Sydney WATER

Appendix N Soils and Contamination Impact Assessment

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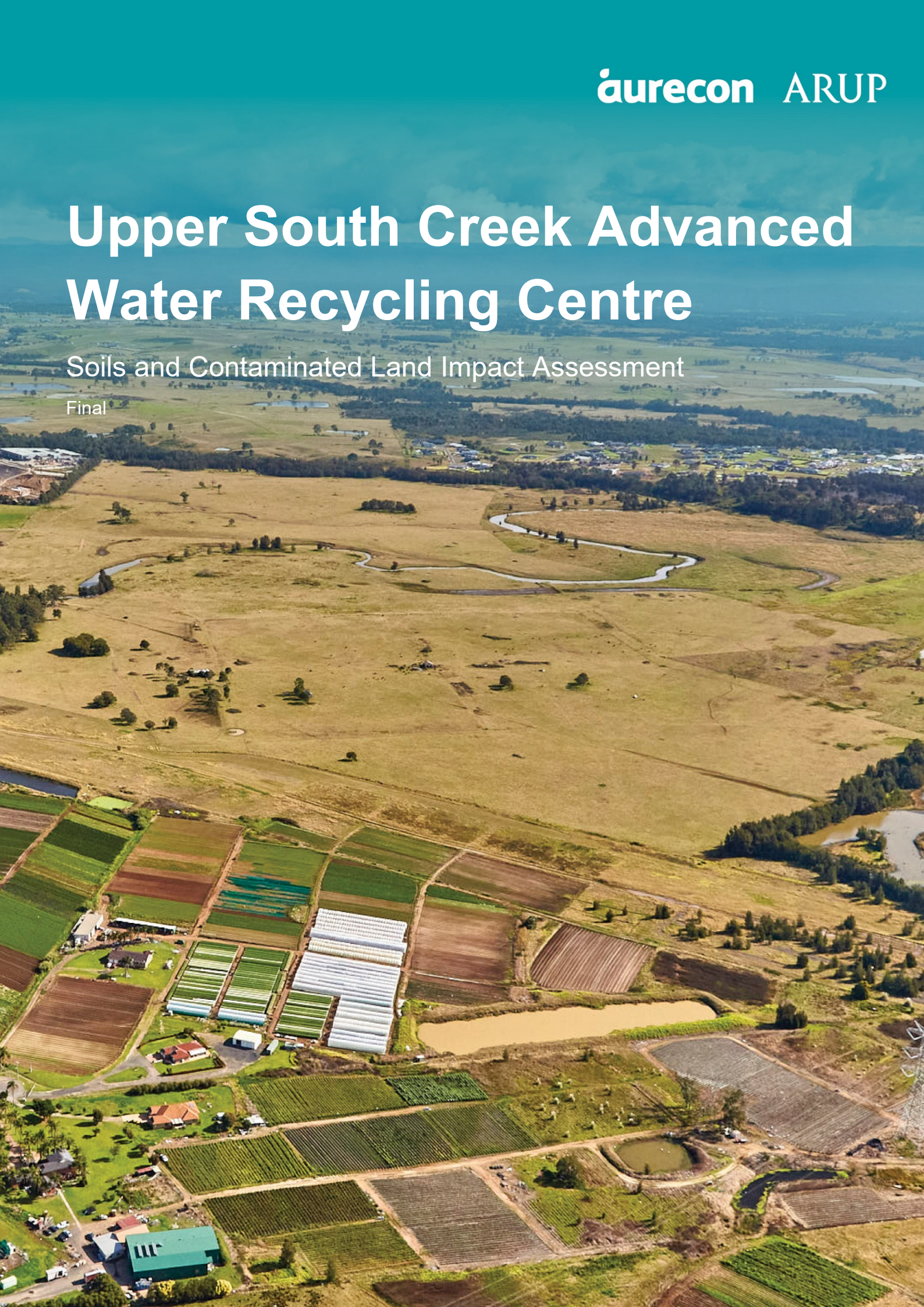
Upper South Creek Advanced Water Recycling Centre

Soils and Contaminated Land Impact Assessment

Final



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Executive Summary

This Soils and Contaminated Land Impact Assessment has been developed to support the Environmental Impact Statement (EIS) for the Upper South Creek Advanced Water Recycling Centre (AWRC) along with the associated treated water pipelines and ancillary infrastructure (collectively referred to as 'the project').

The AWRC would be located in the Kemps Creek precinct of the Western Sydney Aerotropolis, NSW, with pipelines traversing Western Sydney from the Nepean River in the west to Cabramatta in the east.

This report provides a review of the existing soil and contamination conditions along with the potential project impacts during the construction and operation phases. It also provides recommended mitigation measures to minimise any identified residual impacts.

The key areas related to the soils and contamination impacts covered in this report are:

- Potential impacts on existing contamination and soil landscapes and conditions
- Potential changes to salinity and erosion potential for soils
- Changes in soil types, physical parameters and associated soil water interactions for the AWRC site
- Potential for the mobilisation, disturbance or distribution of contaminants already present in soils
- Potential impacts of asbestos contamination of soils in and around the Core Park Road, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street
- Potential for acid sulfate soils (ASS) occurrence within the project boundary and impacts
- Constraints and mitigation measures associated with the potential impacts

This assessment includes review of desktop information and previous reports, site inspections and intrusive investigations, sampling and analysis which have been collated and summarised. An assessment of potential impacts, residual and cumulative impacts have been assessed and mitigation measures provided.

Pipelines

The treated water and brine pipelines traverse varied soil landscapes and contamination risks associated with the project. The pipelines alignment follow roads, easements and previously developed lands where soils have either been previously disturbed or have limited environmental value with impacts limited to shallow soils, weathered rock and rock. It is anticipated that the pipelines would be constructed using trenching and under boring methods depending on the location. The contamination risks are generally low to moderate and would be managed during construction. Excavated impacted soils and fill (where considered suitable) could be reused beneficially as engineering fill on the AWRC site or other regional projects to minimise waste generation. Beneficial reuse opportunities for soils would be undertaken within the resource recovery framework in NSW including current approved exemptions and orders. Existing contamination risks and soil quality are not considered to be a significant constraint to the pipeline's alignments construction and operation.

AWRC site

Previous investigations have identified limited and incidental contamination risks associated with the site. These are related to hazardous building materials present in current buildings and areas where former buildings and structures were present across the site. Existing contamination is not a significant constraint to the AWRC site for construction or operation. Construction earthworks, erosion hazards, salinity (slightly to moderately saline soils), importation of engineering fill can be used to manage existing contamination risks by civil engineering design and environmental management. Civil design would incorporate earthworks balances and controls on soils and hydrology to minimise salt movement and exposure of sodic soils, potential for erosion and sedimentation of drainage lines and receiving water bodies.

Construction and operation of the AWRC and pipelines has the potential to impact soils and contamination in the following key ways:

- Removal of topsoils, subsoils, and changes in infiltration where earthworks remove natural soil cover
- Disturbance of ASS near Prospect Creek which is the only area of the project with ASS risk
- Disturbance of contaminated soils during construction via excavations of trenches for pipelines and surface grubbing and deeper excavations
- Mobilisation of contaminants via excavation and disturbance such as leachable contaminants via water and bonded asbestos distribution in soils from earthworks
- Poor demolition of current structures on the AWRC site containing hazardous building materials (HBM), including asbestos containing materials (ACM) and lead paints
- Leaks / spills of chemicals, partially untreated sewage or brine release into soil and groundwater during operation
- Long-term reduction of groundwater levels (drawdown), impacting soils, from operation of pumped underdrainage systems employed and the increase of impervious surfaces created at the AWRC
- Soil erosion, leading to the release of sediment-laden stormwater into receiving waterways
- Increased soil erosion where clayey sodic subsoils are excavated and reused on the surface or exposed in situ for extended periods of time
- Increases in salinity concentrations in soils where the hydrological regimes are changed within the AWRC site and shallow saline groundwater is brought to the surface or mobilises in deep drainage
- Reuse of saline soils excavated near drainage lines and low-lying areas along the pipelines and AWRC and reused as engineering fill increasing salinity release risk to surface waters and groundwater
- Reuse of extracted ground water that has moderate to high salinity and used for dust suppression for the project, impacting surface soils via increased salinity and drainage

The following mitigation measures are recommended for the project. These recommendations are applicable to the detailed design and pre-construction phases of the project life cycle:

- As part of the detailed design phase of the project, a supplementary Detailed Site Investigation (DSI) should be undertaken across the project areas to analyse for the contaminants of potential concern (COPC) and areas of environmental concern (AECs) identified in this assessment. Soil samples should be collected for laboratory analysis to inform contamination and waste characterisation. The sampling density should be in accordance with the ASC NEPM 2013 sampling densities for stockpiled material and guidelines made or endorsed by the NSW Environment Protection Authority (EPA). The analytical results should be compared to the concentrations in the ASC NEPM 2013 for human health and ecological assessment and NSW EPA *Waste Classification Guidelines Parts 1 to 4.* If natural soil is disturbed, it may meet the definition of Virgin Excavated Natural Material (VENM) or Excavated Natural Material (ENM) and the analytical data should be compared to the concentrations and requirements in the *ENM Resource Recovery Order and Exemption* under the Protection of Environmental Operations (Waste) Act 2000

- A Construction and Environmental Management Plan (CEMP) should be prepared prior to construction commencing. The risk of potentially impacted soil migrating from the project area during construction, including dust generation and runoff can be minimised by utilising standard practices such as soil and water management, contamination management, dust suppression, erosion and sedimentation control, salinity management, spill prevention and control, and soil and water monitoring plans. Other controls should include proper use of work health and safety (WH&S) equipment and monitoring of works where asbestos or other contamination is identified under an asbestos management plan (AMP) for the project or specific locations where asbestos has been identified as an impact in this report
- If soils between 2 and 4 m are disturbed (principally within the Prospect Creek area), acid sulfate soils management should be included in the CEMP. Soil samples from near the creek crossing should be collected to inform the necessity and scope of the management required. The assessment should be undertaken in accordance with the NSW ASSMAC Manuel (1998)
- A destructive hazardous materials survey and remedial protocol for clearing or certifying the project impact area is free of asbestos prior to commencing construction activities for the project, this is particularly relevant to buildings and former structures and ground surfaces in the AWRC site

Overall, with the implementation of the proposed mitigation measures, the project is expected to have a low impact on soils and contamination risks. With the implementation of the prescribed mitigation and management measures, construction management plans, recommended intrusive investigations and compliance monitoring the project would have a low impact on soils and contamination.

Glossary and Abbreviations

Term	Abbreviation	Definition
Acid sulfate soil	ASS	Soils that contain appreciable sulfide and may general sulfuric acid where exposed to atmospheric oxygen and rainfall.
Advanced Water Recycling Facility	AWRC	Construction of the AWRC is subject to environmental approval and has been identified as critical infrastructure.
Asbestos containing materials	ACM	Materials that contain asbestos.
Alluvial Soils	-	Soils developed from recently deposited alluvium, normally characterise little or no modification of the deposited material by soil forming processes, particularly with respect to soil horizon development.
Temporary ancillary facilities		These are temporary facilities to support construction including: • access roads • construction compounds • laydown areas • site offices and amenities • parking
Ancillary infrastructure	-	This is permanent infrastructure to support operation of the AWRC and may include a range of infrastructure such as access roads and provision of utilities such as power.
Areas of environmental concern	AECs	-
Australian Height Datum	AHD	A common reference level used in Australia which is approximately equivalent to the height above sea level in meters.
Australian Soil Classification	ASC	Australia's national soil classification, a multi-category scheme with classes defined by diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed soil profile.
Brine pipeline	-	A pipeline to transport brine (salty/concentrated wastewater). Brine water is a by-product of reverse osmosis in the wastewater treatment process.
Chemicals of Potential Concern	COPC	-
Contamination	-	Contamination of land, means the presence in, on or under the land of a substance at a concentration above the concentration at which the substance is normally present in, on or under (respectively) land in the same locality, being a presence that presents a risk of harm to human health or any other aspect of the environment.

Term	Abbreviation	Definition
Construction Environmental Management Plan	CEMP	A CEMP describes how activities undertaken during the construction phase of development will be managed to avoid or mitigate environmental or nuisance impacts, and how those environmental management requirements will be implemented.
Clay	-	Fine-grained material with particles <0.002 mm diameter; composed normally of hydrated aluminium silicate minerals and plastic when moist. Forms a smooth plastic bolus; slight to firm resistance to shearing between thumb and forefinger; handles like plasticine; will form ribbon of 50–75 mm or more; approximate clay content 35 – 50% or more.
Colluvial	-	Describes soil and rock material transported largely by gravity
Colluvium	-	Heterogeneous rock and soil detritus transported by non-fluvial downslope processes, e.g., mass movement, sheet flow.
Contaminated Land Management Act 1997	CLM Act	-
Desktop assessment area	-	The area defined for footprint-related specialist desktop assessments.
Department of Planning, Industry and Environment	DPIE	NSW Government department developing well-connected communities, preserving our environment, supporting our industries and contributing to a strong economy.
Detailed Site Investigation	DSI	-
Early works	-	Before construction commences, we may need to optimise and finalise alignments, and to confirm design and constructability, such as survey works, condition surveys, or investigating utilities.
Ecological investigation limits	EIL	-
Ecological screening levels	ESL	-
Electrical conductivity	EC	Soil electrical conductivity (EC) is a measure of the amount of salts in soil.
Electrical Conductivity of a saturated soil extract	ECe	The Electrical Conductivity of a saturated soil extract.
Exchangeable sodium percentage (soil test)	ESP	Soil exchangeable sodium percentage test performed by a laboratory.
Environmental Impact Statement	EIS	An Environmental Impact Statement is a publicly available document that provides information on a project, including its environmental impacts and mitigation measures, and is used to inform development consent decisions

Term	Abbreviation	Definition
Environmental flows	-	Environmental flows refers to water released from a dam or weir to sustain healthy rivers. Some of our wastewater treatment and water recycling facilities also release treated wastewater into creeks and rivers. This can help improve conditions for native fish, frogs, birds, plants and other animals. It can also reduce the likelihood of algal blooms and enhance recreational uses. Environmental Flows from the Advanced Water Recycling Centre may be used supplement or replace flows that would have been released from Warragamba Dam Environmental flows are very highly treated water as defined in this glossary.
Environment Protection Authority	EPA	The NSW Environment Protection Authority is the primary environmental regulator for New South Wales.
Environment protection licence	EPL	Environment protection licence
Erosion and Sediment Control Plan	ESCP	-
Excavated Natural Material	ENM	-
Hazardous building materials	HBM	Materials such as asbestos, lead based paints and synthetic mineral fibres present in building materials.
Hazardous materials	HAZMAT	-
Horizontal Directional Drilling	HDD	Horizontal directional drilling is a minimal impact trenchless method of installing underground utilities such as pipes in a relatively shallow arc or radius along a prescribed underground path using a surface-launched drilling rig.
Hydrogeological Landscapes	HGL	-
Impact assessment area	-	The area within which project impacts may occur. This will be larger than the actual impact area to give some flexibility in construction impacts. This may be refined as the infrastructure reference design progresses.
Impact area	-	This refers to the actual area impacted by construction and operation. Generally, this is agreed to be 25 m along pipeline alignments. The impacted area is still in development and will be finalised after the reference design is more advanced and desktop assessments and impact assessments are completed.
Megalitres per day	ML	Megalitres per day
Megalitres per year	ML/year	Megalitres per year
Metre	m	Metre

Term	Abbreviation	Definition
Millimetre	mm	Millimetre
New South Wales	NSW	The state of New South Wales
Office of Environment and Heritage	OEH	Office of Environment and Heritage (now known as the Department of Premier and Cabinet (Heritage))
Square metres	m^2	Square metres
Metres below ground surface	mbgs	-
Per- and poly- fluoroalkyl substances	PFAS	-
Preliminary Site Investigation	PSI	-
Project	-	The construction and operation of the Upper South Creek Advance Water Recycling Centre (AWRC), pipelines and all ancillary infrastructure. Construction of the AWRC is subject to environmental approval and has been identified as critical infrastructure. There are many stages and we are at the very early planning. Detailed construction staging will be established by the detailed design contractor. Noting that the timelines aren't finalised, it's expected that construction will start in mid-2022.
Protection of the Environment Operations Act 1997 (NSW)	POEO Act	-
Remedial action plan	RAP	-
Reverse Osmosis (highly treated water)	-	A process where a solution is forced (under pressure) through a semi-permeable membrane separating pure water from dissolved salts.
Roads and Maritime Services	RMS	Roads and Maritime Services (now Transport for New South Wales)
Secretary's Environmental Assessment Requirements	SEARs	These are issued by the Secretary of the NSW Department of Planning, Industry and Environment for projects declared by the Minister of Planning as Critical State Significant Infrastructure. These SEARS provide the technical requirements for the impact assessment of each potential key issue, including the desired performance outcome, requirement and current guidelines.
State environmental planning policy	SEPP	State environmental planning policy
Saline discharge (soil related)	-	Underground saline water which flows or seeps out at the soil surface. Salinity can be concentrated by subsequent evaporation.
Saline soil	-	A soil which contains sufficient soluble salts to adversely affect plant growth and/or land use. Generally, a level of electrical conductivity of a saturation extract >4 mS/cm is regarded as the defining characteristics of a saline soil.

Term	Abbreviation	Definition
Salinity	-	The concentration of soluble salts in water and soil assessed by measurement of electrical conductivity. Excessive salt is toxic to most plants. Saline surface soils are usually bare or have sparse plant cover.
Sand	-	Material within the particle size range of 0.02 – 2.0 mm which can be very fine to very coarse.
Silt	-	Material within the particle size range of 0.002 – 0.02 mm.
Sodic soils	-	Sodic soils have an Exchangeable Sodium Percentage (ESP) >6%. They have low stability when wet, and they set hard when dry, reducing permeability and available water capacity and forming surface crusts that restrict plant establishment and growth. Their degree of dispersion depends on several other factors such as salinity, pH, clay content, mineralogy and organic matter. Not all sodic soils are dispersible, nor are all dispersible soils sodic.
Sodicity	-	A measure of exchangeable sodium in the soil. High levels adversely affect soil stability, plant growth and/or land use.
Soil	-	A natural body consisting of layers or horizons of mineral and/or organic constituents, of variable thickness, that differs from its parent material in morphological, physical, chemical and mineralogical properties and biological characteristics.
State Significant Infrastructure	SSI	State significant infrastructure projects are high priority infrastructure projects that are essential to the State for economic, social or environmental reasons.
Study area	-	General location or region where work may be undertaken.
Sydney Water	-	Sydney Water's vision is to create a better life with world-class water services. We own and operate the wastewater network for Sydney, the Illawarra and the Blue Mountains, servicing over five million customers. We're responsible for 26,169 km of wastewater pipes. Customers own about another 20,000 km of wastewater pipes – on private properties. Most of the wastewater in the network flows by gravity along natural catchment drainage lines to a Water Recycling Centre.
South West Growth Area	SWGA	Growth area precincts within the south western areas of Sydney metropolitan area.
Transport for New South Wales	TfNSW	Transport for New South Wales

Term	Abbreviation	Definition
Treated Water	-	What wastewater becomes after it has been treated. We treat wastewater so clean water can be safely returned to the environment or re-used. We filter the water and disinfect it with chlorine or ultraviolet light (UV). This kills any remaining microorganisms. Treated water is used when it is not necessary to specifically define the level of treatment. Refer to definitions of very high quality treated water and high quality treated water when level of treatment needs to be specified.
Very high quality treated water	-	This is water that has been through the reverse osmosis process where a solution is forced (under pressure) through a semi-permeable membrane separating pure water from dissolved salts.
Treated water pipeline	-	The pipeline that will take the treated water to the environment, whether that is creek, river or ocean. The pipelines will transport water from the centre to release into the Nepean river, Warragamba river, South Creek and to the Malabar system. These pipelines will range in size from about 0.6 m to 1.5 m in diameter and will generally consist of Steel, Glass Reinforced Plastic (GRP) and Polyethylene pipe materials.
Unexploded Ordnance	UXO	-
Upper South Creek	USC	The catchment in which the AWRC will be located. South Creek releases to the Nepean River which flows directly into the Hawkesbury River and then releases out to the Pacific Ocean
Upper South Creek Advanced Water Recycling Centre	-	The centre when complete will be a sophisticated wastewater treatment and resource recovery centre that will produce recycled water, renewable energy and bio-resources. Initially the centre will treat wastewater and produce water suitable for a range of uses including recycling, environmental flows or for a range of industrial/commercial or agricultural uses. The centre will also produce renewable energy and by-products suitable for future land applications.
Virgin Excavated Natural Material	VENM	-
Wastewater	-	The used water that drains down sinks, toilets and drains into the sewerage system. About 99% of this is water.
Water sensitive urban design	WSUD	-
Western Sydney Aerotropolis Growth Area	WSAGA	Growth area precincts around the Western Sydney Airport.
Western Sydney Airport	WSA	-

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1 Introduction

1.1 Background

This Soils and Contaminated Land Impact Assessment has been developed to support the Environmental Impact Statement (EIS) for the Upper South Creek Advanced Water Recycling Centre (AWRC) along with its treated water pipelines and ancillary infrastructure (collectively referred to as 'the project'). The AWRC will be located in the Kemps Creek precinct of the Western Sydney Aerotropolis, NSW, with pipelines traversing Western Sydney from the Nepean River in the west to Cabramatta in the east (Figure 1-1).

This report provides a review of the existing soil and contamination conditions along with the potential project impacts during the construction and operation phases. It also provides recommended mitigation measures to minimise any identified residual impacts.

The project is declared State Significant Infrastructure (SSI) and the Secretary of the Department of Planning, Industry and Environment (DPIE) has issued project specific Secretary's Environmental Assessment Requirements (SEARs). This report addresses both the standard and project specific SEARs relating to land (see Section 1.5).

To support minimising or eliminating potential adverse impacts on the receiving environment caused by the project, this report incorporates proposed mitigation measures including recommendations for the development of specific construction and operational measures in an environmental management plan.

1.2 Project Overview

Sydney Water proposes to build and operate new wastewater infrastructure to service the South West and Western Sydney Aerotropolis Growth Areas. The proposed development would include a wastewater treatment plant in Western Sydney, known as the Upper South Creek Advanced Water Recycling Centre. Together, this Water Recycling Centre and the associated treated water and brine pipelines, will be known as the 'project'. An overview of the location of the proposed infrastructure is provided in Figure 1-1. Further details of each component of the project are provided below.

1.2.1 Advanced Water Recycling Centre

- A wastewater treatment plant with the capacity to treat up to 50 ML of wastewater per day, with ultimate capacity of up to 100 ML per day
- The Advanced Water Recycling Centre will produce:
  - high-quality treated water suitable for a range of uses including recycling and environmental flows
  - renewable energy, including through the capturing of heat for cogeneration
  - biosolids suitable for beneficial reuse
  - brine, as a by-product of reverse osmosis treatment

1.2.2 Treated water pipelines

- A pipeline about 17 km long from the Advanced Water Recycling Centre to the Nepean River at Wallacia Weir, for the release of treated water
- Infrastructure from the Advanced Water Recycling Centre to South Creek to release excess treated water and wet weather flows
- A pipeline about five km long from the main treated water pipeline at Wallacia to a location between the Warragamba Dam and Warragamba Weir, to release high-quality treated water to the Warragamba River as environmental flows

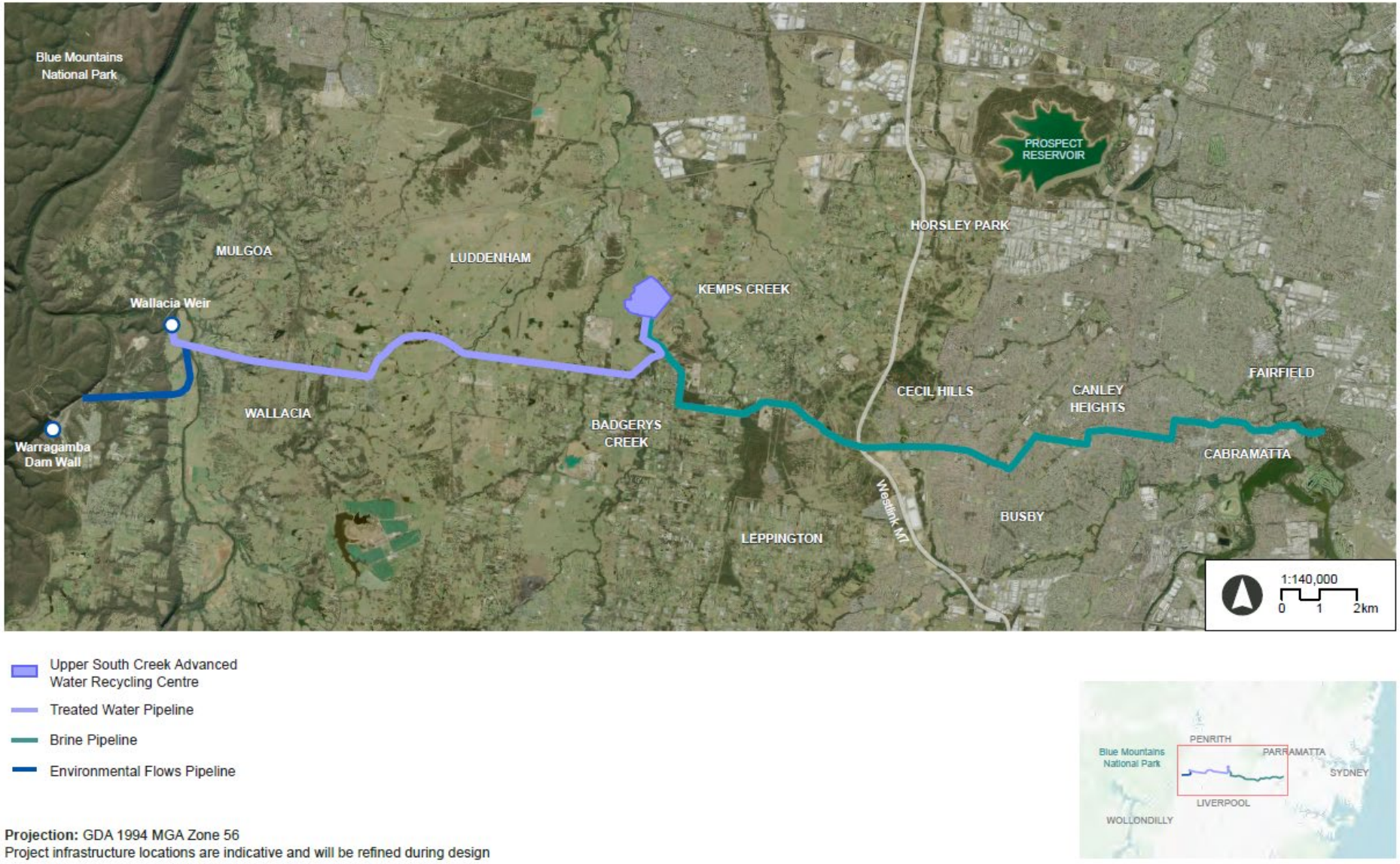
1.2.3 Brine pipeline

- A pipeline about 24 km long that transfers brine from the Advanced Water Recycling Centre to Lansdowne, in south-west Sydney, where it connects to Sydney Water's existing Malabar wastewater network

Sydney Water is planning to deliver the project in stages, with Stage 1 comprising:

- Building and operating the Advanced Water Recycling Centre to treat an average dry weather flow (ADWF) of up to 50 ML per day
- Building all pipelines to their ultimate capacity, but only operating them to transport and release volumes produced by the Stage 1 Advanced Water Recycling Centre

The timing and scale of future stages will be phased to respond to drivers including population growth rate and the most efficient way for Sydney Water to optimise its wastewater systems.



Projection: GDA 1994 MGA Zone 56
Project infrastructure locations are indicative and will be refined during design

Figure 1-1 USC AWRC Project Overview

1.3 Study objectives

The objective of the EIS – Soils and Contaminated Land Impact Assessment is to assess and address potential soil and contamination impacts associated with the construction and operational phase of the project. It also aims to provide guidance on ways of managing the potential sources of soil and contamination impacts to avoid any environmental degradation.

1.4 Assessment areas

The desktop assessment area covers the AWRC site as well as an assessment area either side of the pipeline alignments (treated water pipeline, brine pipeline and upstream environmental flows pipeline). The treated water pipeline and brine pipeline route lengths are both approximately 20 km, the upstream environmental flows pipeline route is an additional 4 km.

The impact area covers the AWRC site via construction. For the pipelines, the impact area covers a 50 m wide centre along the pipeline alignments (treated water pipeline, brine pipeline and environmental flows pipeline). The 50 m buffer area has been included to allow for uncertainty within the current pipeline alignment and changes that may need to occur during detailed design.

1.5 SEARs

The project is SSI and the Secretary of the DPIE has issued project specific SEARs. These SEARS provide the technical requirements for the impact assessment of each potential key issue, including the desired performance outcome, requirement and current guidelines.

The assessment has been prepared to fulfil the requirements included in the SEARs, which are outlined in Table 1-1 below.

Table 1-1 Key land related SEARs and associated scope of works

SEARS matter to be addressed by study	Location SEARs addressed in report
26. An assessment of the impacts of the project on soils and land capability of the site and surrounds, including:	
a) verifying the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within, and in the area likely to be impacted by, the project.	Section 4.12 Section 8
b) assessing the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines.	Section 9.6 Section 10.1 Table 11-1 and Table 11-2
c) assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	Section 5 Section 8 Section 9.2 Section 10.2 Table 11-1 and Table 11-2 Table 13-1 and Table 13-2 Section 14

SEARS matter to be addressed by study	Location SEARs addressed in report
d) assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	Section 4.11 Section 9.4 Table 11-1 and Table 11-2
e) assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Section 4.11 Section 9.4 Table 11-1 and Table 11-2
f) assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	Section 4.6.1 Section 4.9 Section 10.1 Table 11-1 and Table 11-2
g) assess the potential for asbestos contamination around the Core Park area, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street, and long-term monitoring requirements and potential for remediation works.	Section 8.1 Section 10.2 Table 11-1 and Table 11-2 Table 13-1 and Table 13-2 Section 14 Appendix D Figures

2 Legislation and Policy Context

2.1 Legislation, policy and guidelines

The following sections summarises the current legislative requirements and guidelines relevant to soil and contamination considerations for the project. Table 2-1 outlines the legislation and policy context with regard to soils and contamination, including guidance documents.

Table 2-1 Legislation, policy and guidelines

Legislation/Policy/Guidelines	Brief description and intent	How legislation/policy/guideline is relevant to the study
Contaminated Land Management Act 1997 (NSW) (CLM Act).	The general object of this Act is to establish a process for investigating and (where appropriate) remediating land that the Environment Protection Authority (EPA) considers to be contaminated significantly enough to require regulation. Several clauses within the act relate to responsibility for contaminated land (clause 6) and duty to report contamination (clause 60) to the EPA. These clauses will be adhered to when construction and operation of the project is undertaken.	Development of the project may disturb contaminated land where remedial actions are necessary as part of the project construction. The Act provides a process for investigation and remediation land to be in accordance with the intent of the Act.
Protection of the Environment Operations Act 1997 (NSW) (POEO Act).	The POEO Act is the key piece of environment protection legislation administered by the EPA. The objects of this Act include to protect, restore and enhance the quality of the environment in New South Wales (NSW), having regard to the need to maintain ecologically sustainable development. The following are key clauses, parts and chapters relevant to the construction and operation of the project: • Chapter 3 – Environmental Protection Licenses for construction and operation of the project. • Part 5.7 – Duty to notify of pollution incidents for construction and operation of the project.	Development of the project will produce spoil and waste as part of construction. A construction Environmental Protection License (EPL) will be required for the management and mitigation of pollution and releases.

Legislation/Policy/Guidelines	Brief description and intent	How legislation/policy/guideline is relevant to the study
Environmentally Hazardous Chemicals Act 1985 (NSW) (EHC Act).	The EPA may declare substances to be chemical wastes for the purposes of the Act. Examples of substances that have been declared include dioxin contaminated waste materials and PCB (polychlorinated biphenyl) wastes. The EPA may make chemical control orders with respect to assessed chemicals or declared chemical wastes. These CCOs may regulate activities such as the manufacture, processing, conveying, buying, selling or disposal of the chemical or declared waste.	Development of the project may disturb hazardous chemicals where remedial actions are necessary as part of the project construction.
Protection of the Environment Operations (General) Regulation 2009).	The Protection of the Environment Operations (General) Regulation 2009 provides for the administration of EPLs and establishes the method of calculating licence fees, including load-based licence fees, and environmental protection notice fees.	As the project will require a construction EPL Under Chapter 3 of the POEO Act 1997, the Regulation provides administrative requirements for the application, fees and general requirements for the works.
Protection of the Environment Operations (Waste) Regulation 2014.	The Waste Regulation allows the EPA to protect human health and the environment and provides a platform for a modern and fair waste industry. It includes strict thresholds for EPLs and outlines the waste levy system. Clause 93 imposes the requirements for resource recovery orders and exemptions in NSW.	The project will generate virgin soils and contaminated soils as a waste via excavation, therefore, the methodology and management of wastes must be in accordance with the Regulation. Resource recovery exemptions and orders are issued under clause 93 and are relevant for spoil reuse for the project.

Legislation/Policy/Guidelines	Brief description and intent	How legislation/policy/guideline is relevant to the study
Dangerous Goods (Road and Rail Transport) Act 2008	The EPA regulates the transport of dangerous goods in NSW. Dangerous goods are substances and objects that pose acute risks to people, property and the environment due to their chemical or physical characteristics. When transporting dangerous goods, training is required as well as a licence for both the driver and the vehicle.	Movement and transport of contaminated soils and spoil from project construction will occur. Transport of dangerous goods must be in accordance with the Act.
WHS Regulation 2017 (NSW).	The WHS Regulation 2017 (NSW) provides a framework to protect the health, safety and welfare of all workers and others in relation to NSW workplaces and work activities. Regulations set out specific requirements for particular hazards and risks, such as noise, machinery, and manual handling.	The project will include management of soils and contamination as part of the works. Protection of health and safety through safety in design via engineering concept design and management of contamination risks must be considered for recommended mitigation and remedial actions.
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020	The aims of this policy is to facilitate development in the Western Sydney Aerotropolis in accordance with the objectives and principles of the Western Sydney Aerotropolis Plan. This includes to protect, maintain and enhance, and to minimise the impact of development on, trees and vegetation, soil quality and the health of waterways and to contribute to the conservation of biodiversity.	The SEPP is relevant in regard to the development and planning approaches to ensure soil quality is retained and salinisation is not exacerbated due to development. Develop needs to consider the objectives and development controls associated with the SEPP and wider precinct planning.

Legislation/Policy/Guidelines	Brief description and intent	How legislation/policy/guideline is relevant to the study
Western Sydney Aerotropolis Development Control Plan (DCP) Phase 1 2020	This DCP provides controls which guide development to achieve connectivity, liveability, productivity, and sustainability by protecting and enhancing the green and blue assets of the area and encouraging ecologically sustainable development and reducing the impacts of development on the environment.	The DCP Phase 1 provides performance outcomes in section 4.7, 4.8 and 4.9 for soil and contaminated land aspects.
Guidance documents relevant to contaminated land: NSW EPA, 2020. *Sampling Design Guidelines for Contaminated Land.* NSW EPA, 2007. *Guidelines for the Assessment and Management of Groundwater Contamination.* NSW EPA, 2020. *Guidelines for Consultants Reporting on Contaminated Land.* NSW EPA, 2012. *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases.* NSW EPA, 2014. *Waste Classification Guidelines – Part 1 to Part 4.* NSW EPA, 2015. *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997.* NSW EPA, 2017. *Guidelines for the NSW Site Auditor Scheme (Third Edition).* *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013).* Other guidelines made or approved under section 105 of the Contaminated Land Management Act 1997	Provide guidance and methodology for the assessment of land contamination hazards and reporting and remedial requirements.	The project will disturb contaminated soils and other media such as groundwater as part of earthworks primarily. Assessment and interpretation of contamination and severity is required to assess potential for environmental impact and mitigation measures. Guidance documents provide the technical framework for assessment of impacts.

Legislation/Policy/Guidelines	Brief description and intent	How legislation/policy/guideline is relevant to the study
Guidance documents relevant to acid sulfate soils (ASS): Acid Sulfate Soils Management Advisory Committee, 1998. *Acid Sulfate Soils Manual.* Acid Sulfate Soils Management Advisory Committee, 1998. *Acid Sulfate Soils Assessment Guidelines.* Queensland Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland. 2004. *Acid Sulfate Soils Laboratory Methods Guidelines.*	Provide guidance and methodology for the assessment of ASS and interpretation of soil analytical results.	The project has the potential to disturb ASS in low lying areas of the landscape where ASS may occur. Assessment and interpretation of ASS conditions and presence is required to assess potential for environmental impact and mitigation measures. Guidance documents provide the technical framework for assessment of impacts.
Guidance documents relevant to soils and salinity: DECC, 2008. *Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) and Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries).* DECCW, 2010. *Guidelines for developments adjoining land and water managed by the Department of Environment, Climate Change and Water.* NSW OEH, 2012. *The land and soil capability assessment scheme: Second approximation.* CSIRO, 2008. *Guidelines for Surveying Soil and Land Resources*. CSIRO, 2009. *Australian Soil and Land Survey Handbook.* DLWC, 2002. *Soil and Landscape Issues in Environmental Impact Assessment*. DLWC, 2002. *Site investigations for Urban Salinity*.	Provide guidance and methodology for the assessment of erosion and salinity hazards (primarily) and interpretation of soil analytical results.	The project will disturb soils with high erosion and salinity risk. Assessment and interpretation of soil conditions and severity is required to assess potential for environmental impact and mitigation measures. Guidance documents provide the technical framework for assessment of impacts.

Legislation/Policy/Guidelines	Brief description and intent	How legislation/policy/guideline is relevant to the study
Australian Geomechanics Society, 2007. *Landslide risk management guidelines* presented in Australian Geomechanics Society.		
Guidance documents relevant to water quality: Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia (ANZG), 2018. *Guidelines for Fresh and Marine Water Quality: Water Quality Management Framework*	The Water Quality Guidelines provide guidance on the management of water quality for natural and semi-natural water resources in Australia and New Zealand.	To be considered at the interplay of the soil / water interface, given the absence of site-specific guideline values, the ANZG's give directions to default guideline values for a range of stressors relevant to different community values, such as aquatic ecosystems, human health and primary industries. There relevance is associated primarily with the association of release of saline or contaminated waters from the project to receiving systems such as creeks and rivers.

3 Assessment Methodology

3.1 Assessment Overview

The following tasks were carried out as part of this soil and contamination assessment:

- A desktop review of existing information, aerial photography and previous ground investigation reports to assess the current environmental conditions of the desktop assessment area, soil types, land capability and establish the sources of potential contamination historically as well as during the construction and operational phase of the project
- A site walkover and inspection of sections of the impact assessment area to confirm the findings of the background desktop assessment and assess the impact assessment area for potential signs and sources of land contamination. The inspection to include observation and recording of the desktop assessment area terrain, surface condition, topography, vegetative cover, drainage pathways, contaminated land risk areas and surrounding land uses. The site walkover informed the DSI and additional soil testing requirements
- Review of relevant legislation, policy and guidelines to address SEARs and agency requirements
- Assessment of soil laboratory results from the associated Detailed Site Investigation (DSI) analysing Chemicals of Potential Concern (COPC) and the development of a Conceptual Site Model (CSM) that evaluates the source -> pathway -> receptor linkages (SPR) and any implications and/or potential risks during the infrastructure upgrades and the ongoing industrial uses of the locations
- Assessment of landscape salinity based on collated soil, surface water and groundwater testing and interpretation of conditions, potential impacts and mitigation measures
- Review of soil erosion potential and assessment of soil types present and sodicity via desktop and intrusive site investigation soil sampling and analysis.
- Review and assessment of existing asbestos related reports, information and management plans in effect for the Core Park area, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street. Outline risks of encountering asbestos, current preventative management and requirements for remediation.
- Construction and operation impact assessment to inform potential construction, operational and cumulative impacts, in conjunction with possible mitigation controls for the project
- Production of this report

3.2 Desktop Assessment

Numerous sources of publicly available information relevant to local and regional subsurface and soil and contamination conditions were assessed and are listed in the references. Data from these information sources were collated and reviewed as part of this report, to inform the following soil and land characteristics for the project:

- Local climatic conditions
- Topography, soil and geology, including erodibility and soil fertility
- Land use
- Hydrology and hydrogeology

- ASS and salinity in the desktop assessment area
- Existing and potential contaminated lands and hazardous materials

In addition, a number of previous investigations and reports containing information on soil conditions have been reviewed in the desktop assessment area. A summary of the previous investigations and reports from which soil and contamination characteristics have been derived is provided in Table 3-1. Relevant data sourced from these reports are summarised in Section 8 and Section 9.

Table 3-1 Sources of Information – Previous Investigations and Reports

Document Title	Author	Date Published
WSAGA Reticulation Amplifications Options Assessment and Detailed Design, Preliminary Site Investigation (Contamination)	AAJV	2019a
WSAGA Reticulation Amplifications Options Assessment and Detailed Design, Contamination Site Investigation Report	AAJV	2019b
WSAGA Reticulation Amplifications Detailed Design – Geotechnical Investigation Report	AAJV	2019c
Site Assessment Report – Farnsworth Avenue, Warragamba NSW	ADE	2017
Asbestos Clearance Inspection Report, Farnsworth Avenue, Warragamba NSW	ADE	2019a
Asbestos Inspection Report – Part Lot 310 DP 210651 and Lot 6 DP 209076, Farnsworth Avenue, Warragamba NSW	ADE	2019b
Clearance Certification	Airsafe	2016a
Clearance Certification	Airsafe	2016b
Upper South Creek Wastewater Treatment Plant Options Assessment – Preliminary Site Investigation (Contamination).	Aurecon Arup	2019a
Resilience Planning: Prospect South to Macarthur Distribution System, Detailed Site Investigation	Aurecon Arup	2019b
Upper South Creek Water Factory Pipeline Alignments Option Concept Design – Preliminary Site Investigation	Aurecon Arup	2020a
Upper South Creek Advanced Water Recycling Centre Reference Design, Geotechnical Desk Study – Advanced Water Recycling Centre	Aurecon Arup	2020b
Upper South Creek Advanced Water Recycling Centre Reference Design, Geotechnical Desk Study - Treated water, Environmental Flows and Brine Pipelines	Aurecon Arup	2020c
Upper South Creek Advanced Water Recycling Centre Reference Design, Geotechnical Interpretive Note – Brine Pipeline	Aurecon Arup	2020d
Upper South Creek Advanced Water Recycling Centre (AWRC) and Pipelines – Detailed Site Investigation	Aurecon Arup	2021
Upper South Creek Advanced Water Recycling Centre (AWRC) – Hazardous Materials Survey Memo	Aurecon Arup	2021a
Detailed Site Inspection, Sampling and Analysis Quality Plan - Eighteenth Street, Core Pare Road and Warragamba STP, Warragamba	CH2M	2017a

Document Title	Author	Date Published
Detailed Site Investigation, Eighteenth Street and Core Park Road, Warragamba	CH2M	2017b
Validation Report, Core Park Road, Warragamba	CH2M	2017c
Limited Site Investigations – Eighteenth Street, Warragamba	CH2M	2017d
Limited Site Investigations – Warragamba Eighteenth Street Viewing Platform and Roadway	CH2M	2017e
Remedial Strategy – Warragamba Viewing Platform and Surrounding Land	CH2M	2017f
Contaminated Land Management Plan– Warragamba Viewing Platform and Surrounding Land	CH2M	2018a
Validation Report, Warragamba Dam Viewing Platform and Eighteenth St	CH2M	2018b
Suggested Site Inspection Checklist – Warragamba Viewing Platform and Eighteenth Street	CH2M	2018c
Suggested Site Inspection Checklist – Warragamba Viewing Platform and Eighteenth Street	CH2M	2019
Heritage Assessment Historic Period Resources, University of Sydney Western Sydney Lands Badgerys Creek Farm Centre, Elizabeth Drive, Badgerys Creek	CRM	2019
Western Sydney Airport Environmental Impact Statement – Appendix L3: Groundwater assessment	GHD	2015
Assessment of Asbestos Contamination Surrounding Warragamba Dam Viewing Platform, Eighteenth Street, Warragamba	Hibbs	2017a
Qualitative Risk Assessment – Asbestos Cement Debris, Warragamba Dam Viewing Platform	Hibbs	2017b
Asbestos Management Plan (Soil Impacts) – Warragamba Dam Viewing Platform	Hibbs	2017c
Risk Assessment and Removal Plan, Warragamba Dam, Eighteenth St, Warragamba NSW 2752	Integrated Environmental	2016
The Northern Road Upgrade, Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park Environmental Impact Statement – Appendix L: Soils, water and contamination assessment	Jacobs	2017
University of Sydney Preliminary Site Investigation, Badgerys Creek, NSW	JBS&G	2018
Warragamba Dam Viewing Platform, Eighteenth Street, Warragamba, NSW	NSW EPA	2018
Combined Phase 1 & 2 ESA, Warragamba STP, Warragamba NSW 2752	Parsons Brinckerhoff	2018
Environmental Impact Statement – Geology, Soils and Water: Proposal for a Second Sydney Airport at Badgerys Creek or Holsworthy Military Area	PPK	1999
M12 Motorway Environmental Impact Statement – Appendix O Soils and contamination assessment report	RMS	2019
Asbestos Clearance Inspection, Viewing Platform, Eighteenth Street, Warragamba NSW 2752	Safe Environments	2017

Document Title	Author	Date Published
Sydney Metro – Western Sydney Airport, Scoping Report	Sydney Metro	2020
Asbestos Remediation Clearance Certificate	WSP	2015
Stage 1 Preliminary Site Investigation and Sampling, Analysis and Quality Plan, Sydney Water Warragamba Dam Viewing Platform, Warragamba NSW	WSP	2016
Detailed Site Investigation, Sydney Water Warragamba Dam Viewing Platform, Warragamba NSW	WSP	2017
Badgerys Creek Development – Elizabeth Drive Geotechnical Investigation	PSM	2018

3.3 Site Inspection

A walkover of the AWRC site was conducted on the 20th of April 2020. The visit focused on visual inspection of the site including the condition and geomorphology of South Creek and Kemps Creek, topography, soil and flood plain.

Site inspections of the impact assessment areas were conducted for the Preliminary Site Investigation (PSI) for the AWRC and pipelines (Aurecon Arup, 2019a; Aurecon Arup, 2020a). Additional site inspections were conducted for intrusive investigations at a later date. Section 5 and Section 8 summarise the relevant information in the PSI report and additional site inspections. The purpose of the site inspections was to observe and record soil and potential contamination conditions to inform the intrusive investigations being planned and undertaken.

A hazardous materials survey of existing structures and ground surfaces was undertaken in July 2020 to identify hazardous building materials at the AWRC site. This survey was observational, no analysis of samples was undertaken.

3.4 Intrusive Soil Investigations

Contamination Assessment

Soil and contamination investigations were undertaken to inform the assessment of potential impacts and mitigation measures for the project and inform the contamination conceptual site model (CSM). The data is used to assess soil conditions and potential contamination within the project and is compared to guidance documents and criteria within as outlined in Table 2-1.

The PP undertook a DSI for the AWRC and pipelines routes (Aurecon Arup, 2021). Across the pipeline alignments, a total of 405 samples were collected, with 326 scheduled for analysis of a suite of contaminants of potential concern (COPC). At the AWRC site, 259 samples were collected with 214 samples scheduled for the same analytical suite. Investigation locations consisted of a combination of geotechnical test pits and boreholes, and environmental test pits and boreholes. Investigation locations are presented in **Appendix D**.

The samples were tested for the following COPCs:

- Benzene, toluene, ethyl benzene, xylene and naphthalene (BTEXN)
- Total recoverable hydrocarbons (TRHs)
- Polycyclic aromatic hydrocarbons (PAHs)

- Phenolic compounds
- Heavy Metals (arsenic, cadmium, chromium, copper, lead, nickel, mercury and zinc)
- Organochlorine pesticides (OCPs) and organophosphate pesticides (OPPs)
- Polychlorinated biphenyl (PCBs)
- Asbestos containing materials (ACM)
- Per- and poly- fluoroalkyl substances (PFAS)

The samples were screened against the following proposed project land use commercial and industrial investigation levels (ASC NEPM 2013):

- ASC NEPM 2013 Health-based Investigation Levels (HIL) (D)
- ASC NEPM 2013 Health Screening Levels (HSL) (D)
- FSANZ 2017 HBGV D Soil
- NEPM 2013 Health Screening Levels (HSL) (D) for asbestos
- NSW EPA Waste Classification Guidelines – Part 1: Classifying Waste

The findings of the DSI are summarised in Section 9.1.

Soil Quality Assessment

Additionally, laboratory testing for soil salinity parameters, exchangeable sodium percentage (ESP) and ASS was also undertaken to inform soil quality and chemistry. These results are used to determine how saline soils are and their propensity for erosion and chemical changes to occur based on the project construction and operation. Guidelines used to assess soil quality are as outlined in Table 2-1. A summary of results is presented in Sections 9.4, 9.5 and 9.6.

3.5 Conceptual Site Model (Contamination)

This impact assessment is based on establishing a broad Conceptual Site Model (CSM) for the project and provides qualitative and quantitative information on the potential risks to human health and the environment. The CSM analysis 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). When there are linkages between the sources pathways and receptors then there may be potential risks that require management or remediation. The extent of necessary management or remediation are based on investigations in the areas of environmental concern (AECs) to establish contaminates of potential concern (COPC) if present. The investigation and remediation or management of elevated COPC concentrations present an impact assessment consideration for the project.

The evaluation of risk in the CSM is 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, residential gardening may occur, and people spend more time at home. This is opposed to an industrial setting which would likely have extensive hard stand, limited occupancy times, security and exclusion and other occupational health and safety controls to manage risks to employees.

The impact assessment compares collected intrusive investigation and desktop data to established Tier I screening values that are established in the National Environmental Protection Measure 1999, as amended in 2013. 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. Environmental design can also be used at the concept engineering design stage to minimise both short term (construction) and longer term (operational) impacts.

It is necessary to evaluate if the identified project contamination AECs 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.

During project construction, disturbance of soil will be required for the project and importation of soil for engineering fill. Any soil removed during construction and/or operation will require assessment for beneficial reuse within the project or management and/or disposal in accordance with the *NSW Waste Management Guidelines 2014 Parts 1-4* and any applicable *Resource Recovery Orders and Exemptions* (RRO/RREs) under the *Protection of Environment Operations Act 1997* (POEO Act).

3.5.1 Risk Ratings for Contamination

The risk assessment rating matrix used to determine contamination risk is defined in this section. Qualitative risk is assessed by estimating the likelihood of each identified potential Source-Pathway-Receptor linkage occurring and the foreseeable consequence of the exposure. Consequences are broadly defined by the definitions outlined below:

Classification	Human Health	Ground/Surface water	Ecological	Built Environment
Severe	Irreversible damage to human health or death	Substantial pollution of sensitive water resources	Significant change to the number of one or more species or ecosystems.	Irreparable damage to buildings, structures or the environment.
Moderate	Non-permanent effects to humans	Substantial pollution of non-sensitive water resources or small-scale pollution	Change to population densities of non-sensitive species.	Damage to sensitive buildings, structures or the environment.
Mild	Slight short tern health effects to humans	Slight pollution to non-sensitive water resources	Some changes to population densities but with no negative effects on the function of the ecosystem	Easily repairable effects of damage to buildings or structures.
Negligible	No measurable health effects to humans	Insubstantial pollution to non-sensitive water resources	No significant changes to population densities in the environment or in any ecosystem	Very slight non-structural damage or cosmetic harm to buildings or structures.

Likelihood ratings are defined as:

- **Rare** – Has not occurred in the past 5 years OR may occur in exceptional circumstances, i.e. less than 10% chance of occurring in the next 24 months if the risk is not mitigated.
- **Unlikely** – May have occurred once in the last 5 years OR has a 10-30% chance of occurring in the future if the risk is not mitigated.
- **Possible** – Has happened during the past 5 years but not in every year OR has a 40-60% chance of occurring in the next 24 months if the risk is not mitigated.
- **Likely** – Has happened at least once in the past year and in each of the previous 5 years OR has a 60-90% chance of occurring in the next 24 months if the risk is not mitigated.
- **Almost Certain** – Has happened several times in the past year and in each of the previous 5 years OR has a > 90% chance of occurring in the next 24 months if the risk is not mitigated

After consideration of likelihood and consequence, the overall risk ratings are assessed in accordance with.

	Likelihood				
Consequence	**Rare**	**Unlikely**	**Possible**	**Likely**	**Almost Certain**
Severe	Low	Low to Moderate	Moderate to High	Very High	Very High
Moderate	Negligible to Low	Low	Moderate	Moderate to High	High
Mild	Negligible	Low	Low	Low to Moderate	Moderate
Negligible	Negligible	Negligible	Negligible to Low	Low	Low

Risk ratings are defined as:

- **Negligible** – The presence of the identified source does not give rise to the potential to cause significant harm.
- **Low** – It is possible that harm could arise to a designated receptor from an identified source though this is likely to be mild.
- **Moderate** – It is possible that harm could arise to a specific receptor, but it is unlikely that such harm would be significant.
- **High** – A designated receptor is likely to experience significant harm from an identified source without remedial action.
- **Very high** – There is a high probability that severe harm could arise.

3.6 Impact Assessment

The impact assessment for construction and operation of the project incorporated quantitative and qualitative methods to assess the potential impacts pre- and post-mitigation attributable to the activities and the physical changes proposed by the project.

Proposed activities associated with the project development, construction and operation have been reviewed to identify those activities with the potential to lead to a disturbance or a change in soils and contamination conditions. These activities are indicated in Section 6.1 for the construction phase and Section 6.2 for the operational phase of the project.

Pipelines

The pipeline infrastructure will primarily be at surface and below ground and therefore potential impacts to soil quality and contamination associated with the pipelines are expected, predominantly associated with the construction phase where stripping, grubbing and earthworks would be required. Potential soil and contamination impacts associated with the construction of the trenched pipeline sections and ancillary works have been quantitatively assessed using desktop and intrusive site investigation data (further detailed in Section 11). Where intrusive site data could not be collected, qualitative assessment of impacts has been undertaken for example for areas of the project with significant information already available such as Core Park area, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street for the environmental flows pipeline.

AWRC Site

Significant above ground changes are expected to occur during the construction phase of the AWRC site, these changes will mostly remain in place during the operational phase as well. Given these expected changes a more detailed intrusive investigation for soil quality and contamination was undertaken to provide for quantitative impact assessment.

Potential soil and contamination impacts associated with the construction of the trenched pipeline sections and ancillary works have been quantitatively assessed using desktop and intrusive site investigation data (further detailed in Section 11).

3.6.1 Impact Significance

The significance of any potential project impact on the local landscape, soils and contamination has been determined by considering the sensitivity of the environment related to the assessed criteria as well as the magnitude of the expected change. The CSM risk rating referred to in section 3.5.1 applies to the impact significance for contamination related assessment. The resultant matrix of significance is shown in Table 3-2.

Table 3-2 Matrix of significance

Magnitude of Impact	Sensitivity of Environmental Values		
	High	Moderate	Low
High	Major	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Negligible

The *Sensitivity of Environmental Values* evaluation is influenced by the following criteria:

- Condition of the environmental value, i.e. how far is it understood to have already been changed from its original natural form or state?
- How unique or rare is the condition or value or it's dependant ecological receptors?
- How sensitive are the dependant receptors to changes?

- Does the project exacerbate contamination risks to human health from potential existing contamination present?
- How do the site investigation intrusive results compare against the identified soil quality and contamination criteria?
- Does the project interact with soil and contamination that has a detrimental environmental outcome?

The *Magnitude of Impact* evaluation is influence by the following criteria:

- If a qualitative assessment has been conducted, how do the results compare to the pre-development conditions?
- How do the results compare against the identified soil quality and contamination criteria?
- For quantitative assessments the following is considered
  - Expected duration of impact: Temporary vs. long-lasting/permanent
  - Expected extent of impact: Local vs. regional/widespread
  - Estimated degree of change from pre-development conditions

4 Existing Environment

This section outlines the existing environment associated with the project inclusive of soils and contamination related information. The desktop assessment area is outlined in the figures presented that used a two km buffer from the AWRC and pipeline alignments and considers the more immediate impact area as discussed in Section 1.4. The existing environment information and previous investigations undertaken, informs the impact assessment and CSM for soils and contamination outlined in Section 3.5 and 10.

4.1 Climate

The Department of Environment and Science provides an enhanced climate database called SILO (Scientific Information for Land Owners) that holds Australian climate data from 1889. The interpolated climate data is stored on a regular 0.05° latitude x 0.05° longitude grid, which is approximately 5 km x 5 km. This database was used to obtained long-term geostatistical determined climate records at 150.75ºE, 33.85ºS near geographical centre of the AWRC for the period 1 January 1900 to 30 April 2020 (119 years). This is considered representative for the entire desktop assessment area for the purposes of this assessment.

Table 4-1 provides annual rainfall and evaporation statistics generated for the site over the 119-year period. The mean annual evaporation (1,456 mm) exceeds annual rainfall (746 mm) by a factor of 2 (Table 4-1). Further details on cycles and climatic conditions for the project are provided in the *Surface Water* and *Groundwater Technical Studies* for the project.

Table 4-1 Annual rainfall and evaporation statistics

Statistic	Annual Rainfall (mm)	Annual Pan Evaporation (mm)	FAO-56 Potential Evapotranspiration (mm)
Mean	746	1,456	1,227
Minimum	314 (year 1944)	1,257 (year 2011)	N/A
Median	725	1,445	N/A
Maximum	1,724.5 (year 1950)	1,881 (year 2019)	N/A

4.2 Topography

Available LiDAR data with 1-m resolution was used to define the physiographic context of the project. The AWRC site is located within a regional alluvial plain associated with the South Creek and Kemps Creek watercourses. The topography in the area is predominately flat, with a gentle slope towards the north as indicated by the surface elevation data presented in Figure 4-1 . Elevations across the centre of the site generally range between 35 to 40 mAHD (Australian Height Datum).

The treated water pipeline (**Figure 4-2**) follows gently sloping topographies, with elevations generally ranging from 30 m to 90 mAHD, from the low-lying areas around the South Creek/Kemps Creek (35 – 40 mAHD) through to the Nepean River valley (35 mAHD), traversing a small ridge in the vicinity of The Northern Road, Luddenham (90 mAHD).

The brine pipeline alignment, shown in **Figure 4-3**, heading out east from the AWRC site at 40 mAHD elevation, follows gently sloping topographies, rising from 40 mAHD, rising to reaching a high point at Cecil Hills (80 mAHD) before sloping down again towards Prospect Creek in Fairfield at 10 mAHD.

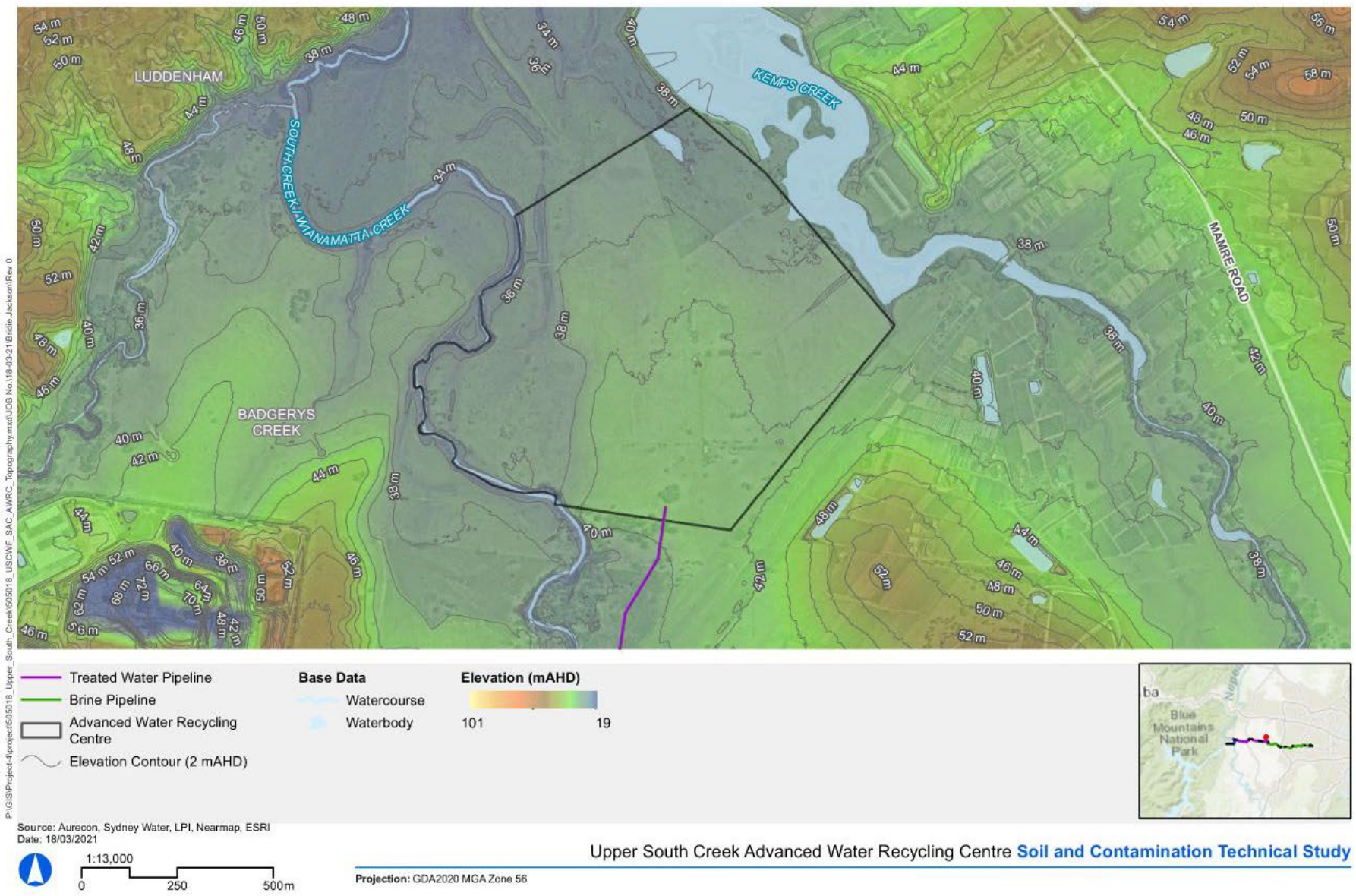


Figure 4-1 Topography - AWRC site

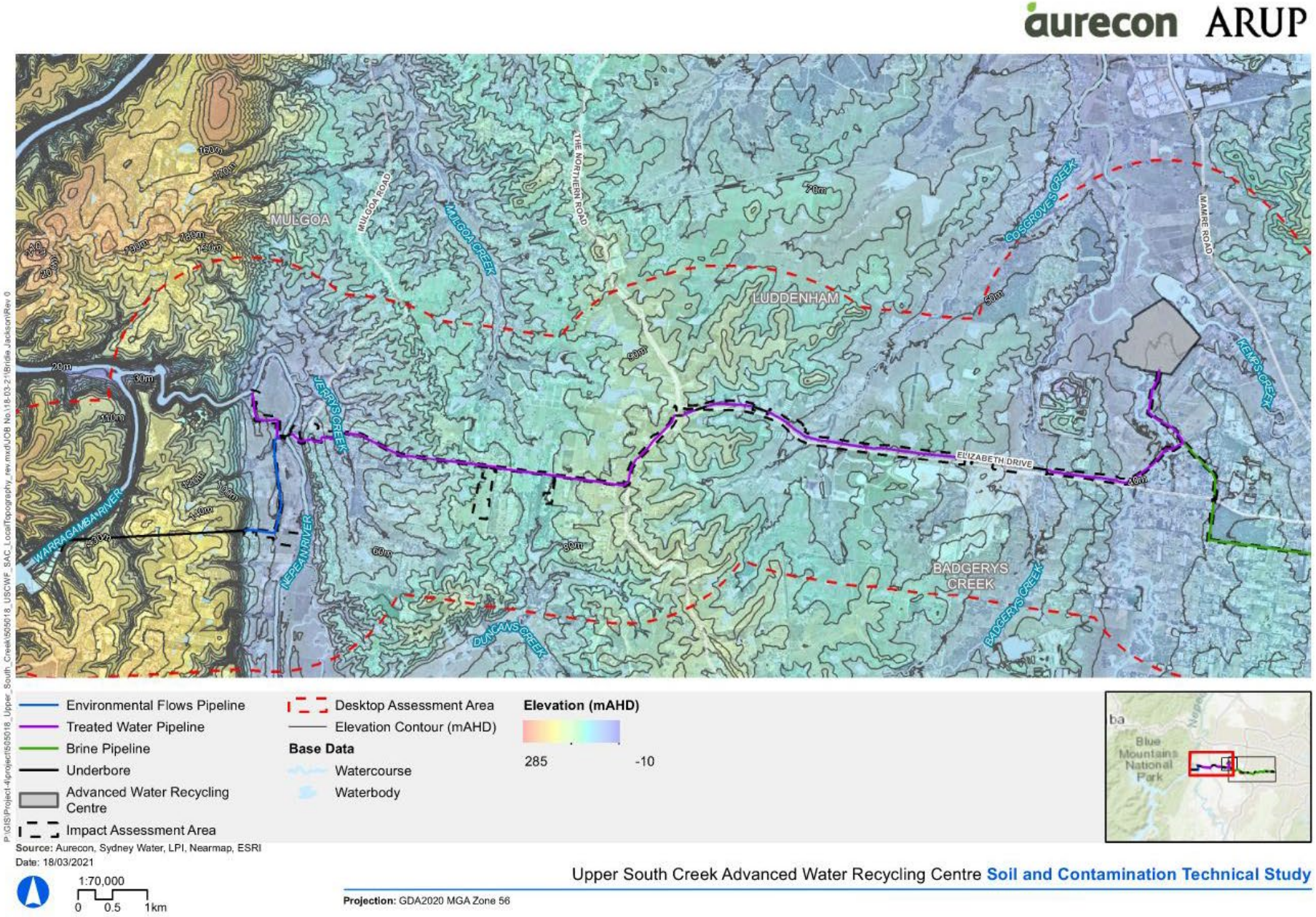


Figure 4-2 Topography – Treated water pipelines

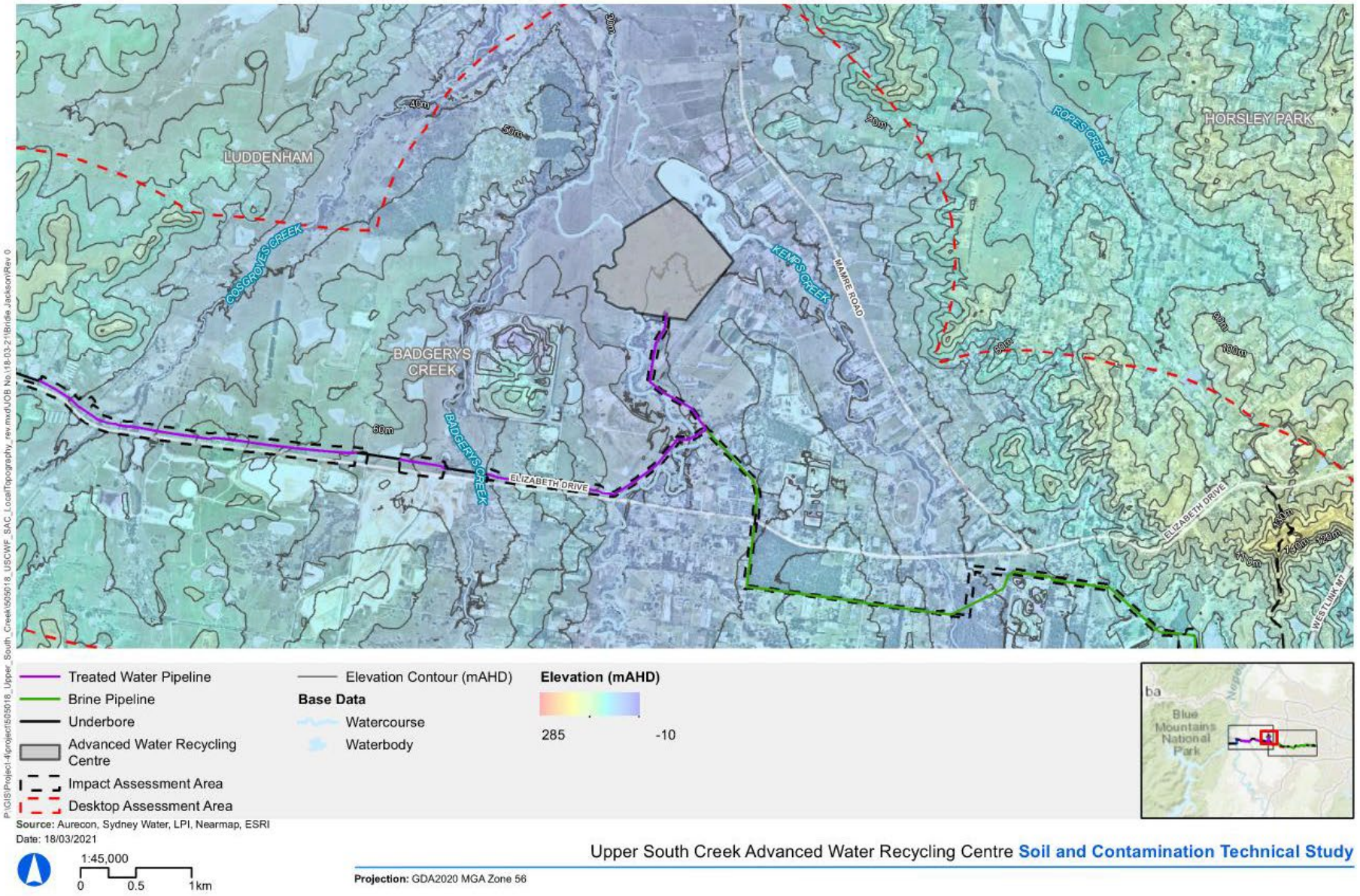


Figure 4-3 Topography - Brine pipeline

The environmental flows pipeline continues south along a plateau adjacent to the Nepean River valley before turning west towards the Warragamba River. Shortly after this direction change, the pipeline route encounters a fairly steep ridge with the surface elevation increasing from 61 m to 153 m within a distance of 300 m (slope of 31%). At this point the proposed construction methodology is a tunnelled section cutting into the east side of the ridge line at 66 m and exiting on the west side of the ridge line at an elevation of 34 m close to the Warragamba River for release The complete elevation profile for the pipeline along its 4.5 km length, is presented in Figure 4-4.

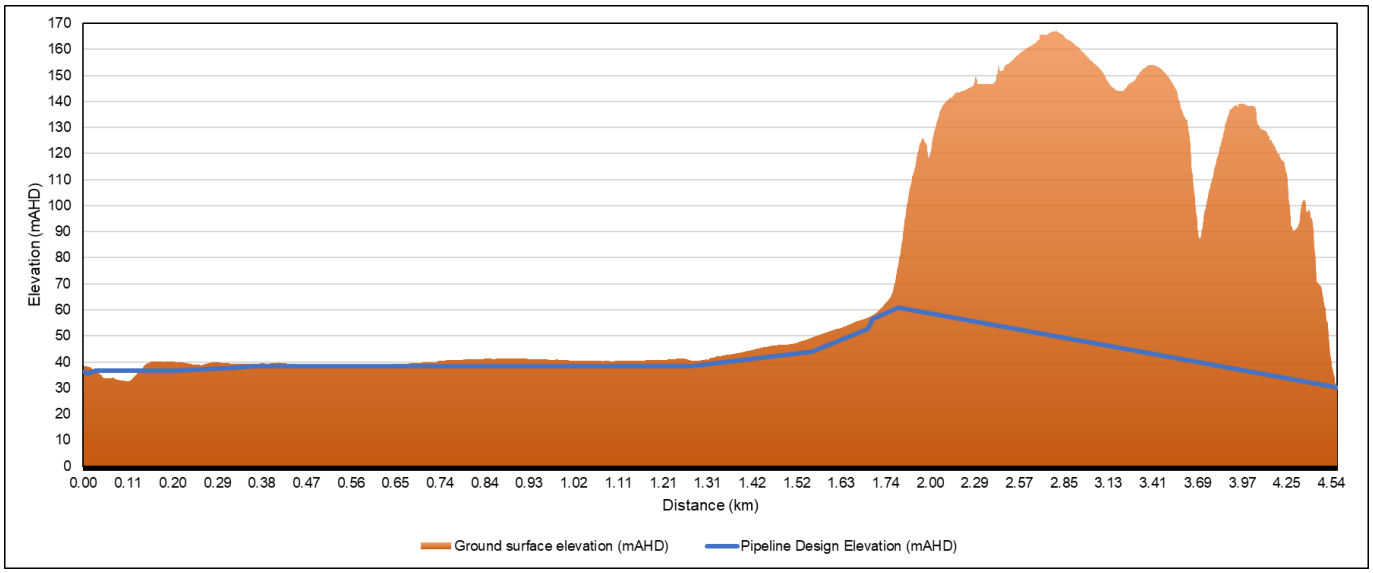


Figure 4-4 Elevation profile along the environmental flows pipeline

Within the local surrounding area, the landscapes are typified by a mixture of urbanised areas associated with current residential and commercial developments, and open areas of grasslands and low rolling hills.

4.3 Drainage and Hydrology

The hydrology of the site is described in detail in the *Surface Water Specialist Study* Appendix to the EIS (Aurecon Arup, 2021c). A brief summary of features is provided below.

The majority of the project area, including the AWRC, treated water pipelines and the western portion of the brine pipeline are located in the Hawkesbury-Nepean catchment. The eastern portion of the brine pipelines is within the boundaries of the Georges River catchment, which has an area of 960 km^2 and is one of the most highly urbanised catchments in Australia.

The Hawkesbury-Nepean catchment provides drinking water, agricultural and fisheries produce, recreational opportunities and tourism resources for Metropolitan area of Sydney and is one of the largest coastal basins in NSW with an area of 21,400-km^2 (NSW DPI, 2017). Over its 470 km flowing length, it originates from the headwaters of the Nepean River in Goulburn before joining the Hawkesbury river in the west of Sydney and draining to Broken Bay. Major drainage features of the catchment include:

- Hawkesbury, Nepean, Wingecarribee, Wollondilly, Mulwaree, Tarlo, Nattai, Coxs, Kowmung, Grose, Capertee, Colo and Macdonald Rivers
- Berowra, Mangrove, Cattai, South and Mooney creeks

The majority of the desktop assessment area lies within the Lower Nepean River Management Zone of the Hawkesbury-Nepean Catchment. While almost half the Hawkesbury-Nepean Catchment is protected in national parks and water catchment reserves, the AWRC lies within the Badgerys Creek, South Creek and Kemps Creek sub-catchments which have been extensively modified and disturbed due to increasing urbanisation and associated land clearing.

Several rivers and streams intersect the proposed pipeline alignments: from west to east the pipelines are intersected by the Nepean River, Badgerys Creek, South Creek, Kemps Creek, Cabramatta Creek, Clear Paddock Creek and Prospect Creek.

The Hawkesbury River is the ultimate downstream receiving environment and is located about 29 km from the project at the closest point.

The AWRC is located within a floodplain bordered by Kemps Creek to the northeast and South Creek to the southwest. Surface water flow would be consistent with the topography, outward toward both creeks.

Some local drainage ditches also exist within the AWRC, most prominently observed in a generally straight line from northeast to southwest. Any remaining release should percolate through the soil into groundwater. The creeks and their associated ecosystem are the environmental receptors for potential impacts from the AWRC development.

4.4 Land Usage

The AWRC site as well as a parts of the pipeline alignments are located within the Western Sydney Aerotropolis growth area, which is currently undergoing rezoning on a regional scale (WSAP, 2020). Future land use changes are expected to change the bulk of the rural and primary production zoned areas to enterprise, agribusiness, commercial and industrial, mixed use and environment and recreation land uses.

The AWRC itself represents a change in land use from the current rural zoning. Following construction of the pipelines, land use within the pipeline corridors will be unchanged.

4.5 Regional Geology

The project is located within the Permo-Triassic Sydney Basin. The Sydney Basin is characterised by sub-horizontal sedimentary deposits, which mainly comprise sandstone with interbedded shale layers deposited unconformably on a basement of the Lachlan fold belt (Haworth, R.J., 2003).

Surface outcrops of geological units associated with the project areas has been determined from a review of the NSW Seamless Geology dataset (Department of Regional NSW, 2020) and are presented in Figure 4-5, Figure 4-6 and Figure 4-7. A depositional and descriptive summary of the geological units (in order of age: oldest to most recent) that occur within the project area is presented in Table 4-2 below.

Table 4-2 Relevant geological units within the impact assessment area

Age	Stratigraphic unit	Depositional environment	Description
Anthropocene	Anthropogenic Fill	Sub-aerial	Highly variable fill materials (includes topsoil, embankments, road pavements, landscaped areas etc.)
Quaternary	Alluvial Sediments/Deposits	Non-marine rivers, creeks and streams	Loose, unconsolidated fine to medium grained sand, silt and clay.

Age	Stratigraphic unit	Depositional environment	Description
Triassic	Bringelly Shale	Swampy alluvial plain with streams flowing from the west.	Variable sedimentary rock types. Black and grey shales and sandstones with small scale bedding.
	Minchinbury Sandstone	Shoreline marine environment	Fine to medium grained quartz sandstone with calcite and volcanic lenses.
	Ashfield Shale	Low energy marine environment	Black mudstones and grey shales with small scale bedding.
	Hawkesbury Sandstone	Braided alluvial channel fill	Medium to coarse-grained quartz sandstone with minor shale and laminite lenses. Sandstones are either massive or cross-bedded sheet facies with vertical or sub-vertical joint sets. The combination of bedding planes and widely spaced joints gives sandstone outcrops a distinctive blocky appearance.

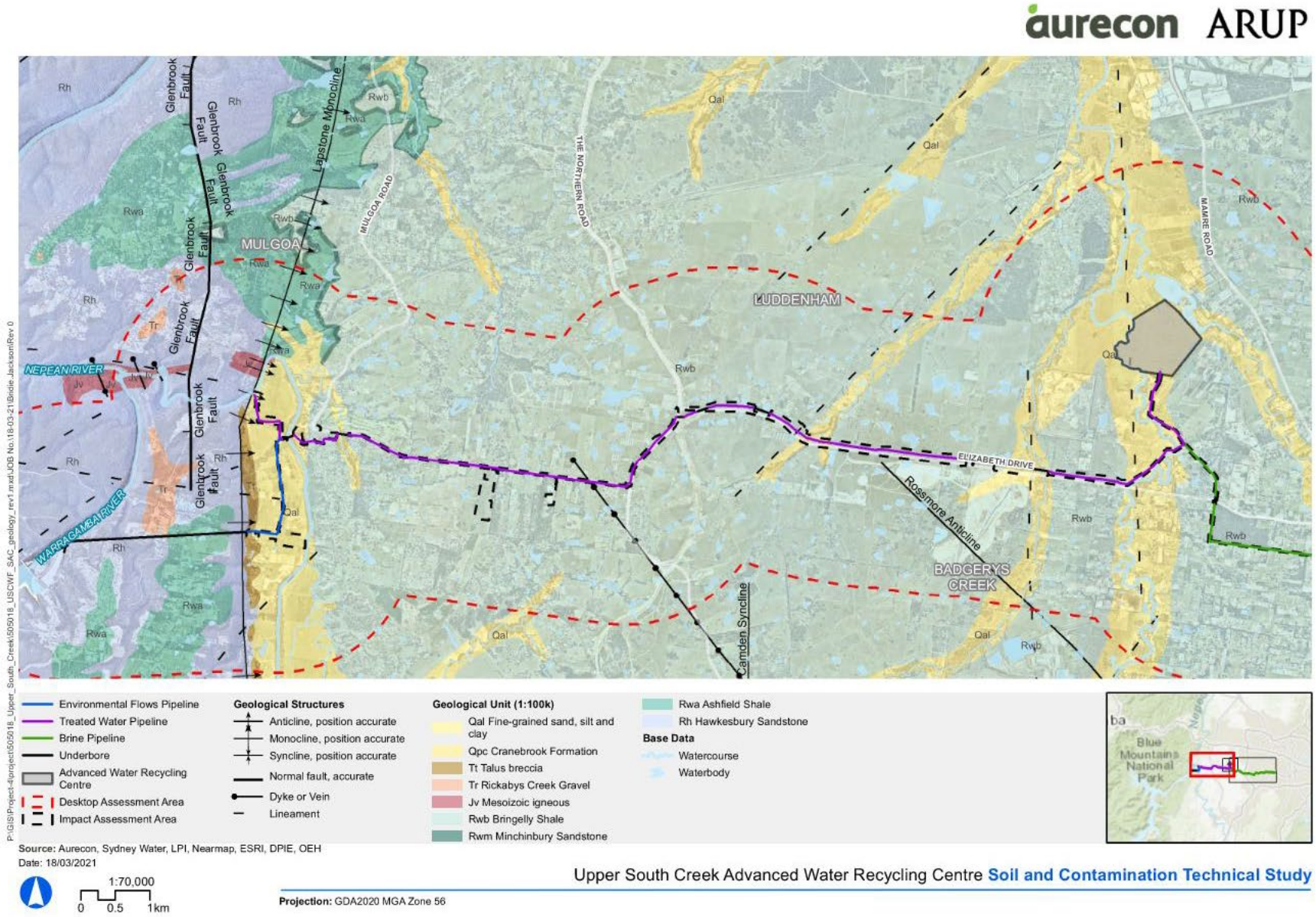


Figure 4-5 Regional Surface Geology – Treated water pipelines

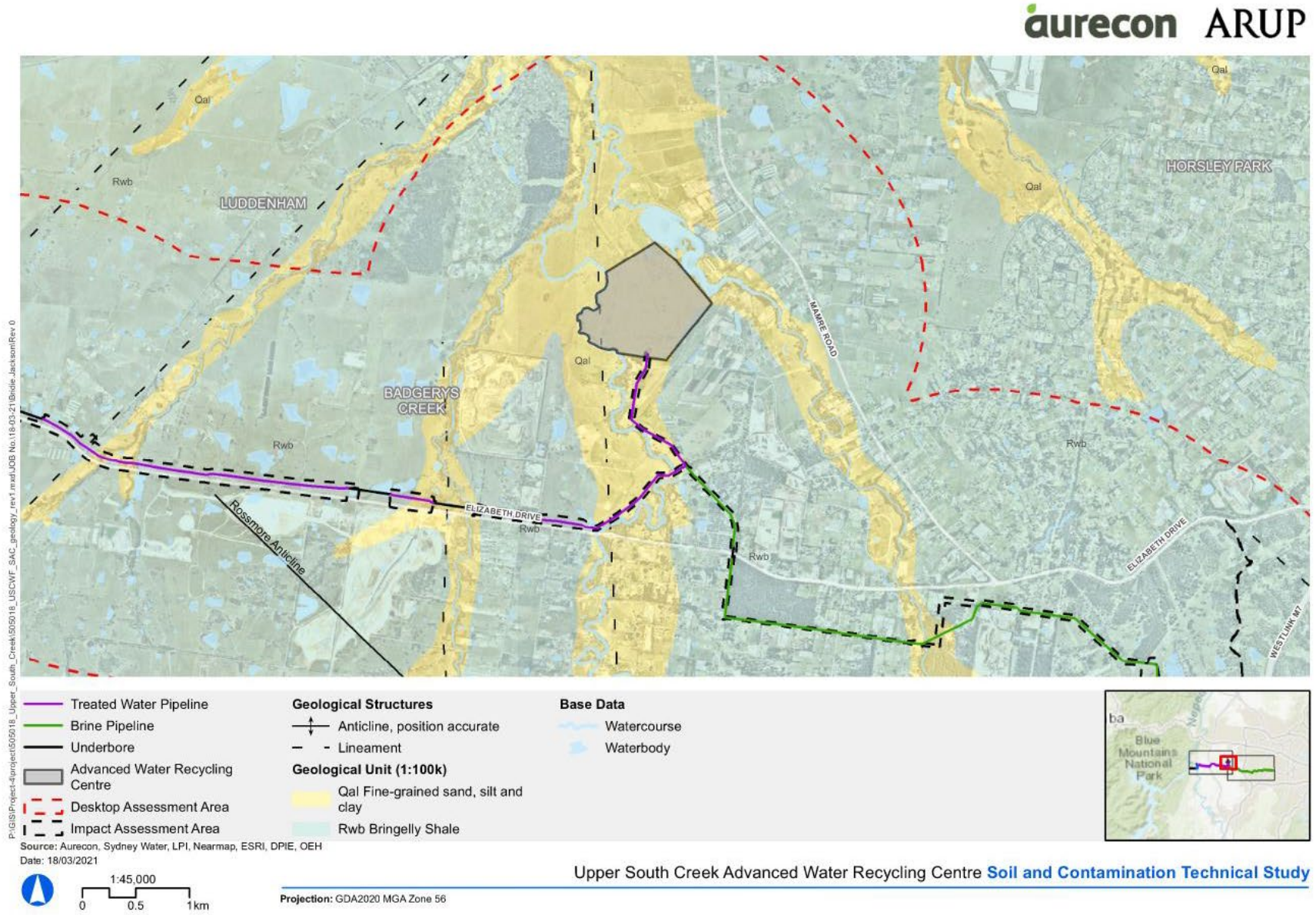


Figure 4-6 Regional Surface Geology – AWRC site

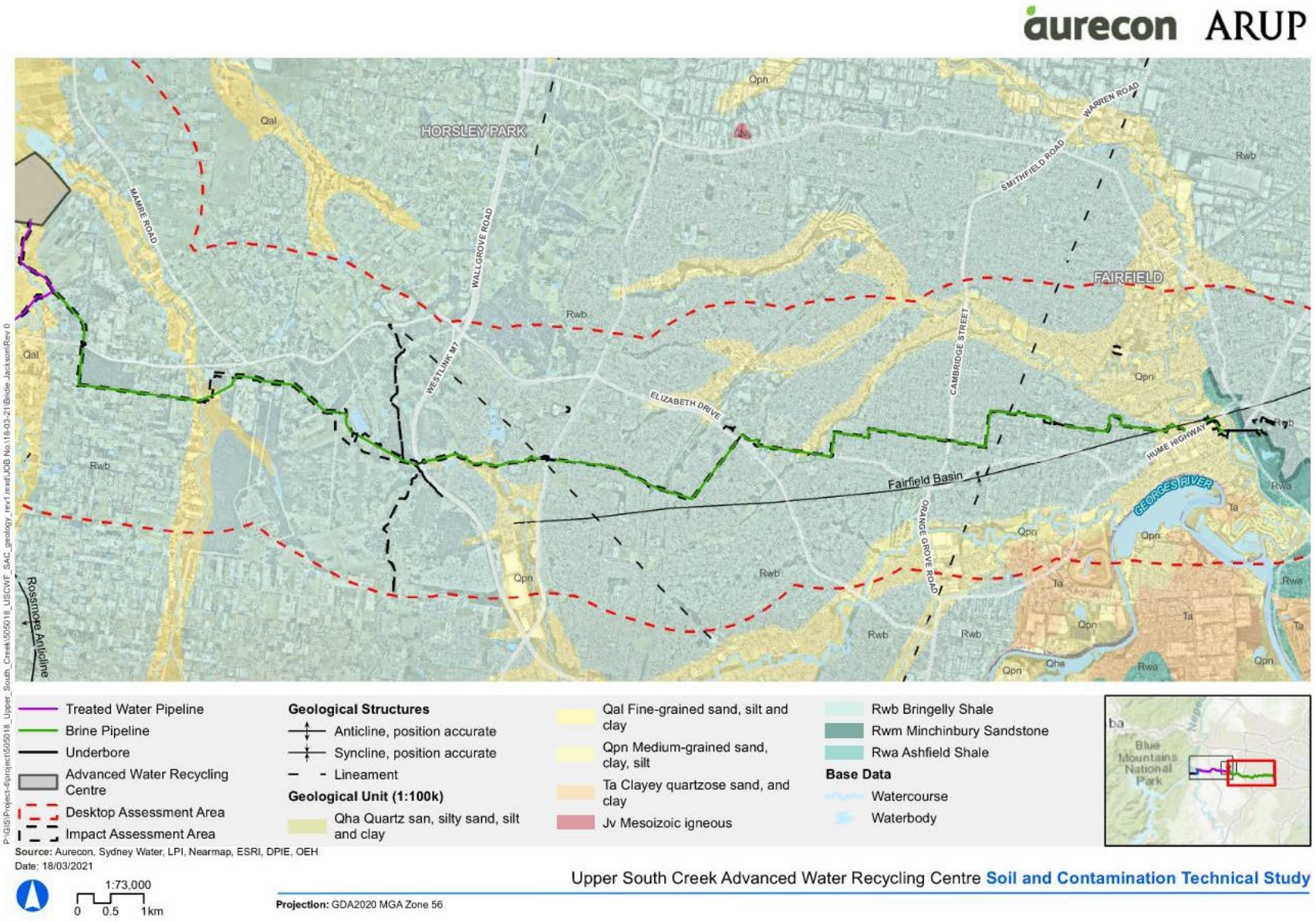


Figure 4-7 Regional Surface Geology – Brine pipeline

4.6 Soil Landscapes

Soil landscapes defined through the Sydney 1:100,000 Soil Landscape Map (DPIE, 2005) indicates the proposed project areas spans over eleven soil landscape units:

- Berkshire Park – Alluvial landscape
- Blacktown – Residual landscape
- Disturbed Terrain – Disturbed landscape
- Falconbridge – Residual landscape
- Gymea – Erosional landscape
- Hawkesbury – Colluvial landscape
- Hazelwood – Colluvial landscape
- Luddenham – Erosional landscape
- Picton – Colluvial landscape
- Richmond – Alluvial landscape
- South Creek – Alluvial landscape

A summary of soil landscapes across the desktop assessment area is presented in Table 4-3 and shown in Figure 4-8, Figure 4-9 and Figure 4-10. Detailed soil landscape reports and properties for the 11 landscapes are presented in **Appendix A.**

Table 4-3 Relevant soil landscape units in the desktop assessment area

Soil landscape	Location in desktop assessment area
Berkshire Park	A small area to the south of the Kemps Creek Hi-Quality Group. Sites: Brine pipeline
Blacktown	Across the majority of the site to the east of Wallacia. Sites: Treated water Environmental flows Brine pipeline AWRC
Disturbed Terrain	On the Brandown Quarry, site and multiple areas to the south within the Liverpool area Sites: Brine pipeline
Falconbridge	On the western end of the site, surrounding the Warragamba River. Sites: Environmental flows
Gymea	In Warragamba and Wallacia, directly adjacent to the Hawkesbury soil landscape. Sites: Environmental flows

Soil landscape	Location in desktop assessment area
Hawkesbury	On the valleys along the banks of the Warragamba and Nepean River. Sites: Environmental flows
Hazelwood	At the Nepean River south of Blaxland Crossing to Bents Basin. Site: Environmental flows
Luddenham	Sections of Wallacia, Luddenham, Cecil Park and Cecil Hills Sites: Treated water Brine pipeline
Picton	Within vegetated lots along the M7, surrounded by Luddenham soil landscapes. Sites: Brine pipeline
Richmond	Low lying areas near the Nepean River and Prospect Creek Sites: Treated water Environmental flows Brine pipeline
South Creek	Along the banks of South Creek and its tributaries including Kemps Creek, Badgerys Creek and Cosgrove Creek. Covers the majority of the AWRC. Sites: Treater water Brine pipeline AWRC

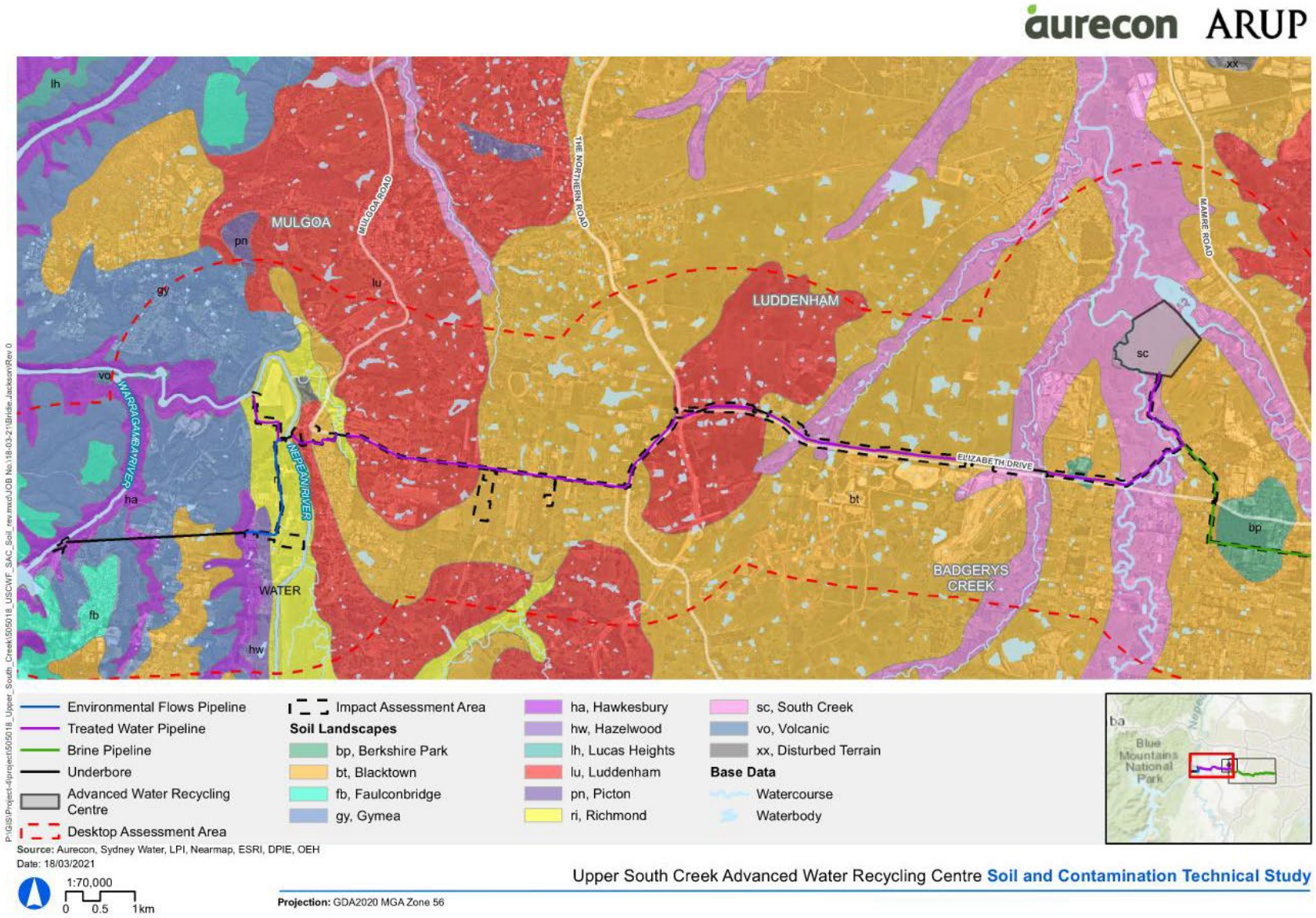


Figure 4-8 Soil Landscapes – Treated water pipelines

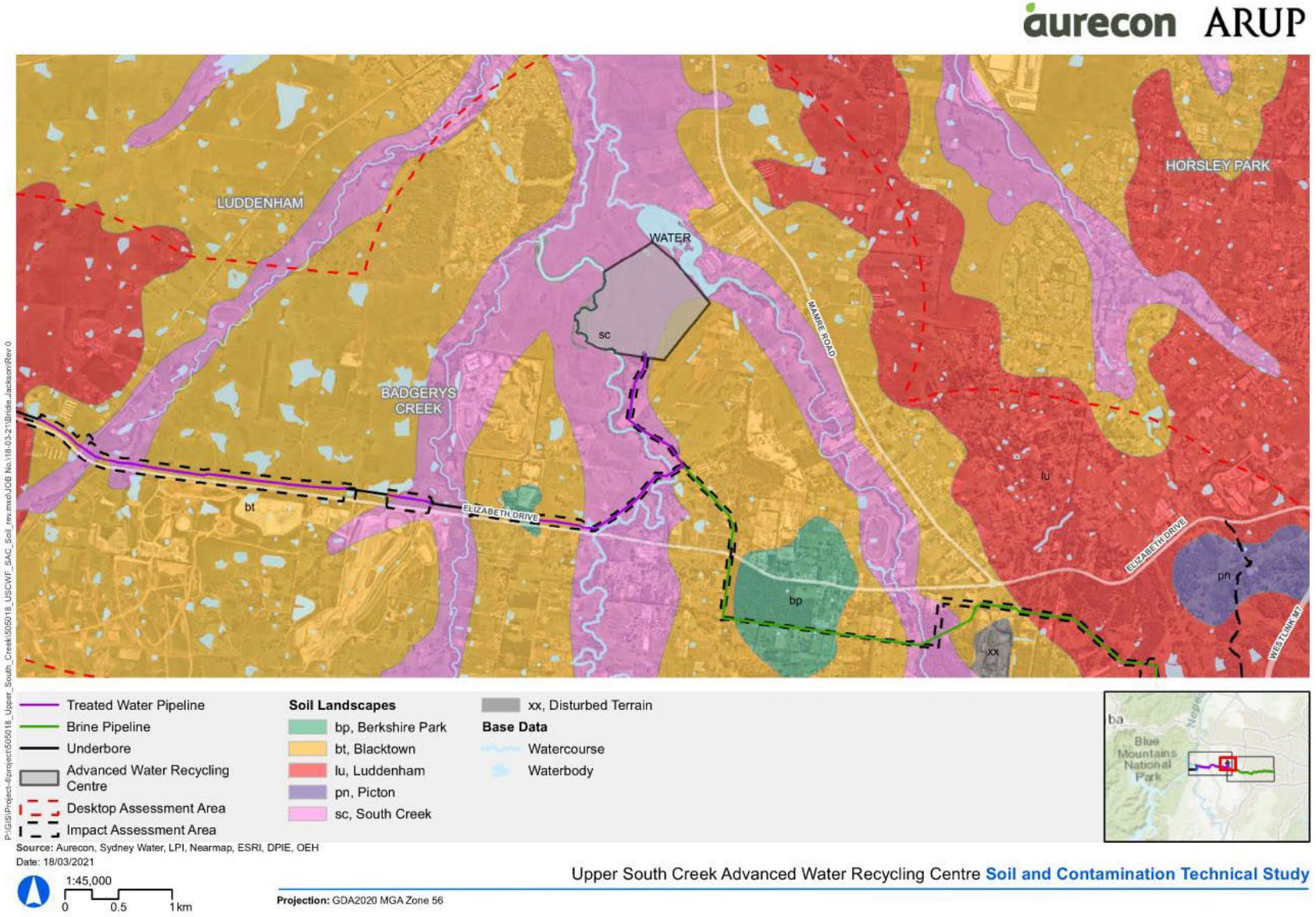


Figure 4-9 Soil Landscapes – AWRC site

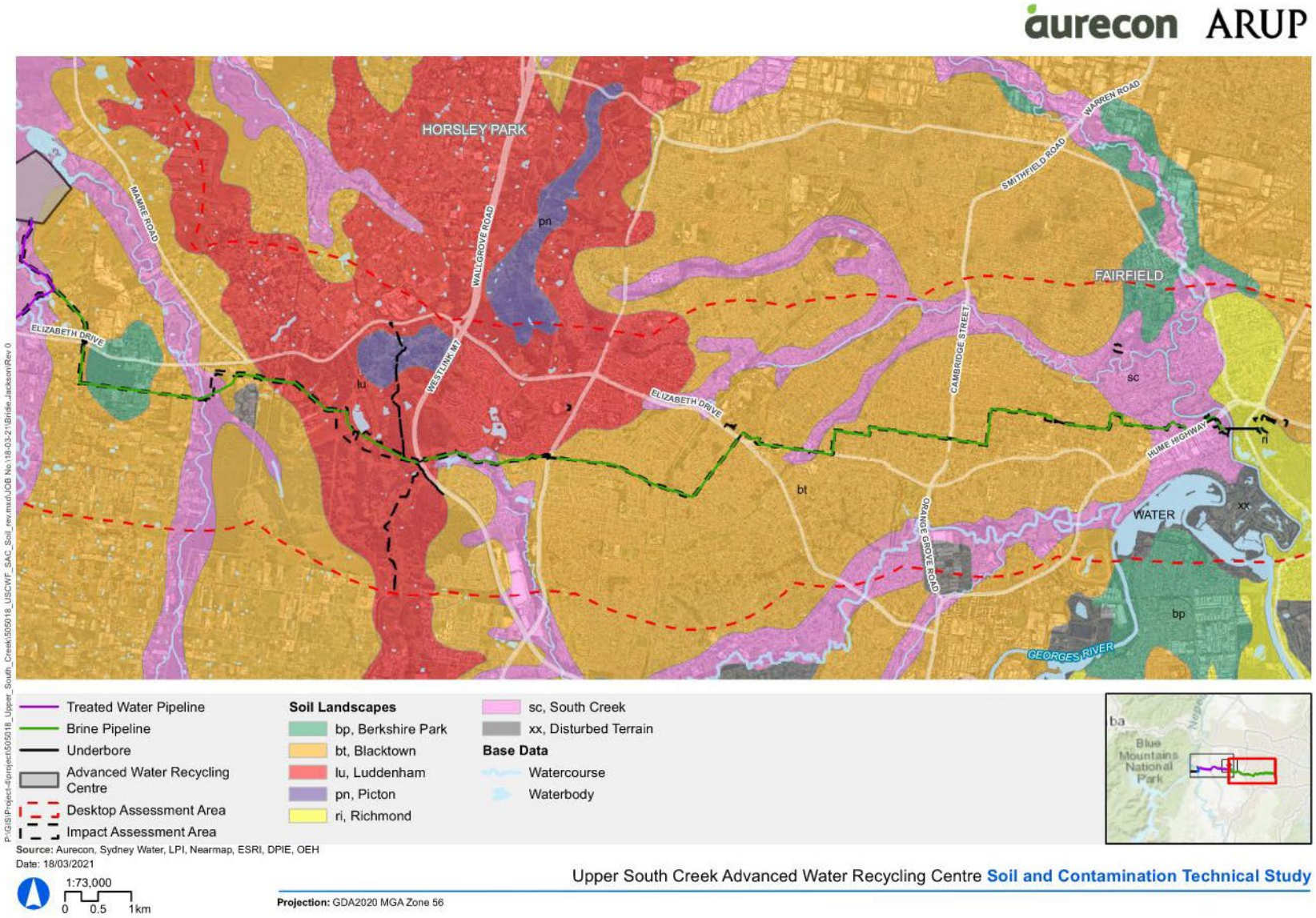


Figure 4-10 Soil Landscapes – Brine pipeline

4.6.1 Soil Landscape Erodibility

Soil erodibility information for each soil landscape, as well as soil type details are presented in **Appendix A**. The following provides a summary of erodibility hazard information for each soil landscape (without management and mitigation applied to the landscape):

- For Berkshire Park soil types are susceptible to wind erosion hazard on cleared land. Gully, sheet and rill erosion may occur on dissected areas
- For Blacktown soil types are susceptible to localised water erosion hazards with localised moderately reactive plastic subsoils. Gully, sheet and rill erosion may occur on cleared areas where vegetation is not maintained.
- For Gymea soil types areas with damaged or destroyed vegetative cover can suffer severe sheet erosion
- For Hawkesbury soil types severe sheet erosion often occurs during storms and after ground cover is destroyed by bushfires
- For Hazelwood soil types they are susceptible to water erosion on localised slopes
- For Luddenham soil types disturbed land can suffer sheet erosion
- For Picton soil they are susceptible to slumps and sheet erosion due to the steep hills
- For Richmond soil types they can suffer water erosion on localised terrace edges
- For South Creek soil types, they are highly susceptible to water erosion due to the active floodplain nature of the landscape. Streambank and gully erosion are common results of concentrated flow

4.6.2 Australian Soil Classification

The NSW DPIE Soil and Land Information (eSPADE) online mapping for the desktop assessment area indicates it is situated across six ASC, these are described in Table 4-4 and shown in Figure 4-11, Figure 4-12 and Figure 4-13.

Table 4-4 Australian soil classification within the assessment area

Soil classification	Sites	Location in the desktop assessment area	Description
Dermosols	Brine pipeline	Within the Western Sydney Parkland	Soils other than Vertosols, Hydrosols, Calcarosols and Ferrosols which: • Have B2 horizons with structure more developed than weak1 throughout the major part of the horizon, and • Do not have clear or abrupt textural B horizons
Hydrosols	Treated water Brine pipeline AWRC	Across the desktop assessment area within and adjacent to waterways.	Soils other than Organosols, Podosols and Vertosols in which the greater part of the profile is saturated for at least 2-3 months in most years.

Soil classification	Sites	Location in the desktop assessment area	Description
Kurosols	Treated water Environmental flows Brine pipeline	Across the majority of the desktop assessment area in locations with higher elevation, typically areas further that 500 m from a waterway	Soils other than Hydrosols with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is strongly acid.
Kurosols, Natric	Treated water Brine pipeline AWRC	Across the desktop assessment area, within and adjacent to waterways.	
Rudosols	Environmental flows	The western extent of the pipeline desktop assessment area, between the Warragamba and Nepean Rivers.	Soil with negligible (rudimentary) pedologic organisation apart from (a) minimal development of an Al horizon or (b) the presence of less than 10% of B horizon material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present.
Alluvial Tenosols	Treated water Environmental flows	Along the western banks of the Nepean River.	• Soils that do not fit the requirements of any other soil orders and generally with one or more of the following: • A peaty horizon • A humose, melacic or melanic horizon, or conspicuously bleached A2 horizon, which overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials • A horizons which meet all the conditions for a peaty, humose, melacic or melanic horizon except the depth requirement, and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials • A1 horizons which have more than a weak development of structure and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials • An A2 horizon which overlies a calcrete pan, hard unweathered rock or other hard materials;
Rudosols and Tenosols	Treated water Environmental flows	The western extent of the pipeline desktop assessment area, between the Warragamba and Nepean Rivers.	

Soil classification	Sites	Location in the desktop assessment area	Description
			or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials • Either a tenic B horizon, or a B2 horizon with 15% clay (SL) or less1 , or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite which contains between 10 and 50% of B horizon material (including pedogenic carbonate) • A ferric or bauxitic horizon >0.2 m thick • A calcareous horizon >0.2 m thick

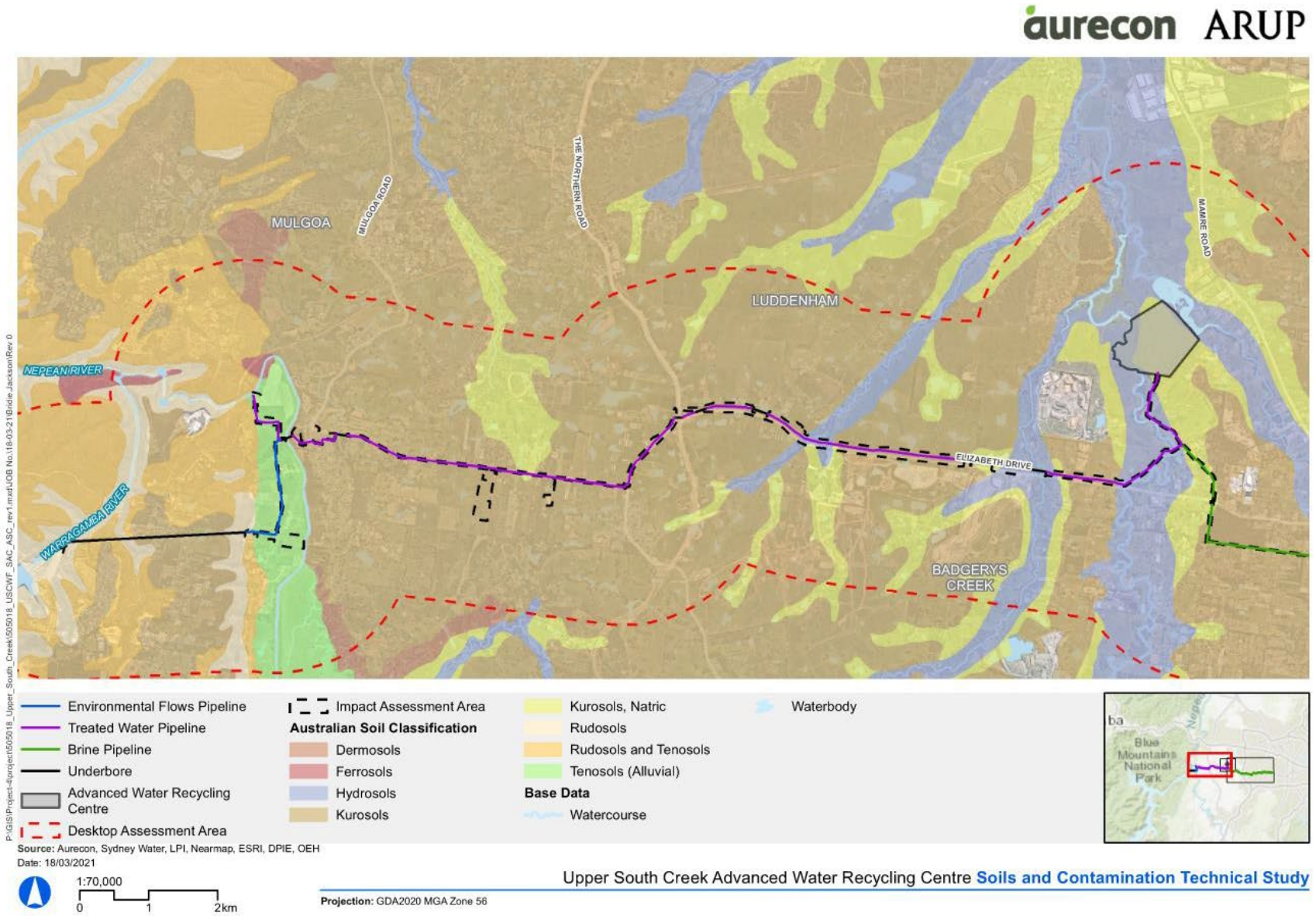


Figure 4-11 Soil Classification – Treated water pipelines

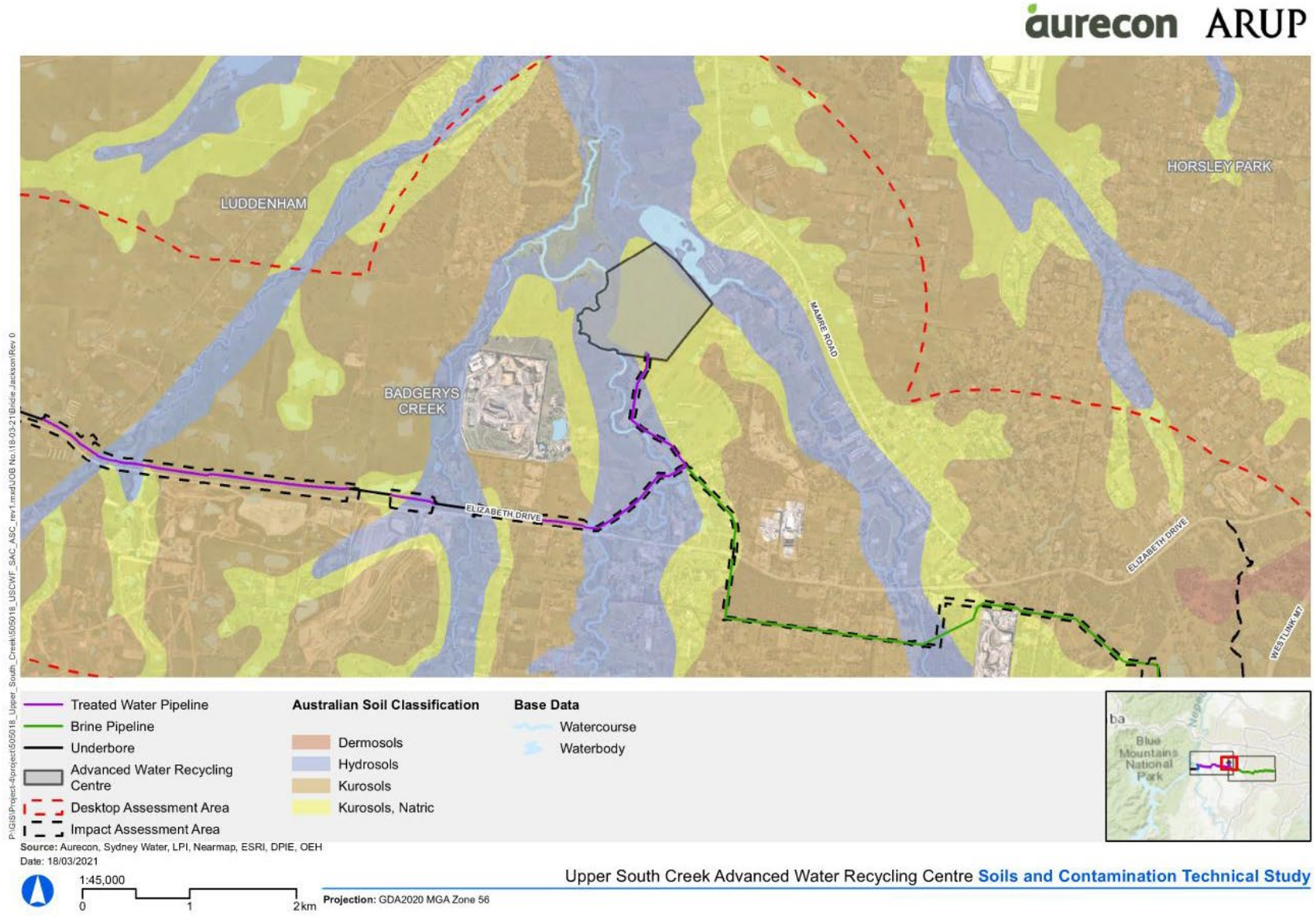


Figure 4-12 Soil Classification – AWRC site

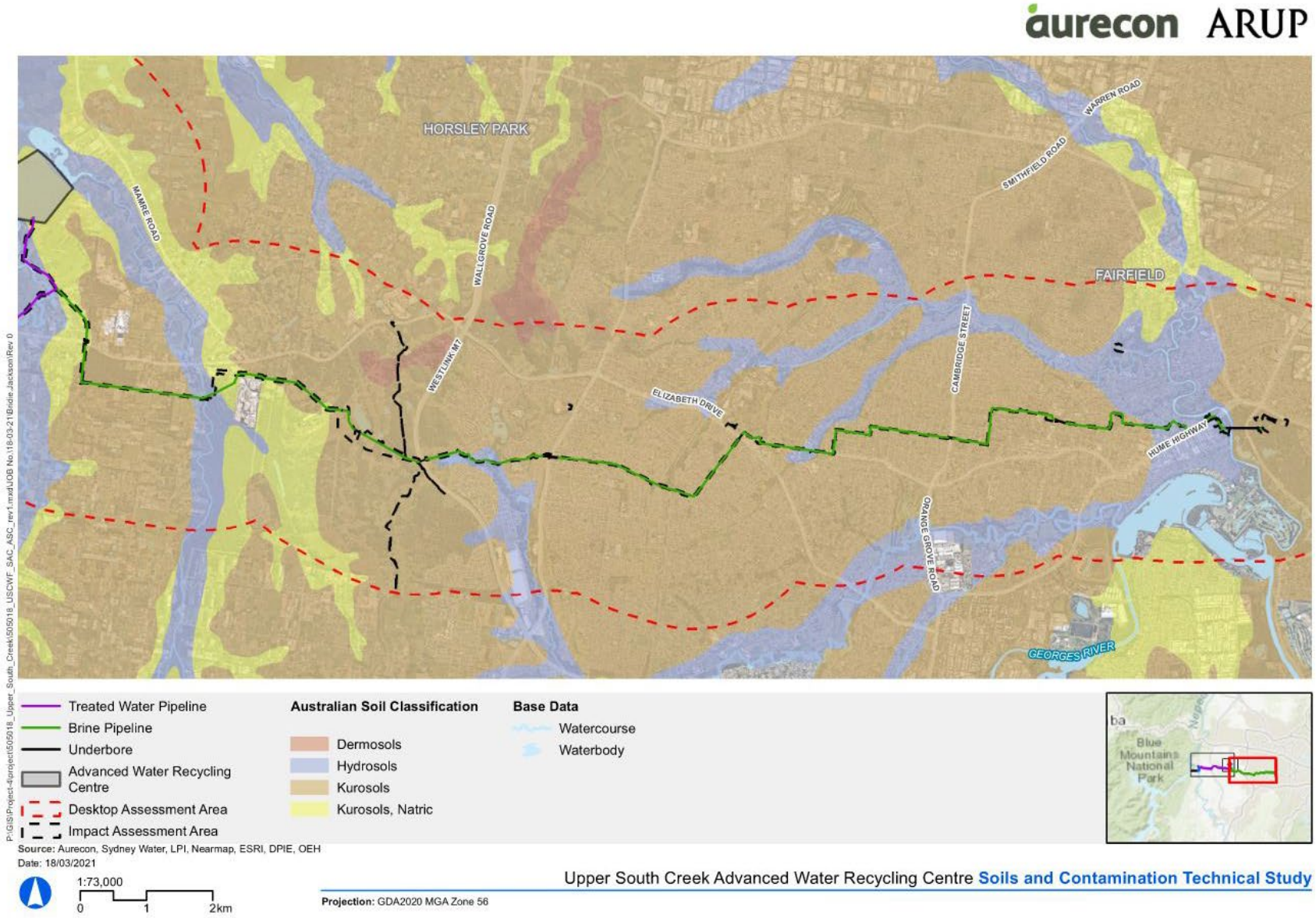


Figure 4-13 Soil Classification – Brine pipeline

4.7 Hydrological Soil Groups

The NSW DPIE Soil and Land Information (eSPADE) online mapping for the desktop assessment area indicates it is situated across four hydrological soil groups, these are described in Table 4-5 and shown in Figure 4-14, Figure 4-15 and Figure 4-16. Hydrologic soil group provides an index of the rate that water infiltrates a soil and is an input to rainfall-runoff models that are used to predict potential stream flow.

Table 4-5 Hydrological soil groups within the desktop assessment area

Class	Sites	Location in the assessment area	Description
Group A (high infiltration)	• Treated water pipelines	The western extent of the pipeline desktop assessment area, along the vegetated slopes of the Warragamba River, and a nearby tributary.	Soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
Group B (moderate infiltration)	• Treated water pipelines	A small section in the western extent of the pipeline desktop assessment area along the Nepean River.	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
Group C (slow infiltration)	• Treated water pipelines • Brine pipeline	Across the majority of the desktop assessment area in locations with higher elevation, typically areas further that 500m from a waterway.	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
Group D (very slow infiltration)	• Treated water pipelines • Brine pipeline • AWRC	Across the desktop assessment area within and adjacent to waterways.	Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

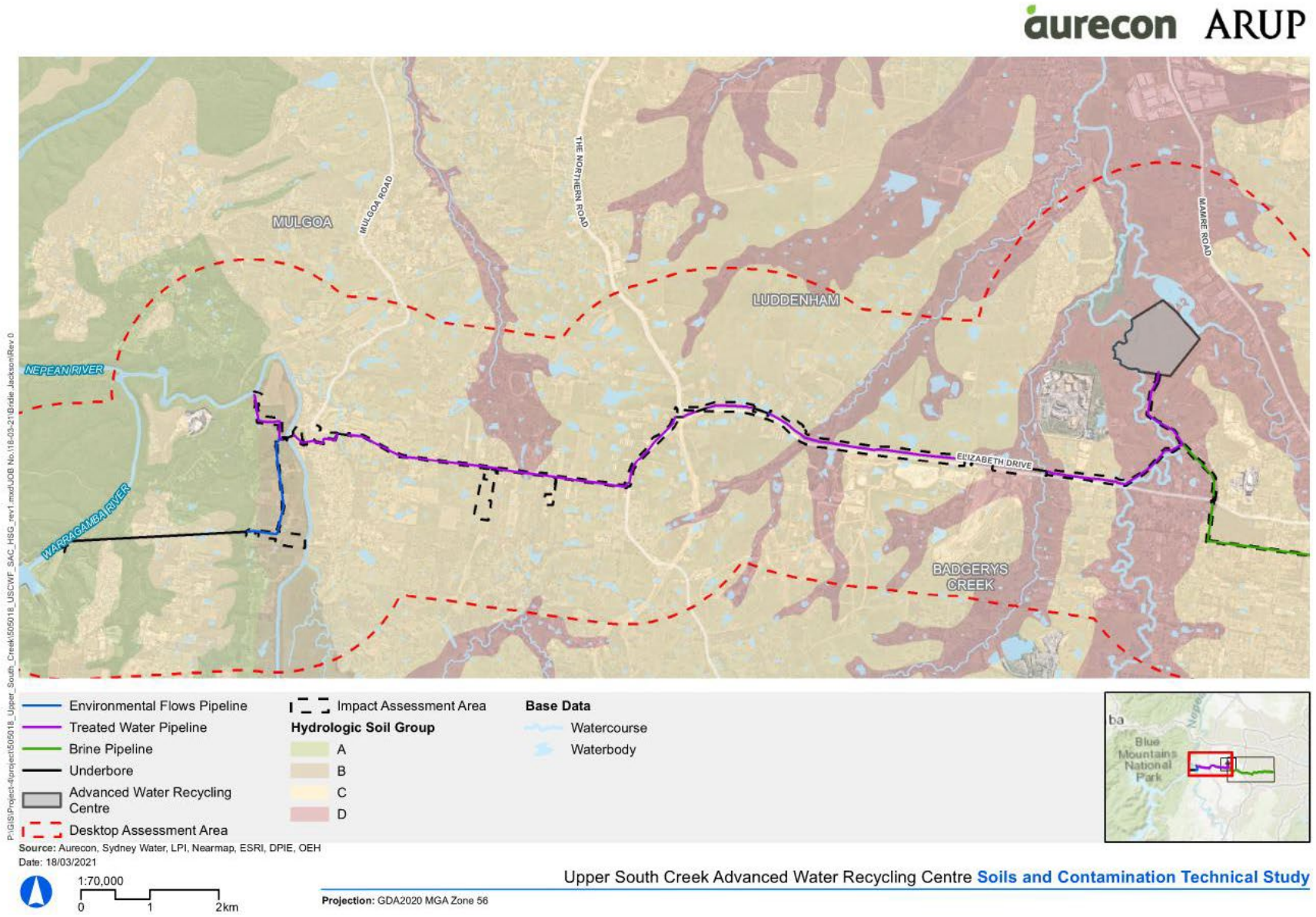


Figure 4-14 Hydrological Soil Groups – Treated water pipelines

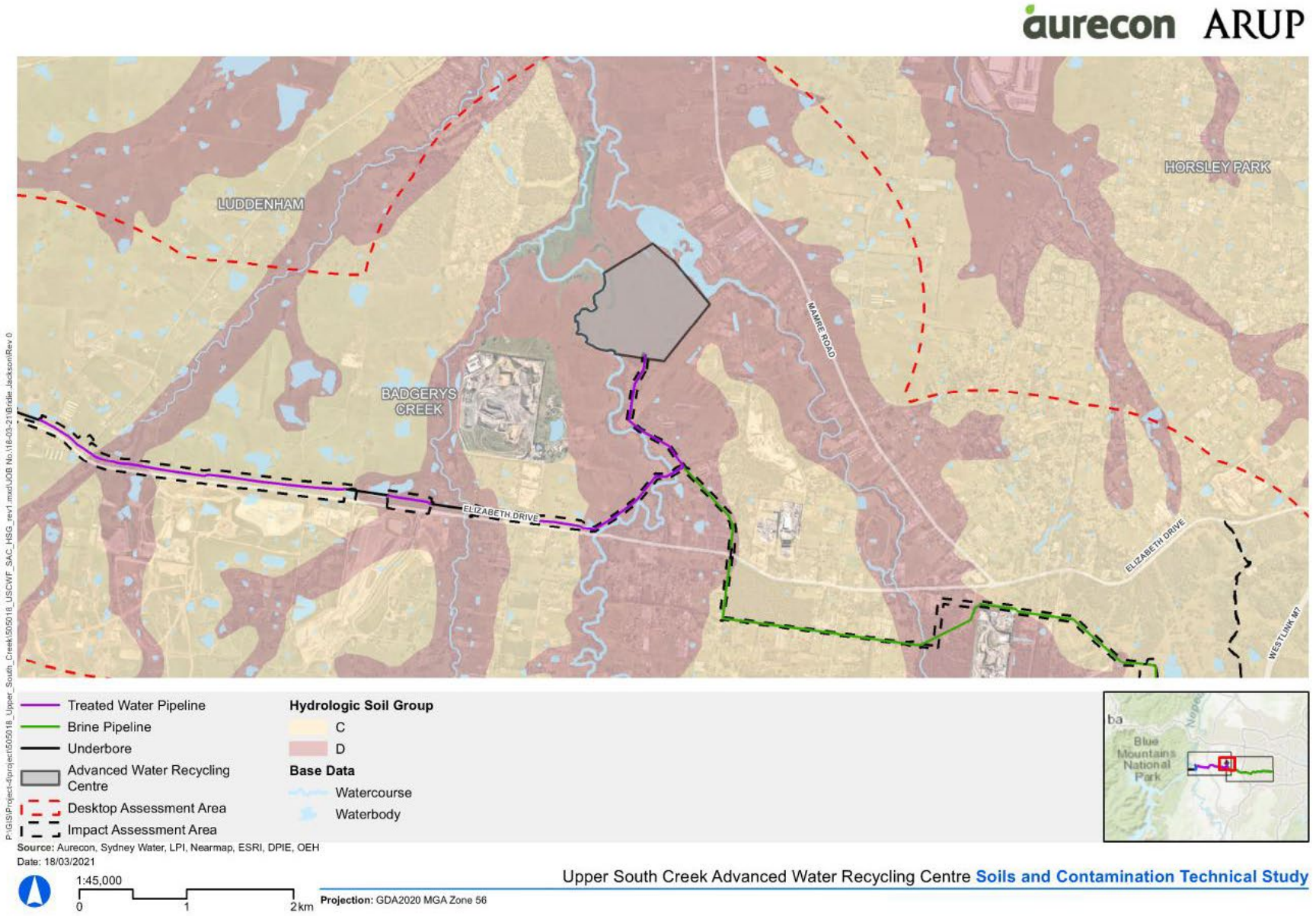


Figure 4-15 Hydrological Soil Groups – AWRC site

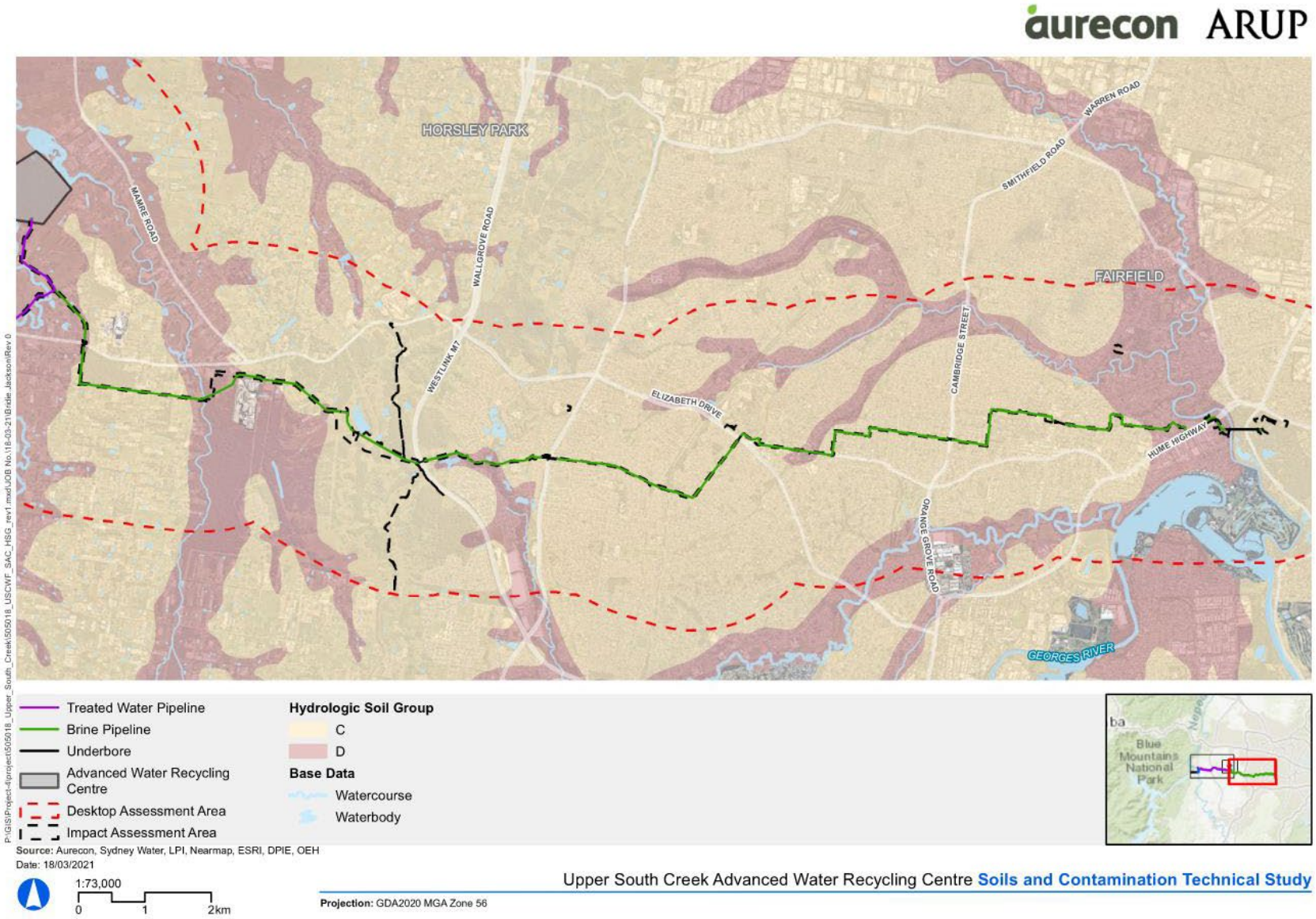


Figure 4-16 Hydrological Soil Groups – brine pipeline

4.8 Inherent Soil Fertility

The NSW DPIE Soil and Land Information (eSPADE) online mapping for the desktop assessment area indicates it is situated across four inherent soil fertility classifications, these are described in Table 4-6 and shown in Figure 4-17, Figure 4-18 and Figure 4-19. Inherent soil fertility is a relative indicator of the soil's capacity to retain and release nutrients for uptake by plants and is associated with clay and organic matter content. This is an important feature of the Western Sydney Airport (WSA) development (WSAP, 2020) around green, blue and brown corridors, and the green Parklands City vision.

Table 4-6 Inherent soil fertility classifications within the desktop assessment area

Class	Sites	Location in the desktop assessment area
Low	• Treated water pipelines	The western extent of the pipeline desktop assessment area, along the vegetated slopes of the Warragamba River, and a nearby tributary.
Moderately low	• Treated water pipelines • Brine pipeline • AWRC site	Across the majority of the desktop assessment area
Moderate	• Treated water pipelines • Brine pipeline	In strips across the desktop assessment area, including to both sides of the Nepean river, at the Western Sydney Parklands and to the east of the Prospect Creek.
Moderately High	• Treated water pipelines	Along the banks of the Nepean River

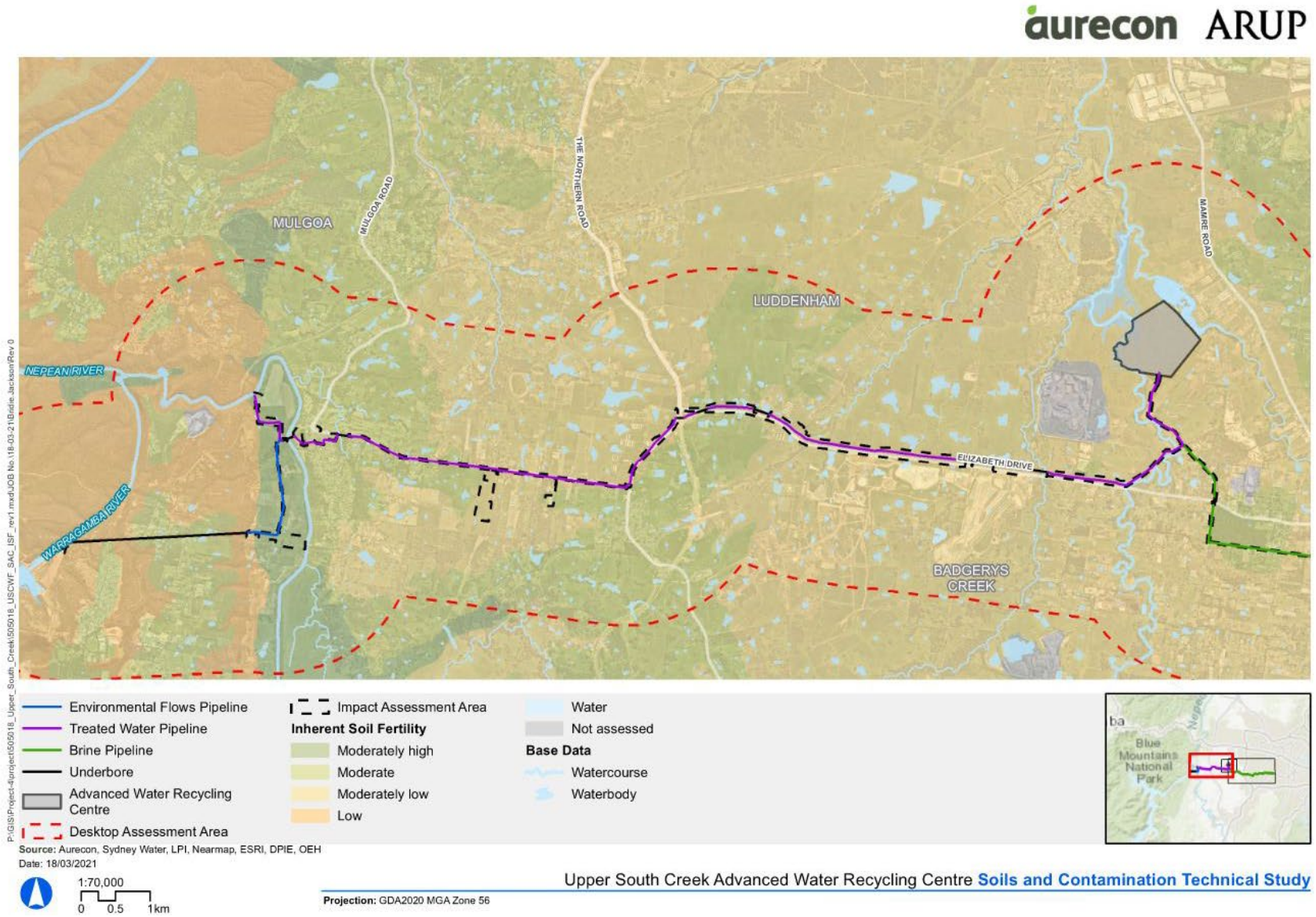


Figure 4-17 Soil Fertility – Treated water pipelines

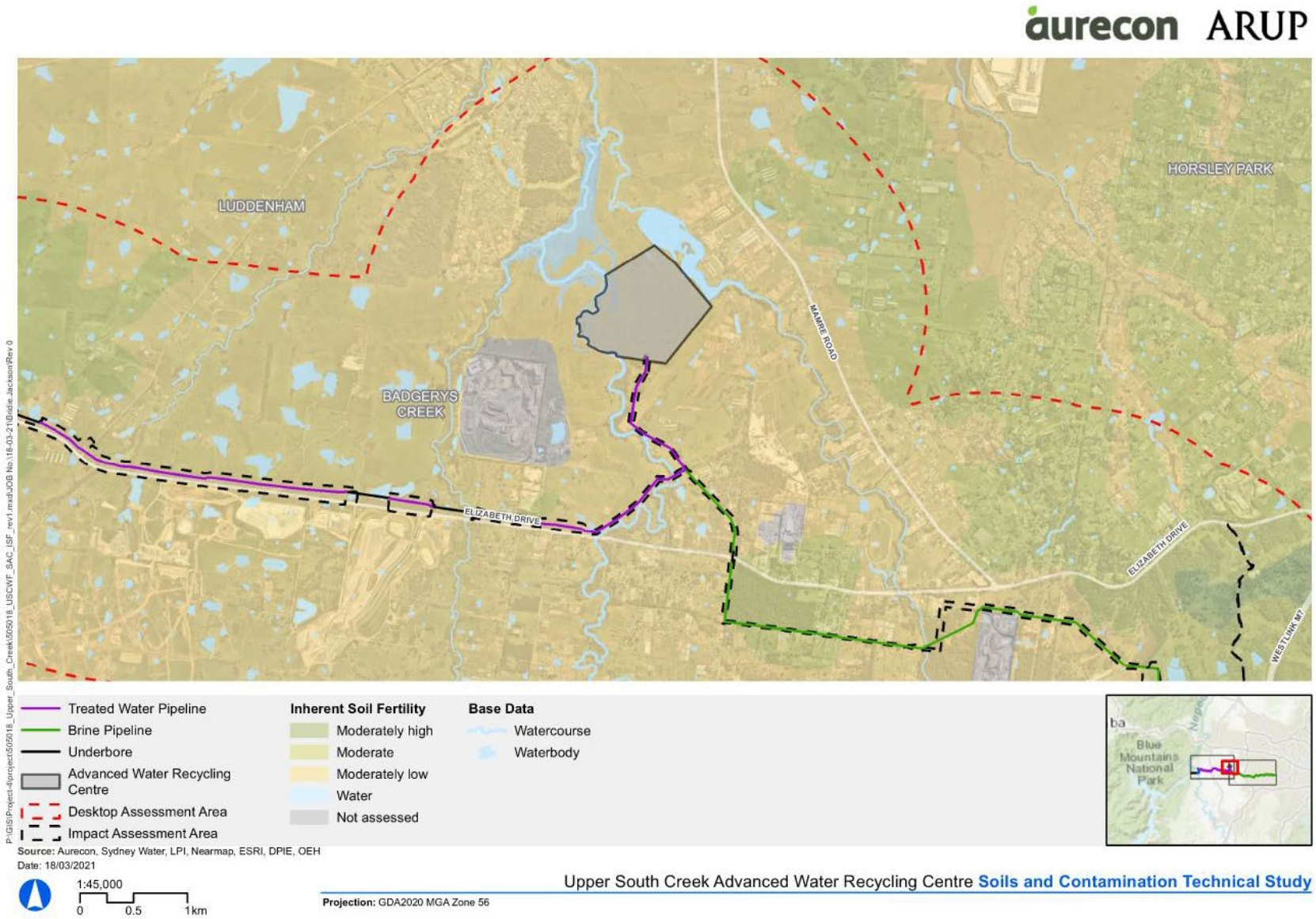


Figure 4-18 Soil Fertility – AWRC site

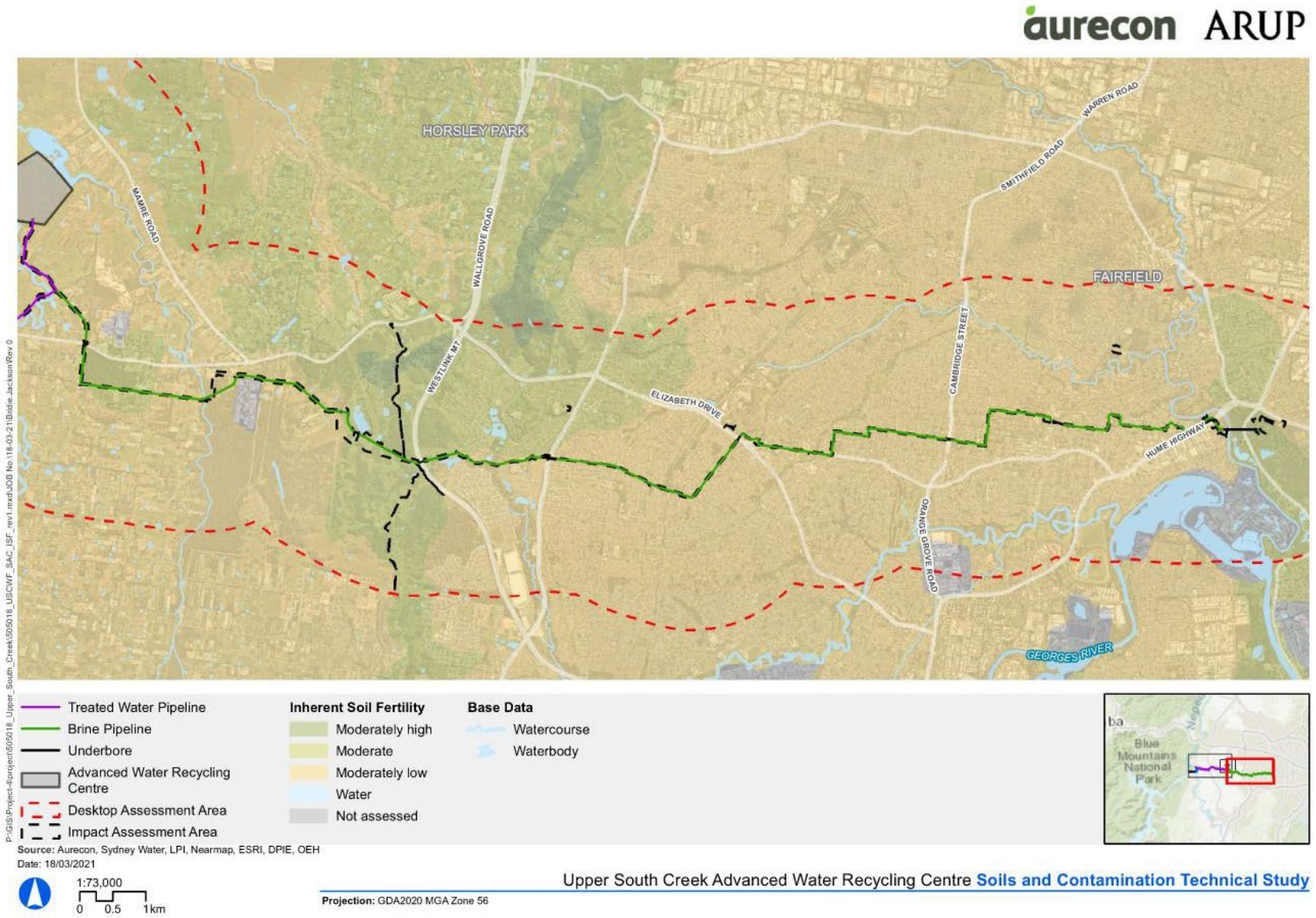


Figure 4-19 Soil Fertility – Brine pipeline

4.9 Land and Soil Capability Class

The land and soil capability class system has eight classes which represent a decreasing capability of the land to sustain land use. The classes are assessed using eight key soil and landscape limitations (water erosion, wind erosion, salinity, topsoil acidification, shallow soils/rockiness, soil structure decline, waterlogging and mass movement). Class 1 represents land capable of sustaining most land uses including those that have a high impact on the soil (e.g. regular cultivation), whilst class 8 represents land that can only sustain very low impact land uses (e.g. nature conservation).

The NSW DPIE Soil and Land Information (eSPADE) online mapping for the desktop assessment area indicates it is situated across five land and soil capability classes, these are described in Table 4-7 and shown in Figure 4-20, Figure 4-21 and Figure 4-22.

Table 4-7 Land and soil capability classes within the desktop assessment area

Class	Sites	Location in the desktop assessment area	Description
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)			
1	N/A	N/A	**Extremely high capability land:** Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	N/A	N/A	**Very high capability land:** Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	• Treated water pipelines	Rural lots along the western bank of the Nepean River.	**High capability land:** Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)			
4	• Treated water pipelines • Brine pipeline • AWRC site	Residential areas of Warragamba and along Silverdale Rd, scattered sections of the alignment from Nepean River to the M7. Eastern section from the M7 to Lansdowne, often further than 500 m from a waterway.	**Moderate limitations / low capability land:** Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.

Class	Sites	Location in the desktop assessment area	Description
5	• Treated water pipelines • Brine pipeline • AWRC site	Low lying areas around creeks and a small section around the Nepean River.	**Moderate to severe limitations / low capability land:** Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)			
6	• Treated water pipelines • Brine pipeline • AWRC site	Sections of plateaus adjacent to the Warragamba River and scattered sections of the alignment from Nepean River to the M7	**Severe limitations / Low capability land:** Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation
Land generally incapable of agricultural land use (selective forestry and nature conservation)			
7	• Treated water pipelines • Brine pipeline	Hilly, vegetated slopes along the banks of the Warragamba River and a nearby tributary.	**Very severe limitations / low capability land:** Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	N/A	N/A	**Extremely severe limitations / low capability land:** Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

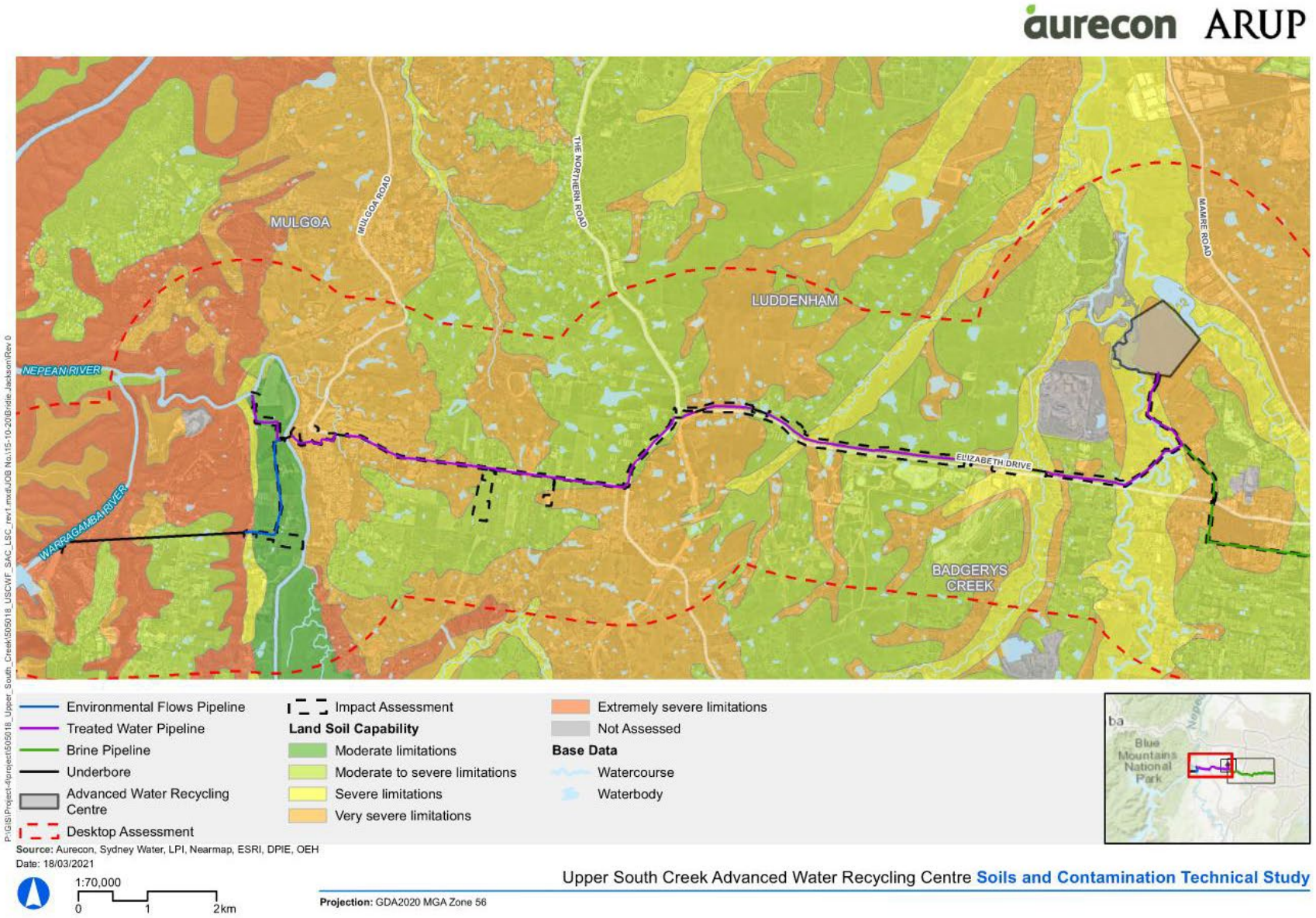


Figure 4-20 Soil and Land Capability Class – Treated water pipelines

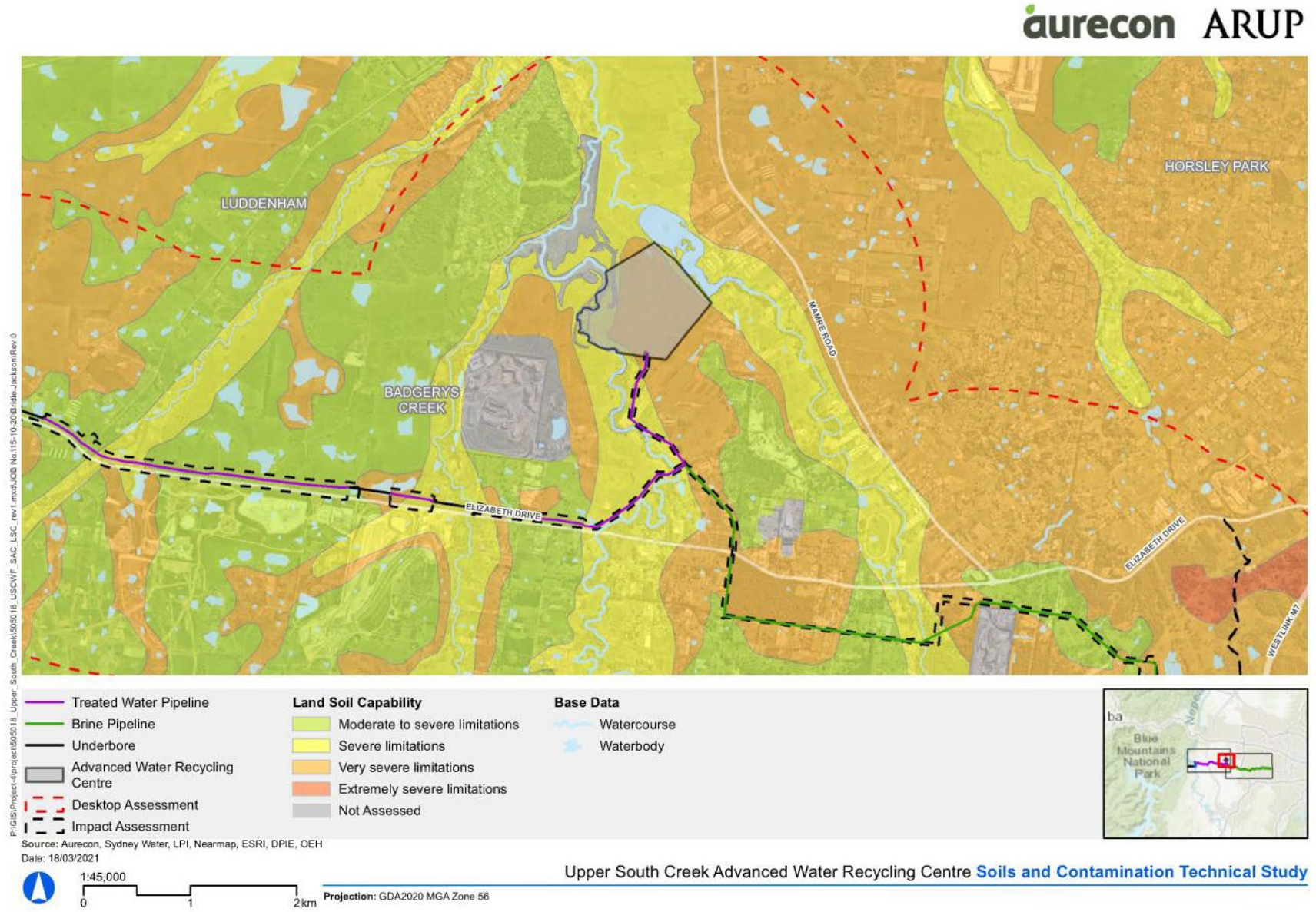


Figure 4-21 Soil and Land Capability Class – The AWRC site

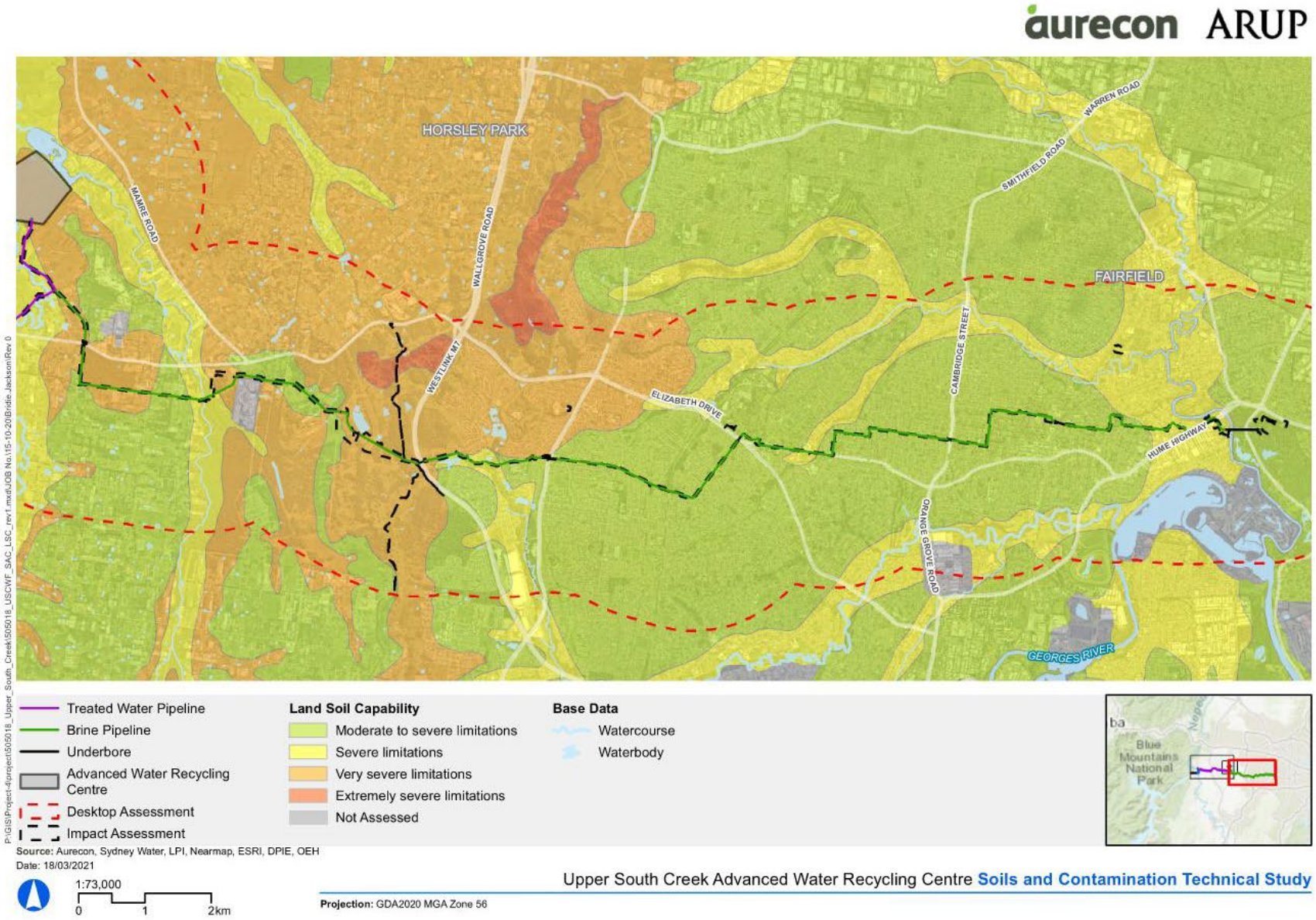


Figure 4-22 Soil and Land Capability Class – Brine pipeline

4.10 Hydrogeological Landscapes

Hydrogeological Landscapes (HGL) are defined by similar areas of salt stores and pathways for salt mobilisation, relying on several factors for their characterisation: geology, soils, slope, regolith depth, and climate. The combination of these factors provides a structure for understanding how salinity manifests in the landscape, the differences in salinity development, and the impacts (land salinity/ salt load/ water electrical conductivity (EC)) in the landscape (DPIE, 2011a) (DPIE, 2011b).

A review of HGL mapping presented in Figure 4-23, Figure 4-24 and Figure 4-25, indicates the desktop assessment area intersects nine main HGLs. Table 4-8 portrays the nine HGLs and their definitive characteristics as described in the associated landscape information reports. The most prominent HGL within the desktop assessment area is the Upper South Creek (and Upper South Creek Variant A) HGL, which is intersected by the treated water pipeline east of Luddenham, the AWRC and brine pipeline in the vicinity of Kemps Creek and between Cecil Hills and Prospect Creek in Lansdowne.

Table 4-8 Summary descriptions of HGLs relevant to the desktop assessment area

Hydrogeological Landscape	Relevance to project feature(s)	Description
Hawkesbury	Intersected by environmental flows pipeline, in elevated areas between Warragamba River and Nepean River.	The Hawkesbury HGL is characterised by plateau, scarps, benches and hills on sandstones from the Triassic Hawkesbury Sandstone and Narrabeen Group as well as minor outbreaks of Tertiary Basalt and Jurassic Volcanics. Unconsolidated colluvial sediments and talus derived from Triassic sedimentary rocks have been deposited on the slopes and valley floors across this HGL. Depth to water table is typically deep (>8 m below ground level; m bgl). Land salinity is low, groundwater is generally fresh (EC less than 0.8 dS/m).
Mid-Nepean River	Intersected by environmental flows and treated water pipelines in low-lying areas west of the Nepean River.	The Mid-Nepean River HGL is characterised by floodplains and gentle rises on the active floodplain of the Nepean River, comprising unconsolidated alluvial sediments of fine-grained sands, silts and clays of the Quaternary period derived from the surrounding Wianamatta Group rocks and Hawkesbury Sandstone. Localised perching of water tables occurs above clay lenses during wetter periods. Depth to water table is typically shallow to intermediate (0-8 m bgl) with seasonal variation. Land salinity is low, groundwater is generally fresh (EC between 0.8-1.6 dS/m).
Mulgoa	Intersected by treated water pipeline in Wallacia, east of the Nepean River and again in the vicinity of Elizabeth Dr in Luddenham.	The Mulgoa HGL is characterised by hillslopes and benches on Triassic shale and sandstones (Bringelly Shale and Ashfield Shale) overlain by unconsolidated colluvial and alluvial gravels, sands and silts deposited on lower slopes and along streams. Localised perching of water tables occurs above clay lenses during wetter periods. Depth to water table is intermediate (2-8 m bgl) with seasonal variation. Land salinity is moderate, groundwater is generally brackish (EC between 1.6-4.8 dS/m).

Hydrogeological Landscape	Relevance to project feature(s)	Description
Greendale	Intersected by treated water pipeline between Park Rd in Wallacia and Elizabeth Dr in Luddenham.	The Greendale HGL is characterised by low rises, gently sloping plains and ponded drainage lines on Triassic Wianamatta Group rocks (predominately Bringelly Shale) overlain by unconsolidated sediments of sands, silts and clays of the Quaternary period. Localised perching of water tables occurs above clay lenses during wetter periods. Depth to water table is intermediate (2-8 m bgl) with seasonal variation. Land salinity is moderate, groundwater is generally brackish (EC between 1.6-4.8 dS/m).
Upper South Creek	Intersected by treated water pipeline east of Luddenham, the AWRC and brine pipeline in the vicinity of Kemps Creek	The Upper South Creek HGL is characterised by low, undulating hills with colluvial/ alluvial foot slopes and plains (often ponding) and drainage lines on Triassic Wianamatta Group rocks (predominately Bringelly Shale). Depth to water table is intermediate (2-6 m bgl). Land salinity is high, groundwater is generally saline (EC greater than 4.8 dS/m).
Mount Vernon	Intersected by the brine pipeline in Cecil Park	The Mount Vernon HGL is characterised by steep low hills on Triassic Wianamatta Group rocks (predominately Bringelly Shale). Alluvial sands and gravel are present along current streams. Depth to water table is intermediate (2-6 m bgl). Land salinity is moderate, groundwater is generally brackish (EC between 0.8-1.6 dS/m).
Denham Court	Intersected by the brine pipeline in Cecil Hills	The Denham Court HGL is characterised by steep low hills on Triassic Wianamatta Group rocks (predominately Bringelly Shale). Quaternary alluvial soils (fine-grained sands, gravels, silts and clays) are present along drainage lines. Depth to water table is intermediate (2-6 m bgl). Land salinity is moderate, groundwater is generally fresh (EC less than 0.8 dS/m).
Upper South Creek variant A	Intersected by the brine pipeline between Cecil Hills and Prospect Creek in Lansdowne	The Upper South Creek Variant A HGL is characterised by low, undulating hills with colluvial/ alluvial foot slopes and plains (often ponding) and drainage lines on Triassic Wianamatta Group rocks (predominately Bringelly Shale). Depth to water table is intermediate (2-6 m bgl). Land salinity is high, groundwater is generally brackish to saline (EC between 1.6-4.8 dS/m).
Moorebank	Intersected by the brine pipeline east of Prospect Creek	The Moorebank HGL is characterised by alluvial deposits associated with the Georges River, including broad, flat alluvial plains intersected by present day drainage channels (e.g. Prospect Creek). Unconsolidated materials comprise Neogene alluvial sediments (sands and clays) overlying small areas of Triassic Hawkesbury Sandstone and Wianamatta Group shales (predominately Ashfield Shale). Depth to water table is shallow to intermediate (0-8 m bgl) with seasonal variation. Land salinity is moderate, groundwater is generally fresh (EC between 0.8-1.6 dS/m).

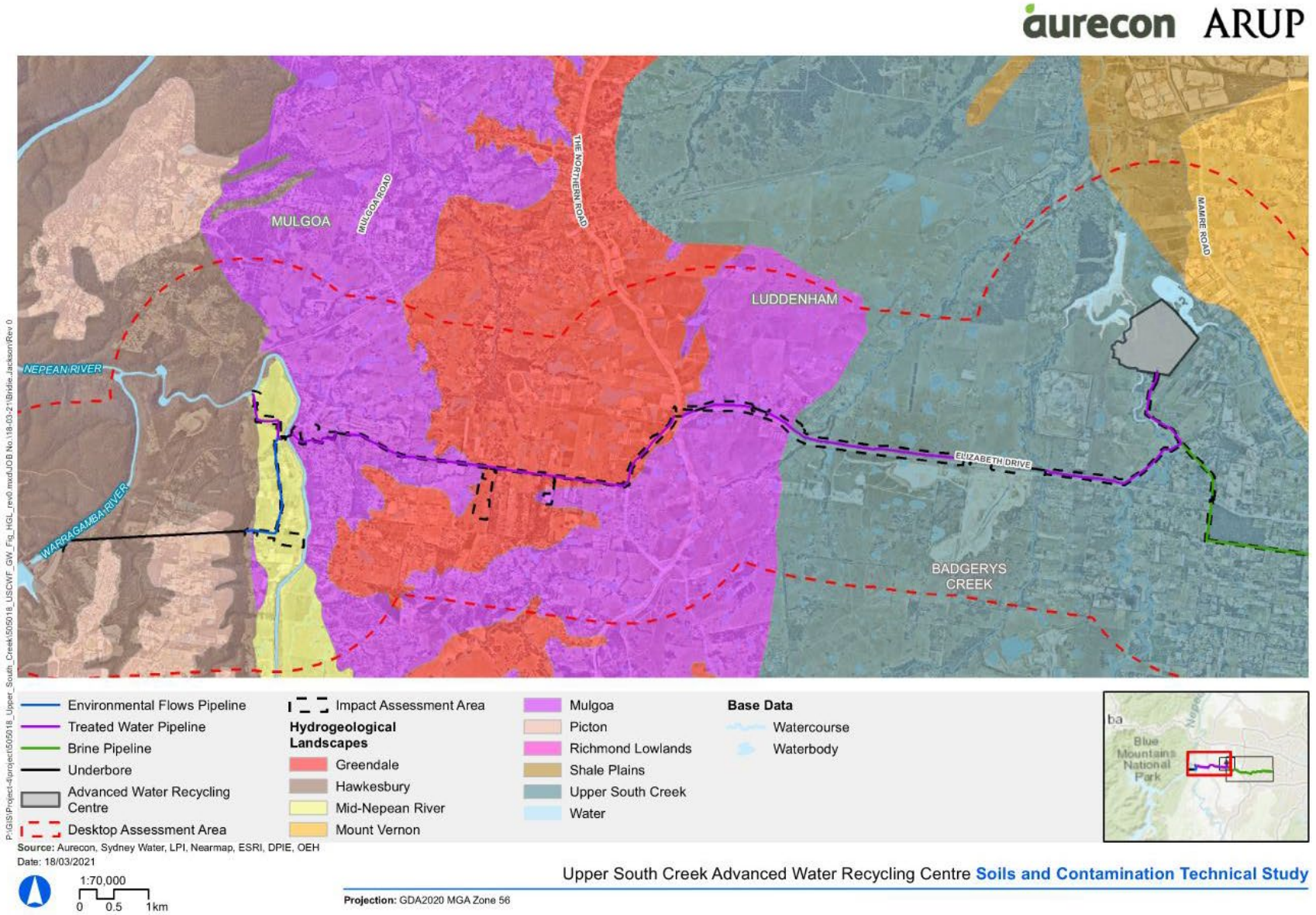


Figure 4-23 Hydrogeological Landscapes – Treated water pipelines

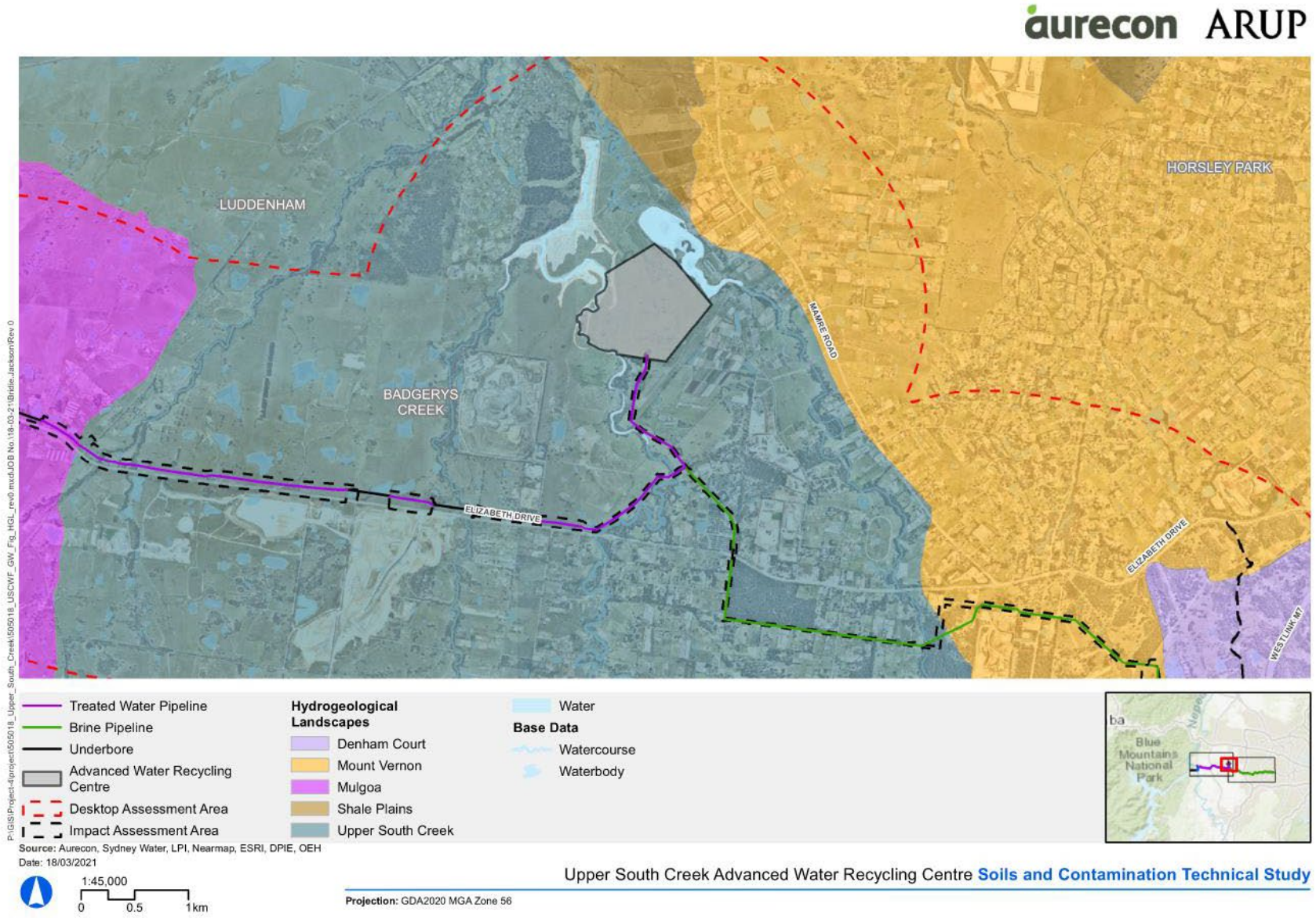


Figure 4-24 Hydrogeological Landscapes – AWRC site

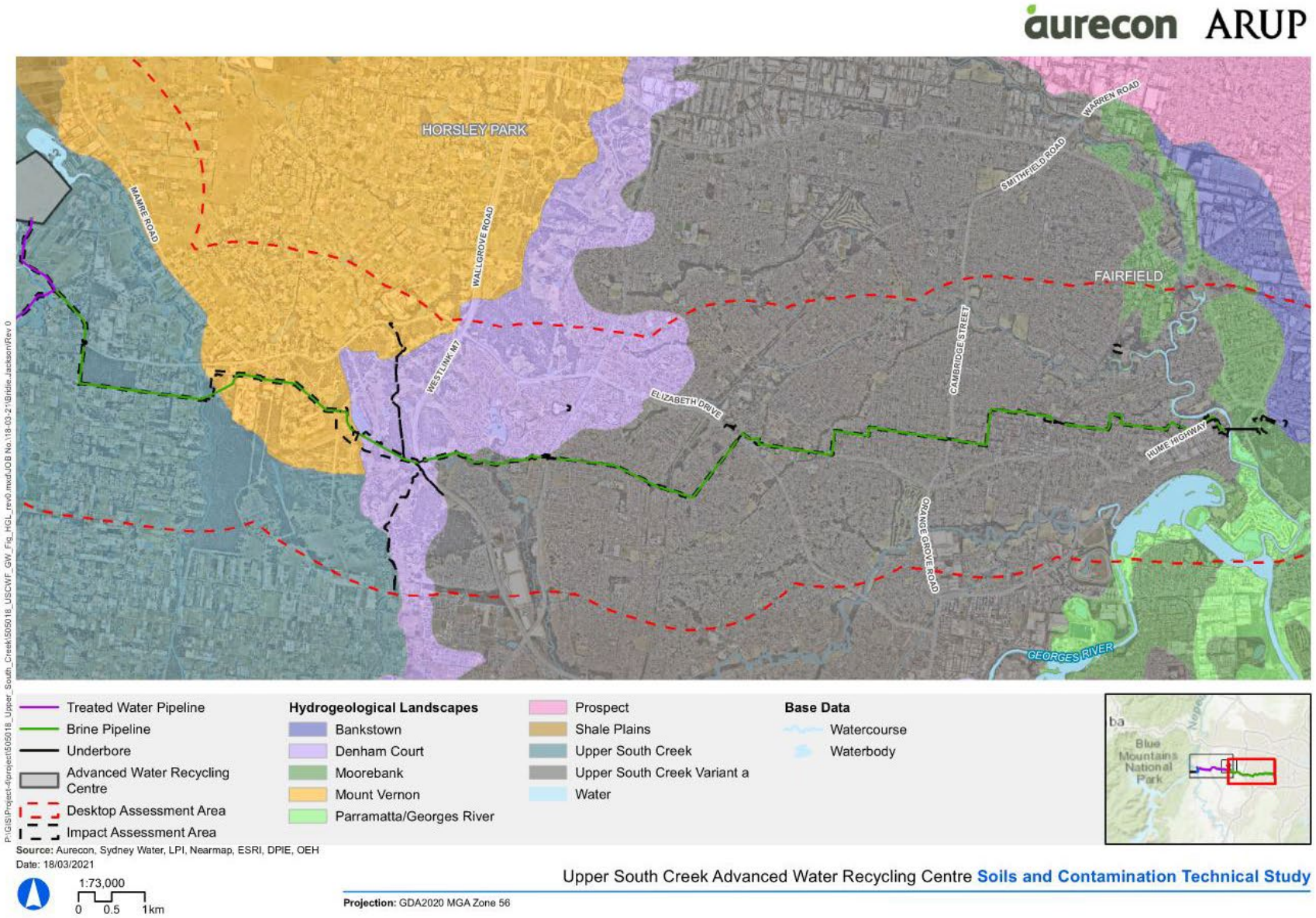


Figure 4-25 Hydrogeological Landscapes – Brine pipeline

4.11 Salinity

Salinity occurrence in the region is associated with historical evaporation of inland seas, prevailing winds carrying ocean salt and the weathering of sedimentary rocks with connate salt. Dissolved salt infiltrates into groundwater where it gets left behind by natural wetting/drying cycles and therefore concentrates. Salinity is therefore associated with drainage systems or low lying/flat grounds with shallow water tables where there is high potential for the ground to become waterlogged.

A review of the Sydney Metropolitan Western Hydrogeological Landscapes (DPIE, 2011) for the project desktop assessment area indicates a variable salinity risk across the project as summarised in Table 4-9 and presented in Figure 4-26, Figure 4-27 and Figure 4-28. Areas to the west around Warragamba and Wallacia have a very low to moderate salinity risk, while all other areas are within moderate to high salinity risk areas, with some areas of known salinity.

Areas with high salinity potential include the low-lying areas around Cosgrove Creek and along Kemps Creek.

Given that the AWRC is located within a regional alluvial plain and is in a topographic low lying/flat area, there is potential for salinity to be present in soils and groundwater in this area. Water quality data from June 2018 in Kemps Creek and South Creek alongside the AWRC reported electrical conductivities of 1,889 and 2,640 µS/cm respectively, indicating brackish water.

Previous investigations on groundwater in the Wianamatta Group (Bringelly Shale, Minchinbury Sandstone and Ashfield Shale) have reported salinities between 5,000 and 26,000 ppm (PPK, 1999; McNally, 2004).

Groundwater salinity in the Hawkesbury Sandstone is variable, ranging from fresh to brackish in the upper aquifers and freshening with depth.

Table 4-9 Salinity risk within the desktop assessment area

Class	Sites	Location in the desktop assessment area	Description
Very Low	• Treated water pipelines	The western extent of the pipeline desktop assessment area, near the Warragamba and Nepean Rivers.	Areas in which salinity processes do not operate or are of minor significance. Soils are rapidly drained and underlying strata (Hawkesbury / Narrabeen Sandstones) are highly permeable, resulting in continual flushing and removal of salts in the landscape. No salinity has been reported in these areas, nor is expected to occur.
Moderate	• Treated water pipelines • Brine pipeline • AWRC site	Across the majority of the desktop assessment area, particularly in locations with higher elevations, typically 200 m away from waterways.	Covers all areas of Wianamatta Group shales (Ashfield or Bringelly shales) and tertiary alluvial terrace geologies where high or known salinity is apparent.
High	• Treated water pipelines • Brine pipeline	Across the desktop assessment area, typically nearby waterways.	Areas where soil, geology, topography and groundwater conditions predispose a site to salinity. These conditions are similar to those occurring in areas of known salinity. These areas are most common in lower slopes and drainage systems where water accumulation is high.

Class	Sites	Location in the desktop assessment area	Description
Known Salinity	• Treated water pipelines • Brine pipeline	A small section within the Western Sydney Parklands and along the sections of Cosgrove Creek and Oaky Creek.	Areas where there is a known occurrence of saline soil, or where air photo interpretation and field observations have confirmed more than of these: • Scaling • Salt efflorescence • Vegetation dieback • Salt tolerant plant species • Waterlogging • A high relative wetness index occurs in these areas

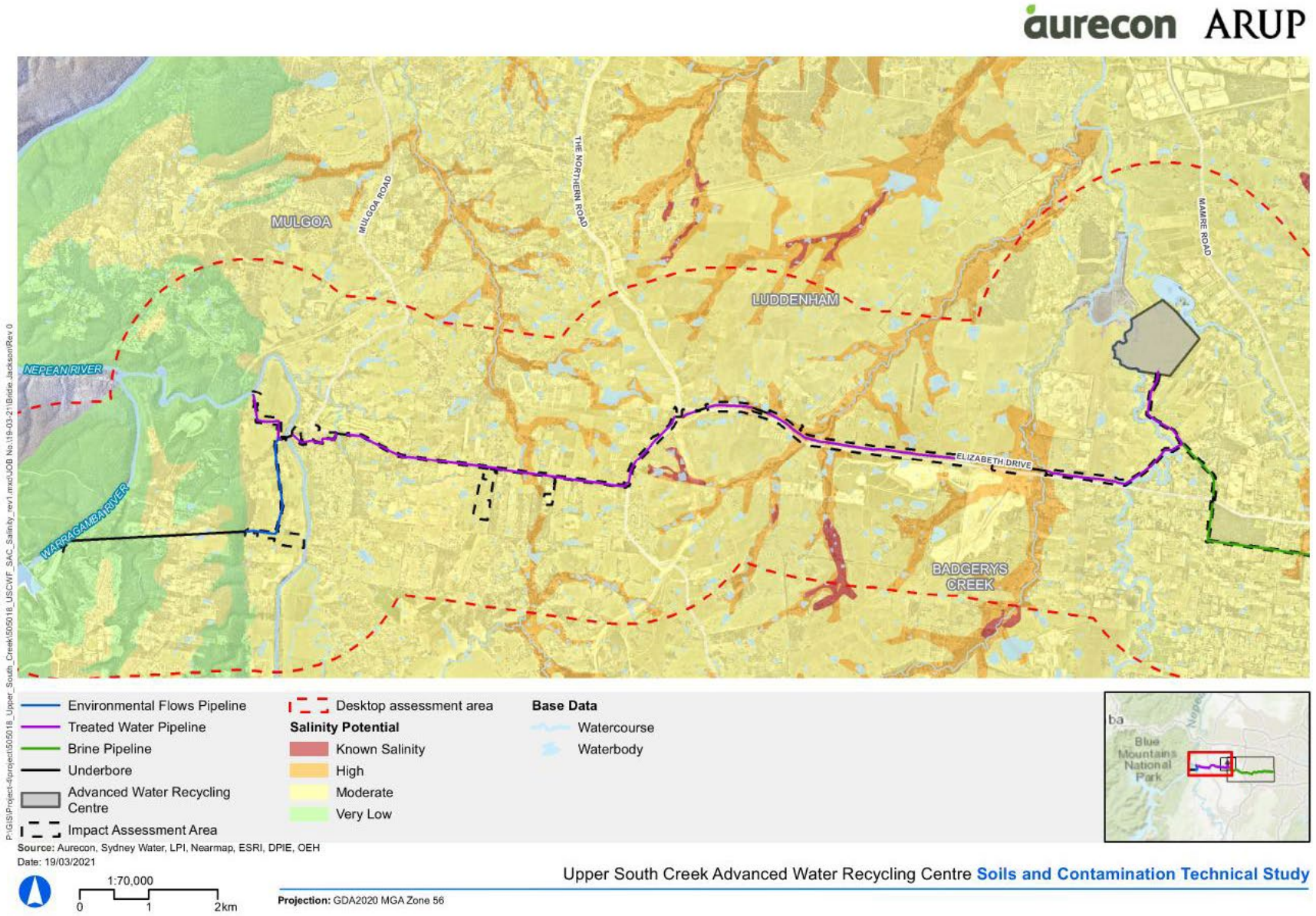


Figure 4-26 Distribution of Salinity Risk – Treated water pipelines

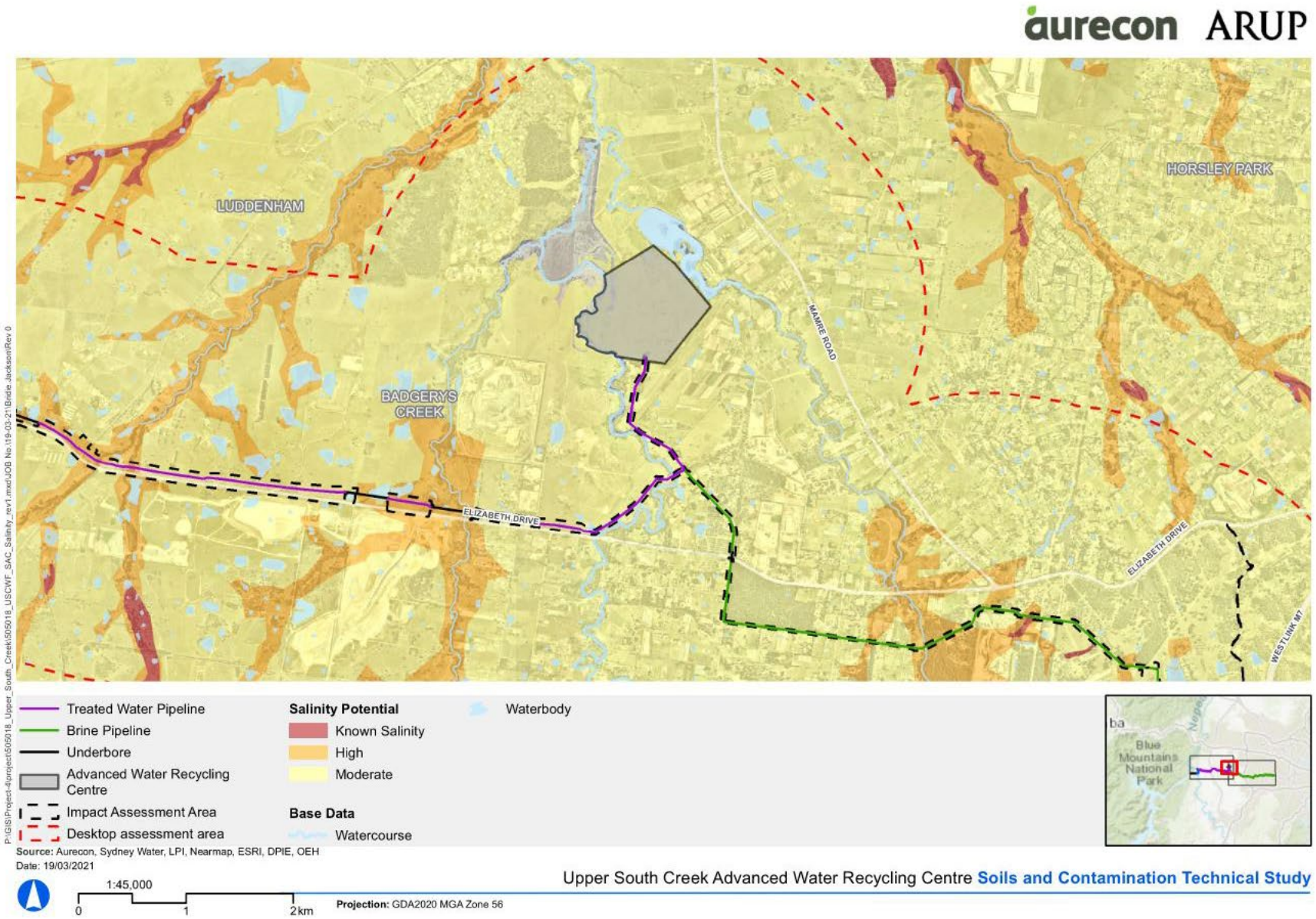


Figure 4-27 Distribution of Salinity Risk – AWRC site

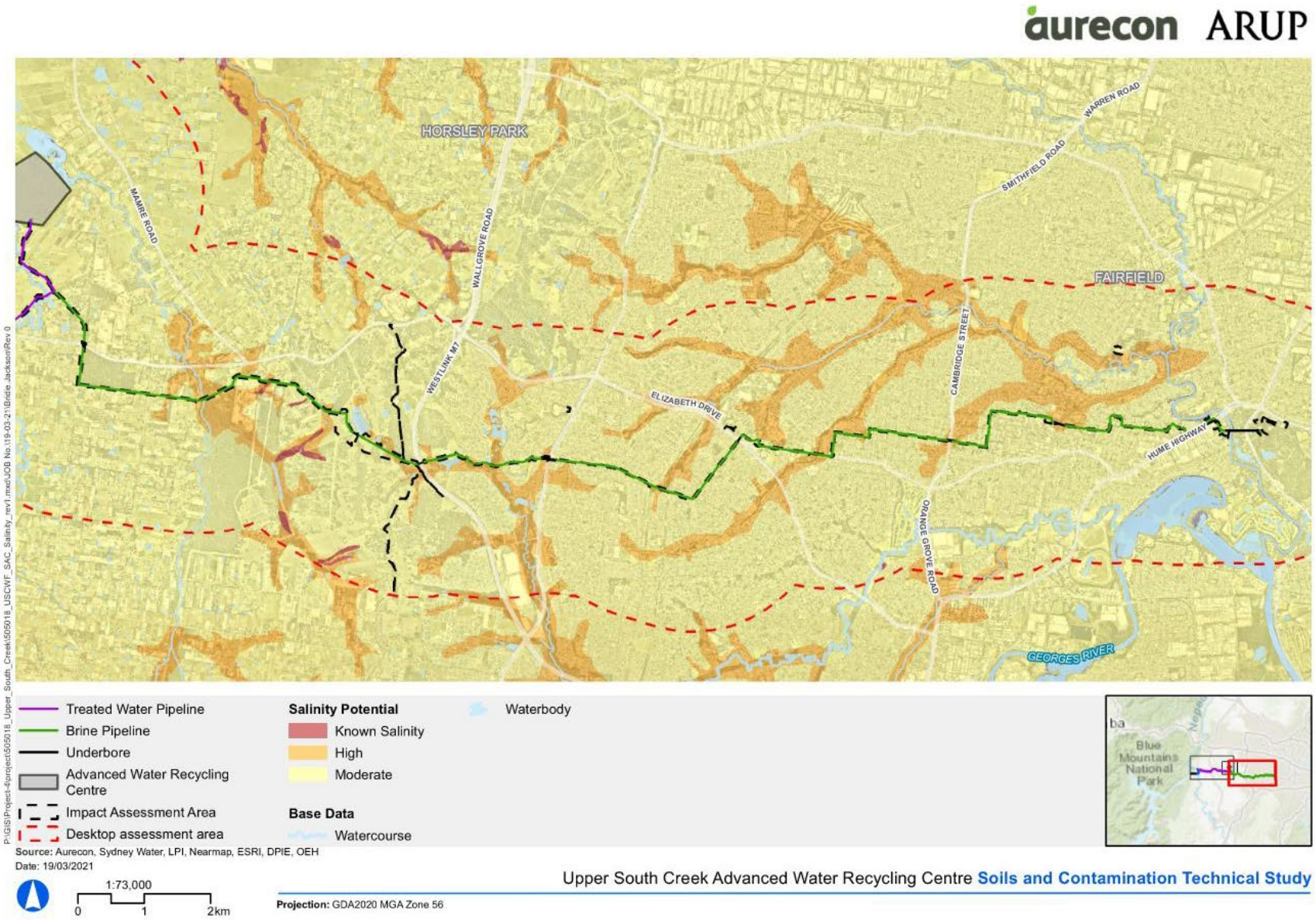


Figure 4-28 Distribution of Salinity Risk – brine pipeline

4.12 Acid Sulfate Soils

ASS refer to soils containing sulfides. When the sulfides contained in ASS are exposed to oxygen, such as from groundwater drawdown and/or excavation, sulfuric acid can be generated, which may result in a number of detrimental effects on groundwater dependant ecosystems, underground structures and receiving water bodies, including:

- Sulfuric acid causing leaching/mobilisation of metals from otherwise stable soil matrices, increasing the concentration of heavy metals in the groundwater to potentially toxic levels
- Reduced durability of underground structures, such as steel and concrete, through corrosion
- Degradation of soil quality in affected areas, preventing vegetation growth

The Bankstown Local Environmental Plan (LEP) 2015 and Fairfield LEP 2013 (the only Councils in the desktop assessment area with ASS risk mapping) indicates it is situated across four ASS probability classes:

- Class 1 – located within the eastern portion of the brine pipeline, along the banks of Prospect Creek
- Class 3 – located within the eastern portion of the brine pipeline, to the south of the alignment along Prospect Creek, adjacent to Class 4
- Class 4 – located within the eastern portion of the brine pipeline, to the south of the alignment along Prospect Creek, adjacent to Class 3
- Class 5 – located within the eastern portion of the brine pipeline, within a 500 m radius of Prospect Creek

The mapping provides an estimation of ASS presence within the desktop assessment area. ASS probability mapping classes across the desktop assessment area is presented in Figure 4-29.

Table 4-10 presents the ASS probability class and definitions with Classes 1, 3, 4 and 5 ASS present, as discussed above within the desktop assessment area. Please note that development conditions regarding ASS impacts are not required to be met for the project and are provided for information purposes only.

Table 4-10 ASS probability classes and development consent conditions (Bankstown LEP, 2015; Fairfield LEP 2013)

Class	Restriction to works
1	Any works.
2	Works below the natural ground surface. Works by which the water table is likely to be lowered.
3	Works more than 1 metre below the natural ground surface. Works by which the water table is likely to be lowered more than 1 metre below the natural ground surface.
4	Works more than 2 metres below the natural ground surface. Works by which the water table is likely to be lowered more than 2 metres below the natural ground surface.
5	Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below 5 metres AHD and by which the water table is likely to be lowered below 1 metre AHD on adjacent Class 1, 2, 3 or 4 land.

A search of the DPIE ASS risk map indicates that the majority of the project area is not located within an area of potential ASS including the AWRC site and surrounds.

Some potential ASS risk areas are present around Prospect Creek in the eastern portion of the desktop assessment area as outlined in Figure 4-30, including:

- A high potential for occurrence of ASS along the brine pipeline for bottom sediments and surrounding embankments where Hume Hwy intersects Prospect Creek
- A high potential for occurrence of ASS for bottom sediments in the George Rivers near Moorebank, and a low probability for occurrence of ASS along the sides of the Georges River
- Areas surrounding the Georges River in Chipping Norton and Millperra, where a mixture of ASS probability zones are present, including disturbed terrain, high probability ASS, high probability bottom sediments, and low probability for ASS

The risk of disturbing ASS within the desktop assessment area is present within the eastern portion of the brine pipeline. The main disturbance mechanisms will be ground disturbance by excavation, Horizontal Directional Drilling (HDD) and localised dewatering / ground water management for the pipelines.

Review and interpretation of ASS conditions from previous desktop assessment area site investigations and analytical testing are summarised in Section 8.

4.13 Mine Subsidence

Review of the NSW Government Subsidence Advisory mine subsidence districts mapping (2017) indicates that the desktop assessment area is not within an area of mine subsidence risk. The closest mine subsidence district is South Campbelltown where the northern most area is within the suburb of Menangle Park (approximately 20 km to the south of the AWRC and desktop assessment area). There is therefore a low risk of encountering mine subsidence within the desktop assessment area.

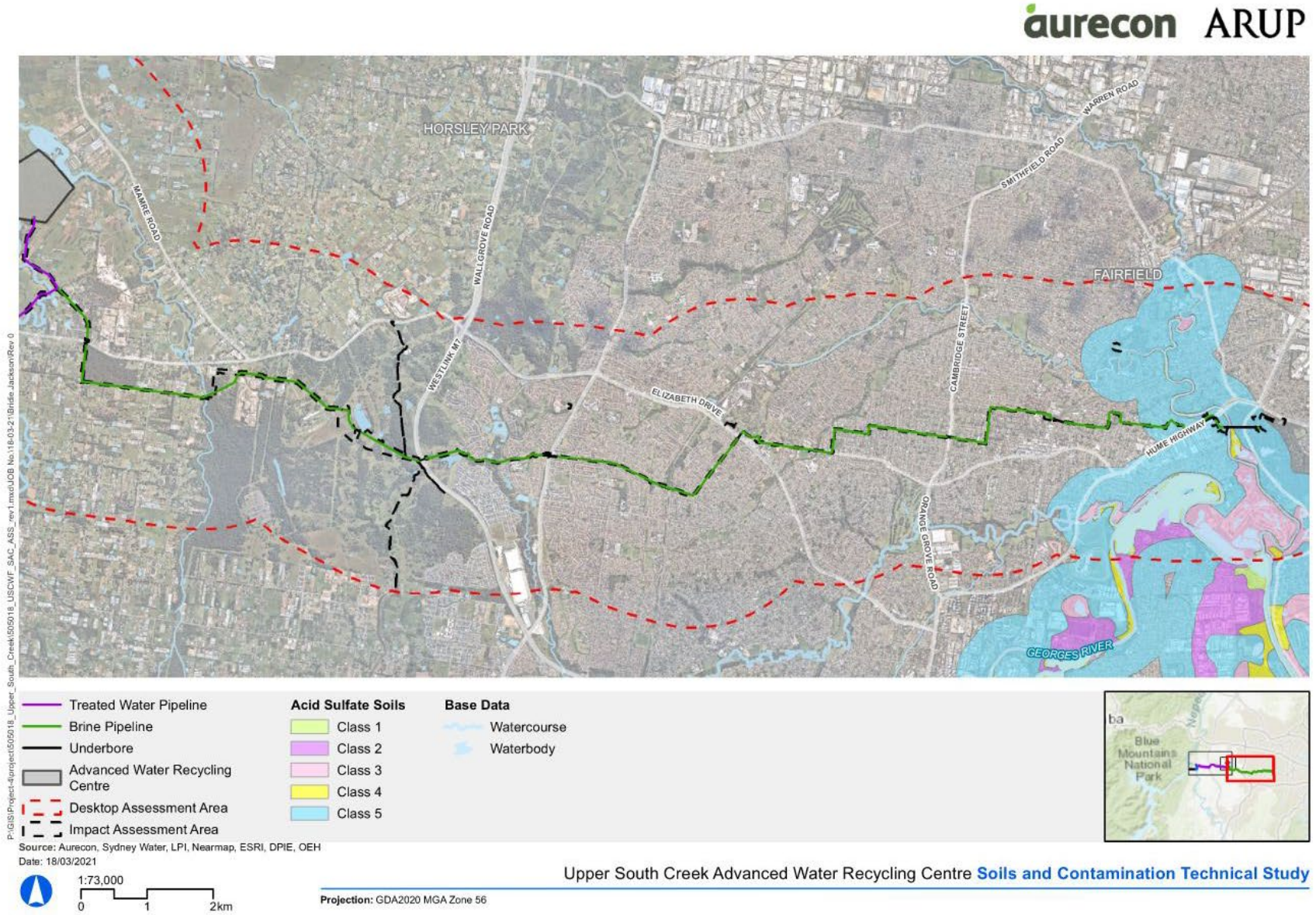


Figure 4-29 Acid sulfate soils probability and classes within the desktop assessment area

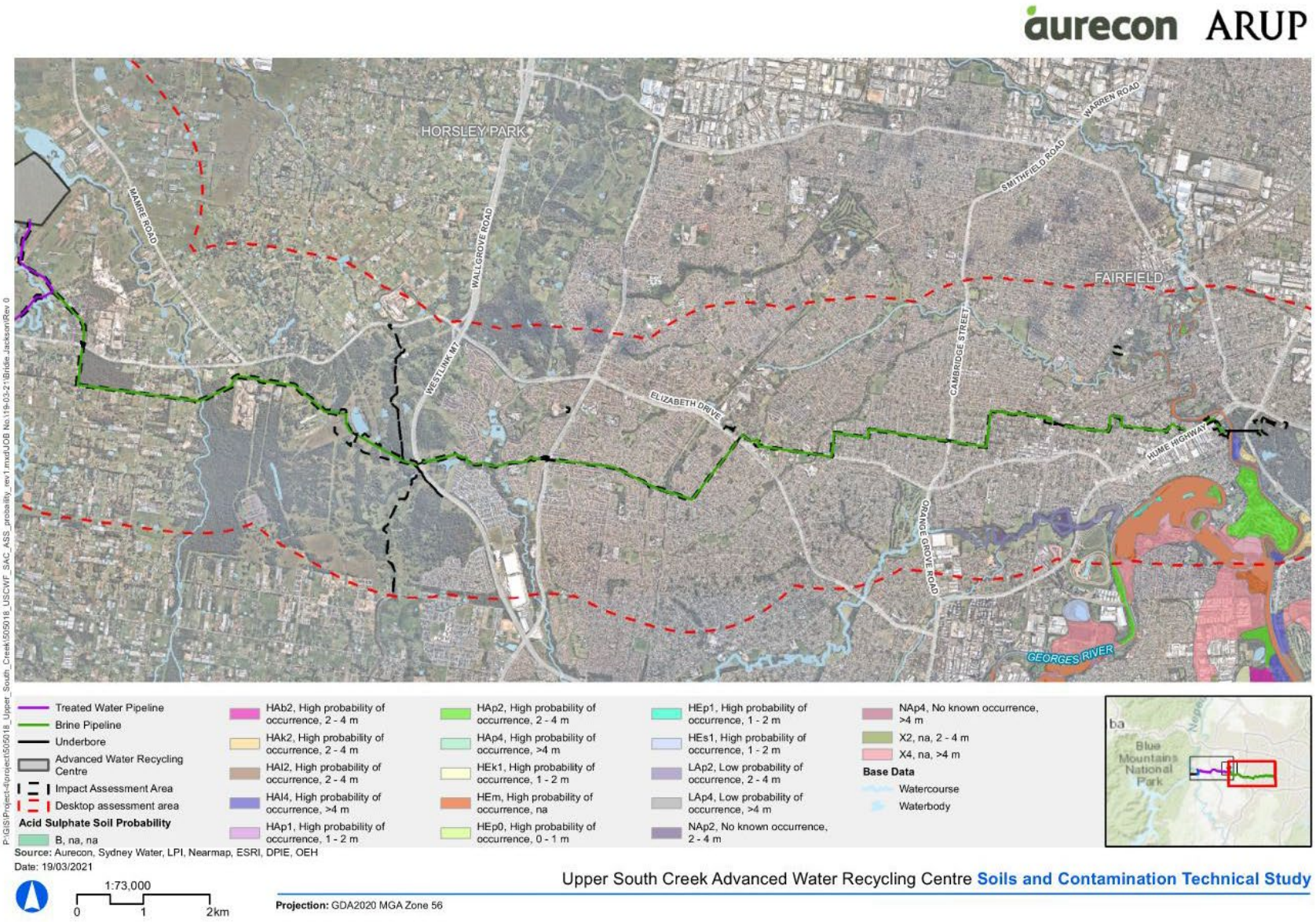


Figure 4-30 Distribution of Acid sulfate soil risk within the desktop assessment area

5 Site Inspection of Impact Assessment Area

Site inspections of the impact assessment areas were conducted for the PSIs for the AWRC and pipelines (Aurecon Arup, 2019a; Aurecon Arup, 2020a). Additional site inspections were conducted during intrusive investigations. The following sections are summarised from the relevant information in the PSI report and additional site inspections undertaken in 2020.

5.1 Advanced Water Recycling Centre Site

Site inspections were undertaken in June 2020 as part of intrusive ground investigations on the site. The following was noted:

- The AWRC site is located on a flat paddock currently used for cattle grazing. A number of cattle were present on the site during the site inspection
- Vegetation on site appeared relatively healthy with the ground covered densely in grass and weeds. Blackberry bushes were scattered around the site. Common Pigweed was noted along the banks of South Creek to the west while a few Marsh Buttons were noted to the north-east near Kemps Creek. Both plants are potential indicators of salinity in the area.
- The soil on site consisted predominantly of clay. The site visits noted that following rain events, the soil remains very wet and muddy, with water visible on the surface.
- South Creek is present to the west of the site, with erosion visible along the creekbank
- An abandoned farmhouse is present around the centre of the site. Fibre cement pieces and wire mesh were observed scattered around the house.
- Two radio telescope dishes were observed on the AWRC site: one on the south-western end and one to the east
- Mounds of soil at the SUEZ Kemps Creek Resource Recovery Park were visible to the south-west of the site

5.2 Pipelines

A site inspection for the proposed pipeline alignments was conducted on the 21st and 27th November 2019 to assess for the potential risk of subsurface impacts along and in the vicinity of the impact assessment areas. Additional inspections were also undertaken throughout March to May 2020 as part of intrusive fieldworks. The general observations from the site inspection findings are presented in Table 5-1.

Table 5-1 Site inspection summary

Option	Site inspection notes and ground condition
Treated water	• The alignment mainly runs through bushland, rural land and rural farmland, with some rural living. Some residential and commercial buildings are present at central Wallacia, including a service station • Large scale earthworks were observed along Elizabeth Dr for the Western Sydney Airport • No unusual odours or staining were observed

Option	Site inspection notes and ground condition
Environmental flows	• The alignment runs through bushland and rural living • Weir Rd was residential • No unusual odours or staining were observed
Brine pipeline	• The alignment runs primarily through residential areas from the east up to M7. Beyond M7, the alignment is mostly bushland, rural living and agricultural land. • The eastern end of the alignment is present within Shortland Brush. A lake with wildlife is present to the south of the alignment. The alignment runs through Prospect Creek to Lansvale Reserve. • A playground and a public toilet were noted to the north of the alignment within Lansvale Reserve. Residential housing was present to the west of the reserve. • Industrial businesses and warehouses were noted on Hume Hwy, including an EPA notified service station • The alignment passes through the Western Sydney Parkland and along the eastern edge of the Sydney International Shooting Centre, adjacent to an access track • Range Rd leads to the Brandown Quarry. Some farm waste and a stockpile were noted • A truck and equipment yard, skip bins, mechanical waste and two shipping containers were noted on eastern Cross St • The eastern section of Cross St had illegal dumping of domestic waste on the north and agricultural lots on the south • Andreasen Green Wholesale Nurseries was present to the north of Elizabeth Dr, with several large farm buildings and warehouses present further north at CR & M Ash & Sons • No unusual odours or staining were observed

6 Project activities

6.1 Construction Phase

6.1.1 AWRC Site

The key construction phase activities for the proposed AWRC site include the following:

- Establishment site runoff control
- Establishment of bench. The detailed approach to this has not been finalised but a typical methodology would involve:
  - Grubbing
  - Removal and stockpiling of 200-300 mm of topsoil for re-use later (following chemical and geotechnical testing for suitability). An area of approximately 115,000 m2 will need to be stripped equating to a topsoil volume around 34,500 m3
  - Geotechnical investigation identified the underlying 200 mm of material below the topsoil is unsuitable for construction and is to be removed and disposed offsite
  - Stormwater management (e.g. installation of appropriate erosion and sediment controls)
  - A water tank will be required for dust suppression
  - Cut and fill to bench levels with import of quality engineered fill as required and removal of any excess / poor quality material if it cannot be re-used on site elsewhere for landscaping purposes
  - Filling performed in layers of up to about 300 mm, which is compacted before the next layer is added. The fill depth on this site will generally increase from southeast to northwest up to a depth of about 2.5 m
- Excavation for construction of below surface infrastructure, including targeted dewatering of surficial local aquifer systems to required depths.
- Installation of subfloor drainage, foundations and underground infrastructure.

6.1.2 Pipelines

Key construction phase activities associated with the installation of the pipelines will include the following:

- Excavation (trench, shafts and/or pits) for construction of below surface infrastructure, including targeted dewatering of surficial local aquifer systems to required depths.
- Installation of foundations and underground infrastructure.
- Installation of aboveground civil, mechanical and electrical plant and equipment.

Different construction methods are proposed along the pipeline routes. In general, the pipelines will be constructed using standard trenching methods. Where existing infrastructure (above and below ground) or major watercourses are intersected, trenchless methodologies (i.e. Horizontal Directional Drilling (HDD), pipe jacking and micro-tunnelling) will be employed.

Trenchless sections completed using HDD generally involve the activities listed above, in addition to the following:

- Mobilising the drill equipment and installing measures to manage groundwater if required.
- Inject a bentonite-based drilling fluid to lubricate the drill head and flush the drilled hole. Remove drill cuttings to be contained, collected and recycled/disposed.
- As the HDD bore and drill head advances, a casing pipe and the pipeline is inserted while grouting the annulus.

Trenchless sections completed using microtunneling / pipe-jacking generally involve the activities listed above, in addition to the following:

- Establish launch and reception shafts, install jacking frame and headwalls.
- Mobilising the drill equipment and installing within the launch pit, including measures to manage groundwater if required.
- Remove drilling fluids and cuttings via vacuum extraction.
- Once the jacking pipe reaches the reception shaft, the pipeline is inserted, and annulus is grouted.

6.2 Operational Phase

6.2.1 AWRC Site

The primary activities that could lead to groundwater impacts associated with the operational phase of the project all relate to site stormwater management practices as well as potential underdrainage systems for underground structure flotation management.

The key operational phase activities for the proposed AWRC site include the following:

- On and off-site irrigation
- Pumped underdrainage systems
- Storage and use of chemicals and contaminants

6.2.2 Pipelines

During standard operating conditions limited activities will be conducted directly relating to the operation of the pipelines. However, maintenance activities or breakdowns leading to potential impacts to local groundwater systems are:

- Pipe leaks/bursts

7 Contamination Risk Review

Detailed assessment of contamination risks for the desktop assessment area have been reported in PSIs and DSIs for the AWRC and pipelines (Aurecon Arup, 2019a; Aurecon Arup, 2021a). The PSIs include a detailed assessment of NSW Government databases and historical aerial photography review for the desktop assessment area. The following sections are summarised from the relevant information in the PSI reports and relevant contamination risks identified.

7.1 Contaminated Sites Notified to the NSW EPA

Under Section 60 of the *Contaminated Land Management Act 1997* (CLM Act), a person whose activities has contaminated land, or a landowner whose land has been contaminated, is required to notify the EPA if certain conditions are met. For example, if contaminant levels are above current or approved land use criteria and people have been (or will foreseeably be) exposed to the contamination, the EPA is to be notified.

The EPA maintains a register of sites of which it has been notified under Section 60 of the CLM Act. The register identifies sites of which the EPA is aware in its regulatory role and is not a list of all contaminated sites in NSW.

A search of the NSW EPA public register (notified sites and the contaminated land record) of contaminated sites was undertaken on the 19 May 2021. The results identified a number of records for addresses within 200 m of the pipeline alignments. No notified sites are within 200 m of the AWRC site. Sites have been summarised in Table 7-1 and shown in Figure 7-1, Figure 7-2 and Figure 7-3.

Most of the notified sites are listed as not requiring regulation under the CLM Act. However, the Caltex service station on 141 Hume Hwy was formerly regulated for contamination under the CLM Act.

The risks of the EPA notified sites impacting the pipeline alignments are considered to be low due to management class and/or distance from the pipelines. Metro Service Station Bonnyrigg is considered to be moderate risk due to known contamination and distance from pipeline.

Table 7-1 EPA notified contaminated sites within the desktop assessment area

Contaminated Land Record	Site Location	Site Description	Approximate distance from project feature / impact area
Caltex Service Station	3019-3035 The Northern Rd, Luddenham	Service Station	115 m from treated water
BP-Branded Service Station Bonnyrigg	451 North Liverpool Rd, Bonnyrigg	Service Station	10 m from brine pipeline
Metro (Formerly United & AP SAVER) Service Station Bonnyrigg	709 Cabramatta Rd W, Bonnyrigg	Service Station	10 m from brine pipeline
Caltex Service Station Cabramatta	168 John St, Cabramatta	Service Station	10 m from brine pipeline
Mobil Service Station	44 Hume Hwy, Lansvale	Service Station	7 m from brine pipeline

Contaminated Land Record	Site Location	Site Description	Approximate distance from project feature / impact area
Coles Express Lansvale	99 Hume Hwy, Lansvale, Canley Vale	Service Station	40 m from brine pipeline
Caltex (former Mobil) Lansvale Service Station	141 Hume Hwy, Lansvale	Service Station	200 m from brine pipeline
BP Lansvale	115-119 Hume Hwy, Cabramatta West	Service Station	50 m from brine pipeline
Caltex Service Station	1163 Mamre Road, Kemps Creek	Service Station	1.1 km east of the AWRC
United Petroleum petrol station	1465-1467 Elizabeth Drive, Kemps Creek	Service Station	1.2 km south-east of the AWRC
BP Petrol Station	Lot 5 / 1443 Elizabeth Drive, Kemps Creek	Service Station	1.3 km southeast of the AWRC

A search of the Sydney Water spatial hub contamination annotations was undertaken on the 26th March 2020.The results identified two records for EPA notified sites – Metro Service Station Bonnyrigg at 709 Cabramatta Road West, Bonnyrigg, and Caltex Lansvale Service Station, at 141 Hume Hwy, Lansvale. Both these sites are already listed in Table 7-1 above.

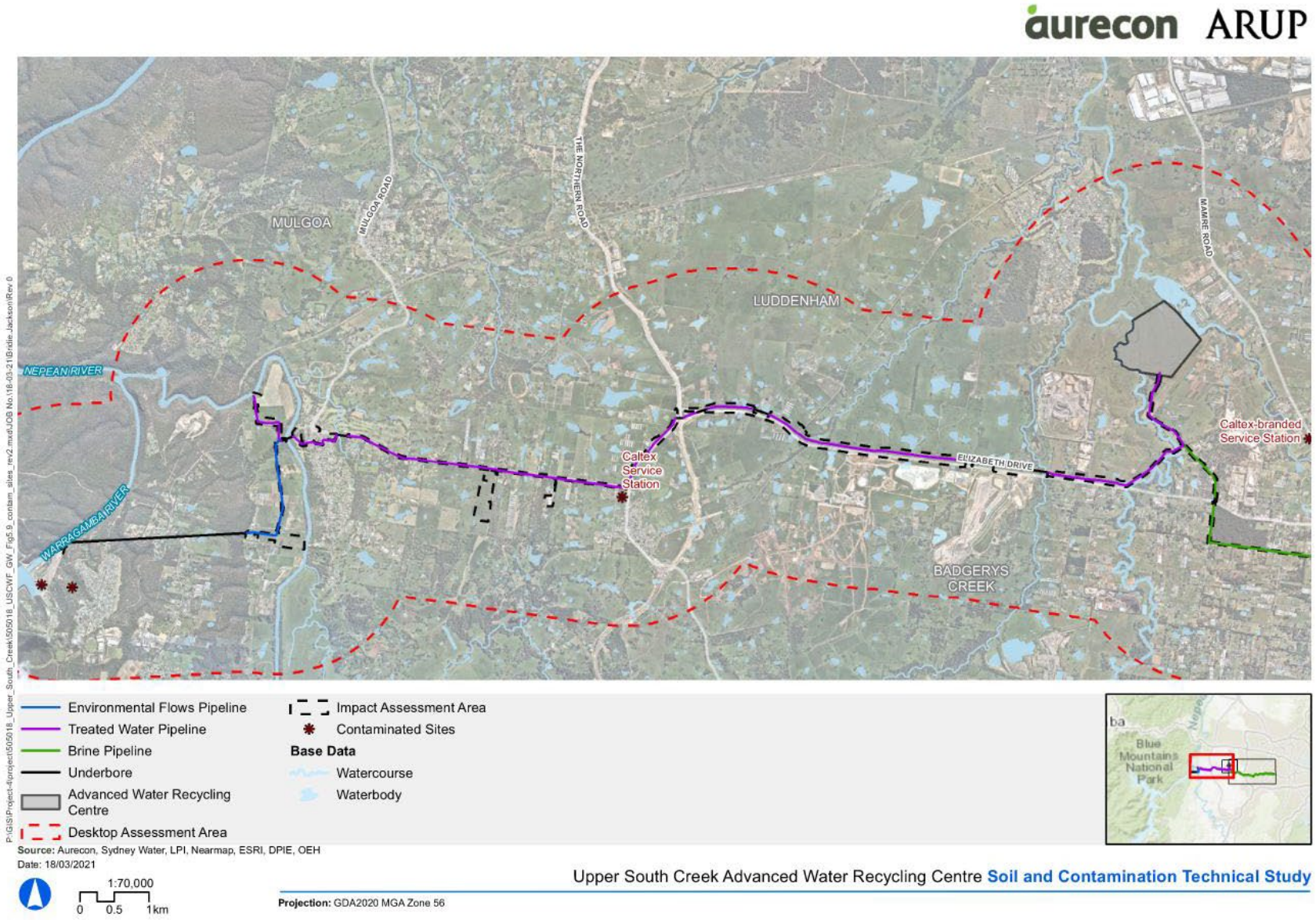


Figure 7-1 Contaminated sites notified to the EPA – Treated water pipelines

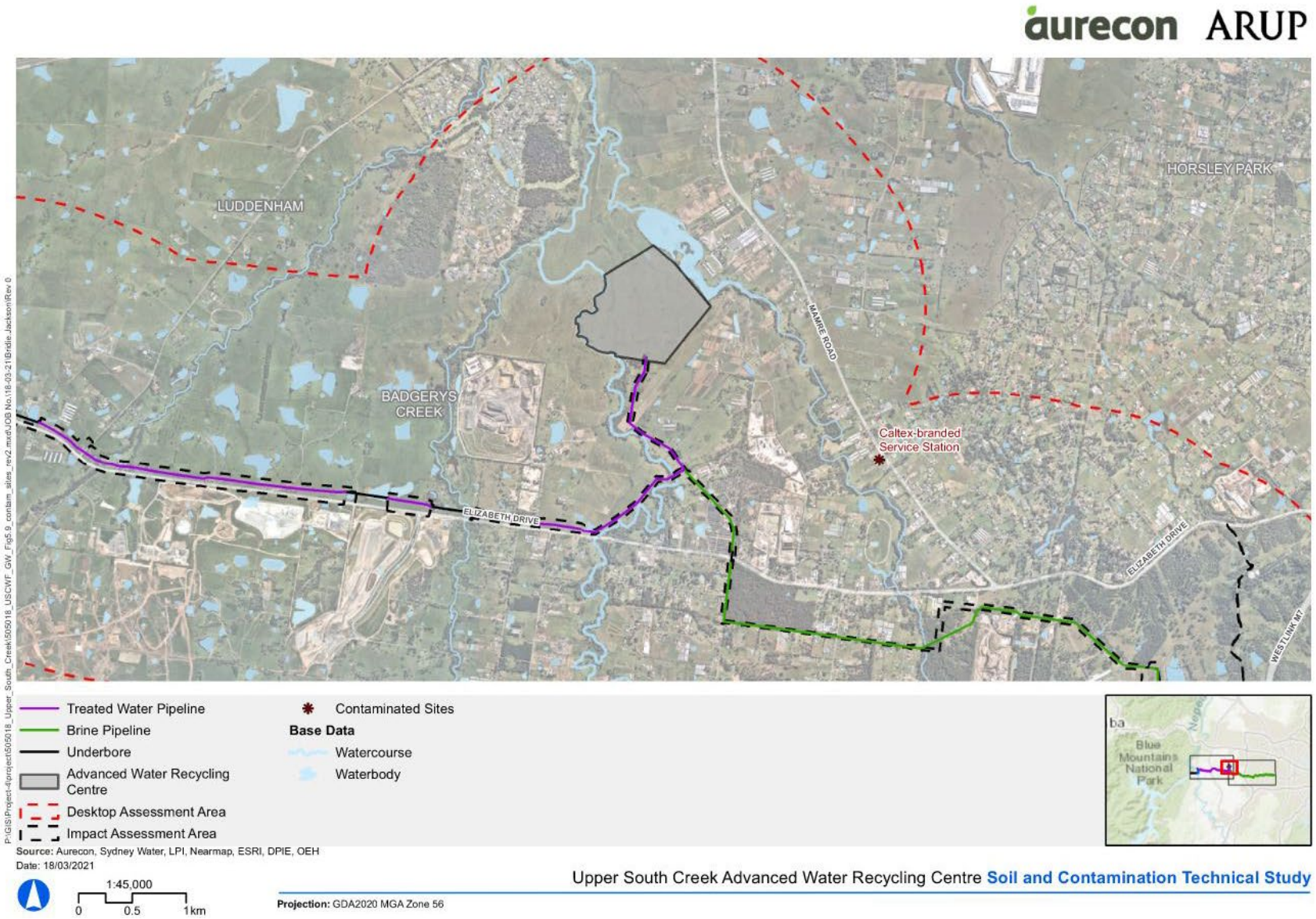


Figure 7-2 Contaminated sites notified to the EPA – The AWRC site

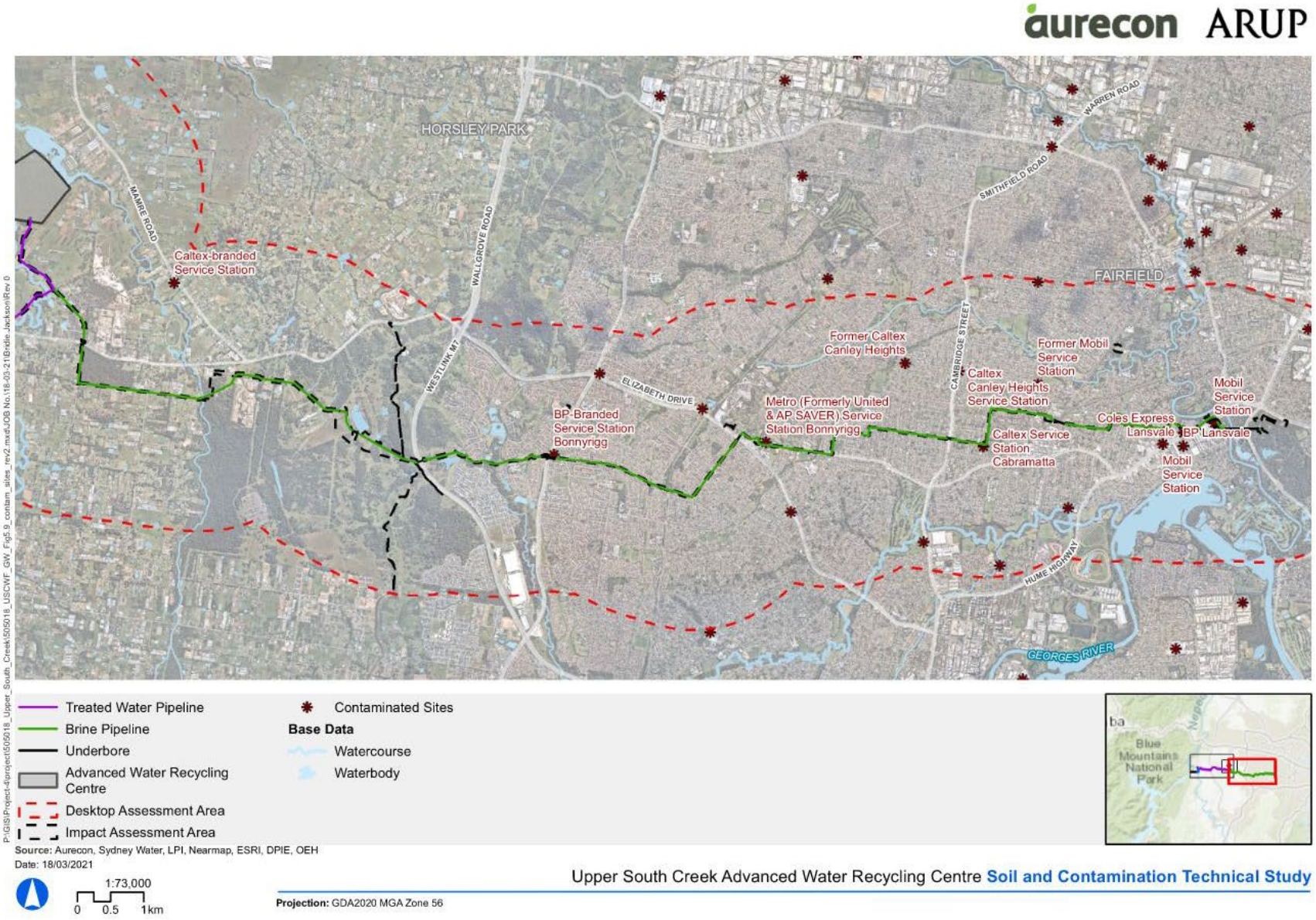


Figure 7-3 Contaminated sites notified to the EPA – Brine pipeline

7.2 NSW Government PFAS Investigation Program

The environmental and potential human health impacts from exposure to PFAS are of increasing concern worldwide. Environmental legislation in many jurisdictions includes obligations and duties to prevent environmental harm, nuisances and contamination. PFAS contamination can be environmentally significant due to its persistence and potential for bioaccumulation.

The PFAS National Environmental Management Plan was designed to regulate PFAS in the environment. The NSW EPA is currently undertaking a state-wide PFAS investigation program to identify the use and impacts of legacy PFAS.

Two PFAS investigation sites were identified within a 5 km radius of the desktop assessment area and are summarised below and shown in Figure 7-4.

Kemps Creek NSW Rural Fire Service at 245 Devonshire Rd, Kemps Creek

The NSW Rural Fire Services is investigating PFAS contamination stemming from the historical use of fire-fighting foams at its Kemps Creek site. The site is located 3.1 km from the brine pipeline and 4.5 km from the treated water pipeline.

A DSI to investigate PFAS impacts was completed in April 2018 which verified the presence of PFAS at and around the AWRC in soil, sediment, surface and groundwater. The detection of PFAS is not unexpected given the past use of PFAS-containing fire-fighting foams at the site. PFAS has also been used in many domestic and industrial products and background levels may be present from these other sources. The RFS is currently developing a Site Management Plan to inform management actions for the site.

The EPA and NSW PFAS Taskforce has recommended that specific residents near the depot do not use surface water for drinking, cooking or watering produce.

Bankstown Airport at 3 Avro St, Bankstown

The Sydney Metro Airports (SMA) is investigating PFAS contamination stemming from the historical use of fire-fighting foams at Bankstown Airport. The site is located 2.6 km from the brine pipeline.

Investigations have found PFAS both on and offsite. The detection of PFAS is not unexpected given the past use of PFAS-containing fire-fighting foams at the site. PFAS has also been used in many domestic and industrial products and background levels may be present from these other sources.

The SMA is conducting DSIs to better understand the extent of the presence of PFAS. Residents have been informed that fish and seafood from the nearby Georges River can be eaten, noting the existing advisories and restrictions in place. Additionally, regular consumers of fish from the Georges River should follow precautionary dietary advice to minimise their exposure to PFAS.

The overall PFAS groundwater contamination risk is considered to be low due to the distance from the sites to the proposed alignments and due to shallow depths of proposed construction works.

7.3 Department of Defence Unexploded Ordnance

Unexploded Ordnance (UXO) refers to ammunition which has been fired but has not functioned as designed and could be dangerous as they may easily become functioning with little handling. The Department of Defence maintains a record of sites confirmed as or suspected of being contaminated with UXO (Department of Defence, 2020).

Records indicate that there are several potential locations within a 5 km radius of the desktop assessment area, these are summarised in Table 7-2 and shown in Figure 7-4.

Table 7-2 UXO sites within 10 km of desktop assessment area

Name	Description	Distance from desktop assessment area
Defence Establishment Orchard Hills (NSW)	Defence Controlled Area.	3.1 km north of treated water
UXO Area: Liverpool (NSW)	ID:134 This site used to be part of the Defence Liverpool Area.	2.5 km south of brine pipeline
UXO Area: Bankstown Airport (NSW)	ID: 138 This area was a major WWII airfield. Small quantities of ammunition up to 20mm have been found.	2.6 km south-east of brine pipeline

The risk of encountering UXO within the project area is generally considered to be low due to the varying distance from UXO sites to alignments and or/ no known UXO occurrence information.

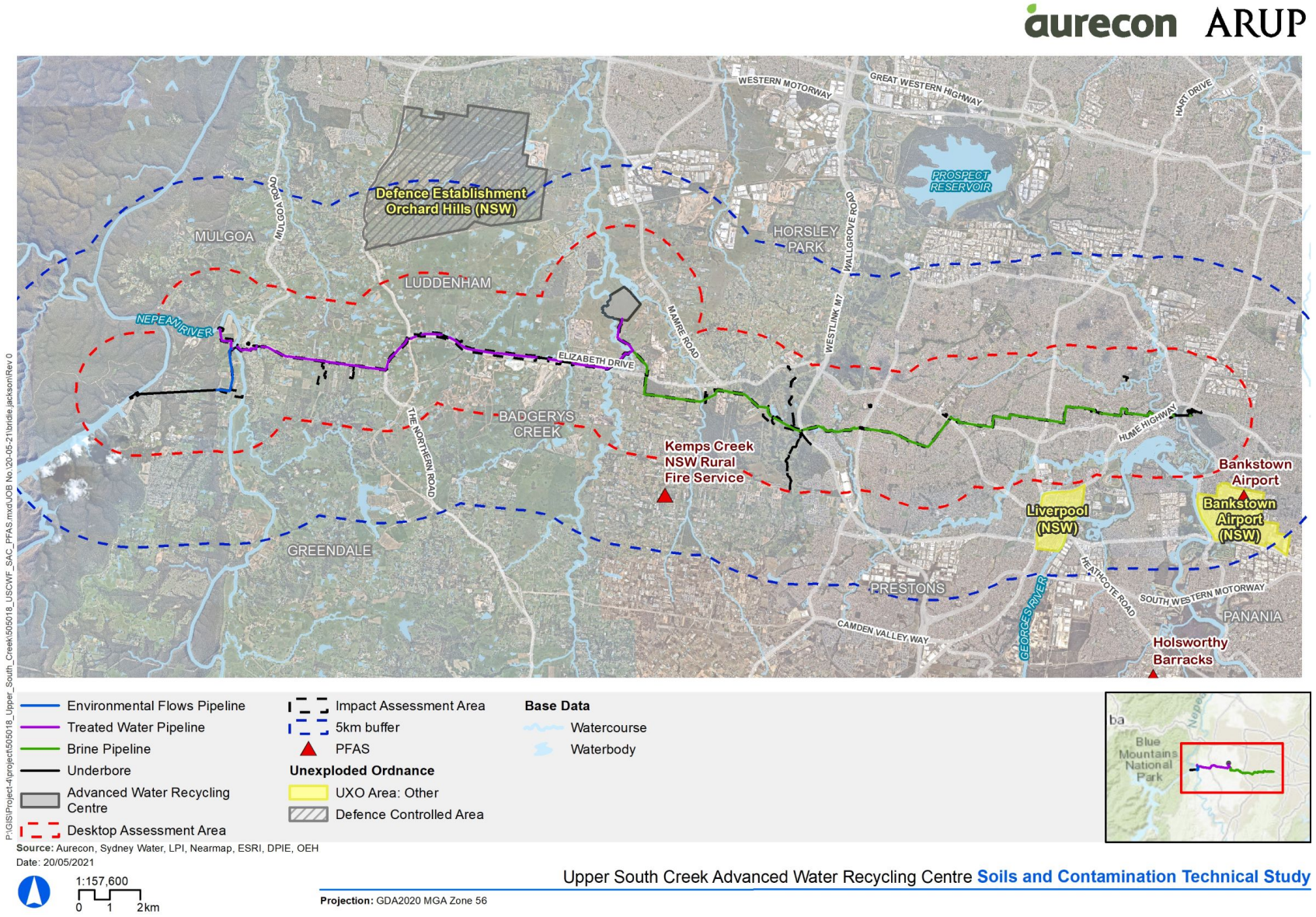


Figure 7-4 UXO and PFAS Investigation areas

7.4 Historical Aerial Photograph Review

A review of historical aerial photographs of the desktop assessment area was conducted by viewing approximately one aerial photograph per decade (Aurecon Arup, 2019a, Aurecon Arup, 2020a). The imagery indicated that the desktop assessment area has remained largely agricultural and rural/residential land use since the 1940s, particularly in the western extent between Wallacia and Cecil Hills. Rural residential building density has increased in suburban pockets, particularly in the eastern extent of the alignment. Industrial activities are located at numerous locations along the alignment zoned for this land use.

A summary of historical aerials for each of the pipeline alignments and the AWRC are provided in Table 7-3. Key potentially contaminating activities identified were:

- Historical and existing landfilling activities at the SUEZ Resource Recovery Park
- Historical filling of the lot between the SUEZ Resource Recovery Park and the AWRC
- Historical and existing quarrying at the Hi Quality Group Quarry
- Stockpiles on an adjacent lot originating from the quarry
- Historical and existing quarrying and landfilling activities at the Brandown Quarries/Landfill

Table 7-3 Summary of historical aerial imagery

Site	Desktop assessment area land use observations	Surrounding land use observations
AWRC	Land cleared for rural and agricultural land use with small farm tracks across the site. A radio telescope tower is located in the northern section in the 1950's imagery. A second was built in the early 1960's and both were removed in the 1990's. In the 1980's, vegetation was cleared, farm buildings and small dams were constructed in the centre and southern section of the site. Stockpiling and filling seen at various locations of the site in the 2000's and 2010's	Mainly rural lots with some agricultural land use. The site for the SUEZ facility was cleared in the 1960's and begun quarrying in the north eastern corner of the site in the 1980's. SUEZ quarry operations expanded to the present day area in the 1990's. the area between South Creek and SUEZ landfill has was filled in the early 2010's.
Treated water	Mainly rural lots with some agricultural lots, with some rural residences in Wallacia. From the 1940s to 1980s, residential housing slowly increased particularly around Wallacia, and some commercial shops were built in Wallacia. Some primary production sheds and greenhouses were seen in Luddenham in the 1990s. A large area between South Creek and SUEZ appeared to have been used for storage of excess resource recovery materials in 2009, which was then filled in 2012.	Mainly rural lots with some agricultural. Residential housing, which slowly increased from the 1940s to 1980s, was present at Wallacia. In the 1980s, quarrying began at the SUEZ facility (1986). The SUEZ quarry expanded to the current day extent by 1994. Primary production buildings were seen in Luddenham in the 1990s Some primary production and agricultural lots were present at Luddenham and Kemps Creek from at least the 1990s, and at Badgerys Creek from at least the 2000s.

Site	Desktop assessment area land use observations	Surrounding land use observations
Environmental flows	Bushland and rural lots except for the residential area at Core Park Road. Stockpiles were seen to the east of Core Park Road in the 1980s. The stockpiles were removed by the 1990s, with slight filling observed.	Bushland, residential, rural living and agricultural lots. The Wallacia WWTP was constructed in the 2000s.
Brine pipeline	Scattered residential housing with bushland lots, with mostly agricultural lots, rural living and undeveloped land past Cabramatta West in the 1940s. Residential housing increased over the years until almost all land to the east of the M7 have been developed to mainly residential, with some small areas of commercial and industrial. Rural living also increased over the years on Western Road. Industrial buildings were built and increased along the Hume Highway from the 1960s to 1980s. Earthworks and stockpiles were seen on lots on Hume Hwy in the 1960s. Operations at Brandown Quarries / Landfill began in the 1950s and expanded to current day extent by 2000s. Stockpiles seen on site.	Scattered residential housing with bushland lots, with mostly agricultural lots, rural living and undeveloped land past Cabramatta West in the 1940s. Residential housing density increased over the years until almost all land to the east of the M7 have been developed to mainly residential, with some small areas of commercial and industrial. Cabramatta Station transitioned from residential to commercial from the 1970s to 1980s. Rural living, agricultural and primary production lots increased over the years around Kemps Creek. In 1986 quarrying began at the SUEZ facility. The SUEZ quarry expanded to the current day extent by 1994. Between the 1960s and 1990s filling was undertaken along Green Valley Creek for redirection of the watercourse. In 2009, large structures, stockpiles and settlement ponds were seen on the SUEZ site. A large area between South Creek and SUEZ appeared to have been used for storage of excess resource recovery materials in 2009, which was then filled in 2012. In 2016, some lots along Clifton Ave have been cleared of vegetation and appeared to be used for storage of materials from the Hi-Quality quarry.

7.5 National Waste Management Site Database

Records indicate that there are three sites located within the desktop assessment area that is on the National Waste Management Site Database. These findings are summarised in Table 7-4.

Table 7-4 National Waste Management Site Database

Organisation	Name	Process	Address	Distance from desktop assessment area	Status
Sita Australia Pty Ltd	Elizabeth Drive Landfill	Landfill	Elizabeth Drive, Kemps Creek	450 m south-west of AWRC	Current

Organisation	Name	Process	Address	Distance from desktop assessment area	Status
NSW Investments Pty Ltd	Kemps Creek Landfill	Landfill Reprocessing Transfer Station	16-23 Clifton Avenue, Kemps Creek	200 m east of brine pipeline	Current
Brandown Pty Ltd	Brandown Pty Ltd	Landfill	Lot 90, Elizabeth Drive, Cecil Parks	Adjacent to brine pipeline	Current

7.6 Licensed Activities Under the POEO Act 1997

Records indicate that there are four currently licensed activities within the desktop assessment area under the *Protection of the Environment Operations Act* (POEO) 1997. These relate to primary production, quarrying and landfill activities on adjacent properties. POEO licence details for the site are summarised in Table 7-5.

The risks of the licensed activities impacting the project is generally considered to be low due to activity and/or distance from the pipeline options. Brandown Pty Limited is considered to be moderate risk due to licensed waste activities and distance from the project.

Table 7-5 POEO Licensed activities within 1 km of the desktop assessment area

Licence Number	Organisation	Name	Licensed Activity	Address	Distance from desktop assessment area	Status
10812	Baiada Poultry Pty Limited	Luddenham Broiler Farm	Bird accommodation	2907 The Northern Road, Luddenham, NSW 2745	Adjacent to treated water pipeline	Current
12618	Brandown Pty Limited	Brandown Recycling Yard	Recovery of general waste Waste storage - other types of waste Composting	Elizabeth Drive, Kemps Creek, NSW, 2178	Adjacent to brine pipeline	Current
20593	Hi-Quality Quarry (NSW) Pty Ltd	Hi Quality Kemps Creek Central	Recovery of general waste Waste storage - other types of waste Crushing, grinding or separating Land-based extractive activity	503-1519 Elizabeth Drive, Kemps Creek, NSW, 2178	540 m north of treated water pipeline	Current

Licence Number	Organisation	Name	Licensed Activity	Address	Distance from desktop assessment area	Status
12889	SUEZ Recycling and Recovery Pty Ltd	SUEZ Advanced Waste Treatment Facility	Recovery of general waste Waste storage - other types of waste Composting	1725 Elizabeth Drive, Kemps Creek, NSW, 2178	500 m south west of AWRC site	Current

7.7 Former Licensed Activities Under the POEO Act 1997

Records indicate that there is one former licence within the 1 km of the desktop assessment area that has been surrendered. Licence number 7498 was issued to the Bankstown City Council for 'other activities' being undertaken in the Bankstown LGA waterways. The licence was surrendered on the 7th September 2000.

This is considered to have a low risk of impacting the project as it is a licence for councils to maintain waterway health through controlled use of pesticides.

8 Previous Investigation Reports

A number of previous reports were reviewed, and a summary of the findings are presented in Table 5-17. Detailed summary information is presented in **Appendix C**.

Table 5-1 Summary of previous investigation reports findings

Assessment Area	Distance to impact assessment area	Main contamination risk	Risk rating for contamination to impact or constrain project
AWRC	Within AWRC	Some heavy metal exceedances of ecological investigation levels (EILs) and minor TRH exceedances of public open space land use management and/or ecological screening levels (ESLs). Fragments of ACM on ground surface and surficial soils in proximity to and within footprints of the majority of historical site structures within the AWRC, and within the footprint of the former CSIRO Radio Telescopes. Groundwater with copper, zinc and nitrogen in exceedance of ANZECC 2000 freshwater 95% guideline in groundwater. Groundwater with copper, nickel, zinc, ammonia and nitrogen exceedances also present adjacent to SUEZ.	Low to moderate.
Kemps Creek	To the south of the treated water pipeline Along and at areas 200 m to the north of the brine water pipeline	ACM within waste piles along Elizabeth Drive. Several zinc, copper and lead exceedance of urban, residential and open space EILs adjacent to Brandown Quarries / Landfill. Noted to be natural levels. Asbestos in soil at Range Road. Asbestos fragments also noted at the corner of Elizabeth Drive and Range Road. Zinc and PAH exceedances of public open space land use EILs in stockpiles within Hi-quality Quarry Group Head Office	Low to moderate.
Warragamba Wastewater Treatment Plant	To the immediate north of the environmental flows pipeline	ACM within fill. Several heavy metal exceedance of ecological health guidelines applicable at the time of reporting.	Low to moderate due to under boring through this area Surface construction works may encounter asbestos in soils

Assessment Area	Distance to impact assessment area	Main contamination risk	Risk rating for contamination to impact or constrain project
Core Park Road	Several lots roughly 100 m to the south of the environmental flows pipeline	Non-friable asbestos cement sheeting debris and a friable asbestos wiring within a dump zone. Surface PACM and friable asbestos in surficial soil. Site has been remediated.	Low to moderate due to under boring in the area and known remediation Surface construction works may still encounter asbestos in soils
Megarritys Creek	Areas roughly 250 m and further to the south of the environmental flows pipeline	ACM present at the surface.	Low to moderate due to under boring in the area Surface construction works may encounter asbestos in soils
Warragamba Dam Viewing Platform and Eighth Street	Bushland roughly 500 m and further south-west of the environmental flows pipeline	ACM and friable asbestos present within surficial soils. Noted to have been remediated in some areas (for example excluding inaccessible slopes and deeper soils). Several heavy metal and benzo(a)pyrene exceedances of human and ecological health guidelines.	Low to moderate due to distance to project and under boring in the area Surface construction works may encounter asbestos in soils

8.1 Pipelines

In general, the previous reports found little or low risk of contamination along the desktop assessment area. However, the following low to moderate contamination risks were found:

- Heavy metal impacts at the disused Warragamba Sewage Treatment Plant to the east of the environmental flows pipeline, near the Warragamba River
- ACM in the Core Park Rd Dump Zone to the west of the environmental flows pipeline

Further consideration of these risks and impacts are detailed in Section 11.

8.2 AWRC

Report summaries for the AWRC were obtained from the AWRC options assessment report (Aurecon, 2019) which looked at a broader area in consideration for the proposed location of the AWRC.

The University of Sydney Fleurs Radio telescope site on which the AWRC is proposed was formerly used as a farming land, which was leased by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in 1936 to build a prototype for a new form of radio telescope. Additional arrays were added over time, with University of Sydney taking over the site in 1963. The existing infrastructure began to fall into disarray, with part of the telescope removed in 1990. The station was closed in 1991, with two of the dish antennae relocated and remaining site infrastructure demolished in 2005.

An environmental investigation undertaken (JBS&G 2018) noted a variety of potential sources of onsite contamination relating to historical and current use of the site. Soil sampling conducted found the following:

- Reworked natural materials (used as filling) were observed at several locations surrounding existing or historical structures which were noted to include anthropogenic materials including construction and demolition waste and fragments of ACM sheet board. These materials were encountered to a maximum depth of 0.1 metres below ground surface (mbgs).
- Soil samples showed heavy metal exceedances of adopted ecological investigation limits (EILs), minor TRH exceedance of management limits and/or ecological screening levels (ESLs). Other COPCs assessed did not exceed adopted human health criteria, and PFAS was not reported in any soil samples adjacent to the adjacent airstrip (not within the AWRC impact assessment area).
- Fragments of ACM (friable and non-friable) was identified on the ground surface and in surficial soils in reworked natural soils in some locations in proximity to former building structures as well as near footprints of a majority of historical site structures, Asbestos in the form of ACM, asbestos fines (AF), and/or fibrous asbestos (FA) exceeded adopted health screening levels in surface soils at some locations.

Investigation locations undertaken as part of JBS&G 2018 investigation are presented in **Appendix D**.

Further consideration of these risks and impacts are detailed in Section 11.

9 Intrusive Investigations and Soil Analysis

9.1 General information

Aurecon ARUP undertook a contamination DSI for the AWRC and pipelines routes (Aurecon Arup, 2021a) which included some salinity and soil quality sampling and analysis to inform soil quality conditions as part of the impact methodology. Investigation locations undertaken as part of this DSI are presented in **Appendix D.**

Fill materials were observed at one location within the AWRC from the surface to a depth of 0.1 m bgl. Fill material down to a maximum depth of 2.1 m was present at various locations along the pipelines. Anthropogenic items such as blue plastic pieces, glass fragments, brick fragments were present in some areas along the brine pipeline. It was also noted during the siteworks that high levels of volatile vapour were observed at BP_BH15 (Cabramatta Rd, West Bonnyrigg) along the brine pipeline, potentially originating from the adjacent service station. Additional investigation locations were taken around BP_BH15, including on the other side of the road to assess alternate pipeline routes. Results indicated that hydrocarbon impacts at BP_BH15 were localised, with surrounding locations showing negligible concentrations of hydrocarbons. Sample locations and maps indicating areas are presented in **Appendix D**.

9.2 Hazards to Human Health

Laboratory analysis of soil samples collected and analysed indicated the following:

- Concentrations of chemical COPC within the AWRC site were all below the adopted investigation levels
- TRH C_6-C_{10} in sample BP_BH15_2.0-2.2_150420 (Cabramatta Rd, West Bonnyrigg), located along the brine pipeline exceeded the adopted HSL for commercial/industrial land use. These exceedances are likely a result of a UPSS leak from the adjacent service station as the nearest hydrocarbon source.
- Concentrations of all other chemical COPC within the AWRC and pipelines were below the adopted investigation levels
- Asbestos was detected in a fragment of bonded cement sheeting within sample EED_TP02_1.5-1.6_220520_FRAG (now outside of the treated pipeline impact area) and EED_TP07_0.1-0.3_210520_FRAG. EED_TP07 is located adjacent to service stations along the treated water pipeline on Park Road.

Based on the laboratory results, the investigation concluded and recommended the following:

- The overall potential for hazards to cause harm to human health in an onsite construction worker exposure scenario are considered to be low risk
- A potential vapour hazard to onsite intrusive workers may exist adjacent to the petrol station located at 709 Cabramatta Rd West Bonnyrigg due to minor exceedances of the soil vapour intrusion HSL criteria. It is considered likely that these risks can be mitigated via further localised site investigations and design prior to construction.
- Asbestos fragments were detected at EED_TP02 (now outside of the treated pipeline impact area) and EED_TP07 (Park Road) along the treated water pipeline alignment and although soil

asbestos results did not report any free or respirable fibres were present, potential hazards to human health due to asbestos may be present

9.3 Waste classification

Laboratory analysis of the soil samples showed the following:

- Chromium and nickel exceeded the Guidelines contaminant threshold (CT) values for general solid waste (CT1) in several samples from the AWRC. Toxicity characteristic leaching procedure (TCLP) testing carried out on the samples indicated that all samples can be classified as general solid waste.
- Benzo(a)pyrene, chromium, lead and nickel exceeded the Guidelines contaminant threshold (CT) values for general solid waste (CT1) and restricted solid waste (CT2) in several samples along the pipelines. TCLP testing carried out on the samples indicated that all samples can be classified as general solid waste.

Based on the laboratory results, the PP concluded and recommended the following:

- Soils excavated along the pipeline alignments and at the AWRC would be classified as General Solid Waste (Non-Putrescible), however, further testing may be required during construction to confirm specific waste classifications for soils and any stockpiles generated for off-site disposal (if required)
- Some material may meet the requirements for Excavated Natural Material (ENM) or Virgin Excavated Natural Material (VENM) and could be beneficially re-used, however further testing is required to validate this
- Any spoil or excavated materials that contain asbestos would be classified as ‘special waste – asbestos waste’

9.4 Soil salinity as electrical conductivity (EC 1:5 and ECe)

Additional laboratory testing for soil salinity parameters was undertaken for this EIS. The results for electrical conductivity of a saturated soil extract (ECe) are presented in Tables 1a to 1c - **Appendix B** with additional soil parameters including sulfate, chloride and exchangeable ions. The ECe results for the AWRC site ranged from 0.1 – 5.6 dS/m. The ECe results for the brine pipeline alignments ranged from 0.1 – 7.0 dS/m. The ECe results for the brine pipeline alignments ranged from 0.1 – 7.8 dS/m.

Results indicate that the soil samples across the AWRC site (Table 1a in **Appendix B**) exhibit non saline near surface soils and in several instances indicate a vertical salinity profile of saline to moderately saline within the 1 to 3m bgl range of samples analysed. This salinity profile is expected with increasing depths towards the water table and closer to South Creek.

Results indicate that the soil samples across the brine pipeline (Table 1b in **Appendix B**) are typically non saline with the exception of borehole locations around Clear Paddock Creek, Green Valley Creek and other low-lying drainage lines. The salinity concentrations are increasing with depths towards the water table.

Results indicate that the soil samples across the treated water pipeline (Table 1c in **Appendix B**) are typically non saline with the exception of one location of moderately saline soils at borehole EDNO1_BH01 located approximately 50 m to the west of South Creek. The salinity concentrations are increasing with depths towards the water table.

Saline classifications (relating primarily to agricultural impacts to crops) are detailed below based on the definitions from DLWC, 2002 and ECe concentrations:

- Non-saline: <2 dS/cm
- Slightly saline: 2 – 4
- Moderately saline: 4 – 8 dS/cm
- Very saline: 8 – 16 dS/cm
- Highly saline: >16 dS/cm

9.5 Exchangeable sodium percentage (ESP)

ESP is a measurement of soil sodicity. High sodium levels increase the erosion risk of soils. They also affect the drainage potential of soils. Sodic soils tend to lose their structure when wet and are therefore poorly draining. In extreme cases, they become so dispersive that they become prone to tunnel erosion. The importance with respect to a salinity assessment is both the risk that they can form poorly drained areas where salts can accumulate, but also where salt issues exist, plant stabilisation may be poor and erosion hazard can be high.

The ESP in soil is calculated using the following formula:

- ESP (%) = (Exchangeable Na / CEC) x 100
- Where CEC = Cation Exchange Capacity

Capacity ESP is classified as per Hazelton and Murphy, 2007 as follows:

- Non-sodic: < 5% ESP
- Moderately sodic: 5 – 10% ESP
- Highly sodic: > 10% ESP

Tables 1a to 1c - **Appendix B** shows the Exchangeable Cations, ESP and sodic classification for soils analysed. Results indicate a generally highly sodic soil landscape across the AWRC and therefore there is a high erosion risk. Several surface soils (0.0 – 0.2 m depth) are non-sodic and moderately sodic. One sample at a depth of 0.4 – 0.5 m within ENV_AWRC_TP23 (AWRC site) was moderately sodic, while another sample at a depth of 0.9 – 1.0 m within ENV_AWRC_TP29 (AWRC site) was non-sodic. Soils across the treated water and brine pipeline ranged from non-sodic to highly sodic. Surface soils (0.0-0.4 m) were generally non-sodic to moderately sodic while deeper soils (0.4m+) analysed were generally highly sodic. Results are indicative of a potentially dispersive sub soil across the pipelines.

9.6 ASS

Tables 3a to 3b - **Appendix B** provide a summary of ASS laboratory results for the AWRC and pipelines. Results for each area are summarised below.

For the AWRC site, although the NSW ASSMAC (1998) action criteria of 0.03 %S / 18 mol H+/t were exceeded for many soil samples using net acidity, the acidity present is from actual acidity which is considered to be natural and not from sulfidic sources. Where sPOS %S (potential acidity) results are above the criteria, they are considered to be from rootlets and organic materials in the near surface samples (which the SPOCAS laboratory method has difficulty distinguishing) and ASS is considered highly unlikely to be present in the shallow soils (0.0 to 0.2m bgl). Therefore, for the AWRC site, no ASS management plans are considered to be required for construction.

For the pipeline alignments to the west (under bores, environmental flows, treated water) ASS is not considered likely to be encountered based on the laboratory testing and lithology encountered during site investigations. For the brine pipeline to the east, the only area where ASS could potentially be encountered in around Prospect Creek and banks. Two boreholes (BDNO5_BH23 and BDNO5_BH24) drilled on either side of Prospect Creek do not indicate ASS presence based on laboratory results obtained.

9.7 Hazardous Materials Survey (AWRC Site)

A hazardous materials survey of the AWRC site was undertaken by Aurecon Arup licensed asbestos assessors (LAAs) in July 2020 and identified structures, buildings and areas of ground with likely asbestos present. The findings are outlined in Table 9-1 with Figure 5-1a provided in Appendix D outlining suspected hazardous materials locations and sources. The hazardous materials survey was limited to observation of surface areas and structures within the AWRC site.

Table 9-1 Hazardous materials survey inspection summary

Locations in Appendix D Figure	Suspected Hazardous Materials	Location Coordinates
1	Former radio telescope presumed to contain asbestos wrapping to electrical cabling and potential insulating boards to electrical distribution boards (EDB's)	33°51'16" S, 150°46'27'E
2	Building debris presumed to be asbestos containing corrugated and compressed fibre cement sheeting (FCS) ~80m²	33°51'22" S, 150°46'27"E
3	Former agricultural shed debris presumed to be asbestos containing corrugated and compressed fibre cement sheeting (FCS) ~600m²	33°51'23" S, 150°46'27"E
4	Northern dwelling presumed to be contain asbestos-containing fibre cement sheeting (FCS) in the internal/external walls, ceilings, eaves & gable ends, asbestos vinyl floor tiles (VFT's), PCB containing capacitors (PCB's) within the light fittings, lead containing paint systems presumed throughout building and biohazard (bird faeces)	33°51'25" S, 150°46'27"E
5	Shed adjacent to the northern dwelling presumed to be constructed with asbestos-containing fibre cement sheeting (FCS) in the internal/external walls, ceilings and roof ~20m², lead containing paint systems throughout, moulded asbestos communications pit and PCB containing capacitors (PCB's)	33°51'27" S, 150°46'27"E
6	Centre dwellings presumed to contain fibre cement sheeting (FCS) in the internal/external walls, ceilings and roof, lead containing paint systems throughout, PCB containing capacitors to fluorescent light fittings and biohazard (bird faeces)	33°51'30"S, 150°46'31"E
7	Southern dwellings presumed to hold E-waste throughout, asbestos containing fibre cement sheeting (FCS) in the internal/external walls, ceilings & gable ends, bituminous electrical backing boards (EBB's), PCB containing capacitors (PCB's) within light fittings, biohazard (bird faeces)	33°51'34"S, 150°46'28"E
8	Southern debris pile presumed to contain asbestos fibre cement sheet (FCS) debris	33°51'39"S, 150°46'27"E

Locations in Appendix D Figure	Suspected Hazardous Materials	Location Coordinates
9	Comms cabling presumed to be throughout grounds, suspected asbestos containing sheathing	33°51’33”S, 150°46’24”E
10	Lean-to shed, contains presumed corrugated asbestos fibre cement sheeting to roof (FCS)	33°51’33”S, 150°46’20”E
11	Former radio telescope presumed to contain asbestos wrapping to electrical cabling and potential asbestos electrical distribution boards (EDB’s)	33°51’34”S, 150°46’4”E

10 Soils Cross Section and Contamination Conceptual Site Model

The following sections describe the Conceptual Site Model (CSM) related to soil/salinity properties and potential subsurface contamination for the desktop assessment area and impact area. The information presented in Section 4 has been used to develop the CSM. The CSM forms a basis in assessing potential land impacts during construction and operation of the AWRC and pipelines and mitigation measures during construction and operation of the project.

CSMs are generally accompanied by pictorial, diagrammatic and/or tabular interpretations and representations of site subsurface conditions as well as corresponding potential impacts and receptors. In this section, conceptual cross-sections illustrating key soil / salinity and contamination processes encountered in the impact area are presented.

10.1 Soil summary

A summary of potential soil, salinity and stability risks for the project is summarised below in Table 10-1. Risk ratings assigned to each of the potential risks for the project is summarised. A graphical CSM cross section assessing soil and salinity aspects in presented in Figure 6-1.

Table 10-1 Summary soil and land constraints, locations and risk ratings

Soil Aspect	Location	Risk Rating	Risk Rating Discussion
Salinity	Across the project area	Moderate	Soil salinity testing of samples taken during the intrusive investigation indicated that the samples tested were non-saline to moderately saline within the AWRC and closer to drainage lines along the pipeline alignments. Typically, saline soils are present at depth (not in the upper 0.5 m bgl) with salinity concentrations increasing closer to drainage lines and groundwater tables as would be expected based on western Sydney salinity occurrence. Excavation of soils below 2.0 m depth and soils within and around the fluctuating groundwater table are likely to have high to very high salinity. The project is only likely to excavate deeper soils for portions of pipelines near water ways and creeks (on either side) and infrastructure associated with the AWRC such as the bioreactor.
Soil erodibility	Across the project	Moderate	The project area is located across multiple soil landscapes, most of which have moderate to severe erodibility potential. Exchangeable sodium percentage (ESP) results are indicative of a dispersive clayey sub soil across the treated water and brine pipeline, termed sodic soils. Sodic soils are sensitive to salt ingress and wetting causing clays to disperse and erode undercutting soils above.

Soil Aspect	Location	Risk Rating	Risk Rating Discussion
Land stability	Along the brine pipeline and steep slopes nearing environmental flows pipeline	Low	Two areas of potential slope instability are present within the desktop assessment area: to the west and east of the M7, and the area between Prospect Creek and Henry Lawson Drive. Intrusive investigations indicated historical landslides or creep to the east of the M7. The steep slopes near the environmental flows pipeline may have risks associated with under boring and construction laydown areas. The majority of other areas have low slopes or near flat lands that are considered stable based on the project design.
Soil Reactivity	Across the project	Moderate	Medium and high plasticity alluvial and residual clays originating from Bringelly Shale present across the site are susceptible to shrink/swell movements with changes in soil moisture.
ASS	On the eastern end of the brine pipeline	Low	The eastern side of the brine pipeline and under bore may have ASS present. The risk of ASS disturbance is negligible to low across the AWRC and other pipeline alignments.

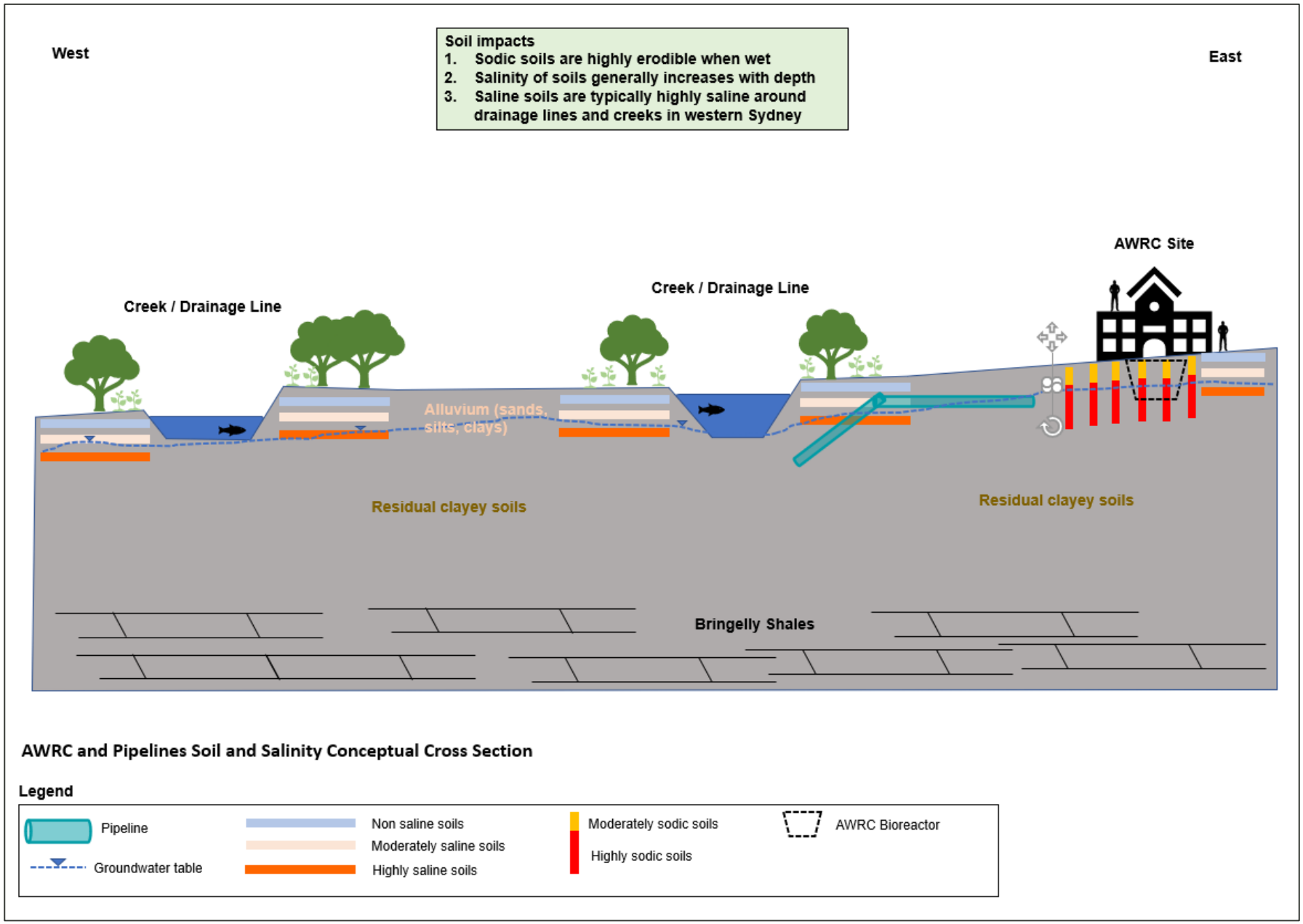


Figure 10-1 Conceptual site model cross section, soil and salinity for AWRC and pipelines

10.2 Land Contamination

Several potential contamination sources, referred to as areas of environmental concern (AECs), were identified as part of the previously prepared assessment reports summarised in Section 8 and the intrusive investigations summarised in Section 9. These AECs related to activities/observations such as illegally dumped waste, landfilling activities, petroleum storage and dispensing or stockpiled material. These AECs were identified as having the potential to cause harm to human health or ecological receptors during construction activity (land disturbance) and operation of the project, without mitigation measures in place.

A summary of potential human health and ecological hazards for the project is summarised below in Table 10-2. Risk ratings assigned to each of the potential risks for the project is summarised below in Table 10-3.

The AECs along the treated water and brine pipelines are shown on Figure 6-2a to d and for the AWRC on Figure 6-3.

A preliminary CSM assessing contamination aspects for the project is presented in Figure 10-2.

Table 10-2 Summary of historical potential contamination

AEC # (Figures 6-1a to d), Appendix D	Location	Sites	Potential contamination	Historical contamination summary
1	Former and current agricultural land usage AWRC – current and former structures such as farm sheds and radio towers containing asbestos and heavy metals	AWRC site Treated water pipelines Brine pipeline	Pesticide and herbicide use Chemical/fuel use and storage Structures containing hazardous building materials (HBM), including irrigation lines Historical filling and stockpiles on site	ACM fragments were present in soils and in buildings on site across the AWRC site. Areas of ACM impact are located and limited to former structures and surrounding current structures across the AWRC site. Zinc and copper had minor and localised exceedances of adopted tier 1 screening criteria for ecological receptors (ASC NEPM 2013) (JBS&G, 2018).
2	Air strip on Lot 2/DP88836	AWRC site	Use of historical fire-fighting foams containing PFAS for airfield activities. Noted to be low likelihood of presence.	Small air strip with limited use and no known fire training adjacent to the AWRC site to the immediate south-east. No exceedances of adopted guidelines (PFAS NEMP 2.0, 2020) for PFAS from Sydney Water analysis (2020) and JBS&G, 2018 previous site investigations.
3	Kemps Creek Rural Fire Service	AWRC site Brine pipeline Treated water	Use of historical fire-fighting foams containing PFAS	No exceedances (AAJV, 2019b). Distance from project impact areas unlikely to impact project from source site.
4	Western Rd to Brandown Quarry	Brine pipeline	Historical filling	Ecological exceedances (ASC NEPM 2013) for zinc, copper and nickel in soil. Copper and zinc exceedance in groundwater. Metal concentrations noted to be natural and at background concentrations (Aurecon Arup, 2019b).
5	Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	AWRC site Access road	Former landfilling activities	Results from soil sampling near the site found no exceedances. However, no samples were done within the site. Possible contamination within the site (RMS, 2019).

AEC # (Figures 6-1a to d), Appendix D	Location	Sites	Potential contamination	Historical contamination summary
6	SUEZ Kemps Creek Resource Recovery Park	AWRC site Treated water	Historical and current landfilling activities	Groundwater containing elevated copper, zinc, ammonia, nitrogen and nickel levels, and gas containing methane and carbon dioxide exceedances above adopted guidelines (ASC NEPM 2013 and NSW EPA *Assessment and management of hazardous ground gases,* 2020) were found adjacent to the site (RMS, 2019).
7	Potential area of fill next to South Creek	AWRC site	Historical filling	Exceedances of adopted tier 1 screening criteria (ASC NEPM 2013) for copper and zinc in groundwater (RMS, 2019)
8	Corner of Elizabeth Drive and Range Road, Kemps Creek	Brine pipeline	Illegal dumping of building materials and household waste	ACM present within the soil to the north of Range Road (RMS, 2019).
9	Western Sydney Airport	Treated water	Construction and associated contaminants	No exceedances of adopted tier 1 screening criteria (ASC NEPM 2013) (AAJV, 2019b).
10	Elizabeth Dr between The Northern Rd and M7	Treated water Brine pipeline	Dumped domestic and C&D waste Suspected ACM Historical filling	No exceedances in soil of adopted tier 1 screening criteria (ASC NEPM 2013) (AAJV, 2019b). Asbestos cement sheeting present in waste piles along roadway and at surface of piles.
11	Warragamba Sewage Treatment Plant	Environmental flows	Historical filling	Heavy metals and E.coli in soil samples. ACM present on site (Parsons Brinckerhoff, 2008).
12	Park between Core Park Rd and Weir Rd	Environmental flows	Historical filling	ACM present in soils. Area has since been remediated (CH2M, 2017a, 2017b, 2017c)
13	Core Park Rd Dump Zone	Environmental flows	Illegal dumping of various items ACM	Asbestos cement sheeting, friable asbestos wiring and a fluorescent light fitting present (IE, 2016).
14	Megarritys Creek	Environmental flows	ACM from illegal dumping	ACM present on surface (WSP, 2015, ADE, 2017, 2019a, 2019b).

AEC # (Figures 6-1a to d), Appendix D	Location	Sites	Potential contamination	Historical contamination summary
15	Warragamba Viewing Platform and Eighteenth St	Environmental flows	Historical filling ACM within fill	ACM in soils and on surface exceeded the adopted tier 1 screening criteria (ASC NEPM 2013). TRH, benzo(a)pyrene and naphthalene exceedances of adopted tier 1 screening criteria (ASC NEPM 2013) in localised areas. The area has been remediated but residual ACM is still present on site in sub soils and likely deeper due to legacy issues and former Warragamba Dam construction housing made from asbestos sheeting and asbestos products.
16	Petrol Stations	Treated water Brine pipeline	Petrol storage, dispensing and spills	TRH C_6-C_{10} and TRH C_6-C_{10} exceeded the adopted tier 1 screening criteria (ASC NEPM 2013) in one sample along the brine pipeline (Aurecon Arup 2019b)

Table 10-3 Risk ratings of historical potential contamination

AEC # (Figures 6-1a to d), Appendix D	Location	Sites	COPCs	Impact / Risk Rating (per Section 3.5.1)	Discussion of risk / impact rating
1	Former and current agricultural land usage AWRC – current and former structures such as farm sheds and radio towers containing asbestos and heavy metals	AWRC site	ACM Heavy metals	Moderate	ACM fragments were present in soils and in buildings on site across the AWRC site. Zinc and copper exceeded adopted EIL and ESL (JBS&G, 2018). Zinc and copper ecological screening criteria exceedances (ASC NEPM 2013) previously identified. These impacts are considered to be low due to the engineering design of the project and future landscaping and placement of vegetation and suitable soils for landscaping.
2	Air strip on Lot 2/DP88836	AWRC site	PFAS	Low	Because there are no exceedances for PFAS and the air strip is small with no previous known fire training occurring. The impact significance is low. If present, PFAS can migrate in through surface water and groundwater pathways.
3	Kemps Creek Rural Fire Service	AWRC site Brine pipeline Treated water	PFAS	Low	Because there are no known exceedances from investigations undertaken for the project and AEC 3 is about 500m from the project brine pipeline alignment, the impact significance is low.
4	Western Rd to Brandown Quarry	Brine pipeline	Heavy metals	Low	Because ecological exceedances (ASC NEPM 2013) for zinc, copper and nickel in soil are noted concentrations at background levels, along with pipelines not having future ecological value or landscaping the impact significance is low.

AEC # (Figures 6-1a to d), Appendix D	Location	Sites	COPCs	Impact / Risk Rating (per Section 3.5.1)	Discussion of risk / impact rating
5	Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	AWRC site	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, ACM	Low	Because soil sampling near the site found no exceedances of adopted tier 1 screening criteria (ASC NEPM 2013) and AEC 5 is 1.7 km from the brine pipeline the impact significance is low.
6	SUEZ Kemps Creek Resource Recovery Park	AWRC site Treated water	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, ACM	Moderate	There is potential for contaminated groundwater to migrate to the AWRC site as topography indicates that groundwater is expected to flow from west to east. However, the presence of South Creek between the two sites will act as a barrier or hydrogeological divide to the migration of groundwater and landfill gas. The impact significance for migration of contaminated groundwater is moderate. Landfill gas is deemed to have a low impact significance to the project due to the distance between the two sites (400 m).
7	Potential area of fill next to South Creek	AWRC site	Heavy metals	Low	Because exceedances for copper and zinc in groundwater are expected to be from background levels the impact significance is low.
8	Corner of Elizabeth Drive and Range Road, Kemps Creek	Brine pipeline	ACM	Moderate	Because of ACM present within the soil to the north of Range Road and parts of AEC 8 are within the impact area for the project and will be disturbed during construction, the impact significance is moderate.
9	Western Sydney Airport	Treated water	TRH, BTEX, PAH, heavy metals, PCB, nutrients, ACM	Low	Because there are no adopted tier 1 screening criteria (ASC NEPM 2013) exceedances and the treated water pipeline does not intersect with AEC 9 the impact significance is low.

AEC # (Figures 6-1a to d), Appendix D	Location	Sites	COPCs	Impact / Risk Rating (per Section 3.5.1)	Discussion of risk / impact rating
10	Elizabeth Dr between The Northern Rd and M7	Treated water Brine pipeline	TRH, BTEX, PAH, heavy metals, PCB, ACM	Low	Because there are no adopted tier 1 screening criteria (ASC NEPM 2013) exceedances in soil and asbestos cement sheeting present in waste piles will not likely be disturbed by construction of the treated water pipeline, the impact significance is low.
11	Warragamba Sewage Treatment Plant	Environmental flows	Heavy metals ACM E. Coli	Low	Because AEC 11 is 500 m from the environmental flows pipeline. Soil disturbance from construction is not expected, therefore the impact significance is low.
12	Park between Core Park Road and Weir Road	Environmental flows	ACM	Moderate	Whilst ACM is present in surface soils, AEC 12 is next to the environmental flows pipeline which will be tunnelled beneath surface soils. Construction compound C1 will be within areas potentially impacted with ACM in surface soils, therefore the impact significance is moderate.
13	Core Park Road Dump Zone	Environmental flows	ACM PCBs	Moderate	Whilst ACM is present in surface soils, AEC 13 is next to the environmental flows pipeline which will be tunnelled beneath surface soils. Construction compound C1 will be within areas potentially impacted with ACM in surface soils, therefore the impact significance is moderate.
14	Megarritys Creek	Environmental flows	ACM	Low	Whilst ACM is present in surface soils AEC14 is next to the environmental flows underbore pipeline, disturbance of surface soils is not expected at this location, therefore the impact significance is low.
15	Warragamba Viewing Platform and Eighteenth Street	Environmental flows	TRH, BTEX, PAH, heavy metals, PCB, ACM	Low	Because AEC 15 is 700 m from the environmental flows pipeline. Soil disturbance from construction is not expected, therefore the impact significance is low.

AEC # (Figures 6-1a to d), Appendix D	Location	Sites	COPCs	Impact / Risk Rating (per Section 3.5.1)	Discussion of risk / impact rating
16	Petrol Stations	Brine pipeline Treated water	TRH, ACM	Moderate	Because of the TRH exceedance in soil samples associated with the service station near Cabramatta Rd, West Bonnyrigg, AEC 16 may be subject to disturbance at this location for pipeline construction, therefore the impact significance is moderate.

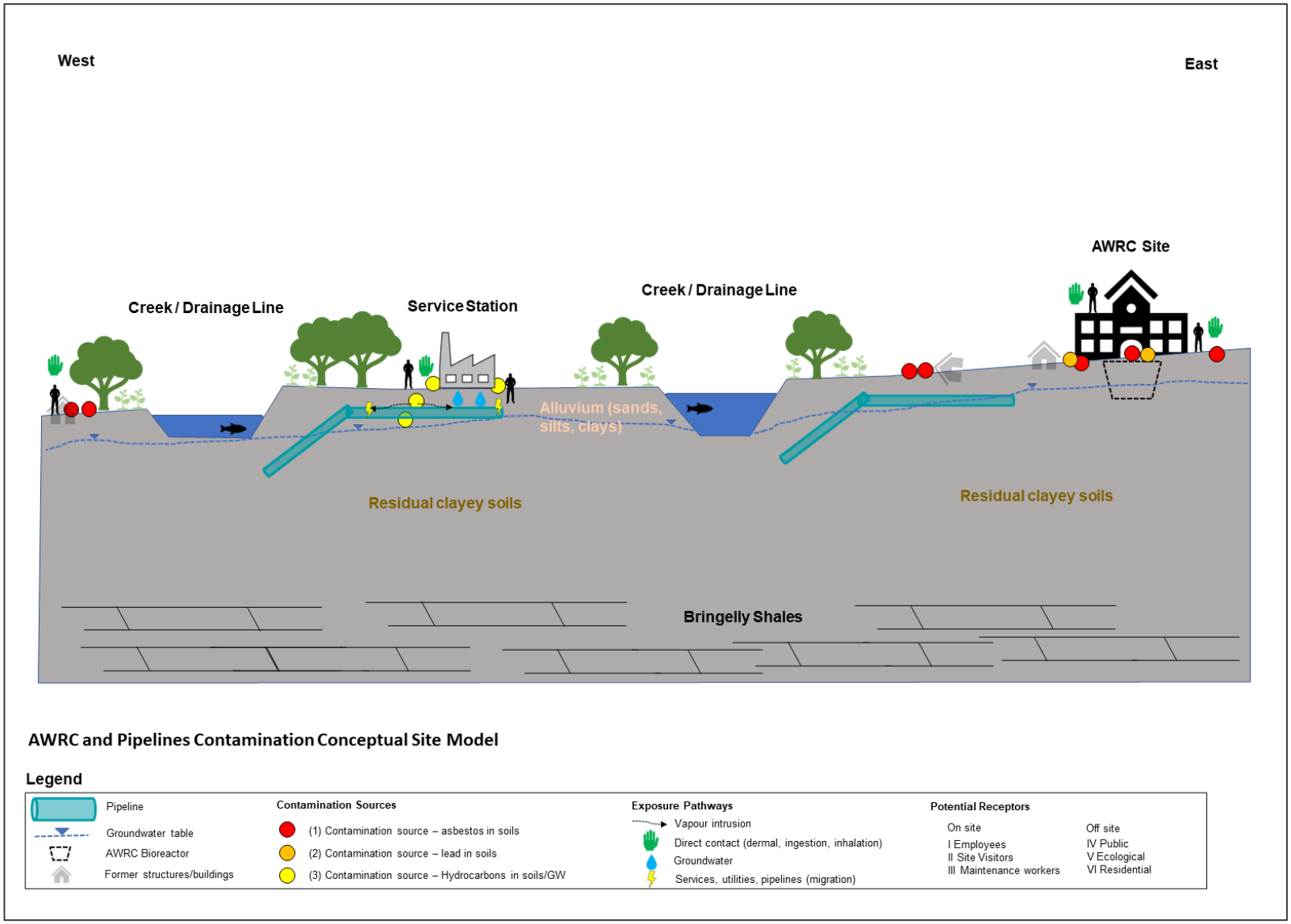


Figure 10-2 Conceptual site model, contamination for AWRC and pipelines

11 Impact assessment

Soil and contamination related impacts associated with the project must be identified. Recognising any potential impacts that may occur during the construction and operational phases will lead to informed mitigation measures to prevent, minimise and / or contain these impacts. This section discusses the project's potential soil, land and contamination impacts based on the desktop assessment, previous reports review, site inspections and intrusive site investigations.

The following sections respond to the SEARs (Section 1.3) while providing an overview of potential construction and operational phase impacts. The potential impacts have been assessed with consideration to the relevant components of the design, which were developed iteratively during the assessment to reduce potential impacts to soils and contaminated land across the project.

The potential impacts associated with the construction phase activities of the project are identified and assessed in Table 11-1, any additional impacts potentially arising during the operational phase are indicated in

Potential Impact	Project location/Activity	Impact significance
• Contamination – disturbance of soils containing contamination during construction	**AWRC site, access roads:** Stripping, grubbing, shallow and deep excavations	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) Known contamination of shallow soils in certain portions of the AWRC site exist. If these materials were not well managed, contamination impacted soils could spread, increase risk of exposure and contaminate other areas of the AWRC site. AECs are described in Section 10 and figures indicating AECs in Appendix D.
• Contamination – disturbance of soils containing contamination during construction	**Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) Known and unknown contamination risks exist along the pipeline routes for shallow trenched soils and near surface soils. If these materials were not well managed, contamination impacted soils could spread, increase risk of exposure and contaminate other areas of the Pipelines route or migrate outside of the construction boundary. AECs are described in Section 10 and figures indicating AECs in Appendix D.
• Contamination – mobilisation and distribution of contaminants present in soil across the project during construction	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) If these materials were not well managed during construction, contamination impacted soils could migrate outside of the construction boundary, resulting in increased exposure risks and potential for additional waste disposal requirements.
• Contamination – Generation of contaminated	**AWRC site and Pipelines:**	Significance: Low Sensitivity of environmental values: Low Magnitude of impact: Low (temporary)

Potential Impact	Project location/Activity	Impact significance
waste streams during construction from trench spoil and excavations of unsuitable materials	Stripping, grubbing, shallow excavations, trenching, demolition	Waste streams will be generated due to the project type and size. The waste streams will be characterised and either beneficially reused or disposed as a waste to licensed facilities.
• Contamination – poor handling of hazardous building materials during demolition and surface scrapping of contaminated shallow soils, principally asbestos in shallow soils	**AWRC site, access roads:** Demolition of structures, stripping, grubbing, shallow and deep excavations	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) Demolition of localised structures and shallow impacted soils could generate contamination within and around the demolition zones. Demolition is likely to be localised to minor buildings and former structures on the AWRC site. AECs are described in Section 10 and figures indicating AECs in Appendix D.
• Contamination – Disturbance of known asbestos contamination within soils around the Core Park area, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street, near Warragamba Dam.	**Pipelines:** Stripping, grubbing, shallow excavations, trenching, trenching, HDD/under bore pits, construction compound C1	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (temporary) Existing known contamination exists in these areas, impacts would be temporary. Disturbance of soils and asbestos could generate exposure scenarios for workers and the public. AECs are described in Section 10 and figures indicating AECs in Appendix D. The majority of the areas impacted by ACM will be tunnelled under, however, construction compound C1 will require ground disturbance and likely impact localised asbestos in soils.

Potential Impact	Project location/Activity	Impact significance
• Contamination – Storage and management of contaminant sources such as fuels, chemicals, building materials, wastes (e.g. demolition), hazardous materials, pathogens, unexpected finds, have potential to cause harm to the nearby environment (receptors) and human health (construction workers who handle the materials)	**AWRC site Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (temporary) Historical contamination and contamination found during investigations, and existing buildings containing hazardous materials are likely to be disturbed during construction works. Storage, handling, and use of chemicals will occur as part of construction.
• Salinity – Disturbance and distribution of moderate to highly saline soils from deep excavations at the AWRC site and trenches and under boring on either side of creek and drainage lines where higher salinity risk is present.	**AWRC site and Pipelines:** Shallow and deep excavations, trenching, HDD/under bore pits	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (temporary) Moderate to high risk salinity is present in deeper soils within the AWRC site and around some creeks and drainage lines for pipelines. Section 9.4 and Appendix B present intrusive soil results which indicate reuse of these soils could generate saline conditions if placed on the surface of used for landscaping.
• Salinity – Reuse of extracted saline groundwater from excavations and application to ground	**AWRC site and Pipelines:** Dust suppression and saline groundwater reuse on land surface via application to land	Significance: Moderate Sensitivity of environmental values: Low (localised and temporary) Magnitude of impact: Moderate (temporary) Saline waters sprayed on non-saline soils and sub soils could impact soil salinity, durability of structures and increase soil sodicity and erosion potential.

Potential Impact	Project location/Activity	Impact significance
surface for dust suppression or other construction management reuse opportunities.		
• Soils – loss of soil fertility from the removal of topsoil's and soil profile health from construction activity. Replacement of soils not in accordance with soil health guidelines and local soil drainage conditions.	**AWRC site and Pipelines:** Broadscale stripping, grubbing, shallow excavations, trenching, filling of land with engineering fill platform at AWRC site	Significance: Low Sensitivity of environmental values: Negligible Magnitude of impact: Low (unlikely) Soil fertility for cropping and agistment is not commonly undertaken in the project and surrounding areas are being developed as growth areas. High quality agricultural land use is not present in the project area so magnitude of development is considered to be low.
• Soils – increased erosion from surface construction activity and stockpiling of spoil for ground preparation and landscaping	**AWRC site, access road and Pipelines:** Stripping, grubbing, shallow excavations, trenching, landscaping, access roads	Significance: Moderate Sensitivity of environmental values: Moderate Magnitude of impact: Moderate (temporary) Pipeline excavations would be localised and linear with more erosion impacts associated with trenched sections. Under boring pipelines would have a reduced impact and be localised to boring entry and exit sites. AWRC site will have broad topsoil and sub soil excavation and will produce stockpiles of spoil, some for reuse and some for disposal off site or beneficial reuse. Ground surfaces will be modified from pre-development conditions.
• Soils – Acid sulfate soils disturbance via excavation or de-watering of groundwater for infrastructure, principally near and around Prospect Creek in the eastern portion of the brine pipeline.	**Pipelines:** Deep and shallow excavations, dewatering near Prospect Creek at the eastern end of the brine pipeline	Significance: Moderate Sensitivity of environmental values: Low (temporary and localised) Magnitude of impact: Low Excavations would be minor and localised to the pipeline construction. Construction works would be temporary not change pre-development conditions significantly.

Potential Impact	Project location/Activity	Impact significance
• Soils – Sodic subsoils could become exposed and cause increased rates of erosion and sediment transport to surface water receptors.	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, exposed soils upon heavy rainfall events	Significance: Moderate Sensitivity of environmental values: Moderate Magnitude of impact: Moderate (temporary and local) Increased erosion and sediment from exposed sub soils and increased salinity expression leading to sodic soils becoming more mobile. Sodic soils are present within the AWRC site and pipelines at variable depths and concentrations. A summary of site investigation results is provided in Section 9.5 and results from investigations in Appendix B.
• Soils – Reuse of sodic subsoils and saline soils on the ground surface for the project where characterisation of soil quality has not been undertaken or understood.	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits, landscaping	Significance: Moderate Sensitivity of environmental values: Low (unlikely) Magnitude of impact: Low (temporary and local) Reuse of sodic soils at the ground surface could generate increased erosion impacts when wet and increased instability of soil profile.
• Soils – Slope instability and landslides from cutting into soil and rock for project elements. Destabilisation of soils and slopes.	**AWRC site and pipelines:** Installation of underground infrastructure and pipelines, under-boring, construction of AWRC site deeper excavations	Significance: Low Sensitivity of environmental values: Low (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change) Slope stability would impact localised areas only and large scale cutting for access roads and or into slopes is not apparent in project. Under-boring of pipelines uses techniques that manage risks associated with land stability as part of the methodology.
• Land – Mine subsidence from underlying former mining activity and potential for project construction to introduce surface impacts such as instability and depressions in ground surface	**AWRC site and pipelines:** Installation of underground infrastructure and pipelines, under-boring, construction of AWRC site deeper excavations	Significance: Low Sensitivity of environmental values: Low Magnitude of impact: Low (temporary and local, minimal change) Based on the information reviewed in Section 4.13 and 10, the project is not in a proclaimed mine subsidence district, is not undermined, and is not subject to any imposed conditions by the NSW Government Subsidence Advisory.

Table 11-2.

The AECs along the treated water and brine pipelines are shown on Figure 6-2a to d and for the AWRC on Figure 6-3, Appendix D.

Table 11-1 Impact assessment outcomes and significance (Construction phase)

Potential Impact	Project location/Activity	Impact significance
• Contamination – disturbance of soils containing contamination during construction	**AWRC site, access roads:** Stripping, grubbing, shallow and deep excavations	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) Known contamination of shallow soils in certain portions of the AWRC site exist. If these materials were not well managed, contamination impacted soils could spread, increase risk of exposure and contaminate other areas of the AWRC site. AECs are described in Section 10 and figures indicating AECs in Appendix D.
• Contamination – disturbance of soils containing contamination during construction	**Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) Known and unknown contamination risks exist along the pipeline routes for shallow trenched soils and near surface soils. If these materials were not well managed, contamination impacted soils could spread, increase risk of exposure and contaminate other areas of the Pipelines route or migrate outside of the construction boundary. AECs are described in Section 10 and figures indicating AECs in Appendix D.
• Contamination – mobilisation and distribution of contaminants present in soil across the project during construction	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) If these materials were not well managed during construction, contamination impacted soils could migrate outside of the construction boundary, resulting in increased exposure risks and potential for additional waste disposal requirements.

Potential Impact	Project location/Activity	Impact significance
• Contamination – Generation of contaminated waste streams during construction from trench spoil and excavations of unsuitable materials	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, trenching, demolition	Significance: Low Sensitivity of environmental values: Low Magnitude of impact: Low (temporary) Waste streams will be generated due to the project type and size. The waste streams will be characterised and either beneficially reused or disposed as a waste to licensed facilities.
• Contamination – poor handling of hazardous building materials during demolition and surface scrapping of contaminated shallow soils, principally asbestos in shallow soils	**AWRC site, access roads:** Demolition of structures, stripping, grubbing, shallow and deep excavations	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Moderate (temporary) Demolition of localised structures and shallow impacted soils could generate contamination within and around the demolition zones. Demolition is likely to be localised to minor buildings and former structures on the AWRC site. AECs are described in Section 10 and figures indicating AECs in Appendix D.
• Contamination – Disturbance of known asbestos contamination within soils around the Core Park area, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street, near Warragamba Dam.	**Pipelines:** Stripping, grubbing, shallow excavations, trenching, trenching, HDD/under bore pits, construction compound C1	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (temporary) Existing known contamination exists in these areas, impacts would be temporary. Disturbance of soils and asbestos could generate exposure scenarios for workers and the public. AECs are described in Section 10 and figures indicating AECs in Appendix D. The majority of the areas impacted by ACM will be tunnelled under, however, construction compound C1 will require ground disturbance and likely impact localised asbestos in soils.

Potential Impact	Project location/Activity	Impact significance
• Contamination – Storage and management of contaminant sources such as fuels, chemicals, building materials, wastes (e.g. demolition), hazardous materials, pathogens, unexpected finds, have potential to cause harm to the nearby environment (receptors) and human health (construction workers who handle the materials)	**AWRC site Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (temporary) Historical contamination and contamination found during investigations, and existing buildings containing hazardous materials are likely to be disturbed during construction works. Storage, handling, and use of chemicals will occur as part of construction.
• Salinity – Disturbance and distribution of moderate to highly saline soils from deep excavations at the AWRC site and trenches and under boring on either side of creek and drainage lines where higher salinity risk is present.	**AWRC site and Pipelines:** Shallow and deep excavations, trenching, HDD/under bore pits	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (temporary) Moderate to high risk salinity is present in deeper soils within the AWRC site and around some creeks and drainage lines for pipelines. Section 9.4 and Appendix B present intrusive soil results which indicate reuse of these soils could generate saline conditions if placed on the surface of used for landscaping.
• Salinity – Reuse of extracted saline groundwater from excavations and application to ground surface for dust suppression or other construction management reuse opportunities.	**AWRC site and Pipelines:** Dust suppression and saline groundwater reuse on land surface via application to land	Significance: Moderate Sensitivity of environmental values: Low (localised and temporary) Magnitude of impact: Moderate (temporary) Saline waters sprayed on non-saline soils and sub soils could impact soil salinity, durability of structures and increase soil sodicity and erosion potential.

Potential Impact	Project location/Activity	Impact significance
• Soils – loss of soil fertility from the removal of topsoil's and soil profile health from construction activity. Replacement of soils not in accordance with soil health guidelines and local soil drainage conditions.	**AWRC site and Pipelines:** Broadscale stripping, grubbing, shallow excavations, trenching, filling of land with engineering fill platform at AWRC site	Significance: Low Sensitivity of environmental values: Negligible Magnitude of impact: Low (unlikely) Soil fertility for cropping and agistment is not commonly undertaken in the project and surrounding areas are being developed as growth areas. High quality agricultural land use is not present in the project area so magnitude of development is considered to be low.
• Soils – increased erosion from surface construction activity and stockpiling of spoil for ground preparation and landscaping	**AWRC site, access road and Pipelines:** Stripping, grubbing, shallow excavations, trenching, landscaping, access roads	Significance: Moderate Sensitivity of environmental values: Moderate Magnitude of impact: Moderate (temporary) Pipeline excavations would be localised and linear with more erosion impacts associated with trenched sections. Under boring pipelines would have a reduced impact and be localised to boring entry and exit sites. AWRC site will have broad topsoil and sub soil excavation and will produce stockpiles of spoil, some for reuse and some for disposal off site or beneficial reuse. Ground surfaces will be modified from pre-development conditions.
• Soils – Acid sulfate soils disturbance via excavation or de-watering of groundwater for infrastructure, principally near and around Prospect Creek in the eastern portion of the brine pipeline.	**Pipelines:** Deep and shallow excavations, dewatering near Prospect Creek at the eastern end of the brine pipeline	Significance: Moderate Sensitivity of environmental values: Low (temporary and localised) Magnitude of impact: Low Excavations would be minor and localised to the pipeline construction. Construction works would be temporary not change pre-development conditions significantly.

Potential Impact	Project location/Activity	Impact significance
• Soils – Sodic subsoils could become exposed and cause increased rates of erosion and sediment transport to surface water receptors.	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, exposed soils upon heavy rainfall events	Significance: Moderate Sensitivity of environmental values: Moderate Magnitude of impact: Moderate (temporary and local) Increased erosion and sediment from exposed sub soils and increased salinity expression leading to sodic soils becoming more mobile. Sodic soils are present within the AWRC site and pipelines at variable depths and concentrations. A summary of site investigation results is provided in Section 9.5 and results from investigations in Appendix B.
• Soils – Reuse of sodic subsoils and saline soils on the ground surface for the project where characterisation of soil quality has not been undertaken or understood.	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits, landscaping	Significance: Moderate Sensitivity of environmental values: Low (unlikely) Magnitude of impact: Low (temporary and local) Reuse of sodic soils at the ground surface could generate increased erosion impacts when wet and increased instability of soil profile.
• Soils – Slope instability and landslides from cutting into soil and rock for project elements. Destabilisation of soils and slopes.	**AWRC site and pipelines:** Installation of underground infrastructure and pipelines, under-boring, construction of AWRC site deeper excavations	Significance: Low Sensitivity of environmental values: Low (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change) Slope stability would impact localised areas only and large scale cutting for access roads and or into slopes is not apparent in project. Under-boring of pipelines uses techniques that manage risks associated with land stability as part of the methodology.

Potential Impact	Project location/Activity	Impact significance
• Land – Mine subsidence from underlying former mining activity and potential for project construction to introduce surface impacts such as instability and depressions in ground surface	**AWRC site and pipelines:** Installation of underground infrastructure and pipelines, under-boring, construction of AWRC site deeper excavations	Significance: Low Sensitivity of environmental values: Low Magnitude of impact: Low (temporary and local, minimal change) Based on the information reviewed in Section 4.13 and 10, the project is not in a proclaimed mine subsidence district, is not undermined, and is not subject to any imposed conditions by the NSW Government Subsidence Advisory.

Table 11-2 Impact assessment outcomes and significance (Operational phase)

Potential Impact	Project location/Activity	Impact significance
• Contamination – Residual contamination, which is not suitably remediated, mitigated, or managed during the construction phase of the project. Contamination issues during operation that could impact the environment and exposure to contamination for workers and the public.	**AWRC site and Pipelines:** Former areas of ground disturbance that were contaminated and poorly remediated or management approach is inadequate. Asbestos impacted areas around Warragamba Dam.	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (localised) Residual contamination not sufficiently remediated or managed during construction could have an impact during the operation phase of the project. The impact would be localised and require addressing during the operation phase to limit potential contamination exposure scenarios to workers and the public.

Potential Impact	Project location/Activity	Impact significance
• Contamination – Contaminated runoff from the operation of vehicles, machinery, and infrastructure, chemical spills, waste management and overflow/leakages of untreated or partially treated wastewater.	**AWRC site and Pipelines:** AWRC site and pipelines across the project	Significance: Moderate Sensitivity of environmental values: Low Magnitude of impact: Low (localised) Any spills or accidental discharges will be temporary in nature but could lead to localised contamination (e.g. hydrocarbons, metals, suspended sediments, nutrients and biological constituents such as faecal coliforms). The magnitude of impact would be governed by the local sensitive receptors and distance to the source of impact.
• Salinity – Increased stormwater or recycled water irrigation around the AWRC site could mobile salts in the landscape and impact surface water receptors and degrade soils in localised areas where groundwater levels rise to the near surface or daylight at break of slope.	**AWRC site, access roads:** Irrigation of land with recycled water or stormwater	Significance: Moderate (existing local impacts) Sensitivity of environmental values: Moderate (localised and temporary) Magnitude of impact: Moderate (localised) Uncontrolled irrigation of the landscape around the AWRC site could impact the localised hydrologic cycles and increase salt mobilisation. These hydrologic changes could impact soil drainage, salinity and pre-development site conditions.
• Salinity – Secondary salinisation, which is changes in landscape salt movement over time resulting from construction activities, through processes such as the removal of vegetation, altering hydrology, general land use changes and extraction of groundwater. • Pipelines and under-boring locations have less impact on land and salinity across the project due to their linear nature and reduced land and water table disturbance and no irrigation to land. •	**AWRC site:** AWRC site and immediate surrounds where landscape changes and irrigation to land will occur during operation phase.	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Moderate (localised) Changes to the soil profile, increased hardstand, changes to vegetation and species cover and irrigation of land using recycled water and stormwater could impact long term salinity compared to pre-development conditions. The impact would reach an equilibrium over time based on final landform and rates of irrigation applied to land.
• Salinity – Brine leaking from the pipelines during operation may cause localised saline contamination to soils and cause erosion and increased salt levels in surface soils and sub soils.	**Brine pipeline:**	Significance: Low Sensitivity of environmental values: Low

Potential Impact	Project location/Activity	Impact significance
	Leaking of brine fluid from the pipeline alignment and junctions	Magnitude of impact: Low (localised) Water leaking from the pipelines during operation may cause localised increases to groundwater levels and potentially induce groundwater contamination. Water transmitted through the treated water and environmental flows pipelines will be of high quality and unlikely to cause significant impacts to groundwater quality. Water transmitted through the brine pipeline will have much higher total dissolved solids and leaks/bursts occurring across this pipeline is likely to cause a localised decline in groundwater quality. Refer to *Groundwater Impact Assessment* for further detail on impacts and mitigation related to groundwater.
• Soils – erosion of soil via scouring, water pressure at release points and releases of sediment-laden stormwater due to: – New infrastructure and sealed surfaces – Incorrectly designed scour protection measures – Poor manufacturing tolerances of pipes and infrastructure – Poor drainage design and sediment basin designs	**AWRC site, pipeline corridors, and access roads:** Across parts of the project that have release points such as environmental flows, irrigation to land and stormwater and WSUD infrastructure	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (localised) Sediment management procedures are required to prevent generation of downstream impacts. Lack of maintenance could cause increased erosional impacts especially if design or construction of drainage and sediment basins is inadequate.
• Soils – increased erosion of soils where landscaping and final landform design and construction is unsuitable for the soils present over the operational phase.	**AWRC site and access roads:** Associated with AWRC site and access roads as pipelines will be underground.	Significance: Low Sensitivity of environmental values: Moderate Magnitude of impact: Low (localised) Where design, construction and landscaping does not adequately address soil types and quality across the AWRC site, impacts may occur during the operation phase. These may include increased sediment transport where vegetation does not grow adequately, poor soil structure for growing medium and sediment transport to receiving waters and ecological receptors.

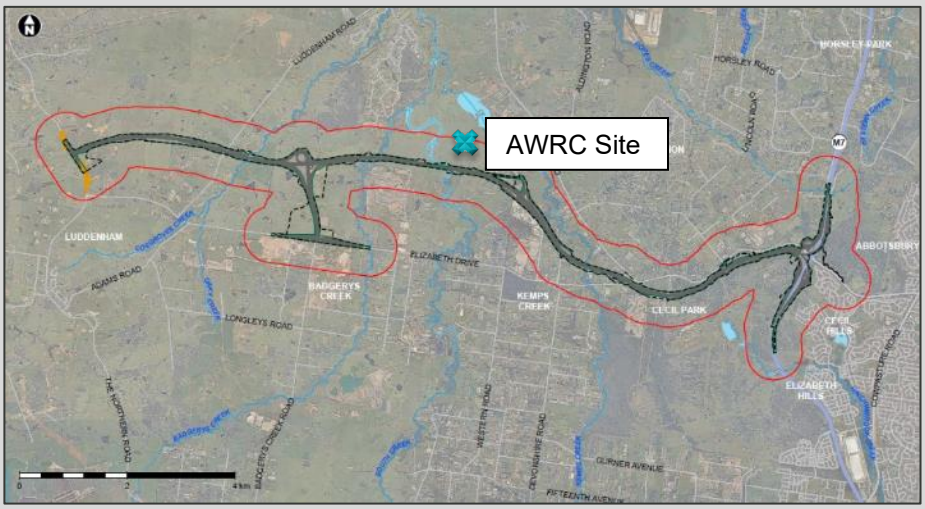
12 Cumulative Impacts

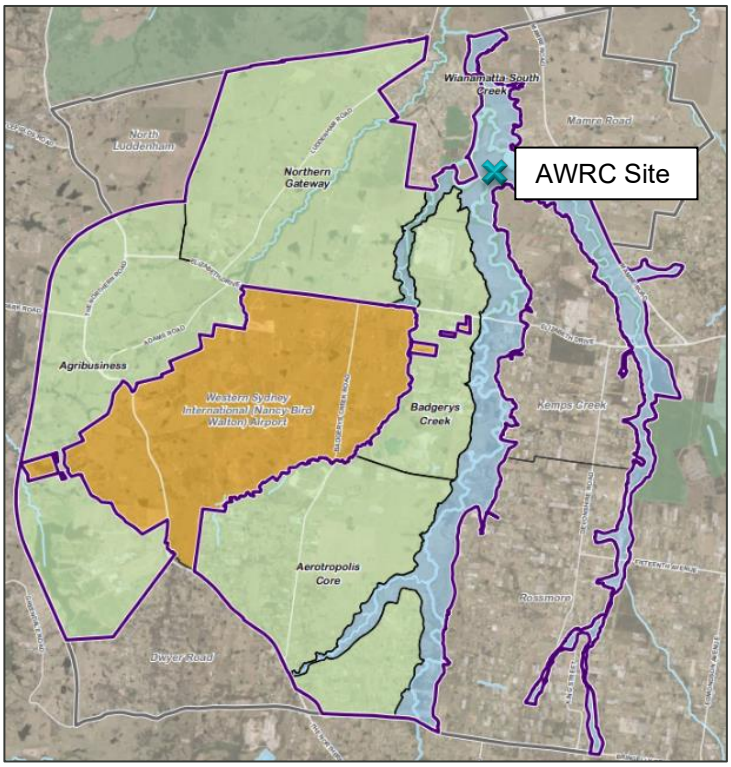
Western Sydney been earmarked for major growth and urbanisation within the near future. This growth is the primary driver for the development of the AWRC project. The rapid change in topography, surface coverage and general land use will result in major impacts to the natural environment.

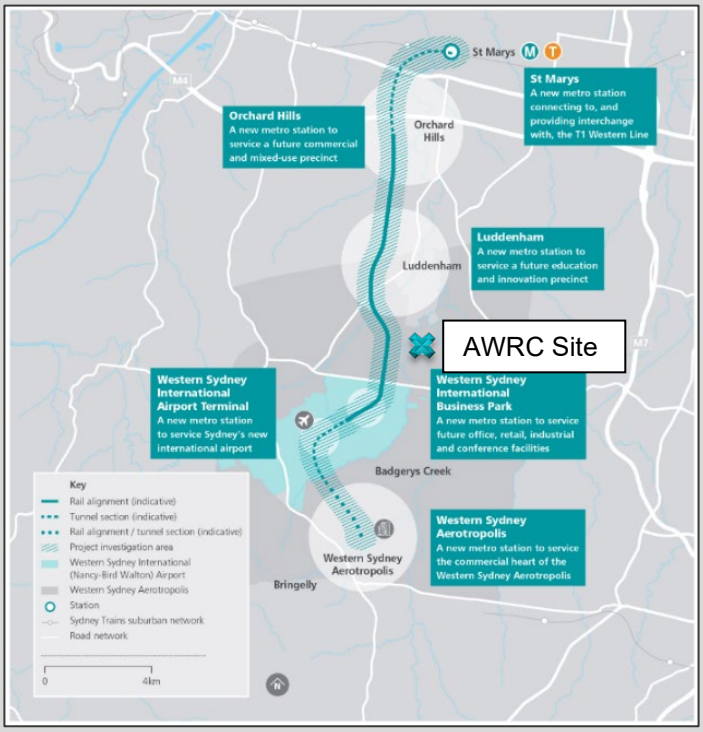
When considered in isolation, any identified project impacts may be considered minor. These minor impacts may, however, may be compounded, when the cumulative impacts of multiple projects on the same receivers are considered. As such, the potential soil and contamination impacts identified and discussed in Section 11, need to be considered alongside recently completed, ongoing and proposed projects. The major projects currently being proposed within close proximity to the desktop assessment area are indicated in Table 12-1.

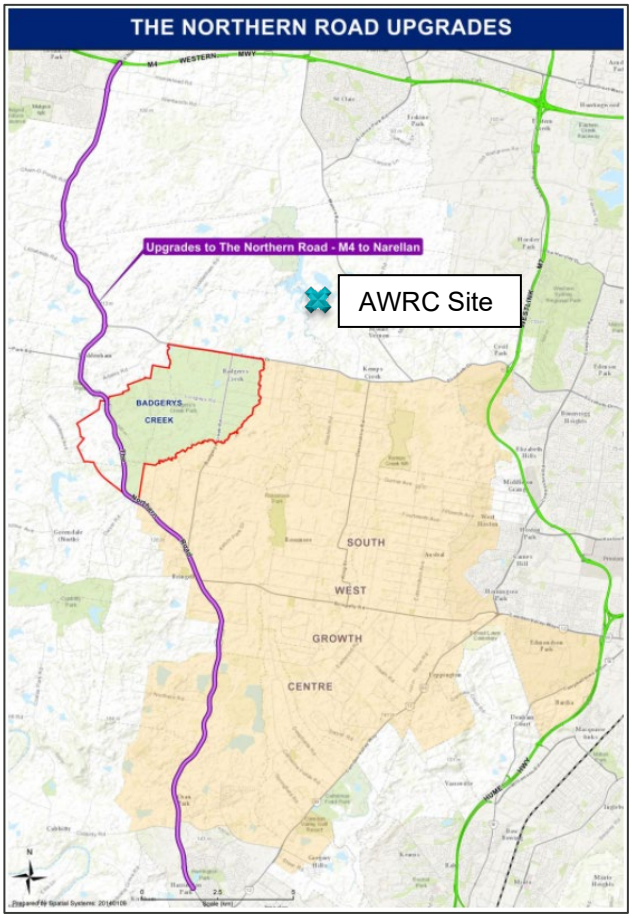
Table 12-1 Proposed major projects in close proximity to the project

Project	Project description, relation to current proposed AWRC project and expected cumulative impacts
Western Sydney Airport	**Description:** The proposed Western Sydney Airport site will be located approximately 3.2 km south-west of the AWRC site, south of Elizabeth Drive. The site is primarily drained by Badgerys Creek and Cosgroves Creek. Construction at the Western Sydney Airport site has already commenced. The Western Sydney Airport EIS topography, geology and soils assessment (GHD, 2016) concluded that: • Impacts to soil erosion and degradation during project construction are not expected to be significant (provided appropriate management measure are implemented) • Potential contamination impacts are not expected to be significant and would be avoided by implementing appropriate management measures • Given the recognised potential for salinity in the proposed airport soils, further soil salinity sampling is expected to be undertaken prior to construction • A remedial action plan (RAP) would be prepared prior to construction of the proposed airport to ensure the land would be suitable for its intended use • Measures to mitigate and manage soil erosion and degradation, land contamination, and wastewater reuse will be collated in environmental management plans prior to construction of the proposed airport **Interaction:** The interaction between the Western Sydney Airport and AWRC site is expected to be minimal due to physical distance. The interaction between the Western Sydney Airport and the treated water pipeline will occur principally along the Elisabeth Drive northern boundary of the airport during construction. **Cumulative impacts:** The Western Sydney EIS indicated that the key risks to soil are erosion, salinity, storage of fuel and the use of reclaimed water for irrigation. However, given that these impacts are expected to be managed with the implementation of appropriate control and monitoring measures, the cumulative risk from this project is considered to be low.

Project	Project description, relation to current proposed AWRC project and expected cumulative impacts
M12 Motorway	**Description:** The proposed M12 Motorway will run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 km and would be opened to traffic prior to opening of the Western Sydney Airport.  **Interaction:** The AWRC site itself is located within the extents of the M12 impact area. The pipelines will follow a similar alignment to the M12 along portions of their routes. The interaction between the M12 Motorway and the treated water pipeline will occur principally along the Elisabeth Drive northern boundary of the airport during construction along with work immediately south of the AWRC site. **Cumulative impacts:** Based on the soil and contamination assessment and the proposed design, the project is expected to generate negligible impacts to soil salinity and ASS, with potential to cause soil erosion. The report also noted that there were several areas with potential or known contamination within the construction boundary. Additionally, the project requires the demolition of several buildings which contain hazardous materials. However, given that these impacts are expected to be managed with the implementation of appropriate remediation, control and monitoring measures, the cumulative risk from this project is considered to be low.

Project	Project description, relation to current proposed AWRC project and expected cumulative impacts
Aerotropolis priority precincts	**Description:** The Western Sydney Planning Partner (WSPP) has identified several initial precincts which will targeted for early land release and development. These precincts all directly border the Western Sydney Airport site, they include: the Aerotropolis Core, Badgerys Creek, Northern Gateway, Agribusiness and adjoining areas of Wianamatta-South Creek as indicated below. These precincts are primarily located within the South Creek catchment as the discharge pipelines will transect several of them.  **Interaction:** Interaction will occur within the impact area for pipelines and the AWRC site which is within the initial precincts. An integrated water management plan and land capability assessment targeting these precincts has been developed. This includes the Phase 1 DCP for initial precincts with associated objectives and benchmarks for soil and contamination management during future development. The purpose of the plan is to identify measures and control mechanisms to ensure sustainable soil and contamination management practices are established and consequently mitigate the cumulative impacts that the rapid urbanisation may lead to. **Cumulative impacts:** As future development within the initial precincts will be controlled via the *State Environmental Planning Policy (Western Sydney Aerotropolis)* 2020 and Phase 1 DCP, the cumulative risk from this project and future development is considered to be low.

Project	Project description, relation to current proposed AWRC project and expected cumulative impacts
Sydney Metro – Western Sydney Airport	**Description:** The proposed new railway will link St Marys to the new airport and the Western Sydney Aerotropolis, alignment indicated below (Sydney Metro, 2020).  **Interaction:** The project footprint is primarily located within the South Creek catchment (or its tributaries). The expected interaction between the projects is minimal, with the metro construction to occur principally intersecting the treated water pipeline. **Cumulative impacts:** The Sydney Metro West EIS soils, water and contamination assessment notes soil and contamination issues associated with the project includes leaks and spills of fuel, oil and other hazardous materials, salinity and erosion. The expected impacts to soils and contamination are considered to be minimal with the implementation of appropriate control and monitoring measures, the cumulative risk from this project is considered to be low.

Project	Project description, relation to current proposed AWRC project and expected cumulative impacts
The Northern Road Upgrade	**Description:** The Northern Road between Mersey Road and Glenmore Parkway is being upgraded and includes upgrades at the intersection of Elizabeth Drive along the treated water pipeline.  **Interaction:** The interaction between the Northern Road Upgrade and AWRC site is expected to be minimal due to physical distance. The interaction between the Northern Road Upgrade and the treated water pipeline will occur principally along the Northern Road at Luddenham, Elisabeth Drive and Park Road during construction. **Cumulative impacts:** The Northern Road upgrade EIS soils, water and contamination assessment (Jacobs, 2017) concluded that the project is expected to generate negligible impacts to ASS, with potential to cause soil erosion. The report also noted that there were several areas with potential or known contamination within or close to the project area. However, the majority of them represent a low risk. Given that these impacts are expected to be managed with the implementation of appropriate remediation, control and monitoring measures, the cumulative risk from this project is considered to be low.

Project	Project description, relation to current proposed AWRC project and expected cumulative impacts
Warragamba Dam Raising	**Description:** Warragamba Dam Raising is a project to provide temporary storage capacity for large inflow events into Lake Burragorang to facilitate downstream flood mitigation and includes infrastructure to enable environmental flows. **Interaction:** The EIS for this project is still being developed and thus potential impacts have not been assessed and published as yet. **Cumulative impacts:** Cumulative impacts are expected to be minimal as the dam is located upstream of the e-flows discharge location, and the raising is aimed at storing major flood events rather than retaining more water on a regular basis.

These proposed major projects along with the general expected future urban development in the area have the potential to alter existing soil and contamination conditions, such as alterations to current soil landscapes, exposure of subsoils, increased erosion and soil movement from sodicity, mobilisation of salt and the disturbance of contaminants present in the landscape. These alterations could exacerbate any impacts arising from the construction and operation of the AWRC and pipelines.

Generally major projects are designed and delivered in accordance with current environmental legislation and incorporate sufficient control measures to mitigate associated impacts and primarily targeting a neutral or beneficial impacts outcome. Given the widespread expected urbanisation of the local environment, which would include numerous small-scale developments, the cumulative impacts from these smaller developments could become a more likely source of compounded impacts.

Most soil and contamination impacts associated with the AWRC project are expected to be minor and short-term (during construction). The AWRC project is not expected to generate significant soil and contamination impacts during operation. If the proposed mitigation measures are incorporated, the project would have a minor contribution to any foreseen cumulative soil and contamination impacts from other identified projects in the vicinity.

13 Mitigation measures

A summary of the identified potential impacts along with their proposed mitigation measures and resultant impact significance are provided for the construction phase activities and are listed in Table 13-1. Any additional impacts associated only with the operational phase are indicated with their proposed mitigation measured in Table 13-2.

Table 13-1 Mitigation and effectiveness (Construction phase)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Contamination – disturbance of soils containing contamination during construction	**AWRC site, access roads:** Stripping, grubbing, shallow and deep excavations	• Further assessment of identified contamination AECs (typically asbestos in soils) prior to construction to determine remedial or management actions (if required). The AECs to be assessed are shown in Figures in Appendix D. The investigations are to be undertaken in accordance with guidelines made or endorsed by the EPA (outlined in Table 2-1) and the ASC NEPM 2013. The additional supplementary investigations must consider detailed engineering design and construction methodology to inform management, remedial or risk assessment approaches. • Destructive hazardous materials (HAZMAT) asbestos and lead paint surveys of any buildings or structures within the AWRC site prior to demolition, clearing or earthworks. • Data obtained from these assessments will provide site specific remediation recommendations and outline locations, quantities and condition of materials identified in order to inform cost estimates and scheduling of remediation works.	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		• Contamination management strategies are to be undertaken in accordance with Sydney Water internal policy for managing contamination risks and NSW EPA *Guidelines for Consultants Reporting on Contaminated Land* (2020). • Any remediation required will be undertaken based on a project specific remedial action plan (RAP). The RAP will define remedial goals and objectives, performance criteria for remedial effort and remediation methodology. A validation report will be prepared after remedial effort and be in accordance with the NSW EPA *Guidelines for Consultants Reporting on Contaminated Land* (2020). • All contamination related reports and documents prepared as part of the project must be prepared or reviewed and approved by a certified contamination practitioner (CEnvP-SC or equivalent).	
• Contamination – disturbance of soils containing contamination during construction	**Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits	• Further assessment of identified contamination AECs (typically asbestos in soils, heavy metals and some hydrocarbon impacts) prior to construction to determine remedial or management actions (if required). The AECs to be assessed are shown in Figures in Appendix D. The investigations are to be undertaken in accordance with guidelines made or endorsed by the EPA (outlined in Table 2-1) and the ASC NEPM 2013. • Data obtained from these assessments will provide site specific remediation	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		recommendations and outline locations, quantities and condition of materials identified in order to inform cost estimates and scheduling of remediation works. • Contamination management strategies are to be undertaken in accordance with Sydney Water internal policy for managing contamination risks and NSW EPA *Guidelines for Consultants Reporting on Contaminated Land* (2020). • Any remediation required will be undertaken based on a project specific remedial action plan (RAP). The RAP will define remedial goals and objectives, performance criteria for remedial effort and remediation methodology. A validation report will be prepared after remedial effort and be in accordance with the NSW EPA *Guidelines for Consultants Reporting on Contaminated Land* (2020). • All contamination related reports and documents prepared as part of the project must be prepared or reviewed and approved by a certified contamination practitioner (CEnvP-SC or equivalent).	
• Contamination – mobilisation and distribution of contaminants present in soil across the project during construction	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations	• Further assessment of identified contamination AECs (typically asbestos in soils and lead) prior to construction to characterise extent and type of contaminants. • Destructive hazardous materials (HAZMAT) asbestos and lead paint surveys of any buildings or structures within the AWRC site prior to demolition or earthworks. The report will outline	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		confirmed hazardous materials present and recommendations for materials management during demolition and removal from the AWRC site. • The contractor will follow the remedial action plan (RAP) for the project where remedial effort is undertaken. This will include methodology to minimise risks of distribution of asbestos or other contamination by having both 'clean' and 'contaminated' zones and access points between the two. • Compliance monitoring by the contractor and recording of waste volumes, waste types, stockpiles register and survey for all remedial effort where excavations and stripping of surface soil contamination occurs for the project. Keeping all records during construction for waste disposal and importation of materials such as engineering fill and ENM or VENM soils. • Air monitoring for asbestos fibres and dusts during all remedial works where asbestos is a contaminant of concern.	
• Contamination – Generation of contaminated waste streams during construction from trench spoil and excavations of unsuitable materials	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, trenching, demolition	• All contaminated waste to be disposed off site from the project must be characterised in accordance with the EPA *Waste Classification Guidelines* (2014). • Spoil and soils sourced from pipeline trenching and under bore construction activity can be reused under an NSW EPA approved resource recovery exemption where the materials are sourced from within the project boundary. These	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		materials can be reused under specific management measures within the AWRC site for landscaping, noise mounds, engineering fill and similar uses. The materials if contamination is present within the spoil, must be non-leachable to ensure that leaching of contaminants (such as heavy metals) does not occur long term where reused. Specifically, reuse within the project boundary should aim to reuse suitable spoil from both a contamination and geotechnical perspective to minimise offsite waste disposal in accordance with the NSW EPA waste avoidance hierarchy. • All engineering fill materials (soil) imported to the site would be validated to ensure they meet the classification of VENM or ENM before being transported to the site.	
• Contamination – poor handling of hazardous building materials during demolition and surface scrapping of contaminated shallow soils, principally asbestos in shallow soils	**AWRC site, internal access roads:** Demolition of structures, stripping, grubbing, shallow and deep excavations	• Further assessment of identified contamination AECs (typically asbestos in soils and lead) prior to construction to determine remedial or management actions (if required). • Destructive hazardous materials (HAZMAT) asbestos and lead paint surveys of any buildings or structures within the AWRC site prior to demolition or earthworks. • Earthworks planning to ensure that contaminated zones (based on AECs detailed in this report) do not distribute asbestos or any other contamination away from the source zones. Earthworks planning will be provided in the project RAP and civil engineering documentation at detailed design.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Contamination – Disturbance of known asbestos contamination within soils around the Core Park area, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street, near Warragamba Dam.	**Pipelines:** Stripping, grubbing, shallow excavations, trenching, trenching, HDD/under bore pits	• Further assessment of identified contamination AECs (typically asbestos in soils) prior to construction to characterise extent of asbestos impact for areas construction will disturb. • Assessment at detailed design and prior to construction the under bore pits, under bore alignment and areas of ground disturbance required. Mitigation must include consideration of minimal disturbance of known asbestos impacted areas or remedial measures such as placement of capping layers over disturbance areas instead of stripping and grubbing ground surface. • The AECs to be assessed are shown in Figures in Appendix D. The investigations are to be undertaken in accordance with guidelines made or endorsed by the EPA (outlined in Table 2-1) and the ASC NEPM 2013. • Data obtained from these assessments will provide site specific remediation recommendations and outline locations, quantities and condition of materials identified in order to inform cost estimates and scheduling of remediation works. • Contamination management strategies are to be undertaken in accordance with Sydney Water internal policy for managing contamination risks and NSW EPA *Guidelines for Consultants Reporting on Contaminated Land* (2020). • Any remediation required will be undertaken based on a project specific remedial action plan (RAP). The RAP will define remedial goals and	Significance: Moderate Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		objectives, performance criteria for remedial effort and remediation methodology. A validation report will be prepared after remedial effort and be in accordance with the NSW EPA *Guidelines for Consultants Reporting on Contaminated Land* (2020). • All contamination related reports and documents prepared as part of the project must be prepared or reviewed and approved by a certified contamination practitioner (CEnvP-SC or equivalent). • All contaminated waste to be disposed off site from the project must be characterised in accordance with the EPA *Waste Classification Guidelines* (2014).	
• Contamination – Storage and management of contaminant sources such as fuels, chemicals, building materials, wastes (e.g. demolition), hazardous materials, unexpected finds, have potential to cause harm to the nearby environment (receptors) and human health (construction workers who handle the materials)	**AWRC site Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits	• Storage of chemicals and fuels during construction must be within containers suitable for the contained goods and where necessary, to all Australian Standards and supplier storage recommendations to prevent spills, leaks and contamination impacts. • Construction storage areas for fuels and chemicals must be engineered with bunds and containment devices or systems to prevent leaks and spills to the environment. • Unexpected contamination conditions may be encountered due to previously unknown heterogeneities in the subsurface or changes in the project scope. Therefore, an unexpected finds protocol will form part of the CEMP.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		• All contaminated waste to be disposed off site from the project must be characterised in accordance with the EPA *Waste Classification Guidelines* (2014). Refer to the Waste Impact Assessment (Aurecon Arup 2021)	
• Salinity – Disturbance and distribution of moderate to highly saline soils from deep excavations at the AWRC site and trenches and under boring on either side of creek and drainage lines where higher salinity risk is present.	**AWRC site and Pipelines:** Shallow and deep excavations, trenching, HDD/under bore pits	• Construction within areas of moderate to high risk saline soils will be managed in accordance with the CEMP. Specific measures will also include (but not be limited to): – Ongoing groundwater monitoring of salinity – Identification and management of saline discharge sites – Progressive stabilisation and revegetation of exposed areas following disturbance as soon as is practicable – Further site investigation testing to confirm the presence of saline soils in areas of high salinity potential prior to disturbance. • Review existing soil salinity information developed for the project. Develop and implement a soil sampling program based on detailed engineering designs and construction methodology prior to construction to assess excavated soils. Analyse soils for salinity to determine beneficial reuse options. • Soil salinity management methods will be developed in accordance with the NSW Department of Primary Industries (2014) *Salinity Training Handbook* and *NSW guidelines for*	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		salinity management and those guidelines listed in Table 2-1.	
• Salinity – Reuse of extracted saline groundwater from excavations and application to ground surface for dust suppression or other construction management reuse opportunities.	**AWRC site and Pipelines:** Dust suppression and saline groundwater reuse on land surface via application to land	• Extracted groundwater is saline and should not be used for surface dust suppression within the AWRC site and pipelines. • Where testing and analysis of waters indicates groundwater is non saline or treated to a suitable level of water quality, extracted groundwater can be used for dust suppression. The criteria and water quality parameters to be met must take into account local receptors and be included in the project CEMP. Further analysis of suitable criteria will be undertaken during detailed design.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)
• Soils – loss of soil fertility from the removal of topsoil's and soil profile health from construction activity. Replacement of soils not in accordance with soil health guidelines and local soil drainage conditions.	**AWRC site and Pipelines:** Broadscale stripping, grubbing, shallow excavations, trenching, filling of land with engineering fill platform at AWRC site	• Soils will be replaced and land formed in accordance with the project Landscaping Plans for the AWRC site and engineering designs for compacted materials for pipelines. • Soil fertility via topsoil will be retained during stripping and grubbing of the AWRC site and stockpiled for future reuse as planting medium. • Soil profiles will mimic existing natural soil profiles where possible. The project Landscaping Plans will use suitable imported soil and aggregates to ensure soil fertility and soil profile health is retained based on site specific analysis of the AWRC site constraints and planting requirements.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)
• Soils – increased erosion from surface construction activity and stockpiling of spoil for ground preparation and landscaping	**AWRC site, access road and Pipelines:** Stripping, grubbing, shallow excavations,	• A project specific Erosion and Sediment Control Plan (ESCP) will be implemented as part of Construction Environmental Management Plan (CEMP). This plan provides mitigation to minimise	Significance: Low Sensitivity of environmental values: Moderate (localised)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
	trenching, landscaping, access roads	the risk of erosion and prevent sediment migration. • Standard erosion control measures consistent with those detailed in Landcom (2004) *Managing Urban Stormwater guidelines* will be adopted and water sensitive urban design (WSUD) for sedimentation basins on the AWRC site. Monitoring of sedimentation basins prior to release will occur to ensure water quality is within criteria for the project and receiving waters. • The implemented plan would, include appropriate temporary and permanent control measures including drainage channels and sediment retention basins. This would apply to all areas likely to be impacted and will address the appropriate sediment basins as well as elaborate on management of wet weather events. • The construction contractor will consider mitigation measures for: – Limiting heavy trucks and machinery to construction access roads and paths. – Vegetation removal is to be minimised as far as practicable noting that vegetation removal across the AWRC site and Pipelines will be required in impact areas. – Schedule construction works that could exacerbate erosion and sediment transport to avoid wet weather and heavy rainfall, where possible. – Stormwater management features, including drains, swales and detention basins would be	Magnitude of impact: Low (temporary and local)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		constructed progressively to manage potential flow increases. Detention basins will be monitored and only discharged when project specific criteria are suitable. – Where required, temporary drainage would need to be installed to manage on-site surface water. – Special placement, compaction and covering of stockpiled soils and spoil (for example topsoils stripped from the AWRC site and spoil from trenches for Pipelines).	
• Soils – Acid sulfate soils disturbance via excavation or de-watering of groundwater for infrastructure, principally near and around Prospect Creek in the eastern portion of the brine pipeline.	**Pipelines:** Deep and shallow excavations, dewatering near Prospect Creek at the eastern end of the brine pipeline	• Further confirmatory ASS investigations around Prospect Creek (under bore) during detailed design will be undertaken. The investigations will determine if ASS is present based on soil analytical testing and interpretation of results. • If ASS is encountered and could be disturbed around Prospect Creek, mitigation measures would involve preparation of an ASSMP that include results of investigations for ASS, extents of ASS, handling, monitoring, treatment, reuse or disposal offsite requirements. The ASS mitigation measures would be in accordance with the NSW ASSMAC Guidelines (1998). • ASS will be managed via neutralisation treatment with agricultural lime upon excavation, validation that the ASS has been treated to the correct level and then either beneficially reused or disposed to a licensed waste facility. • The ASSMP will form part of the project CEMP for construction.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Soils – Sodic subsoils could become exposed and cause increased rates of erosion and sediment transport to surface water receptors.	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, exposed soils upon heavy rainfall events	• Sodic soils are present within the AWRC site and pipelines at variable depths and concentrations. A summary of site investigation results is provided in Section 9.5 and results from investigations in Appendix B. • Sodic sub soils have been identified typically not at the soil surface with moderate to high sodicity present in soils at depths greater than 0.5 m depth. Additional salinity and sodic soil investigations and characterisation will occur as part of detailed design for the project and characterise these soils and extents. • Sodic soils should not be excavated where possible as part of the project and where they are, they should be managed and handled as part of the project controls for erosion within the Sediment and Erosion Control Plan (ESCP). • Environmental compliance and auditing during earthworks at the AWRC site and Pipelines will be undertaken to ensure compliance with the mitigation measures outlined in the ESCP and CEMP.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)
• Soils – Reuse of sodic subsoils and saline soils on the ground surface for the project where characterisation of soil quality has not been undertaken or understood.	**AWRC site and Pipelines:** Stripping, grubbing, shallow excavations, trenching, HDD/under bore pits, landscaping	• Sodic sub soils have been identified typically not at the soil surface with moderate to high sodicity present in soils at depths greater than 0.5 m depth. Additional salinity and sodic soil investigations and characterisation will occur as part of detailed design for the project and characterise these soils and extents. • No highly sodic soils (as defined in Section 9.5 and summary table data in Appendix B) shall be	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
		reused within the project as surface soils that could be highly erodible when exposed to wet weather events. • Environmental compliance and auditing during earthworks at the AWRC site and Pipelines will be undertaken to ensure compliance with the mitigation measures outlined in the ESCP and CEMP.	
• Soils – Slope instability and landslides from cutting into soil and rock for project elements. Destabilisation of soils and slopes.	**AWRC site and pipelines:** Installation of underground infrastructure and pipelines, under-boring, construction of AWRC site deeper excavations	• Normal engineering design and practice are to be implemented in accordance with relevant Australian Standards and their engineering design principals throughout the construction process. • The Australian Geomechanics *Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning*, 2007 will be used and referred to for any excavations into slopes for the project (which are minimal and related to pipeline trenches on slopes and under boring pit entry and exit points).	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)
• Land – Mine subsidence from underlying former mining activity and potential for project construction to introduce surface impacts such as instability and depressions in ground surface	**AWRC site and pipelines:** Installation of underground infrastructure and pipelines, under-boring, construction of AWRC site deeper excavations	• Review of information for potential mine subsidence indicates that the project is not in a proclaimed mine subsidence district and is not subject to any imposed conditions by the NSW Government Subsidence Advisory. • No project specific mitigation measures are proposed due to the negligible risk associated with mine subsidence of land.	Significance: Low Sensitivity of environmental values: Low (unlikely) Magnitude of impact: Negligible (unlikely)

Table 13-2 Mitigation and effectiveness (Operational phase)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Contamination – Residual contamination, which is not suitably remediated, mitigated, or managed during the construction phase of the project. Contamination issues during operation that could impact the environment and exposure to contamination for workers and the public.	**AWRC site and Pipelines:** Former areas of ground disturbance that were contaminated and poorly remediated or management approach is inadequate. Asbestos impacted areas around Warragamba Dam.	• As outlined in construction mitigation measures in Table 9-1, additional site investigations for contamination to inform detailed design and construction will be undertaken. These investigations will provide recommendations on management of contamination during construction and outlining management approaches for residual contamination if present after construction. • For the operation phase of the project, Sydney Waters EMS and quality systems will manage residual contamination risks as part of their operational guidelines and record of residual contamination types, extents, responsibilities and management via their Spatial Hub or other digital record as required. • Other land owner stakeholders such as WaterNSW for asbestos impacted soils around Warragamba Dam will be informed of final residual contamination extents and management required post construction to inform their internal EMS and quality systems to manage any residual contamination. • Residual contamination management will follow guidance as outlined in Table 2-1, especially the guidance document and sections within: NSW EPA, 2020. *Guidelines for Consultants Reporting on Contaminated Land.*	Significance: Low Sensitivity of environmental values: Low Magnitude of impact: Negligible (unlikely to occur)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Contamination – Contaminated runoff from the operation of vehicles, machinery, and infrastructure, chemical spills, waste management and overflow/leakages of untreated or partially treated wastewater.	**AWRC site and Pipelines:** AWRC site and pipelines across the project	• Engineering design has removed high risk contamination run off and chemical spill risks as part of the project design. • Adopt controls for storage and handling of chemicals, as outlined in the relevant Material Safety Data Sheets for each chemical. • Implement a spill response plan and incident response procedure. • For the operation phase of the project, Sydney Waters EMS and quality systems will manage operational environmental management and monitoring activity as suitable for the project elements. This includes operational incident management procedures for spills, leaks and overflows. • All chemical storage and delivery areas to be designed to have sufficient storage volumes to contain a worst-case spill, including the full volume being delivered and the full volume stored simultaneously • Any spills that occur outside the containment area shall be contained within a first flush structure across roads and hardstand. Once full, flow bypass to surrounding waterways via the stormwater management system. Refer to *Surface Water Impact Assessment* (Aurecon Arup 2021)	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (unlikely to occur)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Salinity – Increased stormwater or recycled water irrigation around the AWRC site could mobile salts in the landscape and impact surface water receptors and degrade soils in localised areas where groundwater levels rise to the near surface or daylight at break of slope.	**AWRC site, internal access roads:** Irrigation of land with recycled water or stormwater	• Controlling the irrigation rate to ensure the landscape water balance deficit is replenished and no significant change deep drainage occurs.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (temporary and local, minimal change)
• Salinity – Secondary salinisation, which is changes in landscape salt movement over time resulting from construction activities, through processes such as the removal of vegetation, altering hydrology, general land use changes and extraction of groundwater. • Pipelines and under-boring locations have less impact on land and salinity across the project due to their linear nature and reduced land and water table disturbance and no irrigation to land.	**AWRC site:** AWRC site and immediate surrounds where landscape changes and irrigation to land will occur during operation phase.	• Irrigation of recycled water or stormwater to land within the AWRC site will be managed to minimise salt movement by using application rates suitable to minimise deep soil drainage. • Irrigation studies have been undertaken to inform sustainable irrigation rates considering the nature of deeper saline soils across the AWRC site and potential for salt movements if over irrigation were to occur. • Monitoring of surface water and groundwater during and after construction and into operation will mitigate and regulate the irrigation to land application rates. These can be adjusted based on monitoring results, climate and wet weather events. • The proposed irrigation rate (4.5 ML/Ha/yr) makes up the local rainfall deficit or shortfall between rainfall (approximately 700 mm/yr) and potential evapotranspiration (approximately 1200 mm/yr). • Controlling the irrigation rate to ensure the landscape water balance deficit is replenished and no significant change deep drainage occurs	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: low (minimal change)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Salinity – Brine leaking from the pipelines during operation may cause localised saline contamination to soils and cause erosion and increased salt levels in surface soils and sub soils.	**Brine pipeline:** Leaking of brine fluid from the pipeline alignment and junctions	• Sydney Water designs its pipelines to a high standard to minimise the risk of leaks including leak detection systems. Sydney Water's standard procedures include regular inspections and incident response procedures would also manage this potential risk and impact.	Significance: Low Sensitivity of environmental values: Low Magnitude of impact: Low (temporary and localised)
• Soils – erosion of soil via scouring, water pressure at release points and releases of sediment-laden stormwater due to: – New infrastructure and sealed surfaces – Incorrectly designed scour protection measures – Poor manufacturing tolerances of pipes and infrastructure – Poor drainage design and sediment basin designs	**AWRC site, pipeline corridors, and internal access roads:** Across parts of the project that have release points such as environmental flows, irrigation to land and stormwater and WSUD infrastructure	• Design of the project with measures to minimise erosion during operation (e.g. energy dissipation at release locations, design of scour valves on pipelines to minimise erosion, stormwater management on AWRC site, establishment of restoration in cleared areas). • The design includes engineered permanent control measures including drainage channels and sediment retention basins for the AWRC site. • The engineered permanent control measures including drainage channels and sediment retention basins consider both dry and wet weather events to manage sediment laden water during operations.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (unlikely to occur)

Potential Impact	Project location/Activity	Mitigation measure	Impact significance following mitigation
• Soils – increased erosion of soils where landscaping and final landform design and construction is unsuitable for the soils present over the operational phase.	**AWRC site and internal access roads:** Associated with AWRC site and access roads as pipelines will be underground.	• Landscaping design and engineering design have considered soil types and slopes for the AWRC site and vegetation plans have considered suitable species for ensuring soil retention. • Environmental compliance audits and monitoring as part of asset management will continually assess operational environmental impacts and rectify via audit recommendations where observed soil erosion at the AWRC site has occurred. Where erosion is observed, mitigation measures include re-seeding and planting as well as addition of topsoil to improve soil structure. • Engineered erosion control products can be applied (such as geofabrics) to the erosion affected areas of the AWRC site where deep erosion or broad scale erosion occurs over the operational phase.	Significance: Low Sensitivity of environmental values: Moderate (existing local impacts) Magnitude of impact: Low (unlikely to occur)

13.1 Effectiveness of Mitigation Measures

Residual impacts are those that remain after the implementation of avoidance and minimisation measures and after mitigation measures have been implemented for the project ("Impact significance following mitigation" rating of "moderate" or above). These impacts are discussed below.

Construction

The erosion and sedimentation controls outlined in Table 13-1 and Table 13-2 would be designed to mitigate erosion. For any weather events such as major storms or strong winds that exceed the design capacity of controls, material may travel beyond the site boundary and potentially into receiving waterways. For instance, if the sediment basins are full after containing the volume generated by the design event, then some overflow with high turbidity may occur. The potential residual impact would depend on the intensity and duration of the weather event and therefore the amount of material leaving site.

For such weather events, and where it can be demonstrated the erosion and sedimentation controls have been implemented and maintained effectively, the incident is classified as an incident and handled in accordance with the Sydney Water *SWEMS0009 Responding to incidents with an environmental impact*.

In addition, regular inspection, monitoring and maintenance of erosion and sediment control structures would be undertaken in accordance with the Blue Book and other Erosion and Sediment Control Plan guidance. In addition, inspections would be undertaken immediately prior to and following rainfall events and rectifications made as required.

Similarly, in the event of an unexpected leak or spill or if unexpected contamination is encountered, potential contamination impacts to surface or groundwater may occur before appropriate containment or clean-up operations can be implemented. For example, an unexpected fuel leak from AWRC or vehicles that reaches a waterway or drain prior to containment. Similarly, to the control of erosion and sediments, regular inspections, compliance audits and monitoring of surrounding soils and water will be undertaken. Refer to the *Surface Water and Groundwater Technical Studies* for management measures specific to these areas.

Operation

Potential residual impacts may occur during operation of the project in the event of unforeseen leaks or spills of materials that could potentially contaminate soils and nearby waterways or seep into groundwater if uncontained, for example in the event of a leak either from the pipelines or the AWRC elements.

Residual impacts during the operational stage is expected to be low. However, for such events, the incident is to be handled in accordance with the Sydney Water *SWEMS0009 Responding to incidents with an environmental impact.*

Refer to the *Surface Water and Groundwater Technical Studies* for management measures specific to these areas.

13.2 Management of Change / Unexpected Conditions

This impact assessment is based on the project's concept design. As the project progresses, changes to the design may be necessary which could change the magnitude of the identified soil and contamination impacts. The impact assessment has been carried out to provide some flexibility for these changes, for example a wider impact assessment area has been included so lateral alignment changes within this area have been accounted for. Where possible, a conservative approach has been adopted to assess 'worst-case' scenarios.

Design changes with the most potential to affect the magnitude of identified soil and contamination impacts would include:

- Excavation depths and extents (e.g. increasing the depth of the bioreactors)
- Pipeline construction methodology (e.g. trenchless vs trenched)
- Construction scheduling and pipeline lay rate
- Increased surface areas for stripping and grubbing surface soils at the AWRC site
- Modification of under boring and related construction activity that increases the need for surface works and impacts from asbestos in soils around the Warragamba Dam area for the environmental flows pipeline.

Such changes to the design and construction should be assessed as part of tender evaluations to determine the change in magnitude of the potential soil and contamination impacts.

In addition, it is possible that unexpected contamination conditions may be encountered due to previously unknown heterogeneities in the subsurface. For example, it is possible that during the earthworks at the AWRC site or pipelines, previously unknown contamination is identified during construction. To manage this uncertainty, the project CEMP will have a contamination unexpected findings protocol (UFP) that addresses these unknowns and data gaps.

Therefore, the impact assessment outlined in this report is considered sufficient to inform the project's Environmental Impact Assessment. It is recommended that the feasibility of the proposed mitigation measures be assessed in response to any additional information on soil and contamination conditions that is collected during detailed design or pre-construction monitoring (outlined in Section 12). During construction and operation, it is recommended that the mitigation measures be implemented through adaptive management strategies to mitigate soil and contamination impacts in response to the specific methodologies, schedules and potential unexpected conditions.

14 Monitoring, Site Investigations and Remediation Requirements

14.1 Monitoring

Monitoring is important in ensuring construction and operational phase mitigation measures are effective, and soil and contamination impacts across the project do not exceed acceptable limits. Monitoring of groundwater, surface water and other aspects are discussed in their respective specialist technical studies for the project.

Monitoring will involve the following specifically for soils and contamination aspects of the project during construction and operation:

- Management and monitoring of the removal, transport and disposal or beneficial reuse of pipeline spoil or spoil generated from the AWRC site that is contaminated or has no intended use on site
- Monitoring or soil and sediment erosion controls to be detailed in project CEMP and specific monitoring plans attached to the CEMP such as the ESCP
- Inspection and auditing of mitigation measures during construction to make sure they operating effectively

It is proposed that any further assessment proposed above is undertaken at a later development stage (i.e. not as part of this EIS approval process). It is deemed that the collated background information and current datasets provide an adequate understanding of soil quality and contamination conditions for EIS determination purposes.

14.2 Site investigations of AECs

Further supplementary site investigations will be undertaken prior to construction within contamination AECs identified in this assessment and areas of potential impact. The additional supplementary investigations must consider detailed engineering design and construction methodology to inform management, remedial or risk assessment approaches. The AECs include those detailed within the figures 6-2a-d and 6-3 of this assessment in Appendix D. These will include:

- Further assessment of identified contamination AECs prior to construction to determine management, remedial or risk assessment approaches where soil disturbance will occur
- Further assessment of the extent of ASS around Prospect Creek and if an ASS management plan in accordance with the project CEMP is required for construction
- Undertake a pre demolition destructive hazardous material survey of any buildings and structures within the AWRC (AEC 1) site prior to demolition, clearing or earthworks to confirm hazardous materials

14.3 Remediation

Extensive remediation is not expected at the AWRC site or along the pipeline alignments. As noted throughout this report, incidental impacts may be encountered in specific, localised areas. The control and mitigation measures outlined in the management plans and in

Table 13-1 and Table 13-2**Error! Reference source not found.** should be adequate to address any impacts encountered. If subsurface impacts are encountered, soil will be excavated and disposed off-site at an appropriately licenced facility or beneficially reused at the AWRC site under the construction EPL or other resource recovery approval process. If significant or gross chemical contamination is encountered, additional measures or remediation may have to be considered dependant on the risk to human health and the environment. Under these circumstances, a project area specific RAP or project wide RAP would be implemented and validation record of the remedial works undertaken.

15 Conclusion

The AWRC site and pipelines traverse varied soil landscapes and contamination risks associated with the project. The pipelines construction methodology (trenching and under boring principally) follows roads, easements and previously developed lands where soils have either been disturbed or have limited environmental value with impacts limited to shallow soils, weathered rock and rock. Contamination AECs identified along the pipelines would be managed during construction, and impacted soils and fill (where considered suitable) could be reused beneficially as engineering fill on the AWRC site or nearby projects where resource recovery exemptions and orders are adhered too for beneficial reuse. This would minimise waste generation while also reducing transport to licensed waste facilities in western Sydney. Beneficial reuse would be undertaken in accordance with resource recovery orders and exemptions made by the EPA during construction and operation. Existing contamination risks and AECs are not considered to be a significant constraint to the pipeline's alignments during construction and operation.

The AWRC site footprint investigations as part of concept design has identified limited and incidental contamination AECs associated with the site. These are related to HBM present in current buildings and areas where former buildings and structures were present across the site. Existing contamination is not a significant constraint to the AWRC site and construction and earthworks and importation of engineering fill can be used to manage existing contamination risks via environmental design. Erosion hazards (principally via sodic soils) and slightly to moderately saline soils are present within the AWRC site and management through imposed design and controls on earthworks and hydrology (sediment basins) will minimise salt movement and exposure of sodic soils and potential for erosion and sedimentation of drainage lines and water bodies.

Construction and operation of the AWRC and pipelines have the potential to impact the soils and contamination in the following key ways:

- Removal of topsoils, subsoils and changes in infiltration where earthworks remove natural soil cover
- Disturbance of ASS near Prospect Creek which is the only area of the project with ASS risk
- Disturbance of contaminated soils during construction via excavations of trenches for pipelines
- Mobilisation of contaminants via excavation and disturbance such as leachable contaminants via water and asbestos fibres via airborne deposition
- Poor demolition of current structures on site containing HBM including ACM and lead paints
- Leaks / spills of chemicals, partially untreated sewage or brine release into the soil and groundwater
- Long-term reduction of groundwater levels (drawdown) from operation of pumped underdrainage systems employed and the increase of impervious surfaces created at the AWRC
- Soil erosion, leading to the release of sediment-laden stormwater into receiving waterways
- Increased soil erosion where sodic subsoils are excavated and reused on the surface or exposed in situ for extended periods of time during wet weather events
- Increases in salinity concentrations in soils where the hydrological regimes are changed within the AWRC site and shallow saline groundwater is brought to the surface

- Reuse of saline soils excavated near drainage lines and low-lying areas along the pipelines and AWRC site and reused as engineering fill increasing salinity release risk to surface waters and groundwater

Overall, with the implementation of the proposed mitigation measures, the project is expected to have a low impact to soils and contamination risks. With the implementation of the prescribed mitigation and management measures, construction management plans, recommended intrusive investigations and compliance monitoring the project would have a low impact on soils and contamination.

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Appendix A – Soil Landscape Properties and Reports

Soil landscapes and erodibility information

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
Berkshire Park	A small area to the south of the Kemps Creek Hi-Quality Group. Sites: Brine pipeline	Dissected, gently undulating low rises on the Tertiary terraces of the Hawkesbury/Nepean River system.	• Weakly pedal orange heavy clays and clayey sands, often mottled. Ironstone nodules common. Large (up to 20 cm) silcrete boulders occur in sand/clay matrix. Solods, yellow podzolic soils, red podzolic soils, chocolate soils, structured plastic clays, structured clays • bp1—Dark brown sandy loam. • bp2—Brown apedal sandy clay loam. • bp3—Brown sandy clay with up to 20% ironstone nodules. • bp4—High chroma (bright coloured) clay with up to 90% stones.	• Very high wind erosion hazard if cleared. • Gully, sheet and rill erosion on dissected areas. • Localised seasonal waterlogging, localised flood hazard. • Impermeable subsoils. • Low fertility.	• Existing erosion is confined to areas being mined for sand or used as unsealed roads. Sheet and rill erosion occur as well as some wind erosion.	• bp1 – low erodibility as it is well graded but low in organic matter. • bp2, bp3 – moderate erodibility being low or very low in organic matter. • bp1, bp4 – highly erodible; it has a high silt and fine sand fraction and is very low in organic matter and can be moderately dispersible.	• The erosion hazard for non-concentrated flows is low to moderate. • Calculated soil loss for the first twelve months of urban development is up to 19 t/ha for topsoil and up to 44 t/ha for exposed subsoil. • For concentrated flows the erosion hazard is high.

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
Blacktown	Across the majority of the site to the east of Wallacia. Sites: Treated water Environmental flows Brine pipeline AWRC	Gently undulating rises on Wianamatta Group shales. Broad rounded crests and ridges with gently inclined slopes.	• Shallow to moderately deep (>100 cm) hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines. • bt1—Friable brownish black loam. • bt2—Hardsetting brown clay loam. • bt3—Strongly pedal, mottled brown light clay. • bt4—Light grey plastic mottled clay.	• Localised seasonal waterlogging. • Localised water erosion hazard. • Moderately reactive highly plastic subsoil. • Localised surface movement potential.	• No appreciable erosion occurs on this unit. Minor sheet and gully erosion may be found where surface vegetation is not maintained.	• Blacktown soil materials have moderate erodibility. • bt1, bt2 – often hardsetting and they have high fine sand and silt content but they also have high to moderate organic matter content. • bt3, bt4 – very low in organic matter. Where they are also highly dispersible and occasionally sodic the erodibility is high.	• The erosion hazard for non-concentrated flows is slight to moderate but ranges from low to very high. • Calculated soil loss during the first twelve months of urban development for topsoil and exposed subsoil tends to be low (7–11 t/ha). • Soil erosion hazard for concentrated flows is moderate to high.

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
Disturbed Terrain	On the Brandown Quarry, site and multiple areas to the south within the Liverpool area Sites: Brine pipeline	Occurs within other landscapes and is mapped as xx. The topography varies from level plains to undulating terrain, and has been disturbed by human activity to a depth of at least 100 cm. Most of these areas have been levelled to slopes of <5%	• The original soil has been removed, greatly disturbed or buried. Landfill includes soil, rock, building and waste material.	• Dependent on nature of fill material and include subsidence resulting in a mass, movement hazard, soil impermeability leading to poor drainage, and low fertility.	• N/A	• N/A	• N/A
Falconbridge	On the western end of the site, surrounding the Warragamba River. Sites: Environmental flows	Level to gently undulating crests and ridges on plateau surfaces of the Hawkesbury Sandstone. Local relief <20 m, slopes <5%. Infrequent rock outcrop.	• Shallow (<50 cm) earthy sands and yellow earths; some siliceous sands/lithosols associated with rock outcrop. • fb1—Loose, brownish black loamy sand. • fb2—Earthy, yellow clayey sand. • fb3—Yellow, earthy sandy clay loam.	• Shallow, highly permeable soil • Localised non-cohesive soils • Very low soil fertility • Localised water erosion hazard • Localised rock outcrop	• Minor sheet erosion occurs as sheetwash. Severe sheet erosion usually follows loss of vegetation cover due to bushfires.	• fb1 - highly permeable, coarse, loose sand grains which have a very low to low erodibility depending on organic matter present. • fb2, fb3 - very low in organic matter and consist of fine sand grains which are weakly cemented in a clay matrix and	• The erosion hazard for non-concentrated flows is low to moderate. • Calculated soil loss during the first 12 months of urban development ranges up to 6 t/ha for topsoil and up to 18 t/ha for exposed subsoil.

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
						are moderately erodible.	• Soil erosion hazard for concentrated flows is also low
Gymea	In Warragamba and Wallacia, directly adjacent to the Hawkesbury soil landscape. Sites: Environmental flows	Undulating to rolling rises and low hills on Hawkesbury Sandstone. Rock outcrop <25%. Broad convex crests, moderately inclined side slopes with wide benches, localised rock outcrop on low broken scarps.	• Shallow to moderately deep (30–100 cm) yellow earths and earthy sands on crests and insides of benches; shallow (<20 cm) siliceous sands on leading edges of benches; localised gleyed podzolic soils and yellow podzolic soils on shale lenses; shallow to moderately deep (<100 cm) siliceous sands and leached sands along drainage lines. • gy1—Loose, coarse sandy loam.	• Steep slopes. • Water erosion hazard. • Rock outcrop. • Localised rockfall hazard. • Localised non-cohesive soils. • Shallow highly permeable soil. • Very low soil fertility.	• Severe sheet erosion occurs following bushfires which destroy or damage stabilising vegetative cover. Minor gully erosion occurs along unpaved or poorly maintained roads and fire trails especially those frequented by four-wheel drive vehicles and trail bikes.	• gy1, gy2 – composed of coarse sand grains and have very low erodibilities as they are freely drained and are held together by high organic matter contents (gy1) and/or nondispersive clays (gy2). • gy3 – moderately erodible as it has a weakly coherent earthy fabric with low organic matter content. • gy4 – highly erodible as it is very low in organic matter and consists	• The erosion hazard for non-concentrated flows is generally high to very high but can range from moderate to extreme. • Calculated soil loss for the first twelve months of development ranges up to 19 t/ha for topsoil and 464 t/ha for subsoil. • Soil erosion hazard for concentrated flows is high to extreme.

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
			• gy2—Earthy, yellowish brown clayey sand. • gy3—Earthy, yellowish sandy clay. • gy4—Strongly pedal, yellowish brown clay.			predominantly of fine sands in a clay matrix.	
Hawkesbury	On the valleys along the banks of the Warragamba and Nepean River. Sites: Environmental flows	Rugged, rolling to very steep hills on Hawkesbury Sandstone. Rock outcrop >50%. Narrow crests and ridges, narrow incised valleys, steep side slopes with rocky benches, broken scarps and boulders.	• Shallow (<50 cm) discontinuous lithosols/siliceous sands associated with rock outcrop; earthy sands, yellow earths and some locally deep sands on inside of benches and along joints and fractures; localised yellow and red podzolic soils associated with shale lenses; siliceous sands and secondary yellow earths along drainage lines.	• Steep slopes. • Mass movement hazard. • Rockfall hazard. • Water erosion hazard. • Shallow soils. • Rock outcrop. • Non-cohesive soils (localised). • Stony. • Highly permeable soils of low fertility.	• Severe sheet erosion often occurs during storms and after ground cover is destroyed by bushfires (Atkinson, 1984). Minor gully erosion occurs along unpaved tracks and fire trails, especially those used regularly by four-wheel drive vehicles, motorcycles and horses.	• ha1 – low erodibility. It consists of highly permeable, loose, coarse sands and organic matter. Highly susceptible to concentrated flow erosion, especially when the organic matter is removed by hot bushfires. • ha2, ha3 – moderate erodibility. They have low organic matter	• Erosion hazard for non-concentrated flows is generally very high and ranges from moderate to extreme.

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
			• ha1 – Loose, coarse quartz sand. • ha2 – Earthy, yellowish brown sandy clay loam. • ha3 – Pale, strongly pedal light clay			contents and weak fabrics.	
Hazelwood	At the Nepean River south of Blaxland Crossing to Bents Basin. Site: Environmental flows	A very narrow unit of steep concave east facing slopes intersected by parallel drainage lines. Local relief to 100 m; sideslope >60% with undulating colluvial footslopes >10%.	• Highly variable soils due to the nature of the colluvial parent material. Yellow solodic soils, chocolate soils and earthy sands. Lithosols occur on upper slopes and occasionally elsewhere • hw1—Dark brown clayey sand • hw2—Olive brown sandy clay loam • hw3—Bright brown sandy loam • hw4—Dark reddish brown light clay	• Localised steep slopes, localised mass movement hazard as minor slipping on midslopes, • Localised water erosion hazard, localised non-cohesive soils as relatively unconsolidated materials on lower slopes • Low fertility. • Sodic subsoil.	• N/A	• hw1, hw3 – low erodibility. They are dominated by coarse sand, poorly bound with clay and silt fractions. The subsoils are moderately erodible. • hw2, hw1 – moderately erodible. hw2 has an earthy fabric. • hw4, hw5 – generally moderately erodible having a high percentage of coarse sand,	• Erosion hazard for this soil landscape for non-concentrated flows is high to very high. • The calculated soil loss for the first twelve months of urban development ranges up to 172 t/ha for topsoils and 300 t/ha for exposed subsoils.

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
			• hw5—Greyish brown medium to heavy clay • hw6—Brown columnar structured sandy clay loam			although they may be dispersible. • hw6 – moderately graded porous earthy material with moderate erodibility.	• The erosion hazard for concentrated flows is high to extreme.
Luddenham	Sections of Wallacia, Luddenham, Cecil Park and Cecil Hills Sites: Treated water Brine pipeline	Undulating to rolling low hills on Wianamatta Group shales, often associated with Minchinbury Sandstone. Narrow ridges, hillcrests and valleys.	• Shallow (<100 cm) dark podzolic soils or massive earthy clays on crests; moderately deep (70-150 cm) red podzolic soils on upper slopes; moderately deep (<150 cm) yellow podzolic soils and prairie soils on lower slopes and drainage lines. • lu1—Friable dark brown loam. • lu2—Hardsetting brown clay loam. • lu3—Whole coloured, strongly pedal clay.	• Water erosion hazard. • Localised steep slopes. • Localised mass movement hazard. • Localised shallow soils. • Localised surface movement potential. • Localised impermeable highly plastic subsoil. • Moderately reactive.	• Minor gully erosion is evident along unpaved roads. Moderate sheet erosion occurs on disturbed areas (e.g. cultivated lands). Small areas of moderate to severe sheet erosion occur in overgrazed paddocks on many hobby farms. Evidence of previous erosion is commonplace, especially where eroded	• lu1, lu2 – moderate erodibility as they have moderate organic matter percentage, have stable aggregates and are well graded. • All the other soil materials are moderately erodible as they are finely graded. • lu3–lu5 – clays may be locally dispersible and, in those circumstances, should be	• The erosion hazard for non-concentrated flows ranges from moderate to very high. • The calculated soil loss for the first twelve months of urban development ranges up to 135 t/ha for topsoil and up to 97 t/ha for exposed subsoil.

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
			• lu4—Mottled grey plastic clay. • lu5—Apedal brown sandy clay.		topsoil has been deposited against fences.	considered highly erodible.	• The erosion hazard for concentrated flows is high to very high.
Picton	Within vegetated lots along the M7, surrounded by Luddenham soil landscapes. Sites: Brine pipeline	Steep sideslopes, Wianamatta Group shale and shale colluvial materials usually with a southerly aspect. Local relief 90–300 m, slope gradients >20%	• Shallow to deep (50–200 cm) red and brown podzolic soils on upper slopes. Brown and yellow podzolic soils on colluvial material. Yellow podzolic soils on lower slopes and in drainage lines. • lu1—Friable dark brown loam. • pn1—Dark brown clay loam • pn2—Reddish brown sticky clay. • pn3—Brown stony light clay.	• Steep slopes • Mass movement (slump) hazard • Water erosion hazard • Localised shallow soils • Localised surface movement potential • Some impermeable and highly plastic subsoils.	• Slumps and sheet erosion occur throughout this soil landscape. Small discontinuous gullies occur where subsoils are more plastic.	• pn1 - coherent with earthy fabric, has high organic matter content, but has a relatively high percentage of silt and fine sand. Moderately erodible. • pn2 - moderately erodible, having small smooth-faced aggregates which contain a large percentage of silt and are prone to slaking. • pn3 - highly erodible, consisting of	• The erosion hazard for this soil landscape for non-concentrated flows is high. • The steep slopes are subject to mass movement when saturated. • Calculated soil loss for the first twelve months of urban development ranges to 295 t/ha for topsoil on steeper slopes and up to 171 t/ha

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
						somewhat structured, dispersible clay and silt. Slope failure due to throughflow and development of percolines is common.	for exposed subsoil. • Soil erosion hazard for concentrated flows is high to very high.
Richmond	Low lying areas near the Nepean River and Prospect Creek Sites: Treated water Environmental flows Brine pipeline	Quaternary terraces of the Nepean and Georges Rivers. Mainly flat. Splays and levees provide local relief (<3 m).	• Poorly structured orange to red clay loams, clays and sands. Texture may increase with depth. Ironstone nodules may be present. Plastic clays in drainage lines. Deep acid non-calcic brown soils, red earths and red podzolic soils, occur on terrace surfaces with earthy sands on terrace edges. • ri1—Loose reddish brown loamy sand. • ri2—Brown sandy clay loam.	• Localised flood hazard. • Localised seasonal waterlogging. • Localised water erosion hazard on terrace edges.	• N/A	• ri1, ri2 – moderately erodible. They have a high fine sand fraction and have low organic matter content. They are, however, not dispersible. • ri3, ri4 – very high erodibility due to very low organic matter and a high fine sand and silt content. They are also moderately dispersible.	• Due to low slopes and generally good vegetation cover the erosion hazard for non-concentrated flows on the Richmond soil landscape is low. During periods of drought or dry seasons this may increase in some areas. • The calculated

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
			• ri3—Brown mottled light day. • ri4—Brown mottled stiff medium-heavy clay.				soil loss on the terrace surface in the first twelve months of urban development is low at 29 t/ha for topsoil and 49 t/ha for exposed subsoil. • The erosion hazard for concentrated flows is moderate to high.
South Creek	Along the banks of South Creek and its tributaries including Kemps Creek, Badgerys Creek and Cosgrove Creek. Covers the majority of the AWRC.	Floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain. Usually flat with incised channels; mainly cleared.	• Often very deep layered sediments over bedrock or relict soils. Where pedogenesis has occurred structured plastic clays or structured loams in and immediately adjacent to drainage lines; red and yellow podzolic soils are	• Flood hazard. • Seasonal waterlogging. • Localised permanently high water tables. • Localised water erosion hazard. • Localised surface	• This is a dynamic soil landscape; there are many areas of erosion and deposition. Streambank erosion and sheet erosion of floodplains are common. In depositional phases streams	• The erodibility of these soil materials is high. • sc1 – moderately dispersible and has more than 50% fine sand, but it contains moderate amounts of organic matter.	• The erosion hazard for South Creek soil landscape is potentially very high to extreme. • This is an active floodplain and is presently

Soil landscape	Location in desktop assessment area	Geology	Soils (desktop assessment area landscape)	Qualities and limitations	Existing Erosion	Erodibility	Erosion Hazard[1]
	Sites: Treater water Brine pipeline AWRC		most common terraces with small areas of structured grey clays, leached clay and yellow solodic soils. • sc1—Brown apedal single-grained loam. • sc2—Dull brown clay loam. • sc3—Bright brown clay.	movement potential.	may be partially or completely blocked by sedimentation or vegetated bars.	• sc2, sc3 – high fine sand and silt fractions with a very low percentage of organic matter.	being reworked by fluvial processes. Apparent stability is probably short term. • Streambank and gully erosion are common results of concentrated flow.

[1] – Erosion hazard based on 'urban development' scenario which is considered closest to the project although preventative and mitigation measures are likely to be more robust on a larger scale infrastructure project based on central control of environmental management and monitoring.

bp	BERKSHIRE PARK	Alluvial

LOCATION

This soil landscape covers a wide area between the lower terraces of the Hawkesbury/Nepean River system and west of South Creek. It is dissected along the eastern edge by South Creek and its tributaries, and overlain by the Agnes Banks sands at Agnes Banks and Pitt Town.

LANDSCAPE

Geology

The soils of this landscape are the result of three depositional phases of Tertiary alluvial/colluvial origin. The lowest deposit is the St Marys formation. This is overlain by the Rickabys Creek gravel formation which is of varying thickness and, in turn, is topped by the Londonderry Clay formation. All of these formations are derived from sandstone and clay. Erosion of the surface has led to exposure of all three formations in different locations.

Topography

Flat terrace tops dissected by present day small drainage channels and narrow drainage lines. Small remnant surfaces occurring to the east and south are at a slightly higher elevation (approximately 20 m).

Vegetation

Very little natural vegetation remains other than in Castlereagh State Forest, which contains three vegetation associations based on *Eucalyptus fibrosa* (broad-leaved ironbark), *Angophora bakeri* (narrow-leaved apple) and *E. sclerophylla* (scribbly gum) (Murphy, 1973). *Melaleuca decora* and *M. nodosa* (paperbarks) often occur as a small tree layer (Benson, 1981).

The shrub understorey species are dominated by members of the families Fabaceae, Papilionaceae, Sapindaceae, Proteaceae and Myrtaceae.

Landuse

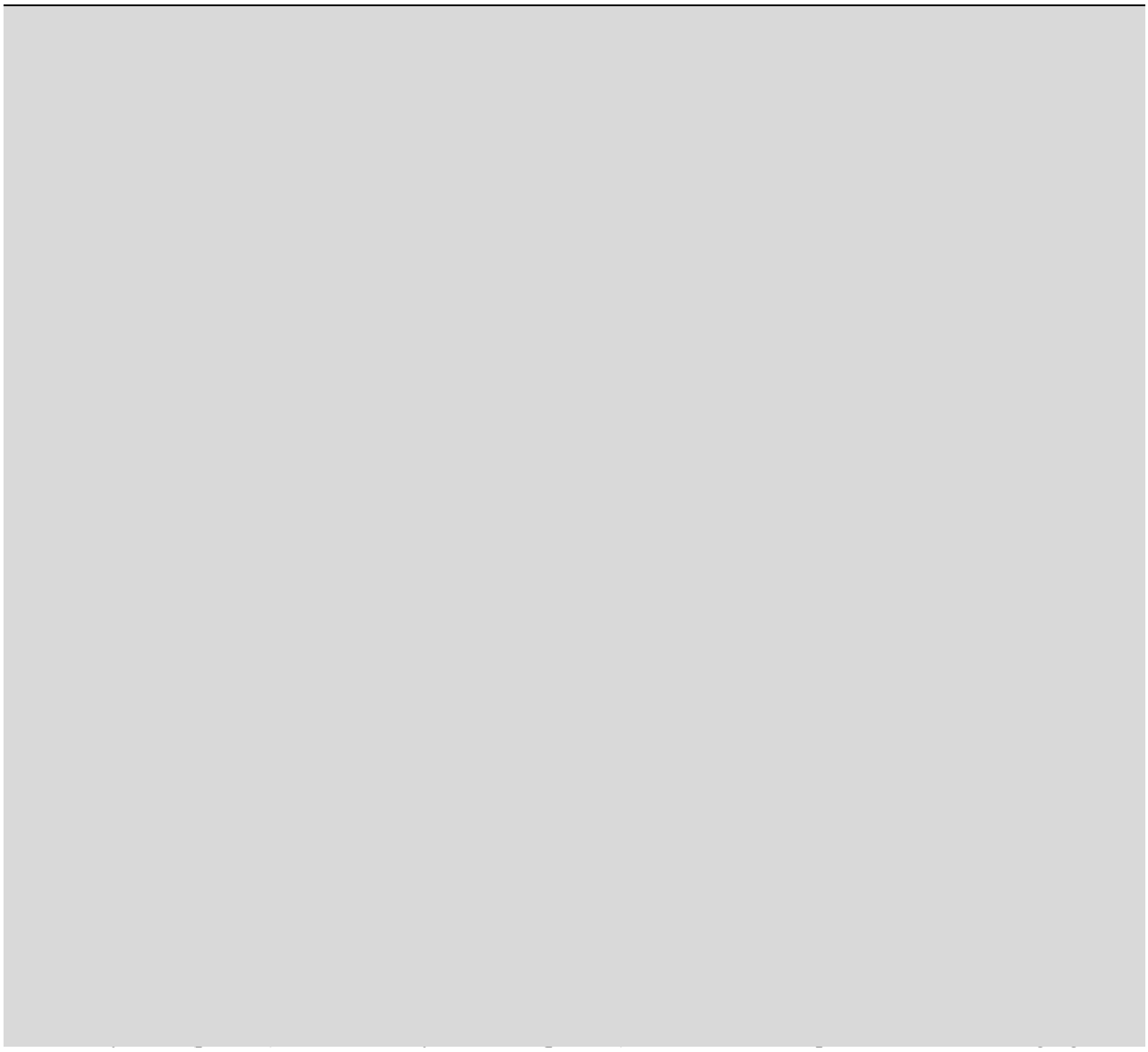
Mainly used for small farms. Small areas are left as uncleared scrub. The Castlereagh State Forest consisting of approximately 320 ha of native forest is also contained within this unit. Quarries have been dug for gravel extraction.

Existing Erosion

Existing erosion is confined to areas being mined for sand or used as unsealed roads. Sheet and rill erosion occur as well as some wind erosion.

Associated Soil Landscapes

Anges Banks (**ab**) soil landscape lies conformably on top of the Berkshire Park soil landscape. Small unmapped areas of South Creek (**se**) soil landscape may occur in drainage lines and ephemeral channels.



small gravel to boulder size in a variety of shapes although usually rounded or subrounded. Roots and

LIMITATIONS TO DEVELOPMENT

Soil Limitations

bp1 High erodibility (localised)
Very strongly acid
Low fertility
Low available water capacity
Very high aluminium toxicity

bp2 Hardsetting (localised)
Very strongly acid
Low fertility
Low available water capacity
Very high aluminium toxicity

bp3 Stoniness (localised)
High credibility
Low permeability (localised)
Strongly acid
Low fertility
Low available water capacity
Very high aluminium toxicity (localised)

bp4 Extreme stoniness
Sodicity
High erodibility
Low permeability (localised)
Strongly acid
Low fertility
Low available water capacity

Fertility

General fertility is low. The soils of this unit are strongly to very strongly acid with low nutrient status. They are severely deficient in nitrogen and phosphorus although they do have a moderate CEC. The lower layers are stony and the upper layers have a high potential for aluminium toxicity.

Erodibility

The topsoil **bp1** has low erodibility as it is well graded but low in organic matter. **bp2** and **bp3** have moderate erodibility being low or very low in organic matter but, having less fine sand than **bp1**, **bp4** is highly erodible; it has a high silt and fine sand fraction and is very low in organic matter and can be moderately dispersible.

Surface Movement Potential Erosion Hazard

The erosion hazard for non-concentrated flows is low to moderate. Calculated soil loss for the first twelve months of urban development is up to 19 t/ha for topsoil and up to 44 t/ha for exposed subsoil. For concentrated flows the erosion hazard is high.

These deep clay soils are slightly reactive to stable.

Landscape Limitations

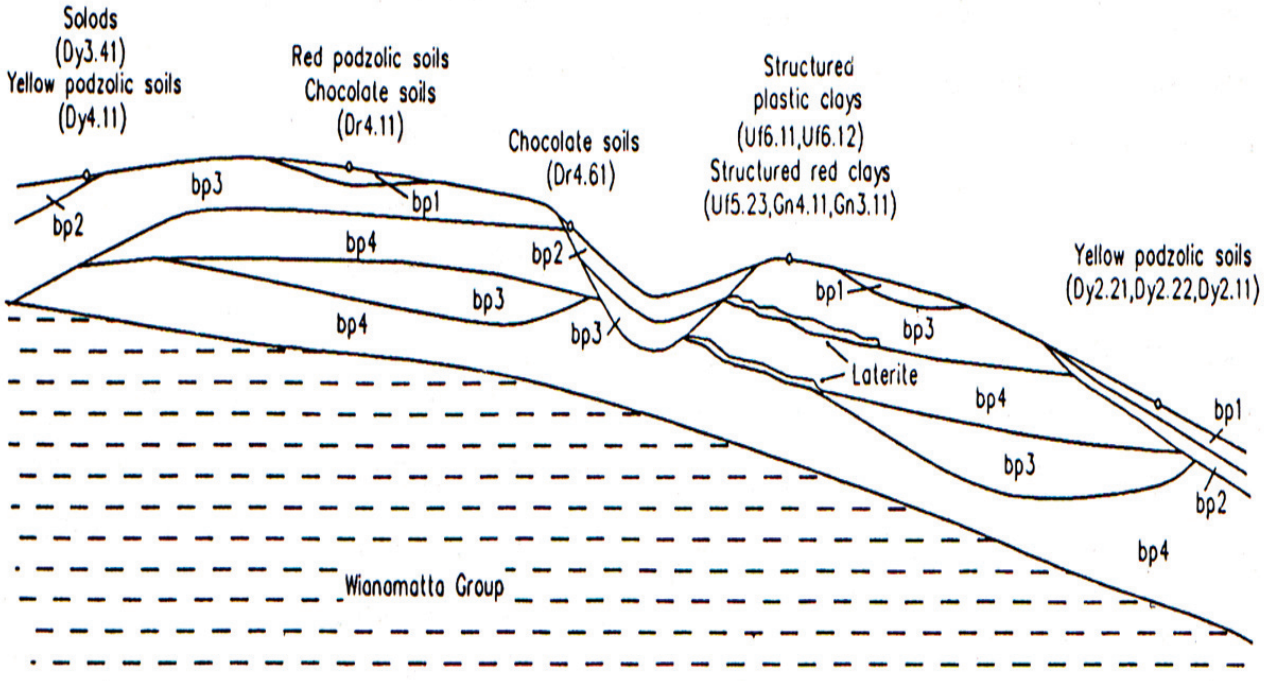
Flood hazard (localised), seasonal waterlogging (localised), water erosion hazard (localised).

Urban Capability

Capable of urban development in flood free areas.

Rural Capability

Capable of supporting grazing and regular cultivation.



Distribution diagram of the Berkshire Park soil landscape showing the occurrence and relationship of dominant soil materials

bt	BLACKTOWN	Residual

Landscape—gently undulating rises on Wianamatta Group shales. Local relief to 30 m, slopes usually >5%.

LOCATION

Occurs extensively on the Cumberland Lowlands. Examples include Blacktown, Mount Druitt, Glossodia and Leppington.

Isolated examples are found at Bilpin on the Blue Mountains plateau surface and along the Silverdale Road south of Wallacia.

LANDSCAPE

Geology

Wianamatta Group—Ashfield Shale consisting of laminite and dark grey siltstone, Bringelly Shale which consists of shale with occasional calcareous claystone, laminite and infrequent coal, and Minchinbury Sandstone consisting of fine to medium-grained quartz lithic sandstone.

Topography

Gently undulating rises on Wianamatta Shale with local relief 10–30 m and slopes generally >5% but occasionally up to 10%. Crests and ridges are broad (200–600 m) and rounded with convex upper slopes grading into concave lower slopes. Outcrops of shale do not occur naturally on the surface. They may occur, however, where soils have been removed.

Vegetation

Almost completely cleared open-forest and open-woodland (dry sclerophyll forest). The original woodland and open-forest were dominated by *Eucalyptus tereticornis* (forest red gum), *E. crebra* (narrow-leaved ironbark), *E. moluccana* (grey box) and *E. maculata* (spotted gum) (Benson, 1981).

Further west near Penrith remnant stands of *E. punctata* (grey gum) occur. Between Liverpool and St Marys the dominant species are *E. globoidea* (white stringybark) and *E. fibrosa* (broad-leaved ironbark), with *E. longifolia* (woollybutt) as an understorey species. Individual trees or small stands of *E. sideroxylon* (mugga ironbark) are occasionally found on crests.

Landuse

The dominant landuses are intensive residential (Fairfield, Blacktown and Mt Druitt), horticulture and animal husbandry (Vineyard, Scheyville and Leppington) and light and heavy industry (Yennora and Moorebank).

Existing Erosion

No appreciable erosion occurs on this unit. Minor sheet and gully erosion may be found where surface vegetation is not maintained.

Associated Soil Landscapes

South Creek (**sc**) soil landscape occurs along drainage depressions. Picton (**pn**) soil landscape occurs on steeper south and southeast facing slopes. Small areas of Luddenham (**lu**) soil landscape may also occur.

often becoming more numerous with depth. The pH varies from strongly acid (pH 4.5) to slightly acid

LIMITATIONS TO DEVELOPMENT

Soil Limitations

btl Strongly acid

bt2 Hardsetting
Low fertility
Strongly acid
High aluminium toxicity

bt3 High shrink-swell (localised)
Low wet strength
Low permeability
Low available water capacity
Salinity (localised)
Sodicity (localised)
Very low fertility
Very strongly acid
Very high aluminium toxicity

bt4 High shrink-swell (localised)
Low wet strength
Stoniness
Low available water capacity
Low permeability
Salinity (localised)
Sodicity (localised)
Low fertility
Strongly acid
Very high aluminium toxicity
High erodibility (localised)

Fertility

General fertility is low to moderate. Soil materials have low to moderate available water capacity, low CEC values, hardsetting surfaces (**bt2**), very low phosphorus and low to very low nitrogen levels. The subsoils (**bt3**, **bt4**) may be locally sodic with low permeability. When **bt1** is present its higher organic matter content and moderate nitrogen levels result in higher general fertility.

Erodibility

Blacktown soil materials have moderate erodibility. The topsoils (**bt1**, **bt2**) are often hardsetting and they have high fine sand and silt content but they also have high to moderate organic matter content. The subsoils (**bt3**, **bt4**) are very low in organic matter. Where they are also highly dispersible and occasionally sodic the erodibility is high.

Erosion Hazard

The erosion hazard for non-concentrated flows is slight to moderate but ranges from low to very high. Calculated soil loss during the first twelve months of urban development for topsoil and exposed subsoil tends to be low (7–11 t/ha). Soil erosion hazard for concentrated flows is moderate to high.

Surface Movement Potential

The deep clay soils are moderately reactive. These are generally found on side-slopes and footslopes. Shallower soils on forests are slightly reactive.

Landscape Limitations

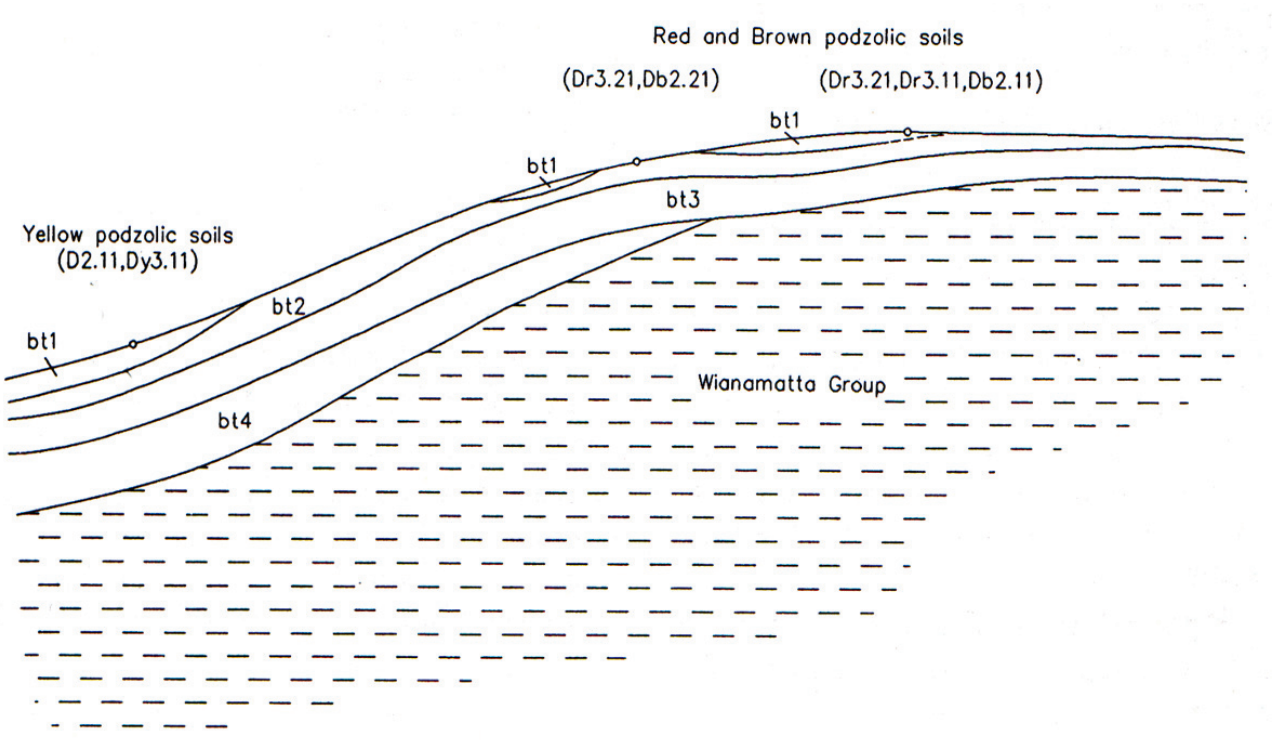
Seasonal waterlogging (localised), water erosion hazard (localised), surface movement potential (localised).

Urban Capability

High capability for urban development with appropriate foundation design.

Rural Capability

Small portions of this soil landscape which have not been urbanised are capable of sustaining regular cultivation and grazing.



Distribution diagram of the Blacktown soil landscape showing the occurrence and relationship of dominant soil materials.

xx	DISTURBED TERRAIN	Disturbed

Landscape—occurs within other landscapes and is mapped as **xx**. The topography varies from level plains to undulating terrain, and has been disturbed by human activity to a depth of at least 100 cm. Most of these areas have been levelled to slopes of <5%. The original vegetation has been completely cleared.

Soils—the original soil has been removed, greatly disturbed or buried. Landfill includes soil, rock, building and waste material.

Limitations—dependent on nature of fill material and include subsidence resulting in a mass, movement hazard, soil impermeability leading to poor drainage, and low fertility. Care must be taken when these sites are developed. A survey at a suitable scale as well as geotechnical analysis should be undertaken because of variability of materials throughout the sites. Advice from local councils should be sought concerning localised areas of disturbed terrain.

LOCATION

Numerous areas of disturbed terrain occur throughout the Penrith region. Geologically, most of these are underlain by alluvial and volcanic materials. Large areas of landfill include Penrith Lakes Scheme (Nepean River), Georges River Basin near Liverpool (e.g., Chipping Norton) and areas west of Bankstown including Bankstown Airport.

Quarried areas include Prospect, Erskine Park and Berkshire Park.

There are also numerous areas of disturbed terrain too small to represent at a scale of 1:100 000.

Underlying Material

Artificial fill. This can be dredged sand or mud, rocks and local soil materials. It can also include demolition rubble, industrial and household waste. In pits or quarries bedrock is usually exposed (e.g., dolerite at Prospect).

Landuse

Landuse is varied and includes commercial and industrial complexes, sporting or recreational areas, quarries, airports and waste disposal sites. Local parks are underlain by compacted waste.

In quarries bedrock is exposed. Most disturbed sites are eventually artificially topsoiled and revegetated or covered by concrete and bitumen.

Historical Information

Many of these disturbed sites were surveyed prior to their disturbance, e.g., Prospect and Penrith Lakes (see previous surveys).

Additional information is provided in Appendix 7.9.

fb	FAULCONBRIDGE	Residual

Landscape—level to gently undulating crests and ridges on plateau surfaces of the Hawkesbury Sandstone. Local relief <20 m, slopes <5%. Infrequent rock outcrop. Partially cleared Eucalypt woodland.

Soils—shallow (<50 cm) earthy sands (U4.21, Uc522) and yellow earths (Gn1.21, Gn2.21); some siliceous sands/lithosols (Uc1.2) associated with rock outcrop.

Limitations—shallow, highly permeable soil, localised non-cohesive soils, very low soil fertility, localised water erosion hazard, localised rock outcrop.

LOCATION

Ridge and plateau surfaces of the Hawkesbury Sandstone on the Blue Mountains and Woronora Plateaux and the MacDonald Ranges.

LANDSCAPE

Geology

Hawkesbury Sandstone consisting of medium to coarse-grained quartz sandstone with minor shale and laminite lenses.

Topography

Level to gently undulating broad crests and ridges on plateau surfaces. Local relief <20 m and slopes <5%. Broad convex ridge crests (300–800 m) are the dominant landform element. Rock outcrop is occasionally present.

Vegetation

Partially cleared low eucalypt woodland with a dry sclerophyll shrub understorey. The low woodland includes *Eucalyptus gummifera* (red bloodwood), *E. oblonga* (narrowleaved stringybark) and *E. capitellata* (brown stringybark). Other species include *E. piperita* (Sydney peppermint) and *E. sclerophylla* (scribbly gum). The open, dry sclerophyll shrub understorey is dominated by members of the families Proteaceae, Fabaceae, Epacridaceae and Myrtaceae.

Landuse

Mostly uncleared bushland, reserved as National Parks (e.g., Blue Mountains National Park at Glenbrook), Water Board Catchment Areas (e.g., Monkey Creek Catchment), Warragamba Dam and recreation areas (e.g., Cattai State Recreation Area). Bushwalking, horse and trail bike riding and driving offroad vehicles are common activities.

Existing Erosion

Minor sheet erosion occurs as sheetwash. Severe sheet erosion usually follows loss of vegetation cover due to bushfires.

Associated Soil Landscapes

Small areas of Lucas Heights (**lh**) and Gymea (**gy**) soil landscapes are included within this unit.

SOILS

Dominant Soil Materials

fb1—Loose, brownish black loamy sand.

This is a loose sand to fine sandy loam with apedal single-grained structure and porous sandy fabric. This soil material is often water repellent. It occurs as topsoil (A horizon).

Colour is usually brownish black (7.5YR 3/1) and may range from brownish black (5YR 3/1) to bright yellowish brown (10YR 6/6). This material varies from extremely acid (pH 3.0) to strongly acid (pH 4.5). There are a few sandstone rock fragments. Charcoal fragments and roots are common.

fb2—Earthy, yellow clayey sand.

This is a yellow clayey sand with apedal massive structure and porous earthy fabric. This material is water repellent. It occurs as an A2 horizon.

The texture can increase gradually with depth to a sandy clay loam. The colour ranges from reddish brown (5YR 4/8) to bright yellowish brown (10YR 6/6). Faint yellow or orange mottles are occasionally present. The pH varies from extremely acid (pH 3.5) to slightly acid (pH 6.0). Few sandstone rock fragments and charcoal fragments occur. Roots may be either common or rare.

fb3—Yellow, earthy sandy clay loam.

This is a yellow sandy clay loam with apedal massive to weakly pedal structure and porous earthy fabric. It occurs as subsoil (B horizon).

The texture can increase gradually with depth to a sandy clay. Colour is commonly light grey (10YR 8/1) to dull yellow orange (10YR 7/4). Orange mottles often occur with depth. This material varies from extremely acid (pH 3.0) to strongly acid (pH 4.5). Sandstone fragments are common but charcoal fragments and roots are rarely present.

Occurrence and Relationships

Up to 10cm of loose, brownish black loamy sand (**fb1**) overlies sandstone bedrock producing lithosols or siliceous sands (Uc1.2) or it can overlie 15–30 cm of earthy, yellow clayey sand (**fb2**) and up to 30 cm of yellow, earthy, sandy clay loam (**fb3**) [earthy sands (Uc5.22) or yellow earths (Gn1.21, Gn2.21)]. The boundaries between **fb1** and **fb3** are usually clear. There is a diffuse to gradual boundary between **fb2** and **fb3**. Total soil depth is usually 30–100 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

fbl High permeability
Low available water capacity
Low fertility
High aluminium toxicity
Strongly acid

fb2 Very low fertility
Low available water capacity
Localised stoniness
Very strongly acid
Very high aluminium toxicity
High permeability (localised)

fb3 Low available water capacity
Stoniness
Very low fertility
Very strongly acid
Very high aluminium toxicity

Fertility

Very low fertility. The soil materials are very strongly acid, have low water holding capacities, are shallow, highly permeable,with low organic matter content and very low CEC.They are often severely deficient in the nutrients nitrogen and phosphorus.

Erodibility

fbl consists of highly permeable, coarse, loose sand grains which have a very low to low erodibility depending on organic matter present. **fb2** and **fb3** are very low in organic matter and consist of fine sand grains which are weakly cemented in a clay matrix and are moderately erodible.

Erosion Hazard

The erosion hazard for non-concentrated flows is low to moderate. Calculated soil loss during the first 12 months of urban development ranges up to 6 t/ha for topsoil and up to 18 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows is also low.

Surface Movement Potential

Shallow depths and low day contents make these soils stable to slightly reactive.

Landscape Limitations

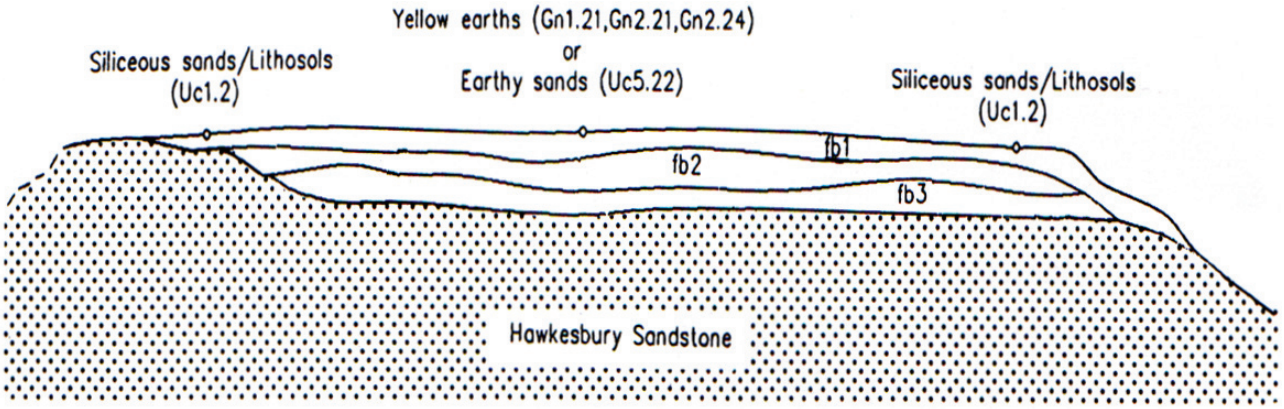
Shallow soil, water erosion hazard (localised), non-cohesive soils (localised), rock outcrop (localised).

Urban Capability

High capability for urban development.

Rural Capability

Not capable of being cultivated but capable of being grazed with careful management.



Distribution diagram of the Faulconbridge soil landscape showing the occurrence and relationship of dominant soil materials.