part of the Structure Plan groundwater assessment relevant to the testing criteria identified as part of the comparative analysis. Recommended management measures are also listed to mitigate impacts that have the potential to manifest because of the proposed SAP development.

Table 5 Key issues and recommendations

Testing criteria	Key issues	Mitigation measures	Recommended implementation stage		
			Concept Design	Approvals Planning	Delivery Planning
Groundwater supply	Contaminated groundwater	Groundwater supply to be provided in whole by Hunter Water	✗	✓	✓
		No water access licences to be granted for direct abstractions within the SAP	✗	✓	✗
		Rainwater harvesting to be utilised as additional mechanism for groundwater supply to mitigate for loss of recharge to the Tomago Aquifer from emplacement of impermeable surfaces	✓	✗	✓
Groundwater recharge	▪ Impermeable surfaces ▪ NoRBE criteria	No runoff allowed to infiltrate to groundwater in the Tomago Aquifer water supply catchment without achieving NoRBE criteria.	✓	✗	✓
		Loss of recharge from impermeable surfaces to be offset by rainwater harvesting as part of water cycle management	✓	✗	✓
		Geosynthetic Clay Liner(s) to be used along drains conveying stormwater runoff from the SAP to mitigate potential infiltration of poor-quality water into Tomago aquifer	✓	✗	✓
		Further assessment of potential impacts from development on groundwater levels resulting from reduced recharge by increase in impermeable surfaces, relative to provisions under the Aquifer Interference Policy. This would include development of a groundwater model to simulate potential impacts of development on groundwater levels and flow paths	✓	✓	✗
Groundwater levels	Exposure of acid sulfate soils	Neutralisation (liming)	✗	✗	✓
		Targeted excavation and offsite disposal	✓	✓	✓
		Local groundwater recharge through emplacement of constructed / managed wetlands	✓	✗	✓
Groundwater flooding	▪ Soil degradation ▪ Ecosystem degradation ▪ Geotechnical risk	Design of appropriate drainage systems within and around the SAP as part of water cycle management and flooding control to control groundwater levels. These also consider risks from sea-level rise, particularly in establishing Eastern and Western development areas within the low-lying regions. Refer to Flooding and Water Cycle Management report (Aurecon, 2021a)	✓	✗	✗
		Strict controls on management of potentially contaminating activities through regulatory licencing	✗	✓	✗

Testing criteria	Key issues	Mitigation measures	Recommended implementation stage		
			Concept Design	Approvals Planning	Delivery Planning
Groundwater quality and pollution	■ Leaking wastewater infrastructure	Strict controls on construction requirements for buried infrastructure including wastewater, stormwater and on on-site storages	✓	✗	✓
	■ Stormwater contamination	Strict controls on management, treatment and disposal of waste materials through regulatory licencing	✗	✓	✗
	■ Leaching of waste materials	Strict controls on effluent discharges through regulatory licencing	✗	✓	✗
	■ Leaks / spills from chemical / hydrocarbon storage tanks Effluent discharge	Strict controls on stormwater management through an appropriate water cycle management plan.	✓	✓	✗
		Strict controls on the management of dewatering and discharges required for construction and ongoing use of the SAP.	✗	✓	✓
	■ Dewatering / discharge impacts	Ongoing groundwater compliance monitoring requirement for any high-risk land-uses	✗	✓	✓
GDEs	■ Impacts from exposure of acid sulfate soils	Further assessment of habitats classed as high potential GDEs to establish impacts from disturbance / impact of ecosystems by SAP development relevant to provisions under the NSW Groundwater Quality Protection Policy and NSW Groundwater Dependent Ecosystem Policy.	✓	✓	✗
	■ Impacts from changes in groundwater levels	Loss of recharge from impermeable surfaces to be offset by rainwater harvesting as part of water cycle management	✓	✗	✓
	■ Impacts from degradation of ecosystem habitats	Local groundwater recharge through emplacement of constructed / managed wetlands	✓	✗	✓
		Direct impacts from habitat clearance in the form of Biodiversity Assessment Method credit obligations (Evolve Ecology, 2021)	✓	✓	✓

7.2 Recommendations not linked to testing criteria

It is recommended that a groundwater management plan should be developed as part of the Concept Design for both the construction and ongoing use of the SAP to mitigate against the potential degradation of groundwater resource in the Tomago Aquifer. The groundwater management plan should include measures for:

- Construction
  - Managing groundwater inflows to excavations during SAP construction
  - Dewatering and discharge of groundwater during SAP construction
  - Management of acid sulfate soils during SAP construction
  - Minimising impacts to groundwater dependent ecosystems during SAP construction
- Ongoing use
  - Mitigating impacts to groundwater quality during ongoing use of the SAP
  - Mitigating impacts to groundwater dependent ecosystems during ongoing use of the SAP
  - Managing groundwater levels during ongoing use of the SAP

The Groundwater Management Plan should include development of a Groundwater Model to test groundwater flow and quality impacts and to inform the water management design. This would also test whether compaction of the saturated zone caused by emplacement of fill would reduce pore spacing and subsequently hydraulic conductivity in the aquifer. Further detail on specific activities for groundwater management should be refined as part of concept and detailed design of the SAP to account for the outcomes of investigations that inform design specifications and activities.

Future development of the Williamtown SAP will be carried out in partnership with the relevant water supply agencies (i.e. Hunter Water) and relevant regulators (including the Natural Resources Access Regulator and WaterNSW) so that development of the SAP will account for the potential growth in demand on water resources, and develop a sustainable strategy. All future development within the Precinct Plan should avoid impact with existing bores (identified in **Section 5.6**) and existing critical utilities infrastructure (Aurecon, 2021c) to ensure continuity of Hunter Waters service, however in the unlikely instance where the SAP development results in a loss of monitoring bores, reference bores, or water supply bores, adequate 'make good' measures should be taken to replace any lost or impaired infrastructure. Again, replacement or augmentation of the water supply network will require engagement with Hunter Water, Natural Resources Access Regulator and WaterNSW.

Overall a key objective of the development is that it should not result in significant changes to groundwater recharge and flows; cause a lowering of the beneficial use category of the groundwater source beyond 40 m from area of disturbance; or affect high priority GDEs in accordance with the Aquifer Interference Policy. With the implementation of the recommendations listed in **Table 5** these specific issues are considered to be low risk in the context of the proposed development. The objectives for no significant hydrogeological change would be documented in the Groundwater Management Plan If these conditions are not met, however, then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of groundwater dependent ecosystems, significant sites or any affected water supply works. Development of the SAP should be undertaken in a manner that mitigates against the potential degradation of the Tomago Aquifer as a groundwater resource.

8 References

AECOM (2017): Environmental Site Assessment December 2017, RAAF Base Williamtown Stage 2B Environmental Investigation. Prepared for Department of Defence, 18 March 2022.

Aurecon (2020a): Contamination (PFAS and Non-PFAS) and Hydrogeology Baseline Analysis. Prepared for NSW Department Planning, Industry and Environment, 18 March 2022.

Aurecon (2020b): Williamtown SAP Flooding and Water Cycle Management Baseline Analysis Prepared for NSW Department Planning, Industry and Environment, 18 March 2022.

Aurecon (2021a): Contamination (PFAS and Non-PFAS) and Hydrogeology Structure Plan Report. Prepared for NSW Department Planning, Industry and Environment, 18 March 2022.

Aurecon (2021b): Williamtown SAP Flooding and Water Cycle Management Baseline Analysis. Prepared for NSW Department Planning, Industry and Environment, 18 March 2022.

Aurecon (2021c): Utilities Infrastructure Report. Prepared for NSW Department Planning, Industry and Environment, 18 March 2022.

ANZG (2018): Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Colquhoun, G (2019) NSW Statewide Seamless Geology dataset. Accessed online at: https://www.resourcesandgeoscience.nsw.gov.au/miners-and-explorers/geoscience-information/projects/nsw-seamless-geology-project#_contacts

Evolve Ecology (2021) Biodiversity Assessment. Williamtown Special Activation Precinct. 28 May 2021.

Hatch Roberts Day (2021) 18 March 2022.

NSW Government (1998) NSW State Groundwater Quality Protection Policy. Department of Land and Water Conservation. Available online at www.water.nsw.gov.au/ArticleDocuments/34/nsw_state_groundwater_policy_framework_document.pdf.aspx.

NSW Government (2002), NSW State Groundwater Dependent Ecosystems Policy. Department of Land and Water Conservation. Available online at www.water.nsw.gov.au/ArticleDocuments/34/groundwater_dependent_ecosystem_policy_300402.pdf.aspx

GHD (2013) RAAF Base Williamtown Stage 1 – Conceptual Site Model for AFFF Contamination February 2013.

Hunter Water (2017): Protecting Our Drinking Water Catchments 2017, Guidelines for developments in the drinking water catchments. March 2017.

Hunter Water (2020) Tomago Sandbeds. In Dams and Catchments. Accessed online at: https://www.hunterwater.com.au/our-water/water-supply/dams-and-catchments/tomago-sandbeds

NSW Department of Primary Industries Water (2016): Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources 2016 Background document. September 2016.

NSW Government (2013) Williamtown 1:25,000 Topographic Map 3rd Edition 9232-2N. Department of Finance and Services.

NSW Government (2016): Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources 2016.

NSW Government (2018): Hunter Water Regulation 2015. Available at: https://www.legislation.nsw.gov.au/view/html/inforce/current/sl-2015-0499

NSW Government (2019): *Hunter Water Act 1991* No 53. Available at: https://www.legislation.nsw.gov.au/view/html/inforce/current/act-1991-053

NSW Government (2021): *Water Management Act 2000*, No 92. Available at **https://www.legislation.nsw.gov.au/view/html/inforce/current/act-2000-092**

NSW Department of Primary Industries (2012): NSW Aquifer Interference Policy. September 2012. ISBN 978 1 74256 338 1.

Woolley DR, Mount TJ and Gill J (1995) Tomago Tomaree Stockton groundwater: technical review. NSW Department of Water Resources, Sydney.

Appendix A – Mapping

Figure 5 Williamtown SAP Structure Plan Superficial Geology

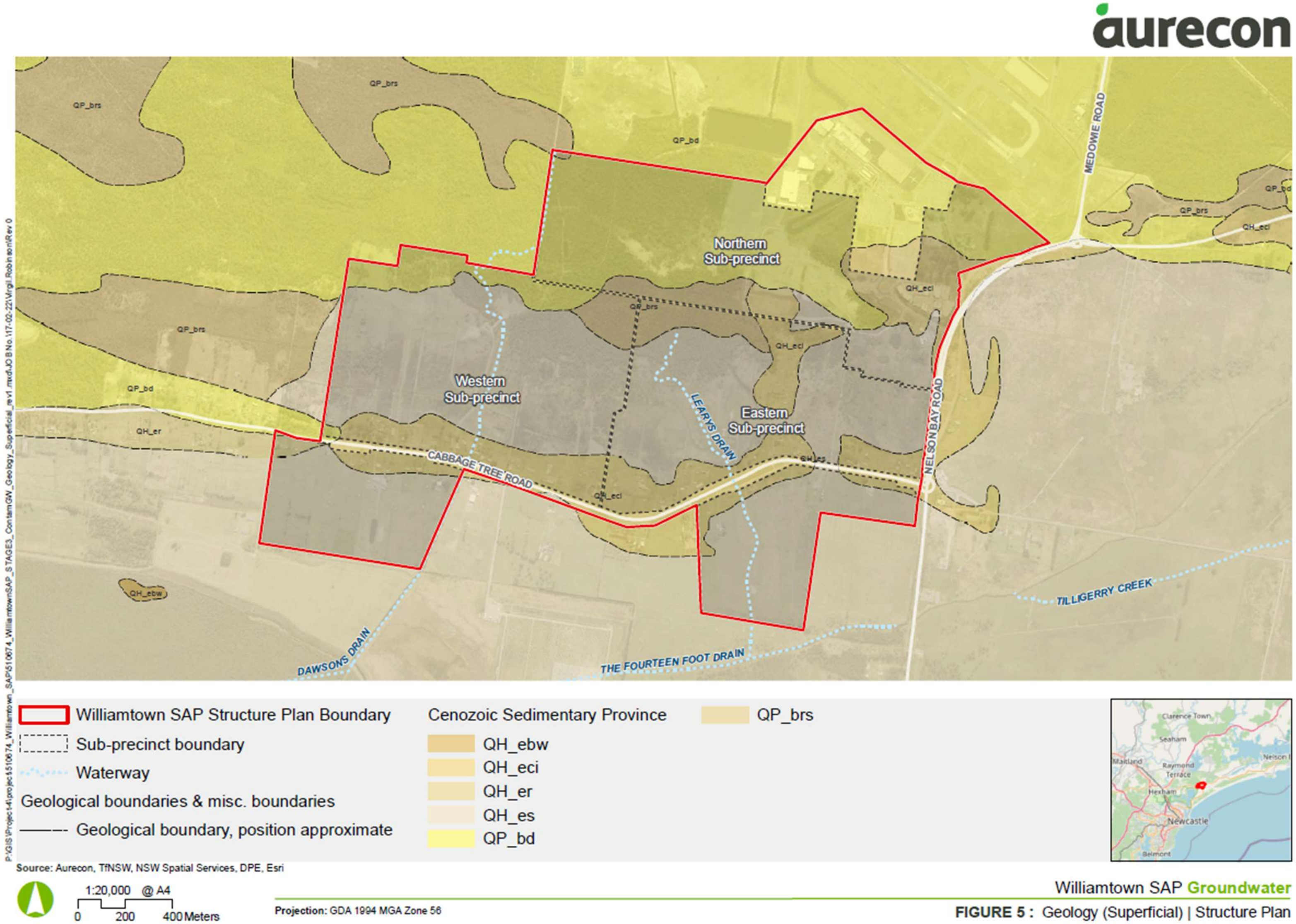


Figure 6 Williamtown SAP Structure Plan Groundwater Levels (mAHD) and Flow Paths

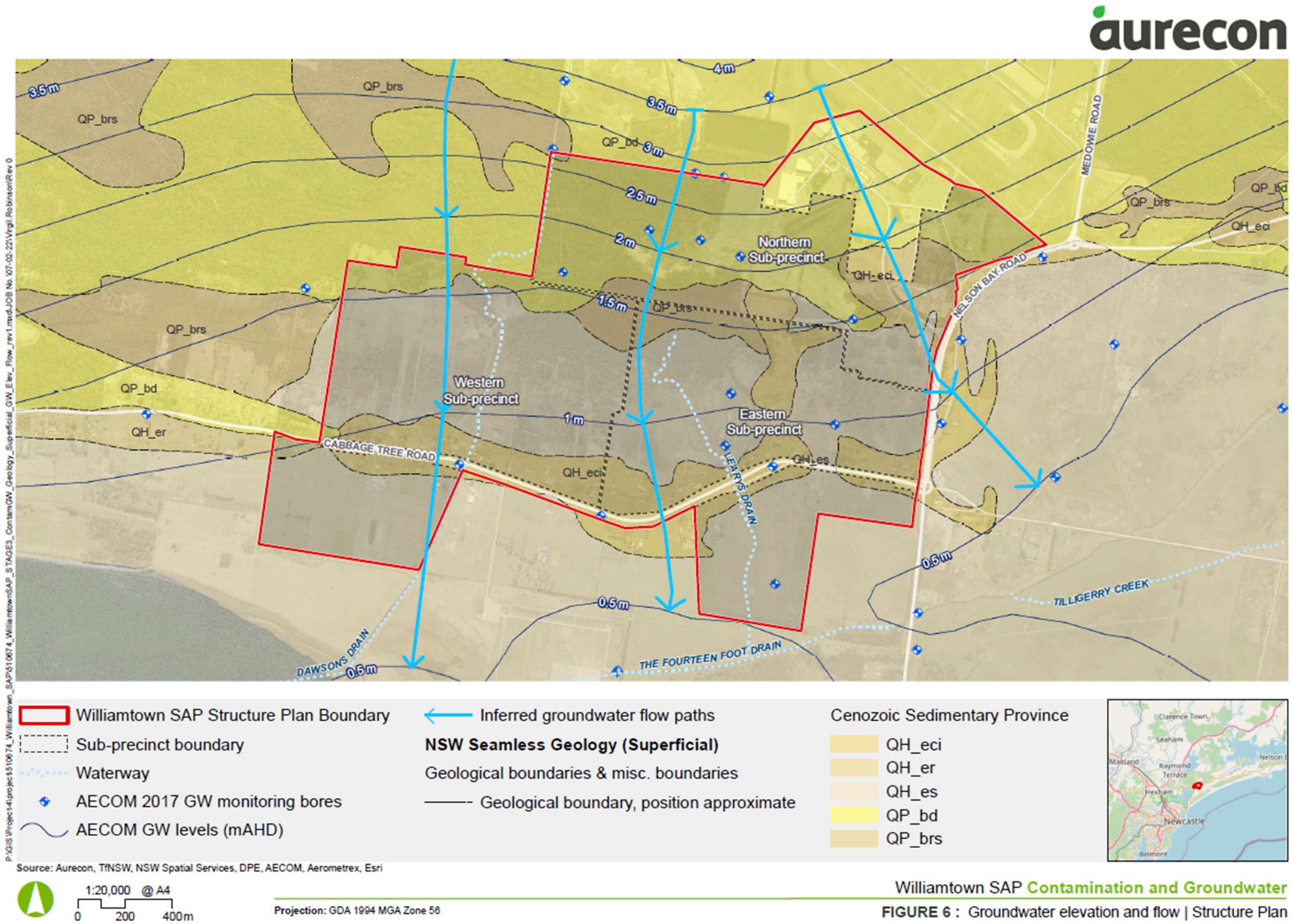


Figure 7 Williamtown SAP Structure Plan Calculated Depth to Groundwater (mbgl)

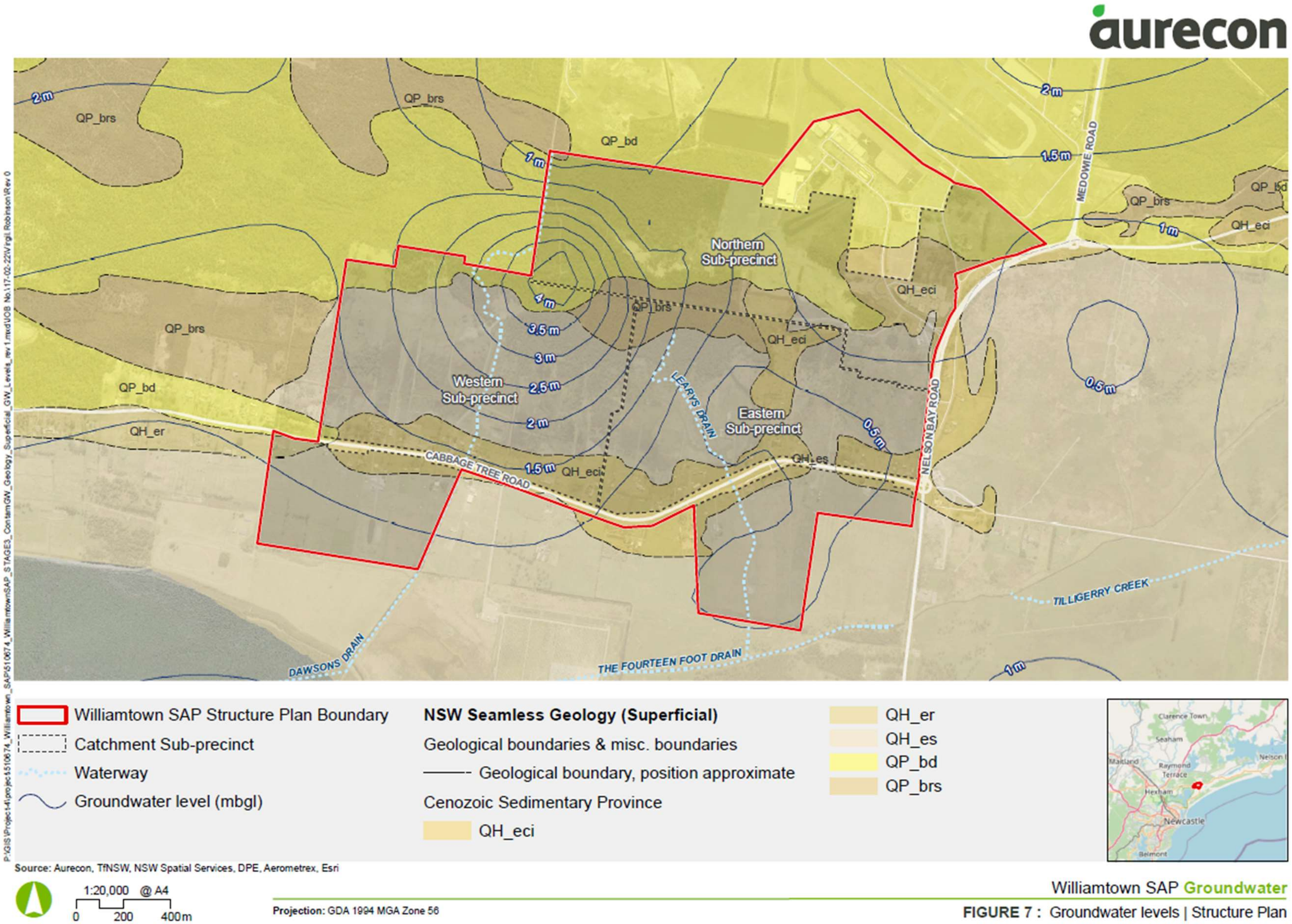


Figure 8 Williamtown SAP Structure Plan Groundwater Dependent Ecosystems

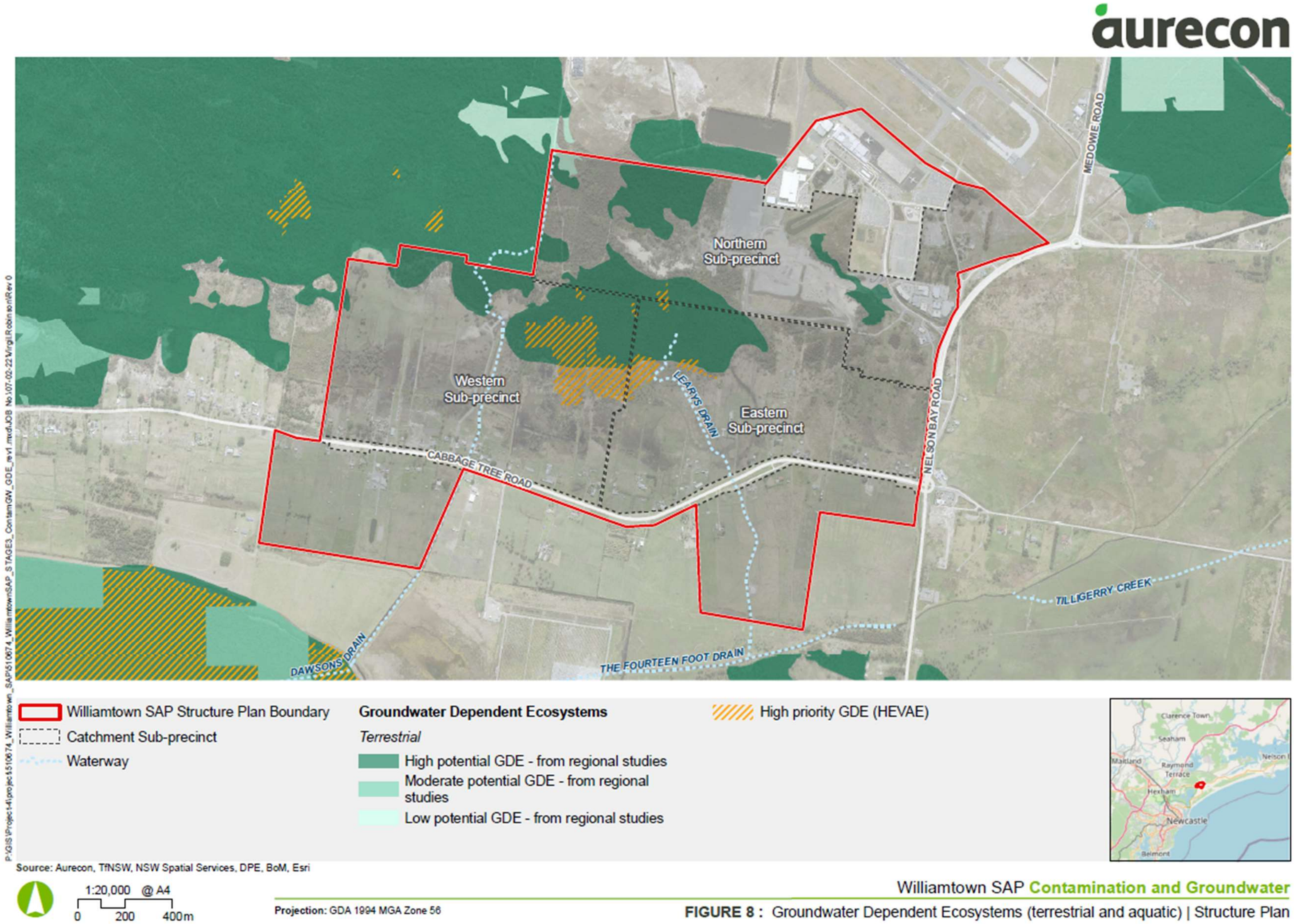


Figure 9 Williamtown SAP Structure Plan Aquifer Vulnerability (Source: Wooley, 1994)

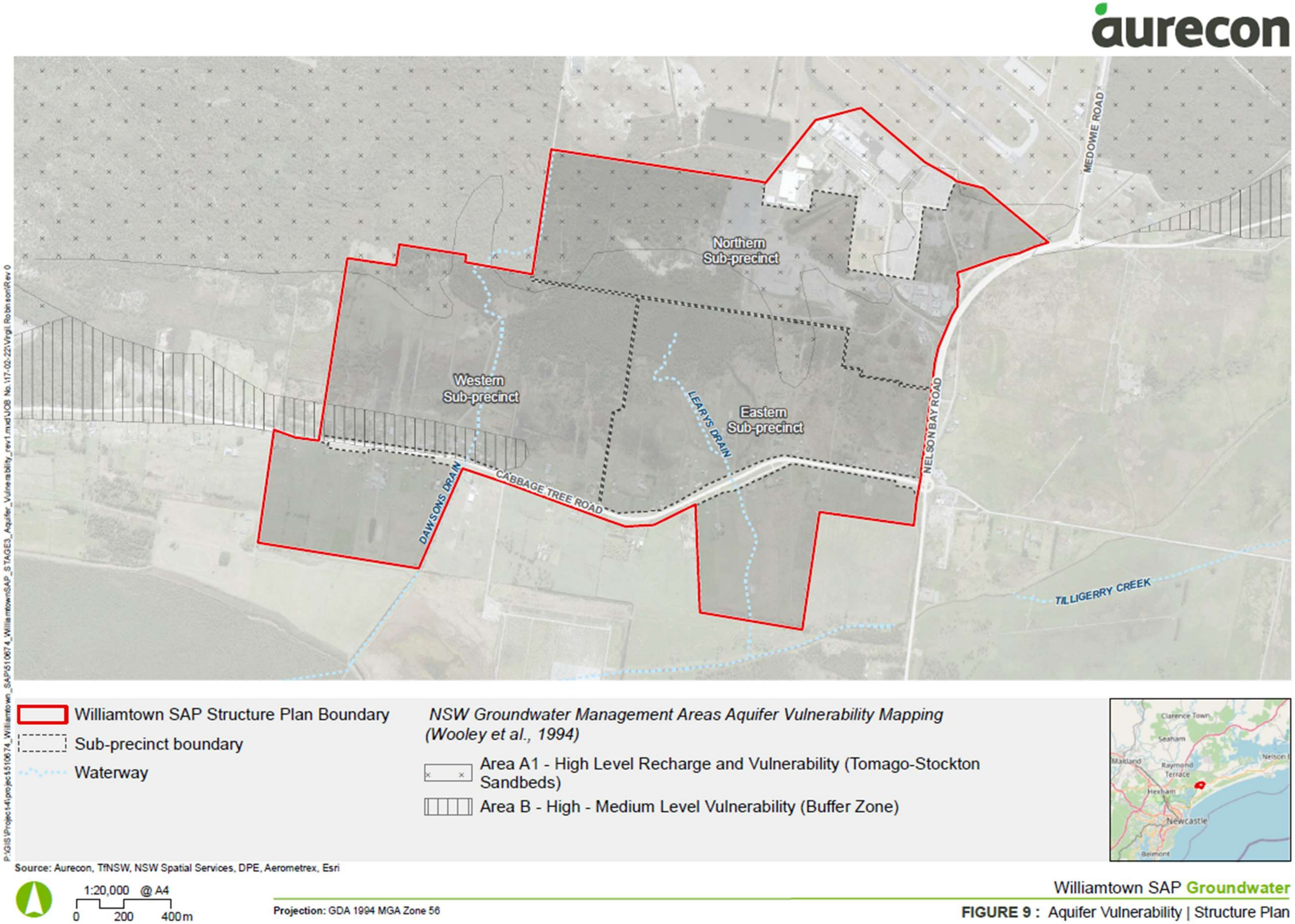
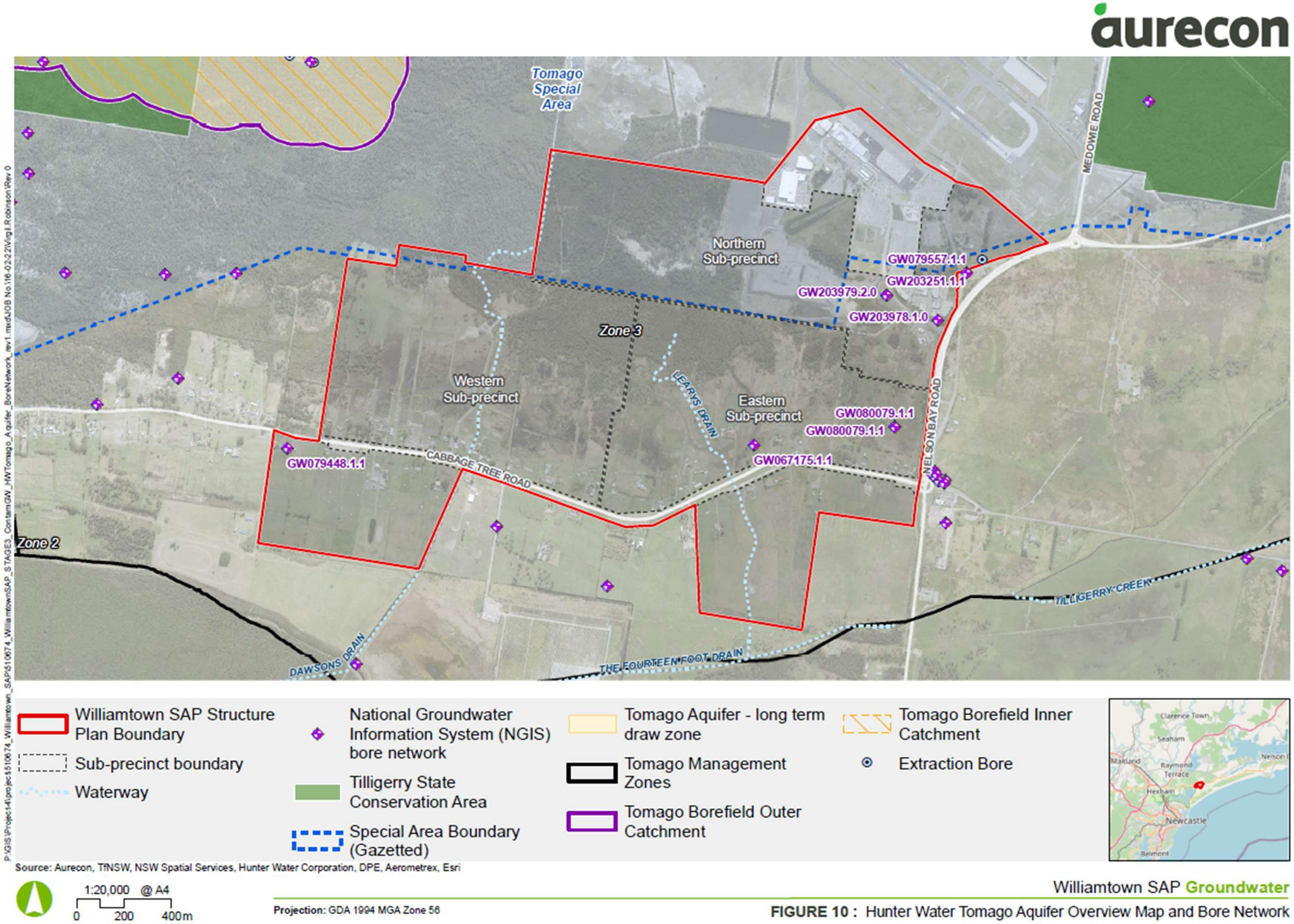


Figure 10 Williamtown SAP Structure Plan Groundwater Supply and Monitoring Network



Document prepared by

Aurecon Australasia Pty Ltd
ABN 54 005 139 873
23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W aurecongroup.com