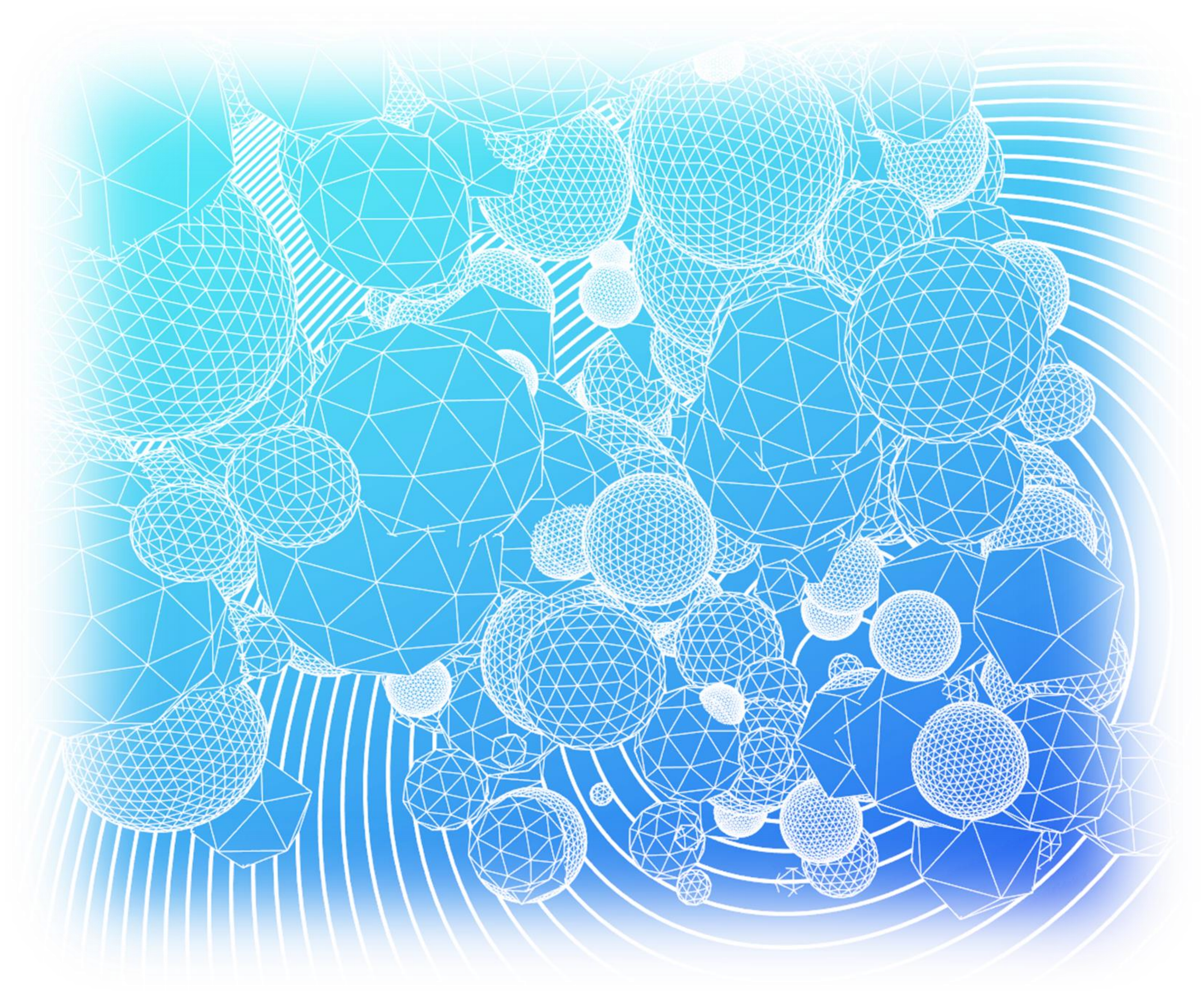
Sydney WATER

Appendix V Health Impact Assessment



Health Impact Assessment: Upper South Creek Advanced Water Recycling Centre

Prepared for: Sydney Water Corporation

7 September 2021

Document History and Status

Report Reference	SWC/2021/USC001
Revision	F – Final
Date	7 September 2021
Previous Revisions	A – Draft (12 March 2021) B – Draft (28 June 2021) C – Final (6 August 2021) D – Final (20 August 2021) E – Final (26 August 2021)

Limitations

Environmental Risk Sciences has prepared this report for the use of Sydney Water Corporation in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the Section 1 of this report.

The methodology adopted, and sources of information used are outlined in this report. Environmental Risk Sciences has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This report was prepared in February/March 2021 and in June/August 2021 and is based on the information provided and reviewed at that time. Environmental Risk Sciences disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Table of Contents

Glossary of Terms and Abbreviations

Term	Definition
AAQ	Ambient air quality.
ABS	Australian Bureau of Statistics.
Acute exposure	Contact with a substance that occurs once or for only a short time (up to 14 days).
Absorption	The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.
Adverse health effect	A change in body function or cell structure that might lead to disease or health problems.
Aerodynamic diameter	Airborne particles have irregular shapes, their aerodynamic behaviour is expressed in terms of the diameter of an idealised spherical particle.
AIHW	Australian Institute of Health and Welfare.
ANZECC	Australia and New Zealand Environment and Conservation Council (now part of ANZG – https://www.waterquality.gov.au/)
Background level	An average or expected amount of a substance or material in a specific environment, or typical amounts of substances that occur naturally in an environment.
Chronic exposure	Contact with a substance or stressor that occurs over a long time (more than one year) [compare with acute exposure and intermediate duration exposure].
dBA	Decibels (A-weighted).
DEC	NSW Department of Environment and Conservation (now known as NSW Environment Protection Authority (NSW EPA))
DECC	NSW Department of Environment and Climate Change (now known as NSW Environment Protection Authority (NSW EPA))
DECCW	NSW Department of Environment, Climate Change and Water (now known as NSW Environment Protection Authority (NSW EPA))
DEFRA	Department for Environment, Food & Rural Affairs.
DEH	Australian Department of Environment and Heritage.
Detection limit	The lowest concentration of a substance that can reliably be distinguished from a zero concentration.
Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An 'exposure dose' is how much of a substance is encountered in the environment. An 'absorbed dose' is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
EIS	Environmental Impact Statement.
EPHC	Environment Protection and Heritage Council.
EU	European Union.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Also includes contact with a stressor such as noise or vibration. Exposure may be short term [acute exposure], of intermediate duration, or long term [chronic exposure].
Exposure assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Term	Definition
Exposure pathway	The route a substance takes from its source (where it began) to its endpoint (where it ends), and how people can come into contact with (or get exposed) to it. An exposure pathway has five parts: a source of contamination (such as chemical substance leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Guideline value	Guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the NSW Department of Environment and Conservation (DEC) or institutions such as the National Health and Medical Research Council (NHMRC), Australia and New Zealand Environment and Conservation Council (ANZECC) and World Health Organization (WHO)), that is used to identify conditions below which no adverse effects, nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source, guidelines would have different names, such as investigation level, trigger value and ambient guideline.
HHRA	Human health risk assessment.
HI	Hazard Index.
ICNG	Interim Construction Noise Guideline.
I-INCE	International Institute of Noise Control Engineering.
Inhalation	The act of breathing.
Intermediate exposure	Contact with a substance that occurs for more than 14 days and less than a year [compared with acute exposure and chronic exposure].
LGA	Local Government Area.
LOAEL	Lowest-observed-adverse-effect level.
LOR	Limit of Reporting.
Metabolism	The conversion or breakdown of a substance from one form to another by a living organism.
Morbidity	This is the condition of being ill, diseased or unhealthy. This can include acute illness (which has a sudden onset and may improve or worsen over a short period of time) as well as chronic illness (which can present and progress slowly over a long period of time).
Mortality	This is the condition of being dead. It may be presented as the number of deaths in a population over time, either in general or due to a specific cause.
NEPC	National Environment Protection Council.
NEPM	National Environment Protection Measure.
NHMRC	National Health and Medical Research Council.
NO_2	Nitrogen dioxide.
NOx	Nitrogen oxides.
NSW	New South Wales.
NSW EPA	NSW Environment Protection Authority.
OEH	NSW Office of Environment and Heritage.
PM	Particulate matter.
$PM_{2.5}$	Particulate matter of aerodynamic diameter 2.5 micrometres (µm) and less.
PM_{10}	Particulate matter of aerodynamic diameter 10 micrometres (µm) and less.
Point of exposure	The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Term	Definition
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
RBL	Rating Background Level.
Receptor	An assessed location for potential air, noise or blasting impacts. Typically, receptors are residences, however, can include commercial and industrial premises, places of worship, schools, etc. Also known as receivers.
Receptor population	People who could come into contact with hazardous substances [see exposure pathway].
Risk	The probability that something would cause injury or harm.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].
SEARs	Secretary's Environmental Assessment Requirements.
Toxicity	The degree of danger posed by a substance to human, animal or plant life.
Toxicity data	Characterisation or quantitative value estimated (by recognised authorities) for each individual chemical substance for relevant exposure pathway (inhalation, oral or dermal), with special emphasis on dose-response characteristics. The data are based on based on available toxicity studies relevant to humans and/or animals and relevant safety factors.
Toxicological profile	An assessment that examines, summarises, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.
Toxicology	The study of the harmful effects of substances on humans or animals.
TSP	Total suspended particulates.
UK	United Kingdom.
US	United States of America.
USEPA	United States Environmental Protection Agency.
WHO	World Health Organisation.
$\mu g/m^3$	Micrograms per cubic metre.
µm	Micrometre or micron

Section 1. Introduction

1.1 Background

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Sydney Water to prepare a Human Health Impact Assessment (HIA) for the proposed Advanced Water Recycling Centre and associated pipelines.

Sydney Water is proposing to build and operate a new treatment facility to provide wastewater services to this area. The project will comprise:

- a new Advanced Water Recycling Centre (AWRC) that would collect wastewater from businesses and homes and treat it to produce high-quality treated water, renewable energy and biosolids for beneficial reuse
- a new green space area around the AWRC, adjacent to South Creek and Kemps Creek, that would support the ongoing development of a green spine through Western Sydney
- a new treated water pipeline from the AWRC to the Nepean River at Wallacia Weir, that would release high-quality treated water to the River during normal weather conditions
- a new pipeline from Wallacia to the Warragamba River, releasing water just below the Warragamba Dam
- new infrastructure from the AWRC to South Creek, that would release excess highly treated water during significant wet weather events
- a new brine pipeline from the AWRC connecting into Sydney Water's existing wastewater system which carries brine to the Malabar plant for treatment
- a range of ancillary infrastructure.

An environmental impact statement (EIS) is being prepared for this project and this HIA addresses the potential risks and benefits to human health posed by this project.

1.2 SEARs

The project has been declared as State Significant Infrastructure (SSI) and the Secretary of the Department of Planning, Industry and Environment has issued project specific environmental assessment requirements (SEARs).

One of the SEARs is assessing the potential health impacts from the project. This has been undertaken in this report using information from reports detailing other assessments required by the SEARs as shown in **Table 1.1**.

Table 1.1: Secretary's environmental assessment requirements

Secretary's environmental assessment requirements
50. A Health Impact Assessment of the project in accordance with the current guidelines.
51. An assessment of the likely risks of the project to public safety including flood risk, subsidence risks, bushfire risks and the handling and use of dangerous goods.
General requirements (g) an assessment of the likely impacts of the project on the biophysical and socio-economic environment, focusing on the specific issues identified below and any other significant issues identified, including: i. a description of the existing environment likely to be affected by the project using relevant and adequate data. ii. an assessment of the potential impacts of the project, including any cumulative impacts, and taking into consideration relevant guidelines, policies, plans and industry codes of practice. iii. a description and details of how the project has been designed to avoid, minimise and offset impacts (through design, or construction or operation methodologies). iv. a description of how any residual impacts will be managed or offset, and the approach and effectiveness of these measures.

1.3 Legislative and policy context

When developing assessments required for the planning applications, it is important to consider the relevant legislation and state and local policies that apply to the project. **Table 1.2** provides a list of the relevant guidance considered in preparing technical assessments that have informed this assessment of potential health impacts.

Table 1.2: Legislation and policy context

Legislation/Policy	Description and objectives	Relevance
Environmental Planning and Assessment Act 1979 (EP&A Act).	The EP&A Act, the Environmental Planning and Assessment Regulation 2000 (NSW) and associated environmental planning instruments (including State Environmental Planning Policies (SEPPs) and Local Environmental Plans (LEPs)) provide the framework for the assessment of the environmental impact of development proposals in NSW. Sections 5.12 and 5.13 of Part 5 of the EP&A Act provide for the declaration of state significant infrastructure (SSI) and critical SSI. Section 5.12(4) of the EP&A Act enables a SEPP or an order of the NSW Minister for Planning (published on the NSW legislation website) to declare development to be SSI.	The project has been declared as State Significant Infrastructure (SSI) and the Secretary of the Department of Planning, Industry and Environment has issued project specific environmental assessment requirements (SEARs). In accordance with section 5.16 of the EP&A Act, the Planning Secretary has prepared the Secretary's Environmental Assessment Requirements (SEARs), which require the preparation of an EIS for the project for submission to the consent authority, the NSW Minister for Planning.
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 are as follows: ▪ to protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development ▪ to provide increased opportunities for public involvement and participation in environment protection ▪ to ensure that the community has access to relevant and meaningful information about pollution ▪ to reduce risks to human health and prevent the degradation of the environment by the use of mechanisms that promote the following— o pollution prevention and cleaner production o the reduction to harmless levels of the discharge of substances likely to cause harm to the environment o the elimination of harmful wastes o the reduction in the use of materials and the re-use, recovery or recycling of materials o the making of progressive environmental improvements, including the reduction of pollution at source	Development of the project will produce spoil and waste as part of construction. An environment protection license (EPL) will be required to operate a wastewater treatment plant and relevant discharges.

Legislation/Policy	Description and objectives	Relevance
	○ the monitoring and reporting of environmental quality on a regular basis ▪ to rationalise, simplify and strengthen the regulatory framework for environment protection ▪ to improve the efficiency of administration of the environment protection legislation ▪ to assist in the achievement of the objectives of the *Waste Avoidance and Resource Recovery Act 2001*.	
Protection of the Environment Operations (General) Regulation 2009.	Key parts of The Protection of the Environment Operations (General) Regulation 2009 include: ▪ Provides for the administration of environment protection licences. ▪ Establishes the method of calculating licence fees, including load based licence fees, and environmental protection notice fees. ▪ Prescribes certain matters for the purposes of the definition of water pollution. ▪ Gives effect to and requires compliance with the National Environment Protection (National Pollutant Inventory) Measure made under the *National Environment Protection Council Act 1994* (Cth). ▪ Prescribes requirements in respect of pollution incident response management plans. ▪ Prescribes certain offences as penalty notice offences and prescribes penalty notice amounts.	The project will involve consideration of many of the matters covered in this regulation
Protection of the Environment Operations (Waste) Regulation 2014.	The Waste Regulation allows the NSW EPA to protect human health and the environment and provides a platform for a modern and fair waste industry. It includes strict thresholds for environment protection licences and outlines the waste levy system.	The project will involve consideration of the matters covered in this regulation
Protection of the Environment Operations (Clean Air) Regulation 2010.	This regulation details NSW EPA requirements for domestic solid fuel heaters, burning (hazard reduction etc), emissions from motor vehicles etc, emissions from industry (i.e. activities and plant), control measures to be applied to storage of volatile liquids like fuels and matters related to cruise ship fuels. Information about what guidance to use when modelling emissions from industry is also provided.	The project will involve consideration of the matters covered in this regulation particularly those related to emissions from industry.
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 EPA considers to be contaminated significantly enough to require regulation. Particular objects of this Act are:	Development of the project may disturb contaminated soils and ground water and so will involve consideration of the matters covered under this Act and relevant Regulations.

Legislation/Policy	Description and objectives	Relevance
	- to set out accountabilities for managing contamination if the EPA considers the contamination is significant enough to require regulation - to set out the role of the EPA in the assessment of contamination and the supervision of the investigation and management of contaminated sites, and - to provide for the accreditation of site auditors of contaminated land to ensure appropriate standards of auditing in the management of contaminated land, and - to ensure that contaminated land is managed with regard to the principles of ecologically sustainable development.	
Department of Urban Affairs and Planning (DUAP) and NSW EPA, 1998. State Environmental Planning Policy No. 55 – Remediation of Land.	The object of this Policy is to provide for a Statewide planning approach to the remediation of contaminated land. In particular, this Policy aims to promote the remediation of contaminated land for the purpose of reducing the risk of harm to human health or any other aspect of the environment. Planning authorities must consider, at the development approval and rezoning stage, if contamination will adversely affect the suitability of a site for its proposed use. If contamination makes it unsuitable for the proposed use, the land must be remediated before it can be developed. SEPP55 - makes remediation permissible - defines when consent is required - requires all remediation to comply with standards - ensures land going through the development consent process is investigated if contamination is suspected - requires councils to be notified of all remediation proposals	This SEPP builds on the requirements of the CLM Act focusing on addressing contamination when land is to be developed/redeveloped. The project will involve consideration of the matters covered in this SEPP.
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. - If you are transporting waste, a waste transporter's licence may be needed. - All licence holders are listed in the dangerous goods public register. This legislation controls the transport of all dangerous goods except: - Class 1 (explosives), regulated under the *Explosives Act 2003* and administered by Safework NSW.	The project will involve consideration of the matters covered in this Act in regard to storage and transport of chemicals used in wastewater treatment and, if required, movement and transport of contaminated soils and spoil from construction.

Legislation/Policy	Description and objectives	Relevance
	- Class 7 (radioactive substances), regulated under the *Radiation Control Act 1990* and administered by the EPA. - Dangerous goods are classified under the Australian Dangerous Goods Code (ADG Code) and the United Nations Manual of Tests and Criteria (UN Manual).	
NSW Government 2014, State Environmental Planning Policy No 33—Hazardous and Offensive Development (NSW Government 2014)	State Environment Planning Policy for the management of potentially hazardous developments.	The project will involve consideration of the matters covered in this SEPP.
NSW Planning 2011, Hazardous and Offensive Development Application Guidelines Applying SEPP 33 (NSW Planning 2011c)	Guidance detailing the framework for applying SEPP 33.	The project will involve consideration of the matters covered in this guidance.
NSW Planning and Infrastructure 2011, Assessment Guideline Multi-level Risk Assessment (NSW Planning and Infrastructure 2011)	Guidance detailing specific parts of the assessment process for potentially hazardous industry.	The project will involve consideration of the matters covered in this guidance.
NSW Planning 2011b, Risk Criteria for Land Use Safety Planning, Hazardous Industry Planning Advisory Paper No 4 (NSW Planning 2011b)		The project will involve consideration of the matters covered in this guidance.
NSW Planning 2011, Hazardous Industry Planning Advisory Paper No 6, Hazard Analysis (NSW Planning 2011a)		The project will involve consideration of the matters covered in this guidance.
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.	The project will include construction of critical infrastructure and management of soils and

Legislation/Policy	Description and objectives	Relevance
	Regulations set out specific requirements for particular hazards and risks, such as noise, machinery, and manual handling.	contamination as part of the works. Protection of health and safety through safety in design (SID) via engineering concept design and management of contamination risks have been considered in this Soils and Contamination Impact Assessment.
Waste Avoidance and Resource Recovery Act, 2001	Promotes waste avoidance and resource recovery to achieve a continual reduction in waste generation by providing for the development of a state-wide Waste Strategy. Introduces a scheme to promote extended producer responsibility for the lifecycle of a product. It establishes the following waste management hierarchy: ▪ Avoidance – minimise the potential for waste generation by avoiding unnecessary consumption of resources ▪ Recovery – reuse, reprocess or recycle waste products to minimise the amount of waste requiring disposal ▪ Disposal – as a last resort, dispose of resources that cannot be recovered.	The waste hierarchy is the governing philosophy that drives the management methodology for the project's waste.
NSW EPA – Waste Classification Guidelines, 2014 (Part 1 Classifying Waste)	Part 1 of the guidelines, covers the classification of wastes into groups that pose similar risks to the environment and human health. These classifications are: ▪ special waste ▪ liquid waste ▪ hazardous waste ▪ restricted solid waste ▪ general solid waste (putrescible) ▪ general solid waste (non-putrescible)	These guidelines were used to classify all defined and identified wastes into the relevant environment and human health risk categories.
NSW EPA – Waste Avoidance and Resource Recovery Strategy, 2014 - 2021	Provides a framework and targets for waste management and recycling in NSW from 2014 to 2021/22. It supports investment in infrastructure, encourages innovation and improves recycling behaviour. It strives to help develop new markets for recycled materials and reduce litter and illegal dumping.	The relevant targets established under this strategy comprise: ○ Increasing recycling rates to 70% for industrial waste and 80% for construction and demolition waste ○ Increasing waste diverted from landfill to 75%

Legislation/Policy	Description and objectives	Relevance
NSW EPA – Asbestos Waste Strategy, 2019-2021	Proposes innovative measures to reduce illegal dumping and unsafe disposal and promotes lawful and appropriate disposal of asbestos waste. A key principle is the strive to making asbestos waste disposal cheaper by working with local government and industry to provide cheaper ways for householders and licensed contractors to lawfully dispose of asbestos waste under certain circumstances.	Used to determine the most environmentally and cost-efficient method of disposing of asbestos waste.
Western Sydney Infrastructure Plan (Australian and NWS Government, 2014)	This plan has been developed to make use of the economic opportunities afforded by Western Sydney Airport. The plan outlines major road infrastructure to be delivered over the next 10 years within the Western Sydney region	Infrastructure schemes identified in this plan will be relevant for the construction and operational phases of the project.
Western Parkland City Place-based Infrastructure Report (Greater Sydney Commission)	This document provides a model to guide schemes and developments which are planned for the Western Parkland City in the future. To ensure they adhere to the outcomes presented in this report.	The report will need to be cognisant of the PIC model and ensure the project outcomes align. This will include an appreciation of the committed infrastructure outlined in the report.
Western Sydney Aerotropolis Draft Precinct Plans	These documents outline the initial Structure Plans for a range of precincts within the Aerotropolis including information on land use and infrastructure	Land use and infrastructure changes in precincts in the vicinity of the project will impact access particularly in operation.
Development Control Plans (DCPs) (Wollondilly Shire, Penrith City, Liverpool City, Fairfield City and Canterbury-Bankstown)	These documents prescribe more detailed planning and design guidelines for developments proposed within the relevant Local Government Area (LGA)	As local councils will be key stakeholders for the project. The relevant DCPs should be referenced to understand potential requirements along certain sections of the pipeline. In particular, the Penrith City DCP dictates requirements relating to access, parking and cycle parking provisions which will apply to the AWRC site.
NSW Noise Policy for Industry (NPfI) (2017), Environment Protection Authority (EPA)	The NPfI provides guidelines for the assessment of noise impacts from the operation of an industrial development onto nearby receivers. The NPfI has superseded the NSW Industrial Noise Policy [2] referred to in the SEARs.	The project will involve consideration of the matters covered in this guidance.
NSW Road Noise Policy, Dept. of Environment, Climate Change and Water 2011 (RNP)	The RNP is used for assessing noise of operation traffic when travelling on the road network from/to a development site.	The project will involve consideration of the matters covered in this guidance.

Legislation/Policy	Description and objectives	Relevance
NSW Interim Construction Noise Guideline (ICNG), EPA 2009	The ICNG provides guidelines for the assessment and management of construction noise. The ICNG provides a range of work practices to minimise construction noise impacts	The project will involve consideration of the matters covered in this guidance.
NSW Road Noise Policy, EPA 2011 (RNP)	The RNP is used for assessing noise of construction traffic when travelling on the road network from/to a construction site.	The project will involve consideration of the matters covered in this guidance.
NSW Assessing Vibration – a technical guideline (AVTG), EPA 2006 (based on BS 6472)	Used for assessing potential vibration disturbance to human occupants of buildings and building contents	The project will involve consideration of the matters covered in this guidance.

1.4 Objectives

The objective of the work is to:

- Prepare a HIA to meet the Secretary's Environmental Assessment Requirements (SEARs)

The HIA will address the human health risks and benefits in each of these areas, where relevant:

- Water - hydrology and quality
- Air quality
- Noise and vibration
- Soil including contamination
- Safety (transport and storage of chemicals & dangerous goods (HAZOP), flooding, bushfire, subsidence)
- Transport and traffic
- Waste

1.5 Available project-specific information

- Jacobs (2020) Air quality impact assessment. Dated 27 November 2020
- Aurecon/ARUP (2021a) Upper South Creek AWRC EIS, Hydrodynamic and Water Quality Impact Assessment. Dated 16 July 2021.
- Aurecon/ARUP (2021b) Upper South Creek AWRC EIS, Surface Water Specialist Study. Revision 0.
- Aurecon/ARUP (2021c) Upper South Creek Advanced Water Recycling Centre: Socio-economic and land use impact assessment (draft). Dated 2 June 2021.
- Aurecon/ARUP (2021d) Upper South Creek Advanced Water Recycling Centre: Noise and vibration impact assessment. August 2021.
- Aurecon/ARUP (2021e) Upper South Creek Advanced Water Recycling Centre: Soils and contamination impact assessment. August 2021.
- Aurecon/ARUP (2021f) Preliminary hazard analysis. Upper South Creek Advanced Water Recycling Centre. August 2021.
- Aurecon/ARUP (2021g) Upper South Creek Advanced Water Recycling Centre: Traffic and transport technical report. August 2021.
- Aurecon/ARUP (2021h) Upper South Creek Advanced Water Recycling Centre: Waste management impact assessment report August 2021.
- Sydney Water (2021a) Upper South Creek Advanced Water Recycling Centre, Environmental Impact Statement, Main Report (Chapter 4 – Project Description) DRAFT
- Sydney Water (2021b) Upper South Creek Advanced Water Recycling Centre, Environmental Impact Statement, Main Report (Chapter 8 – Key waterway impacts) DRAFT
- Sydney Water (2021c) Upper South Creek Advanced Water Recycling Centre, Toxicant review of release streams
- Sydney Water (2020) Fairfield water recycling plant water quality monitoring program (December 2019-March 2020)
- Building Code & Bushfire Hazard Solutions (2020) Bushfire constraints and opportunities report, Upper South Creek Advanced Water Recycling Centre, Kemps Creek, NSW. Dated 21 August 2020.

Section 2. Project description

2.1 Overview of the project

Sydney Water is proposing to build and operate a project to provide wastewater services to the Western Sydney Aerotropolis Growth Area (WSAGA) and South West Growth Area (SWGA).

The proposed development will 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 2.1**. Further details of each component of the project are provided below.

2.1.1 Advanced Water Recycling Centre

The Advanced Water Recycling Centre is 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.

2.1.2 Treated water pipeline

The project will include:

- 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

2.1.3 Environmental flow pipeline

The project will include:

- a pipeline about five kilometres 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.

2.1.4 Brine pipeline

The project will also include:

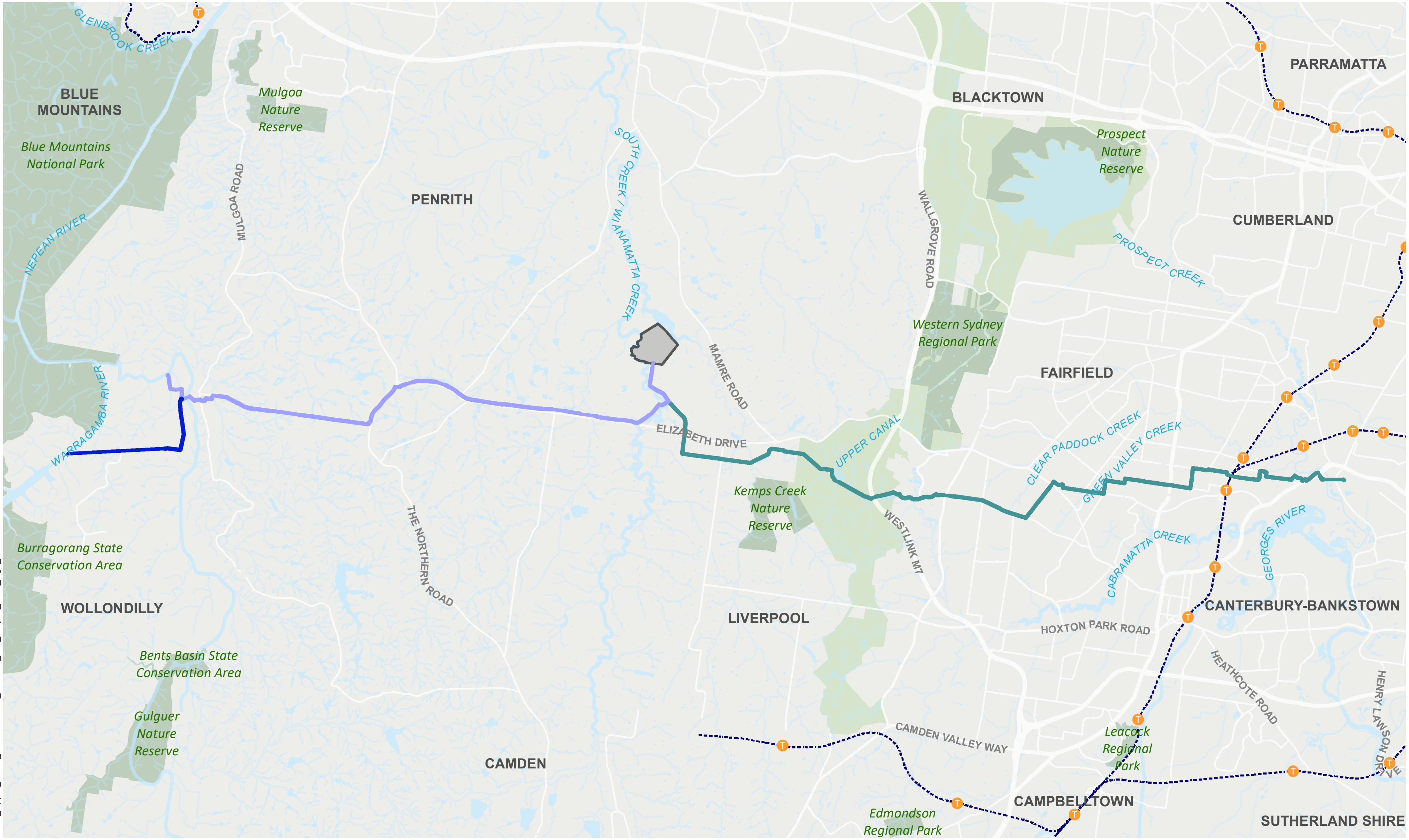
- a pipeline about 24 km long that transfers brine from the Advanced Water Recycling Centre to Lansdowne, in south-west Sydney, where it connects to Sydney Water's existing Malabar wastewater network.

2.1.5 Development program

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 of up to 50ML 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.



Environmental Flows Pipeline
Treated Water Pipeline
Brine Pipeline
Advanced Water Recycling Centre

Base Data
Watercourse
Waterbody
National Parks & Reserves
Western Sydney Parklands

Railway

1:135,000
0 1.5 3km

Figure 2.1

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

P:\GIS\Project-4\project\505018_Upper_South_Creek\505018_USCWF_EIS_Project_desc_high_level.mxd\JOB No:\26-02-21\Bridie.Jackson\Rev 0

2.2 Background information – wastewater

As noted by the World Health Organisation (WHO) (WHO 2018):

"Sanitation saves lives. But history teaches us that it's also one of the key building blocks of development.

Ancient civilizations that invested in sanitary improvements became healthy, wealthy, powerful societies. More recently, modernization and economic growth have followed investments in sanitation systems.

Sanitation prevents disease and promotes human dignity and well-being, making it the perfect expression of WHO's definition of health, as expressed in its constitution, as "A state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity"."

In Australia, having a well managed system for wastewater management is taken for granted by many people. But it is important that such systems are evaluated and expanded as required to ensure this critical component of public health management continues to do its job.

Every day we use water around our houses for drinking, showering, cooking, cleaning and when we use the toilet. When we use water for these purposes, we add chemicals and microorganisms to the water before it gets washed down the drain. Some of the chemicals we add come from the household cleaning products, cosmetics, personal care products and other things we use around the house. Other chemicals are naturally occurring ones that are in the food we eat (like metals taken up by plants when they are grown in soil). Other chemicals are those we all excrete as waste products from the metabolic processes within our body. The metabolic processes are those producing energy and running systems we need to keep us alive like the nervous or endocrine systems. The microorganisms in our bodies also get excreted – both those that are essential for our digestion and those that may bring disease.

This wastewater requires some sort of management. It cannot be discharged directly to soil or waterways without causing unacceptable impacts to the environment and to people. Most houses in Australia are connected to the sewer or another type of wastewater treatment process (septic systems, composting toilets, etc). In most areas, the water is collected together and sent to a wastewater treatment plant. This project is for the construction of one of these plants.

The treatment process is designed to manage the potential for chemicals and microorganisms to reach the environment at levels that might be of concern.

These treatment processes produce a liquid phase – effluent – which is often discharged to a waterway (or recycled for a range of purposes) and a solid phase – sludge. Biosolids comes from further treating the sludge to make it more usable. The additional treatments dry out the sludge to make it easier to handle/transport and further reduce pathogens and volatile organic matter.

Wastewater treatment plants such as the one proposed in this project play an essential role in managing public health impacts from disease causing microorganisms and from the wide range of chemicals we use every day.

2.3 Detailed plant description

The new Upper South Creek AWRC will be located in the Kemps Creek precinct (Penrith local government area) upstream of the confluence of upper South Creek and Kemps Creek. The project will be located on a 80 ha site as shown in **Figures 2.2** and **2.3**. Sydney Water is in negotiations to purchase the site. It is likely that about half the site will be required for the main operational components of the AWRC. Plans for the rest of the site include landscaping to enhance biodiversity, provide visual screening of the operational areas and to make good use of best practice water sensitive urban design.

The AWRC will produce high quality treated water suitable for a range of uses including recycling and environmental flows. It is being designed to treat an average dry weather flow (ADWF) of 50 ML/d with the potential to extend during future stages to enable treatment of flows up to 100 ML/d (subject to separate approvals). Treated water will be released to the Nepean River, South Creek and the Warragamba River.

Tertiary and advanced treated water produced by the AWRC is likely to be suitable for re-use. The project scope for this EIS does not include an assessment of any recycled water schemes and assumes that all treated water from the Water Recycling Centre (other than reclaimed effluent used on-site) will be released to waterways. The EIS, therefore, assesses the maximum discharge volume. It is possible that lesser volumes will be discharged to waterways should recycled water schemes be introduced in the future.

The Water Recycling Centre requires a range of ancillary infrastructure, such as an administration building, car parking, chemical storage, connection to power, roads and water detention basins. The installation of roof-mounted and ground-mounted solar photovoltaics (PV) are also being proposed.

The Water Recycling Centre will treat wastewater through an advanced treatment process. This includes:

- inlet works for preliminary treatment
- primary, secondary and tertiary wastewater treatment
- advanced treatment including reverse osmosis
- disinfection systems
- biosolids handling facilities
- cogeneration for heat and energy production
- odour control facilities
- infrastructure to South Creek for releases of excess flows during wet weather
- pumping stations to transfer treated water to the Nepean and Warragamba Rivers, and to transfer brine to the Malabar system.

The Water Recycling Centre will produce treated water at three different quality levels:

- advanced (the highest level of treatment)
- tertiary (high quality treated water)
- wet weather (lowest level of treatment).

Different types of treated water will be released at different locations, typically:

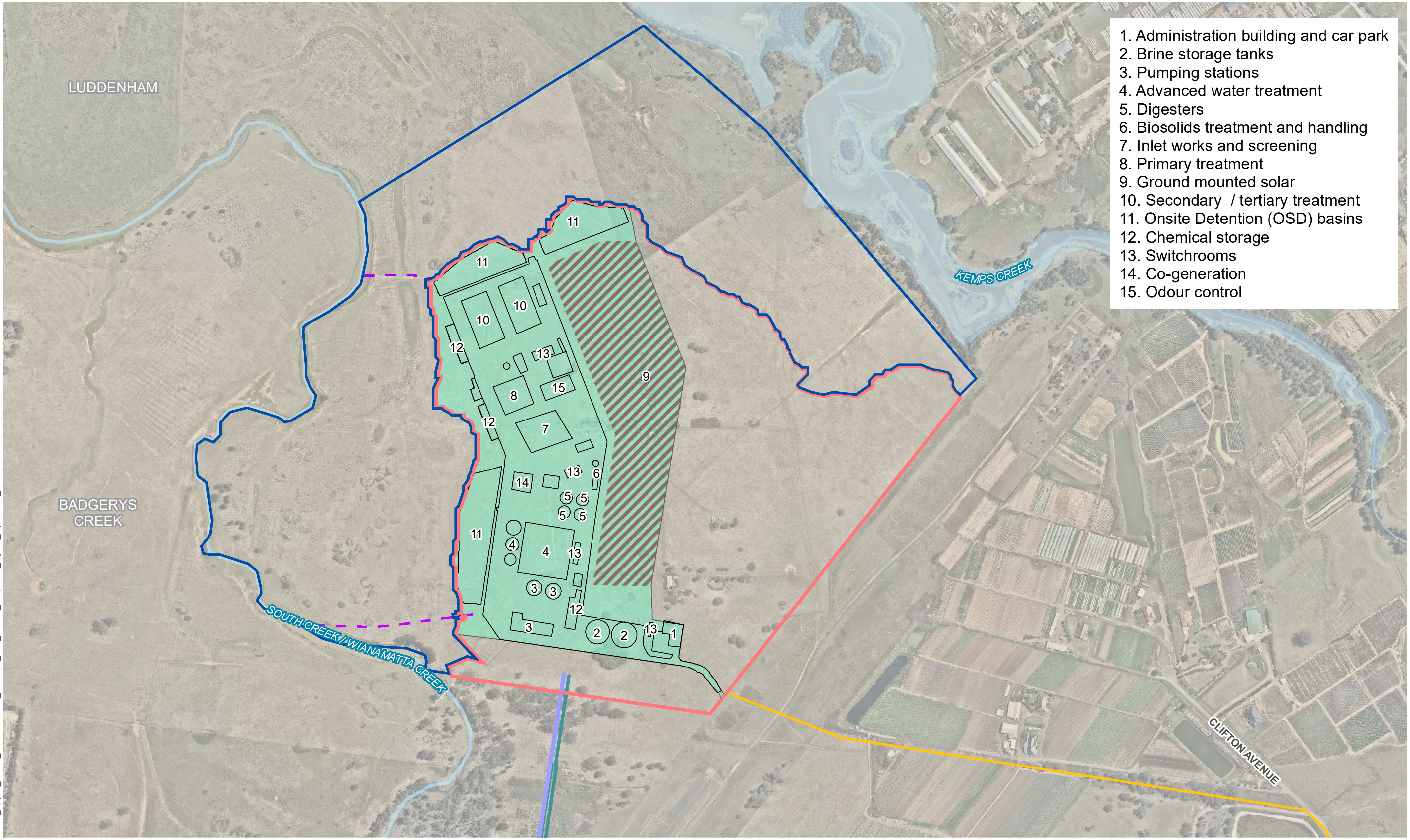
- advanced quality water - preferentially used for dry weather releases to the Nepean River, environmental flows to the Warragamba River and wet weather releases to South Creek
- tertiary quality water – additional volumes released to the Nepean River

- wet weather water – released to South Creek when inflows to the plant exceed the capacity of the tertiary treatment systems.

The advanced and tertiary streams will also be suitable for a range of recycled water uses.

The advanced treatment process produces brine as a by-product which will be transferred to Sydney Water's Malabar wastewater system.

The flows through the new facility are shown in **Figure 2.4**.



Treated Water Pipeline
Brine Pipeline
South Creek release infrastructure
Operational area – AWRC
area
AWRC Layout (Stage 1)
AWRC Access Road
AWRC Footprint
Solar Panels
Watercourse
Waterbody

1:8,000
0 100 200m

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

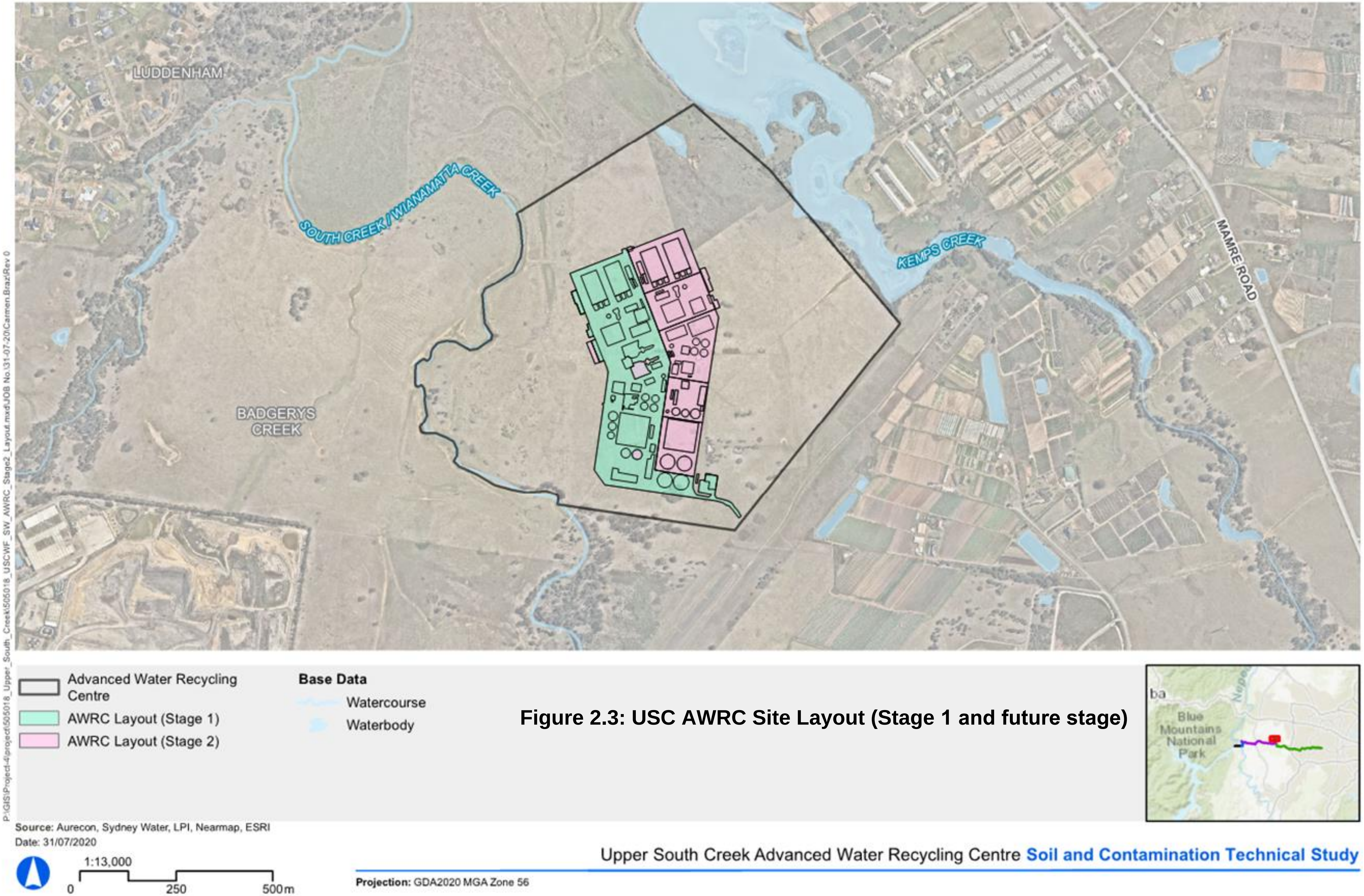


Figure 2.3: USC AWRC Site Layout (Stage 1 and future stage)

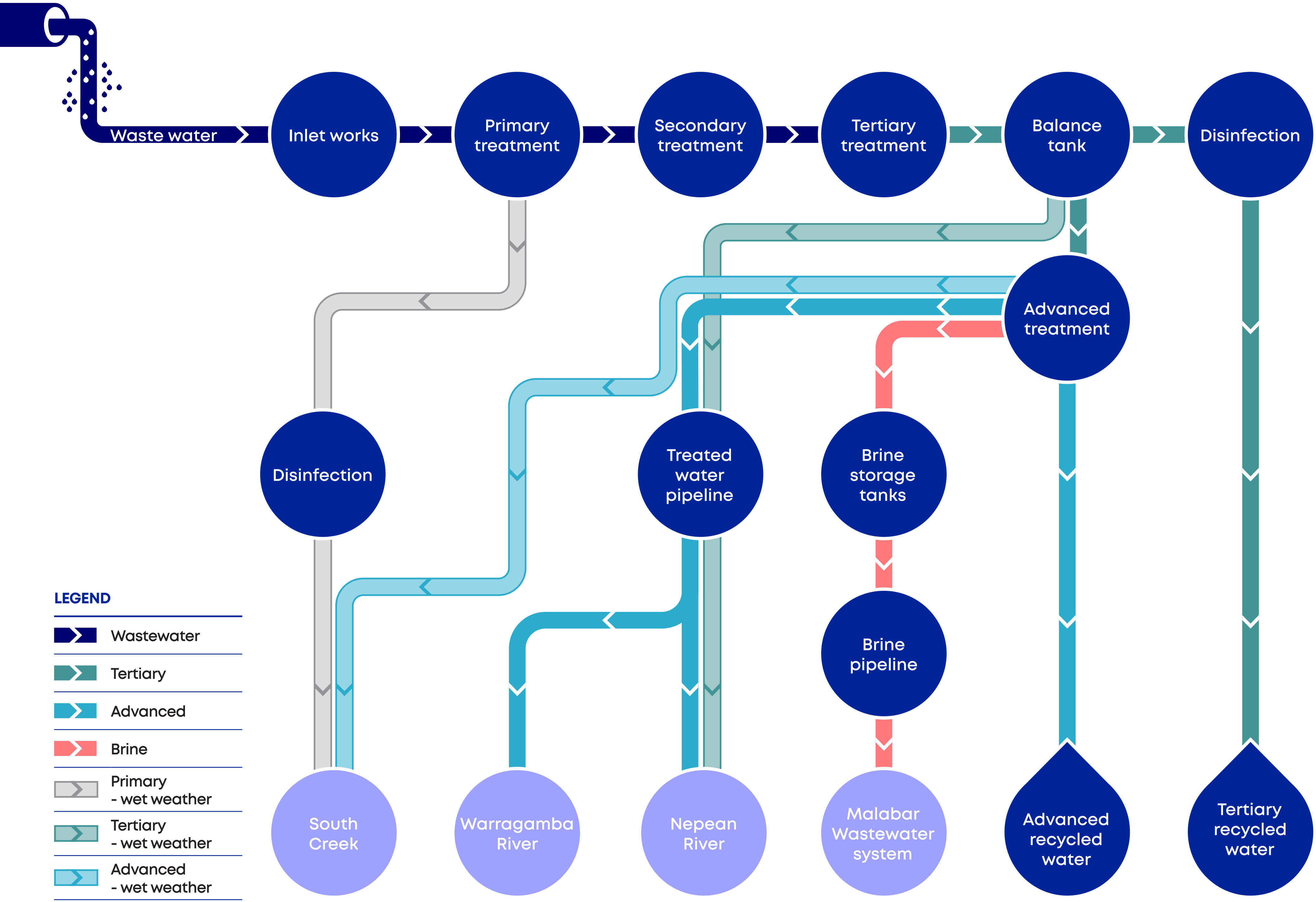

Waste water
Inlet works
Primary treatment
Secondary treatment
Tertiary treatment
Balance tank
Disinfection
Advanced treatment
Disinfection
Treated water pipeline
Brine storage tanks
Brine pipeline
South Creek
Warragamba River
Nepean River
Malabar Wastewater system
Advanced recycled water
Tertiary recycled water
LEGEND
Wastewater
Tertiary
Advanced
Brine
Primary - wet weather
Tertiary - wet weather
Advanced - wet weather

Figure 2.4

Additional details about the AWRC site are included in **Table 2.1**.

Table 2.1: Operational area key wastewater infrastructure

Wastewater infrastructure	Key design details
Inlet work and screening	The inlet works is the entry point for all wastewater arriving at the AWRC. It consists of a combination of concrete structures and mechanical equipment. The incoming wastewater will arrive through a series of buried pipes into the inlet chamber. The main chamber of the inlet works is typically long and narrow, approximately 70 m x 10 m and 3 m deep to provide a series of channels to enable the wastewater to pass through mechanical screens. The inlet works may be constructed at ground level, or elevated several metres in the air, to provide the wastewater with gravity head to convey it to the next process.
Pumping stations	The pumping station building will consist of a concrete, masonry or colourbond building measuring about 60 m x 25 m and 10 m in height. The pumping station is likely to be located on the boundary of the AWRC with its own dedicated access to support after hours maintenance access.
Primary treatment	The primary treatment unit is likely to consist of a single large concrete tank with internal walls to provide separate chambers. The tank is likely to be constructed at ground level and measure about 50 m x 50 m and 5 m in height. The tank will have access walkways around the edges of the chambers and it may be covered with removable covers.
Secondary treatment	The secondary treatment unit is likely to consist of two large open concrete tanks with internal walls to provide separate chambers. The tanks may be constructed at ground level, or partially buried and measure about 50 m x 60 m and 8 m in height. The tank may have access walkways around the edges of the chambers.
Tertiary treatment	The tertiary unit is likely to consist of two large open concrete tanks with internal walls to provide separate chambers. The tanks may be constructed at ground level, or partially buried and measure about 50 m x 20 m and 5 m in height. The tank may have access walkways around the edges of the chambers.
Advanced treatment	The AWTP building will consist of a large equipment slab and a building. The slab will house pipework and pumping equipment while the building would be concrete, masonry or colourbond construction and measure about 70 m x 30 m and 10 m in height.
Disinfection	Both tertiary and advanced treatment provide barrier disinfection for water that will be released to waterways or used for recycled water. Primary treated water will be disinfected with chlorine and dechlorinated with sodium bisulfite prior to release to South Creek.
Biosolids treatment	Biosolids treatment and handling includes digesters and an outloading building for filling trucks. The four digesters will be round concrete or steel tanks constructed at ground level and measure about 25 m in diameter and 20 m in height with a domed top which is the biogas holder. The outloading building will be a steel and concrete building measuring about 50 m x 15 m and 30 m in height. The building houses mechanical equipment in the upper level and has access doors at each end to enable trucks at ground level to pass through it for top loading with biosolids.
Odour control unit (OCU)	The AWRC is likely to have a single centrally located odour control unit to service the whole plant. The OCU will consist of a concrete slab at ground level, and a building that will contain fans, large fibreglass ductwork, and an array of fibreglass tanks. The tanks will be about 10 m in height and there will be stacks about 15 m in height.
South Creek release structure	The AWRC will discharge treated wastewater to South Creek during wet weather flows. The release infrastructure is likely to be a long vegetated swale consisting of an earth embankment construction, rip rap (energy dissipation) and scour structure within the creek. It also includes a discharge chamber, headwall, swale and a bridge across the swale in the form of box culverts.

Wastewater infrastructure	Key design details
Other buildings and tanks	The AWRC site will also have an array of other steel and concrete tanks to provide flow balancing and storage (such as brine), mechanical equipment mounted on concrete slabs and minor buildings for storage. All process units will be comprehensively fitted with pipework, supports, mechanical equipment and instrumentation, pumping equipment and electrical cabling ladder.

Additional details about the treated water pipeline are included in **Table 2.2**.

Table 2.2: Treated water pipeline

Feature	Detail
Location	The AWRC will produce treated water that will be transferred to three different locations. ■ Treated Water pipeline: At the Nepean River near the Wallacia weir. The pipeline will carry tertiary and advanced treated water from the AWRC and will generally follow: ○ Elizabeth Drive, the Northern Road, Park Road, Silverdale Road ■ Environmental Flows pipeline: At the Warragamba River upstream of Warragamba Weir. Flow splitting valves on the western side of the Nepean River along Silverdale Road will separate the Environmental Flows from the treated water flows, which will generally follow: ○ Silverdale Road, Bents Basin Road and then a 2.7 km under bore to the Warragamba River ■ South Creek infrastructure: To South Creek via infrastructure directly adjacent to the AWRC. **Figure 2.5** shows indicative routes for the pipelines.
Pipeline size	Sydney Water will build the pipelines to accommodate all flows from the AWRC when it reaches an ultimate capacity of 100 ML/d. This is to avoid the additional community and environmental disturbance that would occur if they needed to be duplicated in the future.
Ancillary infrastructure	The pipelines will be below ground. However, they have some above ground components including maintenance holes, valve pits and covers, electrical turrets, scour chambers, ventilation structures, concrete hardstands, energy dissipation structures and headwalls.
Discharge structures	The treated water and environmental flows release structures will control release of treated water into the receiving waterways. The release structures will include the following elements: ■ a concrete chamber structure set back from the waterway ■ measures to dissipate the energy of the treated water flows e.g. baffle blocks, concrete rip rap (concrete slab with rocks/boulders) ■ measures to prevent unauthorised access into the chamber and pipeline e.g. grated covers and fencing ■ scour protection along the nearby banks of Nepean and Warragamba rivers to minimise erosion ■ measures to protect the structure from flood impacts e.g. gabion wall structure.

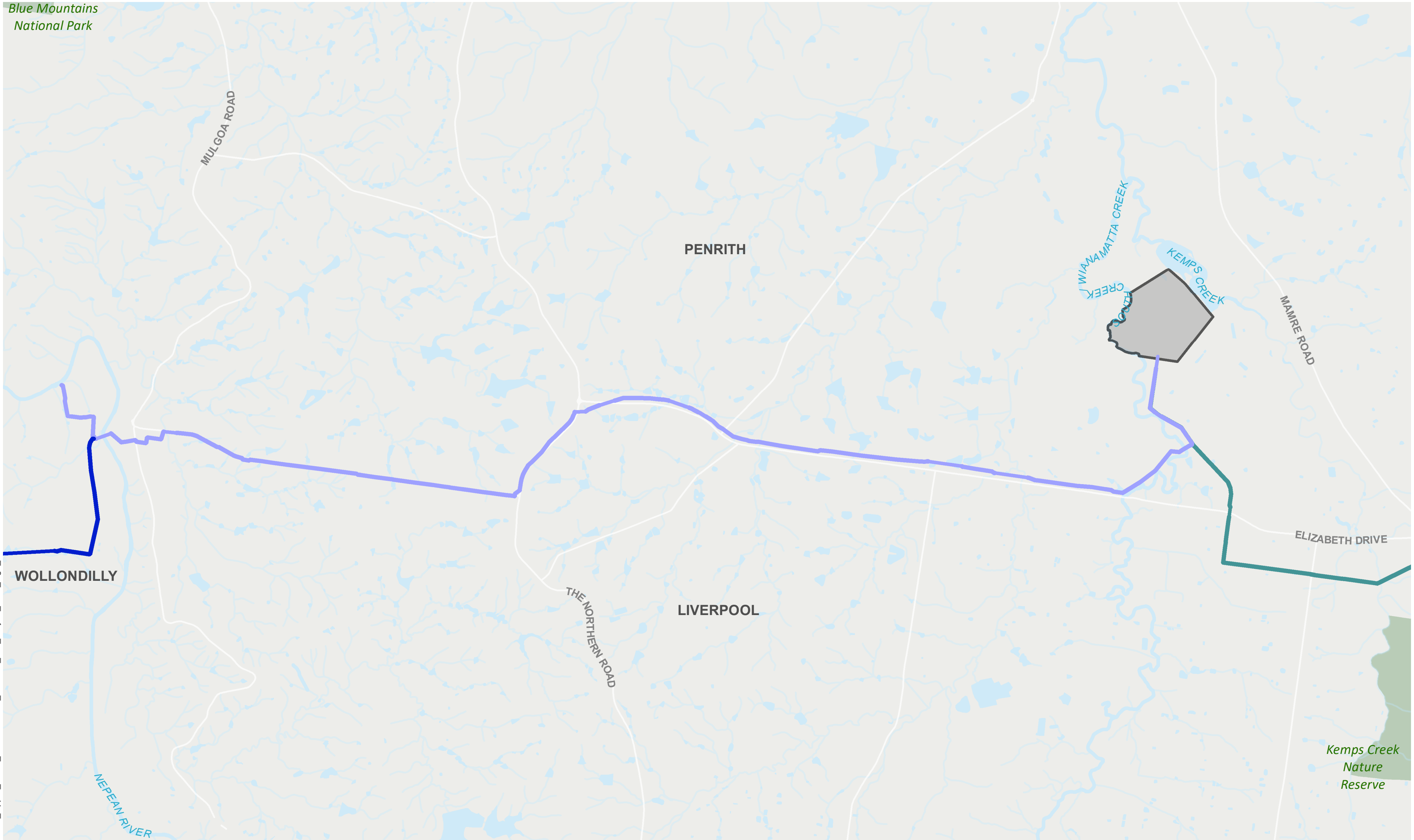
Additional details about the brine pipeline are included in **Table 2.3**.

Table 2.3: Brine pipeline

Feature	Detail
Location	The AWRC will produce a brine stream as a by-product of the RO treatment process. This will be transferred to the Malabar wastewater system by a below ground pipeline about 24 km long. **Figure 2.6** shows indicative route. During
Pipeline size	Sydney Water will build the pipeline to accommodate the expected flows from the AWRC when it reaches an ultimate capacity of 100 ML/d. This is to avoid the additional community and environmental disturbance that would occur if they needed to be duplicated in the future. The brine pipeline will be approximately 0.6 m in diameter and will generally steel, glass reinforced plastic, polyethylene and ductile iron cement line pipe materials.
Brine volumes	For ADWF, up to 50 ML/d: brine flows of 5 to 7.5 ML/d will be transferred to the Malabar wastewater system. At RO capacity (1.3 * ADWF), brine flows of 6.5 to 10 ML/d will be transferred.
Ancillary infrastructure	The pipeline will be below ground. However, it will have some above ground components including maintenance holes, valve structures and electrical turrets.
Additional information	Brine transfer would be stopped during wet weather if risk of overflows exists. Benefit of brine storage is to allow the RO process to continue to operate during wet weather. This results in continuing release of higher quality treated water than if RO was stopped.

Measures have been incorporated into the reference design to minimise impacts to the environment and community, including:

- suitable pipe material has been selected that won't be damaged by the contents being transported. For the brine pipeline, polyethylene (PE) is proposed that can transport the brine material under the required pressures without the risk of leaks and failure.
- the treated water and brine pipelines will operate under pressure which eliminates the need for uncontrolled overflow points that would release treated water into the environment.
- pump out scours along the brine pipeline, meaning that if a section of the pipeline requires maintenance or repair, the pipeline contents can be pumped into a truck for disposal, and not released into the environment
- tanks for temporary brine storage at the AWRC in wet weather when the Malabar system (NGRS) that receives the brine is at full capacity. This will minimise the potential for the brine to displace wastewater in the NGRS, resulting in wastewater overflows into the environment
- odour control units at the AWRC to treat and minimise odour to avoid foul air being released into the environment
- renewable energy in the form of solar and co-generation to offset a portion of the power required to be purchased from the grid to operate the AWRC
- layout of the treatment processes at the AWRC to utilise gravity to move wastewater through the site and reduce the need for pumping (electrical)
- location of the AWRC outside the 1% AEP flood level to minimise flooding and damage to the plant that may result in release of wastewater into the environment.



Environmental Flows Pipeline
Treated Water Pipeline
Brine Pipeline
Advanced Water Recycling Centre

Base Data
Watercourse
Waterbody
National Parks & Reserves
Western Sydney Parklands

1:60,000
0 1.5 3km

Figure 2.5

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

P:\GIS\Project-4\project\505018_Upper_South_Creek\505018_USCWF_EIS_Project_desc_high_level.mxd\JOB No.\26-02-21\Bridie.Jackson\Rev 0

Figure 2.6: Brine discharge main – proposed alignment

2.4 Existing Sydney Water facilities

Sydney Water operates a large existing network of wastewater facilities. This includes:

- 24 separate systems with NSW EPA environment protection licences
- More than 26,000 km of pipes with more than 690 pumping stations to manage the movement of wastewater from homes to treatment plants and to final release
- 16 wastewater treatment plants
- 14 water recycling plants (https://www.sydneywater.com.au/SW/water-the-environment/how-we-manage-sydney-s-water/wastewater-network/index.htm)

Some facilities discharge treated water to the ocean while some discharge to other parts of the Hawkesbury-Nepean River.

Figure 2.7 shows the existing Sydney Water network.

This project will fit into this network to provide similar services for areas being opened for residential development.

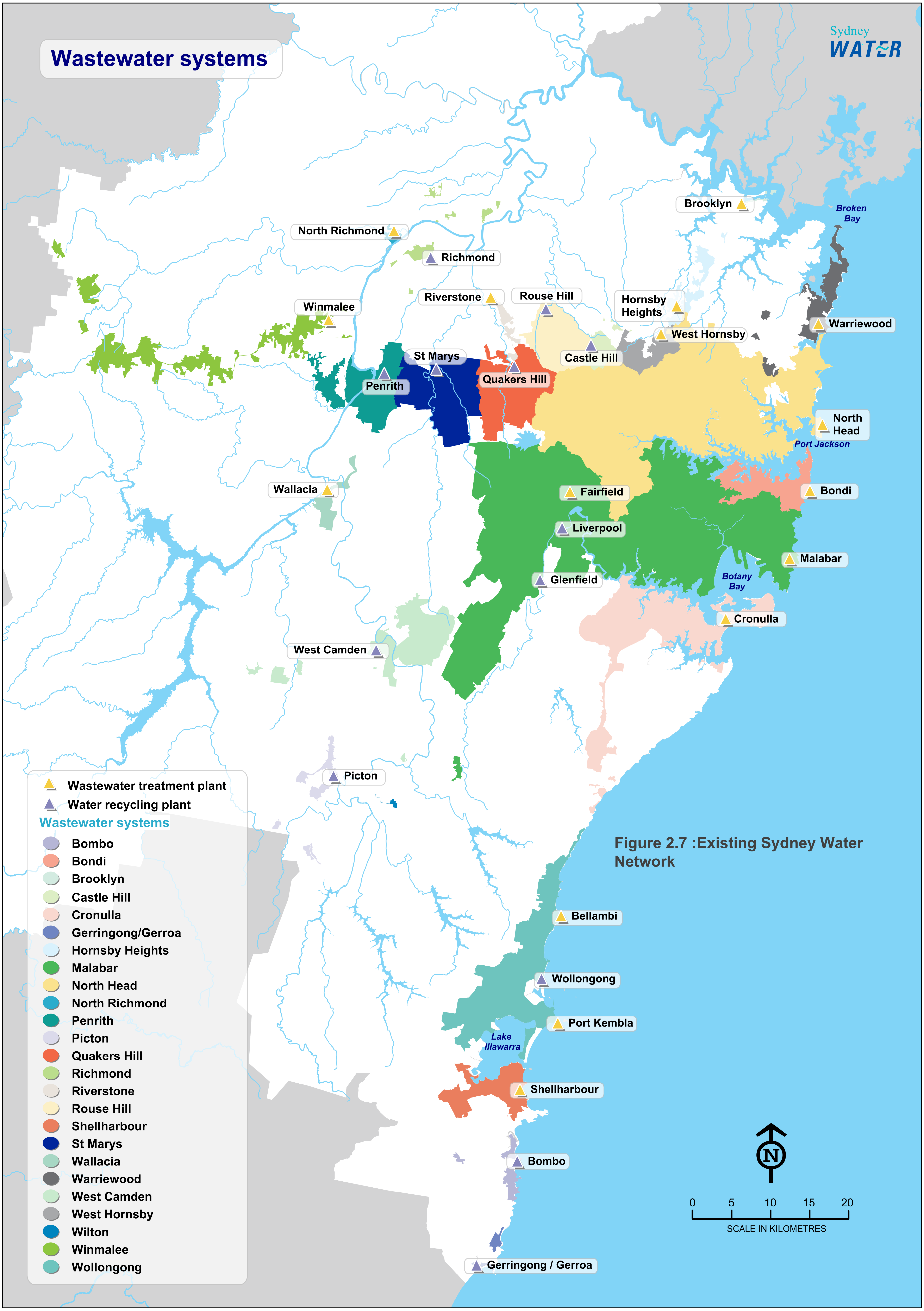


Figure 2.7 :Existing Sydney Water Network

Section 3. Assessment methodology

3.1 Health impact assessment

There is a definite link between human health and development. As society has developed over time health and life expectancy has improved. For example, life expectancy in Australia around 1900 was 50 years but around 2000 it had increased to around 80. Such improvements occur due to improved access to food, housing, work and health care as well as improved infrastructure, regulatory requirements for use of chemicals, heavy equipment and workplace operations, management of industry and vehicle emissions to achieve cleaner air and management of discharges to water and catchment management to achieve cleaner water. Such improvements often arise out of specific individual developments as well as local, regional and state based planning. There are so many aspects of how we live that can impact on health and well being as shown in **Figure 3.1** (enHealth 2017).

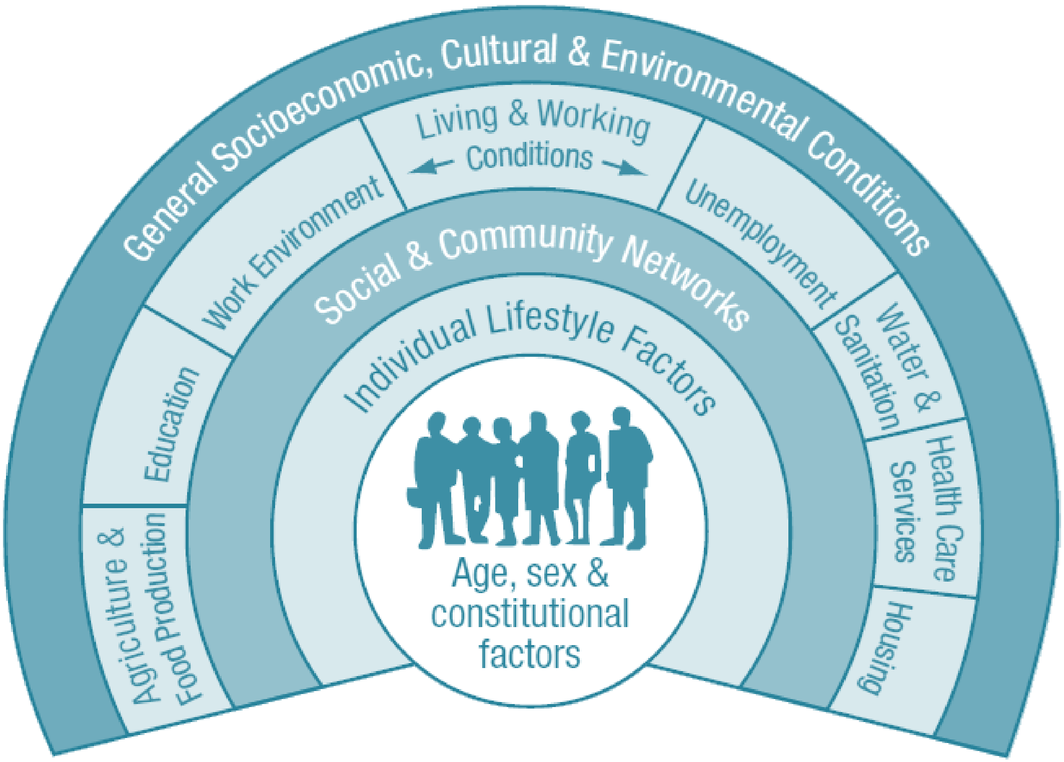


Figure 3.1: Wider determinants of health, as presented by Harris et al (2007)

The link between health and a particular type of development can be positive when a new development provides jobs or improves the way an area works or provides new infrastructure that wasn't there before. The link can also be negative should a development take away existing jobs or take away infrastructure that was important to the local area (or makes it harder to access such infrastructure) or not make the best use of available technology (enHealth 2017).

A health impact assessment (HIA) is designed to look at the positive and negative impacts on health that might arise for a particular development. Such an assessment can then be used to improve the development, where possible, by either maximising the positive impacts or decreasing the negative ones or both. While there are processes for undertaking a risk assessment (or assessment of potential for negative impacts) in a quantitative fashion for some aspects of a development (e.g. evaluation of emissions to air or water or changes in noise), it is much more difficult to evaluate the potential positive impacts from a development as they often only become clear after the development is constructed. This means the potential for positive impacts is usually undertaken in a qualitative way (i.e. a narrative discussion) (enHealth 2017).

3.2 Defining risk and impacts

Risk is commonly defined as the chance of injury, damage, or loss. Therefore, to put oneself or the environment 'at risk' means to participate, either voluntarily or involuntarily, in an activity or activities that could lead to injury, damage, or loss.

Voluntary risks are those associated with activities that we decide to undertake for ourselves such as driving a vehicle, riding a motorcycle and smoking cigarettes. Involuntary risks are those associated with activities that may happen to us without our prior consent or forewarning. Acts of nature such as being struck by lightning, fires, floods and tornados, or exposures to environmental contaminants due to activities by others are examples of involuntary risks.

In relation to the proposed project, the concept of risk more specifically relates to the chance that some aspect of the project will result in a reduction in the health and/or well-being of the local community.

Risk assessment is the process for looking at the potential for negative health impacts – usually for involuntary risks. It is used extensively in Australia and overseas to assist in decision making on the acceptability of the risks associated with the presence of contaminants or stressors in the environment that may impact on human health.

Risks to the public and the environment are determined by direct observation/measurement or by applying mathematical models and a series of assumptions to infer risk. No matter how risks are defined or quantified, they are usually expressed as a probability of adverse effects associated with a particular activity. Risk is typically expressed as a likelihood of occurrence and/or consequence (such as negligible, low or significant) or quantified as a fraction of, or relative to, an acceptable risk number.

In this assessment, the term risk normally refers to the potential for negative impacts on health whereas the term impact has been used to refer to changes due to the project which can have positive or negative impacts on health (i.e. benefits or risks).

Risks or impacts from a range of facilities (e.g. industrial or infrastructure) are usually assessed through qualitative and/or quantitative risk assessment techniques. In general, risk or impact assessments seek to identify all relevant hazards; assess or quantify their likelihood of occurrence and the consequences associated with these events occurring; and provision of an estimate of the risk levels for people who could be exposed, including those beyond the perimeter boundary of a facility.

3.3 Overall approach

3.3.1 General

The methodology adopted for the conduct of the Health Impact Assessment is in accordance with national and international guidance that is endorsed/accepted by Australian health and environmental authorities, and includes:

- *Health Impact Assessment Guidelines*. Published by the Environmental Health Committee (enHealth), which is a subcommittee of the Australian Health Protection Committee (AHPC) (enHealth 2017)
- *Health Impact Assessment Guidelines*. Published by the Environmental Health Committee (enHealth), which is a subcommittee of the Australian Health Protection Committee (AHPC) (enHealth 2001)
- Harris, P., Harris-Roxas, B., Harris, E. & Kemp, L., *Health Impact Assessment: A Practical Guide*, Centre for Health Equity Training, Research and Evaluation (CHETRE). Part of the UNSW Research Centre for Primary Health Care and Equity. University of NSW, Sydney (Harris 2007)
- *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards,* 2012 (enHealth 2012)
- Schedule B8 Guideline on Community Engagement and Risk Communication, National Environment Protection (Assessment of Site Contamination) Measure, 1999 (National Environment Protection Council (NEPC 1999 amended 2013))
- National Environmental Protection (Air Toxics) Measure, Impact Statement for the National Environment Protection (Air Toxics) Measure, 2003 (NEPC 2003)
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual* (Part F, Supplemental Guidance for Inhalation Risk Assessment), EPA-540-R-070-002, January 2009 (United States Environment Protection Agency(USEPA 2009)).

Other Australian or international guidance relevant to each specialist area has also been considered. The HIA has evaluated the guidance used in the other specialists reports to determine if these guidelines are based on the protection of health (workplace or community). Where they are based on matters other than specific protection of health, the HIA has considered a more detailed evaluation of health impacts to ensure any potential for impacts on health are appropriately considered. Guidance relevant for this aspect of the work has been referenced in the relevant section of this HIA.

3.3.2 Study area

The study area for the purposes of this HIA is the site of the AWRC as well as areas adjacent to the various pipelines. In addition, users of the waterways downstream of the project have also been considered during this assessment.

3.3.3 Data evaluation and issue identification

This task involved a review of all available information that relates to the proposed design and outcomes from relevant specialist studies undertaken for the project. Such studies included those related to:

- Air quality
- Noise and vibration
- Use of hazardous chemicals
- Potential soil contamination
- Water quality
- Traffic and transport
- Waste management

This aspect of the assessment also considered the available guidelines relevant in each area, whether these guidelines are based on the protection of community health, and if a more detailed evaluation of specific impacts is required.

3.3.4 Exposure assessment

This involved the identification of populations located in the project study area (see **Section 4**) which may be exposed to impacts from the project. The existing environmental conditions at the site as well as the health of the existing population have been considered in relation to the key health effects (with specific health effects termed health endpoints) in this assessment.

3.3.5 Hazard assessment

The objective of a hazard or toxicity assessment is to identify the adverse health effects and quantitative toxicity values or exposure-response relationships that are associated with the key pollutants and stressors that have been identified and evaluated as part of this assessment, where this is relevant.

For this assessment, national guidelines based on the protection of health have been adopted, in the main.

3.3.6 Risk characterisation

Risks have been characterised using quantitative and qualitative assessment methods in this assessment.

The assessment has also considered the level of uncertainty associated with the concept design, and all aspects of the technical studies relied on for the conduct of the Health Impact Assessment and within the Health Impact Assessment. The final determination of risks to human health was based on the quantification of risks as well as consideration of these uncertainties.

3.3.7 Features of the assessment

The Health Impact Assessment has been carried out in accordance with international best practice and general principles and methodology accepted in Australia by groups/organisations such as National Health and Medical Research Committee (NHMRC), NEPC and enHealth (enHealth 2017).

There are certain features of such assessments that are important to acknowledge.

These relate to the limitations of the methodology and the constraints applied within the assessment to ensure a focus on aspects that can be influenced as part of the Project. These are summarised below:

- The assessment does not present an evaluation of the health status of any specific individuals in the community. Rather, for those aspects where a more quantitative assessment was undertaken, it is a logical process of calculating the potential for exposure to a stressor arising from the project within a community associated the project. This estimate is then compared to regulatory and published estimates of such exposures that a person may be exposed to over a lifetime without unacceptable risks to their health.
- It is usual to ensure such potential for exposures considers a worst case scenario rather than just average levels to ensure risks are assessed appropriately.
- A HHRA or HIA is a systematic tool used to review key aspects of a specific project that may affect the health of the local community. The assessment includes both qualitative and quantitative assessment methods.
- A HHRA or HIA involves a number of aspects where a qualitative assessment is required to be undertaken. Where this is undertaken, it provides a general indication of potential impacts only.
- A HHRA or HIA relies on data provided from other studies prepared for the EIS (as listed for this project in **Section 1.5**). The conclusions of this HIA, therefore, depend on the assumptions and calculations undertaken to generate the data from these other studies utilised in this assessment.
- Conclusions can only be drawn with respect to impacts related to a project as outlined in the EIS. Other health issues, not related to the Project, that may be of significance to the local community are not addressed in the EIS.
- The health impact assessment reflects the current state of knowledge regarding the potential health effects of identified chemicals and pollutants for this project. This knowledge base may change as more insight into biological processes is gained, further studies are undertaken, and more detailed and critical review of information is conducted.

Section 4. Community profile

4.1 General

This section provides an overview of the communities potentially impacted by the project.

The communities within the project area include:

- Penrith local government area (AWRC)
- Wollondilly, Penrith, Liverpool, Fairfield and Canterbury-Bankstown local government areas (various pipelines)

In reviewing key aspects of the local communities that are relevant to the conduct of the Health Impact Assessment, information has been obtained from the Australian Bureau of Statistics (ABS) Census 2016, information relevant to local government areas (LGAs) and health districts (in particular, Western Sydney Local Health District). In some cases, where local data is lacking, information has been obtained (or compared with) data from larger population areas of Sydney and/or NSW.

4.2 Surrounding area and population

The population considered in this assessment includes those who live or work within the vicinity of the AWRC and in areas along the pipelines during both construction and operation.

4.3 Land Use

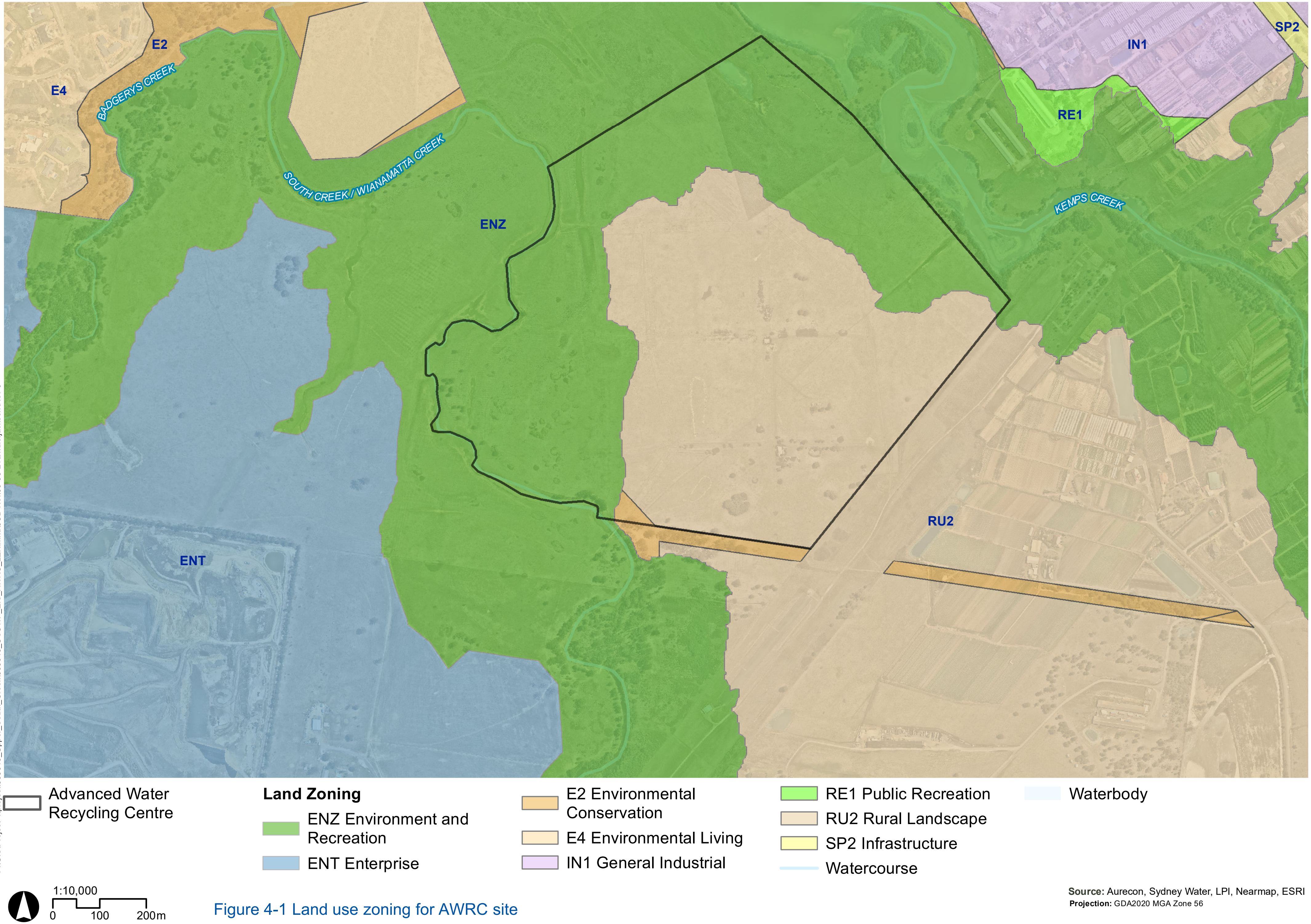
Local Government Area land zoning information has been used to define the current land usage across the study area. Land zoning for the area around the proposed site for the AWRC is presented in **Figure 4.1** as current land usage maps (Aurecon/ARUP 2020b).

The majority of the current land usage along the Treated Water and Environmental Flows pipelines consists of RU2 Rural Landscape and RU1 – Primary Production, intersecting a small area of rural village and public recreation at Wallacia. A large portion of the adjacent land along Elizabeth Drive in Badgery's Creek is zones as SP1 – Special Activities, coinciding with the Western Sydney International Airport currently under construction (Aurecon/ARUP 2020b).

The AWRC site is on land zoned as RU2 – Rural Landscape, E2 – Environmental Conservation under Penrith Local Environmental Plan 2010 and ENZ - Environment and Recreation under State Environmental Planning Policy (Western Sydney Aerotropolis) 2020 (Aurecon/ARUP 2020b).

The brine pipeline alignments intersect areas zoned as RU4 – Primary Production Small Lots south-east of the AWRC, before passing through a mixture of low/medium density residential, public recreation and business development areas around Cecil Hills, Bonnyrigg and Cabramatta (Aurecon/ARUP 2020b).

The nearest private residential properties are approximately 500 m to the south, southeast, east and northeast. The Twin Creeks residential development is located approximately 1.5 km to the northwest. There is also the potential for new dwellings to existing to the northwest of the AWRC (Jacobs 2020).



P:\GIS\Project-4\project\505018_Upper_South_Creek\505018_USCWF_EIS_AWRC_LZN.mxd\JOB No.\09-06-21\bridie.jackson\Rev 0

Figure 4-1 Land use zoning for AWRC site

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

4.4 Population profile

The population within the study area consists of residents and workers as well as those attending schools, day care centres, hospitals and recreational areas.

For the purposes of this HIA, the population statistics have been determined for each of the local government areas (and relevant other statistical areas) which may contain part of the project not just the section closest to the relevant section of the project.

A more detailed assessment of the demographics for the area is provided in the Socio-economic and land use impact assessment (Aurecon/ARUP 2021c). This assessment focuses more specifically on the areas directly adjacent to project components.

The composition of the populations located within the study area is expected to be generally consistent with population statistics for the larger individual suburbs that are wholly or partially included in the study area. Population statistics for the LGAs are available from the Australian Bureau of Statistics (ABS) for the census year 2016 and are summarised in **Table 4.1**.

For the purpose of comparison, the population statistics presented also include the statistics for larger statistical population groups in the area (defined by the ABS SA4) and the larger statistical areas of Greater Sydney and the rest of the NSW (excluding Greater Sydney) (as defined by the ABS).

Table 4.1: Summary of population statistics in study area

Location	Total population		% Population by key age groups					
	Male	Female	0–4	5–19	20–64	65+*	1–14*	30+*
Local government areas								
Penrith	98,822	99,243	7.4	20.3	60.7	11.7	21.1	57.5
Wollondilly	24,207	24,314	6.8	22.2	57.6	13.2	22	59.1
Liverpool	101,351	102,975	7.6	22.4	59.6	10.4	22.7	55.9
Fairfield	97,959	100,855	6.1	20.1	59.9	13.8	19.1	58.9
Canterbury-Bankstown	172,327	173,977	7.2	19.6	59.3	14	20.5	58.6
Larger local statistical areas (SA4 – includes local government areas)								
Sydney – Outer west and Blue Mountains	150,470	156,457	6.8	20	59.2	13.8	20.2	59.6
Sydney – South west	200,618	205,344	7	21.3	59.9	12	21.1	57.4
Statistical areas of Sydney and NSW								
Greater Sydney	2,376,766	2,447,221	6.4	18.2	61.4	13.9	17.4	60.4
Rest of NSW (excluding Greater Sydney)	1,301,717	1,341,813	5.8	18.5	55.1	20.6	17.3	64.6
NSW	3,686,014	3,794,217	6.2	18.3	59.1	16.2	18.5	61.8
Australia								
Australia	11,546,638	11,855,248	6.3	18.5	59.7	15.8	18.7	61.7

Ref: Australian Bureau of Statistics, Census Data 2016
SA = statistical area
* Age groups specifically relevant to the characterisation of risk

Comparing the populations of the study area to that of Greater Sydney, the following is noted:

- These local government areas have higher proportions of children (0-14 years), a lower proportion of working aged individuals and similar or lower proportion of individuals aged over 65 years

The estimated population growth from 2011 to 2041 for these areas are (NSW Planning & Environment 2019):

- Penrith: 83 per cent growth
- Wollondilly: 66 per cent growth
- Liverpool: 108 per cent growth
- Fairfield: 29 per cent growth
- Canterbury-Bankstown: 42 per cent growth

Table 4.2 presents a summary of a selected range of demographic measures relevant to the population of interest with comparison to statistical areas of Greater Sydney and the rest of NSW (excluding Greater Sydney).

Table 4.2: Selected demographics of population of interest

Location	Median age	Median household income ($/week)	Median mortgage repayment ($/month)	Median rent ($/week)	Average household size (persons)	Unemployment rate (%)
Local government areas						
Penrith	34	$1,658	$2,000	$370	2.9	5.7
Wollondilly	37	$1,871	$2,167	$365	3	4.0
Liverpool	33	$1,550	$2,123	$370	3.2	7.5
Fairfield	36	$1,222	$1,800	$350	3.3	10.5
Canterbury-Bankstown	35	$1,298	$2,000	$380	3	8.2
Larger local statistical areas (SA4 – includes local government areas)						
Sydney – Outer west and Blue Mountains	37	$1,589	$1,950	$365	2.7	5.4
Sydney – South west	35	$1,429	$2,000	$365	3.3	8.5
Statistical areas of Sydney and NSW						
Greater Sydney	36	$1,750	$2,167	$440	2.8	6.0
Rest of NSW (excluding Greater Sydney)	43	$1,168	$1,590	$270	2.4	6.6
NSW	38	$1,486	$1,986	$380	2.6	6.3
Australia						
Australia	38	$1,438	$1,755	$335	2.6	6.9

Source: Australian Bureau of Statistics, Census Data 2016

The social demographics of an area have some influence on the health of the existing population.

As shown in **Table 4.2**, the population in the Penrith local government area (LGA) generally has similar levels of unemployment and household income to greater Sydney. Mortgage repayments and rent are marginally lower than in greater Sydney. For the other local government areas that are only relevant for the pipeline developments, some have higher levels of unemployment and lower household incomes than greater Sydney. These other areas have similar mortgage repayments and rents to the Penrith LGA – i.e similar or marginally lower than greater Sydney.

4.5 Existing health of population

4.5.1 General

When considering the health of a local community there are a large number of factors to consider. The health of the community is influenced by a complex range of interacting factors including age, socio-economic status, social networks, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care. Hence, while it is possible to review existing health statistics for the local areas surrounding the project, and to compare them to the same statistics for Greater Sydney area and NSW, it is not possible or appropriate to be able to identify a causal source, particularly in regard to individual or localised sources.

Information relevant to the health of populations in NSW is available from NSW Health for populations grouped by local health districts (where most of the project area is located in the Western Sydney Local Health District). Not all of the health data are available for all of these areas.

Most of the health indicators presented in this report are not available for each of the smaller suburbs/statistical areas surrounding the site. Health indicators are only available from a mix of larger areas (that incorporate the study area), namely the Sydney Local Health District and the Northern Sydney Local Health District. There are few health statistics that are reported for the smaller local government areas relevant to this project. The health statistics for these larger areas (and in some cases data for the Greater Sydney area) are assumed to be representative of the smaller population located within these districts and areas.

4.5.2 Health related behaviours

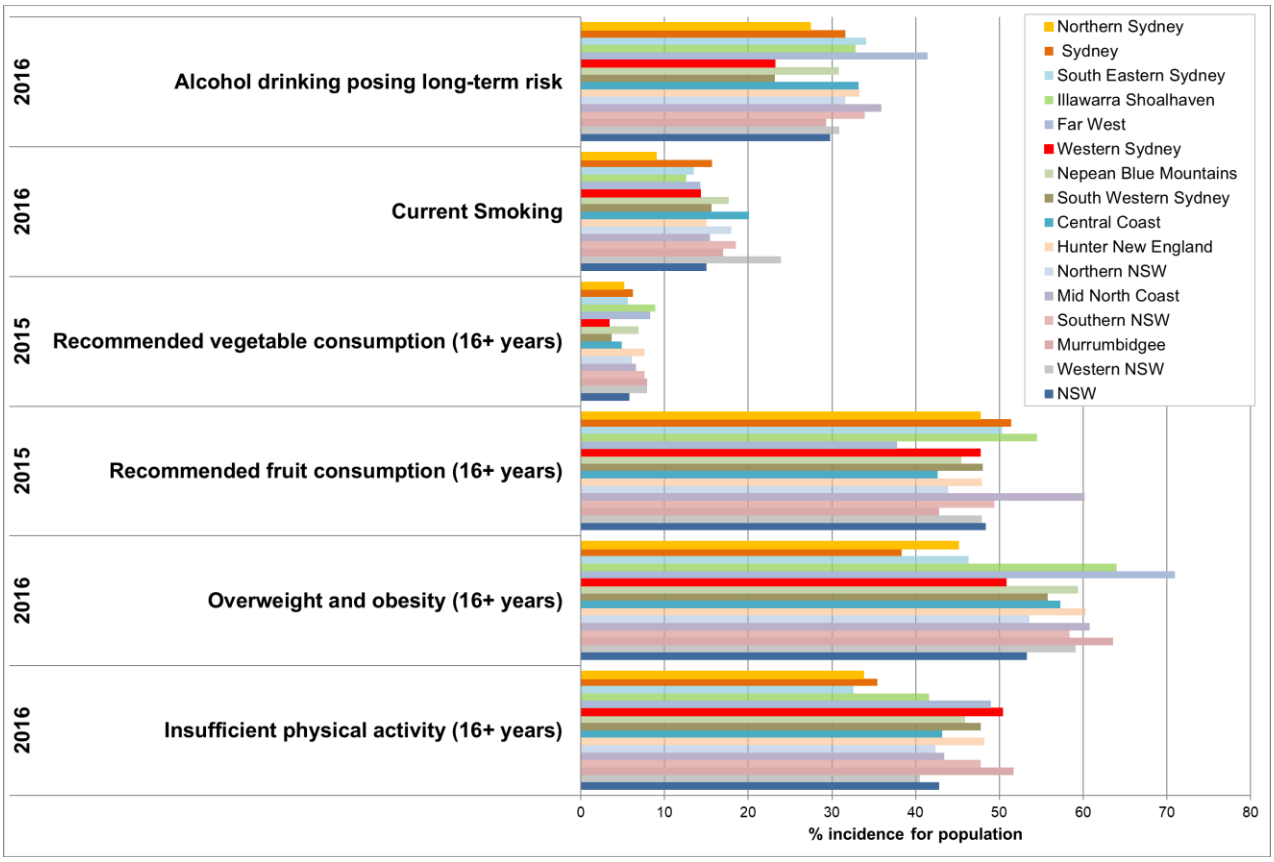
Information in relation to health related behaviours (that are linked to poorer health status and chronic disease including cardiovascular and respiratory diseases, cancer, and other conditions that account for much of the burden of morbidity and mortality in later life) is available for the larger populations within the local health districts in Sydney and NSW. This includes risky alcohol drinking, smoking, consumption of fruit and vegetables, being overweight or obese, and inadequate physical activity. The study population is largely located within the Western Sydney Local Health District. The incidence of these health-related behaviours in these districts, compared with other districts in NSW, and the state of NSW (based on NSW Health data from 2015 and 2016) is illustrated in **Figure 4.2**. The Western Sydney Local Health District is coloured red in the Figure.

Review of this data indicates the population in the Western Sydney Local Health District has:

- higher rates of physical inactivity
- similar levels of being overweight and obese
- similar rates of smoking
- lower rates of vegetable consumption
- similar rates of fruit consumption

- lower rates of excess alcohol consumption

when compared with NSW as a whole (the dark blue bars in the graph).



Note: these health related behaviours include those where the behaviour/factor may adversely affect health (e.g. alcohol drinking, smoking, being overweight/obese and inadequate physical activity) and others where the behaviour/factor may positively affect (enhance) health (e.g. adequate fruit and vegetable consumption). The study area is located in the Western Sydney Local Health District.

Figure 4.2: Summary of incidence of health-related behaviours (Source: HealthStats NSW 2018)

4.5.1 Health indicators

Table 4.3 presents more specific health data relevant to mortality and hospitalisations, addressing all-cases as well as respiratory and cardiovascular disease. The table presents data, where available, for the slightly smaller population areas in the LGAs in the study area with comparison against data for the Western Sydney Local Health District, Sydney and NSW.

Table 4.3: Summary of key health indicators

Health indicator	Rate per 100,000 population (for the year, or years as referenced) – for each area evaluated							
	LGAs					Western Sydney LHD	Sydney (wider metro area)*	NSW
	Penrith	Wollondilly	Liverpool	Fairfield	Canterbury-Bankstown			
Mortality								
All causes – all ages	593.5 (2017/18)	522.4 (2017/18)	510 (2017/18)	500.4 (2017/18)	485.5 (2017/18)	470.3 (2018)	--	506.4 (2018)
All causes (non-trauma) ≥30 years	--	--	--	--	--	--	976.5	--
All causes ≥30 years	--	--	--	--	--	--	**1026**	--
Cardiopulmonary ≥30 years	--	--	--	--	--	--	**412**	**--**
Cardiovascular – all ages	160.6 (2017/18)	155.3 (2017/18)	140 (2017/18)	143.4 (2017/18)	129.8 (2017/18)	125.6 (2017/18)	191.8	136 (2017/18)
Respiratory – all ages	--	--	--	--	--	45.2 (2017/18)	51.5	--
Hospitalisations								
Coronary heart disease	518.7 (2017/19)	558.8 (2017/19)	499.6 (2017/19)	433.6 (2017/19)	456.2 (2017/19)	482 (2018/19)	--	492.5 (2017/19)
COPD >65 years	--	--	--	--	--	--	--	1351.9 (2018/19)
COPD All ages	263 (2017/19)	208.9 (2017/19)	250.5 (2017/19)	174.5 (2017/19)	220.8 (2017/19)	--	--	224.8 (2018/19)
Cardiovascular disease	--	--	--	--	--	--	--	--
All ages	1698.4 (2017/19)	1756.5 (2017/19)	1625.2 (2017/19)	1395.4 (2017/19)	1589.7 (2017/19)	1587.2 (2018/19)	1976	1672.4 (2018/19)
>65 years	--	--	--	--	--	--	**9235**	**--**
Respiratory disease	--	--	--	--	--	--	**--**	**--**
All ages	--	--	--	--	--	1647 (2018/19)	2003	1675.2 (2018/19)
>65 years	--	--	--	--	--	--	**3978**	**--**
Asthma								

Health indicator	Rate per 100,000 population (for the year, or years as referenced) – for each area evaluated							
	LGAs					Western Sydney LHD	Sydney (wider metro area)*	NSW
	Penrith	Wollondilly	Liverpool	Fairfield	Canterbury-Bankstown			
Asthma hospitalisations (ages 5–34 years)	--	--	--	--	--	198.2 (2018/19)	--	154.7 (2018/19)
Asthma hospitalisations (all ages)	172.5 (2017/19)	111.9 (2017/19)	203.3 (2017/19)	142.2 (2017/19)	156.6 (2017/19)	165.1 (2018/19)		142.1 (2017/19)
Asthma emergency department hospitalisations (1–14 years)	--	--	--	--	--	--	**1209**	--
Asthma emergency department hospitalisations (5-34 years)						--	**--**	349.3 (2018/19)
Asthma emergency department hospitalisations (all ages)						--	**--**	297.2 (2018/19)
Asthma prevalence (current) for children aged 2–15 years	--	--	--	--	--	10.4% (2017/19)	--	12.9% (2018/19)
Current asthma for ages 16 and over	--	--	--	--	--	11.7% (2019)	--	11.5% (2019)

* Data for Sydney Metropolitan area for 2010 based on hospital statistics as reported for 2010 and population data from the ABS for 2011 (relevant to each age group considered) used in review of exposure and risks to inform recommendations for updating the National Environment Protection Measure (NEPM) Ambient Air Quality (AAQ) (Golder 2013)

All other data has been obtained from Health Statistics New South Wales, with most recent data and time period listed

-- No data available

Review of this data indicates the population in these areas is generally similar to all of NSW. In regard to Penrith LGA and Western Sydney Local Health District, the following is noted:

- higher (LGA) and lower (LHD) rates of mortality (all causes) than for NSW as a whole
- higher rates of asthma hospitalisations than for NSW as a whole
- similar or lower rates of asthma prevalence than for NSW as a whole
- similar rates of hospitalisations for respiratory diseases compared to NSW as a whole
- higher rates of hospitalisations for heart diseases than for NSW as a whole

Review of the data presented in **Table 4.3** generally indicates that for the population in project area, the health statistics (including mortality rates and hospitalisation rates for most of these categories) are variable but generally similar to those reported in Western Sydney Local Health District and in NSW as a whole.

In regard to Penrith LGA and Western Sydney Local Health District (most relevant for this project), the following is noted:

- higher (LGA) and lower (LHD) rates of mortality (all causes) than for NSW as a whole
- higher rates of asthma hospitalisations than for NSW as a whole
- similar or lower rates of asthma prevalence than for NSW as a whole
- similar rates of hospitalisations for respiratory diseases compared to NSW as a whole
- higher rates of hospitalisations for heart diseases than for NSW as a whole

For the assessment of potential health impacts from the project, where specific health statistics for the smaller populations within the project area are not available (and not reliable due to the small size of the population), adopting health statistics from the whole of Sydney is considered to provide a representative, if not cautious (e.g. over estimating existing health issues), summary of the existing health of the population of interest.

There are a number of statistics where no more specific or recent data than for the Sydney Metropolitan Area in 2010 is available. Where data is available from 2010 as well as more recently, it is observed that the rate of disease or mortality is reducing with time. Hence use of data from Sydney Metropolitan Area for 2010 in this assessment is conservative and is expected to overestimate risk.

Section 5. Health impact assessment: Water

5.1 Introduction

This section presents a review of impacts on health associated with water discharges relevant to the operation of the Project.

The estimation of risk follows the general principles outlined in the enHealth document Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth 2012).

Health impacts associated with water discharges for the project have been assessed on the basis of the information within the technical paper:

- Aurecon/ARUP (2021a) Upper South Creek AWRC EIS, Hydrodynamic and Water Quality Impact Assessment. Dated 16 July 2021.
- Aurecon/ARUP (2021b) Upper South Creek AWRC EIS, Surface Water Specialist Study. Revision 0.
- Sydney Water (2021a) Upper South Creek Advanced Water Recycling Centre, Environmental Impact Statement, Main Report (Chapter 4 – Project Description) DRAFT
- Sydney Water (2020) Fairfield water recycling plant water quality monitoring program (December 2019-March 2020)
- Sydney Water (2021b) Upper South Creek Advanced Water Recycling Centre, Environmental Impact Statement, Main Report (Chapter 8 – Key waterway impacts) DRAFT
- Sydney Water (2021c) Upper South Creek Advanced Water Recycling Centre, Toxicant review of release streams

5.2 Wastewater treatment

5.2.1 Chemicals

Thousands of chemicals are present in wastewater when it reaches a wastewater treatment plant. Some of these chemicals are nutrients like those present in fertilisers used in gardens and agriculture. Other chemicals include a range of naturally occurring and synthetic chemicals.

The chemicals come from food, breakdown products from normal bodily processes (human metabolism), drugs (medicines and recreational), cleaning products (kitchen, laundry, bathroom), cooking, personal care products (shampoo, moisturisers, sunscreens, makeup) and a range of other activities that occur around the house. Some industries discharge to the wastewater system. Water authorities have strict controls on what can be discharged by such industrial facilities which often can require that wastewater be treated prior to discharge to the sewer.

Many chemicals (both natural and synthetic) are ones that are easily broken down into their component parts by the environmental conditions in the wastewater treatment plant (pH, sunlight, oxygen, salinity) or by bacteria (biodegradation). Breaking them down into their component parts produces chemicals like carbon dioxide and water which are easily managed. The breakdown process also produces salts.

Some chemicals are not easily broken apart or are elements (like metals) which cannot break down any further. These longer-lived chemicals tend to move into the solids within a wastewater treatment plant so are likely to end up in the biosolids.

Over the last decade, various researchers and government agencies have utilised this difference in the way chemicals behave in the environment to help classify which chemicals need to be watched/assessed (Brown & Wania 2008; Canadian Government 2017; Howard & Muir 2010; NICNAS 2017).

Work on modelling approaches using characteristics of chemicals that make them more likely to be of concern began in the late 1990s (Brown & Wania 2008; Canadian Government 2017; Howard & Muir 2010; NICNAS 2017).

These approaches focus on quickly identifying chemicals that rapidly degrade when released into the environment and those that do not degrade so easily as well as chemicals that may be bioaccumulative, transport over long distances in the atmosphere, are ozone depleting and those that are particularly toxic. The same concept can be used when looking at the chemicals that might be in wastewater. Most of them will be easily broken into their component parts by the treatment processes within a wastewater treatment plant while some may not. (EPHC 2009; NICNAS 2013, 2017).

5.2.2 Microorganisms

Microorganisms are present in the human digestive system to help metabolise food. It is reported that approximately 1 kg of bacteria are present in an adult digestive system (Nature 2011). These are organisms that people need to function well and they do not cause disease. In addition, when people are unwell, a whole range of other microorganisms may be present in the body – these are the pathogenic or disease-causing organisms. People are always excreting microorganisms – both the ones that are always present and the occasional visitors – and these end up in wastewater.

The organisms that help digest our food and undertake other tasks within the body are not pathogenic – i.e. they do not cause disease. These organisms are present all the time and will be excreted continuously.

The organisms that are able to cause disease are present in the body and excreted when a person is unwell or when they have been exposed to others who are unwell. When people are unwell, they can excrete quite large numbers of these organisms. It is this subset of microorganisms that is most important to consider when evaluating potential risks from microorganisms in wastewater.

The people living in the houses around a wastewater treatment plant will all be excreting the non-pathogenic organisms – the ones that help digest food etc – all of the time. In addition, at any point in time, there will be people who are excreting a small number of pathogenic (i.e. disease-causing subset) organisms along with a small number of people who are contributing large numbers. This means the numbers of pathogenic organisms can be highly variable in wastewater while the numbers of the non-pathogenic organisms will be much more consistent.

Methods to robustly measure the numbers of the pathogenic organisms are limited. The more robust methods measure the presence of some of the non-pathogenic organisms that are definitely related to human manure. These can indicate that the disease-causing organisms are also likely to be present but doesn't actually measure the presence or numbers for the full range of these pathogenic organisms.

In addition to a lack of suitable methods for some organisms, there are also limitations in the analytical methods for some organisms. Often the more robust methods are labour intensive and slow, requiring culturing of organisms or staining methods. Also, some methods can have low recoveries limiting confidence in the reproducibility of these methods. For example, the most recent USEPA method for Cryptosporidium and Giardia still lists acceptance criteria that allow a recovery of less than 20% for a spike added to a sample (i.e. less than 1 in 5 of the organisms added in the spike are picked up in the measurement) (USEPA 2005).

Consequently, disinfection processes are a key part of wastewater treatment to ensure appropriate management of the potential for pathogenic organisms to be present.

5.2.3 Treatment processes

Treatment processes at wastewater treatment plants are designed to manage the potential for chemicals and microorganisms to reach the environment at levels that might be of concern.

The treatment processes include:

- Primary treatment – this step is essentially filtration. Coarse solids are removed using a variety of screens (of different sizes) or the addition of chemicals to assist in settling the solid materials to the bottom of a tank for later removal.
- Secondary treatment – this step involves making use of bacteria to breakdown the organic material in wastewater – the liquid and solids are mixed in within bacteria known to use a wide range of chemicals as food.
- Tertiary treatment – this step usually refers to additional filtration and/or disinfection where a chemical (like chlorine) is added to the liquid effluent to kill microorganisms.
- Advanced treatment refers to more sophisticated treatment processes like advanced oxidation and reverse osmosis when wastewater is to be treated sufficiently to be reused for drinking water or other purposes. Reverse osmosis removes chemicals and microorganisms by pressure driven flow through membranes with pores small enough that only water and other small molecules can get through. The larger molecules remain in the brine.

These treatment processes produce a liquid phase – effluent – which is often discharged to a waterway and a solid phase – sludge. Biosolids comes from further treating the sludge to make it more usable. The additional treatments dry out the sludge to make it easier to handle/transport and reduce pathogens and volatile organic matter.

The wastewater system plays a critical role in managing public health impacts from disease causing microorganisms.

The wastewater system also plays an important role in the management of chemicals we use every day. When industrial chemicals (including chemicals present in every day products like personal care or cleaning products) are assessed by Commonwealth authorities to determine if they are acceptable for use in Australia, one of the control measures that is included in the calculations is the presence of wastewater treatment plants, if it is a chemical that will end up in the sewer system (EPHC 2009).

5.3 Water quality specific project details

The project involves construction and operation of an advanced wastewater treatment facility. Once wastewater has been treated it will be discharged via the treated water pipeline to the Nepean River at Wallacia and to the Warragamba River at the confluence with the Nepean River. During significant wet weather events, some treated water may be discharged into South Creek (Sydney Water 2021a).

The various levels of treatment applied in the AWRC and how the processes are arranged are shown in **Figure 2.4**.

Most of the water treated at the plant will receive primary (screening), secondary (biological treatment), tertiary (filtration/disinfection) and advanced treatment (reverse osmosis).

The AWRC will receive wastewater from the urban areas to be connected into this system. Wastewater needs to be treated to allow it to be managed suitably (as discussed in **Sections 2** and **5.2.3**).

Plants like this are designed based on a certain flow volume into the plant. In this case, the average dry weather flow is the basis of the design. This is the average flow through the system during dry weather. During rain, the flow through the system increases as stormwater may be able to enter into the pipes. This volume assumption allows the plant to have the correctly sized tanks, pipes, pumps, valves etc.

The AWRC (Stage 1) is being designed to manage an average dry weather flow of 50 ML per day. Once flow through the plant increases above 65 ML per day (i.e. 1.3xADWF), there may not be sufficient capacity within the facility (i.e. the tanks, pipes, pumps, valves) to allow all water to receive all levels of treatment (Sydney Water 2021a).

For the majority of time, the treated water to be discharged will have received all levels of treatment including advanced treatment using reverse osmosis and will be released to Nepean River and/or Warragamba River. There will be no discharges to South Creek. This will occur for situations where flows through the plant are 60 ML per day or less (Aurecon/ARUP 2021a).

When flows through the plant are between 60 and 75 ML per day (i.e. mild wet), a blend of advanced and tertiary treated water will be discharged at Wallacia while only advanced treated water will be discharged to Warragamba River. There will be no discharges to South Creek (Aurecon/ARUP 2021a).

When flows through the plant are between 75 and 135 ML per day (i.e. moderate wet), a blend of advanced and tertiary treated water will be discharged at Wallacia while only advanced treated water will be discharged to Warragamba River. Some release of advanced treated water may occur to South Creek (Aurecon/ARUP 2021a).

When flows through the plant are above 135 ML per day (i.e. extreme wet), a tertiary treated water will be discharged at Wallacia. There will be no water released to Warragamba River. Some release of primary and tertiary treated water may occur to South Creek (Aurecon/ARUP 2021a).

Modelling of likely flows to the facility has been undertaken and it has shown that flows greater than 75 ML per day are only likely to occur for a few days per year (3-18 days/year) (Sydney Water 2021a).

5.4 Health impacts associated with changes in water quality

Changes in water quality may impact on human health if chemicals or microbiological organisms increase above relevant guideline values.

To impact on human health, people must be exposed to the water. This occurs via:

- drinking the water
- skin contact with the water
- incidentally ingesting the water.

Water from Nepean River at Wallacia, Warragamba River or South Creek is not a primary source of drinking water but all of these areas are used for recreation. People may also come into contact with water extracted from these locations during work (e.g. irrigation on farms etc).

Guidance is available from national health authorities about the quality of water that will not pose a health risk when such water is used in ways relevant for these locations. Such guidance includes the following sources:

- NHMRC, Australian Drinking Water Guidelines (NHMRC 2011 updated 2021)
- NHMRC, Guidelines for managing risks in recreational water (NHMRC 2008)
- NRMMC, Australian Guidelines for Water Recycling (NRMMC 2006, 2008, 2009a, 2009b)

These documents provide guidelines for individual chemicals and for pathogenic organisms as well as guidance about how to operate systems to ensure water quality is appropriate. These guidelines indicate what concentration of a chemical or microorganism could be present in water without any impacts on health being expected/likely (NHMRC 2008, 2011 updated 2021).

The drinking water guidelines assume a person may drink 2 L of water per day for every day of their lives. The calculations work out a concentration that will not result in an exceedance of a reference dose when that amount is consumed. Reference doses are the dose of a chemical that will not cause impacts on health. They are calculated based on doses that cause no effects in relevant experiments with additional factors (usually 100-1000 fold depending on the data available) to adjust for uncertainty – i.e. the reference dose is the dose that caused no effect divided by 100 or 1000 (or the relevant uncertainty factors) (NHMRC 2008, 2011 updated 2021).

The recreational water guidelines assume a person may incidentally ingest 200 mL of water per day for every day of their lives when they are swimming, surfing, boating etc (NHMRC 2008, 2011 updated 2021).

In both cases, there is an additional 10 fold factor built into the calculations, because there are other ways people may be exposed to common chemicals, only 10% of the reference dose is allowed to come from drinking/recreational water (NHMRC 2008, 2011 updated 2021).

This means the guidelines for drinking and recreation are considered to be appropriately conservative and indicate concentrations of chemicals or pathogenic organisms that are unlikely to cause any impacts to health.

The Australian Guidelines for Water Recycling provide additional advice about specific considerations for handling recycled water. The guidance draws on the drinking and recreational water guidelines to indicate water quality that will be protective for human health.

The approach adopted for this assessment is to compare the estimated concentration of a contaminant that could be in treated water from this facility with the relevant drinking and recreational water guideline. These guidelines are designed to be protective for human health for all uses of water relevant for these locations and have been developed by government authorities. As long as a particular chemical or microorganism is present in treated water below the relevant drinking and recreational water guideline, the risk of health effects is negligible.

In this case, there is an additional level of conservatism built into the approach as the data that are available for chemicals or microorganisms have been measured in treated water prior to discharge into the relevant receiving environment. When the treated water is discharged, it will mix into the river or creek where the discharge occurs. This means the concentrations in the river or creek to which a person may be exposed if they are swimming or boating or extracting the water for irrigation are lower than what is present in the treated water. If concentrations in the treated water are below relevant guidelines, the concentrations in the river/creek will definitely be below the relevant guidelines.

5.5 Existing surface water characteristics

5.5.1 Hawkesbury Nepean River

The Hawkesbury Nepean catchment represents one of the largest coastal basins in NSW. With an area of approximately 21,400 km^2, over 70% of the catchment consists of mountainous terrain, with about 10% of flat terrain (Aurecon/ARUP 2021b).

The headwaters of the Nepean River start near Robertson. It flows north through an unpopulated catchment area, Camden and Penrith. Near Wallacia the river is joined by the dammed Warragamba River; and north of Penrith, near Yarramundi, at its confluence with the Grose River, the Nepean River becomes the Hawkesbury River. It then continues on a meandering course for ~140 km, combining with the significant tributaries of South Creek, Cattai Creek, Colo Creek and MacDonald River before reaching the ocean between Barrenjoey and Box Head (Aurecon/ARUP 2021b).

Figure 5.1 shows the Hawkesbury Nepean River catchment (Aurecon/ARUP 2021b). **Figure 5.2** shows an aerial view of the discharge location at Wallacia (Sydney Water 2021b).

There are a range of stressors that are already relevant for the Hawkesbury Nepean River. The land uses in the catchment that may impact on water quality include urban areas, farms or land clearing. Water quantity in the river can also be impacted by these land uses – e.g. more hard surfaces (roads, buildings, footpaths) can result in more runoff (less water can soak into the ground) and that runoff can run into the river more quickly (that speed can make it more likely for erosion to occur).

Other impacts on water quantity can occur due to extraction. There are also a number of direct discharges into the creek including existing wastewater treatment plants (Aurecon/ARUP 2021b).

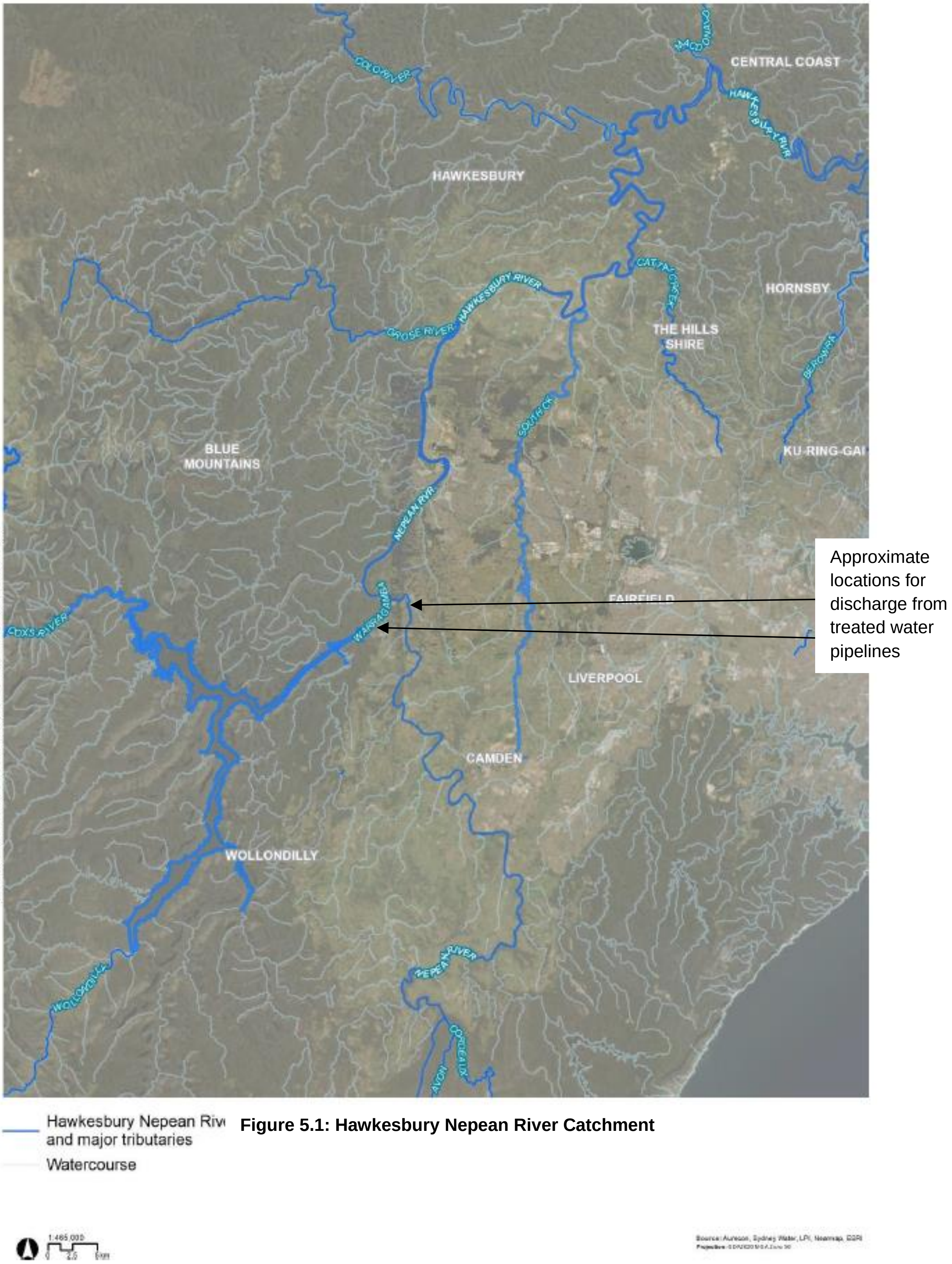


Figure 5.1: Hawkesbury Nepean River Catchment

Figure 5.2: Aerial view of Nepean River discharge location (Wallacia) (Sydney Water 2021b)

Table 5.1 provides background data for water quality in the Hawkesbury-Nepean River.

The parameters listed are those for the primary characteristics of water quality relevant for ecological health – dissolved oxygen (DO), electrical conductivity (EC), pH, turbidity, total nitrogen (TN), oxidised nitrogen (NOx), ammonia (NH_4) and total phosphorus (TP). In addition, chlorophyll a and enterococci levels are also listed.

Dissolved oxygen is the amount of oxygen that is dissolved in water. For aquatic organisms to thrive there needs to be sufficient oxygen in the water but, for people, the presence of dissolved oxygen is not so important. This parameter is, however, an indicator that water has not gone stagnant and so there is a recreational water guideline for dissolved oxygen (NHMRC 2008).

Electrical conductivity is an indicator of the saltiness of the water. Water to be used for drinking should have conductivity less than around 1,000 µS/cm to limit issues with taste. No impacts on health are expected from consuming small amounts of salty water but the taste can be unpleasant so the Australian Drinking Water Guidelines provide guidance (NHMRC 2011 updated 2021). When people are swimming or surfing or boating, it is common for these activities to occur in seawater as well as freshwater so a guideline for conductivity is not needed for recreational situations (NHMRC 2008).

pH is an indicator of the acidic or basic nature of the water. For water that people may drink or come into contact with, it should be neutral – i.e. not acidic or basic but in between. The drinking water and recreational water guidelines for pH are the same and indicate the neutral zone (NHMRC 2008, 2011 updated 2021).

Turbidity indicates how muddy water can be. Total suspended solids is an alternate way of measuring the muddiness or murkiness of water. If water is to be used for drinking it is important to have clear water – this can be achieved by filtration if a drinking water source becomes murky after rains or flooding. The Australian Drinking Water Guidelines provide guidance for acceptable levels of turbidity in water being provided through the drinking water system (i.e. after treatment such as filtration) (NHMRC 2011 updated 2021). Undertaking recreation in murky water can be unpleasant for some situations but does not usually pose a risk to health unless the murkiness is due to algal blooms. This means there is no specific recreational guideline value for turbidity (NHMRC 2008).

Total nitrogen, oxidised nitrogen, ammonia and total phosphorus are indicators for nutrients. Nutrients come from many sources including all types of manure and breakdown of vegetation. There are no guidelines for drinking water for TN or TP and health effects are not expected in most circumstances. There are drinking water guidelines for nitrate and nitrite (i.e. oxidised nitrogen) and ammonia. Impacts on ecological systems will occur at much lower concentrations than would impact on people. It is important to fully assess potential changes in nutrients for this assessment to ensure ecological impacts are not unacceptable and this has been done in other sections of this EIS.

Chlorophyll a is an indicator used to determine how much algae might be present in a waterway and whether it is blooming and/or whether problematic algal species. The chemical, chlorophyll a, is the green pigment in plants and algae, so if the levels are above guidelines that can indicate that algae may be reaching a level of concern which can then trigger more detailed assessment (ANZG 2018).

Enterococci is an indicator of the microbiological quality of the water in a waterway. The recreational water quality guidelines provide guidelines and background information on this particular organism and why it has been chosen as a general indicator of microbiological quality (NHMRC 2008).

These parameters are always present in natural waterways. It is important to understand the normally expected levels in a waterway to assist in determining if changes due to a new activity (such as a discharge from the AWRC) are acceptable (Aurecon/ARUP 2021a,b).

In accordance with ANZECC (2000), the Nepean River is considered a slightly-to-moderately disturbed ecosystem. Elevated concentrations of total nitrogen, oxidised nitrogen and chlorophyll-a, based on ecological based guidelines, are evidenced at all sites, while low levels of total phosphorus and well oxygenated waters generally low in turbidity are also typical of the river system. The slightly elevated enterococci densities measured at N67, N66A and N66B possibly reflect associated landuses and/or wet weather events when elevated microbial indicators are typical (Sydney Water 2021b).

In accordance with ANZECC (2000), Warragamba River is considered a slightly-to-moderately disturbed ecosystem as evidenced by slightly elevated total and oxidised nitrogen concentrations, low total phosphorus, ammonium and chlorophyll-*a* concentrations, based on ecological based guidelines, coupled with well oxygenated waters low in turbidity and *enterococci* densities. This water quality profile is generally typical of forested catchments with low to no urban and agricultural sources of pollution.

It is also noted that water quality at all locations was in compliance with all human health based guidelines.

Table 5.1 provides background data for water quality in the Hawkesbury-Nepean River.

Table 5.1: Available water quality data for the Hawkesbury-Nepean River

Parameter		TN	TP	NOx	NH_4	Chl *a*	DO	pH	Conductivity	Turbidity	Enterococci
Units		mg/L	mg/L	mg/L	mg/L	mg/L	%Sat		µS/cm	NTU	cfu/100 mL
Drinking/ Recreational water guideline		NG	NG	50 or 3	0.5	NG	NG/ >80	6.5-8.5	1,000 (taste)/ NR	5/NR	Primary <40, Secondary 41-200
N67	Nepean River at Wallacia Bridge	1	0.02	0.66	0.01	0.007	94.8	7.45	365	7.3	50
N66A	Nepean River upstream of proposed AWRC release	1.13	0.0225	0.675	0.02	0.006	93.9	7.37	337.5	6.8	47.5
NS66 B	Nepean River downstream of Wallacia Weir and release	1.125	0.0235	0.665	0.02	0.006	98.05	7.47	327	8.1	51
N66	Nepean River upstream of confluence with Warragamba River	1.09	0.022	0.74	0.02	0.004	99.25	7.52	331.5	6.4	25.5
N64	Nepean River downstream of Warragamba River	1.03	0.016	0.66	0.02	0.003	98.3	7.57	305	5.8	32
N57	Penrith Weir	0.66	0.014	0.35	0.01	0.005	96	7.54	301	3.55	Not available
N642	Upstream of Megarritys Creek	0.19	0.009	0.04	0.01	0.002	85.2	7	242	4.3	14.5
N642 A	Downstream of Megarritys Creek and upstream of Wallacia WWTP	0.81	0.013	0.45	0.01	0.002	98	7.53	207	9.9	17
N641	Warragamba River downstream of Wallacia WWTP	0.44	0.009	0.17	0.01	0.001	99.8	7.54	245	3.4	10

Notes:

Guidelines relevant for human health considerations are the drinking water or recreational water quality guidelines. The relevant values listed are those from (NHMRC 2008, 2011 updated 2021)

All values are medians from a dataset containing 16-120 samples. The data were collected between January 2018 – June 2021

Comparison of listed medians with human health based guidelines is indicated by a cell with no shading representing values that are in compliance with recreational water quality guidelines and cells with red/pink shading indicating values above recreational water quality guidelines

Comparison with ecological based guidelines is presented in other sections of the EIS

Enterococci values are compared with secondary recreation guidelines (i.e. boating, wading etc)

NR – not relevant for recreational waters

NG – no guideline for the protection of human health for drinking or recreation as no health impacts are likely to occur at concentrations generally found

Guidelines for NOx are the drinking water guidelines for nitrate and nitrite. It is usual for most of the measured concentrations of NOx to come from nitrate so the 50 mg/L is most relevant. It is noted that all medians are less than (i.e. in compliance) with the nitrite guideline as well as the nitrate one.

Guidelines for NH_4 based on human health are those for drinking water. It is noted that the drinking water guideline for ammonia is based on corrosion of pipes etc. The fact sheet indicates that health effects are not likely to occur until concentrations exceed 1,000 mg/L.

5.5.2 South Creek

The South Creek catchment covers an area of 628 km^2, sitting within the lower region of the Cumberland Plain. The creek starts in Narellan, north west of Campbelltown and then flows generally in a south to north direction through a gently undulating landscape until reaching its confluence with the Hawkesbury River, near Windsor. Land use within the catchment currently consists of a mix of rural farms, remnant native forest and urban areas (Alluvium, 2019). Rural activities include cattle and sheep grazing, market gardening and intensive agriculture such as poultry farming (Aurecon/ARUP 2021b).

The creek has 3 sections which have different characteristics – ephemeral (i.e. water only flows in the creek occasionally), non-ephemeral (water flows all the time) and tidal (water flows in both directions). **Figure 5.3** shows the South Creek catchment (Aurecon/ARUP 2021b). **Figure 5.4** shows an aerial view of the locations of the discharges to South Creek from the AWRC during wet weather.

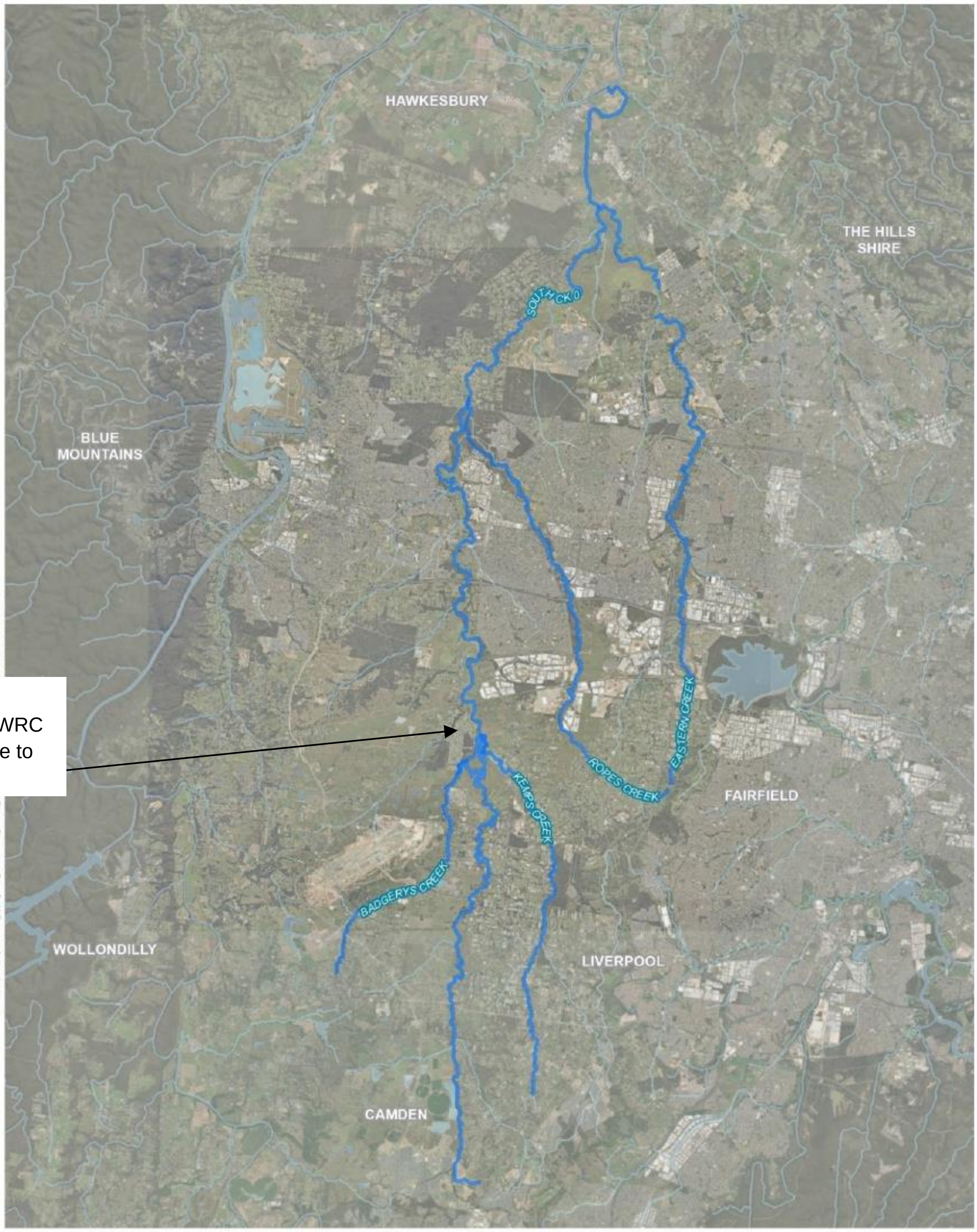


Figure 5.3: South Creek Catchment

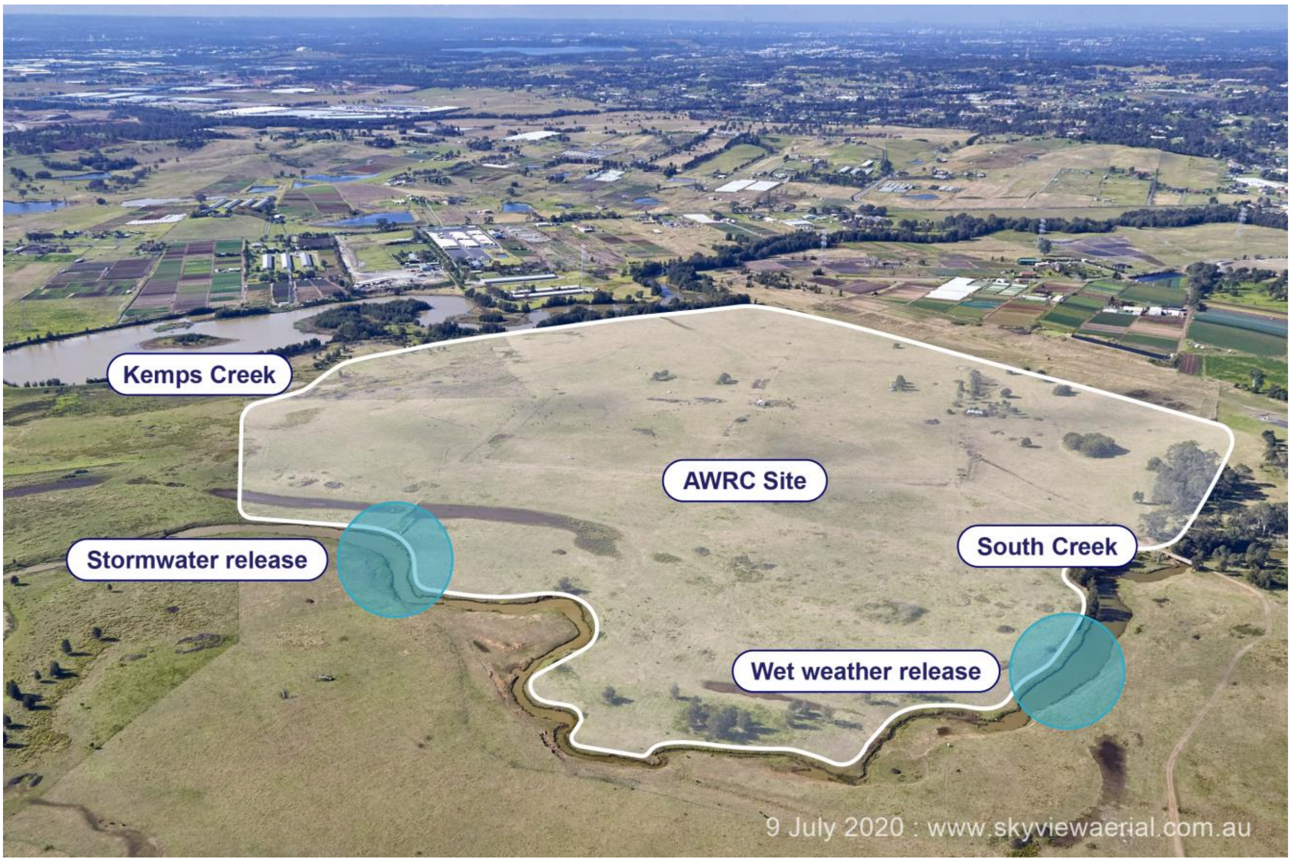


Figure 5.4: Aerial view of South Creek discharge locations (Sydney Water 2021b)

Background information on water quality in South Creek and other waterways relevant to the project is provided in **Table 5.2**. The parameters listed are those discussed above for the primary characteristics of water quality relevant for ecological health – dissolved oxygen (DO), electrical conductivity (EC), pH, turbidity, total nitrogen (TN), oxidised nitrogen (NOx), ammonia (NH_4) and total phosphorus (TP). In addition, chlorophyll a and enterococci levels are also listed.

As noted, these parameters are always present in natural waterways. It is important to understand the normally expected levels in a waterway to assist in determining if changes due to a new activity (such as a discharge from the AWRC) are acceptable (Aurecon/ARUP 2021a,b).

In accordance with ANZECC (2000), South Creek should be considered a highly disturbed ecosystem as evidenced by elevated physical, chemical and microbial stressors. In particular, elevated concentrations of total nitrogen, oxidised nitrogen, total phosphorus and chlorophyll *a*, based on ecological criteria, throughout the catchment combined with generally low levels of dissolved oxygen and elevated enterococci densities reflect the cumulative impacts of urban, peri-urban and agricultural landuses within the catchment. The highest concentration of nutrients was measured at NS450 in Kemps Creek likely indicating the cumulative impacts from upstream landuses. It is also noteworthy that elevated nutrient and chlorophyll *a* concentrations combined with low dissolved oxygen percentage saturation and elevated microbial indicators were also measured at NS45 upstream of the proposed AWRC (Sydney Water 2021b).

It is also noted that there were limited parameters for which human health based guidelines were not met in South Creek – dissolved oxygen in some locations and enterococci in some locations.

Table 5.2: Available water quality data for the streams adjacent to the AWRC site

Parameter		TN	TP	NOx	NH_4	Chl a	DO	pH	Conductivity	Turbidity	Enterococci
Units		mg/L	mg/L	mg/L	mg/L	mg/L	%Sat		µS/cm	NTU	cfu/100 mL
Drinking/ Recreational water guideline		NG	NG	50 or 3	0.5	NG	NG/ >80	6.5-8.5	1,000 (taste)/ NR	5/NR	Primary <40, Secondary 41-200 n/a
NS45	South Creek, upstream AWRC	1.78	0.241	0.88	0.05	0.018	70.3	7.4	1,062	32.5	175
NS44	South Creek, downstream, of AWRC	1.495	0.1505	0.47	0.025	0.024	86.45	7.51	1,030.5	73	76
NS450	Kemps Creek	3.38	0.704	2.38	0.03	0.008	71.7	7.47	1,501	20.5	Not available
NS440	Badgerys Creek	1.49	0.195	0.15	0.05	0.006	59.9	7.24	1,070	11	215
NS35	South Creek downstream, of Kemps Creek and Badgerys Creek	1.32	0.131	0.38	0.05	0.010	80.8	7.44	928	63	265

Notes:

Guidelines relevant for human health considerations are the drinking water or recreational water quality guidelines. The relevant values listed are those from (NHMRC 2008, 2011 updated 2021)

All values are medians from a dataset containing 22-23 samples. The data were collected between January 2018 – June 2021

Comparison of listed medians with human health based guidelines is indicated by a cell with no shading representing values that are in compliance with recreational water quality guidelines and cells with red/pink shading indicating values above recreational water quality guidelines

Comparison with ecological based guidelines is presented in other sections of the EIS

Enterococci values are compared with secondary recreation guidelines (i.e. boating, wading etc)

NR – not relevant for recreational waters

NG – no guideline for the protection of human health for drinking or recreation as no health impacts are likely to occur at concentrations generally found

Guidelines for NOx are the drinking water guidelines for nitrate and nitrite. It is usual for most of the measured concentrations of NOx to come from nitrate so the 50 mg/L is more relevant. It is noted that all medians are less than (i.e. in compliance) with the nitrite guideline as well as the nitrate one.

Guidelines for NH_4 based on human health are those for drinking water. It is noted that the drinking water guideline for ammonia is based on corrosion of pipes etc. The fact sheet indicates that health effects are not likely to occur until concentrations exceed 1,000 mg/L.

5.6 Assessment of health impacts related to surface water quality

5.6.1 Construction

Potential for impacts on water quality during construction is limited to the impacts of stormwater runoff from areas where earthworks are being undertaken. Such stormwater could be impacted by higher levels of suspended solids as it runs across cleared areas and picks up soil as it goes.

This is common with all types of construction. Guidance is available from government sources which indicates requirements for managing stormwater during construction so that stormwater containing excess levels of suspended solids does not enter waterways. This includes stormwater retention ponds which slow the movement of water so the particles can settle out. Works such as those required for this project must be undertaken in accordance with those requirements.

No unacceptable impacts on water quality from stormwater runoff from construction areas is expected for the project.

5.6.2 Operations

General

The focus of this assessment is the potential for impacts on community health from changes in water quality due to discharges from the proposed treatment plant. Potential for such impacts has been subject to more detailed assessment as water will be discharged from the treatment facility into the Nepean River at Wallacia, Warragamba River and, at times, South Creek.

During consultation, NSW Health raised a question about how the wastewater catchment is characterised and any particular health risks from catchment sources in the wastewater. Given the project is developing a new wastewater system to service population growth, the catchment will change over time as urban development occurs, to include a mix of residential, commercial and industrial uses that do not yet exist. Sydney Water has designed AWRC treatment processes based on influent quality in other similar systems across Sydney, which also have a mix of these uses. Sydney Water also requires commercial and industrial premises to hold trade waste agreements to ensure pollutants in that wastewater are appropriately managed.

Detailed water quality modelling has been undertaken and this work is described in detail in Sydney Water (2021b) and Aurecon/ARUP (2021a).

This assessment has also used data for individual chemicals for treated water at the Water Recycling Plant in Fairfield. These data are reported in Sydney Water (2020). This report details campaign sampling which evaluated the presence of a wide range of chemicals and microorganisms. The quality of treated water from the AWRC is expected to be similar. Older data for St Marys STP has been considered in Aurecon/ARUP (2021a). The assessment here has focused on the most recent data for Fairfield.

Information relevant to considering the potential for human health impacts has been taken from these reports – in particular, information from Section 8.7.1 of Sydney Water (2021b).

As noted in **Section 5.5**, consideration of ecological impacts due to discharge of treated water from this plant has been undertaken in Aurecon/ARUP (2021a). This work includes results of ecotoxicity testing undertaken monthly for effluent at Sydney Water STPs that discharge to this river system. For St Marys STP, a review of 10 years worth of ecotoxicity testing, which evaluates the potential impact of the effluent on an aquatic invertebrate (water flea, *Ceriodaphnia dubia*), reported effects above the relevant licence limit on only 1 occasion.

Modelling of water quality in either Nepean River or South Creek has been based on a range of scenarios including:

- Baseline scenario (i.e. current conditions without the project)
- Background scenarios for potential future conditions in 2036 (relevant for the current project) and 2056 (relevant for future expansions if/when these are planned/approved)
- Project scenarios for potential future conditions in 2036 and 2056 with the addition of releases from the AWRC (Sydney Water 2021b).

Assessing water quality changes for these different scenarios allows consideration of the impact of urban development on water quality in the river system with and without the discharges from the AWRC. Water quality and quantity have the potential to change in urban areas as development expands due to the increase in impervious surfaces which direct more water to drainage lines (i.e. creeks and rivers) and washes materials off the land into creeks and rivers (Sydney Water 2021b).

The modelling has focused on South Creek and on the Nepean River separately assuming that releases to each of these systems is line with the following arrangements. This description is taken from Section 4.6.3.5 in Aurecon/ARUP (2021a).

- For the majority of time, the treated water to be discharged will have received all levels of treatment including advanced treatment using reverse osmosis and will be released to Nepean River at Wallacia and/or Warragamba River. There will be no discharges to South Creek under these circumstances. This will occur for situations where flows through the plant are 65[1] ML per day or less (Aurecon/ARUP 2021a).
- When flows through the plant are between 65 and 85[2] ML per day (i.e. mild wet), a blend of advanced and tertiary treated water will be discharged to Nepean River at Wallacia while only advanced treated water will be discharged to Warragamba River. There will be no discharges to South Creek for this situation (Aurecon/ARUP 2021a).
- When flows through the plant are between 75 and 150[3] ML per day (i.e. moderate wet), a blend of advanced and tertiary treated water will be discharged to Nepean River at Wallacia while only advanced treated water will be discharged to Warragamba River. Some release of primary treated water may occur to South Creek (Aurecon/ARUP 2021a).

[1] Flows during dry weather flows are based on a design flow of 1.3x ADWF or less where average dry weather flow for the plant (ADWF) = 50 ML (Aurecon/ARUP 2021a)
[2] Flows during mild wet conditions are based on a design flow of 1.3-1.7x ADWF – 1.7x ADWF = 85 ML (Aurecon/ARUP 2021a)
[3] Flows during moderately wet conditions are based on a design flow of 1.7-3x ADWF – 3x ADWF = 150 ML (Aurecon/ARUP 2021a)

- When flows through the plant are above 150 ML per day (i.e. extreme wet), tertiary treated water will be discharged to Nepean River at Wallacia. There will be no water released to Warragamba River. Some release of primary treated water may occur to South Creek (Aurecon/ARUP 2021a).

Figures 5.5, 5.6 and **5.7** illustrate this information.

This approach allows appropriate modelling as well as mitigation/management of the potential for impacts on water quality where the various grades of water are released.

For the Nepean River, the following key findings were made based on the water quality modelling:

- Changes in water quality from urban development in the catchment are predicted to be greater than changes relating to AWRC releases.
- Modelling predicts that the AWRC releases to the Nepean River will improve water quality for some parameters when compared to the background scenario. The environmental impacts from the treated water releases immediately downstream of the release point are predicted to be predominantly positive (i.e. improvement).
- Further downstream of the initial footprint (~20 km), the impacts are predicted to be either not significant, or to not have negative effects on the river water quality and/or ecosystem health.
- With respect to relevant project waterway objectives (based on ecosystem protection), analysis of the impacts on annual median profiles indicates that overall AWRC releases have the potential to maintain or improve achievement of these objectives.
- During infrequent severe wet weather events (>3 x ADWF), higher concentrations of nutrients are predicted due to the higher proportion of tertiary treated water in the releases. These 'spikes' result in localised downstream impacts on water quality but are short-lived. Nutrient concentrations are predicted to drop quickly to levels lower than the background scenario within a few days (Sydney Water 2021b).

Background water quality for the Nepean River complied with relevant guidelines based on protection of human health. Given the small changes and/or improvements in water quality shown in this modelling, no additional potential for impacts to human health from changes in water quality with releases from the AWRC are expected.

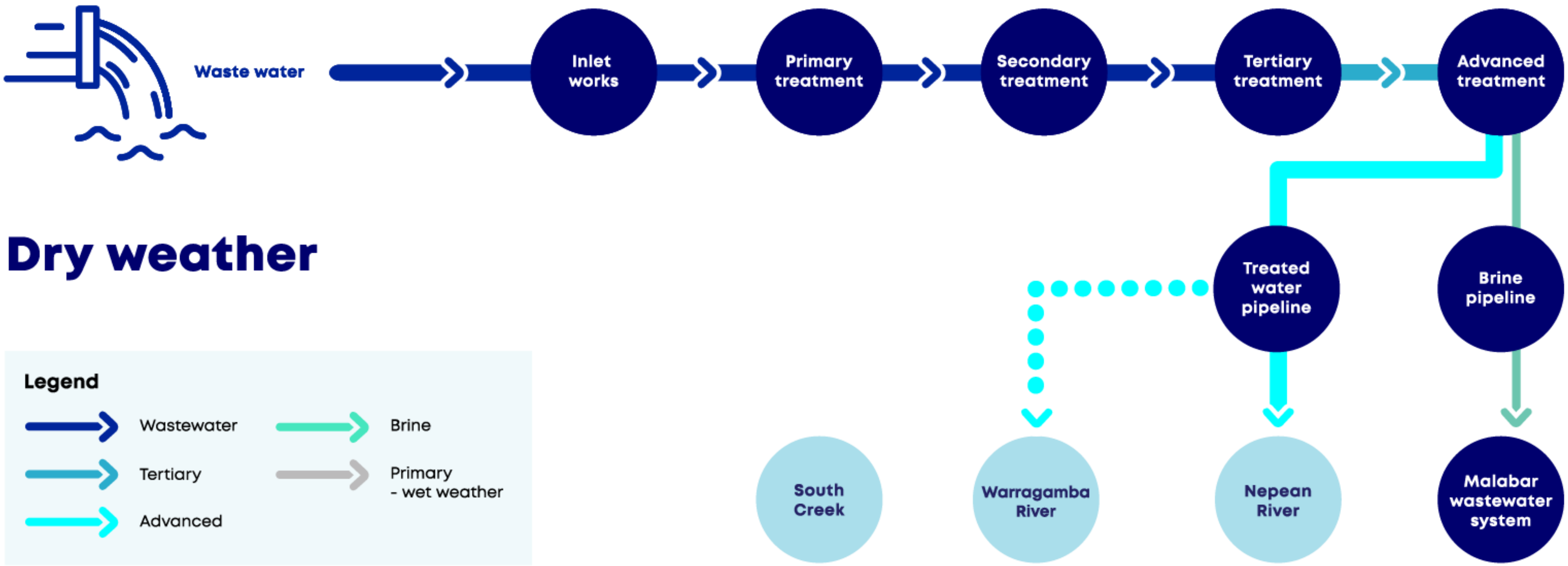


Figure 5.5: Plant flows during dry weather (majority of time)

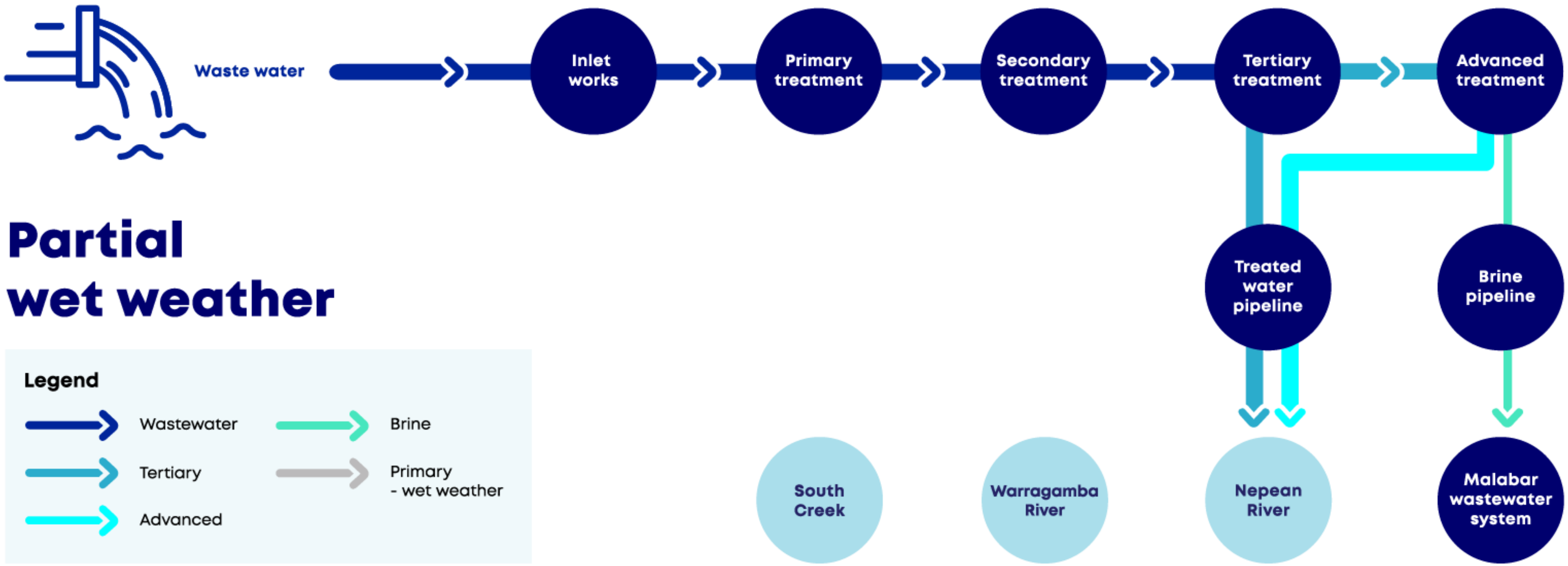


Figure 5.6: Plant flows during mild and moderate wet weather

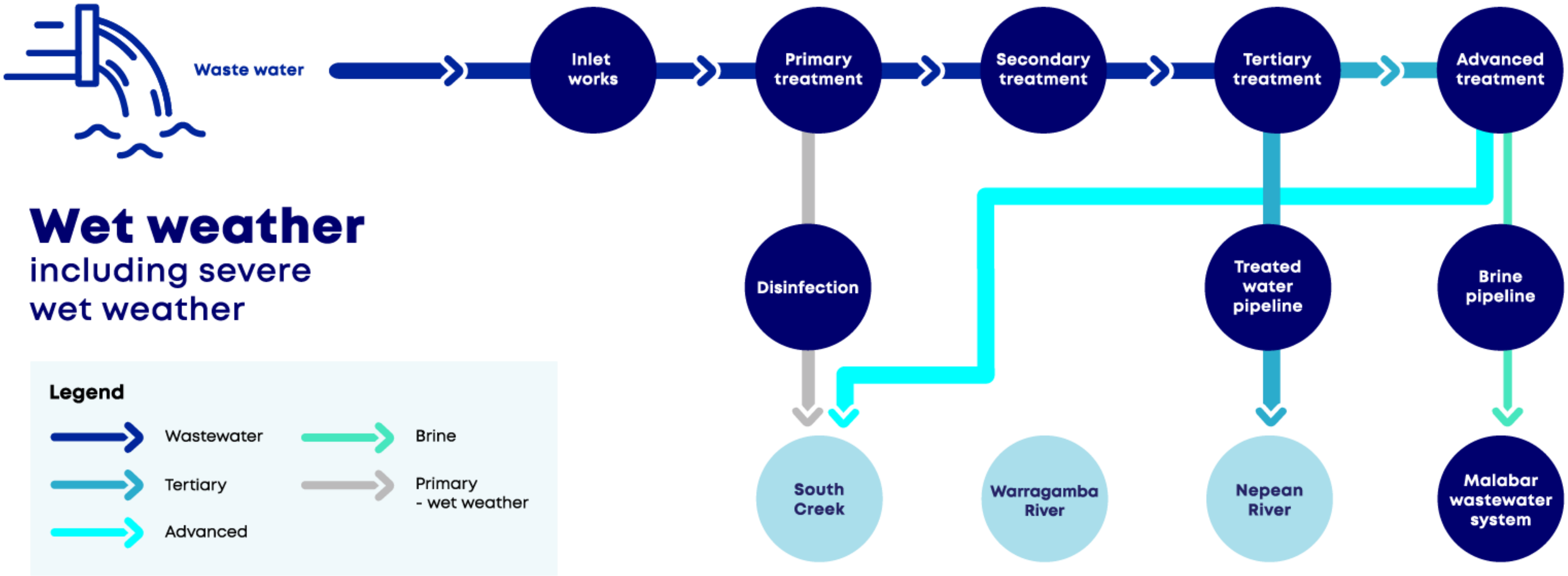


Figure 5.7: Plant flows during wet weather

For South Creek, the following key findings were made based on the water quality modelling:

- Changes in water quality from urban development in the catchment are predicted to be greater than changes relating to AWRC releases.
- Predicted impacts from the releases vary depending on the scale of the wet weather event. Impacts are higher in more severe wet weather events when the proportion of primary treated water is higher.
- All impacts are predicted to be short lived, with concentrations returning to background levels within a day. Changes are either minor or not identifiable downstream of Kemps Creek.
- Overall, there is no predicted impact to the waterway objectives (based on ecosystem protection) from the AWRC releases (based on annual median concentrations) (Sydney Water 2021b).

Background water quality for South Creek was mostly in compliance with relevant guidelines based on protection of human health. Given the small changes and/or improvements in water quality shown in this modelling, no additional potential for impacts to human health from changes in water quality with releases from the AWRC are expected.

Further assessment

Further assessment of a wider range of chemicals that may be present in wastewater has been undertaken for the HIA to further demonstrate the low potential for impacts to human health from this project.

The additional assessment has compared relevant estimates of potential concentrations of various chemicals and microorganisms in the treated water (i.e. prior to discharge) to national drinking water and recreational water guidelines.

It is noted that, when the treated water is discharged, the concentrations in the Nepean or Warragamba River will be even lower than those considered in this assessment.

It is important to consider the potential for drinking water guidelines to be exceeded given that, while these specific discharge locations are not subject to extraction for drinking water use, there is an extraction point for drinking water at North Richmond which is downstream of these discharges. The water extracted at North Richmond is treated prior to being added into the drinking water distribution system.

PRIMARY WATER QUALITY INDICATORS

Table 5.3 shows the primary water quality characteristics of the different types of water to be discharged.

The median concentrations for the primary indicators for water quality will be those in the first column when water is subject to all levels of treatment. This water will be discharged to Nepean River at Wallacia and to the Warragamba River.

When some rain occurs and flows increase, treated water will be a mix of advanced and tertiary treated water so the water quality will be a mix of the first and second column. This water will be discharged to Nepean River at Wallacia.

Only during large rain events (a few days/year), will wet weather treated water (i.e. primary treated) be discharged and only to South Creek. It is noted that the flows through South Creek during such situations will be much higher than normal.

Table 5.3: Indicative concentration of water quality under different treatment levels (Aurecon/ARUP 2021a)

Parameter	Units	Median concentrations		
		Advanced tertiary treated water	Tertiary treated water	Wet weather treated water
Total nitrogen (TN)	mg/L	0.35	2.5	18
Total phosphorus (TP)	mg/L	0.009	1	1
Oxides of nitrogen (NO_x)	mg/L	0.12	1.8	0
Ammonia (NH_3)	mg/L	0.03	0.2	15
Filterable reactive phosphorus (FRP)	mg/L	0.006	0.66	0.66
Chlorophyll *a* (Chl *a*)	µg/L	0	0	0
Dissolved oxygen (DO)	mg/L	9.2	5.9	0
TSS	mg/L	0	1	35
pH	pH units	7	7	7
Conductivity	µS/cm	150	1,500	1,500
Enterococci	CFU/100mL	0	0	7,400

Comparing the values listed in this table (**5.3**) with those in **Tables 5.1** and **5.2** shows that these primary water quality indicators will not change significantly due to the releases proposed for this project. As discussed in **Section 5.3**, most of the time, water released will have advanced treatment. The values listed here in the first column are lower (i.e. indicating better water quality) than water quality data indicates for the existing situations – i.e. there will be potential for improved water quality.

The treatment processes to be used at the AWRC include disinfection. This is designed to ensure appropriate control of microorganisms. The negligible levels of enterococci expected to be in the advanced and tertiary treated water demonstrate the effectiveness of this process in line with extensive national and international experience. Ensuring appropriate control of microorganisms is a critical step in managing the potential for human health impacts from wastewater treatment plants.

OTHER WATER QUALITY PARAMETERS - CHEMICAL

The primary water quality parameters are critical in understanding the efficient operation of the plant and the potential (or otherwise) for significant changes in water quality in the receiving waters. As a result, they are the focus of the detailed modelling to understand the potential for impacts that has been undertaken (Aurecon/ARUP 2021a).

However, as discussed in **Section 5.2.1**, there are a wide range of other chemicals and microorganisms that may be present in wastewater. Further evaluation of these can be undertaken by looking at monitoring results for other Sydney Water wastewater treatment plants.

A detailed monitoring program was undertaken in 2019 and 2020 at the Fairfield water recycling plant. This plant takes secondary treated effluent from Liverpool and Glenfield water recycling plants. This effluent is treated further using reverse osmosis and ultrafiltration with a final disinfection step using chlorine before the treated water is provided into the Rosehill-Camellia recycled water scheme.

Monitoring of treated water from this facility provides appropriate data for consideration within this assessment for water that may be discharged from the AWRC.

Monitoring was undertaken over approximately 3 months.

Chemicals/chemical groups that were analysed included:

- Metals
- Pesticides/herbicides/fungicides
- Nutrients
- Disinfection by-products
- Per and polyfluoroalkyl substances (PFAS)
- Other organic chemicals (those that contain carbon chains)
- Organotin compounds
- Antibiotics
- Illicit pharmaceuticals
- General pharmaceuticals

Microorganisms that were analysed included:

- Cryptosporidium
- Giardia
- Faecal coliforms/bacteria
- Viruses
- Parasites

A total of 350 individual chemicals were evaluated in these treated water samples. Many chemicals were not detected in any samples. Only individual chemicals that were detected above the laboratory limit of reporting on at least one occasion in the ***treated water*** have been considered in this assessment although all groups of chemicals have been discussed.

A wide range of chemicals were detected in the secondary treated effluent from Liverpool and Glenfield plants, as would be expected. A smaller range of chemicals was detected in the effluent from the Fairfield WRP after reverse osmosis treatment, also, as would be expected.

The difference in chemical concentrations between the secondary treated effluent from Liverpool and Glenfield plants and the effluent from the Fairfield WRP demonstrate the effectiveness of advanced wastewater treatment technologies such as reverse osmosis. This technology essentially filters at the molecular level. This means it significantly reduces most of the chemicals in the groups discussed below. It even reduces the dissolved ions that contribute to the conductivity reducing the conductivity to levels well below natural waters. Being effective at reducing these smaller ions also means the system is effective at reducing the larger molecules like pesticides, drugs and PFAS.

NATURALLY OCCURRING CHEMICALS

Chemicals such as metals and nutrients – all of which are naturally occurring – are commonly found in waterways and in wastewater. The chemicals in this group that were detected on at least one occasion in the treated water from Fairfield WRP include those reported in **Table 5.4**.

Table 5.4: Monitoring results for treated water from Fairfield WRP – naturally occurring chemicals

Chemical	Maximum result in effluent (mg/L)	Drinking Water Guideline (mg/L)	Recreational Water Guideline (mg/L)
Heavy metals			
Boron	0.07	4[A]	40
Chromium	0.002	0.05[A]	0.5
Mercury	0.00002	0.001[A]	0.01
Molybdenum	0.0002	0.05[A]	0.5
Zinc	0.004	3[A]	30
Essential minerals			
Calcium	0.045	NG	NG
Magnesium	0.025	NG	NG
Potassium	7	NG	NG
Sodium	7.85	180[AE]	180[AE]
Nutrients			
Total nitrogen	1.27	NG	NG
Nitrate	1.18	50[A]	500[A]
Total phosphorus	0.002	NG	NG
Chloride	8.7	250[AE]	250[AE]

Notes:
A = Australian drinking water guidelines (NHMRC 2011 updated 2021)
AE = Australian drinking water guidelines based on aesthetic qualities not health (e.g. taste/odour) (NHMRC 2011 updated 2021)
NG = no guideline as these are essential minerals or nutrients people need for proper functioning

The results for these chemicals in the treated water are all well below both drinking and recreational water guidelines. At discharge, when the treated water is mixed into the receiving waters, the concentrations will be even lower. No health effects are expected from drinking or contacting water in Nepean River at Wallacia or in Warragamba River in relation to this group of chemicals.

PESTICIDES

A wide range of chemicals that are used as pesticides, herbicides or fungicides were monitored in these water samples. A total of 74 individual chemicals were monitored including commonly used herbicides such as glyphosate and atrazine. None of these chemicals were detected in any sample – that includes those for the secondary treated water from Liverpool and Glenfield plants and those for the advanced treated water from Fairfield WRP.

DISINFECTION BY-PRODUCTS

Disinfection by-products are present in treated water primarily where chlorine is used for disinfection. Disinfection is a critical process to ensure microorganisms that could cause disease are not present at unacceptable levels in treated water. The chemicals in this group that were detected on at least one occasion in the treated water from Fairfield WRP include those reported in **Table 5.5**.

Table 5.5: Monitoring results for treated water from Fairfield WRP – disinfection by-products

Chemical	Maximum result in treated water (mg/L)	Drinking Water Guideline (mg/L)	Recreational Water Guideline (mg/L)
Chloroform	0.0114	0.2[R]	2
Bromodichloromethane	0.0016	0.006[R]	0.06
Dichloroacetic acid	0.002	0.1[R]	1
Total trihalomethanes#	0.013	0.25[A]	2.5

Notes:
A = Australian drinking water guidelines (NHMRC 2011 updated 2021)
R = Australian Guidelines for Water Recycling (NRMMC 2008)
# = total trihalomethanes is the sum of chloroform, bromoform, bromodichloromethane and dibromochloromethane

The results for these chemicals in the treated water are all well below both drinking and recreational water guidelines. At discharge, when the treated water is mixed into the receiving waters, the concentrations will be even lower. No health effects are expected from drinking or contacting water in Nepean River at Wallacia or in Warragamba River in relation to this group of chemicals.

PFAS

PFAS are a family of fluorine-containing compounds with unique properties to make materials stain- and stick-resistant. PFAS are often described as being "ubiquitous in the environment". They have been widely used in man-made products such as paints, roof treatments, hardwood floor protectant, surface protection products (e.g. carpet and clothing treatments) and coatings for cardboard and packaging. Some PFAS are/were used in fire-fighting foams. These compounds are not found in the environment from natural sources, only from anthropogenic sources (ATSDR 2015, 2018)

Most of these chemicals were not detected in the finished treated water. Some were measured above the limit of reporting in the secondary treated effluent from Liverpool and Glenfield plants, but the reverse osmosis treatment process removed them effectively. The chemicals in this group that were detected on at least one occasion in the treated water from Fairfield WRP include those reported in **Table 5.6**.

Table 5.6: Monitoring results for treated water from Fairfield WRP – PFAS

Chemical	Maximum result in treated water (mg/L)	Drinking Water Guideline (mg/L)	Recreational Water Guideline (mg/L)
8:2 diPAP	0.000032	0.00007[A]	0.002[Re]
PFDS	0.0000015	0.00007[A]	0.002[Re]

Notes:
A = Australian drinking water guidelines guideline for PFOS+PFHxS (NHMRC 2011 updated 2021)
Re = Recreational water quality guidelines for PFAS (NHMRC 2019)
PFDS = perfluorodecanesulfonate
8:2 diPAP= 8:2 fluorotelomer phosphate diester
PFOS = perfluorooctanesulfonate
PFHxS = perfluorohexanesulfonate

Guidelines for this group of chemicals are limited. This chemical family is quite large (1,000s of individual chemicals fall into this group) and not all have been able to be tested sufficiently. However, the chemicals that are usually present at the highest levels and which appear to be the most likely to cause effects in people are PFOS and PFHxS. These can accumulate and remain in the body for the longest time (for the PFAS family) allowing time for effects to occur. Guidelines for these 2 chemicals exist and these guidelines can be applied to others in the group. It is considered that this should be conservative. International authorities are beginning to apply guidelines based on PFOS to the sum of a range of these chemicals as more is learned about them so using the guidelines for PFOS+PFHxS to other members of the family is considered appropriate (EU 2020; European Food Safety Authority 2020; Vermont Department of Environmental Conservation 2019).

The results for the 2 chemicals from this group that were detected in the treated water are below both drinking and recreational water guidelines. At discharge, when the treated water is mixed into the receiving waters, the concentrations will be even lower. No health effects are expected from drinking or contacting water in Nepean River at Wallacia or in Warragamba River in relation to this group of chemicals.

OTHER ORGANIC CHEMICALS

Thirty other organic chemicals were monitored for in these samples. These included a range of industrial chemicals and chemicals present in personal care and cleaning products used around the home. None of these chemicals were measured above the limit of reporting in the finished treated water but 5 were measured in the secondary treated effluent from Liverpool and Glenfield plants. The reverse osmosis treatment was effective in removing these chemicals.

ORGANOTIN COMPOUNDS

This group of chemicals includes monobutyltin, dibutyltin and tributyltin. These chemicals have been used as additives in pipes as well as in antifouling treatments. Tributyltin was the active ingredient in paints used on boats to prevent the growth of algae and barnacles. It is no longer permitted for this use. Use as an additive in PVC pipes is also likely to have been discontinued.

Only monobutyltin was detected above the limit of reporting – on 1 occasion in the finished treated water and on 1 occasion in the secondary treated effluent from Liverpool and Glenfield plants. The maximum concentration measured was 0.00002 mg/L and the guideline for this chemical is 0.0007 mg/L (NRMMC 2008).

The results for this chemical were below both the relevant water guideline. At discharge, when the treated water is mixed into the receiving waters, the concentrations will be even lower. No health effects are expected from drinking or contacting finished treated water mixed into water in Nepean River at Wallacia or in Warragamba River in relation to this group of chemicals.

ANTIBIOTICS

A total of 32 different antibiotics were monitored for in the samples. While 5 of the chemicals were detected in the secondary treated effluent from Liverpool and Glenfield plants, only 1 was detected in the finished treated water – trimethoprim. It was only present in 1 of the 10 samples tested.

The maximum concentration for trimethoprim in the finished treated water was 0.0000075 mg/L. The guideline value for this chemical is 0.07 mg/L – from the Australian Guidelines for Water Recycling (NRMMC 2008).

Another antibiotic – sulfamethoxazole – is designated by water authorities as a good indicator for effective operation of the various levels of treatment at such a facility. In this case, this chemical was not detected in the finished treated water in any sample tested confirming appropriate operation of the reverse osmosis plant.

The results for chemicals in this group in the finished treated water were below the relevant water guidelines. At discharge, when the treated water is mixed into the receiving waters, the concentrations will be even lower. No health effects are expected from drinking or contacting finished treated water mixed into water in Nepean River at Wallacia or in Warragamba River in relation to this group of chemicals.

ILLICIT PHARMACEUTICALS

A total of 25 illicit drugs (or their metabolites) were monitored for in these samples. The chemicals in this group that were detected on at least one occasion in the treated water from Fairfield WRP include those reported in **Table 5.7**.

Table 5.7: Monitoring results for treated water from Fairfield WRP – illicit pharmaceuticals

Chemical	Maximum result in treated water (mg/L)	Drinking Water Guideline (mg/L)	Recreational Water Guideline (mg/L)
Buprenorphine	0.000001	0.0005[UK]	--
Cocaine	0.000006	0.0005[UK]	--
Tramadol	0.000014	0.0005[UK]	--

Notes:

UK = Drinking Water Inspectorate in the UK developed an approach for estimating drinking water guidelines for a range of pharmaceuticals (UK DWI 2007).

A range of organisations have adopted a similar approach to the UK DWI including WHO and the Australian Guidelines for Water Recycling when considering such chemicals (NRMMC 2008; WHO 2011a). The UK DWI specifically attempted to deal with illicit pharmaceuticals as well as those used generally in the community. The approach involved assuming an intake of 1 mg/day for a person would not cause effects and then a factor of 1,000 was applied to account for the uncertainty in the assumptions. If people drink 2 L of water per day, then to consume 1 mg/day requires that the water contain less than or equal to 0.5 mg/L. The 1,000 fold factor is then applied to generate a guideline of 0.0005 mg/L for these illicit pharmaceuticals.

The results for chemicals in this group in the finished treated water were below relevant water guidelines. At discharge, when the treated water is mixed into the receiving waters, the concentrations will be even lower. No health effects are expected from drinking or contacting finished treated water mixed into water in Nepean River at Wallacia or in Warragamba River in relation to this group of chemicals.

GENERAL PHARMACEUTICALS

Samples were tested for 55 general pharmaceuticals. Twentyfive were detected in the secondary treated effluent from Liverpool and Glenfield plants, 7 consistently but only 1 chemical was detected in the finished treated water – caffeine. Caffeine was highly variable in the secondary treated effluent from Liverpool and Glenfield plants and was only detected in the finished treated water on 1 occasion. The chemicals that were consistently detected in the secondary treated effluent from Liverpool and Glenfield plants were caffeine, carbamazepine, diclofenac, gemfibrozil, ibuprofen, ketoprofen and triclosan.

Caffeine can be used as a pharmaceutical but is more commonly found in tea, coffee and energy drinks. Carbamazepine, diclofenac, gemfibrozil, ibuprofen and ketoprofen are commonly used pharmaceuticals. Triclosan is used as an antibacterial in personal care products around the home as well as in hospital grade products where the levels are higher.

The reverse osmosis treatment was effective in significantly reducing the concentrations of all these chemicals.

As noted, caffeine was detected on 1 occasion in the finished treated water at 0.0000115 mg/L. The Australian Guidelines for Water Recycling specify a guideline for caffeine of 0.00035 mg/L (NRMMC 2008).

The results for chemicals in this group present in the finished treated water were below relevant water guidelines. At discharge, when the treated water is mixed into the receiving waters, the concentrations will be even lower. No health effects are expected from drinking or contacting finished treated water mixed into water in Nepean River at Wallacia or in Warragamba River in relation to this group of chemicals.

MISCELLANEOUS CHEMICALS

A group of 23 chemicals that did not fit into any of the other categories were monitored as miscellaneous chemicals. Only 2 of these chemicals were detected in secondary treated effluent from Liverpool and Glenfield plants and none of these chemicals were detected in the finished treated water.

OTHER WATER QUALITY PARAMETERS – MICROORGANISMS

The primary water quality parameters are critical in understanding the efficient operation of the plant and the potential (or otherwise) for significant changes in water quality in the receiving waters. As a result, they are the focus of the detailed modelling to understand the potential for impacts that has been undertaken (Aurecon/ARUP 2021a).

However, as discussed in **Section 5.2.1**, there are a wide range of other chemicals and microorganisms that may be present in wastewater. Further evaluation of the microorganisms can be undertaken by looking at monitoring results for other Sydney Water wastewater treatment plants.

A detailed monitoring program was undertaken in 2019 and 2020 at the Fairfield water recycling plant. This plant takes secondary treated effluent from Liverpool and Glenfield water recycling plants. This effluent is treated further using reverse osmosis and ultrafiltration with a final disinfection step using chlorine before the treated water is provided into the Rosehill-Camellia recycled water scheme.

Monitoring of treated water from this facility provides appropriate data for consideration within this assessment for water that may be discharged from the AWRC. Monitoring was undertaken over approximately 3 months (Sydney Water 2020).

Microorganisms that were analysed included:

- Cryptosporidium
- Giardia
- Faecal coliforms/bacteria
- Viruses
- Parasites (Sydney Water 2020).

Monitoring for microorganisms was also undertaken at St Marys advanced water treatment plant in 2010 as part of the Western Sydney Water Initiative – Replacement Flows Project Process Proving Verification (Sydney Water 2021c).

Twelve microbial analytes were tested as part of this work, including:

- Bacteria - total coliforms, E.coli, clostridium perfringens spores, F-specific bacteriophage
- Viruses - reovirus, enterovirus, adenovirus, norwalk virus, rotavirus, hepatitis A
- Parasites - giardia cysts, cryptosporidium oocysts (Sydney Water 2021c).

CRYPTOSPORIDIUM AND GIARDIA

There were no detections for *Cryptosporidium* or *Giardia* in any of the finished treated water samples from the Fairfield plant. The 90th percentile for the data from 2010 at St Marys was less than 1 organism per 50 L. Both these results indicates that the treatment processes proposed for the AWRC provide appropriate controls for these organisms.

FAECAL COLIFORMS/BACTERIA

No bacteria or phage were detected in any of the finished treated water samples from the Fairfield plant. The 90th percentile for the data from 2010 at St Marys was less than 1 organism per 100 mL. Both these results indicates that the treatment processes proposed for the AWRC provide appropriate controls for bacteria.

VIRUSES

All viruses tested were not reported above the limit of reporting in the finished treated water samples from the Fairfield plant. Adenovirus and enterovirus were detected on occasion in the secondary treated effluent from Liverpool and Glenfield plants – the results for the Fairfield plant indicate that these were readily removed using treatment processes that will be present with the AWRC. The 90th percentile for the data from 2010 at St Marys was less than 1 organism per 50 L. These results indicates that the treatment processes proposed for the AWRC provide appropriate controls for viruses.

PARASITES

There were no detections of Helminth or other parasites in any of the tested samples of finished treated water from the Fairfield plant. These results indicate the treatment processes proposed for the AWRC provide appropriate controls for parasites.

5.7 Health surveillance activities

It is noted that the use of sampling wastewater to look for pathogens such as COVID-19 or for illicit pharmaceuticals is becoming more common place. It will be important to include appropriate access locations to allow sampling of influent or effluent for health surveillance activities in the design of the AWRC as such monitoring plays a critical role in public health management.

5.8 Outcomes of health impact assessment: water

Table 5.8 presents a summary of the outcomes of the assessment undertaken in relation to the impacts of changes in water quality, associated with the proposed project, on community health.

Table 5.8: Summary of health impacts – water

Water	
Benefits	Appropriate management of wastewater provides a benefit to society
Impacts	Based on the available data and information in relation to changes in water quality due to the proposed facility during operation or construction, potential impacts on the health of the community have been assessed. The impact assessment has concluded that changes in water quality are unlikely to impact on community health during operations or construction with the inclusion of relevant mitigation measures.
Mitigation	Mitigation measures to manage potential impacts from changes in water quality during operation of the proposed facility include: ■ Ensuring, for each discharge scenario, that the highest relevant level of treatment can be applied to the greatest volume by appropriate maintenance and operation of equipment. ■ Ensure that recycled water supplied to customers from the AWRC meets the Australian Guidelines for Water Recycling as required under Sydney Water's Operating Licence. ■ Undertaking appropriate monitoring, in line with requirements of the Environment Protection Licence under which the AWRC will operate, to ensure the plant is operating as expected. ■ Undertaking appropriate monitoring of the receiving environments to allow for evaluation of any changes in water quality compared to upstream/background that could occur.

Section 6. Health impacts: Air

6.1 Introduction

This section presents a review of impacts on health associated with predicted air emissions and odours relevant to the operation of the Project.

The estimation of risk follows the general principles outlined in the enHealth document Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth 2012).

Health impacts associated with air emissions for the project have been assessed on the basis of the information within the technical paper:

- Jacobs (2020) Air quality impact assessment. Dated 27 November 2020.

6.2 Health impacts associated with air quality changes or odours

6.2.1 Odour

The release of odours from industrial developments can affect a community's quality of life. In any community there will be people who are very sensitive to odours and those that hardly notice them with most people being somewhere in between these two extremes (NSW DEC 2006a).

Unpleasant odours have often been seen as early warning signs of potential issues for human health but there are a range of health complaints that can occur just due to exposure to odours. Complaints like irritation of eyes, nose or throat, headaches, nausea, sore throat, hoarseness, cough, nasal congestion, stress, shortness of breath and others are common in some people when exposed to unpleasant odours (or even pleasant ones). Effects can also occur due to the irritant effects of the odorous chemicals or because people become sensitised to a particular odour over time (learned aversion) (Schiffman & Williams 2005).

People are exposed to many unpleasant odours, often for only short moments in time and these are unlikely to cause health effects but can be annoying. However, when such odours persist or include irritant chemicals, health effects become possible (Schiffman & Williams 2005).

As a result, the NSW EPA provides guidance on the management of odours from sources such as those within the project. There is a legal framework within which this guidance sits as the release of offensive odours into off-site areas is not permitted under the POEO Act (NSW DEC 2006a).

The objective is to ensure that the potential for unpleasant odours in off-site areas is negligible by ensuring appropriate engineering and management of any industrial facilities that could release such odours. The idea is to avoid odours by controlling them at source. This could consist of changing the processes to use or produce less odorous chemicals or appropriate control of emissions from processes where odorous chemicals cannot be avoided (NSW DEC 2006a).

Guidelines have been developed which aim to ensure odours are negligible outside the boundary of a facility. If odours are negligible in off-site areas, then the risks to human health will be negligible. These are discussed in **Section 6.4.2**.

6.2.2 Nitrogen dioxide

The NEPC ambient air quality guideline for the assessment of acute (short-term) exposures to NO_2 relates to the maximum predicted total (cumulative) 1-hour average concentration in air. The guideline of 246 µg/m^3 (or 120 ppb) is based on a lowest observed adverse effect level (LOAEL) of 409 to 613 µg/m^3 derived from statistical reviews of epidemiological data suggesting an increased incidence of lower respiratory tract symptoms in children and aggravation of asthma. An uncertainty factor of 2 to protect susceptible people (i.e. asthmatic children) was applied to the LOAEL. On this basis, the NEPC (and NSW EPA) acute guideline is protective of adverse health effects in all individuals, including sensitive individuals (NEPC 2016).

The NEPC ambient air quality guideline for the assessment of chronic (long-term or lifetime) exposures to NO_2 relates to the maximum predicted total (cumulative) annual average concentration in air. The guideline of 62 µg/m^3 (or 30 ppb) is based on a lowest observed adverse effect level (LOAEL) of the order of 40 - 80 ppb (approx. 75-150 µg/m^3) during early and middle childhood years which can lead to the development of recurrent upper and lower respiratory tract symptoms, such as recurrent 'colds', a productive cough and an increased incidence of respiratory infection with resultant absenteeism from school. An uncertainty factor of 2 was applied to the LOAEL to account for susceptible people within the population resulting in a guideline of 20-40 ppb (38-75 µg/m^3). The most recent review of the data around the effects of nitrogen dioxide confirmed that a guideline based on a threshold (i.e. where exposures below the threshold concentration are not associated with any adverse health effects) is appropriate for this pollutant. On this basis, the NEPC (and NSW EPA) chronic guideline is protective of adverse health effects in all individuals, including sensitive individuals (NEPC 2016).

6.2.3 Dust

Particles or dust are always present in air but concentrations can vary.

When earthworks are undertaken, there can be windblown dust at a site that can add to the existing levels of particles in the atmosphere.

Unlike many other pollutants, particulates comprise a broad class of diverse materials and substances, with varying morphological (shape), chemical, physical and thermodynamic properties, with sizes that vary from less than 0.005 microns to greater than 100 microns. Particulates can be derived from natural sources such as crustal dust (soil), pollen and moulds, and other sources that include combustion and industrial processes.

Numerous epidemiological studies[4] have reported significant positive associations between particulate air pollution and adverse health outcomes, particularly mortality as well as a range of adverse cardiovascular and respiratory effects.

[4] Epidemiology is the study of diseases in populations. Epidemiological evidence can only show that this risk factor is associated (correlated) with a higher incidence of disease in the population exposed to that risk factor. The higher the correlation the more certain the association. Causation (i.e. that a specific risk factor actually causes a disease) cannot be proven with only epidemiological studies. For causation to be determined a range of other studies need to be considered in conjunction with the epidemiology studies.

The potential for particulate matter to result in adverse health effects is dependent on the size and composition of the particulate matter. The common measures of particulate matter that are considered in the assessment of air quality and health risks are:

- Total suspended particulates (TSP): This refers to all particulates with an equivalent aerodynamic particle[5] size below approximately 50 microns in diameter[6]. It is a fairly gross indicator of the presence of dust with a wide range of sizes. Larger particles (termed 'inspirable', comprising particles around 10 microns and larger) are more of a nuisance than a health hazard as they would deposit out of the air (measured as deposited dust) onto the ground close to the source and, if inhaled, are mostly trapped in the upper respiratory system[7] and do not reach the lungs. Finer particles (smaller than 10 microns, termed 'respirable') tend to be transported further from the source and are of more concern with respect to human health as these particles can penetrate into the lungs (see following point). Not all of the dust characterised as total suspended particulates is thus relevant for the assessment of health impacts, and TSP has not been further evaluated in this assessment. The assessment has only focused on particulates of a size where significant associations have been identified between exposure and adverse health effects.

- Fine particulates as PM_{10} (particulate matter below 10 microns in diameter, µm) and $PM_{2.5}$ (particulate matter below 2.5 µm in diameter) and ultrafines (particulate matter below 0.1 µm in diameter), as illustrated in **Figure 6.1.** These particles are small and have the potential to penetrate beyond the body's natural clearance mechanisms of cilia and mucous in the nose and upper respiratory system, with smaller particles able to further penetrate into the lower respiratory tract[8] and lungs. Adverse health effects may result for particles that reach down into the lungs depending on the size, number and nature of the particles (OEHHA 2002). In relation to dust emissions from earthworks, these are predominantly from crustal materials and comprise PM_{10}, with a smaller fraction of $PM_{2.5}$ present.

[5] The term equivalent aerodynamic particle is used to reference the particle to a particle of spherical shape and particle of density one gram per cubic metre.

[6] The size, diameter, of dust particles is measured in micrometers (microns).

[7] The upper respiratory tract comprises the mouth, nose, throat and trachea. Larger particles are mostly trapped by the cilia and mucosa and swept to the back of the throat and swallowed.

[8] The lower respiratory tract comprises the smaller bronchioles and alveoli, the area of the lungs where gaseous exchange takes place. The alveoli have a very large surface area and absorption of gases occurs rapidly with subsequent transport to the blood and the rest of the body. Small particles can reach these areas, be dissolved by fluids and absorbed.

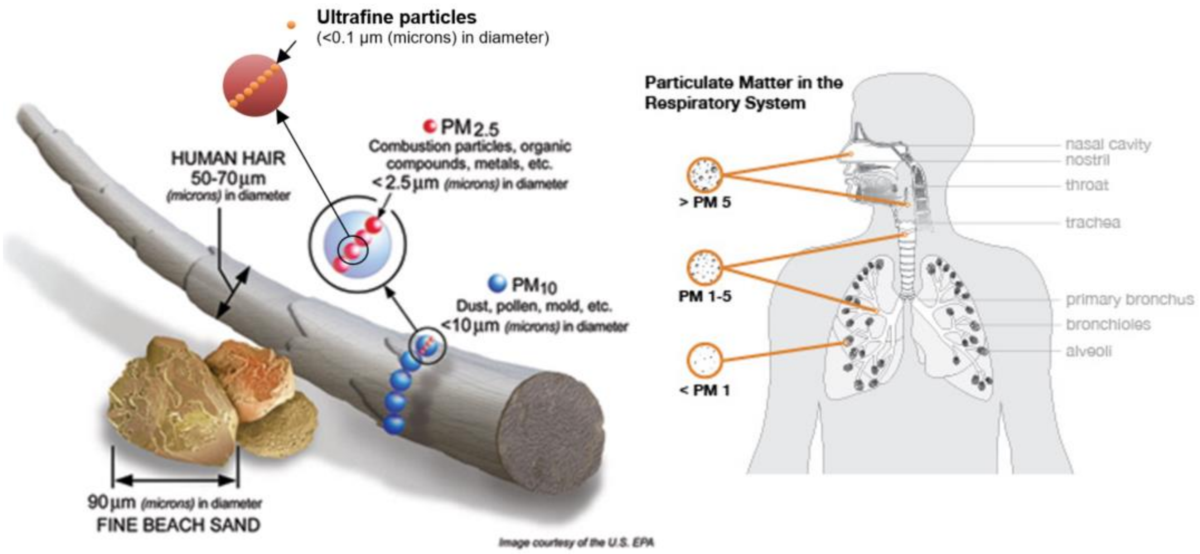


Figure 6.1: Illustrative Representation of Particle Sizes and Penetration into the Lungs

In this case, TSP and PM10 are the primary types of particle that could be emitted from earthworks during construction.

6.3 Description of the approach and guidelines adopted

For this facility, odorous emissions are the major emissions to air. Existing odour information from other Sydney Water facilities has been used to estimate worst case odour levels from the AWRC. The centre will include an odour control facility and so air from many of the key sources from which odours may be emitted will be ducted to this facility for treatment prior to release to the atmosphere (Jacobs 2020).

The wastewater treatment process will include:

- Inlet works for preliminary treatment
- Primary, secondary and tertiary wastewater treatment
- Advanced treatment including through reverse osmosis
- Biosolids handling facilities
- Cogeneration for heat and energy production
- Odour control facilities
- Infrastructure to South Creek for releases during wet weather
- Pumping stations to transfer treated water to the Nepean and Warragamba Rivers, and the brine to the Malabar wastewater system (Jacobs 2020).

Odours from equipment such as the inlet, channels within the plant, presses and screens will be directed to the odour control facility for treatment (Jacobs 2020).

In addition, co-generation of power will occur at the facility using an engine to combust biogas from the wastewater treatment processes. Air emissions from such an engine have also been modelled. The emissions from such an engine are standard pollutants from combustion processes – modelling has focused on nitrogen dioxide (NO_2) which is appropriate for this situation. The plant for cogeneration of power will need to comply with NSW EPA requirements for such equipment (Jacobs 2020).

Modelling of potential odorous emissions at the site has been undertaken using standard air dispersion models as specified by NSW EPA. The air quality assessment for this project has been undertaken in accordance with guidance from the NSW EPA and has made use of the guidelines set out in the National Environment Protection (Ambient Air Quality) Measure (NEPC 2016; NSW EPA 2017a).

Figures 6.2 and **6.3** illustrate the processes which govern how the emissions get mixed into the atmosphere. These processes are relevant for odours and for pollutants like nitrogen dioxide.

Estimating odours or pollutants in off-site areas involves information such as:

- Odour/pollutant concentration (or emission rate) at the AWRC
- Information about how odours or pollutants will leave the odour control facility or the co-generation engine and any other relevant parts of the AWRC
- Information about the meteorological conditions.
- Information about the terrain in the surrounding areas.

All this information is used to estimate how the pollutants/odours are mixed and transported in the air and the concentration that may be present at ground level at different locations.

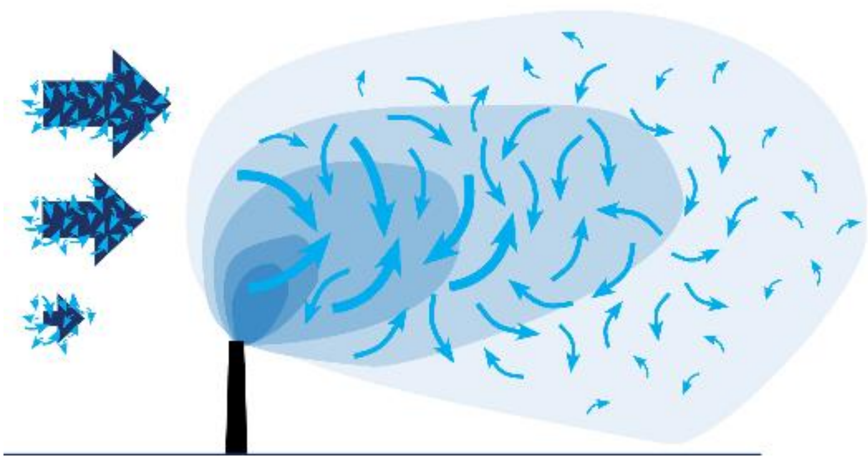


Figure 6.2: Turbulence in the air, how it mixes and dilutes pollutants/odours emitted from a stack (NSW Chief Scientist 2018)

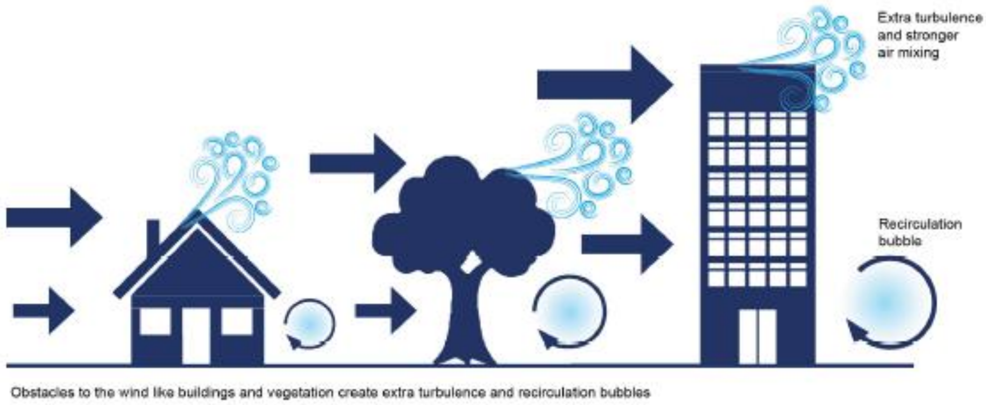


Figure 6.3: Turbulence in the air and how it is affected by buildings and vegetation (NSW Chief Scientist 2018)

Figure 6.2 shows that most of the pollutants/odours remain up in the atmosphere away from where people could be exposed. However, small amounts do eventually reach ground level. The air dispersion modelling determines what proportion of the amount in the stack could reach ground level at different locations. Such modelling looks at worst case weather characteristics (that can actually occur – based on real meteorological data) to ensure that the amount that could reach ground level in areas where people live or work neighbouring the proposed facility are not underestimated.

The modelling has estimated potential ground level concentrations for odour or nitrogen dioxide across a 6 km x 6 km grid around the AWRC.

Meteorological conditions were assessed for 2015 to 2019 and showed little annual variation so the conditions reported for 2019 were used in the modelling.

6.4 Assessment of health impacts from air emissions from the project

6.4.1 General

The most significant emissions to air from the project will be:

- Odour from the AWRC during operation
- Emissions from cogeneration engines at the AWRC during operation
- Dust (that is, particulate matter) during construction (Jacobs 2020).

6.4.2 Operation – odours

The odour dispersion modelling has reported that odours will not exceed the NSW EPA guidelines at almost any locations outside the AWRC site. The NSW EPA guidelines are listed in **Table 6.1**.

Table 6.1: NSW EPA air quality assessment criteria for odour

Population of affected community	Criterion (odour units (OU)) (nose response time average, 99th percentile)
Single rural residence (≤~2)	7
~10	6
~30	5
~125	4
~500	3
Urban (>2000) and/or schools and hospitals	2

NSW EPA has assumed that 7 odour units (OU) at the 99th percentile would be acceptable to the average person as the basis for these criteria. However, as the number of exposed people increases there is more chance that sensitive individuals would be exposed so the criteria decrease as the number of people around a facility increases. The criterion of 2 OU at the 99th percentile is considered to be acceptable for the whole population which includes sensitive individuals. The 99th percentile is the odour level that occurs 1% of the time given the way the plant will operate and the meteorological conditions in the area – i.e. 99% of the time the odour will be lower.

Figure 6.4 shows the contours for the 99th percentile modelling conditions.

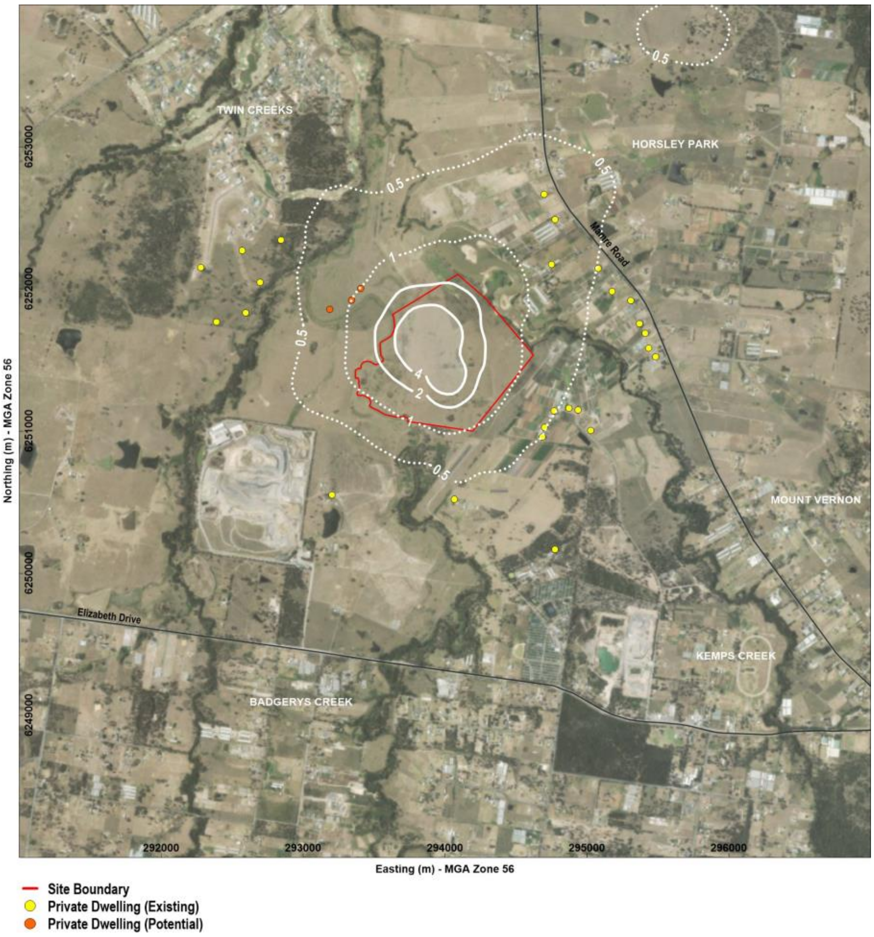


Figure 6.4: Predicted odour levels at the 99th percentile due to the AWRC (Stage 1)

The modelling has assumed that the odour control unit will emit at the maximum level for every hour of the year (500 OU). In addition, the modelling has assumed that biosolids loadout will occur every day of the year throughout the day (7 am to 3 pm). This means the modelling has predicted maximum levels of odour. These levels are unlikely to occur all day every day. The modelling has then determined the 99th percentile to develop the contours. These results are, therefore, conservative and appropriate.

The contours show that there are no off-site locations which are estimated to have 4 OU using this conservative approach. The contours show that the estimated extent of 2 OU is predominantly within the AWRC site. Neither the 2 or 4 OU contours extend close to any residences that are currently located (or proposed) around the facility. It is also important to note that it would be difficult to notice odours at 1 or 2 OU – these sorts of levels are only just noticeable under the controlled conditions in a laboratory and only occur 1% of the time.

It is also noted that there are likely to be changes in land use around the facility in the short term. The M12 motorway is proposed to be constructed close to the southern boundary of the facility and the Western Sydney Airport is under construction nearby. If land use changes from rural residential to workplaces, then the potential for odours will pose an even lower risk.

6.4.3 Operation – nitrogen dioxide

The dispersion modelling for nitrogen dioxide has indicated that levels will not exceed the NSW EPA guidelines at almost any locations outside the AWRC site. The NSW EPA guidelines are listed in **Table 6.2**.

Table 6.2: EPA air quality assessment criteria for nitrogen dioxide

Substance	Averaging time	Criterion
Nitrogen dioxide (NO_2)	1-hour	246 µg/m^3
	Annual	62 µg/m^3

Figure 6.5 shows the contours for the maximum 1 hour average nitrogen dioxide concentrations.

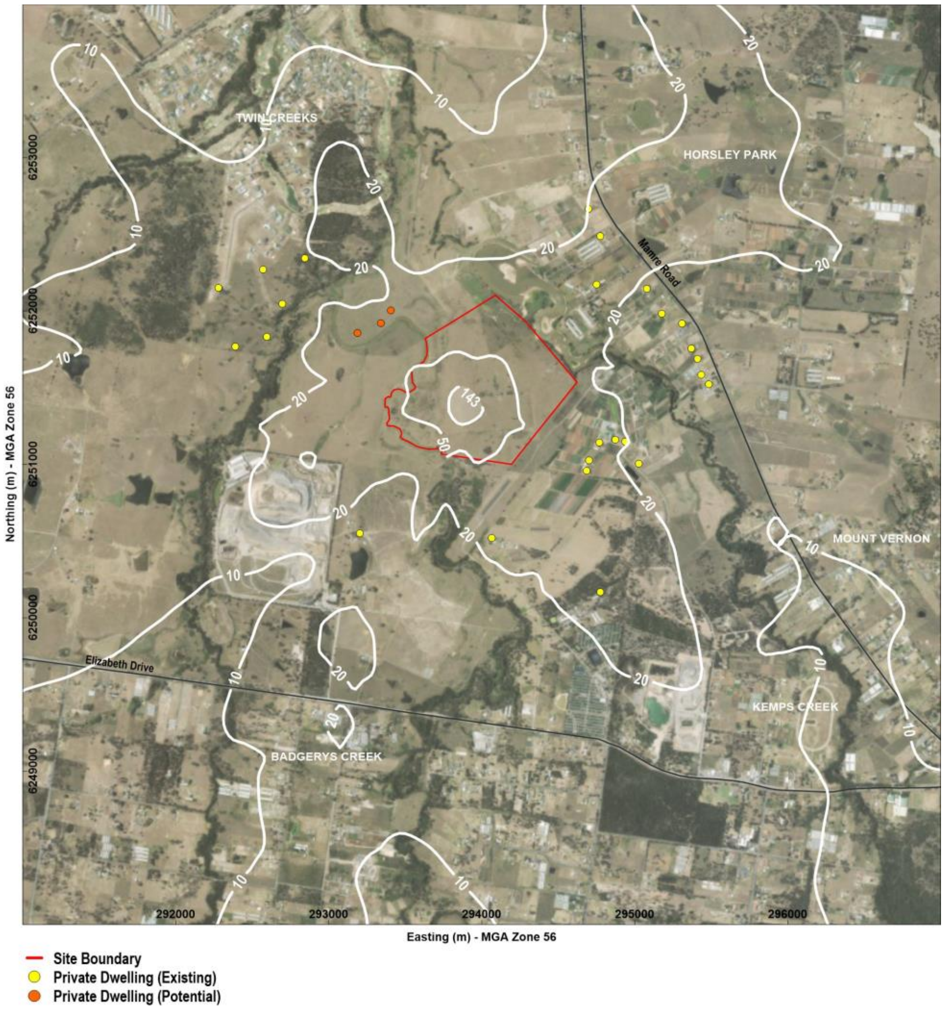


Figure 6.5: Maximum 1 hour average nitrogen dioxide concentrations.

The contours show that the maximum incremental 1 hour average concentrations of nitrogen dioxide are between 50 and 150 µg/m^3 on the site and lower than that in the off-site area. The NSW EPA guideline for 1 hour average cumulative concentrations is 246 µg/m^3. The 1 hour average incremental concentrations in the off-site area are more than 5 times lower than the guideline.

6.4.4 Construction – dust

Construction of the AWRC is anticipated to occur over approximately 36 months. Anticipated works are summarised as follows:

- Site establishment such as installation of environmental controls, roads, fencing, plant and equipment delivery, demolition of existing buildings and contamination management. These works are expected to take 2 months.
- Earthworks such as cut and fill, drainage works, excavation for detention basins and underground infrastructure, dewatering and waste disposal. These works are expected to take 15 months.
- Civil works including roads and stormwater infrastructure works. These works are expected to take 9 months.

- Structure construction such as construction of buildings, treatment works, storage tanks and process units. These works are expected to take 20 months.
- Mechanical and electrical installation such as utility connections. These works are expected to take 9 months.
- Commissioning such as equipment testing and discharging commissioning wastewater. This is expected to take 6 months.
- Landscaping and restoration, expected to take 3 months.

Construction of the pipelines is anticipated to occur over approximately 30 months. Anticipated works are summarised as follows:

- Site establishment such as installation of environmental controls, roads, site compounds fencing, and plant and equipment delivery. These works are expected to take 2 months.
- Earthworks and civil works such as excavation of trenches, dewatering, waste disposal, installation of pipelines and backfill. This is expected to take 24 months.
- Commissioning such as equipment testing and discharging commissioning wastewater. This is expected to take 3 months.
- Landscaping and restoration, expected to take 3 months.

Construction can only occur during standard hours (i.e. 7 am to 6 pm Monday to Friday and 8 am to 12 pm Saturday) unless absolutely necessary.

Detailed modelling of emissions from such earthworks is not possible at this time as it will depend on the order in which a contractor undertakes the work and the equipment used. Instead, the common approach is to ensure best practice procedures are documented in the Construction Environmental Management Plan (CEMP).

Procedures for this site could include:

- Stabilising exposed areas as soon as possible with tarpaulins/geotextiles
- Dust control measures (non-potable water)
- Maintenance of all equipment in good working order
- Switching off equipment and vehicles when not in use
- Modifying/ceasing work practices in windy conditions
- Rehabilitation of areas (spray grass or final vegetation) when earthworks are completed
- Covering all waste during transport.

6.5 Outcomes of health impact assessment

Table 6.3 presents a summary of the outcomes of the assessment undertaken in relation to the impacts on community health of changes in air quality, associated with the proposed project.

Table 6.3: Summary of health impacts – air quality

Air quality	
Benefits	Neutral
Impacts	Based on the available data and information in relation to emissions to air from the proposed facility during operation (odours/nitrogen dioxide), potential impacts on the health of the community have been assessed. The impact assessment has concluded the following: ■ There are no acute inhalation exposure risks of concern. ■ There are no chronic inhalation exposure risks of concern.
Mitigation	No mitigation measures (apart from those incorporated into equipment) are required to manage potential impacts on air quality during operation of the proposed facility. Standard dust control measures during earthworks will be implemented as part of the Construction Environmental Management Plan. Such measures could include: ■ Stabilising exposed areas as soon as possible with tarpaulins/geotextiles ■ Dust control measures (non-potable water) ■ Maintenance of all equipment in good working order ■ Switching off equipment and vehicles when not in use ■ Modifying/ceasing work practices in windy conditions ■ Rehabilitation of areas (spray grass or final vegetation) when earthworks are completed ■ Covering all waste during transport.

Section 7. Health impacts: Noise and vibration

7.1 Introduction

This section presents a review and further assessment of impacts on health associated with noise, relevant to the Project.

Health impacts associated with noise or vibration for the project have been assessed on the basis of the information within the technical paper:

- Aurecon/ARUP (2021d) Upper South Creek Advanced Water Recycling Centre: Noise and vibration impact assessment. Draft dated 19 April 2021.

7.2 Health impacts associated with noise

Environmental noise has been identified (I-INCE 2011; WHO 2011b) as a growing concern in urban areas because it has negative effects on quality of life and well-being and it has the potential for causing health effects. With increasingly urbanised societies, impacts of noise on communities have the potential to increase over time.

Sound is a natural phenomenon that only becomes noise when it has some undesirable effect on people or animals. Unlike chemical pollution, noise energy does not accumulate either in the body or in the environment, but it can have both short-term and long-term adverse effects on people. These health effects include (WHO 1999, 2011b):

- sleep disturbance (sleep fragmentation that can affect psychomotor performance, memory consolidation, creativity, risk-taking behaviour and risk of accidents)
- annoyance
- hearing impairment
- interference with speech and other daily activities
- impacts on children's school performance (through effects on memory and concentration)
- impacts on cardiovascular health.

Other effects for which evidence of health impacts exists, but for which the evidence is weaker, include:

- effects on mental health (usually in the form of exacerbation of existing issues for vulnerable populations rather than direct effects)
- tinnitus (which can also result in sleep disturbance, anxiety, depression, communication and listening problems, frustration, irritability, inability to work, reduced efficiency and a restricted participation in social life)
- cognitive impairment in children (including deficits in long term memory and reading comprehension)
- some evidence of indirect effects such as impacts on the immune system.

Within a community, the severity of the health effects from exposure to noise and the number of people who may be affected are schematically illustrated in **Figure 7.1**.

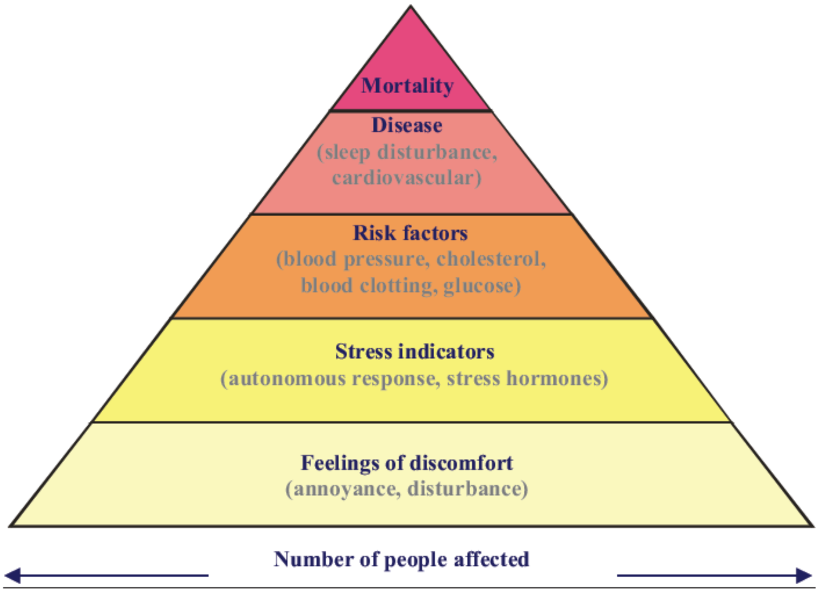


Figure 7.1: Schematic of severity of health effects of exposure to noise and the number of people affected (WHO 2011b)

Often, annoyance is the major consideration because it reflects the community's dislike of noise and their concerns about the full range of potential negative effects, and it affects the greatest number of people in the population.

There are many possible reasons for noise annoyance in different situations. Noise can interfere with communication or other desired activities. Noise can contribute to sleep disturbance, which can obviously be very annoying and has the potential to lead to long-term health effects. Sometimes noise is just perceived as being inappropriate in a particular setting without there being any objectively measurable effect at all. In this respect, the context in which sound becomes noise can be more important than the sound level itself.

Different individuals have different sensitivities to types of noise and this reflects differences in expectations and attitudes more than it reflects any differences in underlying auditory physiology. A noise level that is perceived as reasonable by one person in one context (for example in their kitchen when preparing a meal) may be considered completely unacceptable by that same person in another context (for example in their bedroom when they are trying to sleep). In this situation, the annoyance relates, in part, to the intrusion from the noise. Similarly, a noise level, which is considered to be completely unacceptable by one person, may be of little consequence to another even if they are in essentially the same room trying to undertake the some sorts of activities. In this case, the annoyance depends almost entirely on personal preferences, lifestyles and attitudes of the listeners concerned.

In relation to this project, potential noise impacts have been assessed against criteria developed by the World Health Organization (WHO 1999, 2009) that have been established on the basis of the relationship between noise and health impacts, where annoyance and sleep disturbance are of most significance. The predicted noise impacts are those that would be outside of a dwelling. The predicted impacts need to be below the World Health Organization guideline values that are protective of adverse health effects.

7.3 Assessment methodology

Noise criteria considered in this assessment are those from the NSW EPA Industrial Noise Policy (NSW EPA 2017b) and related documents.

Other guidance and guidelines used in this assessment include:

- Assessing Vibration: a technical guideline (NSW DEC 2006b)
- Interim Construction Noise Guideline (NSW DECC 2009)
- NSW Industrial Noise Policy (NSW EPA 2000)

The criteria used in NSW policy are in line with those available from the World Health Organisation (WHO 1999, 2011b).

For both construction and operations, noise and vibration have been assessed using the following approach:

- Identify relevant locations where people might be present that could be impacted by noise or vibration (i.e. identify sensitive receivers)
- Establish the existing noise/vibration environment at these locations
- Model potential changes in noise or vibration during construction or operations at these locations
- Identify if those potential changes comply with noise/vibration guidelines as determined by government authorities or if mitigation measures are required.

The assessment focuses on potential changes in noise or vibration due to a project. NSW guidance indicates what size of change is permissible using the criteria developed by WHO. The assessment also looks at changes in noise levels at different times of the day not just the average over the day or just during daytime.

The assessment has looked at 15 minute average changes in noise as well as changes over a day to determine if noise impacts from the project could impact on community health. Land uses are also considered in the assessment. The modelled noise levels are those for outside of buildings.

Noise modelling takes into account the types of equipment and activities that will be used/occur at a site and models how noise from the project will decrease with distance from the works in the surrounding areas. The noise will decrease as the distance from the noise source increases and it is also affected by the terrain and meteorological conditions.

7.4 Assessment of health impacts from noise and vibration for the project

The existing noise environment has been evaluated based on similar information from other developments proposed nearby – the M12 motorway and the Western Sydney Airport. Background noise was dominated by natural sounds and traffic along Elizabeth Drive at the AWRC and similar sounds along the pipelines. Given these other developments, the noise environment in the area is likely to change in the future with or without the AWRC. This also means the land uses in the area are also likely to change as the land is redeveloped and large developments like the M12 motorway and Western Sydney Airport are completed (Aurecon/ARUP 2021d).

Modelling of noise and vibration from equipment to be used during construction and operation and from traffic was undertaken. Noise modelling was undertaken assuming no noise mitigation measures were in place. Noise modelling also included traffic to and from the site. The modelling was undertaken using the model SOUNDPLAN v8.1 (Aurecon/ARUP 2021d).

7.4.1 Operation

During operations, modelling at most locations without consideration of noise mitigation measures indicated noise would not change significantly. During worst case meteorological conditions, most locations were no more than 1 or 2 dB(A) above target levels which is unlikely to be noticeable (Aurecon/ARUP 2021d).

Noise due to water travelling along the pipelines or due to discharge of water at the Nepean River at Wallacia or at Warragamba River is also expected to be within the relevant noise criteria as long as valves along the pipelines are appropriately located and designed (Aurecon/ARUP 2021d).

Mitigation measures that may be relevant for operation of the project include:

- ensuring that noise output be a consideration when choosing equipment like pumps
- if quieter equipment is not available, consideration be given to installing enclosures or barriers – this would only apply to the limited pieces of equipment that have higher noise output
- installation of noise controlling louvres with higher ratings than were modelled, if needed and where relevant
- standard procedures during operations like closing roller doors when undertaking certain activities to minimise noise into the surrounding areas (Aurecon/ARUP 2021d).

Modelling to include some of these measures was undertaken and confirmed that these extra noise control measures would be sufficient to meet the requirements of the NSW Industrial Noise Policy (Aurecon/ARUP 2021d).

Vibration during operation is estimated to be in compliance with all requirements given standard mounting and other installation features which minimise vibration from large equipment being transmitted off-site (Aurecon/ARUP 2021d).

Impacts on community health from changes in noise or vibration during operation are expected to be negligible with these mitigation measures included in the project.

7.4.2 Construction

Most works during construction are to be conducted during Standard Hours for which standard practices will be adopted to manage potential impacts. If works are to be undertaken during the night (or outside standard hours), some activities may require mitigation measures such as acoustic barriers, particularly where they are in proximity to residential receivers (Aurecon/ARUP 2021d).

Noise during construction has been modelled and is estimated to be elevated at some locations around the construction compounds and around the AWRC site (i.e. above standard noise management levels). However, noise at the AWRC site is not expected to reach levels that indicate neighbouring areas will be highly noise affected (Aurecon/ARUP 2021d).

Works in areas between the compounds will only be likely to occur over a few hours or days over the life of the project so impacts in these areas will be limited (Aurecon/ARUP 2021d).

Some of the equipment to be used during pipeline construction is expected to reach levels that could be above the highly noise affected triggers at times – for example, when there is need to use a chainsaw or a concrete saw. This is particularly the case when works are very close to neighbouring homes. Further modelling has been undertaken which considers how this equipment might be used (for how long and where). This more detailed assessment has shown there will be some locations which may be highly noise affected at times. Noise mitigation measures in these locations are discussed below (Aurecon/ARUP 2021d).

Vibration during construction is estimated to be in compliance with all requirements with the inclusion of commonly used mitigation measures – such as ensuring relevant equipment is not used too close to sensitive locations (Aurecon/ARUP 2021d).

During construction, the following mitigation measures are proposed:

- Preparation of a construction noise and vibration management plan (CNVMP) detailing all required procedures to be implemented by all contractors. The plan will include constraints on hours of operation, additional considerations for out of hours work, selection criteria for equipment to ensure low noise levels, set back distances from sensitive locations and requirements for alarms.
- Consideration of installation of site hoarding or acoustic enclosures to screen noisy equipment for some of the construction compounds (Compound C6, C12 and C13).
- Standard work practices such as consistent training of all those working at the site, regular site walkovers by managers to check for excess noise, avoiding use of radios, stereos, public address systems and shutting down plant and equipment when not in use.
- For vibration intensive equipment, minimum working distances have been set to ensure that such equipment is not used too close to sensitive locations.

Impacts on community health from changes in noise or vibration during construction are expected to be managed with these mitigation measures included in the project.

7.5 Outcomes of health impact assessment

Table 7.1 presents a summary of the outcomes of the assessment undertaken in relation to the impacts of changes in noise, associated with the proposed project, on community health.

Table 7.1: Summary of health impacts – noise and vibration

Noise and vibration	
Benefits	Neutral
Impacts	Based on the available data and information in relation to changes in noise or vibration due to the proposed facility during operation or construction, potential impacts on the health of the community have been assessed. The impact assessment has concluded that changes in noise are unlikely to impact on community health during operations or construction with the inclusion of relevant mitigation measures. The impact assessment has concluded that changes in vibration are unlikely to impact on community health during operations or construction with the inclusion of relevant mitigation measures.
Mitigation	Mitigation measures to manage potential impacts from changes in noise during operation of the proposed facility could include: ■ ensuring that noise output be a consideration when choosing equipment like pumps ■ if quieter equipment is not available, consideration be given to installing enclosures or barriers – this would only apply to the limited pieces of equipment that have higher noise output ■ installation of noise controlling louvres with higher ratings than were modelled, if needed and where relevant ■ standard procedures during operations like closing roller doors when undertaking certain activities to minimise noise into the surrounding areas. Mitigation measures to manage potential impacts from changes in noise during construction of the proposed facility could include: ■ Preparation of a construction noise and vibration management plan (CNVMP) detailing all required procedures to be implemented by all contractors. The plan will include constraints on hours of operation, additional considerations for out of hours work, selection criteria for equipment to ensure low noise levels, set back distances from sensitive locations and requirements for alarms. ■ Consideration of installation of site hoarding or acoustic enclosures to screen noisy equipment for some of the construction compounds (Compound C6, C12 and C13). ■ Standard work practices such as consistent training of all those working at the site, regular site walkovers by managers to check for excess noise, avoiding use of radios, stereos, public address systems and shutting down plant and equipment when not in use. ■ For vibration intensive equipment, minimum working distances have been set to ensure that such equipment is not used too close to sensitive locations.

Section 8. Health impacts: Soil – contamination

8.1 Introduction

This section presents a review of impacts on health associated with the presence and management of soil contamination relevant to the project. In the main, this relates to any contamination at the site (or along the pipeline routes) and how it will be addressed.

Health impacts associated with contamination have been assessed on the basis of the information within the technical paper:

- Aurecon/ARUP (2021e) Upper South Creek Advanced Water Recycling Centre: Soils and contamination impact assessment. Draft dated 6 November 2020.

Contamination risks to the community are more relevant to the construction phase of the project because exposure to contaminated soil, sediment or groundwater would most likely occur during the construction phase, if not appropriately managed. Operations at the plant are unlikely to result in additional contamination.

8.2 Background/Approach

The approach adopted for the assessment of soil contamination for this project included:

- Desktop review of existing information, aerial photography and previous reports of investigation in areas relevant for the project
- Sampling and analysis of soil samples for relevant locations to inform the development of a conceptual site model for the project
- Consideration of construction activities and their interaction with the possible sources of contamination within the project area (Aurecon/ARUP 2021e).

8.3 Assessment of health impacts

Aurecon/ARUP 2020b includes information about the geology and hydrology of the area. Some of this information has been included in **Section 2** of this report to provide an understanding of the location as part of the community profile (Aurecon/ARUP 2021e).

The site of the Advanced Water Recycling Centre is land that has been used for rural purposes. At the time of a site inspection in 2019, it was being used for cattle grazing. It is not expected that the site is particularly contaminated. All surrounding properties have been used for similar purposes and so are also not expected to be particularly contaminated (Aurecon/ARUP 2021e).

As a result, it is not expected that there will be significant contamination at the site. However, an appropriate investigation has been undertaken to demonstrate that this is the case.

8.3.1 Desktop review

To investigate the potential for soil contamination, a range of government databases and historic aerial photographs were reviewed (Aurecon/ARUP 2021e).

The databases interrogated include:

- register of contaminated sites maintained by NSW EPA – list of all sites that have been declared as needing remediation or requiring other management actions
- listing of notified sites maintained by NSW EPA – list of sites that have the potential to be contaminated but for which investigations are still continuing or investigations to date have shown no further action is required as contamination levels are low, if present at all.
- PFAS investigation information from NSW EPA
- unexploded ordinance database maintained by Dept of Defence
- national waste management database – lists former or current landfills and waste management sites
- NSW EPA licenced sites – lists sites which undertake activities that require a licence under NSW POEO Act (and former licenced sites)
- acid sulfate soils mapping

Potential contaminated sites at the AWRC site or near to the proposed pipelines were primarily current or former service station sites. Most of them were noted to not be significantly contaminated or to have already been remediated (Aurecon/ARUP 2021e).

Other findings from the desktop assessment include:

- Contamination of soil with per and polyfluoroalkyl substances (PFAS) from fire fighting or other uses is unlikely due to the historical use of the site. It is noted that there are 2 sites in the vicinity which are being investigated in regard to these compounds, but they are a significant distance from the project.
- No unexploded ordinance are expected at the site.
- Some current and former landfills are within the vicinity of the project.
- A small number of sites currently undertaking activities that require licences from the NSW EPA are present in the project vicinity.
- Historical filling and quarrying have occurred in the project vicinity.

8.3.2 Soil sampling

In addition to the use of information from government databases, soil was sampled along the pipeline routes and at the AWRC site.

Samples were analysed for the appropriate range of potential contaminants given the historical and current land uses in these areas. Appropriate screening guidelines were used to evaluate the results. At one location along the brine pipeline a soil sample reported some petroleum hydrocarbon contamination. This location was near a service station. At some other locations near service stations some bonded cement sheeting was reported to be present.

The conclusions of the soil sampling and analysis were as follows:

- The overall potential hazards to human health for on-site construction workers are considered to be low.
- There is a potential vapour hazard to on-site intrusive workers in the area immediately adjacent to the petrol station located at 709 Cabramatta Rd West Bonnyrigg due to exceedances of the soil vapour intrusion HSL. This can be managed in a number of ways.
- Asbestos fragments were detected 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. This can be managed in a number of ways.

8.3.3 Risk ranking

Information that has been collected in this assessment from the government databases and on-site investigations have been considered in combination with information about the activities to be undertaken during the construction and operation of the project to generate a risk ranking table. **Table 8.1** provides this ranking.

Table 8.1: Risk ratings of historical potential contamination (Aurecon/ARUP 2021e)

Location	Sites	COPCs	Risk Rating	Reasoning
Agricultural land use	AWRC	ACM, Heavy metals	High	ACM fragments were present in soils and in buildings on site within the AWRC site. Zinc and copper exceeded adopted EIL and ESL.
Air strip on Lot 2/DP88836	AWRC, BP, TW	PFAS	Low	No known exceedances of adopted guidelines
Kemps Creek Rural Fire Service	AWRC, BP, TW	PFAS	Low	No known exceedances of adopted guidelines
Western Rd to Brandown Quarry	BP	Heavy metals	Low	Zinc, copper and nickel exceedances in soil and groundwater. However, the metal concentrations noted to be natural
Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	AWRC	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, ACM	Low	Results from soil sampling near the site found no exceedances. However, no samples were done within the site. There is possible contamination within the site. Low risk due to the distance of the site to the AWRC (1.7 km) and no known exceedances around the site.
SUEZ Kemps Creek Resource Recovery Park	AWRC TW	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, ACM	Moderate	Groundwater containing copper, zinc, ammonia, nitrogen and nickel levels, and ground gas containing methane and carbon dioxide above adopted guidelines were found adjacent to the SUEZ site. Landfill gas is deemed to have a low risk to the project due to the distance between the two sites (400 m). There is a moderate risk associated with groundwater, as topography indicates that groundwater is expected to flow from west to east. However, the presence of South Creek between the two sites may act as a barrier or hydrogeological divide to the migration of groundwater.
Potential area of fill next to South Creek	AWRC	Heavy metals	Low	Copper and zinc exceeded groundwater guidelines. However, this does not present a risk to the project nor would the project likely impact groundwater
Corner of Elizabeth Drive and Range Road, Kemps Creek	BP	ACM	Moderate	ACM was present in the soil located to the north of Range Rd. The pipeline is proposed to be constructed on the south side of the road, but sections of the northern side may be within the impact area.
Western Sydney Airport	TW	TRH, BTEX, PAH, heavy metals, PCB, nutrients, ACM	Low	No known exceedances of adopted guidelines
Elizabeth Dr between The Northern Rd and M7	TW, BP	TRH, BTEX, PAH, heavy metals, PCB, ACM	Low	No known exceedances of adopted guidelines. Asbestos cement sheeting was present in waste piles located on the south side of Elizabeth Dr. However, these waste piles are unlikely to be impacted during construction due to the proposed AWRC pipeline alignment.

Location	Sites	COPCs	Risk Rating	Reasoning
Warragamba Wastewater Treatment Plant	EF	Heavy metals ACM *E. Coli*	Low	Heavy metals and *E. coli* exceedances of superseded guidelines in soil samples. ACM present on-site. Low risk due to the distance (500 m) from a section of the pipeline where surface soils will not be disturbed.
Park between Core Park Rd and Weir Rd	EF	ACM	Low	ACM present in soils. Area has since been remediated. Low risk due to distance (280 m) from a section of the pipeline where surface soils will not be disturbed.
Core Park Rd Dump Zone	EF	ACM PCBs	Low	Asbestos cement sheeting, friable asbestos wiring and a fluorescent light fitting present. Considered low risk as the site is adjacent to a section of the pipeline where surface soils will not be disturbed.
Megarritys Creek	EF	ACM	Low	ACM present on surface. Low risk as the site is adjacent to a section of the pipeline where surface soils will not be disturbed.
Warragamba Viewing Platform and Eighteenth St	EF	TRH, BTEX, PAH, heavy metals, PCB, ACM	Low - Moderate	ACM in soils and on surface exceeded the adopted criteria. TRH, benzo(a)pyrene and naphthalene exceedances in selected areas. The area has been remediated but residual ACM is still present on-site. The majority of the site is considered low risk as it is adjacent to a section of the pipeline where surface soils will not be disturbed. However, there is a moderate risk at the Warragamba exit of the Environmental Flows pipeline where there is fill and potential for ACM to be present.
Petrol Stations	TW, BP	TRH, ACM	High	TRH C6-C10 and TRH C6-C10 exceeded the HSL in one sample at BP_BH15 along the Brine pipeline. Asbestos fragment within samples along the Treated Water pipeline.

Notes:

COPCs chemicals of potential concern
ACM asbestos containing materials
PFAS per and polyfluoroalkyl substances
TRH total recoverable hydrocarbons (petroleum)
BTEX benzene, toluene, ethylbenzene, xylenes (petroleum)
PAH polycyclic aromatic hydrocarbons
OCP organochlorine pesticides
OPP organophosphorus pesticides
PCBs polychlorinated biphenyls
E.coli *Escherichia coli* (microorganism)

8.3.4 Construction activities

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

- Site preparation
- Excavations/earthworks including dewatering where required
- Stormwater management
- Installation of foundations, equipment, buildings and infrastructure

Construction will disturb land at the AWRC site or along the pipelines. This could result in interaction with existing contamination present in these areas. As with most construction projects, soil being disturbed during excavations will be managed in accordance with relevant plans which will require consideration of potential for contamination at known locations (those sites identified above) and classification of waste requirements for materials that need to be disposed. Procedures for unexpected finds will also be required in such plans.

The desktop review of existing information and contamination reports for sites around the site and pipeline routes as well as the results of project specific soil sampling has indicated that contamination in the project vicinity poses a low risk in the main.

There are some possible issues in regards to asbestos sheeting being present and with the quality of groundwater in some locations. These matters are not uncommon for developments in urban areas. There is also one location along the brine pipeline where soils contaminated by petroleum hydrocarbons may need to be managed adjacent to a service station.

Earthworks generally include observation of material as it is excavated to look for remnants of asbestos sheeting as standard practice to ensure it is noticed and managed appropriately. Groundwater contains some elevated levels of metals and nutrients down gradient of landfills in the area. These are naturally occurring compounds and can be present due to natural conditions or due to human activities. Quality of this groundwater would only be relevant should such groundwater need to be removed from an excavation in the relevant area. In such situations, it will be important to manage its disposal appropriately in accordance with government requirements.

As long as these particular aspects (presence of concrete sheeting in a range of locations, presence of petroleum contamination in one location and managing groundwater from dewatering of excavations) are appropriately managed, as has been proposed, no impacts to community health are expected due to contamination through the project construction.

8.3.5 Operational activities

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.

Operational activities at the AWRC site have the potential to impact on surrounding soils as potential receptors of contaminated materials, if appropriate chemical/contaminant management systems and mitigation measures are not in place. Without management measures, the storage and use of chemical at the AWRC during operation has the potential to cause soil and groundwater contamination. Potential operational impacts include:

- Infiltrating runoff may contain low to medium levels of hydrocarbons, metals, suspended sediments and nutrients resulting from the operation of vehicles and machinery (similar to any site with vehicles and heavy machinery).
- Chemical spills may result in other harmful contaminants being transported to the environment.
- Process tanks overflows or leakages may result in partially or untreated wastewater being discharged from the site and entering the soil and groundwater systems.

For the pipelines, leaks from the system would be the main possible pathway for contamination to occur. For most of the pipelines, the water inside is relatively clean – acceptable for discharge into waterways. The brine pipeline contains water with a much higher salt content.

Standard practices, in line with government requirements (such as chemical storage being within bunded areas), at the AWRC and in the operation of the pipelines would be expected to minimise potential risks for contamination during operations and, as a result, any potential to impact on community health.

8.4 Outcomes of health impact assessment

Table 8.2 presents a summary of the outcomes of the assessment undertaken in relation to the impacts of soil contamination, associated with the proposed project, on community health.

Table 8.2: Summary – soil (including contamination)

Soil (including contamination)	
Benefits	Benefits include the clean up of existing contamination at the site and along the pipeline routes where such exists. Only low levels of contamination have been identified but the process of construction will result in some management of existing soils and groundwater contamination.
Impacts	Risks are expected to be low during both construction and operation. The following low risks during construction have been identified: - Potential presence of asbestos sheeting where earthworks are needed - Potential presence of metals and nutrients in groundwater in some locations - Potential presence of petroleum hydrocarbons along the brine pipeline route adjacent to a service station
Mitigation	A range of standard practices will be included in this project to ensure contamination is managed appropriately during construction. These could include: - Preparation of a construction environmental management plan (CEMP) to document all required actions to manage materials including procedures for unexpected finds, observation for asbestos containing materials in excavated material, appropriate dewatering procedures where required and required measures for any soil contaminated by petroleum hydrocarbons adjacent to the relevant service station along the brine pipeline - In accordance with Work Health and Safety regulations, hazardous materials surveys must be undertaken prior to any demolition works

Soil (including contamination)	
	A range of standard practices will be included in this project to ensure contamination is managed appropriately during operation. These could include: - Preparation of an operational environmental management plan (OEMP) to document required actions to appropriately manage the handling of fuel, chemicals, wastes and equipment used during operations. All need to be handled in accordance with government requirements and the OEMP will outline how this is to occur.

Section 9. Health impacts: Safety

9.1 Introduction

This section presents a review of impacts on health associated with issues related to safety in regard to the use of chemicals during the operation of the facility.

Health impacts associated with safe use of hazardous substances have been assessed on the basis of the information within the technical paper:

- Aurecon/ARUP (2021f) Preliminary hazard analysis. Upper South Creek Advanced Water Recycling Centre. Draft dated 19 October 2020.

9.2 Background/Approach

Wastewater treatment requires the use of a range of chemicals. To check whether the storage or use of such chemicals requires consideration under State Environment Planning Policy (SEPP) 33, a multi-level assessment has been undertaken.

SEPP 33 covers developments that may be hazardous or involve the use of hazardous chemicals. NSW guidance about what constitutes hazardous development and how to evaluate whether a particular development can be classified as hazardous is provided in the following documents:

- NSW Government 2014, *State Environmental Planning Policy No 33—Hazardous and Offensive Development* (NSW Government 2014)
- NSW Planning 2011, *Hazardous and Offensive Development Application Guidelines Applying SEPP 33* (NSW Planning 2011c)
- NSW Planning and Infrastructure 2011, *Assessment Guideline Multi-level Risk Assessment* (NSW Planning and Infrastructure 2011)
- NSW Planning 2011b, *Risk Criteria for Land Use Safety Planning, Hazardous Industry Planning Advisory Paper No 4* (NSW Planning 2011b)
- NSW Planning 2011, *Hazardous Industry Planning Advisory Paper No 6, Hazard Analysis* (NSW Planning 2011a)

Hazardous industry are sites where one or more chemicals that are classified as Dangerous Goods are stored in sufficient quantity that if an accident were to occur or if some of the control measures were to fail, it could create a situation that could concern the community. Such events might have the potential to cause significant injury.

The objective of such assessments is to determine if hazardous processes or hazardous materials that may be present on a site in order to undertake relevant activities could potentially have impacts in off-site areas at an unacceptable level.

Government guidance provides screening criteria and checklists to determine whether a particular development might need to be assessed under this regulation. Such criteria include the types of materials used at a site and the amounts of such materials that might be stored at a site.

If a development requires evaluation, the first step in this process is a preliminary hazard analysis (NSW Planning 2011a). The assessment of the suitability of a site to accommodate an existing or proposed development of a potentially hazardous nature must be based on consideration of:

- the nature and quantities of hazardous materials stored and processed on the site
- the type of plant and equipment in use
- the adequacy of proposed technical, operational and organisational safeguards
- the surrounding land uses or likely future land uses
- the interactions of these factors (NSW Planning 2011a).

It involves consideration of the nature of the materials and processes at a development and what, if anything, could go wrong in handling such materials or undertaking such processes.

9.3 Assessment of health impacts – management of hazardous materials

The property proposed for the AWRC has been used for cattle grazing which means it does not currently include use and storage of hazardous materials or processes.

It is noted that storage and handling of all of chemicals used at the site must be in accordance with all government guidance for dangerous goods. Such guidance includes the use of engineering of tanks, bunds and related infrastructure to ensure risks to on and off-site areas are minimised.

Aurecon/ARUP (2021f) undertook the first screening step to determine if the AWRC could fall under this regulation. Threshold amounts for particular chemicals or types of chemicals have been established in NSW guidance.

It is only if the amount to be used/stored on-site exceeds this threshold that further assessment is required. The threshold was exceeded for methanol and the group of chemicals that are corrosive. It is noted that a final decision on whether methanol will be used at the site is still to be taken. For the purposes of this assessment, it has been assumed that it will be used on-site (Aurecon/ARUP 2021f).

Exceeding these thresholds means that further assessment – a preliminary hazard analysis – is required (Aurecon/ARUP 2021f).

The preliminary hazard analysis has looked at what could go wrong. It is noted that engineering and other types of controls are built into equipment, storage and procedures at sites which may be classified as potentially hazardous. Such controls reduce the potential for anything to go wrong. The preliminary hazard analysis is designed to determine what could happen if something does go wrong regardless of how unlikely that will be.

Given the types of materials to be used at the site, the following events are relevant for further consideration:

- Methanol is a flammable substance so a fire could occur if there was a leak from a storage tank and a spark occurred or if a tanker delivering methanol to the site had an accident.

- Biogas is produced in the digester and will be stored for use in co-generation – this is mostly methane and so could explode if it were to leak from the storage and a spark occurred.
- Corrosive substances can react with other chemicals if stored improperly – these reactions can lead to fire (Aurecon/ARUP 2021f).

Other hazards that could occur at the site relate to the handling of water used during fire fighting, should a fire occur at the site (bushfire or fire due to chemicals/processes on-site). It is noted that the site location is classified as bushfire prone. There are a range of requirements that apply to sites that are classified as bushfire prone and about the handling of fire fighting water.

The preliminary hazard analysis has found that the following types of events, were they to occur, will not be sufficient to affect off-site areas:

- Fire due to a leak from storage of methanol given current site layout (location of methanol storage and amount of methanol stored limit the size of any such fire)
- Fire or movement of vapours due to a spill from a tanker transporting methanol to the site should it occur outside of a sensitive receptor like a school (amount of methanol in such a tanker limits the size of any such fire)
- Explosion due to leak from biogas storage given current site layout (location of biogas storage and amount of methanol stored limit the size of any such fire)
- Reactions due to incompatible storage of chemicals given current site layout (strict requirements (in line with government guidance) about how such chemicals can be stored).

More detailed analysis of the potential likelihood of such events is, therefore, not required.

For all potentially hazardous developments there are a range of existing legal requirements that must be included in any designs. These include things like:

- Requirement for environment protection licence (depends on the activity)
- Dangerous goods requirements for on-site storage
- Australian Standard requirements (AS3780-2008) for engineering of structures on-site where corrosive substances are stored
- Dangerous goods requirements for transport
- Bunding requirements

Another mitigation measure to be included in this project is ensuring the layout of the site ensures relevant structures are appropriately placed in regard to the boundaries of the site. Attention to layout will also be considered during any expansion of infrastructure in the future.

One additional step is recommended, if methanol is confirmed for use at the AWRC – detailed consideration of the transport route for delivery to ensure avoidance of sensitive locations to the maximum extent practical. This is a common requirement when transporting dangerous goods on a regular basis to a particular site.

9.4 Assessment of health impacts – flooding

Aurecon/ARUP (2021b) provides information on the assessment of the potential for impacts on the downstream flooding regime due to the project.

Changes to a flooding regime can occur due to:

- Changes to flood prone land
- Changes in peak runoff rates due to larger areas of hardstand etc

Given the installation of the pipelines for this project will be underground as much as possible, there is little impact to flooding regimes from this infrastructure.

The installation of the AWRC will increase the amount of hardstand at this site. This increase in impervious area has the potential for more (or faster runoff) from the site. Flood modelling was undertaken. Only minor changes in peak flood levels were noted and there were no observable changes in the 10% or 1% AEP (annual exceedance probability) events.

A flood preparedness plan will be developed to ensure appropriate stormwater management systems are installed at the AWRC and operated appropriately.

9.5 Assessment of health impacts – bushfire

An assessment of the potential for the AWRC site to be impacted by bushfire was undertaken as part of the overall evaluation of the project (Building Code and Bushfire Hazard Solutions 2020). The AWRC site is noted to be on the "Bushfire prone land map" published by Penrith Council[9]. It is noted that Category 2 vegetation is in this location. Such vegetation is considered to be a lower risk than the other vegetation categories mentioned in the Rural Fire Service (RFS) guidance[10]. It consists of remnant vegetation and lower bushfire risk vegetation. It also includes areas where development in the vicinity means that any ignition would be quickly noticed.

The assessment noted that the extent of this type of vegetation in the vicinity of the AWRC was not sufficient to require specific buffer zones or other bushfire management measures (Building Code and Bushfire Hazard Solutions 2020).

There are no other aspects of the site or location that would trigger specific measures under bushfire protection regulations. However, Sydney Water infrastructure is critical in nature so appropriate consideration of bushfire risks is important (Building Code and Bushfire Hazard Solutions 2020).

Additional guidance from the RFS provides useful information about designing facilities to manage bushfire risks[11]. The assessment for this site notes that the facility will be designed in accordance with the relevant sections of this guidance (Building Code and Bushfire Hazard Solutions 2020).

---

[9] https://www.penrithcity.nsw.gov.au/news/bushfire-prone-land-map-updated

[10] Guideline for Councils on bushfire prone area land mapping (https://www.rfs.nsw.gov.au/resources/publications/building-in-a-bush-fire-area?result_1335_result_page=2)

[11] https://www.rfs.nsw.gov.au/plan-and-prepare/building-in-a-bush-fire-area/planning-for-bush-fire-protection

The major features of such design include:

- ensuring there are sufficient asset protection zones between areas of the AWRC and the surrounding vegetation (category 2)
- ensuring adequate access to water
- electrical services will be installed underground at the site (Building Code and Bushfire Hazard Solutions 2020).

Other aspects to be considered for inclusion (or to be included) are:

- sprinkler system for solar panel area
- safe access/egress designed into the plant
- green roof will use low risk plantings
- adequate water for building protection
- buildings (where relevant) to meet bushfire attack levels.

In addition, a bushfire hazard assessment will be prepared as part of the detailed design works.

Bushfire risk needs to be managed in accordance with government requirements in the design of the facility and, as long as that is done, impacts to human health due to bushfire will be as low as possible and appropriately managed.

9.6 Assessment of health impacts – subsidence

The construction area for the project is not located within any mine subsidence districts as defined by Subsidence NSW. Impacts to subsidence from construction activities, or impact from subsidence on the construction of the project is not anticipated. Given that subsidence is not expected to occur as part of this project, no health impacts from subsidence are expected.

9.7 Outcomes of health impact assessment

Table 9.1 presents a summary of the outcomes of the assessment undertaken in relation to the potential issues relating to safety (including use/storage of hazardous chemicals, flooding, bushfires or subsidence), associated with the proposed project, on community health.

Table 9.1: Summary of health impacts – safety

Safety	
Benefits	Neutral
Impacts	Based on the available data and information, potential impacts on the health of the community due to public safety issues such as flood, subsidence, bushfire or handling and use of dangerous goods have been assessed and determined to be negligible when managed in accordance with government requirements.
Mitigation	Existing legal requirements for the storage and transport of hazardous substances must be complied with at the AWRC. Development of a flood preparedness plan and bushfire hazard assessment during the detailed design phase will be required to ensure appropriate design.

Section 10. Health impacts: Transport and traffic

10.1 Introduction

This section presents a review of impacts on health associated with transport and traffic issues arising from the project.

Health impacts associated with changes in traffic due to the project have been assessed on the basis of the information within the technical paper:

- Aurecon/ARUP (2021g) Upper South Creek Advanced Water Recycling Centre: Traffic and transport technical report. August 2021.

10.2 Background/Approach

The potential for impacts due to changes in transport and traffic during construction or operation of the AWRC or its pipelines has been assessed.

Congested traffic has the potential to impact on health in a number of ways. Increased anxiety, reduced air quality, increased noise, and poor perceptions of an area due to safety issues are all possible.

In this case, traffic levels along roads immediately adjacent to the AWRC site are currently very low. Major roads nearby, like Elizabeth Drive, are more relevant for this assessment.

The assessment of changes in traffic during construction and during operation has been undertaken in accordance with relevant guidance. The assessment was required to assess changes in traffic from this development in addition to those already likely due to the construction of the M12 motorway and the Western Sydney Airport.

The assessment of changes in traffic includes the following steps:

- Understand existing traffic in all relevant areas using available data and historic data from surveys etc including consideration of expected population growth in the area
- Understand potential impacts on traffic from the other large construction projects in the area (M12 and Western Sydney Airport) based on planning documentation
- Evaluate potential traffic during construction including for construction workers (focusing on potential for delays at major intersections)
- Identify any impacts to traffic, public transport, walking and cycling
- Evaluate potential traffic during operation (focusing on potential for delays at major intersections)
- Identify any impacts to traffic, public transport, walking and cycling
- Develop mitigation measures, if required.

10.3 Assessment of health impacts

Health impacts due to traffic at the proposed site for the AWRC are currently minimal as there are no paved roads accessing the site and the local roads are only accessed by those living or working in the area. The existing roads are not through roads that provide desired connections between locations. The provision of public transport and active transport, such as walking and cycling, is limited in the area, given its primary use for rural pursuits.

Operations

The assessment undertaken in Aurecon/ARUP (2021g) once the project is operational evaluated changes in the level of service, degree of saturation and queue length when looking at the potential impacts of the project on traffic at major intersections that could be affected by the project. Changes in traffic due to activities at the AWRC site were the focus of this assessment. Traffic changes due to occasional maintenance along the pipelines were expected to be negligible (Aurecon/ARUP 2021g).

Operations at the plant will require changes in traffic to enable workers to access the site (daily at the beginning and end of the day) and to allow materials to be delivered to or removed from the site. It is expected that there will be no more than 1 or 2 truck movements per day to allow delivery and removal of materials (Aurecon/ARUP 2021g).

One of the benefits of the project will be that a number of local roads/intersections are expected to be upgraded. Local roads connecting Clifton Avenue to the project site are likely to be upgraded by being paved. Clifton Avenue will be realigned as part of the M12 development and will include overbridge access to cross the M12. This will provide benefits to those living and working in the area. Improvements to public transport, walking and cycling routes are proposed for inclusion in the M12 motorway project and for the Western Sydney Airport and related developments (Aurecon/ARUP 2021g).

The closest intersection that might be impacted by the project is the intersection of Clifton Avenue and Elizabeth Drive. The assessment showed that there could be a reduction in the level of service (i.e. increase in the delay to cross) at this intersection, but it was considered that this would only have a low impact on traffic in the area. Mitigation measures for this intersection that may be considered include adjusting the controls at the intersection to enhance opportunities for vehicles to turn onto Elizabeth Drive from Clifton Avenue and to ensure truck movements for the AWRC are scheduled to occur outside of peak traffic periods on Elizabeth Avenue (Aurecon/ARUP 2021g).

Construction

Changes in traffic during construction have been modelled for both the AWRC site and the pipelines. The assessment looked at the potential for construction traffic to change baseline traffic flows on major roads and for the increase in traffic due to construction to be greater than relevant lane capacity requirements in national guidance (Aurecon/ARUP 2021g).

The assessment considered the potential for increase in cars as well as light and heavy vehicles due to construction. It assumed that peak daily vehicle movements at each works compound (the AWRC site and areas along the pipelines) would occur at the same time even though it is not likely that all such works would peak at the same part of the project construction (Aurecon/ARUP 2021g).

The assessment found that there is potential for congestion on Elizabeth Drive, Cowpasture Road and Hume Highway. Congestion along these roads will be due to all the infrastructure projects in the area, not just the development of the AWRC and pipelines. This increased congestion is likely to occur with or without the AWRC project (Aurecon/ARUP 2021g).

Most other roads will only be marginally impacted by this project during construction as there is capacity and/or the increase in the number of vehicles due to the project for a particular road will be smaller as the distance from the project area increase (Aurecon/ARUP 2021g).

Other matters that might need to be managed during construction include:

- movement/access of bus stops or bus routes themselves during works to install the pipelines – impact expected to be temporary
- access to footpaths and cycleways during works to install the pipelines – impact expected to be temporary
- access to homes or businesses during works to install the pipelines – impact expected to be temporary

Such issues will only occur for short periods but ensuring appropriate communication will be important to manage impacts on the community and their wellbeing.

As with many large projects, a construction traffic management plan (CTMP) will be developed for the project and will include requirements for the AWRC and for areas where pipeline construction will occur. The CTMP will include requirements to consult with local and state agencies as well as local communities to develop appropriate management for the various temporary constraints that may impact on traffic flows as a result of this project.

10.4 Outcomes of health impact assessment

Table 10.1 presents a summary of the outcomes of the assessment undertaken in relation to the impacts of changes in traffic associated with the proposed project, on community health.

Table 10.1: Summary of health impacts – traffic

Traffic	
Benefits	Upgrades to local roads as part of this project and upgrades to other major roads in the area due to the various infrastructure projects being proposed will provide benefits to the local community.
Impacts	Based on the available data and information, potential impacts on the health of the community due to the changes in traffic during construction and operation have been assessed. Potential impacts during construction have been determined to be manageable and temporary/short-term in most cases. Potential impacts during operation have been determined to be negligible.
Mitigation	During construction, a construction traffic management plan will be prepared to ensure changes to traffic due to the project are managed appropriately. It will be important that all requirements built into the CTMP are followed by all contractors working for the project. Measures to manage temporary changes to traffic arrangements (affecting access etc) will be based on consultation with local and state agencies as well as the local community. During operation, ensuring truck movements are scheduled outside of peak times would ensure impacts from this project will be negligible.

Section 11. Health impacts: Waste

11.1 Introduction

This section presents a review of impacts on health associated with waste management for the project.

Health impacts associated with waste management have been assessed on the basis of the information within the technical paper:

- Aurecon/ARUP (2021h) Upper South Creek Advanced Water Recycling Centre: Waste management impact assessment report. August 2021.

11.2 Background/Approach

Poor management of wastes can result in a range of unacceptable risks – from impacts on amenity in natural areas due to littering through to potential for fires in poorly stored tyres or waste chemicals through to contamination of land and impacts on waterways from inappropriate dumping of municipal waste. Another impact of poor waste management is the loss of access to resources when materials are disposed inappropriately.

Legal frameworks have been put in place to ensure appropriate management of wastes to the extent practicable. In NSW, this framework is outlined in the following:

- Protection of the Environment Operations Act 1997 (POEO Act) (NSW Government 1997, 2001)
- Protection of the Environment Operations (Waste) Regulation, 2014
- Waste Avoidance and Resource Recovery Act, 2001 (NSW Government 2001)
- NSW EPA – Waste Classification Guidelines, 2014 (Part 1 Classifying Waste) (NSW EPA 2014a) (NSW EPA 2016)
- NSW EPA – Waste Avoidance and Resource Recovery Strategy, 2014 – 2021 (NSW EPA 2014b)

In addition, there is a National Waste Policy (Australian Government 2018).

This assessment evaluated the types of wastes and likely management for the project in line with these requirements.

In particular, the waste management hierarchy, as shown in **Figure 11.1**, was considered.

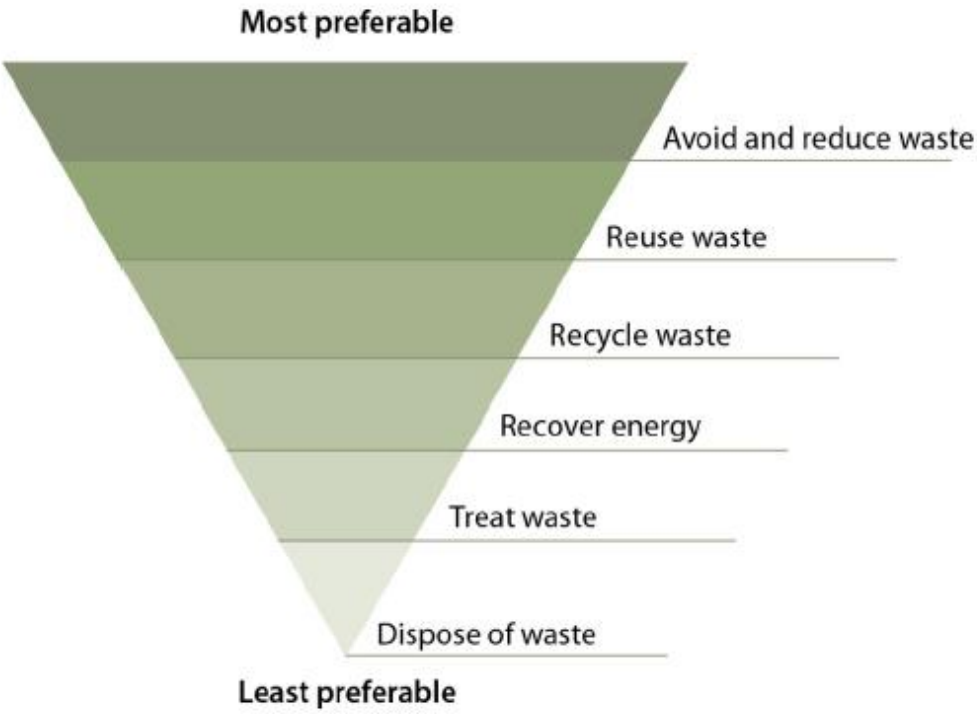


Figure 11.1: Waste management hierarchy (NSW EPA 2014b)

11.3 Assessment of health impacts from wastes

The assessment of waste management associated with the Proposed Project is outlined in the Waste management impact assessment report technical paper.

It is noted that this facility is itself a critical component of waste management for urban areas. Ensuring appropriate (and best practice) management of wastewater is critical to managing public health.

In common with most large developments, this Project would generate waste during construction and operation. Appropriate consideration of the various types of waste and methods of management will ensure that impacts of such waste will be negligible.

The assessment included consideration of the plans for the construction and operation of the facility, review of relevant information regarding waste management for other wastewater treatment plants and water recycling plants operated by Sydney Water as well as the findings of technical studies on soil contamination, traffic and transport, greenhouse gases and safe handling of hazardous substances.

During construction of the AWRC and pipelines, waste streams are expected to include:

- Tyres (from normal use of plant and equipment)
- Oils (from normal use of plant and equipment)
- Fuels, paints etc (normal use during construction)
- Batteries (from normal use of plant and equipment)
- Excavated soils

- Green waste (vegetation cleared from the site prior to excavation)
- Construction wastes (electrical materials, plumbing materials, metals (nuts, bolts etc), packaging, geotextile offcuts, wood etc)
- Office wastes (paper, cardboard)
- Stormwater system wastes (litter, sediment etc)
- Food waste (from construction workforce)
- Drilling muds
- Asbestos containing soils (potential)

During operation of the AWRC and pipelines, waste streams are expected to include:

- Tyres (from normal use of plant and equipment)
- Oils (from normal use of plant and equipment)
- Fuels, paints etc (normal use)
- Chemicals (wastewater treatment chemicals, odour control chemicals)
- Batteries (from normal use of plant and equipment)
- Green waste (landscaping)
- E-waste (computers etc)
- Spent filters (odour control equipment)
- Office wastes (paper, cardboard, plastic)
- Stormwater system wastes (litter, sediment etc)
- Food waste (from construction workforce)
- Maintenance supplies (lightbulbs, equipment maintenance)
- Wood waste (pallets, crates)

As with any development, it is not possible to completely avoid the creation of waste during construction and during operation. Consequently, there is potential for impacts to human health if such wastes are not managed appropriately. The waste management hierarchy provides the framework from mitigating any impacts of these wastes.

The waste hierarchy involves consideration of the opportunities to reduce, reuse, recycle or recover materials before just disposing of materials to landfill that are not needed any further.

During construction, a waste management plan (and spoil management plan) will be prepared to facilitate the reduction, reuse or recycling of wastes as well as appropriate disposal if no other action is possible.

During operation, a waste management system will be implemented to govern the overall usage of materials at the site and maximise reuse and recycling of materials. Waste storage areas will be included in the design and they will be big enough to enable appropriate storage of waste materials for reuse and recycling. Water sensitive urban design principles will help ensure a site design that keeps stormwater as clean as possible and reduces the use of potable water.

11.4 Outcomes of health impact assessment

Table 11.1 presents a summary of the outcomes of the assessment undertaken in relation to the impacts of waste management associated with the proposed project, on community health.

Table 11.1: Summary of health impacts – waste

Waste	
Benefits	Neutral
Impacts	Based on the available data and information, it is not possible to completely avoid the generation of waste materials during construction and operation. Whenever wastes are poorly managed, there is potential for impacts to human health or the environment.
Mitigation	Due to the need to ensure wastes are appropriately managed Governments have established legal frameworks in Australia to establish systems and policies. These requirements including the waste management hierarchy will be implemented when considering the most appropriate outcomes for managing wastes from the construction or operation of the project. The approaches to be adopted will be outlined in the construction waste management plan and a construction spoil management plan which will be in accordance with state requirements and with Sydney Water policies. During operations, appropriate waste management will be considered and achieved through the Sydney Water environmental management system. This system is independently certified and ensures waste management maximises sustainability and minimises risks throughout the life of the project.

Section 12. Conclusions

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Sydney Water to prepare a Human Health Impact Assessment (HIA) for the proposed Advanced Water Recycling Centre and associated pipelines.

Sydney Water is proposing to build and operate a new treatment facility to provide wastewater services to this area. The project will comprise:

- a new Advanced Water Recycling Centre (AWRC) that would collect wastewater from businesses and homes and treat it to produce high-quality treated water, renewable energy and biosolids for beneficial reuse
- a new green space area around the AWRC, adjacent to South Creek and Kemps Creek, that would support the ongoing development of a green spine through Western Sydney
- a new treated water pipeline from the AWRC to the Nepean River at Wallacia Weir, that would release high-quality treated water to the River during normal weather conditions
- a new pipeline from Wallacia to the Warragamba River, releasing water just below the Warragamba Dam
- new infrastructure from the AWRC to South Creek, that would release excess highly treated water during significant wet weather events, estimated to occur at about 3 – 18 days each year
- a new brine pipeline from the AWRC connecting into Sydney Water's existing wastewater system which carries brine to the Malabar plant for treatment
- a range of ancillary infrastructure.

An environmental impact statement (EIS) is being prepared for this project and this HIA addresses the potential risks and benefits to human health posed by this project.

As noted by WHO (WHO 2018):

"Sanitation saves lives. But history teaches us that it's also one of the key building blocks of development.

Ancient civilizations that invested in sanitary improvements became healthy, wealthy, powerful societies. More recently, modernization and economic growth have followed investments in sanitation systems.

Sanitation prevents disease and promotes human dignity and well-being, making it the perfect expression of WHO's definition of health, as expressed in its constitution, as "A state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity"."

In Australia, having a well managed system for wastewater management is taken for granted by many people. But it is important that such systems are evaluated and expanded as required to ensure this critical component of public health management continues to do its job.

This health impact assessment has looked at the potential for impacts to community health due to the project.

It is noted that having such a facility provides a significant benefit to society as long as it is appropriately designed and operated.

Potential impacts to community health for this project have been considered in regard to:

- Water quality
- Air quality
- Changes in noise and vibration
- Soil contamination
- Safety (including safe handling of chemicals, flooding, bushfire, subsidence)
- Traffic
- Waste management

The results of this evaluation of potential impacts to community health are provided in **Table 12.1**.

Table 12.1: Summary of the assessment of potential health impacts for the project

Project	
Benefits	The primary/major benefit of this facility is that it will provide appropriate management of wastewater in an area that is currently not provided with such services. This area is being opened up for residential development and so will need wastewater services. As discussed, providing appropriate management of wastewater is a benefit to society. Other benefits include the clean up of existing contamination at the site and along the pipeline routes where such exists. Only low levels of contamination have been identified but the process of construction will result in some management of existing soils and groundwater contamination. Upgrades to local roads as part of this project and upgrades to other major roads in the area due to the various infrastructure projects being proposed will provide benefits to the local community.
Water	
Impacts	Based on the available data and information in relation to changes in water quality due to the proposed facility during operation or construction, potential impacts on the health of the community have been assessed. The impact assessment has concluded that changes in water quality are unlikely to impact on community health during operations or construction with the inclusion of relevant mitigation measures.
Mitigation	Mitigation measures to manage potential impacts from changes in water quality during operation of the proposed facility include: - Ensuring, for each discharge scenario, that the highest relevant level of treatment can be applied to the greatest volume by appropriate maintenance and operation of equipment. - Undertaking appropriate monitoring, in line with requirements of the Environment Protection Licence under which the AWRC will operate, to ensure the plant is operating as expected.

	■ Undertaking appropriate monitoring of the receiving environments to allow for evaluation of any changes in water quality compared to upstream/background that could occur.
Air quality	
Impacts	Based on the available data and information in relation to emissions to air from the proposed facility during operation (odours/nitrogen dioxide), potential impacts on the health of the community have been assessed. The impact assessment has concluded the following: ■ There are no acute inhalation exposure risks of concern. ■ There are no chronic inhalation exposure risks of concern.
Mitigation	No mitigation measures (apart from those incorporated into equipment) are required to manage potential impacts on air quality during operation of the proposed facility. Standard dust control measures during earthworks will be implemented as part of the Construction Environmental Management Plan. Such measures include: ■ Stabilising exposed areas as soon as possible with tarpaulins/geotextiles ■ Dust control measures (non-potable water) ■ Maintenance of all equipment in good working order ■ Switching off equipment and vehicles when not in use ■ Modifying/ceasing work practices in windy conditions ■ Rehabilitation of areas (spray grass or final vegetation) when earthworks are completed ■ Covering all waste during transport.
Noise and vibration	
Impacts	Based on the available data and information in relation to changes in noise or vibration due to the proposed facility during operation or construction, potential impacts on the health of the community have been assessed. The impact assessment has concluded that changes in noise are unlikely to impact on community health during operations or construction with the inclusion of relevant mitigation measures. The impact assessment has concluded that changes in vibration are unlikely to impact on community health during operations or construction with the inclusion of relevant mitigation measures.
Mitigation	Mitigation measures to manage potential impacts from changes in noise during operation of the proposed facility could include: ■ ensuring that noise output be a consideration when choosing equipment like pumps ■ if quieter equipment is not available, consideration be given to installing enclosures or barriers – this would only apply to the limited pieces of equipment that have higher noise output ■ installation of noise controlling louvres with higher ratings than were modelled, if needed and where relevant ■ standard procedures during operations like closing roller doors when undertaking certain activities to minimise noise into the surrounding areas. Mitigation measures to manage potential impacts from changes in noise during construction of the proposed facility could include: ■ Preparation of a construction noise and vibration management plan (CNVMP) detailing all required procedures to be implemented by all contractors. The

	plan will include constraints on hours of operation, additional considerations for out of hours work, selection criteria for equipment to ensure low noise levels, set back distances from sensitive locations and requirements for alarms. - Consideration of installation of site hoarding or acoustic enclosures to screen noisy equipment for some of the construction compounds (Compound C6, C12 and C13). - Standard work practices such as consistent training of all those working at the site, regular site walkovers by managers to check for excess noise, avoiding use of radios, stereos, public address systems and shutting down plant and equipment when not in use. - For vibration intensive equipment, minimum working distances have been set to ensure that such equipment is not used too close to sensitive locations.
Soil (including contamination)	
Impacts	Risks are expected to be low during both construction and operation. The following low risks during construction have been identified: - Potential presence of asbestos sheeting where earthworks are needed - Potential presence of metals and nutrients in groundwater in some locations - Potential presence of petroleum hydrocarbons along the brine pipeline route adjacent to a service station
Mitigation	A range of standard practices will be included in this project to ensure contamination is managed appropriately during construction. These include: - Preparation of a construction environmental management plan (CEMP) to document all required actions to manage materials including procedures for unexpected finds, observation for asbestos containing materials in excavated material, appropriate dewatering procedures where required and required measures for any soil contaminated by petroleum hydrocarbons adjacent to the relevant service station along the brine pipeline - In accordance with Work Health and Safety regulations, hazardous materials surveys must be undertaken prior to any demolition works A range of standard practices will be included in this project to ensure contamination is managed appropriately during operation. These include: - Preparation of an operational environmental management plan (OEMP) to document required actions to appropriately manage the handling of fuel, chemicals, wastes and equipment used during operations. All need to be handled in accordance with government requirements and the OEMP will outline how this is to occur.
Safety	
Impacts	Based on the available data and information, potential impacts on the health of the community due to public safety issues such as flood, subsidence, bushfire or handling and use of dangerous goods have been assessed and determined to be negligible when managed in accordance with government requirements.
Mitigation	Existing legal requirements for the storage and transport of hazardous substances must be complied with at the AWRC. Development of a flood preparedness plan and bushfire hazard assessment during the detailed design phase will be required to ensure appropriate design.

Traffic	
Impacts	Based on the available data and information, potential impacts on the health of the community due to the changes in traffic during construction and operation have been assessed. Potential impacts during construction have been determined to be manageable and temporary/short-term in most cases. Potential impacts during operation have been determined to be negligible.
Mitigation	During construction, a construction traffic management plan will be prepared to ensure changes to traffic due to the project are managed appropriately. It will be important that all requirements built into the CTMP are followed by all contractors working for the project. Measures to manage temporary changes to traffic arrangements (affecting access etc) will be based on consultation with local and state agencies as well as the local community. During operation, ensuring truck movements are scheduled outside of peak times would ensure impacts from this project will be negligible.
Waste	
Impacts	Based on the available data and information, it is not possible to completely avoid the generation of waste materials during construction and operation. Whenever wastes are poorly managed, there is potential for impacts to human health or the environment.
Mitigation	Due to the need to ensure wastes are appropriately managed Governments have established legal frameworks in Australia to establish systems and policies. These requirements including the waste management hierarchy will be implemented when considering the most appropriate outcomes for managing wastes from the construction or operation of the project. The approaches to be adopted will be outlined in the construction waste management plan and a construction spoil management plan which will be in accordance with state requirements and with Sydney Water policies. During operations, appropriate waste management will be considered and achieved through the Sydney Water environmental management system. This system is independently certified and ensures waste management maximises sustainability and minimises risks throughout the life of the project.

Section 13. References

Project specific references:

Jacobs (2020) Air quality impact assessment. Dated 27 November 2020

Aurecon/ARUP (2021a) Upper South Creek AWRC EIS, Hydrodynamic and Water Quality Impact Assessment. Dated 16 July 2021.

Aurecon/ARUP (2021b) Upper South Creek AWRC EIS, Surface Water Specialist Study. Revision 0.

Aurecon/ARUP (2021c) Upper South Creek Advanced Water Recycling Centre: Socio-economic and land use impact assessment (draft). Dated 2 June 2021.

Aurecon/ARUP (2021d) Upper South Creek Advanced Water Recycling Centre: Noise and vibration impact assessment. August 2021.

Aurecon/ARUP (2021e) Upper South Creek Advanced Water Recycling Centre: Soils and contamination impact assessment. August 2021.

Aurecon/ARUP (2021f) Preliminary hazard analysis. Upper South Creek Advanced Water Recycling Centre. August 2021.

Aurecon/ARUP (2021g) Upper South Creek Advanced Water Recycling Centre: Traffic and transport technical report. August 2021.

Aurecon/ARUP (2021h) Upper South Creek Advanced Water Recycling Centre: Waste management impact assessment report August 2021.

Sydney Water (2021a) Upper South Creek Advanced Water Recycling Centre, Environmental Impact Statement, Main Report (Chapter 4 – Project Description) DRAFT

Sydney Water (2021b) Upper South Creek Advanced Water Recycling Centre, Environmental Impact Statement, Main Report (Chapter 8 – Key waterway impacts) DRAFT

Sydney Water (2021c) Upper South Creek Advanced Water Recycling Centre, Toxicant review of release streams

Sydney Water (2020) Fairfield water recycling plant water quality monitoring program (December 2019-March 2020)

Building Code & Bushfire Hazard Solutions (2020) Bushfire constraints and opportunities report, Upper South Creek Advanced Water Recycling Centre, Kemps Creek, NSW. Dated 21 August 2020.

Other references:

ANZG 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, A joint initiative of the Australian and New Zealand Governments in partnership with the Australian state and territory governments, Online. <http://www.waterquality.gov.au/anz-guidelines>.

ATSDR 2015, *Draft Toxicological Profile for Perfluoroalkyls*, US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry.

ATSDR 2018, *Toxicological Profile for Perfluoroalkyls - Draft*, Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services. <https://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=1117&tid=237>.

Australian Government 2018, *National Waste Policy, Less Waste, More Resources*, Australian Government, state and territory governments and the Australian Local Government Association. <https://www.environment.gov.au/protection/waste/publications/national-waste-policy-2018>.

Brown, TN & Wania, F 2008, 'Screening Chemicals for the Potential to be Persistent Organic Pollutants: A Case Study of Arctic Contaminants', *Environmental science & technology,* vol. 42, no. 14, 2008/07/01, pp. 5202-5209.

Canadian Government 2017, *Canada's approach on chemicals - summary homepage for program* Government of Canada. <https://www.canada.ca/en/health-canada/services/chemical-substances/canada-approach-chemicals.html>.

enHealth 2001, *Health Impact Assessment Guidelines*, Commonwealth Department of Health and Aged Care.

enHealth 2012, *Environmental Health Risk Assessment, Guidelines for assessing human health risks from environmental hazards*, Commonwealth of Australia, Canberra. <https://www1.health.gov.au/internet/main/publishing.nsf/Content/A12B57E41EC9F326CA257BF0001F9E7D/$File/Environmental-health-Risk-Assessment.pdf>.

enHealth 2017, *Health Impact Assessment Guidelines*, enHealth.

EPHC 2009, *Environmental Risk Assessment Guidance Manual for Industrial Chemicals*, Environment Protection and Heritage Council. <http://scew.gov.au/resource/chemical-risk-assessment-guidance-manuals>.

EU 2020, 'Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast)', *Official Journal of the European Union,* vol. 435, no. 23.12.2020, pp. 1-62.

European Food Safety Authority 2020, 'Outcome of a public consultation on the draft risk assessment of perfluoroalkyl substances in food', *EFSA Supporting Publications,* vol. 17, no. 9, p. 1931E.

Golder 2013, *Exposure Assessment and Risk Characterisation to Inform Recommendations for Updating Ambient Air Quality Standards for PM2.5, PMN10, O3, NO2, SO2*, Golder Associates for National Environment Protection Council Service Corporation. <https://www.environment.gov.au/system/files/pages/dfe7ed5d-1eaf-4ff2-bfe7-dbb7ebaf21a9/files/exposure-assessment-risk-characterisation.pdf>.

Harris, P, Harris-Roxas, B., Harris, E. & Kemp, L. 2007, *Health Impact Assessment: A Practical Guide*, Centre for Health Equity Training, Research and Evaluation (CHETRE). Part of the UNSW Research Centre for Primary Health Care and Equity. University of New South Wales.

Howard, PH & Muir, DCG 2010, 'Identifying New Persistent and Bioaccumulative Organics Among Chemicals in Commerce', *Environmental science & technology,* vol. 44, no. 7, 2010/04/01, pp. 2277-2285.

I-INCE 2011, *Guidelines for Community Noise Impact Assessment and Mitigation, I-INCE Publication Number: 11-1*, International Institute of Noise Control Engineering (I-INCE) Technical Study Group on Community Noise: Environmental Noise Impact Assessment and Mitigation.

Nature 2011, 'Microbiology by numbers', *Nat Rev Micro,* vol. 9, no. 9, 09//print, pp. 628-628.

NEPC 1999 amended 2013, *National Environment Protection (Assessment of Site Contamination) Measure Schedule B8 Guideline on Community Engagement and Risk Communication*, National Environment Protection Council,

NEPC 2003, *National Environment Protection (Ambient Air Quality) Measure*, National Environment Protection Council.

NEPC 2016, *National Environment Protection (Ambient Air Quality) Measure*, Federal Register of Legislative Instruments F2016C00215.

NHMRC 2008, *Guidelines for Managing Risks in Recreational Water*, National Health and Medical Research Council, Canberra.

NHMRC 2011 updated 2021, *Australian Drinking Water Guidelines 6, Version 3.6 Updated March 2021, National Water Quality Management Strategy*, National Health and Medical Research Council, National Resource Management Ministerial Council, Canberra.

NHMRC 2019, *Guidance on Per and Polyfluoroalkyl substances (PFAS) in Recreational Water*, Australian Government National Health and Medical Research Council.

NICNAS 2013, *Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework*, National Industrial Chemicals Notification and Assessment Scheme, Commonwealth Department of Health. <https://www.nicnas.gov.au/chemical-information/imap-assessments/what-is-imap>.

NICNAS 2017, *Inventory Multi-tiered Assessment and Prioritisation Program - Homepage*, National Industrial Chemicals Notification and Assessment Scheme, Commonwealth Departmetn of Health. <https://www.nicnas.gov.au/chemical-information/imap-assessments>.

NRMMC 2006, *National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)*, Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, Australian Health Ministers Conference. <http://waterquality.gov.au/guidelines/recycled-water>.

NRMMC 2008, *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Augmentation of Drinking Water Supplies*, Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and National Health and Medical Research Council. <http://waterquality.gov.au/guidelines/recycled-water>.

NRMMC 2009a, *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2). Stormwater harvesting and reuse*, National Water Quality Management Strategy, National Resource Management Ministerial Council, Environment Protection and Heritage Council, National Health and Medical Research Council. <http://waterquality.gov.au/guidelines/recycled-water>.

NRMMC 2009b, *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Managed Aquifer Recharge*, Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and National Health and Medical Research Council. <http://waterquality.gov.au/guidelines/recycled-water>.

NSW Chief Scientist 2018, *Advisory Committee on Tunnel Air Quality - Technical Paper 5: Road Tunnel Stack Emissions*, Advisory Committee on Tunnel Air Quality, NSW Chief Scientist and Engineer. <https://chiefscientist.nsw.gov.au/reports/advisory-committee-on-tunnel-air-quality>.

NSW DEC 2006a, *Assessment and management of odour from stationary sources in NSW*, NSW Department of Environment and Conservation. <http://www.epa.nsw.gov.au/resources/air/20060440framework.pdf>.

NSW DEC 2006b, *Assessing vibration: a technical guideline*, NSW Department of Environment and Conservation. <http://epa.nsw.gov.au/noise/vibrationguide.htm>.

NSW DECC 2009, *Interim Construction Noise Guideline*, NSW Department of Environment and Climate Change. <www.environment.nsw.gov.au/resources/stormwater/0801soilsconststorm2a.pdf>.

NSW EPA 2000, *NSW Industrial Noise Policy*, NSW Environment Protection Authority. <http://epa.nsw.gov.au/noise/industrial.htm>.

NSW EPA 2014a, *Waste Classification Guidelines. Part 1: Classifying Waste*, NSW Environment Protection Authority. <http://www.epa.nsw.gov.au/wasteregulation/classify-guidelines.htm>.

NSW EPA 2014b, *NSW Waste Avoidance and Resource Recovery Strategy 2014–21*, State of NSW and Environment Protection Authority. <https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/wastestrategy/140876-warr-strategy-14-21.pdf>.

NSW EPA 2016, *Addendum to the Waste Classification Guidelines (2014) – Part 1: classifying waste*, NSW Environmental Protection Authority.

NSW EPA 2017a, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, State of NSW and Environment Protection Authority, Sydney. <https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/approved-methods-for-modelling-and-assessment-of-air-pollutants-in-nsw-160666.pdf>.

NSW EPA 2017b, *Noise Policy for Industry*, NSW Environment Protection Authority, Sydney. <https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/noise-policy-for-industry-(2017)>.

NSW Government 1997, *Protection of the Environment (Operations) Act*, NSW Government. <http://www.legislation.nsw.gov.au/maintop/view/inforce/act+156+1997+cd+0+N>.

NSW Government 2001, *Waste Avoidance and Resource Recovery Act*, NSW Government.

NSW Government 2014, *State Environmental Planning Policy No 33—Hazardous and Offensive Development*, NSW Government under Environmental Planning and Assessment Act 1979. <http://www.legislation.nsw.gov.au/inforce/e5ebfcd2-5ebc-11dd-8fae-00144f4fe975/1992-129.pdf>.

NSW Planning 2011a, *Hazardous Industry Planning Advisory Paper No 6, Hazard Analysis*, State of New South Wales through the Department of Planning. <https://www.planning.nsw.gov.au/Policy-and-Legislation/Hazards>.

NSW Planning 2011b, *Risk Criteria for Land Use Safety Planning, Hazardous Industry Planning Advisory Paper No 4*, Sydney.

NSW Planning 2011c, *Hazardous and Offensive Development Application Guidelines, Applying SEPP 33*, State of New South Wales through the Department of Planning. <https://www.planning.nsw.gov.au/Policy-and-Legislation/Hazards>.

NSW Planning & Environment 2019, ***Population projections, 2019 NSW population and household projections***. <http://www.planning.nsw.gov.au/projections>.

NSW Planning and Infrastructure 2011, *Assessment Guideline Multi-level Risk Assessment*, State of New South Wales through the Department of Planning & Infrastructure. <https://www.planning.nsw.gov.au/Policy-and-Legislation/Hazards>.

OEHHA 2002, *Staff Report: Public Hearing to Consider Amendments to the Ambient Air Quality Standards for Particulate Matter and Sulfates*, Office of Environmental Health Hazard Assessment.

Schiffman, SS & Williams, CM 2005, 'Science of Odor as a Potential Health Issue', *Journal of environmental quality,* vol*.* 34, no. 1, pp. 129-138.

UK DWI 2007, *DESK BASED REVIEW OF CURRENT KNOWLEDGE ON PHARMACEUTICALS IN DRINKING WATER AND ESTIMATION OF POTENTIAL LEVELS*, UK Drinking Water Inspectorate. <https://www.dwi.gov.uk/research/completed-research/risk-assessment-chemical/desk-based-review-of-current-knowledge-on-pharmaceuticals-in-drinking-water-and-estimation-of-potential-levels/>.

USEPA 2005, *Method 1623: Cryptosporidium and Giardia in Water by Filtration/IMS/FA*, US Environmental Protection Authority. <https://www.epa.gov/sites/production/files/2015-07/documents/epa-1623.pdf>.

USEPA 2009, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, (Part F, Supplemental Guidance for Inhalation Risk Assessment)*, United States Environmental Protection Agency, Washington, D.C.

Vermont Department of Environmental Conservation 2019, *Environmental Protection Rules, Chapter 35, Investigation and Remediation of Contaminated Properties Rule*, Vermont Department of Environmental Conservation. <https://dec.vermont.gov/waste-management/contaminated-sites/guidance>.

WHO 1999, *Guidelines for Community Noise*, World Health Organisation, Geneva.

WHO 2009, *Night Noise Guidelines for Europe*, World Health Organisation Regional Office for Europe.

WHO 2011a, *Pharmaceuticals in Drinking-water*, World Health Organization, Public Health and Environment Water, Sanitation, Hygiene and Health.

WHO 2011b, *Burden of disease from environmental noise, Quantification of healthy life years lost in Europe*, World Health Organisation and JRC European Commission.

WHO 2018, *Guidelines on Sanitation and Health*, World Health Organisation. <https://www.who.int/water_sanitation_health/publications/guidelines-on-sanitation-and-health/en/>.