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# Williamtown Special Activation Precinct

C3.2E PFAS and non-PFAS Contamination  
Structure Plan Report

**Department of Planning and  
Environment**

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# Executive Summary

NSW Department of Planning and Environment (DPE) has engaged Aurecon to prepare a suite of engineering technical studies to support the Williamstown Special Activation Precinct (Williamstown SAP). Aurecon has collected information from a desktop review of the publicly available information related to the presence of PFAS (per- and poly-fluoroalkyl substances) and non-PFAS contaminants throughout the Williamstown SAP. The data collected has been used to establish areas where future development in the Williamstown SAP may be constrained by PFAS and/or non-PFAS contamination.

Multidisciplinary Enquiry by Design (EbD) workshops were held during the constraints analysis. The EbD workshops were part of an iterative process that allowed for the testing of ideas, solutions, and concepts across all technical streams. The workshops discussed and developed numerous constraints and opportunities for various infrastructure relevant to the Williamstown SAP. The contamination (non-PFAS and PFAS) analysis was fed into the EbD workshops to capture the key master planning constraints and opportunities.

Based on the EbDs and opportunities and constraints analysis, the Williamstown SAP Structure Plan refined by Hatch Roberts Day is centred around the existing Williamstown Airport Precinct, which includes Newcastle Airport, Williamstown RAAF base and Astra Aerolab. The Williamstown SAP incorporates a core development area south of the existing airport. Initial stages of the Williamstown SAP development are to incorporate aerospace and defence contractor industries around the southern airside boundary of the airport. During later stages of the development, other catchments with land uses including research and development, freight and logistics, and a commercial core.

## PFAS Assessment and Constraints

Review of the available background information indicates that extensive PFAS assessment has been conducted at the RAAF Base Williamstown (the Base) and the surrounding areas. The areas of PFAS impacted environmental media are well defined relative to the Williamstown SAP structure plan. Aurecon reviewed environmental media data collected from 2016 to 2019 by AECOM on Base and in the Williamstown SAP area. The previously collected data indicates that soil, sediments, surface water and groundwater within the structure plan boundary are impacted with PFAS. The structure plan boundary is situated directly downgradient of Lake Cochran and other secondary sources on Base. The approximate eastern half of the structure plan is situated over the groundwater plume that is showing the highest PFAS concentrations. Environmental media analytical data indicates that there are exceedances of the NEMP v2 Tier I screening values. This includes soils and sediment in and around the drainage networks, surface water the emanates from the Base and the groundwater plume as noted above.

During the future construction, the potential risks from the PFAS impacted environmental media will need to be managed. The general measures to mitigate the risk of mobilising PFAS during the future development are summarised below. These mitigation measures should be implemented in conjunction with the flooding, WSUD and geotechnical mitigation strategies.

- Flooding is a major constraint to the developable area within the structure plan boundary. The flooding and WSUD and geotechnical management measures, included under separate cover, include a combination of strategies to manage flooding and water quality across the SAP.
  - To facilitate development within the floodplain, bulk filling to above the regional 1% Annual Exceedance Probability plus year 2100 climate change flood level (approximately 2-4 m thickness) will be required.
  - The filling must strike a balance with not creating flood impacts and not mobilising PFAS. This will require design of floodplain management measures to mitigate and offset flood impacts.
  - Bulk filling is also required to facilitate drainage of development lots and roads within the precinct. WSUD measures such as wetlands will also be incorporated to treat stormwater and operate as

detention basins during major events. Further details on the WSUD and flooding strategies are included in *B.3.2E: Flooding and Water Cycle Management Report*.

The flooding and stormwater management strategy would possibly include some or all of the following measures:

- Accommodating flood impacts and repurposing severely flood affected property within the Williamstown SAP
- Flood detention to mitigate impacts on downstream development
- Preserving floodways to mitigate impacts on upstream and adjacent development
- Water quality treatment provided by wetlands within drainage corridors

The flood mitigation and stormwater management measures must also consider the potential to mobilise PFAS impacted groundwater, sediment, soil and surface water. The measures to mitigate the potential mobilisation of PFAS include:

- Bulk filling for flood immunity
- If necessary, groundwater could be pumped, treated and reinjected into the aquifer to maintain current recharge levels during the construction phase.
- Installation of a geosynthetic clay liner (GCL) in areas of bulk filling to separate clean material from potentially PFAS impacted groundwater and soil.
- Several minor drains within the development are being removed / filled in and will be replaced by formal pit and pipe networks lines. Where the drains are modified by either expansion or installation of new ones or filled in and replaced with a pit and pipe drainage network, PFAS impacted soil / sediment may have to be managed. The most efficient manner would be stabilisation with powdered activated carbon (PAC) and off-site disposal once a suitable facility that will receive the material is located. Alternatively, an SAP specific Resource Recovery Order and Resource Recovery Exemption under the *Protection of the Environment Operations (Waste) Regulation 2014 (Waste Regulation)* could be developed in consultation with the appropriate agencies. Establishing a SAP specific RRO / RRE could provide a sustainable option to beneficially reuse PFAS impacted soil
- The new drainage pit and pipe network could be sealed to prevent groundwater intrusion
- The water quality wetlands are envisioned to be constructed in areas downstream of each catchment area across the SAP. Based on the available data, there is a low likelihood of encountering elevated concentrations of PFAS in soil or groundwater this area. There could be trace amounts of PFAS in soils in these areas so during excavation / construction, the soil could be managed as above. Future monitoring of water quality leaving these basins will be required during the operational phase of the Williamstown SAP.
- Where WSUD measures in the street or on lot are proposed with unlined bases, the risk of PFAS intrusion into these measures should be assessed during concept or detailed design and the design adapted accordingly;
- Passive treatment systems constructed of PAC should be installed at the stormwater collection outlets to treat any minor amounts of PFAS that has entered the drainage system prior to release to local waterways. The WSUD measures will be designed to treat frequent storm events (up to around the 3-month Annual Recurrence Interval). High flows which bypass the WSUD measures will be allowed to discharge untreated. In other areas, the need for passive treatment should be evaluated based on the risk of encountering PFAS.

It is envisaged that a combination of the above mitigation measures would be employed to minimise the potential that PFAS will be mobilised during and after construction of the Williamstown SAP. It is important to note that the development of the Williamstown SAP is not intended to remediate the PFAS impacts but ensure PFAS is not mobilised to areas where it is not currently detected. The proposed combination of mitigation measures is summarised as:

- The eastern portion of the Williamstown SAP is situated over the heart of the PFAS groundwater plume. In this area, a GCL would be necessary. The addition of PAC to the bottom 0.5-0.75 m of the clean fill material could also be considered as complimentary and conservative measure.
- The analytical data indicates limited to no elevated PFAS concentrations in the western portion of the Williamstown SAP. In this area, the need for a GCL should be critically evaluated. Addition of PAC into the bottom 0.5-0.75m of fill material should be sufficient to mitigate risks of clean fill interacting with PFAS impacted environmental media or becoming a secondary source.
- A passive treatment system should be installed at the most downstream end of Dawsons Drain and Leary's Drain. The majority of the water that would flow through these drains would be considered "clean" as it would only interact with the clean imported fill material and future buildings and ancillary facilities. However, there are likely PFAS impacted soils / sediments in the drains that could continue to leach to stormwater. These drains will continue to receive drainage from the Base as well which has to be assumed to be PFAS impacted. As a precautionary and conservative measure, the outlets to these drains should be equipped with a passive treatment system;

These mitigation measures will require ongoing operation and maintenance (O&M) and monitoring, the requirements of which will be developed in future stages of the project. The O&M and monitoring requirements will be detailed in a Long Term Environmental Management Plan (LTEMP) which will be developed in future stages of the project.

An additional consideration for the SAP development will be the maintenance of the monitoring well network in the structure plan boundary area. These monitoring wells were installed by Defence and will need to be maintained for long term monitoring of the groundwater plume. Protection of these monitoring wells should be integrated into the bulk filling plan. The location of the network is noted in the AECOM Interim Monitoring Event Report - RAAF Base Williamstown report (2019). Additionally, development control plans or other planning mechanisms will be required for installation of the GCL. The control measures would revolve around foundation design, service installation and plantings with deep root zones to ensure the GCL is not damaged.

## Non PFAS Assessment and Constraints

The review of the available background information has identified numerous Areas of Potential Environmental Concern (APECs) throughout the SAP area where non-PFAS Contaminants of Potential Concern (COPCs) may be present at concentrations above the applicable Tier I screening values. There are several APECs within the Williamstown SAP structure plan boundary. However, specific reports related to investigation of these areas have not been reviewed so specific concentrations of COPCs in environmental media are not known at these sites at this time. The constraints rating has been based on the land use at the APEC and Aurecon's experience with previous similar projects. Therefore, the constraints analysis for the non-PFAS APECs is qualitative and can be refined when environmental media samples are analysed to determine if COPCs are present.

Specific mitigation measures cannot be developed without additional information on the APECs and environmental media analytical data. Investigation of soil and / or groundwater should be undertaken as part of, or prior to, concept design to confirm the extent and significance of non-PFAS contamination in the identified APECs. The data collected will inform likelihood of remediation required under the SEPP 55 process, inform potential design constraints, risks to human and ecological receptors as well as establishing a preliminary waste classification of the excavated soils.

# 1 Introduction

## 1.1 Background and Context

NSW Department of Planning, Industry and Environment (DPIE) has engaged Aurecon to prepare a suite of environmental technical studies to support the Williamstown Special Activation Precinct (SAP) Master Plan. The Williamstown SAP Master Plan process follows five key stages as illustrated in **Figure 4 – Appendix A**

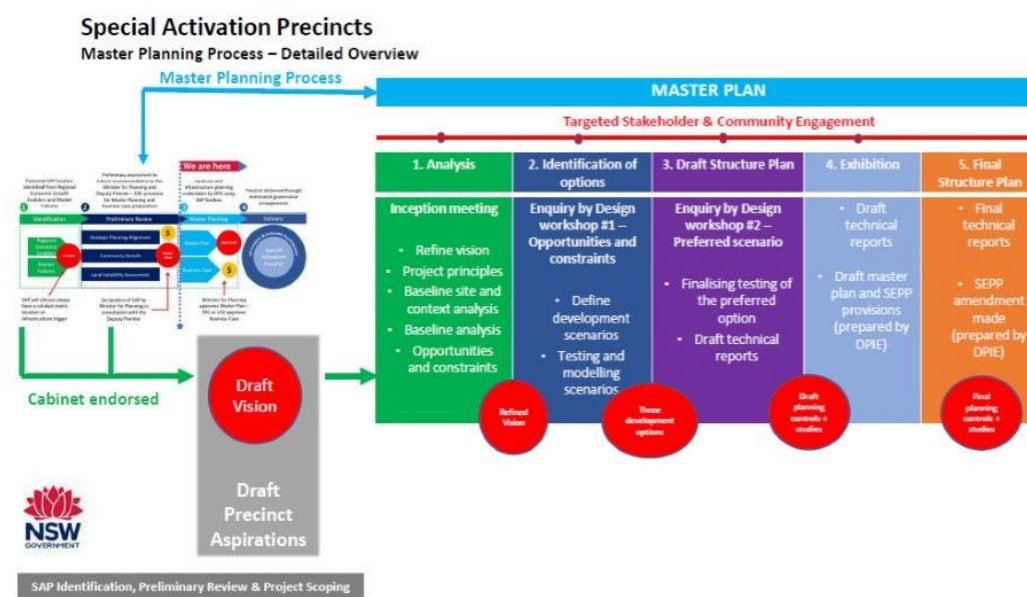


Figure 1 Williamstown SAP Master Plan Process

### Figure 1-1: Summary of SAP Master Planning Process

Multidisciplinary Enquiry by Design (EbD) workshops were held during the constraints analysis. The EbD workshops were part of an iterative process that allowed for the testing of ideas, solutions, and concepts across all technical streams. The workshops discussed and developed numerous constraints and opportunities for various infrastructure relevant to the Williamstown SAP. The contamination (non-PFAS and PFAS) analysis was fed into the EbD workshops to capture the key master planning constraints and opportunities.

The workshop discussed and developed numerous constraints and opportunities for various infrastructure relevant to the precinct and SAP area. The Structure Plan scenarios were developed to align with the precinct vision. These scenarios are based on spatial outcomes and growth scenarios were further tested throughout the constraints analysis.

Based on the EbDs and opportunities and constraints analysis, the Williamstown SAP Structure Plan refined by Hatch Roberts Day is centred around the existing Williamstown Airport Precinct, which includes Newcastle Airport, Williamstown RAAF base and Astra Aerolab. The Williamstown SAP incorporates a core development area south of the existing airport. Initial stages of the Williamstown SAP development are to incorporate aerospace and defence contractor industries around the southern airside boundary of the airport. During

later stages of the development, other catchments with land uses including research and development, freight and logistics, and a commercial core.

To maximise and balance the outcome, the scenarios required assessment by each technical discipline and the overall objectives of the Williamstown SAP. Through the process of a Strength, Weakness, Opportunity and Threat (SWOT) Analysis, the scenarios are tested and evaluated in this report in relation to PFAS and non-PFAS contamination. The following tasks were undertaken during the iterative process to test various constraints and opportunities:

- Updated strategic context and regulatory review based on our developing understanding of the Williamstown SAP development
- Review of the key findings from the Stage 1 baseline analysis, particularly the opportunities and constraints
- Review of the proposed scenarios and updated understanding of the constraints and opportunities from the baseline report and other technical streams
- Establishment of an assessment framework for this technical stream and integrating other technical streams as applicable
- Comparative analysis that assessed and compared opportunities and constraints against established testing criteria
- SWOT analysis to evaluate the strengths, weaknesses, opportunities and threats

In developing the SWOT analysis, collaboration was conducted with the other Williamstown SAP technical packages, particularly geotechnical and flooding. This has helped to integrate our understanding of the constraints and opportunities and align the preliminary mitigation measures required for the proposed scenarios.

## 1.2 Williamstown SAP and Objective

The purpose of this Report is to consolidate and test the opportunities and constraints developed during the constraints analysis phase against the Williamstown SAP's vision. The overall objective is to establish a structure plan that would progress to further stages of design and development.

The vision has been iteratively tested and refined throughout this process, while identifying project ideas and opportunities for the precinct. All consultant teams met for two rounds of EbD workshops to align constraints and opportunities, which were based off their findings from prior assessments and investigations.

## 1.3 Williamstown SAP Scope

During the Preliminary EbD workshop, the broader consultant team were briefed on opportunities and constraints of all the disciplines, which were further tested, modelled and refined in this Report. The scope of works for this Report includes:

- An assessment of the relevant opportunities and constraints from other disciplines to identify the strengths and weaknesses in terms of potential constraints posed by the presence of PFAS and non-PFAS contamination.
- Areas where further assessment, management or remediation may be required to facilitate development of the Williamstown SAP structure plan boundary.
- Proposed general mitigation measures to manage PFAS and non-PFAS contamination that may be encountered during future SAP development stages.
- An understanding of the interdependencies between the technical studies, opportunities and constraints.



- A demonstration that future development within the precinct will not result in the further mobilisation of PFAS and / or non-PFAS contamination or generate negative impacts to local stakeholders or the natural or built environment.
- General recommendations on any further assessment required to support each scenario.

## 1.4 Williamstown SAP Contamination (PFAS and non-PFAS) Strategic Context

### 1.4.1 Non-PFAS Contamination

Non-PFAS contamination within NSW and the Williamstown SAP is managed and monitored by the NSW Environment Protection Agency (EPA) and planning authorities, including the Department of Planning, Industry and Environment and local councils. The EPA regulates the investigation, remediation, and ongoing monitoring of contaminated land to protect human health and the environment.

Contamination may pose a potential risk to human health and / or the environment, limit one or more beneficial land uses and / or increase development costs for the Williamstown SAP. Contaminated land is typically grouped in areas that have been used for heavy development or industry such as Defence bases and operations, airports, industrial facilities or agricultural activities, or individual sites that store chemicals, such as service stations and dry cleaners.

The management framework for contaminated land in NSW broadly consists of two tiers:

- The EPA, which uses its authority under the *Contaminated Land Management Act 1997* (CLM Act) to regulate sites with COPC concentrations that are “significant enough to warrant regulation” given the site’s current or approved use. There is a wide range of local, state and federal legislation and guidelines that are enforced by the EPA during this process.
- Planning authorities, who regulate potentially contaminated sites under the planning and development process, including State Environmental Planning Policy No. 55 - Remediation of Land and the Managing Land Contamination - Planning Guidelines (SEPP 55). These are sites that may contain measurable COPC concentrations and pose potential risks to human health or the environment but are not deemed to be “significant enough to warrant regulation.” The SEPP55 process is managed through the Development Application process. The requirements for assessment and / or remediation are listed as Conditions of Consent with which a developer or responsible party must comply. The SEPP55 process also typically requires the engagement of a NSW EPA Accredited Auditor. An Auditor is a private company or individual that acts on behalf of the EPA to ensure assessment and remediation works are completed in accordance with all relevant local, state and federal legislation guidelines.

The EPA also administers the NSW site auditor scheme, makes or approves guidelines for assessing and remediating contaminated land, and manages the public record of regulated sites under the CLM Act. The EPA may also:

- Review technologies under the *Environmentally Hazardous Chemicals Act 1985* (EHC Act) and assess proposed technologies for treating certain chemical wastes (such as scheduled chemical wastes) to establish their effectiveness.
- Assess licence applications for remediation proposals as part of the integrated development assessment process.
- Issue and enforce licences that regulate waste treatment, storage and/or disposal facilities, under the *Protection of the Environment Operations Act 1997* (POEO Act) or the EHC Act.
- Issue clean-up and prevention notices under the POEO Act.

The National Environmental Protection (Assessment of Site Contamination) Measure 2013 is the primary piece of federal legislation that governs the assessment of site contamination in Australia. It is a statutory

instrument that specifies national standards for a variety of environmental issues when investigating contaminated sites. The NEPM is binding on all Governments that are members of the National Environment Protection Council (NEPC), which was established under the *Commonwealth National Environment Protection Council Act 1995*.

### 1.4.2 PFAS Contamination

PFAS stands for per- and poly-fluoroalkyl substances and are manufactured chemicals used in products that resist heat, oil, stains and water. The chemicals have been used in Australia and around the world in many common household products and specialty applications.

Legacy firefighting foams containing perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) as active ingredients were once used extensively worldwide and within Australia, including at Defence bases, due to their effectiveness in fighting liquid fuel fires. Perfluorohexane sulfonate (PFHxS) is also commonly found in the legacy firefighting foam as an impurity in the manufacturing process.

The Williamstown SAP includes properties impacted by PFAS contamination; landholders may have suffered loss or damage as a result of this contamination. During future stages of the SAP process, it will be critical to engage with the local stakeholders to help develop the mitigation measures that will have the least impact on the local community and the sensitive local environment.

PFAS contamination within the RAAF Base Williamstown is not regulated by NSW state or local government agencies as the Base is Commonwealth property. Aurecon understands that the Department of Defence has engaged an NSW EPA Accredited Auditor who reviews the assessment and remediation works completed and endorses that the works meet the applicable guidelines and legislation. However, the NSW EPA has regulatory jurisdiction for areas outside the RAAF Base Williamstown boundary but within the Williamstown SAP area.

In 2015, NSW EPA promulgated a 'PFAS Investigation Area', along with health advisories for businesses, properties and residents within the boundaries. In 2017, the Williamstown PFAS Management Area Map was issued which divided the PFAS impacted region into three 'Management Zones' where certain activities were prescribed or not recommended:

- Primary Management Zone – significant PFAS concentrations where strongest health advice applies.
- Secondary Management Zone – areas which have elevated levels of PFAS.
- Broader Management Zone – topography and hydrology of the area indicates PFAS may be detected in the future in this area.

The intent of the management zones was to enable the effective application of health advice regarding use and management of groundwater across the wider Williamstown region, along with health advisories issued by NSW Health regarding contact with impacted water and home grown produce. The most recent PFAS Management Area Map (December 2017) is presented in **Figure 5 – Appendix A**. The PFAS management zones occupy approximately one-third of the area of the Williamstown SAP.

Immediately south of the base and extending to Cabbage Tree Road is the Primary Management Zone, this area contains the highest groundwater PFAS concentrations. The groundwater plume extends south from the base covering this area, being driven by hydraulic head from Lake Cochran on the south boundary of the Base. Between Cabbage Tree Road and Fourteen Foot Drain to the south, and from the eastern base boundary extending east along Nelson Bay Road to Tilligerry Creek is the Secondary Management Zone, and the remainder of the areas adjacent are classified as the Broader Management Zone.

## 1.5 Regulatory Framework – Non-PFAS Contamination

The following section provides a summary of the legislation and guidelines relating to the assessing, managing and remediating sites where sites have been “traditional” chemicals of potential concern (COPCs).

- National Environmental Protection Measure for the Assessment of Contaminated Sites 1999 (Amendment 2013)
- Contaminated Land Management Act 1997 (CLM Act)
- Protection of the Environment Operations Act 1997 (POEO Act)
- Protection of the Environment Operations (Waste) Regulation 2014
- Protection of the Environment (Operations) Excavated Natural Material Exemption 2014
- Waste Avoidance and Resource Recovery Act 2001
- NSW EPA, Guidelines for Consultants Reporting on Contaminated Sites, 2020
- NSW EPA, Waste Classification Guidelines Parts 1 to 4, 2014
- New South Wales State Environmental Planning Policy Number 55 – Remediation of Land
- NSW Protection of the Environment Operations (Underground Petroleum Storage Systems [UPSS]) Regulation 2014
- Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act)

## 1.6 Regulatory Framework – PFAS Contamination

The PFAS National Environmental Management Plan (NEMP) provides nationally agreed guidance on the management of PFAS contamination in the environment, including prevention of the spread of contamination. It supports collaborative action on PFAS by the Commonwealth, state and territory and local governments around Australia. The NEMP is an Appendix to the Intergovernmental Agreement on a National Framework Responding to PFAS Contamination.

## 2 Summary of Baseline Assessment Information

### 2.1 Non-PFAS Baseline Analysis Summary

Contamination may limit a particular beneficial land use or increase costs for developers. The investigation and remediation of contaminated land is important to protect human health and the local environment. This sub-section presents a preliminary assessment of sites that may be impacted by non-PFAS chemicals of potential concern (COPCs) based on the information collected from desktop assessments and its suitability for land development. The following descriptions are general provisions that apply to any contaminated land project associated with a redevelopment project. The exact planning pathways for the Williamstown SAP may differ slightly than the general provisions below.

#### 2.1.1 Areas of Environmental Concern

Available site historical data and observations review identified the Areas of Environmental Concern (AECs) and COPCs within or directly adjacent to the Williamstown SAP in **Table 1**, below and also shown on **Figure 7 – Appendix A**. Additional details on the APECs are included in **Appendix B**. If there are significant COPC concentrations these could migrate and lead to subsurface impacts in the SAP. Management or remediation may be required to restore one or more beneficial land uses.

There is also potential to encounter Acid Sulfate Soils and Potential Acid Sulfate Soils in the Williamstown Area. The ASS/PASS risk mapping produced from the NSW SEED web portal is included in **Figure 2 – Appendix A**.

**Table 1 Potentially Contaminated Land in the Williamstown SAP**

Activity	Location
Car and bus washes	Located throughout the Williamstown SAP.
Cranes used for construction or development	Two small sites located near the western and south western boundary adjacent to Tomago Road
Department of Defence – Williamstown RAAF Base and Airport	Centre of the Williamstown SAP with historical legacy and operational issues associated with hydrocarbons spills, metal contamination, sewage treatment, UXO and waste materials.
Energy Australia Sub Station	A small site located south of Tomago Road near the southern boundary adjacent to Nelsons Bay Road
Filing of Land	Medium sized site located near the eastern boundary adjacent to Lemon Tree Passage Road
Landfills	Numerous small and large landfills located throughout the Williamstown SAP.
Landfill – Effluent Lagoon	Large site located directly south of Williamstown RAAF Base Airport, north of the intersection of Tomago Road and Nelsons Bay Road
Landscape supplies	Two medium sized sites, one located to the immediate north of the Williamstown SAP, adjacent to Richardson Road and another located near the eastern boundary of the SAP, adjacent to Lemon Tree Passage Road
Large area used for car parking / storage	Located immediately west of the Williamstown SAP adjacent to Tomago Road
Large area used for truck parking / storage	Located near the eastern boundary adjacent to Lemon Tree Passage Road
Lattice Manufacturing	Medium sized site located to the immediate north of the Williamstown SAP, adjacent to Richardson Road
Plant Driving School – Mechanical Workshop	Small site located near the north western boundary.

Activity	Location
Pontoon and Dredging	Large site located near the north eastern boundary
Retail Plant Nursery	Numerous small and medium sized sites located predominately near the eastern and western boundary.
Sand mining and extraction	Numerous small and large sites located throughout the Williamstown SAP. Large site located adjacent to the south eastern boundary of the Williamstown SAP, immediately south of Nelsons Bay Road.
Sewage Treatment Works	The Grahamstown Water Treatment plant is located along the western boundary adjacent to Tomago Road.
Small Industrial Sheds	Small site located near the eastern boundary, south of Nelsons Bay Road
Small Light Industrial Workshop	Small site located near the eastern boundary south of Nelsons Bay Road
Smelter	One small site adjacent to south western boundary
Timber Yard	Small site located near the south eastern boundary adjacent to Nelsons Bay Road

## 2.1.2 Preliminary Constraints Analysis Approach

Qualitative hazards assessed for each of these AEC's were completed by estimating the likelihood of each identified potential Source-Pathway-Receptor linkage occurring and the foreseeable consequence of the exposure. The process followed in completing this is detailed in **Table 8** in **Appendix B**. Hazard ratings generated from this analysis are defined as:

- **Highly constrained:** High likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management.
- **Moderately constrained:** Moderate likelihood of encountering non-PFAS contamination at concentrations in some areas of the Scenario boundary that may require additional assessment, remediation or management.
- **Minimally constrained:** Low likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management or limited / isolated areas where non-PFAS contamination may require assessment, remediation or management.
- **Negligible:** No APECs identified within the Williamstown SAP.

It should be noted that the constraint rankings showed on **Figure 8 (Appendix A)**, are grouped as Negligible. Minimal, Moderate and High. The hazard ratings indicate the potential to encounter COPCs at concentrations above the applicable Tier I screening values as outlined in the NEPM 2013 and other applicable guidelines. The hazard ratings do not indicate that the AEC is actually contaminated rather the potential to encounter contamination that may be a constraint to consider in future stages of the project.

## 2.1.3 Constraints Analysis Findings

A qualitative assessment of the exposure potential and a hazard rating of the AECs identified through desktop study are listed in **Table 8 (Appendix B)**. This includes an assessment of the potential exposure pathways and receptors that may be affected through land development within the Williamstown SAP.

It is likely that chemicals of potential concern (COPCs) are present at concentrations above the applicable Tier 1 screening values at some specific sites within the Williamstown SAP. Overall, the likelihood of contaminants being present at concentrations that pose a risk of harm is considered to be 'Low' and 'High' in some specific areas, near landfills and mining activities.



The spread of hazard ratings for the Williamstown SAP was as follows:

- Seven 'Negligible to Low' ratings
- Thirteen 'Low' ratings
- Three 'Low to Moderate' ratings
- Six 'Moderate' ratings
- Eleven 'Moderate to High' ratings
- Seven 'High' ratings

The seven 'High' ratings included the following descriptions / contaminating activities:

- Demolition and liquid waste on land
- Department of Defence RAAF Williamstown RAAF Base & Airport development & land disturbance
- Department of Defence UXO
- Filling of land
- RAAF Drop Zone
- Sand extraction

## 2.1.4 Constraints Analysis Review Findings

To manage the risks of non-PFAS contamination as part of the land development, remediation and further quantification of the extent of contamination may be required.

Any additional assessment, management or remediation that may be required would be in accordance with the process in the State Environmental Planning Policy No 55 - Remediation of Land (SEPP 55). The SEPP55 provides for a State-wide planning approach to the remediation of contaminated land. In particular, it aims to promote the remediation of contaminated land for the purpose of reducing the risk of harm to human health or any other aspect of the environment:

- By specifying when consent is required, and when it is not required, for a remediation work, and
- By specifying certain considerations that are relevant in rezoning land and in determining development applications in general and development applications for consent to carry out a remediation work in particular, and
- By requiring that a remediation work meet certain standards and notification requirements.

It contains the following provisions:

- A consent authority must not consent to the carrying out of any development on land unless:
  - It has considered whether the land is contaminated, and
  - If the land is contaminated, it is satisfied that the land is suitable in its contaminated state (or will be suitable, after remediation) for the purpose for which the development is proposed to be carried out, and
  - If the land requires remediation to be made suitable for the purpose for which the development is proposed to be carried out, it is satisfied that the land will be remediated before the land is used for that purpose.
  - Before determining an application for consent to carry out development that would involve a change of use on any of the land, the consent authority must consider a report specifying the findings of a preliminary investigation of the land concerned carried out in accordance with the contaminated land planning guidelines.

- The applicant for development consent must carry out the investigation required and must provide a report on it to the consent authority. The consent authority may require the applicant to carry out, and provide a report on, a detailed investigation (as referred to in the contaminated land planning guidelines) if it considers that the findings of the preliminary investigation warrant such an investigation.
- The land concerned is:
  - land that is within an investigation area,
  - land on which development for a purpose referred to in **Table 1** to the contaminated land planning guidelines is being, or is known to have been, carried out,
  - to the extent to which it is proposed to carry out development on it for residential, educational, recreational or childcare purposes, or for the purposes of a hospital-land:
  - in relation to which there is no knowledge (or incomplete knowledge) as to whether development for a purpose referred to in **Table 1** to the contaminated land planning guidelines has been carried out, and
  - on which it would have been lawful to carry out such development during any period in respect of which there is no knowledge (or incomplete knowledge).
- General Procedures Post Rezoning:
  - A Phase 1 investigation will generally be required for each individual land parcel as part of the Development Application requirements, regardless of whether contamination is thought to be present. This is a preliminary site investigation which should identify all past and present potentially contaminating activities and potential contamination types and discuss the site condition and provide a preliminary assessment of the contamination and the need for further investigations.
  - Should further investigation be required, a Phase 2 detailed investigation (intrusive) and a subsequent Remediation Action Plan (RAP) will also be required to be prepared to support the Development Application. Development consent will not be granted for the intended land use unless these requirements are met.

NSW Guidelines for Reporting on Contaminated Sites (EPA, 2020) advises that a Phase 2 investigation should provide comprehensive information on the type, extent and level of contamination and any other issues raised in the preliminary investigation. The Phase 2 should provide to an assessment of:

- Contaminant dispersal in air, surface water, groundwater, soil and dust
- Potential effects on public health, the environment and building structures
- Off-site soil, sediment and biota impacts (if applicable)
- The adequacy and completeness of all information used to make decisions on remediation.

A Phase 2 investigation would likely be required on lots where a land use change is proposed, such as existing commercial or open space areas proposed for residential development. As the remediation requirements are more lenient for commercial and open space areas, this assessment will ensure that the more rigorous requirements for residential developments can be achieved. Following the Phase 2 investigation and should the investigation identify the need to remediate the site, a Remediation Action Plan (RAP) may need to be prepared (by a suitably qualified person) for sites where contamination has been identified. The objective of the RAP is to set remediation goals to ensure the site is suitable for its proposed use and will pose no unacceptable risk to human health or the environment.

The appropriate environmental safeguards will need to be established, and proof of necessary approvals and licences required by regulatory authorities should also be included.

After remediation works are complete, a validation report must be prepared (by a suitably qualified person) to ensure that all objectives in the RAP have been achieved. This report must assess the results of post-remediation testing and provide reasons where targets have not been achieved. The report should also confirm that all licence conditions and approvals have been met, including evidence that any soil disposed of

off site is done in accordance with the RAP. Guidance on these requirements can be found in the Contaminated Sites Sampling Design Guidelines (NSW EPA, 1995).

An ongoing site monitoring program may be required where full remediation cannot be achieved, or where on-site containment of contamination is proposed. The program should detail the strategy, parameters, locations and frequency of monitoring, as well as the associated reporting requirements.

### 2.1.5 Preliminary non-PFAS contaminated land constraints map

Based on the information gathered from the baseline data review (Aurecon 2020) and the risk assessment the potential contaminated land constraints within the Williamstown area presented in **Figure 8 - Appendix A**.

Based on the combination of non-PFAS contamination hazards, the following potential risks to the construction and operations activities during future Williamstown SAP are possible:

- Hazards to future site users;
- Hazards to onsite construction workers;
- Hazards to the onsite and adjacent environment from construction activities disturbing or mobilising contaminated materials; and
- Hazards to the onsite and adjacent environment from site operations disturbing or mobilising contaminated materials.

The AECs identified have been categorised into 'highly', 'moderately' and 'minimally' constrained areas for **Figure 8 - Appendix A**. These are defined as:

- **Highly constrained:** High likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management
- **Moderately constrained:** Moderate likelihood of encountering non-PFAS contamination at concentrations in some areas of the Scenario boundary that may require additional assessment, remediation or management
- **Minimally constrained:** Low likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management or limited / isolated areas where non-PFAS contamination may require assessment, remediation or management
- **Negligible:** No APECs identified within the Scenario Boundary.

It should be noted that the information included in this report is based on review of publicly available information and information supplied by Port Stephens Council and Hunter Water. Specific reports or information on these AECs were not reviewed as part of this Baseline Analysis. The identification of potentially contaminating activities and related COPCs are based on the nature of the activities at the identified AEC. Aurecon utilised our experience with similar sites and information included in the POEO to summarise the potentially contaminating activities and COPCs. It is important to note that activities at the identified AECs may not have led to subsurface contamination or with all the listed COPCs. As a conservative baseline of information, to inform future stages of the project, all potentially contaminated sites have been identified as an AEC. During future stages of this project, additional detail will be requested and reviewed to further refine the AEC table. This could include the need to undertake intrusive investigations at select AECs to further refine the information included in **Table 8 in Appendix B**.

## 2.2 Summary of Baseline Information – PFAS

### 2.2.1 Contamination (PFAS)

The Williamstown SAP area includes properties impacted by PFAS contamination; landholders may have suffered loss or damage as a result of this contamination. During future stages of the SAP process, it will be

critical to engage with the local stakeholders to help develop the mitigation measures that will have the least impact on the local community and the sensitive environment.

PFAS contamination associated with the RAAF Base Williamstown is not regulated by NSW state or local government agencies as the Base is Commonwealth property. Aurecon understands that the Department of Defence has engaged a NSW EPA Accredited Auditor which reviews the assessment and remediation works completed and endorses that the works meet the applicable guidelines and legislation. However, the NSW EPA has regulatory jurisdiction for areas within the SAP that are outside of the Base boundaries. The PFAS risk ranking and PFAS Management Areas are shown on **Figure 5** and **Figure 9**, respectively Appendix A.

In 2015, NSW EPA promulgated a 'PFAS Investigation Area', along with health advisories for businesses, properties and residents within the boundaries. In 2017, the Williamstown PFAS Management Area Map was issued which divided the PFAS impacted region into three 'Management Zones' where certain activities were prescribed or not recommended:

- Primary Management Zone – significant PFAS concentrations where strongest health advice applies
- Secondary Management Zone – areas which have elevated levels of PFAS
- Broader Management Zone – topography and hydrology of the area indicates PFAS may be detected in the future in this area

The intent of the management zones was to enable the effective application of health advice regarding use and management of groundwater across the wider Williamstown region, along with health advisories issued by NSW Health regarding contact with impacted water and home grown produce. The most recent PFAS Management Area Map (December 2017) is presented in **Figure 5 - Appendix A**. The PFAS management zones occupy approximately one-third of the area of the Williamstown SAP.

Immediately south of the base and extending to Cabbage Tree Road is the Primary Management Zone, this area contains the highest groundwater PFAS concentrations.

The groundwater plume extends south from the base covering this area, being driven by hydraulic head from Lake Cochran on the south boundary of the Base. Between Cabbage Tree Road and Fourteen Foot Drain to the south, and from the eastern base boundary extending east along Nelson Bay Road to Tilligerry Creek is the Secondary Management Zone, and the remainder of the areas adjacent are classified as the Broader Management Zone.

The institutional controls include the NSW Government precautionary advice to minimise exposure to PFAS originating from the Base. These recommendations were initially made for the 2015 Investigation Area and where updated in 2017 for the NSW EPA Williamstown Management Area. These controls are listed in **Table 2**.

Table 2 Institutional Controls

Item	NSW Government Precautionary Advice
Primary Management Zone	<p>Groundwater, bore water and surface water should NOT be used for any purpose. Additionally, do not utilise groundwater or surface water for any beneficial purpose including, including in creeks and drains that might lead to incidental ingestion (swallowing).</p> <p>Home grown foods produced in this area should NOT be consumed. This includes home-slaughtered meat, poultry, eggs, milk, fruit and vegetables.</p>
Secondary and Broader Management Zones	<p>Do not use groundwater, bore water or surface water for drinking or cooking. Avoid swallowing groundwater or surface water when bathing, showering, swimming and paddling (including in creeks and drains). Groundwater and surface water should NOT be used for swimming or paddling pools</p> <p>Avoid eating home grown food produced in your area – including home-slaughtered meat, eggs, milk, poultry, fruit and vegetables</p>

## 2.2.2 RAAF Base Williamstown Summary

Aurecon has reviewed several recent and historical reports related to the extensive assessment activities conducted on around the RAAF Base Williamstown (the Base). All of the reports were prepared by AECOM and referenced in the following discussions.

The nature, extent, fate and transport of the contamination within the Management Area based on the ESA (AECOM, 2107a) and PFAS Area Management Plan (PMAP, AECOM 2019b) is generally described by the following:

Extent of groundwater impacts:

- Data collected shows multiple overlapping PFAS plumes exist – generally originating from the on-Base Source Areas described in **Table 9** in Appendix B. The AECOM investigations have identified that concentrations decrease with distance from the Base. Sorption-desorption and the transfer of PFAS through both groundwater and surface water are significant processes.
- The dominant groundwater flow direction is to the south and south-east. The PFAS plumes originating from the primary Source Areas on the Base and are merging and moving southward through the Management Area, with the available PFAS data indicating that the PFAS plume is approximately 5 km long and 5 km wide (across the axis of migration).
- PFAS is also present in groundwater to the east of the Base, including Salt Ash, likely to be related to surface water migrating along the drain network (Moors Drain and associated tributaries) before infiltrating to groundwater.
- Groundwater in the Tomago Sand beds aquifer flows to the south-east from the Base and the deeper flow paths in this system discharge upward into the upper reaches of the Tilligerry Creek drainage system. This provides a pathway for the PFAS plume to move deeper in the aquifer south of the Base then discharge upward into the creek's upper reaches to the south-east.
- The isolated detections of PFAS in areas away from the groundwater plume are likely a result of flooding and overbank flow away from the drainage network, or an unidentified off-Base source.



#### Extent of **surface water** impacts:

- All major on-Base drains contain PFAS in surface water and sediments.
- Runoff from the south-western boundary of the Base principally discharges through Dawsons Drain. The three principle discharge points on the eastern boundary all discharge to Moors Drain. The flow mechanism in Moors Drain is anticipated to be a result of a gaining-losing stream from the adjacent shallow water table, and the vertical flow component would be minor. Where these drains intersect the groundwater plume, it is inferred that when groundwater levels are elevated, discharge to surface water can occur, causing groundwater to enter open drains.
- When groundwater levels are lower (such as in prolonged dry weather) it is inferred that PFAS impacted water in the drains is leaching into underlying shallow groundwater. It is inferred that the separate plume of groundwater impact observed in the Salt Ash / Tilligerry Creek area (from Moors Drain) and along Cabbage Tree Road (from Dawsons Drain), are likely to be caused by this mechanism (although it is also possible that there is an unidentified PFAS source in these areas).
- It is likely that flooding from the major drains has and will disperse PFAS to surface soils and potentially to shallow groundwater as water levels fall.

#### Extent of **sediment** impacts:

- Approximately 20 sediment samples were collected from the off-Base drains that lead to Fullerton Cove and other discharge points. Nearly all samples showed measurable PFAS concentrations but at very low concentrations <0.001 mg/kg in most instances. Although the low concentrations, there is still potential for PFAS to leach from the sediment to stormwater.
- Given the age of the PFAS groundwater plume, it is likely in chemical equilibrium. PFAS concentrations over time are expected to reduce as Defence continues to remediate the identified primary and secondary sources on the RAAF Base. PFAS impacted groundwater will likely need to be managed in the areas directly south of the Base and up to Cabbage Tree Road. PFAS impacted sediments in off Base drains would also require management during implementation of the flood management strategy. General mitigation measures are outlined in later sections of the report.

## 2.2.3 Identified Constraints and Consequences

There are multiple PFAS Source Areas spread over a wide area of the Base. Each Source Area has different potential to contribute to PFAS impacts which are variably migrating off the Base via groundwater migration or in stormwater flow via drains across the eastern and western boundaries. The key PFAS migration pathways include:

- Groundwater migration to the south of the Base; and
- Surface water runoff to the east of the Base to Moors Drain and south of the Base to Dawsons Drain.

The relative contribution of PFAS impacts from each of the PFAS source areas identified by the Environmental Site Assessment (ESA, AECOM, 2017a), and other source types and pathways that are identified to be contributing to off-Base exposure risk. PFAS source areas are described as

- a) "Primary Sources" – where AFFF containing PFAS is understood to have been used or disposed of (e.g. a fire training area), or
- b) "Secondary Sources" – where PFAS has migrated to a location (typically via effluent or surface water) where it creates a concentration of impact that can then migrate from that location into groundwater or surface water (e.g. Southern Area).

A detailed summary of the Conceptual Site Model (CSM) for each of the identified sources on Base is included in **Table 9 – Appendix B** of the PFAS Management Area Plan 2019. The primary and secondary

PFAS sources are described in which is based on information included in the AECOM reports. The PFAS constraint rating for the Williamstown SAP area is presented in **Figure 9 - Appendix AA**.

Similar to the non-PFAS contamination, the constraints ratings are defined as:

- **Highly constrained:** High likelihood of encountering PFAS contamination at concentrations that may require additional assessment, remediation or management
- **Moderately constrained:** Moderate likelihood of encountering PFAS contamination at concentrations in some areas of the Scenario boundary that may require additional assessment, remediation or management
- **Minimally constrained:** Low likelihood of encountering PFAS contamination at concentrations that may require additional assessment, remediation or management or limited/isolated areas where non-PFAS contamination may require assessment, remediation or management
- **Negligible:** No PFAS identified within the Scenario Boundary or could migrate to the scenario in any environmental media.

### 3 Scenario testing

In the Williamstown SAP design development process, all existing constraints and opportunities identified in the baseline assessment summarised above, were holistically evaluated to identify preferred elements which should be included in the Structure Plan (**see section 5**) areas for further investigation and no-go zones. This included the main PFAS and non PFAS limitation constraints identified in **Section 2** and **Section 3**.

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 Williamstown SAP, comparative assessments were conducted to explore the strengths, weaknesses, risk and opportunities of each development scenario.

The risk assessment was based on specific testing criteria such as current and future land use zonings, likelihood of encountering PFAS and non PFAS contamination and mobilisation, likelihood of remediation being required, and volumes of soil that may be disturbed and potential for re-use or need for off-site disposal. The testing methodology and criteria for PFAS and non-PFAS COPCs was aimed to determine the likelihood and relative significance of potential financial and health liabilities associated with the management of excavated soils and/or need for remediation relative to each scenario. Finally, the scenarios were considered in terms of the Williamstown SAP vision and principles, as shown in **Figure 5-1**.

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 Structure Plan Boundary. This included establishing areas where future development in the SAP may be constrained by PFAS and/or non-PFAS contamination, reviewing environmental media, developing mitigation measures to reduce the risk of mobilising PFAS during the construction, after construction and future development, and suggesting strategy for flood and stormwater management.

## 4 Testing methodology

### 4.1 Risk Assessment Overview

The risk of encountering elevated non-PFAS COPC concentrations through the Williamstown SAP area is generally considered to be low to moderate, noting specific APECs as identified in **Figure 8 - Appendix A**. It is known that measurable PFAS concentrations are present in various environmental media on and near the Base and in areas downgradient to the south and south east. The testing methodology for PFAS and non-PFAS COPCs is aimed to determine the likelihood and relative significance of potential financial and health liabilities associated with the management of impacted environmental media and/or need for remediation relative to the master plan boundaries.

To provide qualitative information on the potential risks to human health and the environment, this assessment was based on establishing a broad Conceptual Site Model (CSM) across the Williamstown SAP area and the proposed precincts for all scenarios. Generally, a CSM provides an assessment of the fate and transport of COPCs relative to site specific, subsurface conditions with regard to their potential risk to human health and the environment. It is based on evaluating the linkages between potential sources of contamination – pathways by which contamination moves through the environment and potential human or ecological receptors (SPR linkages). If there are linkages between the sources, pathways, and receptors, then there may be potential risks that require management or remediation. The extent of necessary remediation would be based on investigations in the APECs to establish COPC concentrations (if present). The investigation and remediation of elevated COPC concentrations present a cost consideration into future planning decisions. Future investigations and remediation activities in areas off-Base would be conducted in accordance with the SEPP 55 process and the other applicable legislation and guidelines listed above.

Managing PFAS impacted media in off-Base areas would have to be evaluated based on the master plan boundaries and a determination of liability for the necessary mitigation measures. Management of PFAS contaminated media would be required to facilitate a certain type of development or flood mitigation strategy. This would likely be conducted outside of a consent driven planning framework and function more as a waste management exercise.

The evaluation of risk in the CSM is also based on the sensitivity of land use. For example, a low-density residential land use is more sensitive than an industrial/commercial land use. Under a residential land use, there is more potential of exposure to COPCs (if present) as soil is exposed, gardening, maintenance or recreation may occur, and people generally spend more time at home. This is opposed to an industrial setting which would likely have extensive hard stand, limited occupancy times and other occupational health and safety controls to manage risks to employees.

Each scenario has established Tier I screening values that are established in the *National Environmental Protection Measure 1999*, as amended in 2013 and NEMP v2 2020. The Tier I screening values are lower for sensitive land uses (e.g. residential) which indicate more remediation could be necessary if COPCs are present. The Tier I screening values for less sensitive land uses (e.g. industrial) are higher which indicates less remediation could be required if COPCs are present.

It is also necessary to evaluate if the APECs are near to any sensitive environmental receptors that could be impacted by COPCs (if present). Environmental receptors include a broad range of flora and fauna, surface water bodies and groundwater as noted in previous sections of this report.

During future development, disturbance of soil and sediment will likely be required in some areas. Additionally, sediment from the off-site drains would likely be removed to increase the capacity of these drains as a flood mitigation strategy. Bulk filling in the southern and south eastern portions of the SAP will likely be required for development and flood mitigation strategies. These strategies are further discussed in later sections.

Any soil or sediments removed during construction and/or operation will require management and/or disposal in accordance with the *NSW Waste Management Guidelines 2014 Parts 1-4* and Addendum 1 and any applicable Resource Recovery Orders and Exemptions (RRO/RREs) under the *Protection of Environment Operations (Waste) Act 2014* (POEO Act). Management and/or disposal of soil and sediment will be a cost consideration during future development. It is likely that some of the soil across the SAP investigation area (outside of the identified APECs) will meet the definitions of Excavated Natural Material or Virgin Excavated Natural Material (ENM/VENM) and as such could be beneficially reused for a range of uses.

## 4.2 Assumptions and limitations

It should be noted that the information included below is based on review of publicly available information and information supplied by Port Stephens Council and Hunter Water. Specific reports or information on the non-PFAS APECs were not reviewed as part of this report. The identification of potentially contaminating activities and related COPCs are based on the nature of the activities at the identified non-PFAS APECs. Aurecon utilised our experience with similar sites and information included in the POEO to summarise the potentially contaminating activities and COPCs at or near the non PFAS APECs. It is important to note that activities at the identified APECs may not have led to subsurface contamination or with all the listed COPCs.

The information on the location of PFAS impacts is based on review of publicly available information and reports. Extensive information is publicly available on the Department of Defence PFAS Management web portal. The information most relevant to the Williamstown SAP is included in **Section 5.3** and **Table 5**, below. No sampling of environmental media has been undertaken by Aurecon. Some of the information contained in the following sections will require further evaluation through collection of environmental media samples during future stages of the Williamstown SAP development.

## 4.3 Testing Criteria

The following testing criteria has been based on information collected through desktop review and is therefore only qualitative. The proposed location and layout of particular land uses are included in the Williamstown SAP structure plan boundary in **Figure 5-2**, below and summarised in **Table 4**. The land use will be generally light industrial/commercial. However, environmental media samples have not been collected and as such, the evaluation of potential risks can be further quantified if/when sampling is undertaken. Typically, this is completed prior to or during concept design. **Table 3** identifies the testing criteria utilised for the scenarios from a soils and contamination perspective.



Table 3 Summary of testing criteria

Testing Criteria	Details
Current and future land use zonings	<p>Evaluate the changes in land uses to determine if a more sensitive or less sensitive land use than the current land use may be proposed. This is broadly between heavy industrial, light commercial/industrial, residential and conservation. Changing to a more sensitive land use may require more remediation or management if elevated COPC concentrations are present. The current land zonings in the Williamstown Study Area are shown on <b>Figure 5</b> – Appendix A</p> <p>Proposed land use zonings throughout the SAP investigation area are detailed in <b>Table 4</b>, below.</p>
Likelihood of encountering PFAS contamination and mobilisation	<p>Multiple PFAS sources have been identified near RAAF Base Williamstown in the Baseline Analysis. PFAS impacted groundwater has been migrating offsite towards the areas of the SAP for several decades. Therefore, the PFAS concentrations are expected to improve over time. However, the mechanisms that result in PFAS migration off the RAAF base (i.e. mass flux), are not fully understood, with limited temporal and spatial information across the SAP and predicted PFAS extent in environmental media. Plume movement could potentially change under future environmental conditions. It is possible that some mitigation measures and/or management may be required near boundaries adjacent to the Base and for the sediment in the off-Base drains. The necessity for mitigation measures to prevent migration is based on establishing CSM and the likelihood of SPR linkages. The mitigation measures will be implemented in conjunction with the flood mitigation strategies.</p> <p>Investigations and mitigation measures would represent a cost consideration for future development</p>
Likelihood of remediation being required	<p>Multiple non-PFAS APECs were identified throughout the SAP investigation area in the Baseline Analysis. It is possible that some remediation and/or management may be required in and around the APECs if elevated COPCs are present. The necessity for remediation is based on establishing CSM and the likelihood of SPR linkages.</p> <p>Investigations and remediation would represent a cost consideration for future development.</p>
Volumes of soil that may be disturbed and potential for re-use or need for off-site disposal	<p>The volumes of soil that may be disturbed and require management or disposal will be a cost consideration during future development. If soils meet the definition of ENM/VENM, then they can be re-used for a variety of beneficial uses. If soils contain measurable COPC concentrations, they may require off-site disposal. Given the volume of fill material required, limited volumes of spoil are anticipated to be produced but some ground preparation will be required prior to importation of fill material.</p>

## 5 Structure Plan

### 5.1 Methodology and Approach

The Final EbD workshop was held on the 27th to 30th of April 2021 and this workshop involved the further testing of the previously prepared scenarios and development of the Williamstown SAP structure plan. The structure plan considers land use, transport, infrastructure, PFAS, environmental, social, aboriginal heritage and economic matters in conjunction with the SAP vision.

**Figure 5-1** provides an outline of the key principles which were incorporated into the masterplan.



**Figure 5-1** The 7 SAP Principles which governed the masterplan

The structure plan leverages the preferred elements of all the scenarios developed, further explores the items under investigation and where possible avoids the identified high constraint zones. The previously identified strengths and opportunities of each scenario were pursued 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 Hatch Roberts Day is centred around the existing Williamstown Airport Precinct, which includes Newcastle Airport, Williamstown RAAF base and Astra Aerolab. The Williamstown SAP incorporates a core development area south of the existing airport. Initial stages of the Williamstown 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 5-2** adheres to the existing drainage and flooding characteristics and incorporates the inclusion of the Dawsons Drain and Learys Drain reserve. Additionally, it maintains hydrological regime for the biodiversity corridor, facilitates controlled flooding throughout the SAP precinct and utilises floodplains South of Cabbage Tree Road to offset impacts.

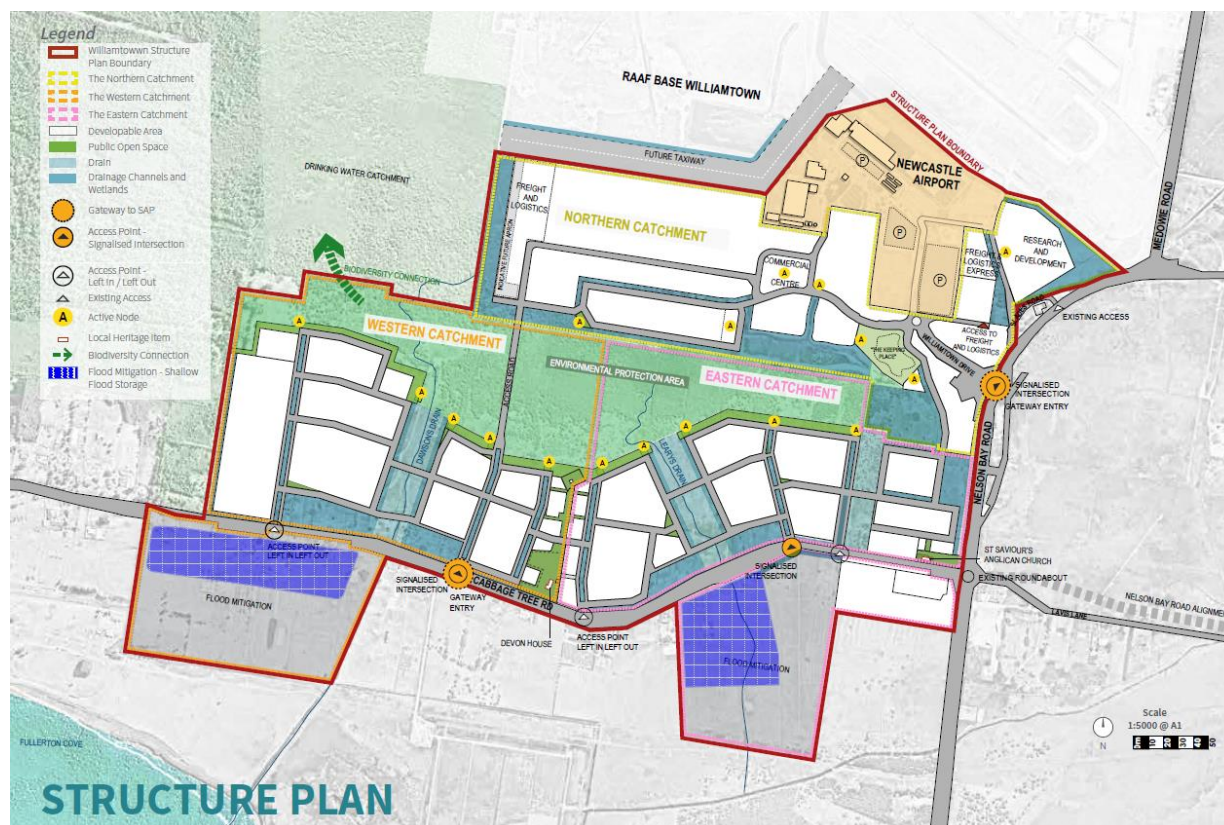


Figure 5-2 Williamstown SAP Structure Plan

During the EBD workshop the area was subdivided in to general precincts that have indicative land uses related to each. These are presented in **Table 4** below with our understanding of the probable associated building and infrastructure types for each

Table 4 The structural characteristics for each land use in the structure plan

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.
pAll 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.

## 5.3 PFAS and Non-PFAS assessment of structure plan

### 5.3.1 PFAS Constraints

The structure plan is situated south and southwest of the airport and directly downgradient from the Lake Cochran and other secondary sources at the Base. The eastern approximate half of the structure plan is situated over the groundwater plume showing the highest PFAS concentrations. Extensive sampling of groundwater, surface water, soil and sediment has been undertaken in this area by AECOM. The structure plan overlaid on the PFAs constraints map is shown

in **Appendix A**.

The SAP investigation area includes properties impacted by PFAS contamination; landholders may have suffered loss or damage as a result of this contamination. During future stages of the Williamstown SAP process, it will be critical to engage with the local stakeholders to help develop the mitigation measures that will have the least impact on the local community and the surrounding sensitive environment.

Review of the available background information indicates that extensive assessment has been conducted at the Base and the surrounding areas. The areas of PFAS impacted environmental media are well defined relative to the structure plan boundary. The PFAS impacts have migrated from the Base in groundwater to Cabbage Tree Road and to the north-east into Tilligerry Creek. There has been some migration to the east and southeast with ultimate groundwater flow toward Fullerton Cove. Recent groundwater monitoring data indicates that there are limited PFAS concentrations in groundwater to the south of Cabbage Tree Road. It is noted that measurable PFAS concentrations have been detected historically in some monitoring wells to the south of Cabbage Tree Road and in Fullerton Cove but concentrations fluctuate with time.

Upward flow of PFAS impacted groundwater into Fourteen Foot Drain and Tilligerry Creek (and other gaining streams) has been noted in Conceptual Site Models (AECOM, 2017) despite the likely impediment of groundwater-surface water expression by less permeable subsurface estuarine clays in the SAP area. Given the age of the PFAS groundwater plume and the phasing out of PFAS use, PFAS concentrations in groundwater are expected to reduce over time as Defence continues to remediate the identified primary and secondary sources on the Base. There is potential for fluctuations in groundwater, surface water and sediment concentrations and the lateral extents of the groundwater plume due to changing environmental conditions or chemical transformation of PFAS.

Measurable PFAS is still present in stormwater and is a key migration pathway to off Base areas. Stormwater becomes impacted when PFAS leaches from soil or sediment. In some areas, groundwater intersects the drains and daylights which is contributing to PFAS migration and impacting stormwater. The area is prone to flooding, with flood water contributing to PFAS impacts in soil, sediment and surface water and with likely interaction between the shallow groundwater and the drainage network. It is important to note however, that processes at the site are still not fully understood, particularly regarding PFAS migration during heavy rainfall events

Aurecon have reviewed environmental media analytical data collected from the structure plan area from the following reports and sources of information:

- AECOM 2017, *RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Site Assessment* December 2017
- AECOM 2018, *RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Risk Assessment* September 2018
- AECOM 2019, *Interim Monitoring Event Report – RAAF Base Williamstown*, December 2018
- AECOM 2019, *Interim Monitoring Event Report – RAAF Base Williamstown*, June 2019

A summary of the analytical data collected from this structure plan area is summarised in **Table 5**, below



Table 5 Summary of analytical data within the structural plan

Environmental Media Investigated	Data Sources	Sampling Locations	Concentration Ranges
Groundwater	AECOM 2017, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Site Assessment December 2017	<p>Sampling was completed on a total of 571 new and existing monitoring wells/bores</p> <ul style="list-style-type: none"> <li>132 'deep' wells (total depths ranging between 17.5 – 20 m bgs)</li> <li>32 'intermediate' wells (total depths ranging between 10 – 12 m bgs)</li> <li>172 'shallow' wells (total depths ranging between 2.8 – 6m m bgs)</li> <li>28 HWC bores</li> <li>207 residential bores.</li> </ul> <p>56 sample locations within proposed structure plan boundary</p>	<p><b>Structure plan area</b></p> <p>PFOS = &lt;0.01 – 440 µg/L (MW167)</p> <p>Number of sample locations with concentrations &gt; LOR = 220</p> <p>PFOA = &lt;0.01 – 10.5 µg/L (MW187S)</p> <p>Number of sample locations with concentrations &gt; LOR = 171</p> <p>PFOS + PFHxS = &lt;0.02 – 522.5 µg/L (MW167)</p> <p>Number of sample locations with concentrations &gt; LOR = 249</p> <p><b>Groundwater Elevation</b></p> <p>December 2016:</p> <p>Number of wells: 70</p> <p>Min SWL (m btoc) = 0.011 (MW151D)</p> <p>Max SWL (m btoc) = 2.767 (MW132I)</p> <p>March 2017:</p> <p>Number of wells: 145</p> <p>Min SWL (m btoc) = 0.007 (MW235D)</p> <p>Max SWL (m btoc) = 4.887 (MW177)</p>



AECOM 2018, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Risk Assessment September 2018

PFAS have been reported to be present in groundwater beneath the Site. Groundwater sampled from areas to the south and east of the Site has also been reported to contain detectable concentrations of PFAS. This transport mechanism is of high significance as it has contributed to PFAS transport off-Site.

- Groundwater flows comparatively slower than surface water, less than one metre per day.
- Groundwater flow is nearly constant over time. Variability occurs within aquifers, but flow is usually slower than in surface water features.
- PFAS concentrations in groundwater are comparatively more stable.
- Groundwater elevations increase during recharge events but slower (hours to days) than in surface water drains. During dry periods, groundwater elevation decreases slowly.
- PFAS is transported slower than the groundwater flow rate because PFAS sorbs to aquifer solids. The rate of retardation varies between individual compounds.

The 2016 Stage 2B EI identified that there is a potential for surface water and groundwater interactions as a result of the highly permeable soils and **shallow groundwater table**. The unlined surface drainage lines both on- and off-Site are likely to contribute to aquifer recharge. In addition, it has been reported in the 2016 Stage 2B EI that groundwater infiltration into the unlined drainage network and Lack Cochran is occurring.

Groundwater is **typically shallow** (0.5 m bgs) in areas to the south of the Site and near Ten Foot Drain, Fourteen Foot Drain and Tilligerry Creek.

It is noted that there are periods of the year where some sections of Dawsons Drain (e.g.DD3) are considered to be losing with surface water migrating to groundwater beneath the drain. The reported concentrations of PFAS in these sections of the drain during gaining conditions indicate that elevated groundwater concentrations are discharging to the surface water and resulting in elevated PFAS concentrations reported at DD3 and in Fourteen Foot Drain.

Concentration ranges are narrower in surface water samples from on-Site compared to ranges in the direct receiving environments off-Site (Dawsons Drain and Moors Drain). This indicates that groundwater discharges to these waterways is contributing significantly to temporal variation in surface water concentrations

Based on the available information it has therefore been assumed that assessment of exposures to surface water in the drainage channels and estuarine environments and ponded water in terrestrial areas is representative of potential groundwater exposures for ecological receptors in both on- and off-Site environments.

There is potential for leaching to groundwater at concentrations which pose a risk to nearby freshwater environments. Risks to aquatic life were further assessed based on reported surface water concentrations.

		This approach was considered appropriate as the groundwater-surface water interaction study indicates that <u>surface water concentrations are representative of groundwater discharges to aquatic environments surrounding the Site.</u>	
	AECOM 2019, Interim Monitoring Event Report – RAAF Base Williamstown, December 2018	<p>118 locations overall (comprising 113 monitoring wells, 3 pump station bores and 2 HWC monitoring wells)</p> <p>35 sample locations within proposed structure plan boundary</p>	<p><b>Structure Plan</b></p> <p>PFOS = &lt;0.01 – 372 ug/L (MW167)</p> <p>Number of sample locations with concentrations &gt; LOR = 67</p> <p>PFOA = &lt;0.01 – 4.56 ug/L (MW167)</p> <p>Number of sample locations with concentrations &gt; LOR = 84</p> <p>PFOS + PFHxS = &lt;0.01 – 398 ug/L (MW167)</p> <p>Number of sample locations with concentrations &gt; LOR = 66</p> <p><b>Groundwater Elevation</b></p> <p>Groundwater Elevation = 0.18 (MW108S – north) to 2.29 (MW167 – north) m BTOC</p>

	<p>AECOM 2019, Interim Monitoring Event Report – RAAF Base Williamstown, June 2019</p>	<p>152 locations (comprising 133 monitoring wells, 4 pump station bores, 4 Hunter Water Corporation (HWC) Monitoring Wells and 11 residential boreholes</p> <p>40 sample locations within proposed structure plan boundary</p>	<p><b>Structure Plan</b></p> <p>PFOS = &lt;0.01 – 391 ug/L (MW167)</p> <p>Number of sample locations with concentrations &gt; LOR = 69</p> <p>PFOA = &lt;0.01 – 4.94 ug/L (MW281S)</p> <p>Number of sample locations with concentrations &gt; LOR = 50</p> <p>PFOS + PFHxS = &lt;0.01 – 402 ug/L (MW167)</p> <p>Number of sample locations with concentrations &gt; LOR = 76</p> <p><b>Groundwater Elevation</b></p> <p>Overall:</p> <p>Minimum SWL = 0.007 m btoc (MW235D)</p> <p>Maximum SWL = 3.314 m btoc (MW132D)</p> <p><b>Structure Plan:</b></p> <p>Groundwater Elevation = 0.15 (MW187S – centre) to 3.11 (MW167 – north) m BTOC</p>
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Surface water	AECOM 2017, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Site Assessment December 2017 – Comprehensive	<p><b>Overall</b></p> <p>Collection of 428 surface water samples (Collection of 21 on-Site and 109 off-Site surface water samples)</p> <p><b>Structure Plan</b></p> <p>20 sample locations within proposed structure plan boundary</p>	<p><b>Overall/Structure Plan</b></p> <p>On-Site:</p> <p>PFOS = &lt;LOR – 14 ug/L (QC502, duplicate of LC_B)</p> <p>Number of sample locations with concentrations &gt; LOR = 20</p> <p>PFOA = &lt;LOR – 0.13 ug/L (DD1)</p> <p>Number of sample locations with concentrations &gt; LOR = 12</p> <p>PFOS + PFHxS = 0.02 (OLA2) – 15.2 ug/L (QC502, duplicate of LC_B)</p> <p>Number of sample locations with concentrations &gt; LOR = 21</p> <p>Off-Site:</p> <p>PFOS = &lt;LOR – 7.82 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 56</p> <p>PFOA = &lt;LOR – 0.74 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 30</p> <p>PFOS + PFHxS = &lt;LOR – 25.9 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 56</p>
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	<p>AECOM 2017, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Site Assessment December 2017 – Weekly</p>	<p>Collection of 175 samples (39 samples on-Site and 136 samples off-Site) from 20 locations</p>	<p><b>On-Site:</b></p> <p>PFOS = 0.06 (DD1) – 9.75 ug/L (BD08)</p> <p>Number of sample locations with concentrations &gt; LOR = 39</p> <p>PFOA = &lt;LOR – 0.19 ug/L (BD08)</p> <p>Number of sample locations with concentrations &gt; LOR = 34</p> <p>PFOS + PFHxS = 0.12 (DD1) – 12.8 ug/L (BD08)</p> <p>Number of sample locations with concentrations &gt; LOR = 39</p> <p><b>Off-Site:</b></p> <p>PFOS = &lt;LOR – 14.2 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 123</p> <p>PFOA = &lt;LOR – 0.68 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 59</p> <p>PFOS + PFHxS = &lt;LOR – 25.9 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 124</p>
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	<p>AECOM 2018, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Risk Assessment September 2018</p>	<p><b>Overall</b></p> <p>On-Site: 39 sample locations</p> <p>South and west of the site: 16 sample locations</p> <p><b>Structural Plan</b></p> <p>On-Site: 3 sample locations (BD03, BD08 and LC)</p> <p>Dawsons Drain: 5 sample locations (DD1, DD2, DD3, DD4 and DD7)</p> <p>Fullerton Cove Ring Drain: 2 sample locations (FCD1 and FCD4)</p> <p>Fourteen Foot Drain: 1 sample location (FFD1)</p>	<p><b>Overall:</b></p> <p>On-Site:</p> <p>PFOS = 0.02 – 63 ug/L (average = 5.9 ug/L)</p> <p>PFOA = 0.01 – 21 ug/L (average = 0.8 ug/L)</p> <p>South and west of the site:</p> <p>PFOS = 0.02 – 35.3 ug/L (average = 2.0 ug/L)</p> <p>PFOA = 0.01 – 2.3 ug/L (average 0.1 ug/L)</p> <p><b>Structural Plan</b></p> <p>On-Site:</p> <p>PFOS = 1.7 – 9.8 ug/L</p> <p>PFHxS = 0.09 – 3.1 ug/L</p> <p>PFOA = 0.03 – 0.2 ug/L</p> <p>Dawsons Drain:</p> <p>PFOS = 0.06 – 35.3 ug/L</p> <p>PFHxS = 0.04 – 39.9 ug/L</p> <p>PFOA = 0.01 – 2.3 ug/L</p> <p>Fullerton Cove Ring Drain:</p> <p>PFOS = 0.08 – 1.6 ug/L</p> <p>PFHxS = 0.03 – 2.9 ug/L</p> <p>PFOA = 0.01 – 2.3 ug/L</p> <p>Fourteen Foot Drain:</p> <p>PFOS = 0.1 – 2.1 ug/L</p> <p>PFHxS = 0.05 – 3.5 ug/L</p> <p>PFOA = 0.05 – 0.1 ug/L</p>
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	<p>AECOM 2019, Interim Monitoring Event Report – RAAF Base Williamstown, December 2018</p>	<p><b>Overall</b></p> <p>24 sample locations</p> <p>(11 sample locations within proposed structure plan boundary)</p> <p><b>Structure Plan</b></p> <p>On-Site: 4 sample locations (LC_B, LC, MD6 and MD7)</p> <p>Dawsons Drain: 4 sample locations (DD1, DD2, DD3 and DD5)</p> <p>Fourteen Foot Drain: 1 sample location (FFD4)</p> <p>Ten Foot Drain: 2 sample locations (TFD1 and TFD2)</p>	<p><b>Overall</b></p> <p>PFOS = &lt;0.01 – 30.7 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 3</p> <p>PFOA = &lt;0.01 – 1.43 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 6</p> <p>PFOS + PFHxS = &lt;0.01 – 53.1 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 3</p> <p><b>Structure Plan</b></p> <p>On-Site:</p> <p>PFOS = 0.83 – 7.43 ug/L</p> <p>PFOS + PFHxS = 1.09 – 8.69 ug/L</p> <p>PFOA = 0.1 – 0.11 ug/L</p> <p>Dawsons Drain:</p> <p>PFOS = 0.83 – 30.7 ug/L</p> <p>PFOS + PFHxS = 1.59 – 53.10 ug/L</p> <p>PFOA = 0.04 – 1.43 ug/L</p> <p>Fourteen Foot Drain:</p> <p>PFOS = 0.96 ug/L</p> <p>PFOS + PFHxS = 1.98 ug/L</p> <p>PFOA = 0.08 ug/L</p> <p>Ten Foot Drain:</p> <p>PFOS = &lt;0.01 – 2.34 ug/L</p> <p>PFOS + PFHxS = &lt;0.01 – 3.26 ug/L</p> <p>PFOA = &lt;0.01 – 0.05 ug/L</p>
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	<p>AECOM 2019, Interim Monitoring Event Report – RAAF Base Williamstown, June 2019</p>	<p><b>Overall</b></p> <p>22 sample locations</p> <p>(10 sample locations within proposed structure plan boundary)</p> <p><b>Structure Plan</b></p> <p>On-Site: 4 sample locations (LC_B, LC, MD6 and MD7)</p> <p>Dawsons Drain: 4 sample locations (DD1, DD2, DD3 and DD5)</p> <p>Ten Foot Drain: 2 sample locations (TFD1 and TFD2)</p>	<p><b>Overall</b></p> <p>PFOS = &lt;0.01 – 4.78 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 22</p> <p>PFOA = &lt;0.01 – 0.4 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 9</p> <p>PFOS + PFHxS = &lt;0.01 – 11.9 ug/L (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 22</p> <p><b>Structural Plan</b></p> <p>On-Site:</p> <p>PFOS = 0.440 – 4.110 ug/L</p> <p>PFOS + PFHxS = 0.570 – 4.910 ug/L</p> <p>PFOA = &lt;0.010 – 0.070 ug/L</p> <p>Dawsons Drain:</p> <p>PFOS = 0.140 – 4.780 ug/L</p> <p>PFOS + PFHxS = 0.530 – 11.900 ug/L</p> <p>PFOA = 0.010 – 0.400 ug/L</p> <p>Ten Foot Drain:</p> <p>PFOS = 0.100 – 0.240 ug/L</p> <p>PFOS + PFHxS = 0.100 – 0.940 ug/L</p> <p>PFOA = &lt;0.010 – &lt;0.050 ug/L</p>
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Soil (0.0 – 1.5 mbgs)	AECOM 2017, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Site Assessment December 2017	<p><b>Overall</b></p> <p>Collection of 243 soil samples</p> <p><b>Structure Plan</b></p> <p>26 sample locations within proposed structure plan boundary</p>	<p><b>Overall:</b></p> <p>Shallow unsaturated soil (142):</p> <p>PFOS = &lt;0.0002 – 9.17 mg/kg (F479_BH27_0.5)</p> <p>Number of sample locations with concentrations &gt; LOR = 109</p> <p>PFOA = &lt;0.0002 – 0.0312 mg/kg (F479_BH32_1.5)</p> <p>Number of sample locations with concentrations &gt; LOR = 51</p> <p>PFOS + PFHxS = &lt;0.0002 – 9.370 mg/kg (F479_BH27_0.5)</p> <p>Number of sample locations with concentrations &gt; LOR = 109</p> <p>Saturated soil (47):</p> <p>PFOS = &lt;0.0002 – 0.399 mg/kg (F479_BH47_2.5)</p> <p>Number of sample locations with concentrations &gt; LOR = 31</p> <p>PFOA = &lt;0.0002 – 0.0012 mg/kg (MW246S_3.0)</p> <p>Number of sample locations with concentrations &gt; LOR = 10</p> <p>PFOS + PFHxS = &lt;0.0002 – 0.402 mg/kg (F479_BH47_2.5)</p> <p>Number of sample locations with concentrations &gt; LOR = 31</p> <p><b>Structure Plan</b></p> <p>PFOS = &lt;0.0002 – 0.3300 mg/kg (MW148D)</p> <p>PFOA = &lt;0.0002 – 0.0122 mg/kg (MW148D)</p>
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			PFOS + PFHxS = <0.0002 – 0.5000 mg/kg (MW148D)
	AECOM 2018, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Risk Assessment September 2018	On-Site: 425 sample locations South and west of the site: 31 sample locations	<b>On-Site:</b> PFOS = 0.0003 – 9.2 mg/kg (average 0.2 mg/kg) PFOA = 0.002 – 0.06 mg/kg (average 0.004 mg/kg) <b>South and west of the site:</b> PFOS = 0.0005 – 0.8 mg/kg (average 0.07 mg/kg) PFOA = 0.0003 – 0.01 mg/kg (average 0.003 mg/kg)

Sediment	AECOM 2017, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Site Assessment December 2017	<p><b>Overall</b></p> <p>Collection of 181 sediment samples (26 samples on-Site and 155 samples off-Site)</p> <p><b>Structure Plan</b></p> <p>22 sample locations within proposed structure plan boundary</p>	<p><b>Overall</b></p> <p>On-Site (26):</p> <p>PFOS = &lt;LOR – 14.0 mg/kg (BD08)</p> <p>Number of sample locations with concentrations &gt; LOR = 23</p> <p>PFOA = &lt;LOR – 0.064 mg/kg (BD08)</p> <p>Number of sample locations with concentrations &gt; LOR = 5</p> <p>PFOS + PFHxS = &lt;LOR – 14.05 mg/kg (BD08)</p> <p>Number of sample locations with concentrations &gt; LOR = 24</p> <p>Saturated soil (155):</p> <p>PFOS = &lt;LOR – 1.82 mg/kg (RESI018)</p> <p>Number of sample locations with concentrations &gt; LOR = 134</p> <p>PFOA = &lt;LOR – 0.036 mg/kg (FFD-T6)</p> <p>Number of sample locations with concentrations &gt; LOR = 28</p> <p>PFOS + PFHxS = &lt;LOR – 1.98 mg/kg (RESI018)</p> <p>Number of sample locations with concentrations &gt; LOR = 134</p> <p><b>Structure Plan</b></p> <p>PFOS = &lt;LOR – 1.82 mg/kg (RESI018)</p> <p>PFOA = &lt;LOR – 0.0362 mg/kg (FFD-T6)</p> <p>PFOS + PFHxS = &lt;LOR – 1.98 mg/kg (RESI018 and FFD-T6)</p>
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	<p>AECOM 2018, RAAF Base Williamstown Stage 2B Environmental Investigation – Ecological Risk Assessment September 2018</p>	<p>On-Site: 52 sample locations</p> <p>South and west of the site: 18 sample locations</p>	<p><b>On-Site:</b></p> <p>PFOS = 0.0002 – 22.4 mg/kg (average 0.6 mg/kg)</p> <p>PFOA = 0.0002 – 0.09 mg/kg (average 0.009 mg/kg)</p> <p><b>South and west of the site:</b></p> <p>PFOS = 0.001 – 1.8 mg/kg (average 0.009 mg/kg)</p> <p>PFOA = 0.0003 – 0.04 mg/kg (average 0.008 mg/kg)</p>
	<p>AECOM 2019, Interim Monitoring Event Report – RAAF Base Williamstown, December 2018</p>	<p><b>Overall</b></p> <p>26 locations (paired with the surface water locations with exception of two sediment samples (FC1A and FC1B) collected in Fullerton Cove)</p> <p><b>Structure Plan</b></p> <p>5 sample locations within proposed structure plan boundary</p>	<p><b>Overall</b></p> <p>PFOS = &lt;0.0002 – 0.146 mg/kg (MD1)</p> <p>Number of sample locations with concentrations &gt; LOR = 2</p> <p>PFOA = &lt;0.0002 – 0.0036 mg/kg (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 19</p> <p>PFOS + PFHxS = &lt;0.0002 – 0.206 mg/kg (DD3)</p> <p>Number of sample locations with concentrations &gt; LOR = 1</p> <p><b>Structure Plan</b></p> <p>PFOS = LOR – 0.05 mg/kg (LC_B)</p> <p>PFOA = &lt;LOR – LOR mg/kg</p> <p>PFOS + PFHxS = 0.0011 – 0.0571 mg/kg (LC_B)</p>



	AECOM 2019, Interim Monitoring Event Report – RAAF Base Williamstown, June 2019	<p><b>Overall</b></p> <p>24 locations (paired with the surface water locations with exception of two sediment samples (FC1A and FC1B) collected in Fullerton Cove)</p> <p><b>Structure Plan</b></p> <p>5 sample locations within proposed structure plan boundary</p>	<p><b>Overall</b></p> <p>PFOS = &lt;0.0002 – 0.13 mg/kg (MD1)</p> <p>Number of sample locations with concentrations &gt; LOR = 22</p> <p>PFOA = &lt;0.0002 – 0.0014 mg/kg (MD1)</p> <p>Number of sample locations with concentrations &gt; LOR = 5</p> <p>PFOS + PFHxS = &lt;0.0002 – 0.144 ug/L (MD1)</p> <p>Number of sample locations with concentrations &gt; LOR = 22</p> <p><b>Structure Plan</b></p> <p>PFOS = LOR – 0.05 ug/L (LC_B)</p> <p>PFOA = &lt;LOR – LOR ug/L</p> <p>PFOS + PFHxS = 0.0011 – 0.0571 ug/L (LC_B)</p>
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### 5.3.2 Non-PFAS Constraints

The non PFAS APECS located in the structure plan boundary are shown on **Figure 12** in **Appendix A** and summarised in **Table 6**, below. The risk of encountering Acid Sulfate Soils in the structure plan boundary is shown on **Figure 13** in **Appendix A**.

**Table 6 Summary of non PFAS APECS in structure plan boundary**

APEC	Location
RAAF Base Williamstown and Newcastle Airport (Defence Activities, Ammunitions Production and Testing)	North (adjacent to structure plan)
One Unexploded Ordinance (UXO) Site (north west)	North West (within and adjacent to structure plan)
Plant Driving School – Mechanical Workshop	South West (adjacent to Cabbage Tree Road and within structure plan)
Seven Landfills	Throughout structure plan (along Cabbage Tree Road)
One Sand Extraction, Landfill – Effluent Lagoon – Heavy metals and PFAS	Within the centre of structure plan (adjacent to Base, Newcastle Airport, Cabbage Tree Road and Nelson Bay Road)
Two Car wash bays	North East (adjacent to Newcastle Airport)
Airport – Spray Booth	North East (within Newcastle Airport)
One old service Station	North East (adjacent to the Base)
One notified contaminated land site - Hunter Land Effluent Pond	North (adjacent to the Base)
Two sites where waste has been used filling or land development <ul style="list-style-type: none"> <li>- Filling of land with demolition waste</li> <li>- Demolition and liquid waste on land (signs of contamination)</li> </ul>	Within the centre of the structure plan
No POEO licenses or notices	-
No RFS locations or current Service Stations	-

## 6 Mitigation Measures

### 6.1 Mitigation Measures

#### 6.1.1 PFAS Mitigation Measures

PFAS impacted environmental media, including soil, sediment, groundwater and surface water will likely need to be managed in the areas directly south of the Base and up to Cabbage Tree Road. The general measures to mitigate the risk of mobilising PFAS during the future development are summarised below with further description, advantages, disadvantages and additional data required summarised in **Table 1**. These mitigation measures will be implemented in conjunction with the flooding water cycle management and geotechnical mitigation strategies (Aurecon, 2021a and Aurecon, 2021b, respectively).

Flooding is a major constraint to the developable area within the structure plan boundary. The water cycle management and geotechnical management measures include a combination of strategies to manage flooding and water quality across the SAP. To facilitate development within the floodplain, bulk filling to above the regional 1% Annual Exceedance Probability plus year 2100 climate change flood level (approximately 2-4 m thickness) will be required. The filling should not lead to a deterioration in flood impacts nor PFAS mobilisation. This will require design of floodplain management measures to mitigate and offset flood impacts. Bulk filling is also required to facilitate drainage of development lots and roads within the precinct. Water Sensitive Urban Design (WSUD) measures such as wetland creation will also be incorporated to treat stormwater and operate as detention basins during major storm events. Further details on the WSUD measures and flooding strategies are included in *B.3.2E: Flooding and Water Cycle Management Report* (Aurecon, 2021a).

The flooding and stormwater management strategy would include some or all of the following measures:

- Identifying the development impacts and the land required for SAP flood mitigation measures
- Flood detention to mitigate impacts on downstream development
- Preserving floodways to mitigate impacts on upstream and adjacent development
- Water quality treatment provided swales and end of system wetlands.

The flood mitigation and stormwater management measures must also consider the potential to mobilise PFAS impacted groundwater, sediment, soil and surface water. The potential mitigation measures are summarised as follows:

- Bulk filling for flood immunity
- Groundwater could be pumped, treated and reinjected into the aquifer, if necessary, to maintain current recharge levels and off-set additional impermeable surfaces proposed in the future development.
- In addition to monitoring discharge concentrations during the construction phase, ongoing monitoring should be implemented under an EMP to assess whether mitigation measures are still functioning and to determine when maintenance may be required.
- Installation of a Geosynthetic Clay Liner (GCL) in areas of bulk filling to separate clean material from potentially PFAS impacted groundwater and soil. GCL installation can also be considered in the wetlands described below.
- Several minor drains within the development are being removed / filled in and will be replaced by formal pit and pipe networks lines. Where the drains are modified by expansion, installation of new ones or filled in and replaced with a pit and pipe drainage network, PFAS impacted soil / sediment may have to be managed. The most efficient manner would be stabilisation with powdered activated carbon (PAC) and off-site disposal once a suitable facility that will receive the material is located. Alternatively, a SAP-specific Resource Recovery Order (RRO) and Resource Recovery Exemption (RRE) under the *Protection*

of the Environment Operations (Waste) Regulation 2014 (Waste Regulation) could be developed in consultation with the appropriate agencies. Establishing a SAP specific RRO / RRE could provide a sustainable option to beneficially reuse PFAS impacted soil.

- The new drainage pit and pipe network could be sealed to prevent groundwater intrusion.
- The water quality wetlands are envisioned to be constructed in areas downstream of each sub-catchment area across the SAP. Based on the available data, there is a low likelihood of encountering elevated PFAS concentrations in soil or groundwater in this area. There could be trace amounts of PFAS in soils in these areas so during excavation / construction, the soil could be managed as in the above bullet points. Future monitoring of water quality discharging from these wetlands will be required during the operational phase of the SAP.
- Where WSUD measures in the street or on lot are proposed with unlined bases, the risk of PFAS intrusion into these assets should be assessed during detailed design phase and the design adapted accordingly.
- Passive treatment systems constructed of PAC should be installed downstream of Dawsons Drain and Learys Drain or the WSUD wetlands outlet (**Figure 10 in Appendix A**) to treat any trace levels of PFAS that have entered the drainage system prior to release to local waterways. The WSUD measures will be designed to treat frequent storm events (up to around the 3-month Annual Recurrence Interval event). High flows which bypass the WSUD measures will be allowed to discharge untreated. The proportion of PFAS in stormwater runoff (compared to during baseflow conditions) is unknown at this stage. Defence have embarked on a PFAS mass flux study for the area which will determine if high flows contain significant PFAS levels. In other areas, the need for passive treatment should be evaluated based on the risk of encountering PFAS. Ongoing maintenance of the PAC will be required to anticipate and prevent any breakdown of equipment. This will allow the passive treatment system to continue to run efficiently and prevent any costly unplanned breakages or leaking from unexpected equipment failure.

Table 7 Summary of PFAS mitigation measures

Potential mitigation measure		Conceptual application description	Advantages	Disadvantages	Further concept design/ planning control considerations
Bulk fill for flooding immunity		<p>Between 2 - 4 m of fill material will be required to create a development platform that provides flood immunity for the future development. Clearing and grubbing would be required to prepare the existing ground surface for the bulk filling application. It is preferable to undertake the bulk filling as early works to allow for bulk fill preloading in the development area and account for settling that would occur during this process. It is estimated that the primary settlement and preload duration will take between 2 and 18 months depending on the sub precinct land use. Additional details on the bulk filling requirements can be found in the <i>B.3.2E: Flooding and Water Cycle Management Report</i> (Aurecon, 2021a) and <i>B.2.2G: Geotechnical Report</i> (Aurecon, 2021b).</p>	<p>Advantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>■ The bulk filling would address two constraints: flooding and PFAS management.</li> <li>■ The additional depth of fill would provide a vertical buffer to PFAS impacted groundwater "daylighting" to ground surface.</li> <li>■ The filling and future development would reduce the localised stormwater infiltration into the centre of the modelled PFAS plume. This would tend to reduce local groundwater levels and velocities.</li> <li>■ Compaction of the fill material, weight of fill and weight of buildings could reduce the local subsurface permeability. A reduction in local permeability would tend to decrease local groundwater upwelling velocities and consequently PFAS transport.</li> </ul>	<p>Disadvantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>■ Impacted groundwater PFAS could upwell and interact with the clean bulk fill material. The PFAS could preferentially deposit onto the clean fill material and subsequently create a secondary source.</li> <li>■ This measure should not be used in isolation. One of the additional mitigation measures described below would be required to minimise PFAS impact to the clean fill material.</li> <li>■ If the local subsurface permeability is reduced, this would tend to lead to a reduced subsurface velocity and also a "bulging" effect with a potential localised change in the lateral gradient. This could cause PFAS plume to migrate short distances to the east or west depending on the magnitude in the change of the lateral gradient.</li> <li>■ The existing monitoring well network will need to be protected and maintained for long term monitoring of the PFAS plume.</li> </ul>	<p>Additional details that are required to inform the conceptual design include:</p> <ul style="list-style-type: none"> <li>■ Additional understanding of the impact of the weight of the fill material and future buildings on the subsurface permeability.</li> <li>■ To prevent PFAS ingress into clean fill material a GCL should be installed to prevent ongoing leaching to the environment and will have to be integrated with the bulk filling strategy.</li> </ul> <p>The following items would likely form part of the Environmental Management Plan for the SAP enabling works and would be enforced by the masterplan and delivery plan:</p> <ul style="list-style-type: none"> <li>■ Some targeted modelling may be required to further quantify how a reduction in permeability may affect the fate and transport of the PFAS plume. AECOM has undertaken extensive modelling of the PFAS plume which could be adapted to further establish / understand these conditions.</li> <li>■ Coordination with Defence on maintaining their PFAS Investigation monitoring well network.</li> </ul> <p>Additional details that are required to inform the masterplan and delivery plan include:</p> <ul style="list-style-type: none"> <li>■ A development control plan or SEPP may be required to specify evacuation for building foundation, utility services and trees with deep root zones so they do not damage the GCL layer.</li> </ul>

Potential mitigation measure		Conceptual application description	Advantages	Disadvantages	Further concept design/ planning control considerations
Passive treatment of retained stormwater		<p>The stormwater management strategy includes installation of drainage channels and wetlands across the SAP that direct stormwater to existing drain networks. Details of stormwater management plan are shown on <b>Figure 6-1</b>. As shown, the majority of stormwater will be directed to the existing Dawsons Drain and Learys Drain. An overflow wetland is proposed south of Dawsons Drain that would allow collected stormwater to slowly be released to downgradient areas. The channels, wetlands and the basins would all be constructed above the current grade by contouring the bulk fill material. Therefore, it is anticipated that the majority of stormwater captured by this system would be "clean" as it would not interact with PFAS impacted environmental media. However, the drains could contain soils / sediments that are impacted and / or contain some stormwater flowing from the Defence Base.</p> <p>As a conservative measure, installation of a passive treatment system such as Aqua Gate could be installed on the downstream ends of the detention basins. The aqua gate incorporates a permeable fabric encapsulating powdered activated carbon (PAC) which is installed perpendicular to the flow direction. The reported hydraulic conductivity of this system is approximately <math>3.8 \times 10^{-4}</math> m/sec. The passive filtration system would tend to reduce water discharge velocities. However, it is proposed to slowly release stormwater and it is not anticipated that a passive filtration system would have a significant impact on discharge velocities. Additional details on the Aqua Gate system are included in Appendix D</p>	<p>Advantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>■ This application would remove any incidental soluble PFAS in the stormwater before it is discharged</li> <li>■ Relatively low-cost strategy that can be implemented with a commercially available off-the-shelf solution.</li> <li>■ A similar system has been recently installed at Lake Cochran on the Base and is understood to show early favourable results.</li> <li>■ Ability to demonstrate an innovative solution. Although the technology is relatively simple there are limited examples nationally and globally of passive treatment of PFAS impacted stormwater.</li> <li>■ Given the proposed slow release of stormwater and high hydraulic conductivity of PAC, this application should not have an appreciable impact on stormwater hydraulics</li> </ul>	<p>Disadvantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>■ During large storm events, some bypass of stormwater will be required. If the passive PFAS treatment were installed for all flows it would reduce the velocity of the stormwater which would cause some back-up of water in the basins and additional sedimentation around the device. Under large magnitude events the passive system would have to be bypassed to maintain sufficient velocities for stormwater movement.</li> <li>■ The PAC will have to be replaced over time to continue being effective. This presents an ongoing operation and maintenance task commitment.</li> <li>■ Sampling of discharged stormwater will be required to verify it meets PFAS discharge criteria (and meets other water quality guidelines) prior to discharge.</li> </ul>	<p>Additional details that are required to inform the conceptual design include:</p> <ul style="list-style-type: none"> <li>■ Further modelling of hydraulics to understand the effect of installing a passive treatment.</li> </ul> <p>The following items would likely form part of the Environmental Management Plan for the SAP enabling works and would be enforced by the masterplan and delivery plan:</p> <ul style="list-style-type: none"> <li>■ Operation and maintenance requirements of the passive system will need to be established. This includes how frequently the passive stormwater filtration medium needs to be replaced.</li> <li>■ A stormwater sampling frequency will need to be established to verify it meets any discharge criteria set by the regulators before discharging. This would likely need to be developed in consultation with the NSW EPA and PFAS Technical Advisory Group (TAG).</li> <li>■ An Environmental Management Plan (EMP) is required to maintain these passive treatment systems.</li> </ul>



Potential mitigation measure		Conceptual application description	Advantages	Disadvantages	Further concept design/ planning control considerations
Pump, treat and reinject treated groundwater		Some dewatering or management of groundwater may be required during construction activities. If required, the groundwater could be treated and reinjected into the aquifer in an upgradient location. The treatment would likely include filtration through activated carbon or ion resin exchange. Foam fractionation systems have also shown favourable results recently. Defence is currently undertaking similar works in the northern portion of the Base. The operational data indicates that the PFAS is being removed from the groundwater to meet Hunter Water criteria.	<p>Advantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>■ “Real-time” treatment of any groundwater that requires management is preferable given large volumes of water that may be produced. This would preclude water from having to be stored or transported off-site for disposal.</li> <li>■ Aquifer pumping and reinjection is feasible given the relatively high permeability of the Tomago Sands. This makes the design and operation of a groundwater treatment and reinjection system less complex.</li> <li>■ Mobile style treatment systems are commercially available that have demonstrated effective removal of PFAS from groundwater.</li> </ul>	<p>Disadvantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>■ Large quantities of waste in the form of spent carbon vessels could be produced depending on the volumes of water that require treatment and the PFAS concentrations</li> <li>■ The pre-fabricated systems require a continuous power source which would have to be established near the above ground treatment equipment.</li> <li>■ The hydraulics of a pumping and reinjection system can be complex and additional detailed design would be required (see column to the right).</li> </ul>	<p>Additional details that are required to inform the conceptual design include:</p> <ul style="list-style-type: none"> <li>■ If available, review of operational data from the system operating at the Defence Base could be used to design a similar system.</li> <li>■ If this information is not available, review of aquifer specific properties to inform pumping, treatment and re-injection rates.</li> <li>■ Pre-fabricated treatment systems are available but operational parameters would have to be confirmed to ensure process equipment is specified correctly.</li> </ul> <p>The following items would likely form part of the Environmental Management Plan for the SAP enabling works and would be enforced by the masterplan and delivery plan:</p> <ul style="list-style-type: none"> <li>■ Operation and maintenance requirements including change out rates would be required.</li> </ul>

Potential mitigation measure		Conceptual application description	Advantages	Disadvantages	Further concept design/ planning control considerations
Installation of a GCL		<p>Installation of a GCL in areas of bulk filling to separate clean material from potentially PFAS impacted soil. A GCL is a geosynthetic composite, engineered for environmental containment applications. GCLs consist of a layer of high-quality sodium bentonite powder sandwiched between two or more layers of durable geotextiles, reinforced by needle-punching to improve confinement and internal shear strengths. A GCL is an extremely low permeable liner that provides the equivalent permeability of one metre of compacted clay. New fabrication techniques of the GCLs are incorporating activated carbon with the bentonite to specifically limit PFAS migration through a GCL.</p> <p>The conceptual application would include preparation of the current ground surface and removal of existing vegetation. GCLs are manufactured off-site by specialised companies. It is delivered in rolls that are approximately 4.7m wide and 30 to 45 metres long. Specialised equipment and personnel are required to ensure a GCL is installed per the manufacturer's specifications and that it will perform as designed. A drainage layer would be required above and below the GCL. The drainage layer below the GCL is required to relieve any pressure produced from increasing groundwater levels. The drainage layer above the GCL would be required to manage stormwater that migrates vertically through the fill material and would tend to accumulate on the GCL.</p> <p>Additional technical details on a GCL and general installation procedures are included in Appendix C.</p>	<p>Advantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>The effectiveness of using GCLs to provide containment of wastes and liquids is well established with numerous applications across Australia and globally.</li> <li>A GCL will provide long term protection between the impacted groundwater and clean fill material if installed correctly. A GCL is more durable in the long term versus other types of liners such as HDPE liners.</li> <li>While some specialised equipment and personnel are required, the installation process is relatively straightforward.</li> <li>The addition of activated carbon to new designs of GCLs increases the protection from PFAS migration.</li> <li>If penetrated, GCLs are "self-healing" to a certain extent but this is limited to relatively small penetrations (1-2 cm maximum)</li> <li>Where a GCL is installed, this would reduce the volume of stormwater recharge to the aquifer. This would tend to reduce groundwater flow velocities and thus transport of PFAS in groundwater</li> </ul>	<p>Disadvantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>Installation of a GCL may present a constraint to foundation design for future buildings. If deeper piles are required, their design will need to consider penetrations through a GCL to ensure a preferential pathway is not created.</li> <li>Landscaping vegetation, installed for amenity, with deeper root systems could penetrate the GCL which could create a preferential pathway.</li> <li>The drainage layer required below the GCL would be designed to relieve the pressure from rising groundwater levels. Intercepting rising groundwater may create a preferential pathway for groundwater movement and consequently affect PFAS fate and transport.</li> <li>A drainage layer will be required above the GCL to capture and manage stormwater that vertically migrates down through the fill layer. The collected stormwater would have to be captured and managed in the same manner as described above.</li> </ul>	<p>Additional details that are required to inform the conceptual design include:</p> <ul style="list-style-type: none"> <li>Quantify the impact on the shallow hydrogeology from the drainage layer installed below the GCL. Further understanding of the potential to create a preferential pathway and how any collected groundwater would be managed.</li> <li>Further design of the drainage layers above and below the GCL would be required.</li> <li>Confirmation from the manufacturer that the GCL will be appropriate for this site-specific application.</li> <li>Establish staging requirements for installation of the GCL and the bulk filling and any interactions between the fill and GCL.</li> <li>Confirm the weight of fill material and future structures would not adversely affect the performance of the GCL.</li> </ul> <p>Additional details that are required to inform the masterplan and delivery plan include:</p> <ul style="list-style-type: none"> <li>If deep piles are required for structural purposes, design a sealing mechanism to ensure they do not create a preferential vertical flow pathway</li> <li>Develop a specific planting plan and development controls for vegetation with potentially deep root zones.</li> </ul>

Potential mitigation measure		Conceptual application description	Advantages	Disadvantages	Further concept design/ planning control considerations
Mixing of powdered activated carbon in bulk fill		<p>As described above, a key risk to manage during future construction is to prevent PFAS impacted groundwater from interacting with the imported clean fill material. There are several disadvantages noted for the GCL that could be produce significant constraints to the future design (foundations and vegetation with deep root zones). As an alternative or complimentary measure, PAC could be mixed with the bulk fill material. Theoretically, the PAC would preclude dissolved phase PFAS adsorbing to the clean fill. If PFAS did transfer from the groundwater to the particulate phase adsorbing onto the clean fill material, it would be preferentially adsorbed by the PAC. Once adsorbed to the PAC, the PFAS would be less likely to leach and act as a secondary source.</p> <p>Given the groundwater fluctuations described previously, groundwater would be expected to only interact with the bottom 0.5-0.75 m of the fill material. As such, the PAC would only need to be mixed with the bottom fill layers.</p>	<p>Advantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>Relatively low-cost method to prevent PFAS from adsorbing to clean fill and act as a future secondary source.</li> <li>Easily implemented with conventional equipment by mixing 1-2% weight PAC / weight fill material as it is being placed.</li> <li>PAC has shown to be an effective for a range of COPCs including PFAS</li> <li>The PAC can be mixed uniformly into the fill material</li> <li>Use of PAC could increase the geotechnical stability of the fill material</li> <li>Based on the constraints ratings, use of PAC could preclude the need for a GCL in some areas across the structure plan boundary.</li> </ul>	<p>Disadvantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>During the operational phase of the SAP (i.e., after construction), the PAC will have a finite timeframe for being effective. It is difficult to predict the lifespan of the PAC.</li> <li>If clay is used as the fill material, it would make the uniform mixing of PAC more challenging.</li> <li>Limited supplies of PAC are currently available in Australia due to it being used extensively in environmental remediation applications. Depending on the timing of the bulk filling, the procurement of PAC could present a long lead time.</li> </ul>	<p>Additional details that are required to inform the conceptual design include:</p> <ul style="list-style-type: none"> <li>Further understanding / research to confirm the PAC could prevent PFAS adsorption onto clean fill material and prevent it leaching into the future.</li> <li>Establish a predicted lifespan of the PAC.</li> <li>Refine the understanding of the addition of PAC's effect on the fill materials geotechnical suitability.</li> <li>Determine the fill layers / depths where the PAC would be mixed.</li> </ul> <p>Additional details that are required to inform the masterplan and delivery plan include:</p> <ul style="list-style-type: none"> <li>Further understanding of building design details to inform planning controls to enable alternative solutions where areas where installation of a GCL may be problematic and addition of PAC may be the preferable option.</li> </ul>
Establish RROs / RREs under POEO Act		<p>To provide a sustainable option for re-use of soil waste material generated during construction, numerous RROs / RREs have been established under the Protection of <i>Environment Operations (Waste) Act 2000</i>. RROs / RREs for large infrastructure projects across NSW. These allow re-use of material that may not meet the definitions of Excavated Natural Material / Virgin Excavated Natural Material (ENM / VENM).</p> <p>In consultation with the NSW EPA, a SAP-specific RRO / RRE could be developed which allowed the reuse of soil waste produced during the construction phase. Establishing the RRO / RRE would include determining the sampling and any treatment requirements for re-using the material. This would include specifying sampling densities for in-situ material and ex-situ stockpiled material and concentration acceptance criteria.</p>	<p>Advantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>Provides a sustainable option to re-use soil waste that may be generated during future construction.</li> <li>Would present a significant cost saving from transporting soil / sediment waste to landfill. Additionally, locating landfill facilities, near the SAP, that will accept PFAS impacted soil, could be problematic.</li> <li>Once the requirements are established, the RRO / RRE is legally enforceable and could be integrated into the SAP State Environmental Planning Policy (SEPP) that will be developed.</li> <li>Re-use of soil under an RRO / RRE could be combined with one of the other mitigation measures.</li> <li>Could be used as precedent for re-using soil waste produced at other sites with PFAS impacts.</li> </ul>	<p>Disadvantages of this mitigation measure are:</p> <ul style="list-style-type: none"> <li>Stabilisation may be required for soil / sediment with detectable PFAS concentrations. The stabilisation process would have to be established and demonstrated to be effective in the long term.</li> <li>Extensive sampling of the soil / sediment will be required based on the sampling density established in an RRO / RRE.</li> <li>Soil / sediment with elevated PFAS concentrations may not be able to be re-used depending on the criteria established in the RRO / RRE.</li> </ul>	<p>Additional details that are required to inform the conceptual design include:</p> <ul style="list-style-type: none"> <li>Range of PFAS concentrations in the soil / sediment waste anticipated to be produced.</li> <li>Accurate estimates of volumes of soil / sediment waste that may be produced.</li> <li>Further liaison with the NSW EPA to establish the specifics of the RRO /RRE including sampling densities and concentration acceptance criteria.</li> </ul> <p>The following items would likely form part of the Environmental Management Plan for the SAP enabling works and would be enforced by the masterplan and delivery plan:</p> <ul style="list-style-type: none"> <li>If stabilisation of PFAS impacted soil is required to meet RRO / RRE requirements, bench scale trials or similar may be required to demonstrate its' long-term effectiveness at preventing PFAS leaching potential.</li> <li>Long-term monitoring may be required to confirm that PFAS is not leaching from any soil / sediment that may be re-used</li> </ul>

### 6.1.2 PFAS Mitigation Summary

It is envisaged that a combination of the above mitigation measures would be employed to minimise the potential that PFAS will be mobilised during and after construction. The proposed combination of mitigation measures is summarised as follows and shown below on **Figure 6-1**

The eastern portion of the structure plan is situated over the centre of the PFAS plume. In this area, a GCL would be necessary. The addition of PAC to the bottom 0.5-0.75 m of the clean fill material could also be considered as a complimentary and conservative measure.

- The analytical data indicates limited or no elevated PFAS concentrations in the western portion of the structure plan boundary. In this area, the need for a GCL should be critically evaluated. Addition of PAC into the bottom 0.5-0.75 m of fill material should be sufficient to mitigate risks of clean fill interacting with PFAS impacted environmental media or becoming a secondary source.
- A passive treatment system should be installed at the most downstream end of Dawsons Drain and Learys Drain. The majority of the water that would flow through these drains would be considered “clean” as it would only interact with the clean imported fill material and future buildings and ancillary facilities. However, there are likely PFAS impacted soils / sediments already in the drains that could continue to leach to stormwater. These drains will continue to receive drainage from the Base as well which has to be assumed to be PFAS impacted. As a precautionary and conservative measure, the outlets to these drains should be equipped with a passive treatment system.

An additional consideration for the Williamstown SAP development will be the maintenance of the monitoring well network in the structure plan boundary area. These monitoring wells were installed by Defence and will need to be maintained for long-term monitoring of the groundwater plume. Protection of these monitoring wells should be integrated into the bulk filling plan. The location of the network is noted in the AECOM Interim Monitoring Event Report - RAAF Base Williamstown report (2019). Where there are data gaps for the structure plan precincts, additional monitoring wells may need to be installed to capture groundwater in the area and determine quality and potential for it to be impacted by PFAS.



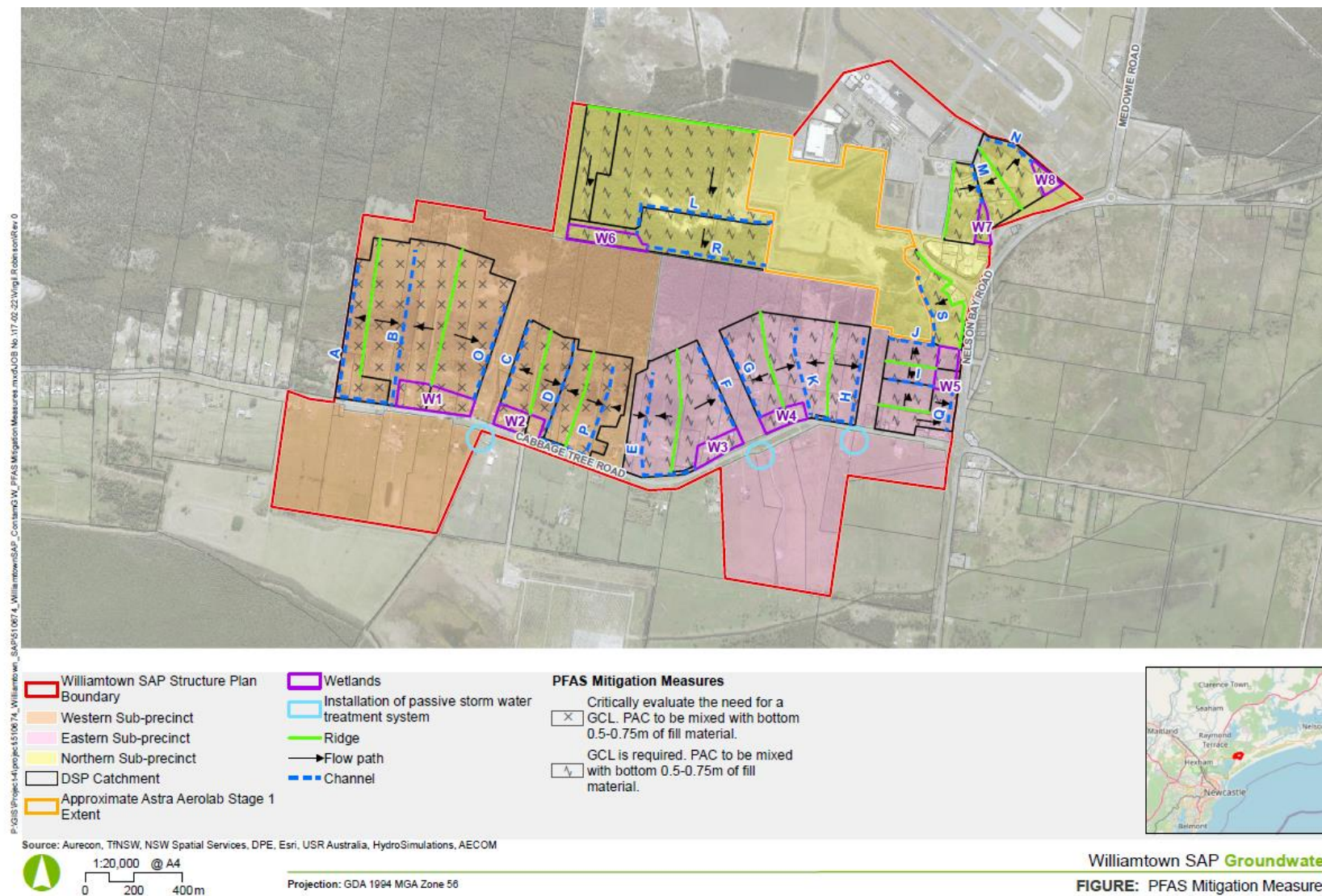


Figure 6-1 Flood, WSUD and PFAS Management and Mitigation Measures

### 6.1.3 Non PFAS Contamination Mitigation

The review of the available background information has identified numerous Areas of Potential Environmental Concern (APECs) throughout the SAP area where non-PFAS Contaminants of Potential Concern (COPCs) may be present at concentrations above the applicable Tier I screening values. There are several within the structure plan boundary. However, specific reports related to investigation of these areas have not been reviewed so specific concentrations of COPCs in environmental media are not known at these sites is not known at this time. The constraints rating has been based on the land use at the APEC and Aurecon's experience with previous similar projects. Therefore, the constraints analysis for the non-PFAS APECs is qualitative and can be refined when environmental media samples and analysed to determine if COPCs are present most likely during concept or detailed design.

Specific mitigation measures cannot be developed without additional information on the APECs and environmental media analytical data. Investigation of soil and / or groundwater should be undertaken as part of, or prior to, concept design in order to confirm the extent and significance of non-PFAS contamination in the identified APECs. The data collected will inform likelihood of remediation required under the SEPP 55 process, inform potential design constraints, risks to human and ecological receptors as well as establishing a preliminary waste classification of the excavated soils.

## 7 Conclusions

This report has provided a review of the structure plan for the Williamstown SAP. Baseline information pertinent to the SAP was reviewed and refined based on the preliminary scenarios. A scenario testing framework was developed and mitigation measures were then recommended for both PFAS and non-PFAS contamination.

### 7.1 Testing Framework

Following the first EbD Workshop in February 2021, the baseline analysis information obtained was updated, where required, to ensure that information obtained in Stage 2 was relevant to the scenarios developed. Based on the Stage 1 information, Aurecon identified areas where future development of the SAP could be constrained by the presence of PFAS and / or non-PFAS contamination. The definitions of the various constraint areas are:

- 'Highly Constrained' land has a high likelihood of encountering PFAS / non-PFAS at concentrations that require additional assessment, remediation or management within the Scenario boundary;
- 'Moderately Constrained' land has a medium likelihood of encountering PFAS / non-PFAS at concentrations in some areas that may require additional assessment, remediation or management;
- 'Low Constrained' land has a low to very low likelihood of encountering PFAS / non-PFAS at concentrations that may require additional assessment, remediation or management or limited/isolated areas where PFAS and non-PFAS may require assessment, remediation or management within the Scenario boundary;
- 'Negligible Constrained' land has no APECs identified within the Scenario Boundary.

Based on these constraints ratings, Aurecon's analysis of the structure plan was carried out using the following key testing criteria:

- Current and future land use zonings
- Likelihood of encountering PFAS and non-PFAS contamination and potential for mobilisation
- Likelihood of remediation being required
- Volumes of soil that may be disturbed and potential for re-use or need for off-site disposal

A framework to analyse and assess the development scenarios was designed using a comparative matrix table with key contamination constraints and opportunities. An evaluation of the constraints from PFAS and non-PFAS contamination for each of the scenarios are provided in this report to inform the Final EbD Workshop, as follows:

- Evaluation of strengths, weaknesses, opportunities and constraints of each scenario with respect to both non-PFAS and PFAS contamination, and consideration of their ability to respond to the findings of Stage 1 and address the precinct vision;
- Identification and development of solutions that could be implemented across the precinct to achieve the precinct vision;
- Identification of the required contamination management needed to support each of the scenarios, including considering the use of innovative and cost-efficient mitigation measures;
- Provision of recommendations for site-specific measures to address and facilitate contamination management opportunities across the precinct;

The Structure Plan refined by Hatch Roberts Day is centred around the existing Williamstown Airport Precinct, which includes Newcastle Airport, Williamstown 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. During



later stages of the development, other sub precincts with land uses including research and development, freight and logistics, and a commercial core.

The structure plan area includes properties impacted by PFAS contamination; landholders may have suffered loss or damage as a result of this contamination. During future stages of the SAP process, it will be critical to engage with the local stakeholders to help develop the mitigation measures that will have the least impact on the local community and the sensitive receiving environment.

## 7.2 PFAS Summary and Mitigation Measures

Review of the available background information indicates that extensive assessment has been conducted at the RAAF Base Williamstown (the Base) and the surrounding areas. The areas of PFAS impacted environmental media are well defined relative to the proposed precincts within the structure plan. The PFAS impacts have migrated from the Base in groundwater to the southern areas of the SAP up to approximately Cabbage Tree Road and to the North-East into Tilligerry Creek. There has been some migration to the east and southeast with ultimate groundwater flow toward Fullerton Cove. Recent groundwater monitoring data indicates that there are not measurable PFAS concentrations in groundwater to the south of Cabbage Tree Road. It is noted that measurable PFAS concentrations have been detected historically in some monitoring wells to the south of Cabbage Tree Road and in Fullerton Cove.

Upward flow of PFAS impacted groundwater into Fourteen Foot Drain and Tilligerry Creek (and other gaining streams) has been noted in Conceptual Site Models (AECOM, 2017) despite the likely impediment of groundwater-surface water expression by less permeable subsurface estuarine clays in the SAP area. Given the age of the PFAS groundwater plume, PFAS concentrations in groundwater are expected to reduce over time as Defence continues to remediate the identified primary and secondary sources on the Base. There is potential for fluctuations in groundwater, surface water and sediment concentrations and the lateral extents of the groundwater plume due to changing environmental conditions or chemical transformation of PFAS.

Measurable PFAS are still present in stormwater and this is a key migration pathway to off-Base areas. Stormwater becomes impacted when PFAS leaches from soil or sediment. In some areas, groundwater intersects the drains and discharges into the surface water system which is contributing to PFAS migration and impacting stormwater. The area is prone to flooding, with flood water contributing to PFAS impacts in soil, sediment and surface water and with likely interaction between the shallow groundwater and the drainage network. It is important to note however, that stormwater processes at the site are still not fully understood, particularly regarding PFAS migration during heavy rainfall events.

Aurecon reviewed environmental media collected from 2016 to 2019 by AECOM on Base and in the Williamstown SAP structure plan area. The previously collected data indicates that soil, sediments, surface water and groundwater within the structure plan boundary are impacted with PFAS. The structure plan boundary is situated directly downgradient of Lake Cochran and other secondary sources on the Defence Base. The eastern half of the structure plan is situated over the modelled groundwater plume that is showing the highest PFAS concentrations. Environmental media analytical data indicates that there are exceedances of the NEMP v2 Tier I screening values. This includes soils and sediment in and around the drainage networks, surface water that emanates from the Defence Base and the groundwater plume.

During the future construction, the potential risks from the PFAS impacted environmental media will need to be managed. The general measures to mitigate the risk of mobilising PFAS during the future development are summarised below. It is recommended that these mitigation measures be implemented in conjunction with the flooding WSUD and geotechnical mitigation strategies.

Flooding is a major constraint to the developable area within the structure plan boundary. The flooding and WSUD and geotechnical management measures included under separate cover include a combination of strategies to manage flooding and water quality across the SAP. To facilitate development within the floodplain, bulk filling to above the regional 1% Annual Exceedance Probability plus year 2100 climate change flood level (approximately 2-4m thickness) will be required. The filling must strike a balance with not creating flood impacts and not mobilising PFAS. This will require design of floodplain management measures to mitigate and offset flood impacts. Bulk filling is also required to facilitate drainage of development lots and

roads within the precinct. WSUD measures such as wetlands will also be incorporated to treat stormwater and operate as detention basins during major events. Further details on the WSUD and flooding strategies are included in *B.3.2E: Flooding and Water Cycle Management Report*.

The flooding and stormwater management strategy would possibly include some or all of the following measures:

- Identifying the development impacts and the land required for SAP flood mitigation measures
- Flood detention to mitigate impacts on downstream development
- Preserving floodways to mitigate impacts on upstream and adjacent development
- Water quality treatment provided by swales and end of system wetlands

Locations of the detention basins and the wetlands have been included on the constraints mapping to visualise the flood mitigation measures relative to the PFAS constraints. The flood mitigation and stormwater management measures must also consider the potential to mobilise PFAS impacted groundwater, sediment, soil and surface water. The mitigation measures are summarised as follows:

- Bulk filling for flood immunity
- If necessary, groundwater could be pumped, treated and reinjected into the aquifer to maintain current recharge levels and off-set additional impermeable surfaces proposed in the future development.
- Installation of a GCL in areas of bulk filling to separate clean material from potentially PFAS impacted groundwater and soil. GCLs can also be considered in the wetlands described below.
- Several minor drains within the development are being removed / filled in and will be replaced by formal pit and pipe networks lines. Where the drains are modified by either expansion or installation of new ones or filled in and replaced with a pit and pipe drainage network, PFAS impacted soil / sediment may have to be managed. The most efficient manner would be stabilisation with PAC and off-site disposal once a suitable facility that will receive the material is located. Alternatively, a SAP specific RRO and RRE under the *Protection of the Environment Operations (Waste) Regulation 2014 (Waste Regulation)* could be developed in consultation with the appropriate agencies. Establishing a SAP specific RRO / RRE could provide a sustainable option to beneficially reuse PFAS impacted soil.
- The new drainage pit and pipe network could be sealed to prevent groundwater intrusion.
- The water quality wetlands are envisioned to be constructed in areas downstream of each sub-precinct area across the SAP. Based on the available data, there is a low likelihood of encountering elevated concentrations of PFAS in soil or groundwater in this area. There could be trace amounts of PFAS in soils in these areas so during excavation / construction, the soil could be managed as above. Future monitoring of water quality discharging from these basins will be required during the operational phase of the SAP.
- Where WSUD measures in the street or on lot are proposed with unlined bases, the risk of PFAS intrusion into these assets should be assessed during detailed design and the design adapted accordingly.

Passive treatment systems constructed of PAC should be installed downstream of Dawsons Drain and Learys Drain or the WSUD wetlands outlet to treat any minor amounts of PFAS that has entered the drainage system prior to release to local waterways. The WSUD measures will be designed to treat frequent storm events (up to around the 3-month ARI event). High flows which bypass the WSUD measures will be allowed to discharge untreated. In other areas, the need for passive treatment should be evaluated based on the risk of encountering PFAS.

It is envisaged that a combination of the above mitigation measures would be employed to provide a multi-barrier approach and minimise the potential that PFAS will be mobilised during and after construction. The proposed combination of mitigation measures is summarised as:

- The eastern portion of the structure plan is situated over the centre of the PFAS plume. In this area, a GCL would be necessary. The addition of PAC to the bottom 0.5-0.75 m of the clean fill material could also be considered as complimentary and conservative measure.
- The analytical data indicates limited to no elevated PFAS concentrations in the western portion of the structure plan boundary. In this area, the need for a GCL should be critically evaluated. Addition of PAC into the bottom 0.5-0.75 m of fill material should be sufficient to mitigate risks of clean fill interacting with PFAS impacted environmental media or becoming a secondary source.
- A passive treatment system should be installed at the most downstream end of Dawsons Drain and Learys Drain. The majority of the water that would flow through these drains would be considered “clean” as it would only interact with the clean fill material and future buildings and ancillary facilities. However, there are likely PFAS impacted soils / sediments in the drains that could continue to leach to stormwater. These drains will continue to receive drainage from the Base as well which has to be assumed to be PFAS impacted. As a precautionary and conservative measure, the outlets to these drains should be equipped with a passive treatment system.

An additional consideration for the SAP development will be the maintenance of the monitoring well network in the structure plan boundary area. These monitoring wells were installed by Defence and will need to be maintained for long term monitoring of the groundwater plume. Protection of these monitoring wells should be integrated into the bulk filling plan. The location of the network is noted in the AECOM Interim Monitoring Event Report - RAAF Base Williamstown report (2019).

## 7.3 Non-PFAS Summary and Mitigation Measures

The review of the available background information has identified numerous Areas of Potential Environmental Concern (APECs) throughout the SAP area where non-PFAS Contaminants of Potential Concern (COPCs) may be present at concentrations above the applicable Tier I screening values. There are several within the structure plan boundary. However, specific reports related to investigation of these areas have not been reviewed so specific concentrations of COPCs in environmental media are not known at these sites is not known at this time. The constraints rating has been based on the land use at the APEC and Aurecon's experience with previous similar projects. Therefore, the constraints analysis for the non-PFAS APECs is qualitative and can be refined when environmental media samples and analysed to determine if COPCs are present.

Specific mitigation measures cannot be developed without additional information on the APECs and environmental media analytical data. Investigation of soil and / or groundwater should be undertaken as part of, or prior to, concept design in order to confirm the extent and significance of non-PFAS contamination in the identified APECs. The data collected will inform likelihood of remediation required under the SEPP 55 process, inform potential design constraints, risks to human and ecological receptors as well as establishing a preliminary waste classification of the excavated soils.

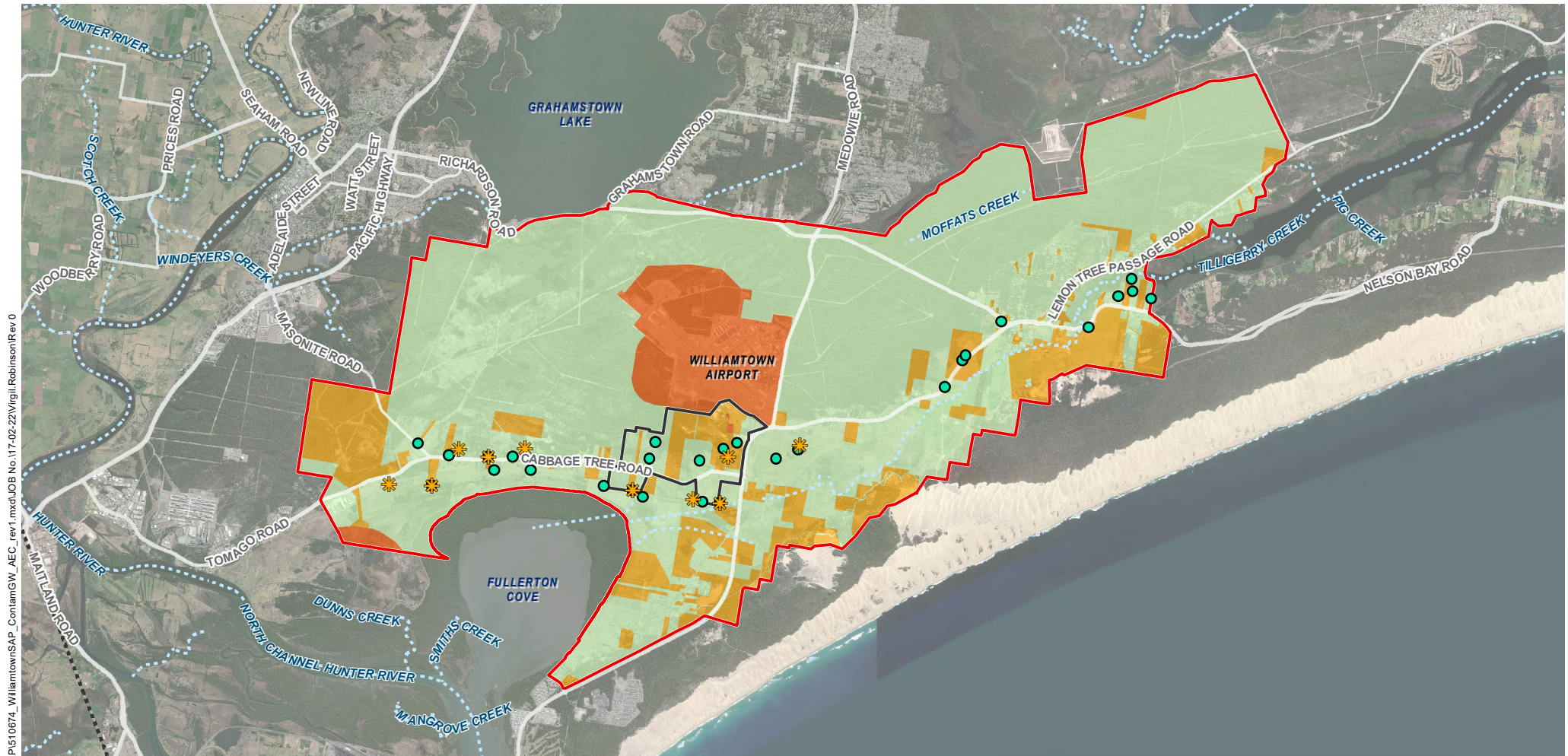
## 8 References

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# Appendix A

## Figures





Williamtown Study Area

Williamtown SAP Structure Plan Boundary

Waterway

Railway

Wetland locations

Flooding retention basins

### Non-PFAS Contamination Constraints

Highly constrained

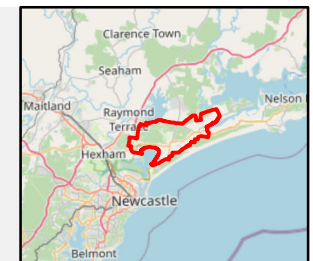
Moderately constrained

Minimally constrained

High likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management

Moderate likelihood of encountering non-PFAS contamination at concentrations in some areas of the Scenario boundary that may require additional assessment, remediation or management

Low likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management or limited/isolated areas where non-PFAS contamination may require assessment, remediation or management



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Source: Aurecon, TfNSW, NSW Spatial Services, DPE, EPA, Port Stephens Council, Esri



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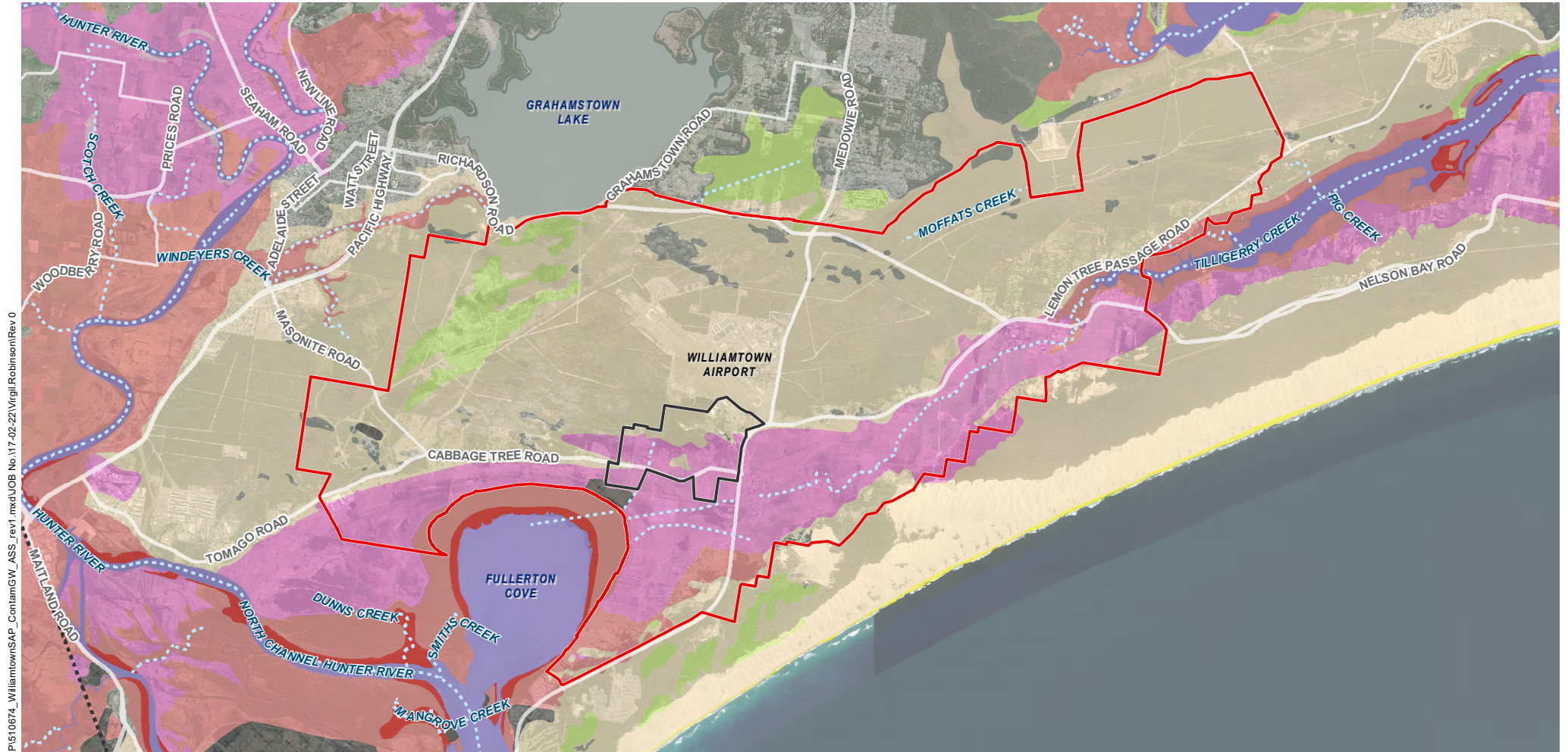
0 2 4km

Projection: GDA 1994 MGA Zone 56

Williamtown SAP Groundwater

FIGURE 1: Non-PFAS Contamination Constraints Map





Williamstown Study Area

Williamstown SAP Structure Plan Boundary

Waterway

Railway

### Acid Sulfate Soil Risk

High Risk 0-1m

High Risk 1-2m

High Risk 2-4m

High Risk above 4m

High Risk Sediments

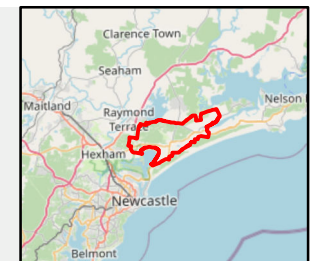
Low Risk 2-4m

Low Risk above 4m

No Risk

Disturbed Terrain

Beach



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



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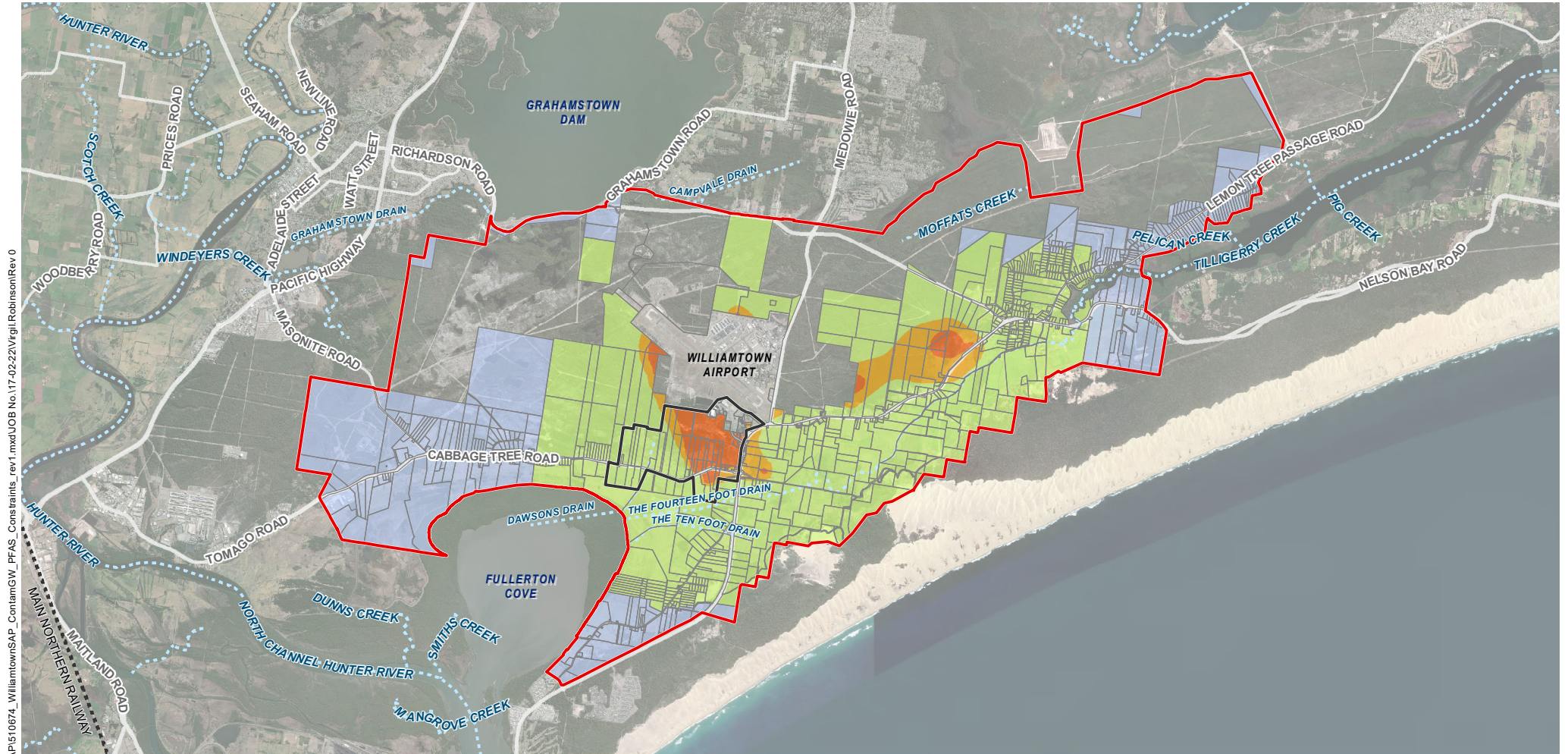
0 2 4 km

Projection: GDA 1994 MGA Zone 56

Williamstown SAP Groundwater

FIGURE 2: Acid Sulfate Soils





- Williamstown Study Area
- Williamstown SAP Structure Plan Boundary
- Waterway
- Railway

#### PFAS Constraints

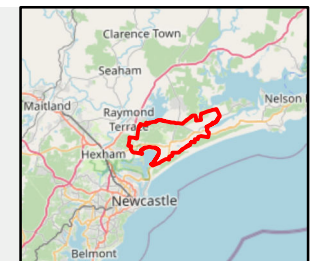
- Highly constrained
- Moderately constrained
- Minimally constrained
- Negligible

High likelihood of encountering PFAS contamination at concentrations that may require additional assessment, remediation or management

Moderate likelihood of encountering PFAS contamination at concentrations in some areas of the Scenario boundary that may require additional assessment, remediation or management

Low likelihood of encountering PFAS contamination at concentrations that may require additional assessment, remediation or management or limited/isolated areas where non-PFAS contamination may require assessment, remediation or management

No PFAS identified within the Scenario Boundary or could migrate to the scenario in any environmental media



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



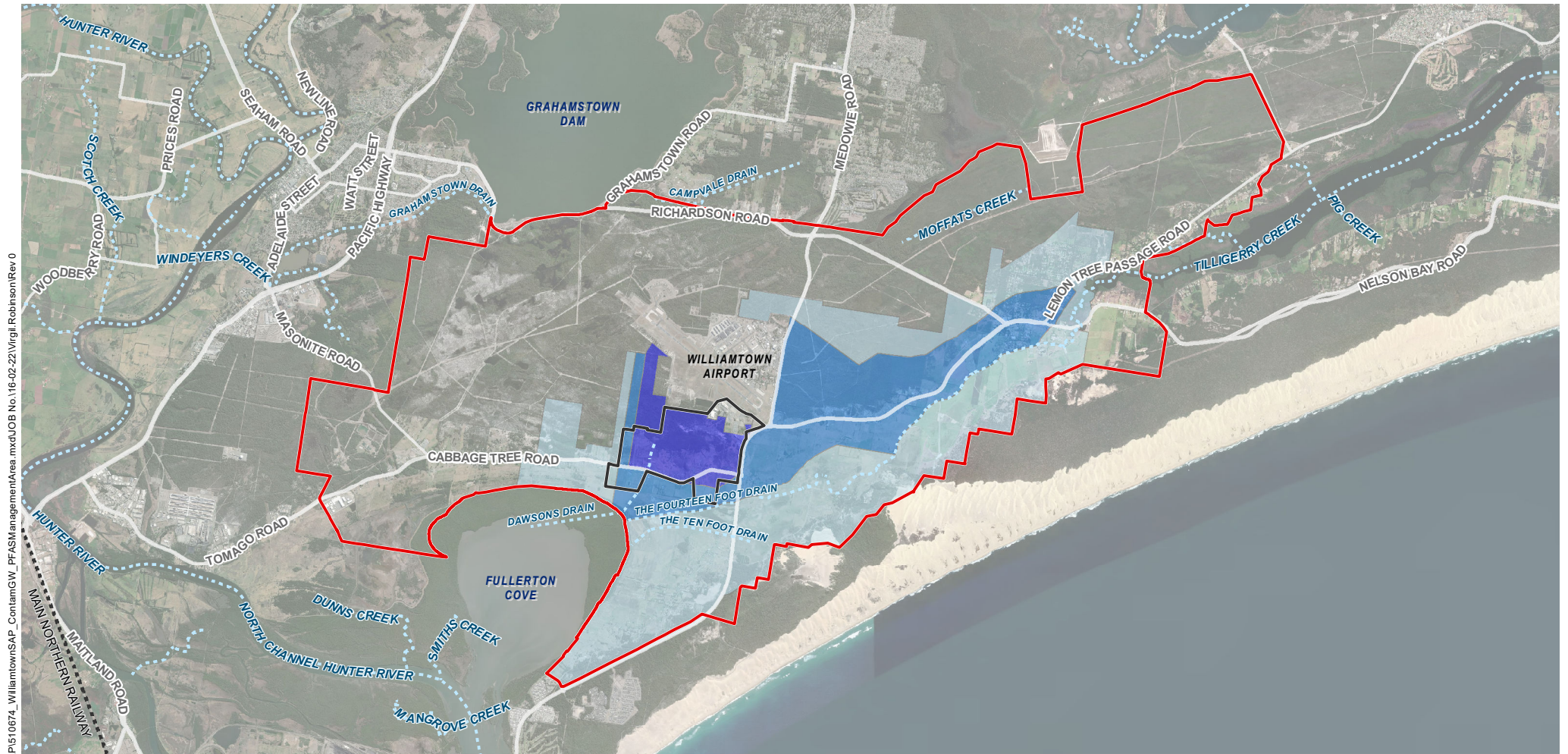
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0 2 4km

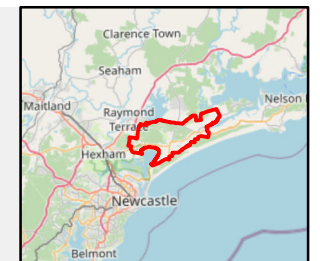
Projection: GDA 1994 MGA Zone 56

Williamstown SAP **Groundwater**  
FIGURE 3: PFAS Groudwater Constraints





- |  |   |
|--|---|
| <span style="border: 2px solid red; padding: 2px;"> </span> Williamstown Study Area                    | <b>NSW EPA PFAS Management Area</b>   |
| <span style="border: 2px solid black; padding: 2px;"> </span> Williamstown SAP Structure Plan Boundary | <span style="background-color: #4a7ebb; color: white; padding: 2px;"> </span> Primary Management Zone   |
| <span style="color: blue;">----</span> Waterway  | <span style="background-color: #8eb9e2; color: white; padding: 2px;"> </span> Secondary Management Zone |
| <span style="color: black;">-----</span> Railway   | <span style="background-color: #cfe2f3; color: white; padding: 2px;"> </span> Broader Management Zone   |



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

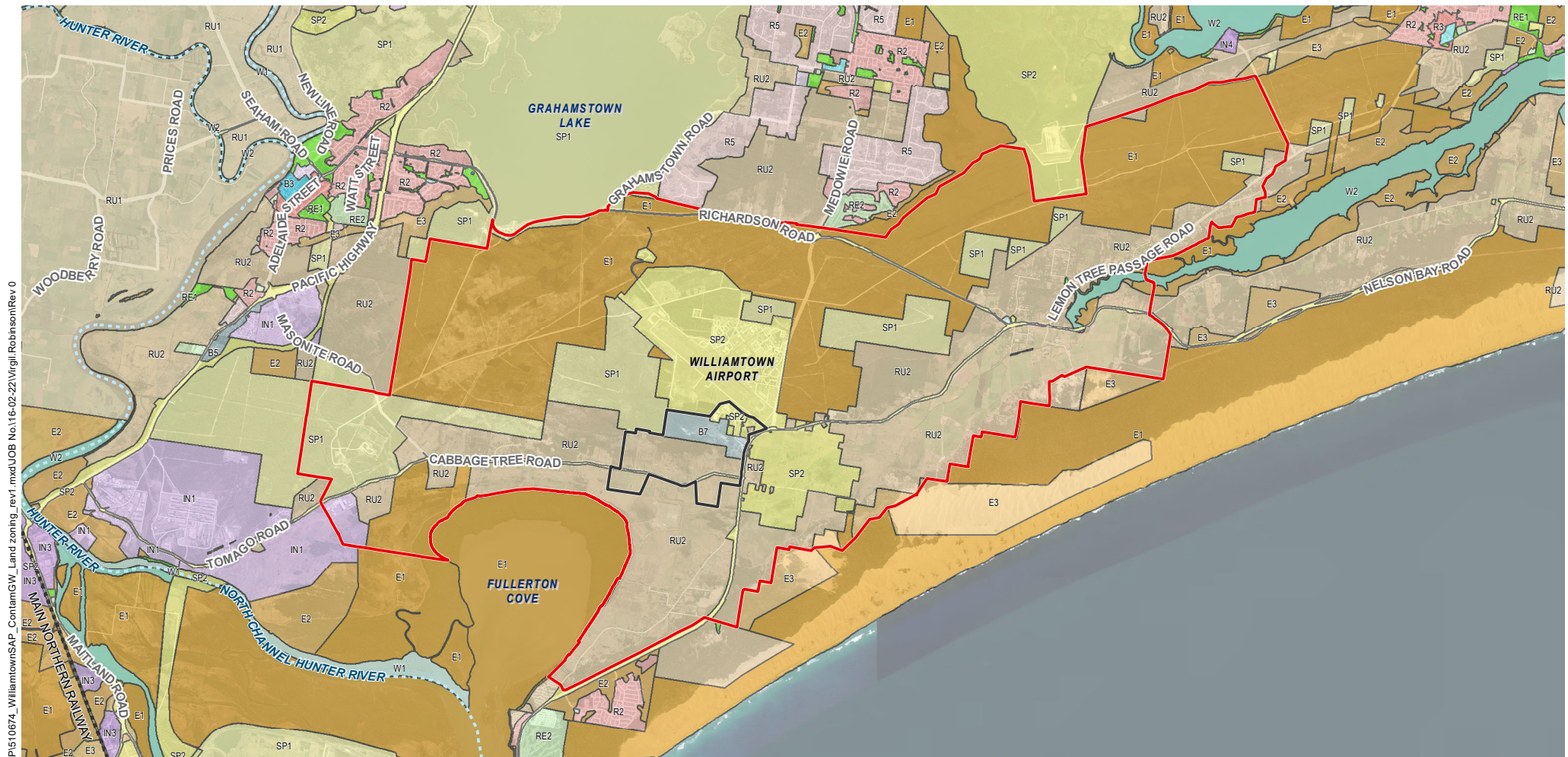


1:120,000 @ A4  
0 2 4km

Projection: GDA 1994 MGA Zone 56

Williamstown SAP **Groundwater**  
**FIGURE 4: PFAS Management Area**

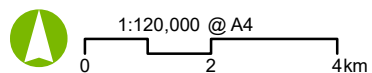




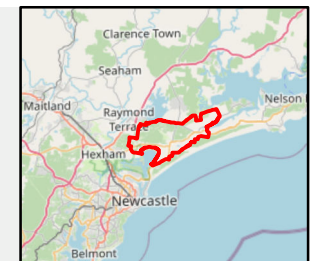
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- |  |  |  |  |
|--|--|--|--|
| <span style="border: 2px solid red; padding: 2px;"> </span> Williamtown Study Area                               | <span style="background-color: #d9e1f2; border: 1px solid black; padding: 2px;"> </span> B5 Business Development               | <span style="background-color: #f2d9e1; border: 1px solid black; padding: 2px;"> </span> IN4 Working Waterfront        | <span style="background-color: #fce4d6; border: 1px solid black; padding: 2px;"> </span> RU2 Rural Landscape       |
| <span style="border: 2px solid black; padding: 2px;"> </span> Williamtown SAP Structure Plan Boundary            | <span style="background-color: #d9f2e1; border: 1px solid black; padding: 2px;"> </span> B7 Business Park                      | <span style="background-color: #f2e1d9; border: 1px solid black; padding: 2px;"> </span> R1 General Residential        | <span style="background-color: #fff176; border: 1px solid black; padding: 2px;"> </span> SP1 Special Activities    |
| <span style="color: blue;">----</span> River   | <span style="background-color: #fce4ec; border: 1px solid black; padding: 2px;"> </span> E1 National Parks and Nature Reserves | <span style="background-color: #f8bbd0; border: 1px solid black; padding: 2px;"> </span> R2 Low Density Residential    | <span style="background-color: #fff176; border: 1px solid black; padding: 2px;"> </span> SP2 Infrastructure        |
| <span style="color: grey;">----</span> Railway   | <span style="background-color: #fff176; border: 1px solid black; padding: 2px;"> </span> E2 Environmental Conservation         | <span style="background-color: #f8bbd0; border: 1px solid black; padding: 2px;"> </span> R3 Medium Density Residential | <span style="background-color: #e0f2f1; border: 1px solid black; padding: 2px;"> </span> W1 Natural Waterways      |
| <b>Land Zoning</b>   | <span style="background-color: #fff176; border: 1px solid black; padding: 2px;"> </span> E3 Environmental Management           | <span style="background-color: #f8bbd0; border: 1px solid black; padding: 2px;"> </span> R5 Large Lot Residential      | <span style="background-color: #e0f2f1; border: 1px solid black; padding: 2px;"> </span> W2 Recreational Waterways |
| <span style="background-color: #e0f2f1; border: 1px solid black; padding: 2px;"> </span> B1 Neighbourhood Centre | <span style="background-color: #f2d9e1; border: 1px solid black; padding: 2px;"> </span> IN1 General Industrial                | <span style="background-color: #d9f2e1; border: 1px solid black; padding: 2px;"> </span> RE1 Public Recreation         |  |
| <span style="background-color: #e0f2f1; border: 1px solid black; padding: 2px;"> </span> B2 Local Centre         | <span style="background-color: #f2d9e1; border: 1px solid black; padding: 2px;"> </span> IN2 Light Industrial                  | <span style="background-color: #d9f2e1; border: 1px solid black; padding: 2px;"> </span> RE2 Private Recreation        |  |
| <span style="background-color: #e0f2f1; border: 1px solid black; padding: 2px;"> </span> B3 Commercial Core      | <span style="background-color: #f2d9e1; border: 1px solid black; padding: 2px;"> </span> IN3 Heavy Industrial                  | <span style="background-color: #d9f2e1; border: 1px solid black; padding: 2px;"> </span> RU1 Primary Production        |  |

Source: Aurecon, TfNSW, NSW Spatial Services, Esri



Projection: GDA 1994 MGA Zone 56

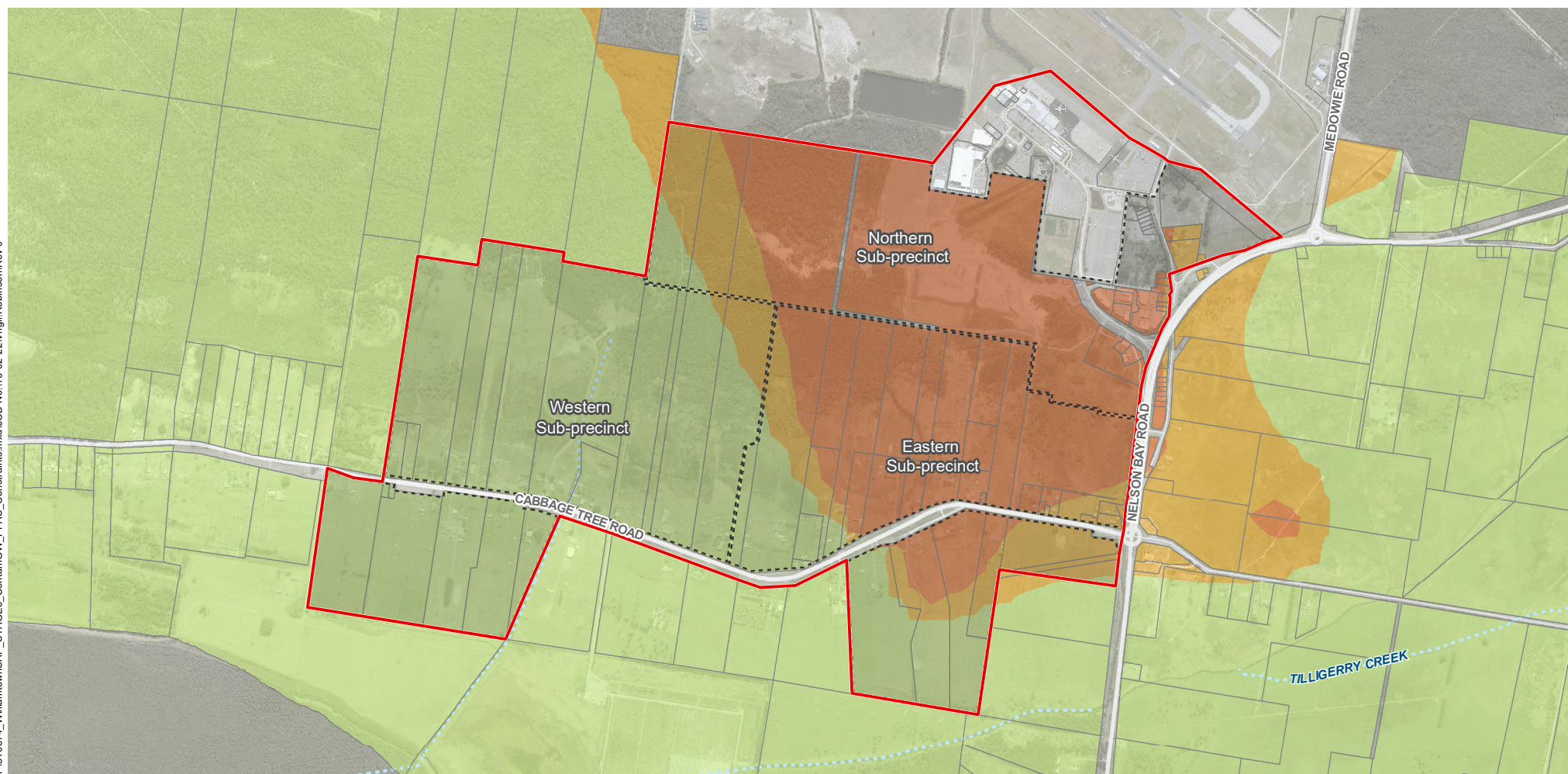


Williamtown SAP **Groundwater**

FIGURE 5: Land zoning



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Williamtown SAP Structure Plan Boundary

Sub-precinct boundary

Waterway

### PFAS Constraints

Highly constrained

Moderately constrained

Minimally constrained

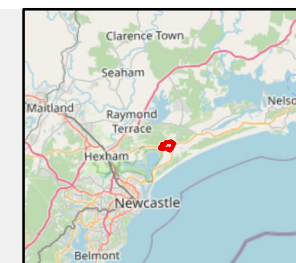
Negligible

*High likelihood of encountering PFAS contamination at concentrations that may require additional assessment, remediation or management*

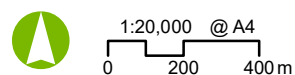
*Moderate likelihood of encountering PFAS contamination at concentrations in some areas of the Scenario boundary that may require additional assessment, remediation or management*

*Low likelihood of encountering PFAS contamination at concentrations that may require additional assessment, remediation or management or limited/isolated areas where non-PFAS contamination may require assessment, remediation or management*

*No PFAS identified within the Scenario Boundary or could migrate to the scenario in any environmental media*



Source: Aurecon, TfNSW, EPA, NSW Spatial Services, Aerometrex, Esri



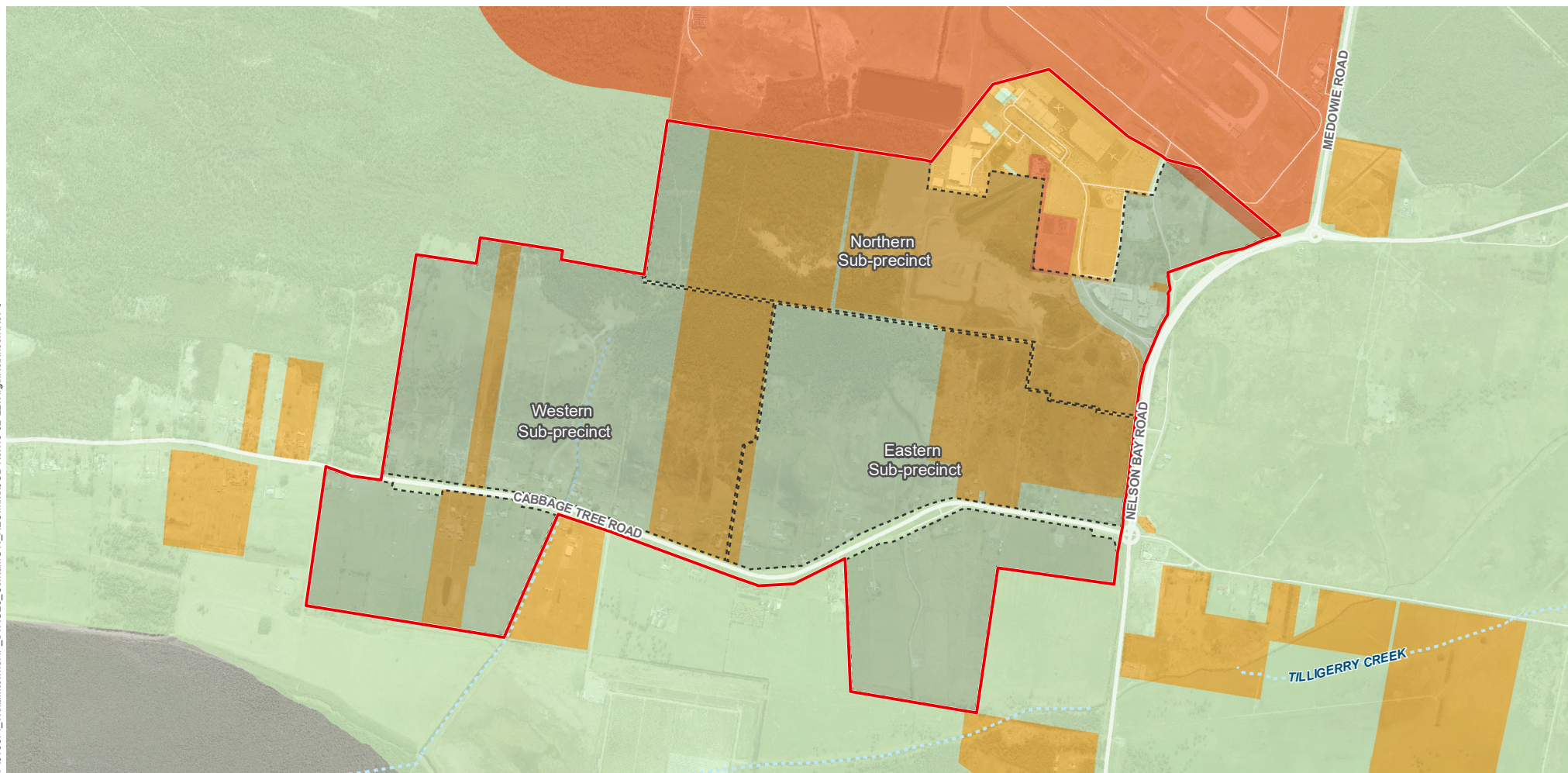
Projection: GDA 1994 MGA Zone 56

Williamtown SAP **Groundwater**

**FIGURE 6: PFAS Groudwater Constraints | Structure Plan**



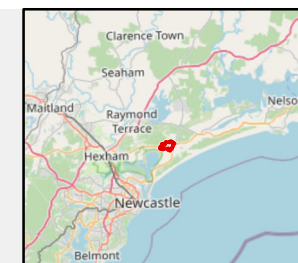
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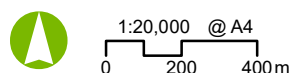
- Williamtown SAP Structure Plan Boundary
- Sub-precinct boundary
- ..... Waterway

### Non-PFAS Contamination Constraints

- Highly constrained**  
*High likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management*
- Moderately constrained**  
*Moderate likelihood of encountering non-PFAS contamination at concentrations in some areas of the Scenario boundary that may require additional assessment, remediation or management*
- Minimally constrained**  
*Low likelihood of encountering non-PFAS contamination at concentrations that may require additional assessment, remediation or management or limited/isolated areas where non-PFAS contamination may require assessment, remediation or management*



Source: Aurecon, TfNSW, NSW Spatial Services, DPE, EPA, Port Stephens Council, Aerometrex, Esri



Projection: GDA 1994 MGA Zone 56

Williamtown SAP **Groundwater**

**FIGURE 7: Non-PFAS Contamination Constraints Map | Structure Plan**

# Appendix B

## APECs, PFAS CSAM and Groundwater Elevations

Table 8 Interim Monitoring Event Report – RAAF Base Williamstown, December 2018

Well ID	Sample ID	Date	Depth to Water (mBTOC)
			mBTOC
MW130D	MW130D_GW_27042018	27/4/2018	1.351
MW260D	0908_MW260D_19112018	19/11/2018	1.730
MW260S	0908_MW260S_19112019	19/11/2018	1.380
MW263D	0908_MW263D_19112020	19/11/2018	0.655
MW263S	0908_MW263S_19112021	19/11/2018	0.650
MW258S	0908_MW258S_19112022	19/11/2018	0.950
MW258D	0908_MW258D_19112023	19/11/2018	0.960
MS257D	0908_MW257D_19112024	19/11/2018	1.210
MW257S	0908_MW257S_19112025	19/11/2018	1.110
MW256D	0908_MW256D_19112026	19/11/2018	0.943
MW118	0908_MW118_19112027	19/11/2018	0.550
MW188S	0908_MW188S_20112018	19/11/2018	0.660
MW188D	0908_MW188D_20112018	20/11/2018	0.574
MW125D	0908_MW125D_20112018	20/11/2018	1.478
MW125S	0908_MW125S_20112018	20/11/2018	1.514
MW146D_A	0908_MW146D_A_20112018	20/11/2018	1.015
MW146S	0908_MW146S_20112018	20/11/2018	1.165
MW126D	0908_MW126D_20112018	20/11/2018	1.160
MW256S	0908_MW256S_20112018	20/11/2018	0.958
MW162D	0908_MW162D_20112018	20/11/2018	2.080
MW121	0908_MW121_20112018	20/11/2018	0.569
MW123	0908_MW123_20112018	20/11/2018	1.120
MW255D	0908_MW255D_20112018	20/11/2018	1.325
MW255S	0908_MW255S_20112018	20/11/2018	1.300
MW130S	0908_MW130S_21112018	21/11/2018	0.843
MW106S	0908_MW106S_21112018	21/11/2018	1.506
MW106D	0908_MW106D_21112018	21/11/2018	1.503
MW209S	0908_MW209S_21112018	21/11/2018	1.088
MW209D	0908_MW209D_21112018	21/11/2018	1.157
W6	0908_W6_21112018	21/11/2018	1.955
W33	0908_W33_21112018	21/11/2018	1.379

## Appendix B AEC Hazard Tables

It should be noted that the information included in **Table B-1** is based on review of publicly available information and information supplied by Port Stephens Council and Hunter Water. Specific reports or information on these AECs were not reviewed as part of this Baseline Analysis. The identification of potentially contaminating activities and related COPCs are based on the nature of the activities at the identified AEC. Aurecon utilised our experience with similar sites and information included in the POEO to summarise the potentially contaminating activities and COPCs. It is important to note that activities at the identified AECs may not have led to subsurface contamination or with all the listed COPCs. As a conservative baseline of information, to inform future stages of the project, all potentially contaminated sites have been identified as an AEC. During future stages of this project, additional detail will be requested and reviewed to further refine the AEC table. This could include the need to undertake intrusive investigations at select AECs to further refine the information included in **Table B-1**. The hazard ratings indicate the potential to encounter COPCs at concentrations above the applicable Tier I screening values as outlined in the NEPM 2013 and other applicable guidelines. The risk ratings do not indicate that the AEC is actually contaminated rather the potential to encounter contamination that may be a constraint to consider in future stages of the project.

**Table B-1 Preliminary Hazard Assessment for Areas of Environmental Concern within the Williamstown SAP study area**

AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
01	Previous development and land disturbance	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus pesticides (OPP), herbicides, polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Development in, below or above road corridors. Excavation, retaining and other ground disturbance Fuel and solvent spills, incidents and leaks Storm water and drainage	Unclassified fill (soil) material, contaminated soils/groundwater. Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.			Almost Certain	Negligible	Low
02	Boral Resources (NSW) Pty Ltd	Heavy Metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS and solvents	Extractive Activities – Land-based extractive activity Scale: > 100000-500000 T extracted, processed or stored	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Waste production and leachate (general and other types of waste) Wastewater, storm water and drainage	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Possible	Mild	Negligible to Low
03	Coastal Sand and Quarry Products Pty Ltd		Extractive Activities – Land-based extractive activity Scale: > 100000-500000 T annual capacity to extract, process or store				Likely		Low to Moderate
04	Hunter Gas Pty Ltd		Petroleum exploration, assessment and production Scale: 0-0.50 PJ annual production capacity				Possible		Negligible to Low
05	Brantang Pty Limited		Crushing, grinding or separating Scale: > 30000-100000 T annual processing capacity Land-based extractive activity Scale: > 100000-500000 T annual				Likely		Low to Moderate



AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
			capacity to extract, process or store  Water-based extractive activity  Scale: > 50000-100000 m3 annual extractive capacity						
06	Mineral Deposits (Operations) Pty Ltd		Mining (Other than Coal) (64)  Scale: > 30000 - 50000 T obtained				Possible	Negligible	Negligible to Low
07	RZM Pty Ltd	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Environmentally Sensitive or Inappropriate Landfilling (81)  Scale: 0 – All	Unclassified fill (soil) material, contaminated soils/groundwater.  Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.				Mild	Low
08	William Walter Redriff	Organochlorine pesticides (OCPs), organophosphorus pesticides (OPP) and herbicides	Spray drains with round-up bioactive to kill alligator weed  Scale: N/A	Contamination of soil/ groundwater from pesticides and herbicides associated with fauna and flora					
09	Williamtown Sand Syndicate Pty Limited		Crushing, grinding or separating  Scale: > 100000-500000 T annual processing capacity  Extractive activities  Scale: > 100000-500000 T annual capacity to extract or process	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Possible	Negligible	Negligible to Low
10	ATB Morton (NSW) Pty Limited	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Land-based extractive activity  Scale: > 100000-500000 T annual capacity to extract, process or store	Fuel and solvent spills, incidents and leaks from construction and maintenance works  Waste production and leachate (general and other types of waste)  Wastewater, Storm water and drainage					
11	Grafil Pty Ltd trading as Macka's Sand and Soil		Crushing, grinding or separating  Scale: > 100000-500000 T processed  Land-based extractive activity  Scale: > 30000-50000 T extracted, processed or stored				Almost Certain	Mild	Moderate

AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
12	Holcim (Australia) Pty Ltd	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Crushing, grinding or separating  Scale: > 100000-500000 T annual processing capacity Land-based extractive activity  Scale: > 100000-500000 T annual capacity to extract, process or store	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.  Fuel and solvent spills, incidents and leaks from construction and maintenance works  Waste production and leachate (general and other types of waste)	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Possible	Negligible	Negligible to Low
13	Macka's Sand Pty Ltd		Land-based extractive activity  Scale: > 500000-2000000 T annual capacity to extract, process or store	Wastewater, storm water and drainage			Almost Certain	Mild	Moderate
14	Rob Lacconi		Unauthorized dumping and stockpiling of building material and demolition waste, illegally use of waste for construction and development				Likely	Mild	Low to Moderate
15	Grafil Pty Ltd trading as Macka's Sand and Soil		Unauthorized dumping and stockpiling of building material and demolition waste, illegally use of waste for development, and illegal stockpiling of asbestos waste and dumping of building and demolition waste adjacent to and in water courses near Oakvale Drive, with no sediment or erosion controls or barriers in place, causing dark brown leachate pooling and strong odours of chicken manure on site. These penalties and clean up notices were issued to both licenced and un-licenced sites within 500m of the proposal area	Unclassified waste (soil) materials including asbestos, chemical contaminants, and heavy metals  Contamination from waste leachate			Almost Certain	Mild	Moderate
16	Port Stephens Council	Heavy Metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic	Unauthorized dumping and stockpiling of building material and demolition waste,	Unclassified waste (soil) materials including asbestos, chemical contaminants, and heavy metals			Possible	Mild	Low

AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
		hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS and solvents	illegally use of waste for development, and illegal stockpiling of asbestos waste and dumping of building and demolition waste adjacent to and in water courses near Oakvale Drive, with no sediment or erosion controls or barriers in place, causing dark brown leachate pooling and strong odours of chicken manure on site. These penalties and clean up notices were issued to both licenced and un-licenced sites within 500m of the proposal area						
17	Defence UXO	Heavy metals and forms nitrate (explosives)	Transport etc excess waste to unlawful facility – other – Corporation	Unclassified waste (soil) materials including asbestos, chemical contaminants, and heavy metals			Almost Certain	Moderate	High
18	Waste which has been used for filling or has caused land contamination	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs), solvents and asbestos	Ammunition and explosives which have been fired but have not functioned as designed	UXOs can be dangerous as they could easily become functioning with little handling				Mild	Moderate
19	Demolition and Liquid waste on land (signs of contamination)	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	The use of waste such as chicken farm waste and demolition waste (including ACM)	Unclassified waste (soil) materials including asbestos, chemical contaminants, and heavy metals.	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Almost Certain		
20	Oil and Fuel Contamination (Vehicle Repair and Restoration)		Stockpiling and dumping of building material and liquid waste Storm water and drainage	Unclassified waste (soil) materials including asbestos, chemical contaminants, and heavy metals.				Moderate	High
21	Dog Kennels	Heavy metals, organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, nutrients and asbestos	Use of fill material Historical application of pesticides Waste management Storm water and drainage	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works			Possible	Mild	Low

AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating					
22	Landfills	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Excavation, retaining and other ground disturbance  Storage of chemicals, solvents, cleaning products and food.  Chemical, solvent and cleaning products spills, incidents and leaks  Storm water and drainage	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.  Chemical, solvent and cleaning products spills, incidents and leaks from construction and maintenance works  Waste production and leachate (general and other types of waste)	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Likely	Moderate	Moderate to high					
23	Service Stations		Deposition of building material and demolition waste (including ACM), leachate and ground gases  Excavation, retaining and other ground disturbance  Fuel and solvent spills, incidents and leaks  Storm water and Drainage	Unclassified fill (soil) material, contaminated soils/groundwater.  Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.										
24	Caltex SALT ASH SERVICE Station		Operation and maintenance of fuel facilities and infrastructure  Above and underground storage of infrastructure, fuels, chemicals and solvents  Fuel and solvent spills, incidents and leaks  Refuelling and fuel deliveries  Workshops  Hazardous materials and waste  Public use	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.  Fuel and solvent spills, incidents and leaks from construction and maintenance works  Storm water and drainage										
25	BP Salt Ash		Two underground petroleum storage systems (UPSS) on site consisting of diesel and ULP 91	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure.										
26	Metro Petroleum		Five underground petroleum storage systems (UPSS) on site consisting of diesel,											

AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
	(Williamstown) Airport		ULP 91, PULP 98 and E10						
27	Car and bus washes	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), solvents and asbestos	Six underground petroleum storage systems (UPSS) on site consisting of diesel, ULP 91, ULP 95, ULP 98 and E10	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid, solvents and cleaning products. Storm water and drainage			Possible	Mild	Low
28	Large area used for car parking and storage		Chemical and cleaning products spills, incidents and leaks Fuel and solvent spills, incidents and leaks Storm water and drainage						
29	Large area used for truck parking and storage		Fuel and solvent spills, incidents and leaks Storm water and drainage						
30	Sewage Treatment Works	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs), PFAS, solvents, nutrients, faecal coliforms and E. Coli	Waste-water treatment and storage Excavation, retaining and other ground disturbance Fuel and solvent spills, incidents and leaks Storm water and drainage	Unclassified fill (soil) material, contaminated soils/groundwater. Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Waste production and leachate (general and other types of waste) Wastewater, storm water and drainage	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Likely	Moderate	Moderate to high
31	Landfills	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Deposition of building material and demolition waste (including ACM), leachate and ground gases Excavation, retaining and other ground disturbance	Unclassified fill (soil) material, contaminated soils/groundwater. Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid Fuel and solvent spills, incidents and leaks from construction and maintenance works					
32	Landfill – Effluent Lagoon	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs), PFAS, solvents,	Fuel and solvent spills, incidents and leaks Storm water and Drainage	Wastewater, storm water and drainage	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Likely	Moderate	Moderate to high



AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
		nutrients, faecal coliforms, E. Coli and asbestos							
33	Smelter	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Deposition of building material and demolition waste (including ACM), leachate and ground gases Excavation, retaining and other ground disturbance Fuel and solvent spills, incidents and leaks Storm water and waste drainage and ponding	Unclassified fill (soil) material, contaminated soils/groundwater. Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Waste production and leachate (general and other types of waste) Wastewater, storm water and drainage					
34	Cranes used for construction or development	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and solvents	Industrial activities, waste production and storage	Contaminated soil / groundwater from industrial activities Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Waste production and leachate (general and other types of waste) Wastewater, storm water and drainage			Unlikely	Mild	Low
35	Department of Defence – Williamstown RAAF Base and Airport	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Development and land disturbance	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Storm water and drainage	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Almost Certain	Moderate	High
36	Energy Australia Sub Station	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs) and solvents	Excavation, retaining and other ground disturbance Operation and maintenance of fuel facilities and infrastructure Above and underground storage of infrastructure, fuels, chemicals and solvents Fuel and solvent spills, incidents and leaks				Possible		Moderate

AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
			Refuelling and fuel deliveries Workshops Hazardous materials and waste Dangerous goods and fire safety Storm water and drainage Services and utilities Security and safety controls						
37	Sand mining and extraction	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Excavation, retaining and other ground disturbance Operation and maintenance of energy related facilities and infrastructure Electrical generation, transmission, and distribution Hazardous materials and waste Dangerous goods Storm water and drainage Services and utilities Security and safety controls	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Almost Certain	Moderate	Moderate
38	Retail Plant Nursery	Organochlorine pesticides (OCPs), organophosphorus pesticides (OPPs) and herbicides	Land-based extractive activities Industrial activities, waste production and storage	Contaminated soil / groundwater from industrial activities Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Waste production and leachate (general and other types of waste) Wastewater, storm water and drainage			Possible	Mild	Low
39	Plant Driving School – Mechanical Workshop	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes	Excavation, retaining and other ground disturbance	Contamination of soil/ groundwater from pesticides and herbicides associated with fauna and flora			Likely	Moderate	Moderate to High



AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
		(BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs) and solvents	Use of pesticides and herbicides Storm water and Drainage						
40	Landscape supplies		Storage of fuels, chemicals, solvents and cleaning products Fuel and solvent spills, incidents and leaks Chemical, solvent and cleaning products spills, incidents and leaks Storm water and drainage	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works			Possible	Mild	Low
41	Lattice Manufacturing		Storage of fuels, chemicals, solvents, paints and cleaning products Fuel and solvent spills, incidents and leaks Storm water and drainage Hazardous materials and dangerous goods	Wastewater, storm water and drainage					
42	Small Industrial Sheds		Industrial activities and waste production				Possible	Mild	Low
43	Small Light Industrial Workshop	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and solvents	Storage of fuels, chemicals, solvents and cleaning products Fuel and solvent spills, incidents and leaks Chemical, solvent and cleaning products spills, incidents and leaks Storm water and drainage	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Wastewater, storm water and drainage	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Likely	Moderate	Moderate to high
44	Asbestos, Sand Extraction	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Workshop Storage of fuels, chemicals, solvents and cleaning products Fuel and solvent spills, incidents and leaks Chemical, solvent and cleaning products	Contaminated soil / groundwater from industrial activities Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works			Almost Certain		High

AEC ID	Description	Contaminants of Potential Concern	Potentially Contaminating Activities	Sources of Potential Contamination	Potential Receptors	Potential Pathways	Likelihood	Consequence	Hazard Rating
			spills, incidents and leaks Storm water and drainage	Waste production and leachate (general and other types of waste) Wastewater, storm water and drainage					
45	Timber Yard	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and solvents	Land-based extractive activities Industrial activities, waste production and storage				Possible	Mild	Low
46	RAAF Drop Zone	Heavy metals and forms nitrate (explosives)	Storage of fuels, chemicals, solvents and cleaning products Fuel and solvent spills, incidents and leaks Chemical, solvent and cleaning products spills, incidents and leaks Storm water and drainage	Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Wastewater, storm water and drainage			Almost Certain	Moderate	High
47	Pontoon and Dredging	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and solvents	Ammunition and explosives which have been fired but have not functioned as designed	UXOs can be dangerous as they could easily become functioning with little handling			Possible		Moderate
48	Filling of Land	Heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), organophosphorus (OPPs), herbicides, polychlorinated biphenyls (PCBs), PFAS, solvents and asbestos	Land-based extractive activities Excavation, retaining and other ground disturbance Industrial activities and waste production Stockpiling and dumping of dredged material Fuel and solvent spills, incidents and leaks Storm water and drainage	Contaminated soil / groundwater from industrial activities Unclassified dredging material, contaminated soils/groundwater. Contaminated soil / groundwater from spills, incidents, and/ or leaking fluid storage & infrastructure. Fuel and solvent spills, incidents and leaks from construction and maintenance works Waste production and leachate (general and other types of waste) Wastewater, storm water and drainage	Contractors, construction and maintenance workers, site staff, surrounding land occupants, surface runoff and groundwater receptors	Direct (dermal) contact with contaminated soils Incidental ingestion of contaminated soils Inhalation of contaminated dusts or gas / vapour Storm water / wastewater inflows to excavations Leaching from contaminated soils into groundwater	Almost Certain	Moderate	High

A summary of the Conceptual Site Model for each identified primary and secondary source based on the information in the AECOM investigations is included in Table A-2, below.

**Table B-2 Summary of Source Type Contributing to off-Base Exposure Risk to Humans and Environment**

Source		Risk contributor		Relative Contribution to PFAS Mass and Risk
ID	Name	Mechanism	Pathway	
Primary Sources				
#1	Former Fire Training Area (FFTA), including the Disused Fire Training Pit (Facility479)	<p>Elevated concentrations of PFAS in soil were previously reported to depths of 2.5 m below ground surface. Soil with PFOS concentrations &gt;0.5 mg/kg to depths of 2.5 m below ground surface was excavated in October2018. Approximately 11 kg of PFOS was removed. The material was subsequently stockpiled in a purpose built containment cell on-Base.</p> <p>Shallow groundwater occurs at depths across the Base and SAP area ranging between 1 and 2.5 m, subject to rainfall. The highest groundwater concentration reported was of PFOS at 465 ug/L. The following plume characteristics were estimated for the groundwater plume with PFOS concentration &gt; 10 ug/L:</p> <ul style="list-style-type: none"><li>An area of 27 ha (approx.)</li><li>PFAS mass of 57 kg (approx.)</li><li>mass flux of 4.5 kg/year (approx.) out of the FFTA footprint</li></ul> <p>These estimates also include the plume for Source #4 (former DEMS Landfill), given that the plumes from Source #4 and Source #1 are likely to be overlapping.</p>	<p>PFAS impacted groundwater migration from the primary source area, principally to the south and south-east. The PFAS plume from this source area is likely to be overlapping (or co-mingling) with the plume from Source#4 (Former DEMS Landfill) immediately south of Source #1 and migrating to off-Base areas to the south. Extraction of PFAS impacted groundwater in off-Base areas via the use of private bores, resulting in direct exposure to off-Base residents via the use of groundwater for multiple purposes, including drinking, cooking, irrigation and stock watering.</p>	<b>Significant</b> based on elevated PFAS concentrations in soil and groundwater and proximity of groundwater impact to the Base boundary/potential for exposure to off-Base residents.
#2	Former/current Fire Station (Facility165)	<p>Elevated concentrations of PFAS in soil to depths of 2.5 m below ground surface. PFAS was also detected in concrete samples. The following characteristics were estimated for the soil impacted with PFOS concentrations &gt; 1 mg/kg:</p> <ul style="list-style-type: none"><li>an area of 0.8 ha (approx.)</li><li>mass of 57 kg (approx.)</li></ul> <p>PFAS was also detected in sediment. The highest PFOS concentration of 22.4 mg/kg was in a drain sample collected adjacent to this source.</p> <p>PFAS in groundwater extends approximately 630 m to the south, with the plume edge appearing to be within the Base boundary. The highest groundwater concentration reported was PFOS of 35.6 ug/L. The following plume characteristics were estimated for the groundwater plume with PFOS concentration &gt; 10 ug/L:</p> <ul style="list-style-type: none"><li>an area of 19 ha (approx.)</li><li>mass of 10.6 kg (approx.)</li><li>mass flux of 0.9 kg/year (approx.) from Source Area</li></ul>	<p>PFAS in soil, sediment and concrete potentially contributes to groundwater and surface water impact via leaching processes.</p> <p>PFAS in surface water with highest concentration of PFOS at 9.75 ug/L was recorded, potentially contributes to impacts in Lake Cochran.</p> <p>PFAS impacted groundwater migration from Source Area, principally to the south. The data suggests that the plume extent is limited to within the Base boundary. If the plume moves further south, it is likely to co-mingle with groundwater impacts at Source #3 (Lake Cochran) and Source #6 (Sewage Treatment Plant).</p> <p>Ecological receptors include terrestrial (land animals) and aquatic biota that may be exposed to PFAS impacted sediment and surface water.</p>	<b>Moderate</b> based on moderate PFAS concentrations in soil and groundwater and significant distance from the Source to the Base boundary.
#4	Former DEMS Landfill (Facility 394)	<p>PFAS was detected in soil, generally at depths &lt; 2 m below ground surface. The highest PFOS concentration was 0.438 mg/kg in a sample collected from 0.7 m depth.</p> <p>Elevated PFAS concentrations in groundwater were reported. The highest groundwater concentration reported was PFOS at 180 ug/L. The following plume characteristics were estimated for the groundwater plume with PFOS concentration &gt; 10 ug/L:</p> <ul style="list-style-type: none"><li>covers an area of 27 ha (approx.)</li><li>mass of 57 kg (approx.)</li><li>mass flux of 4.5 kg/year (approx.) from FFTA footprint overlapping with Source #1 (FFTA).</li></ul> <p>These estimates also include the plume for Source #1, given that the plumes from Source #1 and Source #4are likely to be overlapping.</p>	<p>The PFAS plume in groundwater at Source #4 is likely to be overlapping with the PFAS plume from Source #1(FFTA), given that Source #4 is immediately downgradient of Source#1.</p> <p>Potential for off-Base migration to the south, given that PFAS was detected on the Base boundary. The western extent of the groundwater impact has not been evaluated as monitoring wells have not been installed in the heavily vegetated, inaccessible area to the west of Source #4. However, the plume extent in this direction is expected to be limited as this is cross gradient of the predominant lateral flow direction of groundwater.</p> <p>Potential receptors include extraction of PFAS impacted groundwater in off-Base areas via the use of private bores, resulting in direct exposure to off-Base residents via the use of groundwater for multiple purposes, including drinking, cooking, irrigation and stock watering.</p>	<b>Significant</b> based on elevated PFAS concentrations in groundwater and proximity of groundwater impact to the Base boundary/potential for exposure to off-Base residents.

#7	Former North-Eastern Landfill	<p>PFAS was detected in soil. The highest PFOS concentration of 0.0009mg/kg was in a surface soil sample. Note that there is limited soil data for this source.</p> <p>The highest groundwater concentration reported was PFOS at 4 ug/L.</p>	<p>PFAS plume in this area is at low concentrations and extends approximately 900 m south and south-east. Limited potential for off-Base migration.</p>	<b>Minor</b> based on relatively low PFAS concentrations in soil and groundwater and groundwater flow directions away from the Base boundary.
#11	AFFF use associated with aircraft accidents and other emergency responses	<p>PFAS reported in soil adjacent to the runway. Highest PFOS concentration of 0.0055 mg/kg.</p> <p>The highest groundwater concentration reported was PFOS of 0.23 ug/L, immediately downgradient of the runway.</p> <p>The PFAS in soil and groundwater may be associated with AFFF use for emergencies, also potentially from nearby source areas.</p>	<p>PFAS in the soil is anticipated to be contributing to the impact on surface water and groundwater from leaching process.</p> <p>Ecological receptors include terrestrial biota (land animals) with potential exposure to impacted shallow soil.</p>	<b>Minor</b> based on relatively low PFAS concentrations in soil and groundwater diluted over a relatively large area.
Secondary Sources				
#3	Lake Cochran	<p>Surface water with PFAS detected in the lake and in Dawsons Drain (downstream of the lake), with the highest PFOS concentration of 18.7ug/L. Sediment/ soil with reported PFAS concentrations, with highest PFOS concentration of 2.3 mg/kg in a sediment sample. Shallow groundwater to the south of the lake reported elevated PFAS concentrations. The highest groundwater concentration reported immediately south of the lake was PFOS at 54.4 ug/L.</p>	<p>Lake receives PFAS affected surface water runoff from a large on-Base catchment. Potential for groundwater to be recharging the lake during high rainfall periods and for the lake to recharge groundwater during dry periods with a lowered water table.</p> <p>PFAS impacted surface water migration from Source #3, principally to the south via Dawson's Drain. Dawson's Drain discharges to Fullerton Cove.</p> <p>Terrestrial biota (land animals) and aquatic biota (including fish) with potential exposure to impacted sediment and surface water.</p> <p>Extraction of PFAS impacted groundwater in off-Base areas via the use of private bores, resulting in direct exposure to off-Base residents via the use of groundwater for multiple purposes, including drinking, cooking and irrigation.</p> <p>Potential for direct exposure of PFAS impacted surface water to off-Base residents via recreational use of surface water drains.</p>	<b>Moderate</b> based on moderate PFAS concentrations in surface water, sediment and groundwater and proximity immediately adjacent to Base boundary/potential for exposure to off-Base residents.
#5	Trade Waste Treatment Plant (Facility480) / Hangar 8	<p>PFAS was detected in soil. The highest PFOS concentration of 0.811 mg/kg was in a sample collected at 1.5 m depth. The highest groundwater dissolved concentration reported was PFOS at 35 ug/L. The following plume characteristics were estimated for the groundwater plume with PFOS concentration &gt; 10 ug/L:</p> <ul style="list-style-type: none"> <li>covers an area of 13 ha (approx.)</li> <li>mass of 7.3 kg (approx.)</li> <li>mass flux of 0.9 kg/year(approx.).</li> </ul>	<p>Potential for leakage of dilute PFAS via trade waste pump lines and underground storage tanks to impact soil and groundwater. PFAS plume in this area extends approximately 500m down gradient. The data suggests that the plume is limited to within the Base boundary.</p> <p>Potential for PFAS in groundwater to be one of the multiple contributors to surface water impacts in Moors Drain. Terrestrial biota (land animals) and aquatic biota (including fish) with potential exposure to impacted surface water. Extraction of PFAS impacted groundwater in off-</p> <p>Potential receptors include Base areas via the use of private bores, resulting in direct exposure to off-Base residents via the use of groundwater for multiple purposes, including drinking, cooking, irrigation and stock watering.</p>	<b>Moderate</b> based on moderate PFAS concentrations in soil and groundwater and significant distance from the Source to the Base boundary.
#6	Sewage Treatment Plant (Facility410)	<p>PFAS was detected in soil. The highest PFOS concentration of 0.046 mg/kg was in a sample collected at 0.7 m depth. The highest groundwater concentration reported was PFOS at 13 ug/L. The following plume characteristics were estimated for the groundwater plume with PFOS concentration &gt; 10 ug/L:</p> <ul style="list-style-type: none"> <li>covers an area of 5 ha (approx.)</li> <li>mass of 1.2 kg (approx.)</li> <li>mass flux of 0.2 kg/year(approx.).</li> </ul> <p>These estimates also include the plume for Source #8, given that the plumes from Source #8 and Source #6 are likely to be overlapping.</p>	<p>PFAS plume in this area extends approximately 600m south-east and contributes to elevated PFAS in Source #8 (Southern Area).Extraction of PFAS impacted groundwater in off-Base areas via the use of private bores, resulting indirect exposure to off-Base residents via the use of groundwater for multiple purposes, including drinking, cooking, irrigation and stock watering.</p>	<b>Significant</b> based on moderate PFAS concentrations in soil and groundwater and proximity immediately adjacent to Base boundary/potential for exposure to off-Base residents.

#8	Southern Area (plume off-Base)	<p>The highest groundwater concentration recorded was PFOS of 163 ug/L. The following plume characteristics were estimated for the groundwater plume with PFOS concentration &gt; 10 ug/L:</p> <ul style="list-style-type: none"> <li>Covers an area of 90 ha (approx.)</li> <li>Mass of 113 kg (approx.)</li> <li>Mass flux of 6.3 kg/year (approx.)</li> </ul> <p>These estimates also include the plume for Source #3 (Lake Cochran) and Source #6 (Sewage Treatment Plant), given that the plumes from Sources #3 and #6 and Source #8 are likely to be overlapping.</p>	<p>The PFAS plume extends from the Base to the south, beyond Cabbage Tree Road. The area is prone to flooding, therefore PFAS in shallow groundwater is anticipated to interact with drains and flood conditions during heavy rainfall periods, and contribute to PFAS impacts on soil, sediment and surface waters in the area.</p> <p>Potential for contribution of PFAS to Fullerton Cove, given the detection of PFAS in surface water (Fourteen Foot Drain and Ten Foot Drain) further south and west of the groundwater plume extent. Extraction of PFAS impacted groundwater in off-Base areas via the use of private bores, resulting in direct exposure to off-Base residents via the use of groundwater for multiple purposes, including drinking, cooking irrigation and stock watering.</p> <p>Potential for direct exposure of PFAS impacted surface water to off-Base residents via recreational use of surface water drains. Terrestrial biota (land animals) and aquatic biota (including fish) with potential exposure to impacted sediment and surface water.</p>	<b>Significant</b> based on elevated PFAS concentrations in groundwater and presence of groundwater impact off-Base/potential for exposure to off-Base residents.
#9	Eastern Boundary (run-off to Moors Drain)	<p>PFAS in surface water and sediment was reported at the Base boundary and along Moors Drain to the east.</p> <p>PFOS concentration of 11.8 ug/L was reported in surface water, on the south-eastern boundary of the Base. Concentrations of PFOS ranged between 1 and 4 ug/L along Moors Drain to the east towards Salt Ash.</p> <p>The highest PFOS concentration of 0.0868 mg/kg in sediment along Moors Drain was reported approximately 1 km from the Base boundary, with concentrations reducing to 0.0119 mg/kg further east at Salt Ash.</p> <p>Elevated PFAS concentrations in groundwater were reported along Moors Drain, with the highest PFOS concentration of 3.78 ug/L at approximately 1.5 km along Moors Drain from the Base boundary.</p>	<p>PFAS impacted surface water is migrating to the east via Moors Drain and interacting with groundwater during both losing and gaining stream conditions.</p> <p>PFAS in Moors Drain is anticipated to be contributing to the impact in groundwater towards Salt Ash. The groundwater was previously used for multiple purposes, including drinking via the use of private bores to pump the water.</p> <p>Potential for direct exposure of PFAS impacted surface water to off-Base residents via recreational use of surface water drains. Terrestrial biota (land animals) and aquatic biota (including fish) with potential exposure to impacted sediment and surface water.</p>	<b>Moderate</b> based on moderate PFAS concentrations in surface water and presence of surface water impact off-Base/potential for exposure to off-Base residents.
#10	Sediments containing PFAS in on-Base drains.	<p>PFAS concentrations were reported in a majority of the open drains on Base. Elevated concentrations of PFOS were detected in sediment to the north-west of the runway and immediately north-east of Lake Cochran, with a maximum concentration of 0.029 mg/kg.</p>	<p>The PFAS in sediment and surface water drains is anticipated to be an ongoing contribution of PFAS to surface water and groundwater via leaching. The impact is also likely to be one of the multiple contributors to PFAS impact in surface water at Lake Cochran, Dawson's Drain and Moors Drain.</p> <p>Terrestrial biota (land animals) and aquatic biota (including fish) with potential exposure to impacted sediment and surface water.</p>	<b>Minor</b> based on relatively low PFAS concentrations in sediment and completion of RM-08 (see Table 2-4)
#12	Soil in saturated zone with adsorbed PFAS (excluding sources identified above)	<p>PFAS in soil in saturated zone (i.e. below the water table) was detected in both on-Base and off-Base samples, with the highest concentration of 0.0257 mg/kg.</p>	<p>PFAS in the saturated zone is anticipated to be contributing to the impact on groundwater from adsorption and desorption process.</p>	<b>Minor</b> based on relatively low PFAS concentrations in soil and groundwater diluted over a relatively large area.
#13	Shallow soil with adsorbed PFAS from surface runoff -flooding (excluding sources identified above)	<p>PFAS in shallow soil detected in areas south of the Base, with the highest concentration of 0.33 mg/kg.</p>	<p>PFAS in the shallow soil is anticipated to be contributing to the impact to surface water and groundwater from adsorption and desorption process.</p> <p>Terrestrial biota (land animals) with potential exposure to impacted shallow soil.</p>	<b>Minor</b> based on relatively low PFAS concentrations in soil diluted over a relatively large area.



# Appendix C: Groundwater Elevations

## Interim Monitoring Event Report – RAAF Base Williamstown, December 2018

Table B1 Monitoring Wells within the Structure Plan (Depth to Water MBTOC)

Well ID	Sample ID	Date	Depth to Water (mBTOC)
			mBTOC
MW130D	MW130D_GW_27042018	27/4/2018	1.351
MW260D	0908_MW260D_19112018	19/11/2018	1.730
MW260S	0908_MW260S_19112019	19/11/2018	1.380
MW263D	0908_MW263D_19112020	19/11/2018	0.655
MW263S	0908_MW263S_19112021	19/11/2018	0.650
MW258S	0908_MW258S_19112022	19/11/2018	0.950
MW258D	0908_MW258D_19112023	19/11/2018	0.960
MS257D	0908_MW257D_19112024	19/11/2018	1.210
MW257S	0908_MW257S_19112025	19/11/2018	1.110
MW256D	0908_MW256D_19112026	19/11/2018	0.943
MW118	0908_MW118_19112027	19/11/2018	0.550
MW188S	0908_MW188S_20112018	19/11/2018	0.660
MW188D	0908_MW188D_20112018	20/11/2018	0.574
MW125D	0908_MW125D_20112018	20/11/2018	1.478
MW125S	0908_MW125S_20112018	20/11/2018	1.514
MW146D_A	0908_MW146D_A_20112018	20/11/2018	1.015
MW146S	0908_MW146S_20112018	20/11/2018	1.165
MW126D	0908_MW126D_20112018	20/11/2018	1.160
MW256S	0908_MW256S_20112018	20/11/2018	0.958
MW162D	0908_MW162D_20112018	20/11/2018	2.080
MW121	0908_MW121_20112018	20/11/2018	0.569
MW123	0908_MW123_20112018	20/11/2018	1.120
MW255D	0908_MW255D_20112018	20/11/2018	1.325
MW255S	0908_MW255S_20112018	20/11/2018	1.300
MW130S	0908_MW130S_21112018	21/11/2018	0.843
MW106S	0908_MW106S_21112018	21/11/2018	1.506
MW106D	0908_MW106D_21112018	21/11/2018	1.503
MW209S	0908_MW209S_21112018	21/11/2018	1.088
MW209D	0908_MW209D_21112018	21/11/2018	1.157
V6	0908_V6_21112018	21/11/2018	1.955
V33	0908_V33_21112018	21/11/2018	1.379

MW156D	0908_MW156D_21112018	21/11/2018	1.772
MW124	0908_MW124_21112018	21/11/2018	1.224
MW159D	0908_MW159D_21112018	21/11/2018	2.070
MW159S	0908_MW159S_21112018	21/11/2018	1.800
MW160	0908_MW160_21112018	21/11/2018	1.515
MW155	0908_MW155_21112018	21/11/2018	1.155
MW165	0908_MW165_21112018	21/11/2018	1.141
MW122	0908_MW122_21112018	21/11/2018	1.340
MW162S	0908_MW162S_21112018	21/11/2018	1.940
MW179D	0908_MW179D_22112018	22/11/2018	1.093
MW171S	0908_MW171S_22112018	22/11/2018	0.549
MW281S	0908_MW281S_22112018	22/11/2018	0.989
MW240D	0908_MW240D_22112018	22/11/2018	1.326
MW179S	0908_MW179S_22112018	22/11/2018	1.063
MW202S	0908_MW202S_22112018	22/11/2018	1.150
MW202D	0908_MW202D_22112018	22/11/2018	1.120
MW171D	0908_MW171D_22112018	22/11/2018	0.505
MW240S	0908_MW240S_22112018	22/11/2018	1.233
MW279S	0908_MW279S_26112018	26/11/2018	1.460
MW128	0908_MW128_26112018	26/11/2018	1.290
MW126S	0908_MW126S_26112018	26/11/2018	1.282
MW178	0908_MW178_26112018	26/11/2018	1.122
MW212	0908_MW212_26112018	26/11/2018	1.702
MW163	0908_MW163_26112018	26/11/2018	1.450
MW128D	0908_MW128D_26112018	26/11/2018	0.670
MW103D	0908_MW103D_27112018	27/11/2018	0.905
MW103S	0908_MW103S_27112018	27/11/2018	1.055
MW107S	0908_MW107S_27112018	27/11/2018	0.490
MW107D	0908_MW107D_27112018	27/11/2018	0.535
MW241S	0908_MW241S_27112018	27/11/2018	1.515
MW241D	0908_MW241D_27112018	27/11/2018	1.461
MW195	0908_MW195_27112018	27/11/2018	0.502
MW132D	0908_MW132D_27112018	27/11/2018	2.805
MW132S	0908_MW132S_27112018	27/11/2018	2.820
MW130D	0908_MW130D_27112018	27/11/2018	0.962





MW266S	M0908_MW266S_28112018	28/11/2018	0.470
MW139	0908_MW139_28112018	28/11/2018	0.622
MW271S	0908_MW271S_28112018	28/11/2018	0.615
MW187S	0908_MW187S_28112018	28/11/2018	0.272
MW266D	0908_MW266D_28112018	28/11/2018	0.340
MW271D	0908_MW271D_28112018	28/11/2018	0.645
MW274D	0908_MW274D_28112018	28/11/2018	0.499
MW219S	0908_MW219S_28112018	28/11/2018	0.729
MW223S	0908_MW223S_28112018	28/11/2018	0.878
MW238D	0908_MW238D_28112018	28/11/2018	0.984

MW274S	0908_MW274S_28112018	28/11/2018	0.620
MW225D	0908_MW225D_28112018	28/11/2018	0.360
MW238S	0908_MW238S_28112018	28/11/2018	1.075
MW219D	0908_MW219D_28112018	28/11/2018	0.810
MW187D	0908_MW187D_28112018	28/11/2018	0.285
MW172	0908_MW172_29112018	29/11/2018	0.000
W68	0908_W68_29112018	29/11/2018	0.832
N66	0908_N66_29112018	29/11/2018	1.285
MW175D	0908_MW175D_29112018	29/11/2019	0.960
MW108S	0908_MW108S_29112018	29/11/2019	0.180
MW108D	0908_MW108D_29112018	29/11/2018	0.239
MW168	0908_MW168_29112018	29/11/2018	1.365
MW166	0908_MW166_29112018	29/11/2018	1.350
MW167	0908_MW167_29112018	29/11/2018	2.290
MW236D	0908_MW236D_30112018	30/11/2018	1.080
MW198	0908_MW198_30112018	30/11/2018	1.080
MW196	0908_MW196_30112018	30/11/2018	0.860
MW134I	0908_MW134I_30112018	30/11/2018	2.110
MW134D	0908_MW134D_30112018	30/11/2018	2.170
MW137	0908_MW137_04122018	4/12/2018	1.030
MW140	0908_MW140_04122018	4/12/2018	0.910
MW265D	0908_MW265D_04122018	4/12/2018	0.895
MW229S	0908_MW229S_06122018	6/12/2018	1.095
MW229D	0908_MW229D_06122018	6/12/2018	1.270
MW257D	0908_MW257D_06122018	6/12/2018	1.160
PS9 - Bore 30	0908_PS9(30)_181206	5/12/2018	2.115
PS9(i)	0908_PS9(i)_181206	6/12/2018	1.550
PS59	0908_PS59_181207	6/12/2018	0.100
MW276D	0908_MW276D_06122018	6/12/2018	0.440
MW232D	0908_MW232D_06122018	6/12/2018	1.080
MW232S	0908_MW232S_06122018	6/12/2018	1.130
MW267D	0908_MW267D_07122018	7/12/2018	1.150
MW267S	0908_MW267S_07122018	7/12/2018	1.160
MW235D	0908_MW235D_07122018	7/12/2018	0.260
MW265S	0908_MW235S_07122018	7/12/2018	0.390

Table B2 Monitoring Wells within the Structure Plan study area (south and south east of RAAF BASE Williamstown)

Monitoring Well ID (PFOS ug/L)	Location	Date Sampled	Groundwater Level (mBTC)
MW167 (372)	North	29/11/2018	2.290
MW103D (0.03)	North	27/11/2018	0.905
MW103S (<0.01)	North	27/11/2018	1.055
MW240D (<0.01)	North	22/11/2018	1.326
MW240S (0.02)	North	22/11/2018	1.233
MW107D (<0.01)	Centre (North)	27/11/2018	0.535
MW107S (<0.01)	Centre (North)	27/11/2018	0.490
MW108D (<0.01)	Centre (North)	29/11/2018	0.239
MW108S (0.07)	Centre (North)	29/11/2019	0.180
MW175D (4.43)	Centre (North)	29/11/2019	0.960
W66 (14.8)	Centre (North)	-	-
W68 (15.7)	Centre (North to North East)	29/11/2018	0.832

MW238D (<0.01)	Centre (West)	28/11/2018	0.984
MW238S (<0.01)	Centre (West)	28/11/2018	1.075
MW187D (19.4)	Centre (East)	28/11/2018	0.285
MW187S (148)	Centre (East)	28/11/2018	0.272
MW139 (<0.01)	West (near boundary)	28/11/2018	0.622
MW178 (<0.01)	Centre (South)	26/11/2018	1.122
MW271S (<0.01)	Centre (South)	28/11/2018	0.615
MW271D (<0.01)	Centre (South)	28/11/2018	0.645
MW274D (0.02)	Centre (South East)	28/11/2018	0.499
MW274S (67.6)	Centre (South East)	28/11/2018	0.620
MW140 (<0.01)	South West (Cabbage Tree Road)	4/12/2018	0.910
MW124 (<0.01)	South West (Cabbage Tree Road)	21/11/2018	1.224
MW125D (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.478
MW125S (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.514
MW229D (<0.01)	South (Cabbage Tree Road)	6/12/2018	1.270
MW229S (<0.01)	South (Cabbage Tree Road)	6/12/2018	1.095
MW146S (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.165
MW146D_A (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.015
MW126D (<0.01)	South East (Cabbage Tree Road)	20/11/2018	1.160
MW126S (1.63)	South East (Cabbage Tree Road)	26/11/2018	1.282
MW188D (0.38)	South East (Cabbage Tree Road)	20/11/2018	0.574
MW188S (0.68)	South East (Cabbage Tree Road)	19/11/2018	0.660
MW195 (0.06)	South East (Cabbage Tree Road)	27/11/2018	0.502

Table B3 Surface and sediment locations within the structure plan

Surface and sediment sample locations	Location
DD1 (SW 0.83, SD 0.00)	North (adjacent to Base)
DD2 (SW 0.91, SD 0.00)	South (along Cabbage Tree Road)
DD3 (SW 30.7, SD 0.14)	South East (along Cabbage Tree Road)
LC_B (SW 5.41, SD 0.03)	North (within Base)
LC (SW 4.85, SD 0.03)	North (within Base)
MD6 (SW 0.83, SD 0.02)	North East (adjacent to Base)
MD7 (SW 7.34, SD 0.02)	North East (adjacent to Base)

DD5 (SW 2.64, SD 0.01)	South (South of Cabbage Tree Road)
FFD4 (SW 0.96, SD 0.01)	South (South of Cabbage Tree Road)
TFD1 (SW <<0.01, SD 0.02)	South (South of Cabbage Tree Road)
TFD2 (SW 2.34, SD 0.01)	South (South of Cabbage Tree Road)



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Table B4 Monitoring Wells within the Structure Plan study area (south and south east of RAAF BASE Williamstown)

Monitoring Well ID	Location	Date Sampled	Groundwater Level (mBTC)
MW167	North	30/05/2019	3.11
MW103D	North	31/05/2019	1.71
MW103S	North	31/05/2019	1.99
MW240D	North	31/05/2019	2.118
MW240S	North	31/05/2019	-
MW107D	Centre (North)	31/05/2019	1.00
MW107S	Centre (North)	31/05/2019	0.95
MW108D	Centre (North)	31/05/2019	0.74
MW108S	Centre (North)	31/05/2019	0.63
MW175D	Centre (North)	31/05/2019	1.991
W66	Centre (North)	31/05/2019	2.475
W68	Centre (North to North East)	31/05/2019	2.102
MW238D	Centre (West)	6/06/2019	0.89
MW238S	Centre (West)	6/06/2019	0.98
MW187D	Centre (East)	5/06/2019	~0.200
MW187S	Centre (East)	5/06/2019	~0.150
MW139	West (near boundary)	4/06/2019	0.83
MW178	Centre (South)	21/05/2019	1.23
MW271S	Centre (South)	13/06/2019	0.57
MW271D	Centre (South)	13/06/2019	0.55
MW274D	Centre (South East)	5/06/2019	0.30
MW274S	Centre (South East)	5/06/2019	0.36
MW140	South West (Cabbage Tree Road)	-	-
MW124	South West (Cabbage Tree Road)	22/05/2019	1.82
MW125D	South (Cabbage Tree Road)	22/05/2019	1.66
MW125S	South (Cabbage Tree Road)	22/05/2019	1.70
MW229D	South (Cabbage Tree Road)	24/05/2019	1.47
MW229S	South (Cabbage Tree Road)	24/05/2019	1.26
MW146S	South (Cabbage Tree Road)	21/05/2019	1.40
MW146D_A	South (Cabbage Tree Road)	21/05/2019	1.24



MW126D	South East (Cabbage Tree Road)	21/05/2019	1.40
MW126S	South East (Cabbage Tree Road)	21/05/2019	1.38
MW188D	South East (Cabbage Tree Road)	22/05/2019	0.94
MW188S	South East (Cabbage Tree Road)	21/05/2019	0.98
MW195	South East (Cabbage Tree Road)	27/05/2019	0.69
<b>Additional monitoring wells sampled during June 2019 monitoring event</b>			
MW109D	Centre (East)	31/05/2019	0.868
MW282S	North (adjacent to base)	20/06/2019	1.561
BWS107	South West	4/06/2019	-
MW278S	South (Cabbage Tree Road)	23/05/2019	0.89
MW278D	South (Cabbage Tree Road)	23/05/2019	0.90

Table B5 Surface and sediment locations within the structure plan

Surface and sediment sample locations within structure plan	Location
DD1	North (adjacent to Base)
DD2	South (along Cabbage Tree Road)
DD3	South East (along Cabbage Tree Road)
LC_B	North (within Base)
LC	North (within Base)
MD6	North East (adjacent to Base)
MD7	North East (adjacent to Base)
DD5	South (South of Cabbage Tree Road)
FFD4	South (South of Cabbage Tree Road)
TFD1	South (South of Cabbage Tree Road)
TFD2	South (South of Cabbage Tree Road)

MW156D	0908_MW156D_21112018	21/11/2018	1.772
MW124	0908_MW124_21112018	21/11/2018	1.224
MW159D	0908_MW159D_21112018	21/11/2018	2.070
MW159S	0908_MW159S_21112018	21/11/2018	1.800
MW160	0908_MW160_21112018	21/11/2018	1.515
MW155	0908_MW155_21112018	21/11/2018	1.155
MW165	0908_MW165_21112018	21/11/2018	1.141
MW122	0908_MW122_21112018	21/11/2018	1.340
MW162S	0908_MW162S_21112018	21/11/2018	1.940
MW179D	0908_MW179D_22112018	22/11/2018	1.093
MW171S	0908_MW171S_22112018	22/11/2018	0.549
MW281S	0908_MW281S_22112018	22/11/2018	0.989
MW240D	0908_MW240D_22112018	22/11/2018	1.326
MW179S	0908_MW179S_22112018	22/11/2018	1.063
MW202S	0908_MW202S_22112018	22/11/2018	1.150
MW202D	0908_MW202D_22112018	22/11/2018	1.120
MW171D	0908_MW171D_22112018	22/11/2018	0.505
MW240S	0908_MW240S_22112018	22/11/2018	1.233
MW279S	0908_MW279S_26112018	26/11/2018	1.460
MW128	0908_MW128_26112018	26/11/2018	1.290
MW126S	0908_MW126S_26112018	26/11/2018	1.282
MW178	0908_MW178_26112018	26/11/2018	1.122
MW212	0908_MW212_26112018	26/11/2018	1.702
MW163	0908_MW163_26112018	26/11/2018	1.450
MW128D	0908_MW128D_26112018	26/11/2018	0.670
MW103D	0908_MW103D_27112018	27/11/2018	0.905
MW103S	0908_MW103S_27112018	27/11/2018	1.055
MW107S	0908_MW107S_27112018	27/11/2018	0.490
MW107D	0908_MW107D_27112018	27/11/2018	0.535
MW241S	0908_MW241S_27112018	27/11/2018	1.515
MW241D	0908_MW241D_27112018	27/11/2018	1.461
MW195	0908_MW195_27112018	27/11/2018	0.502
MW132D	0908_MW132D_27112018	27/11/2018	2.805
MW132S	0908_MW132S_27112018	27/11/2018	2.820
MW130D	0908_MW130D_27112018	27/11/2018	0.962

Well ID	Sample ID	Date	Depth to Water (mBTOC)
			mBTOC
MW266S	M0908_MW266S_28112018	28/11/2018	0.470
MW139	0908_MW139_28112018	28/11/2018	0.622
MW271S	0908_MW271S_28112018	28/11/2018	0.615
MW187S	0908_MW187S_28112018	28/11/2018	0.272
MW266D	0908_MW266D_28112018	28/11/2018	0.340
MW271D	0908_MW271D_28112018	28/11/2018	0.645
MW274D	0908_MW274D_28112018	28/11/2018	0.499
MW219S	0908_MW219S_28112018	28/11/2018	0.729
MW223S	0908_MW223S_28112018	28/11/2018	0.878
MW238D	0908_MW238D_28112018	28/11/2018	0.984



MW274S	0908_MW274S_28112018	28/11/2018	0.620
MW225D	0908_MW225D_28112018	28/11/2018	0.360
MW238S	0908_MW238S_28112018	28/11/2018	1.075
MW219D	0908_MW219D_28112018	28/11/2018	0.810
MW187D	0908_MW187D_28112018	28/11/2018	0.285
MW172	0908_MW172_29112018	29/11/2018	0.000
W68	0908_W68_29112018	29/11/2018	0.832
N66	0908_N66_29112018	29/11/2018	1.285
MW175D	0908_MW175D_29112018	29/11/2019	0.960
MW108S	0908_MW108S_29112018	29/11/2019	0.180
MW108D	0908_MW108D_29112018	29/11/2018	0.239
MW168	0908_MW168_29112018	29/11/2018	1.365
MW166	0908_MW166_29112018	29/11/2018	1.350
MW167	0908_MW167_29112018	29/11/2018	2.290
MW236D	0908_MW236D_30112018	30/11/2018	1.080
MW198	0908_MW198_30112018	30/11/2018	1.080
MW196	0908_MW196_30112018	30/11/2018	0.860
MW134I	0908_MW134I_30112018	30/11/2018	2.110
MW134D	0908_MW134D_30112018	30/11/2018	2.170
MW137	0908_MW137_04122018	4/12/2018	1.030
MW140	0908_MW140_04122018	4/12/2018	0.910
MW265D	0908_MW265D_04122018	4/12/2018	0.895
MW229S	0908_MW229S_06122018	6/12/2018	1.095
MW229D	0908_MW229D_06122018	6/12/2018	1.270
MW257D	0908_MW257D_06122018	6/12/2018	1.160
PS9 - Bore 30	0908_PS9(30)_181206	5/12/2018	2.115
PS9(i)	0908_PS9(i)_181206	6/12/2018	1.550
PS59	0908_PS59_181207	6/12/2018	0.100
MW276D	0908_MW276D_06122018	6/12/2018	0.440
MW232D	0908_MW232D_06122018	6/12/2018	1.080
MW232S	0908_MW232S_06122018	6/12/2018	1.130
MW267D	0908_MW267D_07122018	7/12/2018	1.150
MW267S	0908_MW267S_07122018	7/12/2018	1.160
MW235D	0908_MW235D_07122018	7/12/2018	0.260
MW265S	0908_MW235S_07122018	7/12/2018	0.390

Table 9 Monitoring Wells within the Structure Plan study area (south and south east of RAAF BASE Williamstown)

Monitoring Well ID (PFOS ug/L)	Location	Date Sampled	Groundwater Level (mBTOC)
MW167 (372)	North	29/11/2018	2.290
MW103D (0.03)	North	27/11/2018	0.905
MW103S (<0.01)	North	27/11/2018	1.055
MW240D (<0.01)	North	22/11/2018	1.326
MW240S (0.02)	North	22/11/2018	1.233
MW107D (<0.01)	Centre (North)	27/11/2018	0.535
MW107S (<0.01)	Centre (North)	27/11/2018	0.490
MW108D (<0.01)	Centre (North)	29/11/2018	0.239
MW108S (0.07)	Centre (North)	29/11/2019	0.180
MW175D (4.43)	Centre (North)	29/11/2019	0.960
W66 (14.8)	Centre (North)	-	-
W68 (15.7)	Centre (North to North East)	29/11/2018	0.832
MW238D (<0.01)	Centre (West)	28/11/2018	0.984
MW238S (<0.01)	Centre (West)	28/11/2018	1.075
MW187D (19.4)	Centre (East)	28/11/2018	0.285
MW187S (148)	Centre (East)	28/11/2018	0.272
MW139 (<0.01)	West (near boundary)	28/11/2018	0.622
MW178 (<0.01)	Centre (South)	26/11/2018	1.122
MW271S (<0.01)	Centre (South)	28/11/2018	0.615
MW271D (<0.01)	Centre (South)	28/11/2018	0.645
MW274D (0.02)	Centre (South East)	28/11/2018	0.499
MW274S (67.6)	Centre (South East)	28/11/2018	0.620
MW140 (<0.01)	South West (Cabbage Tree Road)	4/12/2018	0.910
MW124 (<0.01)	South West (Cabbage Tree Road)	21/11/2018	1.224
MW125D (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.478
MW125S (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.514
MW229D (<0.01)	South (Cabbage Tree Road)	6/12/2018	1.270
MW229S (<0.01)	South (Cabbage Tree Road)	6/12/2018	1.095
MW146S (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.165
MW146D_A (<0.01)	South (Cabbage Tree Road)	20/11/2018	1.015
MW126D (<0.01)	South East (Cabbage Tree Road)	20/11/2018	1.160

Monitoring Well ID (PFOS ug/L)	Location	Date Sampled	Groundwater Level (mBTC)
MW126S (1.63)	South East (Cabbage Tree Road)	26/11/2018	1.282
MW188D (0.38)	South East (Cabbage Tree Road)	20/11/2018	0.574
MW188S (0.68)	South East (Cabbage Tree Road)	19/11/2018	0.660
MW195 (0.06)	South East (Cabbage Tree Road)	27/11/2018	0.502

Table 10 Surface and sediment locations within the structure plan

Surface and sediment sample locations	Location
DD1 (SW 0.83, SD 0.00)	North (adjacent to Base)
DD2 (SW 0.91, SD 0.00)	South (along Cabbage Tree Road)
DD3 (SW 30.7, SD 0.14)	South East (along Cabbage Tree Road)
LC_B (SW 5.41, SD 0.03)	North (within Base)
LC (SW 4.85, SD 0.03)	North (within Base)
MD6 (SW 0.83, SD 0.02)	North East (adjacent to Base)
MD7 (SW 7.34, SD 0.02)	North East (adjacent to Base)
DD5 (SW 2.64, SD 0.01)	South (South of Cabbage Tree Road)
FFD4 (SW 0.96, SD 0.01)	South (South of Cabbage Tree Road)
TFD1 (SW <<0.01, SD 0.02)	South (South of Cabbage Tree Road)
TFD2 (SW 2.34, SD 0.01)	South (South of Cabbage Tree Road)

## AECOM 2019, Interim Monitoring Event Report – RAAF Base Williamstown, June 2019

Table 11 Monitoring Wells within the Structure Plan study area (south and south east of RAAF BASE Williamstown)

Monitoring Well ID	Location	Date Sampled	Groundwater Level (mBTOC)
MW167	North	30/05/2019	3.11
MW103D	North	31/05/2019	1.71
MW103S	North	31/05/2019	1.99
MW240D	North	31/05/2019	2.118
MW240S	North	31/05/2019	-
MW107D	Centre (North)	31/05/2019	1.00
MW107S	Centre (North)	31/05/2019	0.95
MW108D	Centre (North)	31/05/2019	0.74
MW108S	Centre (North)	31/05/2019	0.63
MW175D	Centre (North)	31/05/2019	1.991
W66	Centre (North)	31/05/2019	2.475
W68	Centre (North to North East)	31/05/2019	2.102
MW238D	Centre (West)	6/06/2019	0.89
MW238S	Centre (West)	6/06/2019	0.98
MW187D	Centre (East)	5/06/2019	~0.200
MW187S	Centre (East)	5/06/2019	~0.150
MW139	West (near boundary)	4/06/2019	0.83
MW178	Centre (South)	21/05/2019	1.23
MW271S	Centre (South)	13/06/2019	0.57
MW271D	Centre (South)	13/06/2019	0.55
MW274D	Centre (South East)	5/06/2019	0.30
MW274S	Centre (South East)	5/06/2019	0.36
MW140	South West (Cabbage Tree Road)	-	-
MW124	South West (Cabbage Tree Road)	22/05/2019	1.82
MW125D	South (Cabbage Tree Road)	22/05/2019	1.66
MW125S	South (Cabbage Tree Road)	22/05/2019	1.70
MW229D	South (Cabbage Tree Road)	24/05/2019	1.47
MW229S	South (Cabbage Tree Road)	24/05/2019	1.26
MW146S	South (Cabbage Tree Road)	21/05/2019	1.40
MW146D_A	South (Cabbage Tree Road)	21/05/2019	1.24

Monitoring Well ID	Location	Date Sampled	Groundwater Level (mBTOC)
MW126D	South East (Cabbage Tree Road)	21/05/2019	1.40
MW126S	South East (Cabbage Tree Road)	21/05/2019	1.38
MW188D	South East (Cabbage Tree Road)	22/05/2019	0.94
MW188S	South East (Cabbage Tree Road)	21/05/2019	0.98
MW195	South East (Cabbage Tree Road)	27/05/2019	0.69
<b>Additional monitoring wells sampled during June 2019 monitoring event</b>			
MW109D	Centre (East)	31/05/2019	0.868
MW282S	North (adjacent to base)	20/06/2019	1.561
BWS107	South West	4/06/2019	-
MW278S	South (Cabbage Tree Road)	23/05/2019	0.89
MW278D	South (Cabbage Tree Road)	23/05/2019	0.90

**Table 12 Surface and sediment locations within the structure plan**

Surface and sediment sample locations within structure plan	Location
DD1	North (adjacent to Base)
DD2	South (along Cabbage Tree Road)
DD3	South East (along Cabbage Tree Road)
LC_B	North (within Base)
LC	North (within Base)
MD6	North East (adjacent to Base)
MD7	North East (adjacent to Base)
DD5	South (South of Cabbage Tree Road)
FFD4	South (South of Cabbage Tree Road)
TFD1	South (South of Cabbage Tree Road)
TFD2	South (South of Cabbage Tree Road)



# Appendix C

## Additional Information – GCL Layer



**GEOFABRICS®**  
Smarter Infrastructure

**ELCOSEAL®**

**Geosynthetic Clay Liner  
Installation Guide**

# ABOUT ELCOSEAL

ELCOSEAL is a needle-punched Geosynthetic Clay Liner (or GCL) produced in Australia in accordance with the ISO 9001:2015 Quality Management System.

ELCOSEAL consists of premium grade sodium bentonite powder, which acts as the swelling and sealing component, embedded and sandwiched between two or more geotextiles. The composite is then needle-punched through all layers and thermally-locked developing high connection strength. Thus, ELCOSEAL is a shear strength transmitting GCL.

ELCOSEAL is generally fast and easy to install, however the performance of the GCL is dependent on the quality of its installation. It is the installer's responsibility to follow these guidelines and the

project specifications and drawings whenever possible. It is the engineer's and owner's responsibility to provide construction quality assurance (CQA) for the installation to ensure that the installation has been executed properly. Variance from this guideline is at the engineer's discretion.

Recommended further reading:

- ASTM D 5888 - *Standard Guide for Storage and Handling of GCLs*
- ASTM D 6102 - *Standard Guide for Installation of GCLs*
- ASTM D 5889 - *Standard Practice for Quality Control of GCLs*
- ASTM D 6072 - *Standard Guide for Obtaining Samples of GCLs*

## BEFORE YOU BEGIN

Prior to delivery of ElcoSeal on-site ensure the project team has:

- Read these guidelines;
- Raise any questions not answered by these guidelines with Geofabrics;
- Read the ElcoSeal Safety Data Sheet and Bentonite Material Safety Datasheet (available on the Geofabrics website);
- All the required equipment to unload, store and install ElcoSeal on site;
- All the required PPE for safe handling and installation of ElcoSeal.

## Personal Protective Equipment

The use of respiratory, eye, hand and body protection is recommended when handling ElcoSeal Geosynthetic Clay Liners. Please refer to the ElcoSeal Safety Data Sheet for more information prior to any commencement of work. ElcoSeal contains powdered sodium bentonite which contains quartz/cristobalite which is classified as hazardous according to the Globally Harmonised System of Classification and Labelling of Chemicals (GHS).



A respirator with a removable dust mask should be used



Safety glasses with side shields should be worn



Wear gloves of impervious material



Wear suitable protective workwear. Overalls are recommended.



GHS Classified as hazardous

# PACKAGING, TRANSPORTATION, UNLOADING & STORAGE

## Packaging

ELCOSEAL rolls are packed in moisture tight plastic wrapping. The standard roll dimensions and weights are listed in Table 1 below.

Every ELCOSEAL roll has a unique roll number on the wrapping label and on the panel itself. This information allows for matching of manufacturing quality assurance (MQA) records.

**!** *After transportation and unloading the plastic wrapping should be checked. Minor damage should be repaired with weather-resistant adhesive tape. Wrapping should only be removed immediately before use.*

**Table 1: ELCOSEAL Roll Dimensions & Freight Capacities**

Grade	Width (m)	Length (m)	Diameter (m)	Roll Mass (kg)	Rolls per B Double	Rolls per 20ft Container	Rolls per 40ft Container
X800	4.7	45	~0.56	~1,035	20	15	22
X1000	4.7	35	~0.52	~915	23	15	24
X2000	4.7	30	~0.56	~890	23	15	25
X3000	4.7	30	~0.57	~940	23	16	23

## Transportation

ELCOSEAL rolls are usually delivered to site in closed containers or covered trailers on flatbed trucks. At the point of unloading, the rolls need to be accessible either from the top of the trailer or the container opening. Please see the table above for average freight capacities for B Double and 20ft and 40ft containers.

Should any damage to rolls occur in transit it must be immediately brought to the attention of Geofabrics, who will advise on the required course of action.



# Unloading

A flat, hard, dry and free draining surface must be provided for unloading and storage. Offloading on site will require heavy equipment: an excavator (tracked or wheeled); front-end loader; or a forklift. Heavy equipment must be correctly rated for the expected load (see Table 1 on the previous page). Rolls may be offloaded using:

- A** A Spreader Bar with steel tube insert through the core of the rolls. Refer to the *ELCOSEAL Spreader Bar Safe Usage Guideline* from the Geofabrics website for detailed information; **OR**
- B** A 'carpet prong', rated to 1,200 kg and matched to the forklift, protruding from the front end of the forklift (>4.5 tonne) or other equipment. The prong should be at least  $\frac{3}{4}$  the length of the ELCOSEAL core and also must be capable of supporting the full weight of ELCOSEAL without significant bending; **OR**
- C** The two slings provided by the Geofabrics (upon request) wrapped around the ELCOSEAL roll at third ( $\frac{1}{3}$ ) points along the roll, fixed to an excavator bucket or a front-end loader. Slings should not be used for general lifting and transportation around the site. If excessive deformation or bending of the roll occurs the integrity of the geocomposite may be affected. A steel tube or similar reinforcement can be inserted into the core of the roll to prevent excessive deformation across the roll during off-

# Storage

ELCOSEAL rolls should be stored in their original, unopened packaging in a location away from construction traffic but sufficiently close to the active work area to minimise handling.

The designated storage area should be level, dry, well-drained, stable, and should protect the product from:

- Precipitation;
- Chemicals;
- Standing water;
- Excessive heat;
- Ultraviolet radiation;
- Vandalism and animals.

ELCOSEAL rolls should always be stored lying flat, continuously supported, and should never be stored standing on one end. Enclosed indoor storage such as shipping containers or a warehouse environment is preferred if ELCOSEAL® is to be stored for long periods.

The maximum storage height is four rolls.

- !** *ELCOSEAL rolls should not be exposed to moisture prior to installation. Damaged wrappers should immediately be repaired with weather resistant tape. Wrapping should only be removed from ELCOSEAL rolls immediately prior to installation.*



# INSTALLATION

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## What You'll Need On Site

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Prior to commencement of installation the following equipment will be required:

- Excavator (tracked or wheeled) or a front-end loader. Equipment should be rated for the expected load. Please see Table 1 on page 2 of this document for roll masses;
- Spreader bar/loading frame;
- HP Paste;
- Trowel;
- Carpet knife or safety knife;
- Felt pens or chalk;
- Measuring tape;
- Broom;
- PPE including dust mask, goggles, gloves and protective workwear.

## Weather Conditions for Installation

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Light rainfall (defined as <5mm/hour intensity) should not affect the installation of ELCOSEAL provided deployed panels are covered and confined by 300 mm of cover soil (or equivalent) within 2 hours of first exposure to the light rain. Heavy direct raindrop impact should be avoided. The ELCOSEAL panels can be covered during heavy rainfall events with a tarpaulin or plastic sheet if there is not enough time to complete soil cover placement.

Avoid placing ELCOSEAL in areas where water is ponding unless panels can be confined immediately (with 300 mm cover soil or equivalent).



*ELCOSEAL rolls should not be exposed to moisture prior to installation. During installation ELCOSEAL panels should be covered with a tarpaulin or plastic sheet during heavy rain events.*

# **Subgrade Preparation**

The preparation of the subgrade before placement of any lining material is critical to the system's performance. The surface(s) upon which ELCOSEAL is to be laid should be suitable for the intended application and function.

ELCOSEAL will generally be placed on either an earthen e.g. compacted clay, or geosynthetic e.g. geotextile or geocomposite) subgrade.

## **Earthen Subgrades**

The surface upon which ELCOSEAL® will be deployed should conform to the following:

- The subgrade should be firm and unyielding (typically compacted to >90% density), without abrupt elevation changes, and be proof rolled with a smooth drum roller immediately prior to deployment of the ELCOSEAL panels. The subgrade should not be disturbed or rutted by the equipment deploying the rolls or other traffic. No foreign matter or stones loose on the surface or penetrating out of the subgrade >10 mm should be allowed. The engineer's approval of the subgrade needs to be obtained immediately prior to roll deployment;
- In applications where ELCOSEAL is the sole or primary barrier, and will be subjected to constant or long-term hydraulic heads exceeding 300 mm (1 ft), subgrade surfaces consisting of gravel or granular soils may not be appropriate due to their large void contents and puncture potential. In these applications, the top 150 mm of the subgrade should possess a particle size distribution where at least 80% of the soil is finer than 0.25 mm (or #60 sieve) - unless the ELCOSEAL grades X2000 or X3000 are being used (see below);
- For X2000 and X3000 grades (with a composite woven/nonwoven carrier geotextile) in high hydraulic head applications:

Subgrade materials recommended without further investigation are:

- » Clays or clay-based mixes;
- » Sandy clays (with > 20% fines);
- » Silty or loamy clays (with > 20% fines)  
[fine grained soils should be placed at suitable moisture contents for construction operations and roll deployment - that provide adequate bearing capacity to deploy the rolls without disturbance of the subgrade - i.e no rutting or large deflections];
- » Well graded sands and gravels (max < 32 mm, d60 < 5 mm, d20 < 0.15 mm).  
[these materials should bind and have good bearing capacity when compacted/rolled].

Subgrade materials not recommended without further investigation:

- » Single-sized and gap-graded sands and gravels of any size or description;
- » Sands or soils that have low bearing capacity at the moisture contents during the construction/deployment operations i.e. materials that do not bind when rolled; will heave/shove under equipment or foot traffic during or after deployment);
- » Subgrades that have a bony or porous appearance after compaction and rolling.

## Geosynthetic Subgrades

When deploying ELCOSEAL over a geosynthetic material such as a geomembrane or geotextile, the surface should be firm and unyielding as per the requirements for earthen subgrades. The equipment used to deploy ELCOSEAL should be approved for use by the Design Engineer and/or the Supplier of the underlying geosynthetic material. Generally, the underlying geosynthetic and ELCOSEAL® rolls will be deployed consecutively such that each layer is side-cast from equipment tracking over the earthen subgrade - unless specialised light rubber tyred dispensers are available and approved by the Design Engineer that allow direct trafficking over the geosynthetics.

## GCL Placement

The ELCOSEAL roll wrapping should only be removed immediately prior to installation. On site, ELCOSEAL is unrolled along the prepared subgrade using the Spreader Bar assembly as shown in Figures 1 and 2 (overleaf).



*ELCOSEAL should only be trafficked by light, low tyre pressure vehicles (no tracked vehicles).*

Rolls must be laid without folds on the subgrade with a standard overlap of 300 mm in both the longitudinal and transverse direction as detailed in Figures 3, 4 and 5. For longitudinal or edge overlaps, the blue coloured line on the underside of the panels can be used to ensure the correct overlap width. The edge of deployed or previously placed panels needs to coincide or match with the visible blue line on the roll being deployed.

The transverse or end overlaps need to be sealed using bentonite paste. The treatment of end (transverse) overlaps is detailed in Figures 6 and 7.

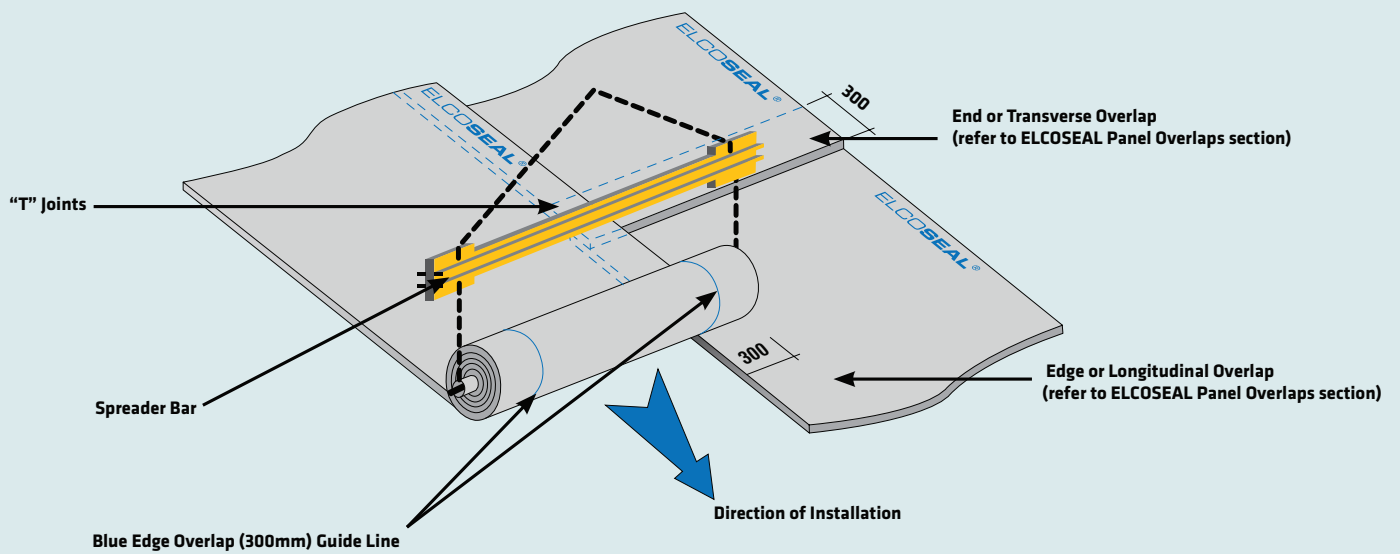
Rolls can be cut to length with a carpet/Stanley knife. When overlapping cut panels, bentonite paste will need to be applied as per the requirements for end (transverse) overlaps on the following page under *ELCOSEAL Panel Overlaps*.

No trafficking or walking should occur over the overlap region during installation. The overlap must also be free from folds and foreign matter e.g. soil. Any soil particles on the laps must be swept away carefully.

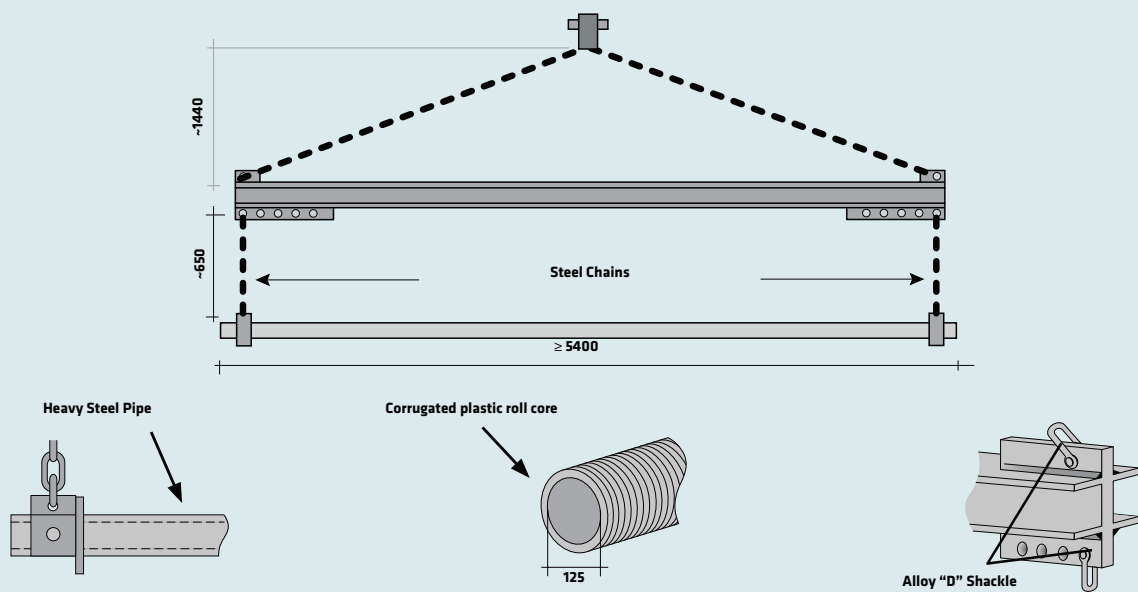
Overlaps should occur in the direction of ground slope in a similar manner to roof tiles.

## Damage to ELCOSEAL During Installation

Where ELCOSEAL has been damaged during installation, covering with an overlapping piece of ELCOSEAL can repair such areas. The overlap should be at least 500 mm and should be completed in accordance with the ELCOSEAL Panel Overlaps section.



**Figure 1 ELCOSEAL deployment using the standard ELCOSEAL Spreader Bar**



**Figure 2 ELCOSEAL typical Spreader Bar assembly**

**!** *Refer to the ELCOSEAL Spreader Bar Safe Use Guide prior to using the lifting equipment and ensure that occupational health and safety requirements have been met and potential hazards eliminated.*

# ELCOSEAL Panel Overlaps

## Logitudinal Overlaps

The longitudinal overlap is where GCL rolls overlap along their length. The installation of a longitudinal overlap can be seen in Figure 1. The width of this overlap shall be a minimum of 300 mm which is indicated by a blue marker line printed on the bottom of the roll. The overlapping area has bentonite powder impregnated into the top nonwoven fibres of the GCL as seen in Figure 3 for grades X800 and X1000 and in Figure 4 for grades X2000 and X3000. When hydrated, the impregnated bentonite will swell into the fibre porespace to provide a sealed hydraulic barrier. An installed cross section can be seen in Figure 5.

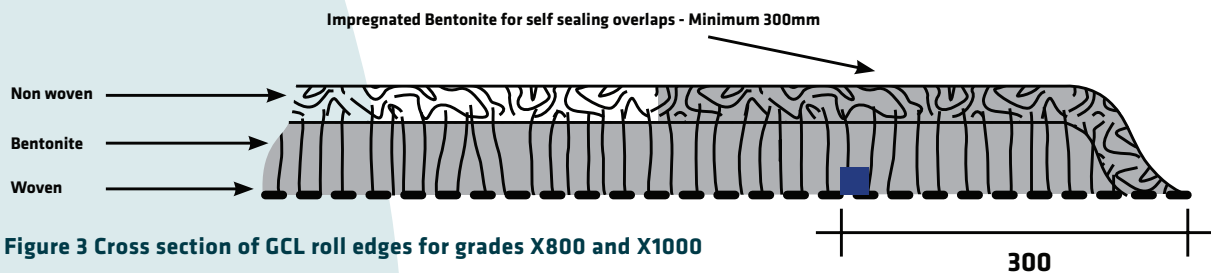


Figure 3 Cross section of GCL roll edges for grades X800 and X1000

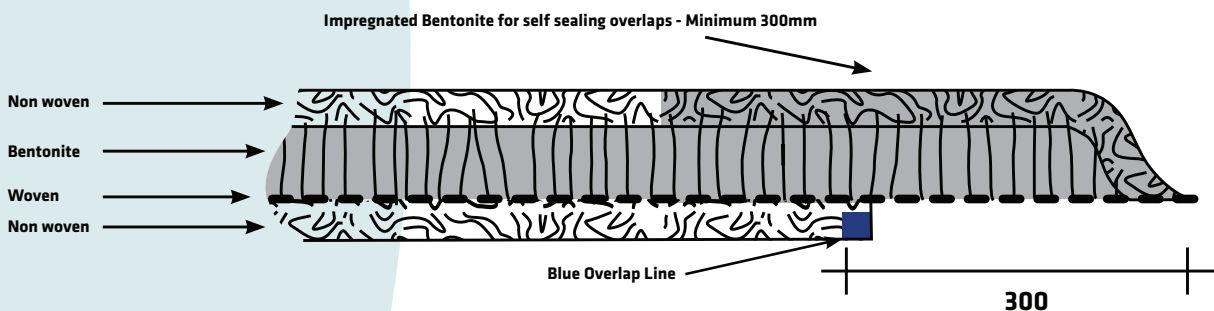


Figure 4 Cross section of GCL roll edges for grades X2000 and X3000

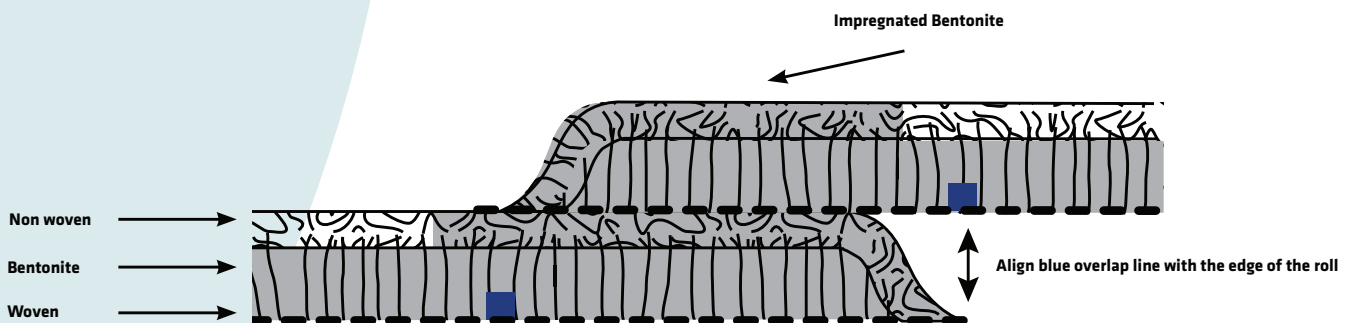


Figure 5 Longitudinal (or edge) overlap with self-sealing impregnated bentonite (X1000 shown)

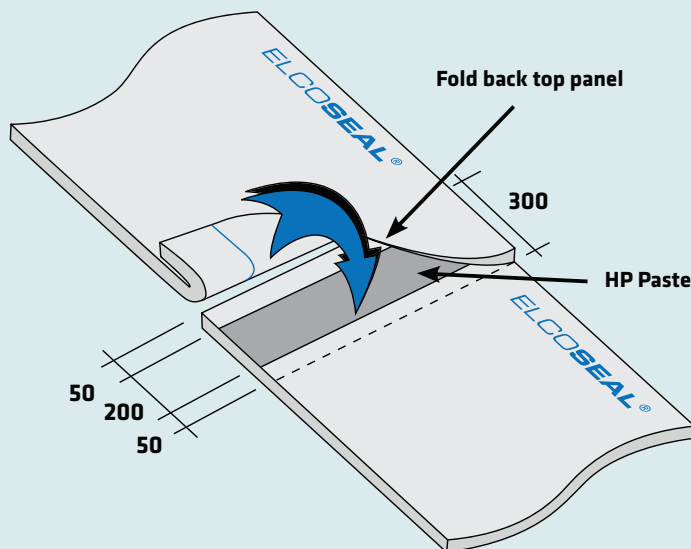


## Transverse Overlaps

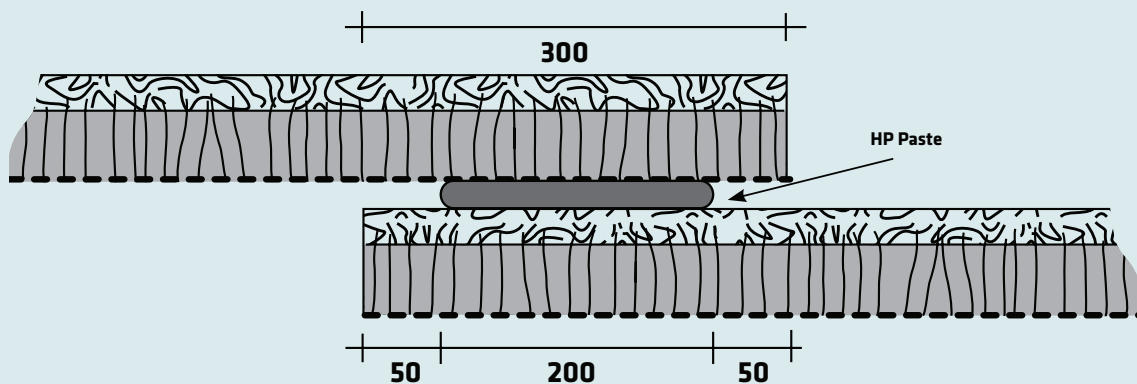
Transverse overlaps occur at the end of rolls. The width of the GCL transverse overlap shall be a minimum of 300 mm. It is recommended that the topside of the underlying ELCOSEAL panel be marked as per Figure 6, as a reference point for paste placement. The top ELCOSEAL panel is then pulled back after marking.

All transverse/roll end overlaps should be sealed with bentonite paste. Geofabrics supplies HP paste which is an extensively tested sealing solution available in 20 L containers. As indicated in Figure 6, HP paste should be placed within the 300 mm overlap with a minimum width of 200 mm and a nominal thickness of 10 mm. The paste can be easily poured from the 20 L container and spread into place using a trowel or broom. Approximately 10L or ½ of a container is used for each roll width at the transverse overlap. Once the paste is applied, the top panel is then rolled back into place and pressed down (Figure 6). Care should be taken to prevent folds or creases. The end overlap cross section for X1000 is shown in Figure 7. If an alternative method of end of roll overlap sealing is required, please consult your local Geofabrics office.

To ensure the integrity of the ELCOSEAL® lining system it is essential that the treatment of end overlaps be carefully supervised. End overlaps in sumps or inverts are to be avoided.



**Figure 6 Transverse (end) overlap installation with applied HP Paste of minimum 200 mm width**



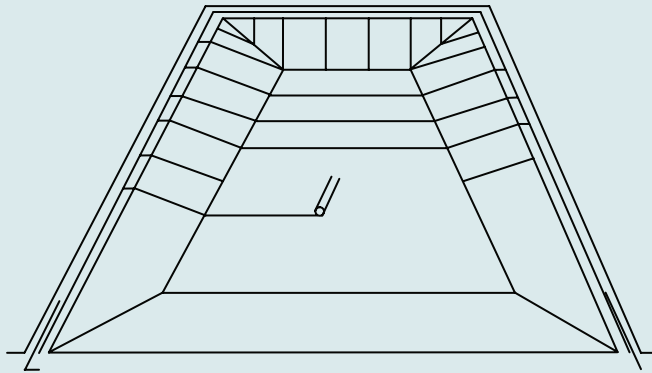
**Figure 7 Transverse (end) overlap cross section (X1000 shown)**

# Installation on Slopes

The stability of lining system components on slopes should be assessed on a case-by-case basis. Geofabrics can assist in this respect upon request.

ELCOSEAL panels should be deployed in the direction of the slope as per Figure 8 and anchored at the crest of the slope (Figure 9). End (or transverse) overlaps on steep slopes should be avoided. If overlaps on slopes are unavoidable, please consult your local Geofabrics branch for information on custom extra-long GCL rolls.

Cover soil should be placed up the slope (starting at the toe). It must not be installed down the slope unless stability for this approach has been carefully investigated.



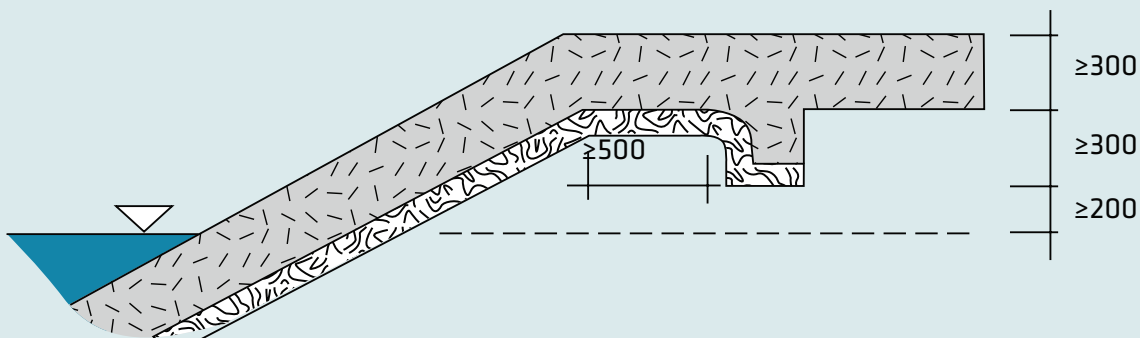
**Figure 8 Recommended panel layout for sloping sites**

## Anchor Trenches

Anchor trench and slope stability considerations should be assessed by the Design Engineer.

As a general guide:

- An anchor trench should be used at the top of slopes steeper than 7H: 1V. (see Figure 9 for a typical anchor trench detail);
- The anchor trench should be constructed free of sharp edges or corners and maintained in a dry condition. The ELCOSEAL panels should be placed down the front face and along the base of the anchor trench. The base of the anchor trench should not contain large gravel or loose material and the trench backfill material should be compacted.

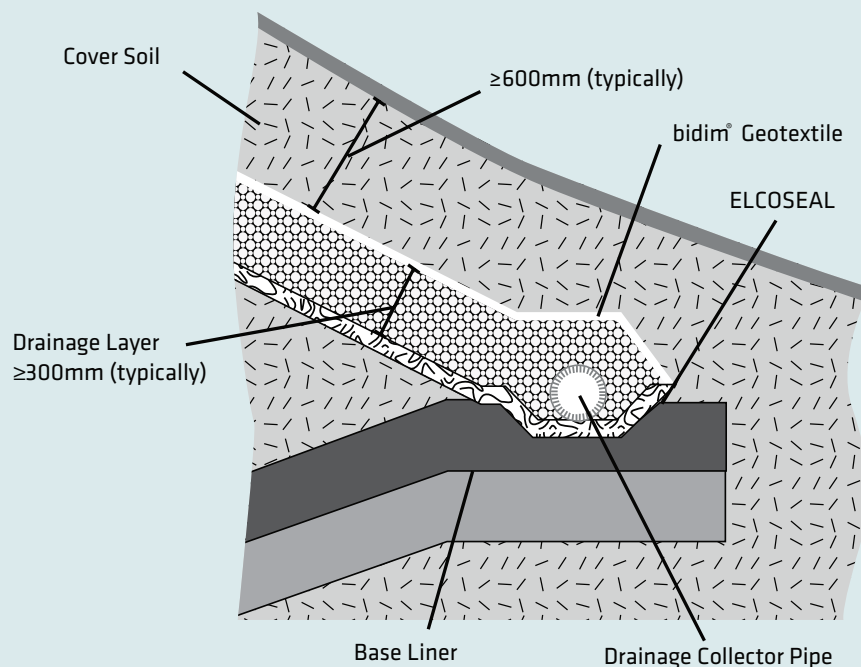


**Figure 9 Typical anchor trench (all dimensions shown are typical values only)**

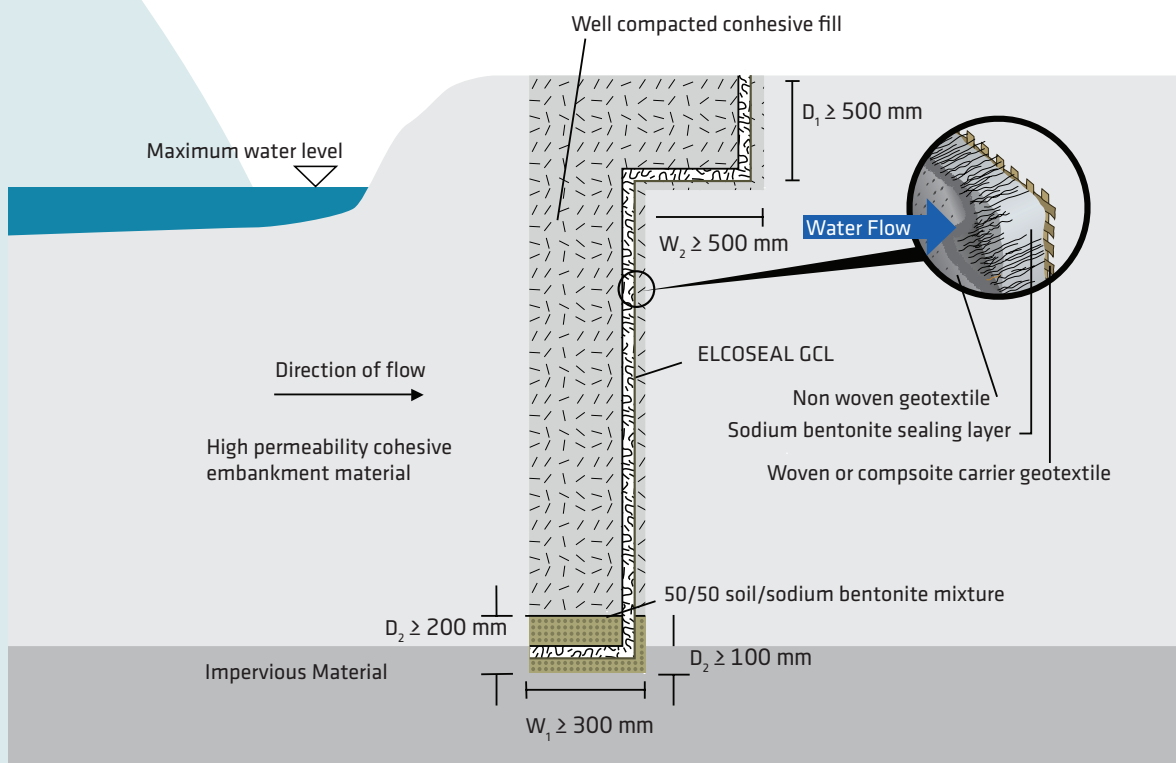
# Connections & Penetrations

Overlaps around connections, penetrations, and where panels have been cut should be carried out according to the principles outlined in Figures 5, 6 and 7. Most situations require site specific design input, however some commonly used details are shown below:

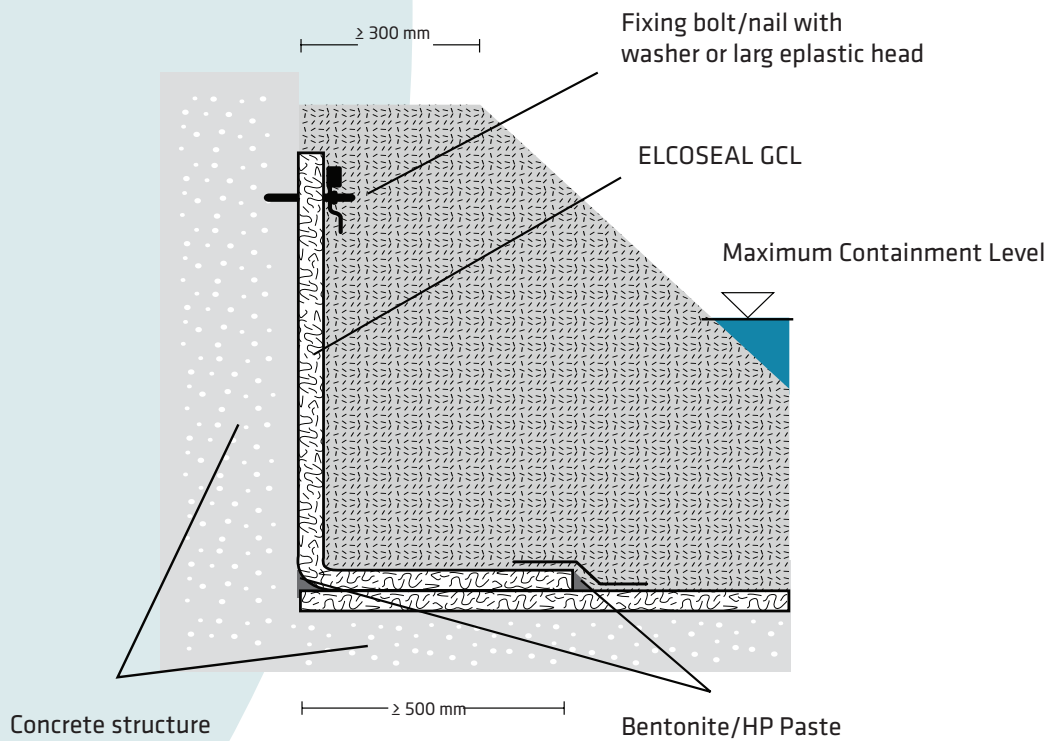
- Integration with thick compacted clay liners is shown in Figure 10;
- Cut-off trenches using ELCOSEAL GCL in cohesive soil are typically constructed as shown in Figure 11;
- Attachment and sealing against concrete structures, can be achieved according to Figures 12a and 12b. These typical connections are appropriate where the structure needs to be waterproofed to a height above and below the maximum containment level. Temporary fixing of the vertical ELCOSEAL panel to the structure (as shown) is required to allow the backfill placement;
- Penetrations such as pipe ducts are typically carried out according to Figure 13;
- Further connection methods and penetrations details can be discussed with Geofabrics.



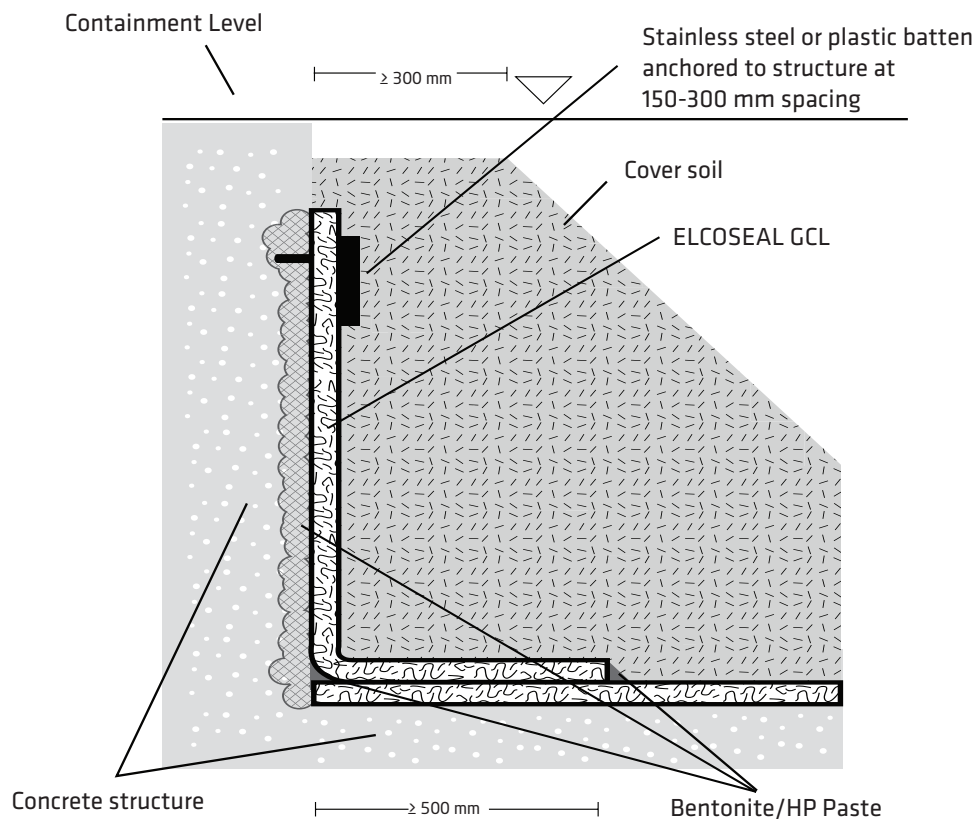
**Figure 10 ELCOSEAL cap connection with base liner**



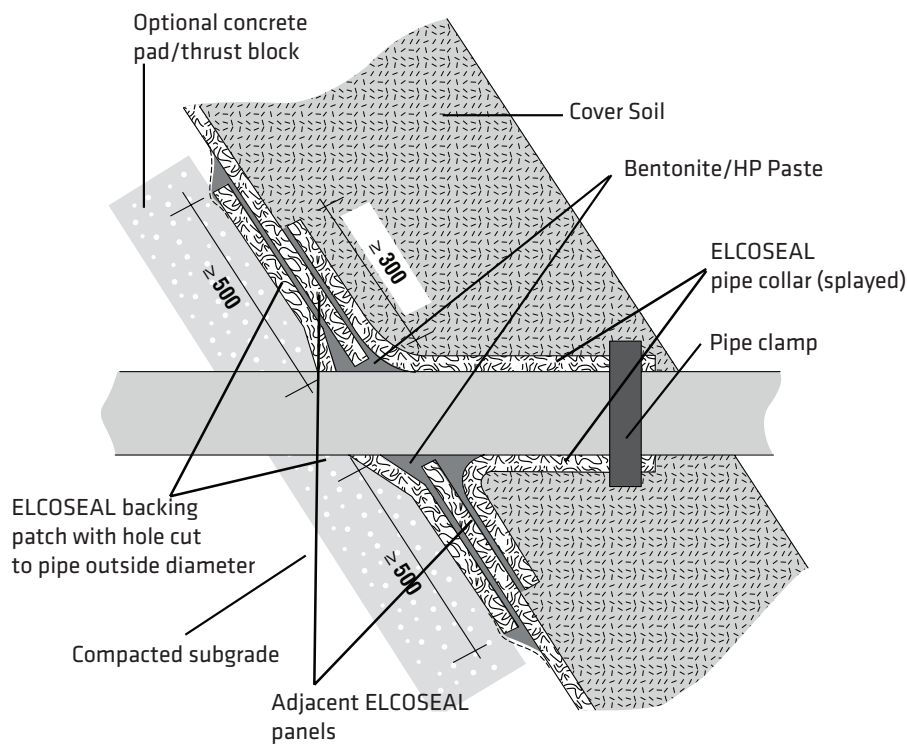
**Figure 11 ELCOSEAL cut off trench detail for cohesive soils**



**Figure 12a Typical connection to a concrete structure where the ELCOSEAL panel if required to extend above the maximum containment level**



**Figure 12b Typical connection to a concrete structure where the ELCOSEAL panel if required to extend below the maximum containment level**



**Figure 13 Typical pipe penetration detail**



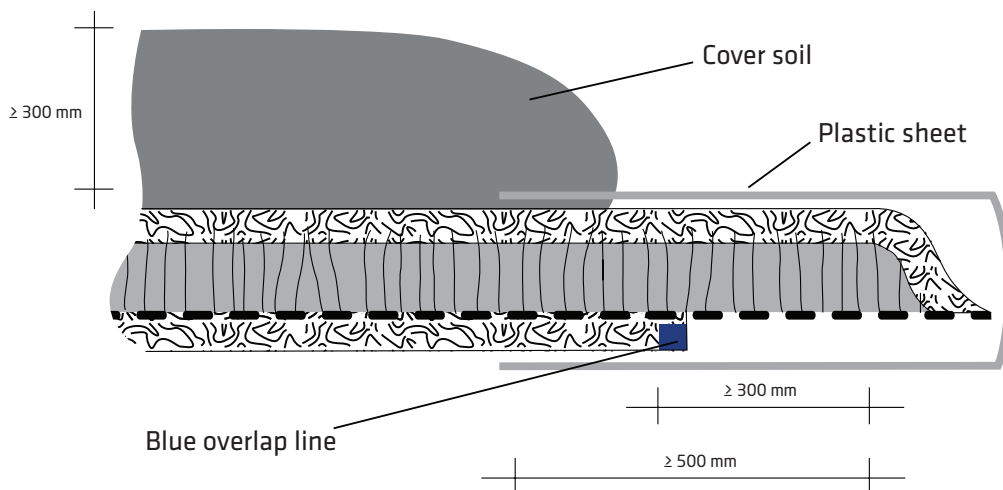
# Preparation for Placing Soil Cover

Where the ELCOSEAL is not confined by the cover soil the same working day as deployment, a temporary layer of plastic should be laid to protect ELCOSEAL from prematurely hydrating (Figure 14).

If the deployed ELCOSEAL panels have hydrated (for example during a rainfall event) without confinement, special operating conditions may need to be imposed during cover soil placement. For example:

- If ELCOSEAL m.c.<sup>1</sup> <50% No special considerations;
- If ELCOSEAL 50% <m.c. <100% Avoid direct traffic (including foot traffic) on panels;
- If ELCOSEAL m.c. >100% Contact Geofabrics for advice.

1. m.c. = moisture content of the bentonite, % by weight



**Figure 14 Covering ELCOSEAL with plastic sheet overnight or during wet weather**

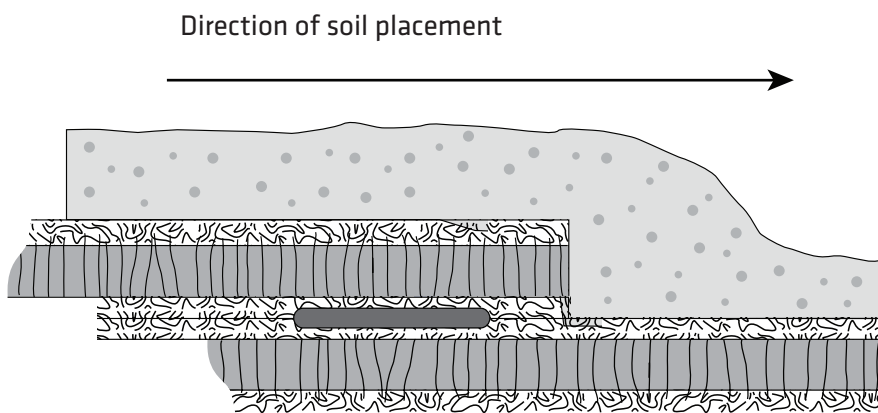
# Soil Cover Placement

A cover soil layer of at least 300 mm thick (approx. 6 kN/m<sup>2</sup> confining stress) should be placed and compacted over ELCOSEAL each working day immediately after the deployed panels have been inspected. In general, fine-grained cohesive material is recommended, although stones up to 32 mm are acceptable if the material is well graded ( $C_u > 5$ ) or stones up to 16 mm if single sized. Silty soils or organic material are not recommended without further stability analysis. Calcareous or limestone based cover soils should be evaluated prior to use.

Disturbance of the overlap area during placement (by means of vehicles spreading cover soil) must be avoided. It may be necessary to place the cover soil in this area manually or carefully using vertical placement by an excavator. The cover should not be pushed or graded in a direction that may cause the overlap to move (Figure 15).

ELCOSEAL may not be trafficked directly. The cover material should be pushed in front of the construction equipment thus creating a safe working platform. Overlaps should not be moved or squeezed during this process. In the case of an expected repeated dynamic load on ELCOSEAL, a sand layer of at least 300 mm should be laid first on the ELCOSEAL.

Generally, temporary access roads should not go over deployed panels. These areas should be sealed last to minimise traffic volume over deployed material. Where site traffic cannot be avoided e.g. the delivery of cover material by lorries) additional protection measures will be required. For temporary roads, a minimum roadbase thickness over ELCOSEAL of 600 mm is acceptable without any further analysis. Shallower coverage or alternative cover materials may be allowed after further analysis or field trials to assess the damage potential.



**Figure 15 Cover soil placement**

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TECHNICAL DATA SHEET:

# ELCOSEAL

## Geosynthetic Clay Liners

**ELCOSEAL Geosynthetic Clay Liners (GCLs) are used as a lining system in landfills and waste containment structures, and for liquid containment in effluent ponds, wetlands and canals.**

Australian made ELCOSEAL GCLs consist of a layer of bentonite bonded between two layers of woven and nonwoven geotextiles. The needle-punching process reinforces the bentonite layer with thousands of fibres, maximising the product's internal resistance. An additional heat treating process called "thermal locking" secures the needle-punched fibres, further improving strength and performance.

ELCOSEAL GCLs have been used in environmental, civil and landfill liner applications since 1996. They have an unmatched sealing capability and are cheaper to install than natural clay layers. When hydrated, the sodium bentonite layer forms a barrier that prevents contamination of surrounding groundwater.

ELCOSEAL GCLs can replace thick, compacted clay layers in composite landfill liners and caps, thanks to the fast swelling sodium bentonite clay liner. This creates a highly effective containment barrier for landfill final cover systems and base landfill liner systems. ELCOSEAL GCLs can self-heal around holes or punctures so there is less chance of leaks due to installation damage.

### SUGGESTED SECTOR APPLICATIONS



Roads



Rail



Coastal



Waste



Mining



Civic &  
Landscaping



Ports &  
Aviation



Water



Primary  
Industries



Sports &  
Recreation



Slopes &  
Walls



Building

## ELCOSEAL GEOSYNTHETIC CLAY LINERS

The values published in this leaflet are to the best of our knowledge true and correct. The product specification may change at any time without prior notice. No warranty is expressed or implied. Manufactured by Geofabrics Australasia Pty Ltd to the ISO 9001:2015 Quality Management System Standard.

PROPERTY		TEST METHOD	MQC <sup>1</sup> REQUENCY	UNITS	ELCOSEAL <sup>®</sup> GRADE			
					X800	X1000	X2000	X3000
GCL Hydraulic Properties								
Hydraulic Conductivity, k	MaxArv <sup>2</sup>	ASTM D5887	40,000 m <sup>2</sup>	m/s	3.5 x 10 <sup>-11</sup>	2.8 x 10 <sup>-11</sup>	3 x 10 <sup>-11</sup>	2.4 x 10 <sup>-11</sup>
	Typical <sup>3</sup>				2.5 x 10 <sup>-11</sup>	1.9 x 10 <sup>-11</sup>	2.4 x 10 <sup>-11</sup>	1.7 x 10 <sup>-11</sup>
Bentonite Characteristics								
Swell Index	Typical	ASTM D5890	40,000 m <sup>2</sup>	mL/2g	≥ 24	≥ 24	≥ 24	≥ 24
Fluid Loss	Typical	ASTM D5891	40,000 m <sup>2</sup>	mL	≤ 15	≤ 15	≤ 15	≤ 15
GCL Components - Mass								
Cover Nonwoven Geotextile Mass per Unit Area	MARV <sup>4</sup>	AS 3706.1	10,000 m <sup>2</sup>	g/m <sup>2</sup>	220	220	220	260
	Typical				250	250	250	300
Bentonite Mass per Unit Area @ 0% Moisture Content	MARV	ASTM D5993	2,500 m <sup>2</sup>	g/m <sup>2</sup>	3,700	4,000	3,700	4,250
	Typical				4,100	4,500	4,250	4,700
Carrier / Composite Geotextile Mass per Unit Area	MARV	AS 3706.1	70,000 m <sup>2</sup>	g/m <sup>2</sup>	110	110	320	350
	Typical				110	110	360	380
Geotextile Configuration (Carrier / Cover)					W / NW <sup>5</sup>	W / NW	W+NW / NW	W+NW / NW
GCL - Mass								
GCL Total Mass per Unit Area @ 0% Moisture Content	MARV	ASTM D5993	2,500 m <sup>2</sup>	g/m <sup>2</sup>	4,030	4,330	4,240	4,860
	Typical				4,460	4,860	4,860	5,380
GCL - Strength Properties								
Strip Tensile Strength (MD) <sup>6</sup>	MARV	ASTM D6768	10,000 m <sup>2</sup>	kN/m	7	8	12	12
	Typical				10	11	15	16
CBR Strength	MARV	AS 3706.4	25,000 m <sup>2</sup>	N	1,400	1,600	3,500	4,100
	Typical				2,000	2,100	4,100	5,300
CBR Elongation	MARV	AS 3706.4	25,000 m <sup>2</sup>	%	10	15	30	30
	Typical				30	40	80	80
GCL - Shear Strength Properties								
Hydrated Peak Internal Shear Strength @ 10kPa Normal Stress	Typical <sup>7</sup>	ASTM D6243	Periodic	kPa	30	30	35	40
Hydrated Peak Internal Shear Strength @ 30kPa Normal Stress	Typical	ASTM D6243	Periodic	kPa	50	50	60	70
GCL Longitudinal Edge Treatment								
Bentonite Impregnation - Width ≥ 300 mm - Typical				-	✓	✓	✓	✓
Edge Sealing Performance	Typical <sup>7</sup>	ASTM STP 1308 (Mod.)10,11	Periodic	m/s	2.5 x 10 <sup>-11</sup>	1.9 x 10 <sup>-11</sup>	2.4 x 10 <sup>-11</sup>	1.7 x 10 <sup>-11</sup>
GCL Roll Dimensions								
Standard Roll Dimensions (Width x Length)				m	4.7 x 45	4.7 x 35	4.7 x 30	4.7 x 30
Typical Roll Mass (standard roll length). Note: Longer custom roll lengths are available to suit project requirements.			(Weighed every roll)	kg	1,395	1,050	960	950
GCL Spreader Bar Requirement				-	Heavy-Duty <sup>8</sup>	Heavy-Duty <sup>8</sup>	Standard <sup>9</sup>	Standard <sup>9</sup>

1. **MQC** = Manufacturing Quality Control – an ongoing system that monitors and tests materials during manufacture to ensure compliance with certification documents and contract specifications.
2. **MaxARV** = Maximum Average Roll Value – a MaxARV is defined as the Mean or Typical values plus 2 standard deviations. Mathematically, it is implied that 97.5% of the results of the tested specimens will be less than the MaxARV. A MaxARV provides a confidence level of 97.5%. **NOTE** – in reference to GCL Permeability, **LOWER IS BETTER**.
3. **Typical** = A typical value is the arithmetic mean of a set of results. This implies that 50% of the tested specimens will typically exceed this value and 50% will typically not meet this value.
4. **MARV** = Minimum Average Roll Value – a MARV is defined as the Mean or Typical values less 2 standard deviations. Mathematically, it is implied that 97.5% of the results of the tested specimens will exceed the MARV. A MARV provides a confidence level of 97.5%.
5. **W**= Woven, **NW**= Nonwoven.
6. **MD** = Roll Machine Direction.
7. **Peak Value** reported at 10kPa or 30kPa normal stress. [The reported values are not intended to replace site specific internal shear or interface friction testing required for design].
8. **Heavy-Duty WLL** (Working Load Limit) = 1,400kg.
9. **Standard WLL** (Working Load Limit) = 1,000kg.
10. **Reference** - Daniel, D.E. Trautwein, S.J. and Goswami, P.K. 1997. Measurement of Hydraulic Properties of Geosynthetic Clay Liners Using a Flow Box, Testing and Acceptance Criteria for Geosynthetic Clay Liners, ASTM STP 1308, p. 196-207.
11. **Modification Reference** - Kendall, P.M., Austin, R. A. 2014. Investigation of GCL Overlap Techniques Using a Large Scale Flow Box, 7th International Congress on Environmental Geotechnics, 3B-3, p. 746-753.



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# MEGAFLO® GREEN

PANEL DRAIN &  
SUBSOIL DRAINAGE SYSTEM



TECHNICAL DATA SHEET



The Megaflo® Green panel drain provides the dimensional stability and field-proven structural strength for quick, effective subsurface drainage. Megaflo® Green consists of a perforated HDPE core wrapped with bidim® Green nonwoven geotextile to prevent soil ingress into the drainage system.

Performance is the distinguishing feature of the panel drain due to its ability to rapidly collect and remove water. Compared to slotted round pipe, **Megaflo® Green** has twice the inflow capacity for an equivalent length and will collect and drain 60% more water in a similar time frame. Its slim 40mm wide profile permits faster and more cost effective installation in a narrower trench.

## ADVANTAGES:

### VERTICAL CRUSH STRENGTH

The high vertical crush strength means **Megaflo® Green** can be installed closer to the surface reducing the cost of excavation.

### ENHANCED PERFORMANCE

The increased height and rapid response times associated with **Megaflo® Green** ensures the system outperforms traditional drainage options. The flat pipe construction prevents intrusion of the cover geotextile allowing flow rates to be maintained despite soil confinement pressure.

### COST EFFECTIVE

The narrow trench width requirement combines rapid installation of the geotextile encapsulated **Megaflo® Green** to provide significant cost savings when compared to traditional French drain systems.

### ENVIRONMENTALLY FRIENDLY

**Megaflo® Green** is manufactured from recycled HDPE, minimising the carbon footprint of the project.



## Megaflo® Green - Technical Data Sheet

Megaflo® Green panel drain is made in Australia, manufactured in a facility certified to ISO9001, Certificate No. FS673633.

MEGAFLO PANEL PROPERTIES		TEST METHOD	UNITS	MEG170G	MEG300G	MEG450G	MEG170G ULTRA	MEG300G ULTRA	MEG450G ULTRA
Panel Width		ASTM D2122	mm	170	315	460	170	315	460
Slot Size		ASTM D2122	mm	> 40			> 40		
Wide Strip Tensile <sup>1</sup>		ASTM D2122	mm	2.8 x 30			2.8 x 30		
Compressive Strength <sup>1,2</sup>	Horizontal	ASTM D2412 (mod)	kPa	> 200			> 200		
	Vertical			> 300			> 300		
Planar Flow @ 0.01 Gradient & 200kPa Confining Pressure <i>(Megaflo® Green installed horizontally)</i>	Rigid Plate Interface	ASTM D4716	litres/min	25	47	68	25	47	68
	Coarse Sand Interface			25	47	68	25	47	68
Planar Flow @ 0.1 Gradient & 200kPa Confining Pressure <i>(Megaflo® Green installed horizontally)</i>	Rigid Plate Interface	ASTM D4716	litres/min	66	122	178	66	122	178
	Coarse Sand Interface			66	122	178	66	122	178
Change in Core Cross-sectional Area under confining pressure of 156.5 kPa		ASTM D6244	%	< 5%			< 5%		
1. The compressive strength of <b>Megaflo® Green</b> should be considered in conjunction with the granular drainage medium. Geofabrics engaged an external consultant to perform a Finite Element Analysis which established that under extreme loads, the effective stress imposed on a <b>Megaflo® Green</b> panel due to it's stiffness and profile is significantly reduced through soil arching of the granular cover. 2. Geofabrics has also conducted compressive testing in a purpose made crush test rig to show <b>Megaflo® Green</b> can withstand extreme loads of up to 1580kPa due to the soil arching effect of the granular fill.									
While <b>Megaflo® Green</b> comes standard with <b>bidim® Green</b> A14G, Australian manufacturing allows flexibility of geotextile choice to suit site conditions. Performance testing is available at the Geosynthetic Centre of Excellence to determine filter suitability in critical applications. The data and specifications contained in this table are obtained from the manufacturer's laboratory testing. To ensure this information is current, please contact your local branch of Geofabrics Australasia. The product values listed on this sheet are Typical Values.									

GEOTEXTILE PROPERTIES	WIDE STRIP TENSILE STRENGTH	TRAPEZOIDAL TEAR STRENGTH	PORE SIZE	FLOW RATE @100mm HEAD
Test	AS 3706.2	AS 3706.3	AS 3706.7	AS 3706.9
bidim® A14G	11 kN/m	300 N	110 µm	320 l/m2/sec
bidim® Green nonwoven geotextile complies with the following road authority specifications: TfNSW R63, Queensland MRTS 27, MRTS 03, MRTS 38, NZ Transit TNZ F/7.				

M160G-08/20

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Megaflo® Green panel drains are manufactured in a facility certified to ISO9001, Certificate No. FS673633.



Proud member of the Infrastructure Sustainability Council of Australia (ISCA). Our products directly contribute to IS credits in infrastructure and civil engineering projects.



A full-page photograph of construction workers installing a drainage system. In the foreground, a worker in an orange high-visibility shirt, blue jeans, and a white hard hat is using a long-handled tool to guide the placement of gravel into a trench. Another worker is visible in the background, also in orange gear, using a shovel. The trench is lined with a grey geofabric material, and a white pipe is visible at the bottom. The ground is dirt and gravel. The top right of the image has a green overlay with white text.

# MEGAFLO<sup>®</sup> GREEN

*PANEL DRAIN &  
SUBSOIL DRAINAGE SYSTEM*

**GEOFABRICS<sup>®</sup>**  
Smarter Infrastructure



## GEOFABRICS

### A Green Drainage Panel Solution

Geofabrics has been providing geosynthetic solutions to the civil engineering market for over 40 years in Australia, New Zealand, Papua New Guinea and across the South Pacific.

On every project we undertake, we have a singular focus: to provide smarter solutions for our clients. For us, smarter infrastructure is about using smart products, smart solutions, and smart people to help our clients develop value engineering opportunities for their projects. We believe this delivers greater opportunities to lower risk, cost and construction time frames whilst increasing maintenance cycles and the whole of life opportunities.

## SUSTAINABILITY

Geofabrics is committed to building a strong, sustainable future for Australia. We are making a positive environmental impact by manufacturing and supplying products that reduce our customer's carbon footprint.

Traditional drainage products are made from unsustainable virgin materials. **Megaflo® Green** is the only Australian made recycled alternative made from 100% recycled HDPE – with no compromise on product quality or performance. **Megaflo® Green** is more environmentally sound than any other drainage product in Australia, has a lower carbon footprint and helps reduce greenhouse gas emissions and reliance on fossil fuels.

## INNOVATION & DEVELOPMENT

Geofabrics' Centre for Geosynthetic Research, Innovation & Development (GRID) is a specialist R&D laboratory that works with clients to develop the right geosynthetic solution for their complex problems.

*Please speak to your local representative to understand how Geofabrics can assist you with your specific or bespoke drainage needs.*

## AUSTRALIAN MADE

**Megaflo® Green** is 100% Australian made with locally sourced recycled polymer. Many of the products we supply are manufactured in our two manufacturing plants in Albury (New South Wales) and Ormeau (Queensland).

We employ more than 100 manufacturing staff, and we support over 1,000 Australian suppliers, many located in regional Australia.

By choosing Geofabrics, you are not only supporting the local economy and reducing your product delivery lead time; you can rest assured that the product you receive meets project specifications - ensuring that performance and life-cycle costs are optimised.



Geofabrics is a proud member of the Infrastructure Sustainability Council of Australia (ISCA).

**Megaflo® Green** is now available on the ISupply directory. Find out how using **Megaflo® Green** on your next project can assist you in achieving IS credits.

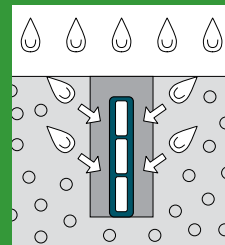
## SUPERIOR DRAINAGE

**Megaflo® Green** panel drain provides the dimensional stability and field-proven structural strength for quick, effective subsurface drainage. **Megaflo® Green** consists of a perforated HDPE core wrapped with **bidim® Green** nonwoven geotextile to prevent soil ingress into the drainage system.

Performance is the distinguishing feature of the panel drain due to its ability to collect and remove water rapidly. Compared to 100mm diameter round pipe, **Megaflo® Green** has **twice the inflow capacity** for an equivalent length and will drain water in less than **60% of the response time**. Its slim 40mm wide profile permits faster and more cost-effective installation in a narrower trench. The design of the **Megaflo® Green** panel drain permits significantly higher flow velocity at the lower head.

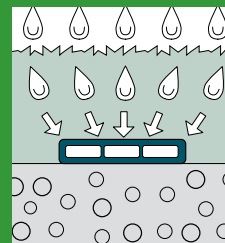
**Megaflo® Green Ultra** is a heavier grade offering greater crush resistance for extreme high fill, high load applications without compromising any of its proven flow.

## PERFORMANCE



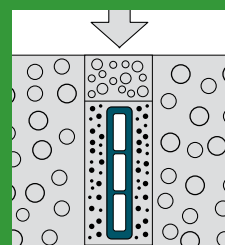
### DRAINAGE

Removal of excess water from a structure whether it be a road, retaining wall or rail is key to long term performance of the structure. **Megaflo® Green** is a unique composite drainage system with an unsurpassed infiltration rate and rigid flow path which ensures effective drainage under the most challenging conditions.



### RAPID RESPONSE TIME

A rapid removal of excess water is a key consideration in roads where excess water can result in significant damage to the pavement surface. The long flat shape of **Megaflo® Green** incorporates a high open area for the inflow of water - allowing rapid response time well over conventional drainage systems.



### STRENGTH

Vertical installation of the **Megaflo® Green** panel utilises a ribbed structure to provide higher strength under traffic loads.

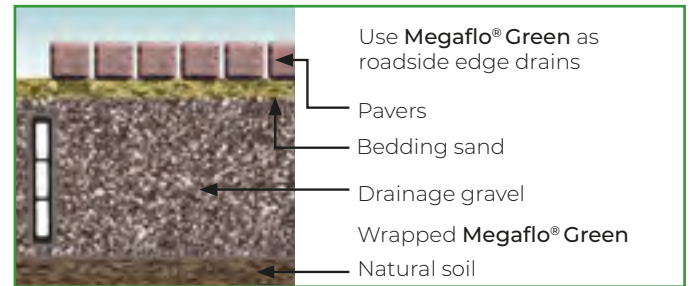
The properties of high compressive modulus, longitudinal stiffness and structural rigidity aids the mechanical performance of **Megaflo® Green**, ensuring the long term hydraulic flow capacity of the drain. High structural strength allows for a minimum cover depth of 100mm recommended in most applications.

**Megaflo® Green** typically requires less backfill in comparison to a traditional trench which results in cost savings and faster installation.

## APPLICATIONS

### ROADSIDE EDGE DRAINS

**Megaflo® Green** provides a faster and higher inflow capacity due to its high trench installation profile and earlier interception of pavement infiltration. **Megaflo® Green** has a high compressive modulus and structural rigidity (preventing deflection under normal service loads), due to its elongated ribbed profile incorporating internal support.



### RAIL

**Megaflo® Green** is manufactured as a corrugated panel supported by internal pillars along the length of the drain. This shape gives a high crush resistance whether the drainage system is used vertically or horizontally.

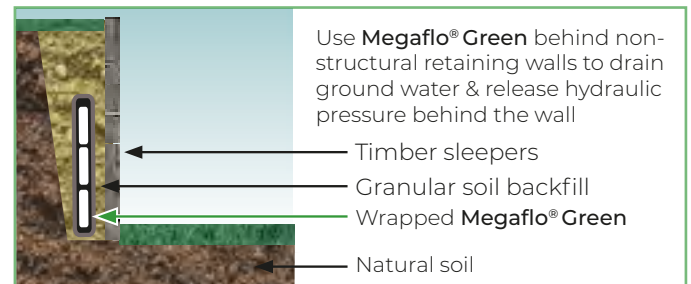
Bearing capacity of foundation material below ballast is affected by excess moisture unless adequate subsurface drainage is in place. **Megaflo® Green** has a profile that offers higher resistance to deformation and loss in discharge capacity required for use under rail track.



### RETAINING WALLS

**Megaflo® Green** provides reliable drainage in specialist construction applications such as retaining walls, shotcrete walls and tunnels.

**Megaflo® Green** drainage system can be utilised vertically or horizontally to remove excess water, preventing the build up of water pressures induced on the structure.



### MINING

**Megaflo® Green** is ideally suited for use as collector drains in mining applications. Its high compressive modulus and structural rigidity prevent deflection and the loss of flow capacity under high load or localised settlement.



### LANDFILL

The high compressive strength of **Megaflo® Green** under normal and inclined loads makes it the ideal product for a range of landfill drainage applications.

## ADVANTAGES



### COST EFFECTIVE

The narrow trench width requirement, coupled with easy and rapid installation of **Megaflo® Green** drastically reduces costs on your project, compared to traditional draining systems.

Furthermore, with a high vertical crush strength, **Megaflo® Green** can be installed closer to the surface, reducing excavation costs.



### ENHANCED PERFORMANCE

The increased height and rapid response times associated with **Megaflo® Green** ensures the system outperforms traditional drainage options. The flat pipe construction prevents intrusion of the cover geotextile allowing flow rates to be maintained despite soil confinement pressure.



### ENVIRONMENTALLY SUSTAINABLE

**Megaflo® Green** is manufactured from recycled HDPE, minimising the carbon footprint of the project.

## MEGAFLO® GREEN DIMENSIONS

PRODUCT DESCRIPTION	HEIGHT	ROLL LENGTH
Megaflo® Green 170	170mm	50m or 100m
Megaflo® Green 300	315mm	50m or 100m
Megaflo® Green 450	450mm	50m or 100m
Megaflo® Green 900	900mm	50m

## FITTINGS

A full range of fittings are available to compliment **Megaflo® Green**. The fitting will assist you in:

- Connecting **Megaflo® Green** to round pipe in roads, basement walls, shotcrete and retaining wall applications.
- Finish lengths of **Megaflo® Green** with end caps.
- Pin the **Megaflo® Green** to the surface, for stability in windy conditions.

Please use the QR code to view the full range of standard and non-standard **Megaflo® Green** fittings.

## OUTLET FITTINGS



JOINER  
COUPLING (CO)



SIDE  
OUTLET (SO)



RIGHT  
OUTLET (RO)



END  
CAP (EC)



END  
OUTLET (EO)



150mm  
U-PINS

# GEOFABRICS®

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Megaflo® Green panel drains are manufactured in a facility certified to ISO9001, Certificate No. FS673633.



Proud member of the Infrastructure Sustainability Council of Australia (ISCA). Our products directly contribute to IS credits in infrastructure and civil engineering projects.



# Appendix D

## Additional Information – Aqua Gate

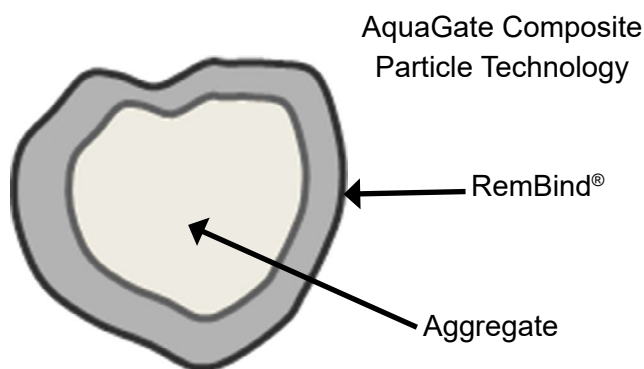
## PFAS Surface and Groundwater Remediation

AquaGate+RemBind is a composite particle consisting of an aggregate core coated with the reactive commercial adsorbent RemBind.

This unique product facilitates the uniform delivery of powdered RemBind, for the *in-situ* passive removal of Per- and Polyfluoroalkyl Substances (PFAS) in groundwater or surface drainage systems.

The AquaGate+RemBind product design combines two proven world-class technologies:

- RemBind is a powdered adsorbent that permanently binds up long- and short-chain PFASs in soil and water. It has been independently validated by government and industry and used commercially worldwide over the past decade.
- AquaBlok (USA) has spent the last decade demonstrating the effectiveness of using powder coated aggregates to treat organic contaminants using permeable reactive barriers (PRBs).



## Benefits

- Cost effective - passive process
- Uniform placement of reactive powders
- Easy to apply with conventional equipment
- Can be manufactured at site
- Combines proven technologies



Leachate control from stockpiles

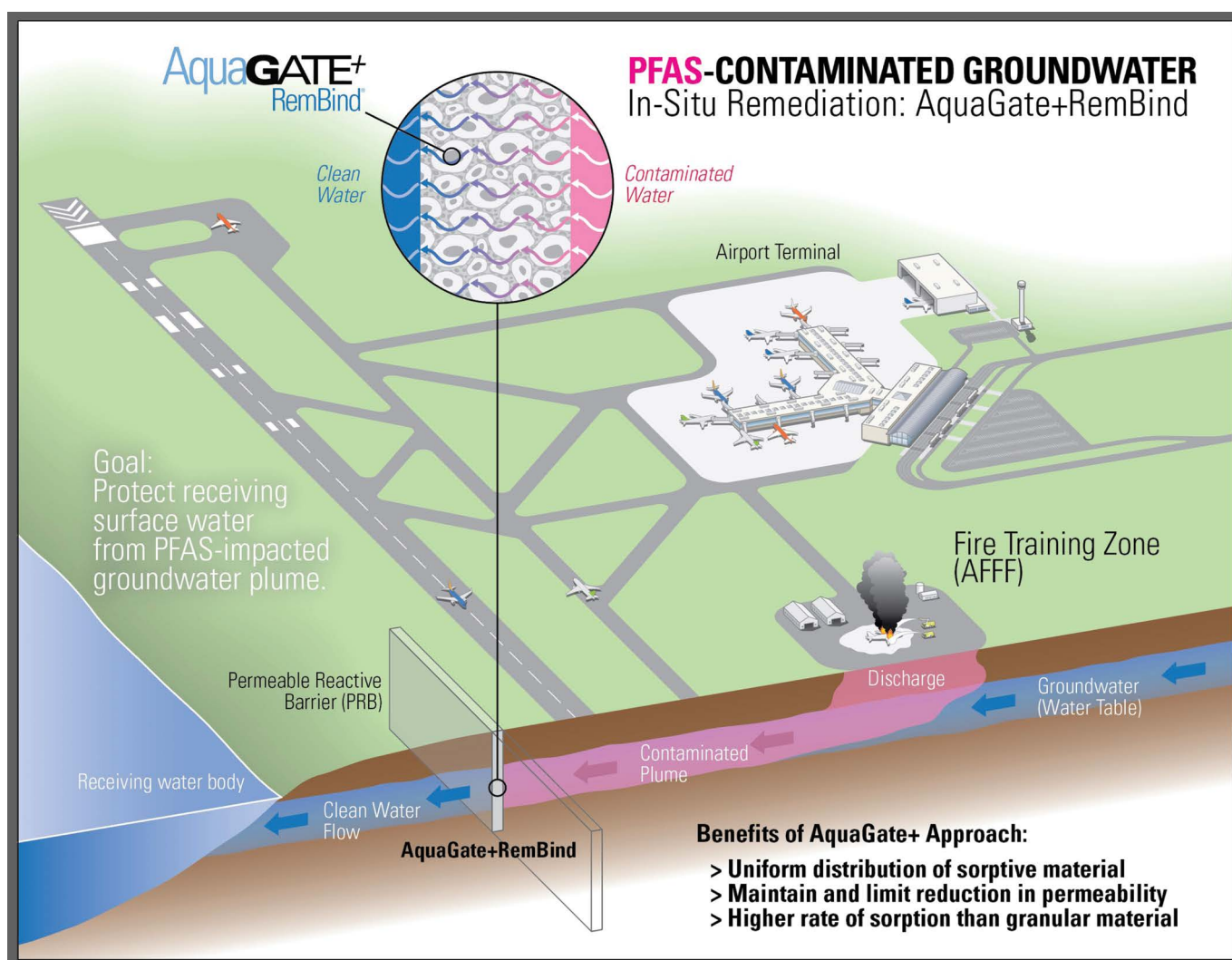
## PFAS Surface and Groundwater Remediation

### Field Applications

#### Groundwater Remediation (Permeable Reactive Barriers)

PFAS compounds are highly soluble in water and are transported rapidly through surface run-off, infiltrating groundwater and impacting surface water and sediments (i.e. in a basin, detention pond, lake or river).

Currently groundwater contaminated with PFAS, the most common approach is to remove the water via a pump-and-treat system and discharge the clean water to a nearby sewer or surface water body. Although it's generally agreed that this approach is expensive and an unsustainable solution, few *in-situ* approaches have been developed or proven. However, AquaBlok's AquaGate approach now offers the ability to utilize RemBind adsorptive materials in a Permeable Reactive Barrier (PRB) configuration to prevent migration of a PFAS groundwater plume.



PFAS compounds are highly soluble in water and are transported rapidly through surface run-off, infiltrating groundwater and impacting surface water.



## PFAS Surface and Groundwater Remediation

### Field Applications

#### Sediment Remediation

At present, the focus on PFAS remediation is on groundwater and drinking water. However, as contaminated groundwater migrates to surface water bodies, such as rivers and lakes, aquatic biota and fish are impacted, as well. There is increasing evidence that these sensitive ecological receptors are impacting the food chain.

To address PFAS accumulations in sediments, AquaGate+RemBind can be applied to limit the impact of PFAS on sensitive biological receptors. In the past the same approach using AquaGate+PAC (powdered activated carbon) and AquaGate+Organoclay have been successful in addressing contamination in sediments.



Sediment Remediation

#### Surface Water Remediation

At most airports and Defence sites, surface water is managed using an above-ground drain system. To minimize the amount of PFAS contamination leaving site in these drains, above ground PRBs containing AquaGate+RemBind can be installed. Testing and design work for this type of system commenced in Australia in 2018.

#### Soil Stockpile Leachate Management

Stockpiles of PFAS contaminated soil often require a liner to be installed to manage leachate runoff. For temporary stockpiles, a layer of AquaGate+RemBind can be used as a liner as a practical, simple method for leachate containment. When the stockpile is moved, the product can be sacrificed with the soil.

#### Emergency Spill Response

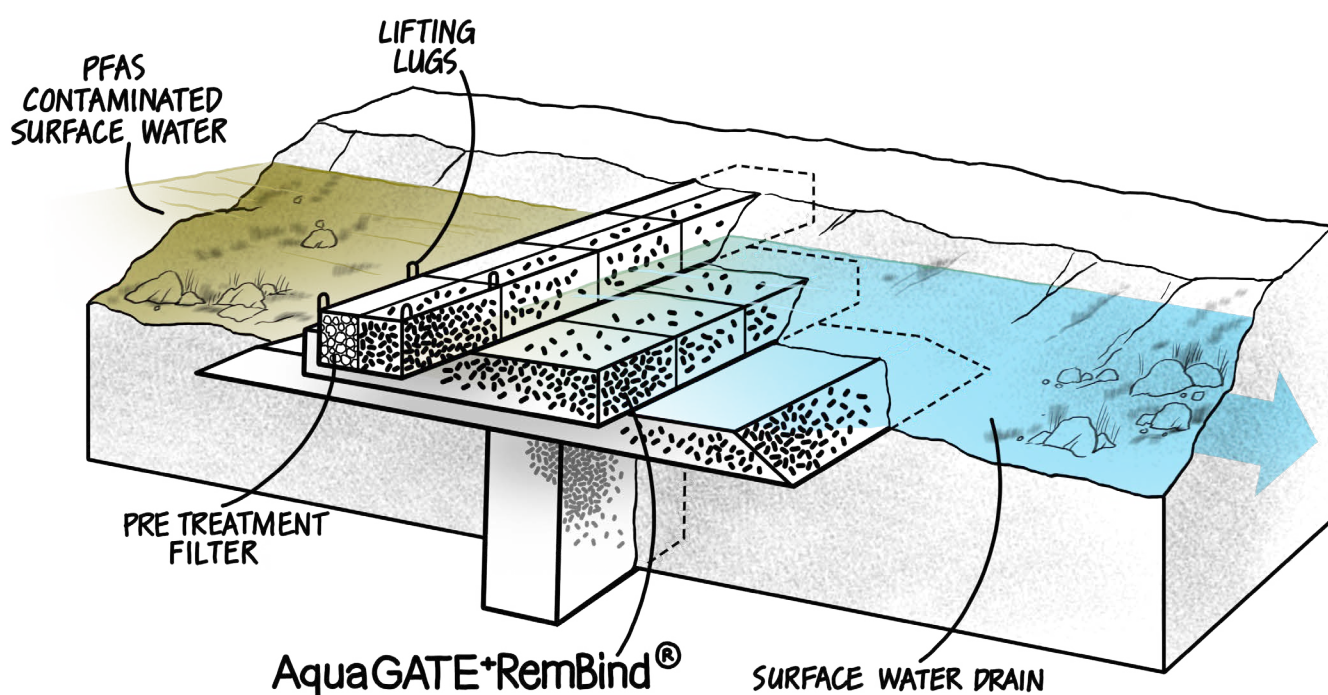
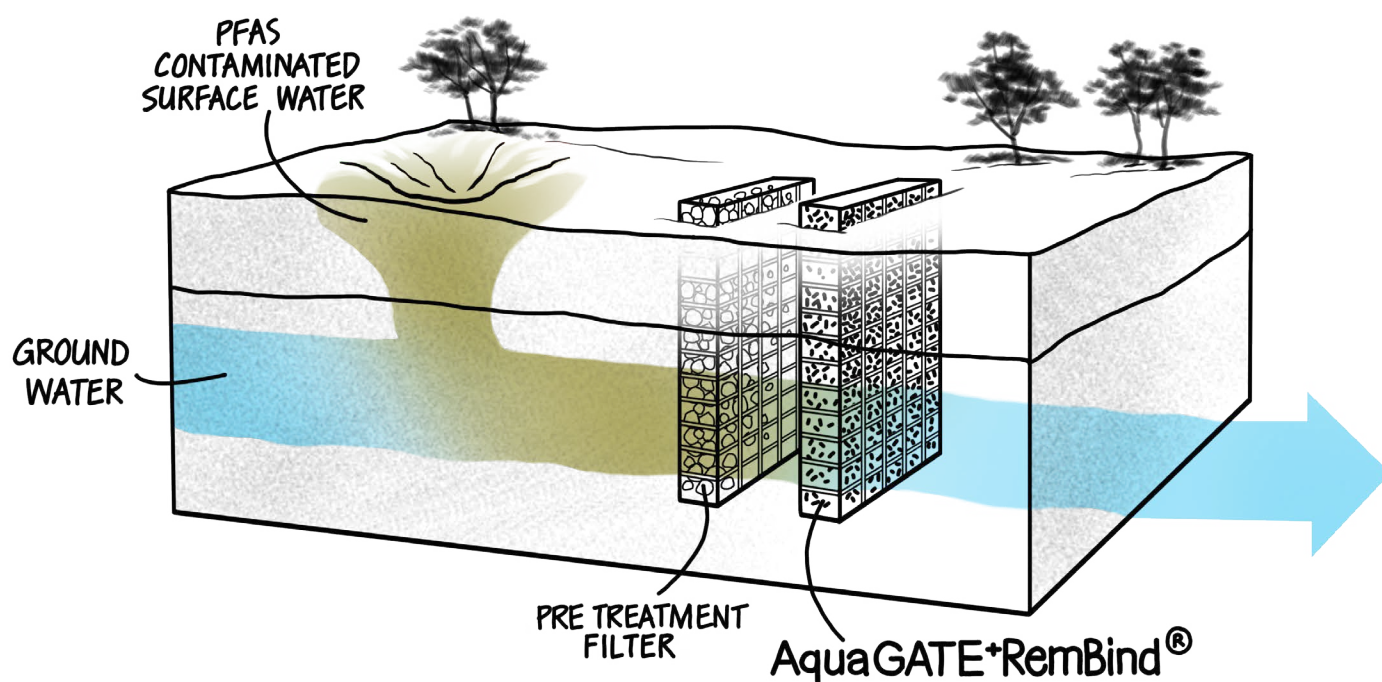
AquaGate+RemBind can be used to mitigate runoff during emergency flood or spill response involving PFAS contaminated water or liquids.



Groundwater Remediation  
(Permeable Reactive Barrier)

## PFAS Surface and Groundwater Remediation

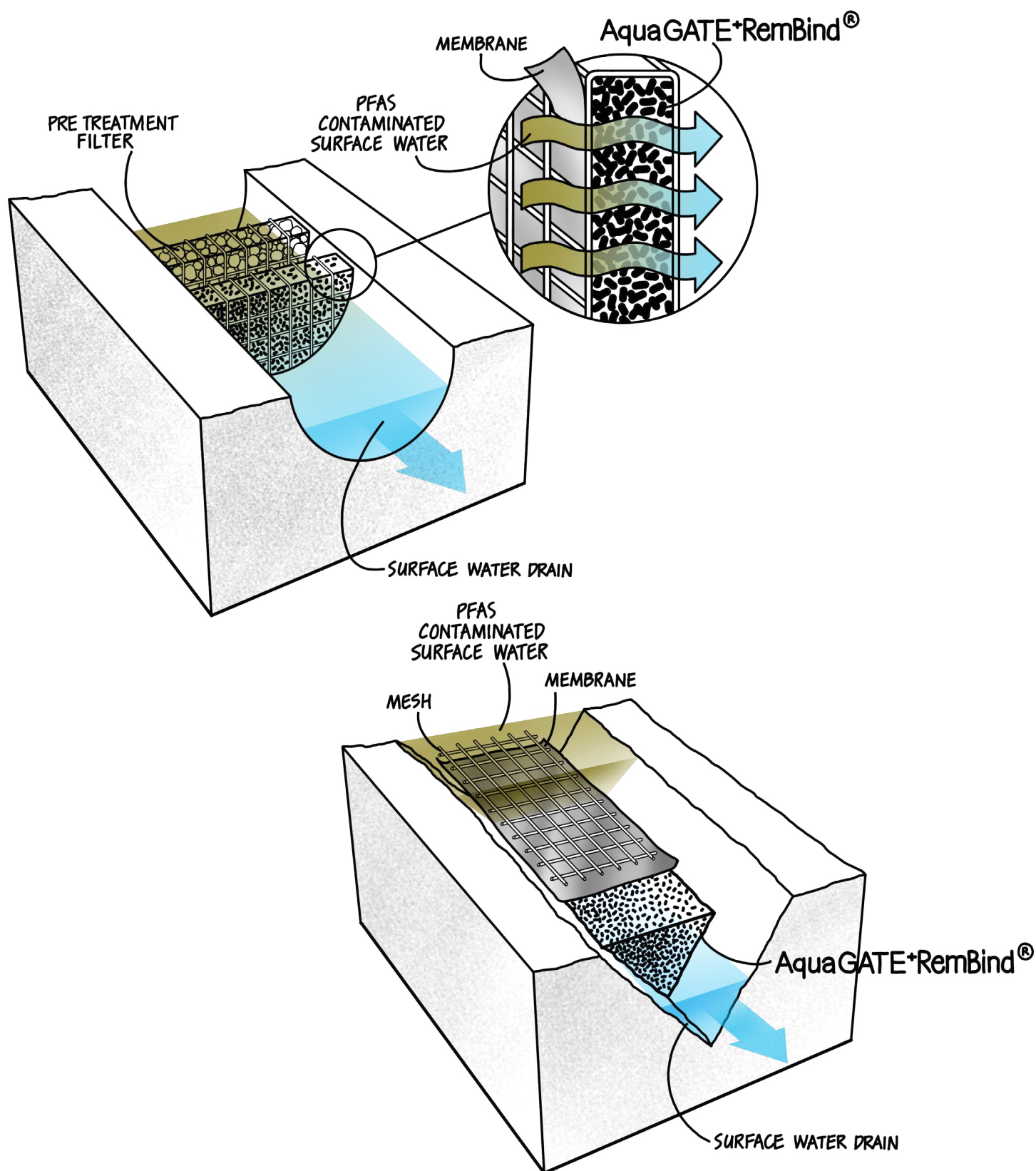
### Site Conceptual Designs





## PFAS Surface and Groundwater Remediation

### Site Conceptual Designs




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**TEST REPORT**

CLIENT:	ZILTEK PTY LTD	FILE No:	890/19
ADDRESS:	2 ANN NELSON DRIVE, THEBARTON, SA 5031	REQUEST No:	83185
PROJECT:	Testing of AquaGate+RemBind for Permeability	DATE RECEIVED:	11.3.19
MATERIAL:	AquaGate+RemBind	DATE TESTED:	14.3.19 to 18.3.19

Test Method AS1289.6.7.1	Results	
Determination of the permeability of a soil - Constant head method for a remoulded specimen.	Field/Client Sample No. 1	
	Laboratory Sample No. 217674	
Compaction method	Sample compacted into permeability mould in 3 equal layers by tapping the side of the mould for each layer	
Permeability mould diameter (mm)	151	
Permeability mould cross sectional area (mm <sup>2</sup> )	17979	
Average height of compacted specimen (mm)	96	
Wet density (t/m <sup>3</sup> )	Before test	After test
Dry density (t/m <sup>3</sup> )	1.446	1.653
Moisture content as per AS1289.2.1.1 (%)	1.297	1.297
Dry density ratio (%)	11.5	27.5
Moisture content ratio (%)	-	-
Surcharge used in test (KPa)	-	-
Percentage of material retained on 19.0mm sieve	3.0	-
Degree of saturation (%)	-	-
Hydraulic gradient	1.2	-
Average Coefficient of permeability (m/sec)	3.8 x 10 <sup>-04</sup>	

Note : Sample provided by client.

SONYA CARR, FILE.

**Document prepared by**

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