BOTANY RAIL DUPLICATION

TECHNICAL REPORT

Technical Report 7 –
Groundwater Impact Assessment

ARTC

Botany Rail Duplication - Environmental Impact Statement

Technical Report 7 –
Groundwater Impact Assessment

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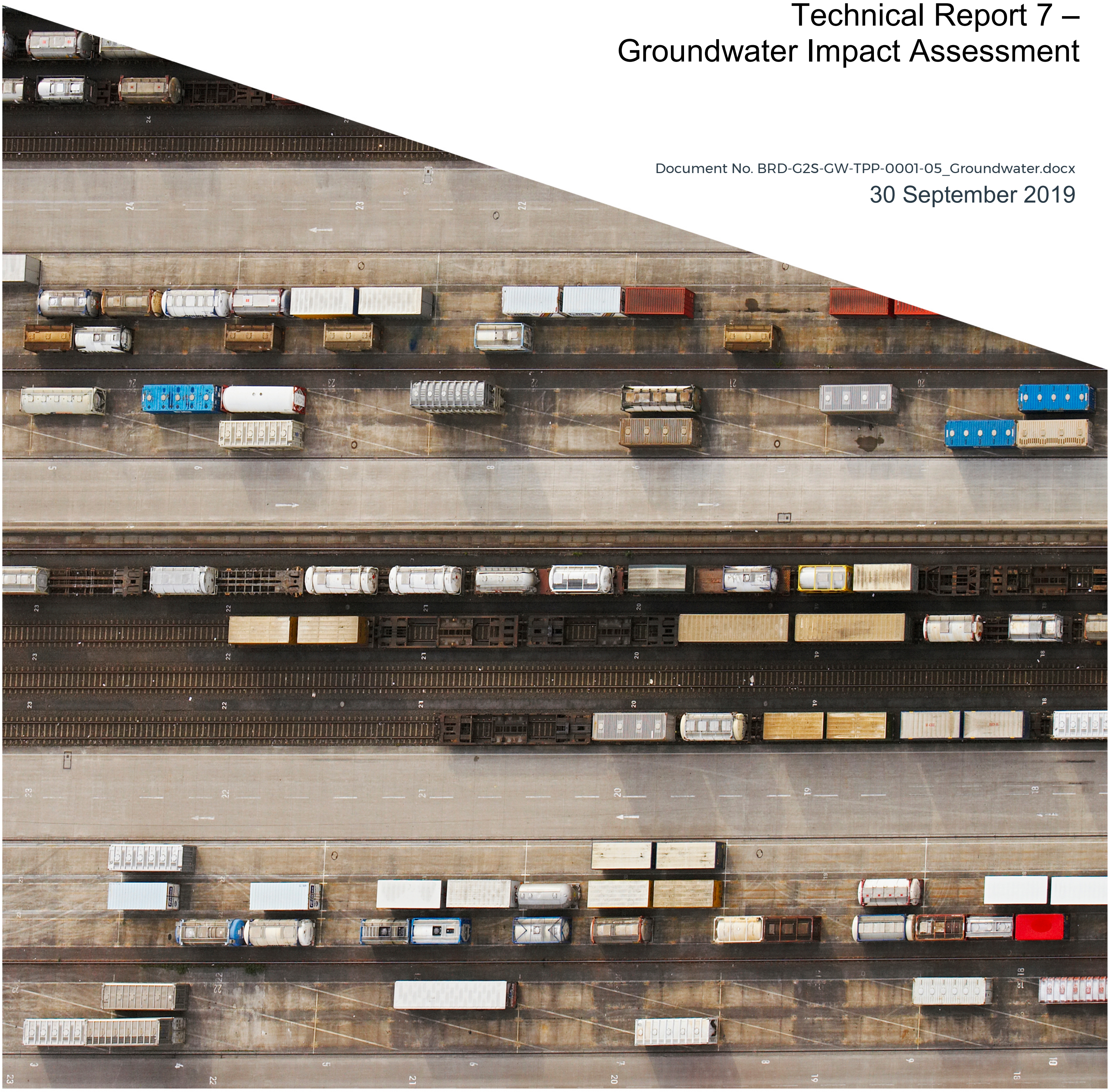

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Glossary and abbreviations

AIP	NSW Aquifer Interference Policy
AMO	Aeronautical Meteorological Office
ANZECC	Australian and New Zealand Environment Conservation Council
ARTC	Australian Rail Track Corporation (the proponent)
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulfate Soils
ASSMP	Acid Sulfate Soils Management Plan
Ballast	Material such as crushed rock or stone used to provide a foundation for a railway track. Ballast usually provides the bed on which railway sleepers are laid, transmits the load from train movements and restrains the track from movement.
BOM	Bureau of Meteorology
Botany Line	A dedicated freight rail line (operated by ARTC) that forms part of the Metropolitan Freight Network. The line extends from near Marrickville Station to Port Botany.
BSAL	Biophysical Strategic Agricultural Land
CEMP	Construction Environment Management Plan
CRD	Cumulative rainfall deviation
construction ancillary facilities	Temporary facilities during construction that include, but are not limited to, construction work areas, sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, parking, maintenance workshops and offices, and construction compounds.
construction compound	An area used as the base for construction activities, usually for the storage of plant, equipment and materials, and/or construction site offices and worker facilities.
Council, the	Bayside Council
detailed design	The stage of design where project elements are design in detail, suitable for construction.
DPI	Department of Primary Industries
EC	Electrical conductivity
EIS, the	Botany Rail Duplication environmental impact statement
embankment	A raised area of earth or other materials used to carry a rail line in certain areas.
EMP	Environmental Management Plan

EPBC	Environment Protection and Biodiversity Conservation Act 1999 (Cth)
existing rail corridor	The corridor within which the existing rail infrastructure is located. In the study area, the existing rail corridor is the Botany Line.
formation	The earthworks/material on which the ballast, sleepers and tracks are laid.
GDE	Groundwater dependent ecosystem
IMT	Immersed tube tunnel
ISCA	Infrastructure Sustainability Council of Australia
impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
LEP	Local Environmental Plan
LGA	local government area
LTAAEL	Long Term Annual Average Extraction Limit
mAHD	Metres Australian Height Datum
mbgl	Metres below ground level
Metropolitan Freight Network	A network of dedicated railway lines for freight in Sydney, linking NSW's rural and interstate rail networks with Port Botany. The Metropolitan Freight Network is managed by ARTC.
NES	National Environmental Significance
NSW WQO	NSW Water Quality Objectives
NWQMS	National Water Quality Management Strategy
OEMP	Operational Environment Management Plan
OLS	Obstacle limitation surface
possession	A period of time during which a rail line is closed to train operations to permit work to be carried out on or near the line.
project site, the	The area that would be directly affected by construction (also known as the construction footprint). It includes the location of operational project infrastructure, the area that would be directly disturbed by the movement of construction plant and machinery, and the location of the storage areas/compounds etc, that would be used to construct that infrastructure.
project, the	The construction and operation of the Botany Rail Duplication

Secretary's environmental assessment requirements (SEARs)	Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning and Environment under section 115Y of the *Environmental Planning and Assessment Act 1979* (NSW).
SWMP	Soil and water management plan
State significant infrastructure	Major transport and services infrastructure considered to have State significance as a result of size, economic value or potential impacts.
study area, the	The study area is defined as the wider area including and surrounding the project site, with the potential to be directly or indirectly affected by the project (e.g. by noise and vibration, visual or traffic impacts). The actual size and extent of the study area varies according to the nature and requirements of each assessment and the relative potential for impacts but which is sufficient to allow for a complete assessment of the proposed project impacts to be undertaken.
TDS	Total dissolved solids
VWP	Vibrating wire piezometer
WAL	Water Access Licence
WSP	Water Sharing Plan

Executive summary

Introduction

Australian Rail Track Corporation proposes to construct and operate a new second track generally within the existing Botany Line rail corridor between Mascot and Botany, in the Bayside local government area. The Botany Rail Duplication would increase freight rail capacity to and from Port Botany.

A groundwater impact assessment has been completed to assess the impacts of the proposed Botany Rail Duplication project on the existing groundwater resources and down-gradient receptors.

The assessment is desktop based. As such, a conservative approach has been adopted for the assessment of impacts and mitigation measures to accommodate any uncertainty.

Groundwater drawdown impacts

The assessment has included establishing reasonable worst case groundwater elevations along the alignment of the project site and comparing those to the project design, particularly subsurface infrastructure. Further to this, consideration has been given to impacts of changed recharge conditions during construction and operation on groundwater drawdown and resource availability/water balance.

A summary of the construction and operation based groundwater drawdown impacts and mitigation measures is presented below.

Construction impacts

The following key points are made in regard to the impacts of construction activities on groundwater:

- Bridge piling works will intersect groundwater but will adopt cast insitu techniques such as wet piles or continuous flight augered piles that do not require pile washout groundwater dewatering.
- Construction excavation activities may intersect groundwater at isolated locations during wet weather, but it is unlikely intersection will occur during dry conditions. Non-dewatering techniques, in line with normal construction practice, will be adopted for other infrastructure such as the track foundations, the CSR and the Qenos pipeline if intersection occurs.
- There is a potential for a minimal increase in groundwater recharge during construction due to re-profiling works exposing more permeable materials and general earthworks.

Based on the above groundwater drawdown impact to groundwater during construction is considered negligible.

Operation impacts

The following key points are made in regard to the impacts of operational activities on groundwater:

- Operational activities are not expected to intersect groundwater or require ongoing dewatering.
- Groundwater recharge will slightly reduce and result in a minimal reduction in the overall water balance and reduced potential for groundwater quality impacts relative to existing conditions.

Based on the above groundwater drawdown impact to groundwater during operation is considered negligible.

Groundwater quality impacts

A summary of the construction and operation based groundwater quality impacts is presented below.

Construction impacts

Due to construction there will be a temporary change in land use above an aquifer that supports industrial groundwater use and that discharges to wetland ecosystems of significance. There is uncertainty with regard to whether construction impacts will change the beneficial use potential (which would represent an adverse impact under the AIP criteria), but given the presence of surface water systems of significance and potential down gradient industrial groundwater users, a precautionary approach has been adopted.

Operation impacts

There will be a reduced potential for infiltration of impacted surface water and rainfall. Further to this, existing groundwater quality data indicates the Botany Sands aquifer is of limited value. As such the potential for a change in beneficial use potential (and hence an adverse impact as defined by the NSW aquifer interference policy criteria) is expected to be low to negligible. Existing ARTC environmental management systems will be continued to limit the potential for groundwater quality impacts.

Cumulative impacts

While there will be increases in recharge during construction, there could be small cumulative reductions in rainfall recharge during operation associated with the combined effects of Sydney Gateway Road project, Botany Rail Duplication project and the WestConnex enabling works north and east precincts. These operational impacts are expected to have negligible impact on groundwater elevations and the Botany Sands water balance compared to existing conditions as they will primarily be replacing existing sealed areas in the vicinity of the Botany Rail Duplication project.

There will be no contribution to cumulative drawdown impacts associated with dewatering during construction or operation as the project will adopt non-dewatering construction techniques in line with normal construction practice.

There may be an increased potential for cumulative groundwater quality impacts from increased rainfall infiltration during the combined construction of the Sydney Gateway Road Project and the Botany Rail Duplication project. This potential impact will be managed by implementing appropriate measures for each project separately.

Mitigation measures

The following mitigation measures are proposed for construction and operation. A baseline monitoring program would be implemented to characterise existing conditions on which groundwater quality impacts associated with construction and operation could be established.

Construction

Potential water quality impacts would be managed by implementing environmental management measures within a site environmental management plan for the enabling works and a soil and water management plan for the main construction works. The relevant management plan would include procedures to minimise potential impacts and monitoring requirements.

As there is an increased risk of a groundwater quality impact during construction of the project (a change in beneficial use potential) relative to existing conditions, a monitoring program is proposed.

The baseline groundwater monitoring program would be continued through construction (on a quarterly basis) for the purpose of identifying and responding to any groundwater quality impacts outside of those predicted. A quarterly monitoring program for 1 year after construction, is expected to be suitable to resolve the emergence of any construction based groundwater quality impacts.

Operation

The existing ARTC environmental management system would be implemented to prevent ongoing groundwater quality impacts. This system includes a range of environmental procedures and protocols.

1. Introduction

1.1 Overview

1.1.1 Background

Australian Rail Track Corporation (ARTC) proposes to construct and operate a new second track predominantly within the existing Botany Line rail corridor between Mascot and Botany, in the Bayside local government area (LGA). The Botany Rail Duplication ('the project') would increase freight rail capacity to and from Port Botany. The location of the project is shown in Figure 1.1.

The project is State Significant Infrastructure in accordance with Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). As State significant infrastructure, the project needs approval from the NSW Minister for Planning and Public Spaces.

This report has been prepared to accompany the environmental impact statement (EIS) to support the application for approval of the project, and address the Secretary of the Department of Planning and Environment's environmental assessment requirements (the SEARs), issued on 21 December 2018.

1.1.2 Overview of the project

The project would involve:

- Track duplication – constructing a new track predominantly within the rail corridor for a distance of about three kilometres.
- Track realignment (slewing) and upgrading – moving some sections of track sideways (slewing) and upgrading some sections of track to improve the alignment of both tracks and minimise impacts to adjoining land uses.
- New crossovers – constructing new rail crossovers to maintain and improve access at two locations (totalling four new crossovers).
- Bridge works – constructing new bridge structures at Mill Stream, Southern Cross Drive, O'Riordan Street and Robey Street (adjacent to the existing bridges), and re-constructing the existing bridge structures at Robey Street and O'Riordan Street.
- Embankment/retaining structures – construction of a new embankment and retaining structures adjacent to Qantas Drive between Robey and O'Riordan streets and a new embankment between the Mill Stream and Botany Road bridges.

Further information on the key elements of the project is provided in the EIS.

Ancillary work would include bi-directional signalling upgrades, drainage work and protecting/relocating utilities.

Subject to approval of the project, construction is planned to start at the end of 2020, and is expected to take about three years for the main construction works to be undertaken. Construction is expected to be completed in late 2023 with commissioning activities undertaken in early 2024.

It is anticipated that some features of the project would be constructed while the existing rail line continues to operate. Other features of the project would need to be constructed during programmed weekend rail possession periods when rail services along the line cease to operate.

The project would operate as part of the existing Botany Line and would continue to be managed by ARTC. ARTC is not responsible for the operation of rolling stock. Train services are currently, and would continue to be, provided by a variety of operators. Following the completion of works, the existing functionality of surrounding infrastructure would be restored.

Key features of the project are shown on Figure 1.2.

Figure 1.1 Botany Rail Duplication location

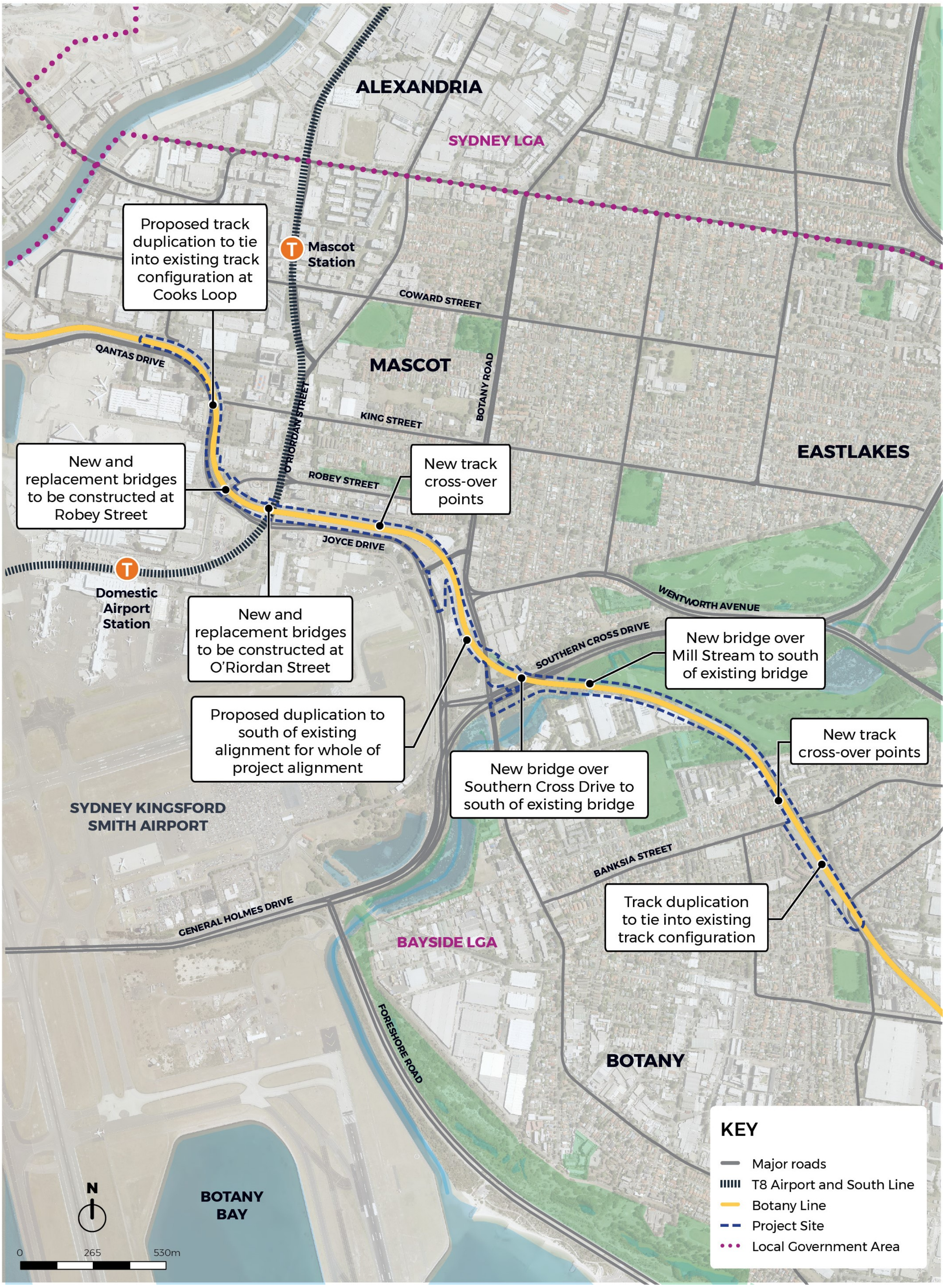


Figure 1.2 Botany Rail Duplication project overview

1.2 Purpose and scope of this report

The purpose of this report is to assess the potential groundwater impacts from the operation and construction of the project. This groundwater impact assessment addresses the relevant SEARs for the EIS, and agency recommendations detailed in Section 2.3. The report:

- describes the existing regional and local hydrogeological environment
- assesses the impacts of constructing and operating the project on groundwater
- recommends measures to mitigate the impacts identified for construction and operation.

1.3 Structure of this report

The structure of the report is outlined below:

- Section 1 – Introduction – provides an introduction to the project and purpose of the report.
- Section 2 – Legislative and policy context – describes the legislative framework on which groundwater impacts are assessed in NSW and the SEARs relevant to this assessment.
- Section 3 – Methodology – describes the methodology adopted for this assessment to characterise groundwater impacts.
- Section 4 – Existing environment – describes the current understanding of the existing environment.
- Section 5 – Assessment of impacts – introduces the impact assessment and sets out the relevant assessment criteria and other matters for consideration.
- Section 6 – Cumulative impacts – details the combined impacts of all the stages of the project as well as other infrastructure projects that are occurring in the surrounding area.
- Section 7 – Management of impacts – details the approach to management of impacts and the measures that will be adopted to minimise impacts.
- Section 8 – Monitoring – details of the proposed monitoring to verify the effectiveness of construction and operation activities at limiting potential impacts to groundwater quality.
- Section 9 – Conclusion – summary of key findings.

2. Legislative and policy context

This section summarises the legislation, guidelines and policies driving the approach to the assessment.

2.1 Relevant legislation

2.1.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires protection of the environment from actions involving Commonwealth land. In addition, the Botany Bay area provides summer habitat for a number of migratory wading birds that are listed under the EPBC Act, and the ponds may also be used on occasion by these species. Therefore threatened biota that are listed under NSW legislation and other aspects of the biodiversity in this area which relate to groundwater are considered.

2.1.2 *Water Act 1912* and *Water Management Act 2000*

The *Water Act 1912* governs licences from water sources in NSW. It also manages the trade of licences and water allocations. The *Water Act 1912* is progressively being replaced by the *Water Management Act 2000* but some provisions are still in place where there are no Water Sharing Plans (WSP) in place.

The *Water Management Act 2000* (WMA 2000) is administered by the NSW Department of Primary Industries (DPI) Water (formerly NSW Office of Water) and is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. The WMA (2000) is also intended to provide a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions.

The *Water Management Act 2000* requires the development of water sharing plans (WSPs) to manage water use and access. The DPI website states that water sharing plans aim to:

- clarify the rights of the environment, basic landholder rights users, town water suppliers and other licensed user
- define the long-term average annual extraction limit (LTAAEL) for water sources
- set rules to manage impacts of extraction
- facilitate the trading of water between users.

WSP for the Greater Metropolitan Region Groundwater Sources

The project is located within the Greater Metropolitan Region Unregulated River Water Sources – Southern Sydney Rivers.

The WSP for the Greater Metropolitan Region Groundwater Sources covers 13 groundwater sources on the east coast of NSW. The background document for the WSP lists the Southern Sydney Rivers Water Source and includes all unregulated surface water in the hydrological catchments of Hacking River, Georges River, Woronora River, Cooks River, Botany Bay and the hydrological catchments east of Hacking River and north of Stanwell Creek and south of Port Hacking. Southern Sydney Rivers have 35,341 ML in total entitlements with 63 licences.

The WSP provides a legislative basis for sharing the water between the environment and the consumer and was considered as part of this assessment.

Botany Sands aquifer

The project is also located within the Botany Sands Groundwater Source, which is under a water management zone. This means it is at a level of more refined implementation of access and trading rules applied. The NSW government has been managing the extraction of groundwater from this source separately due to contamination issues. In August 2003, an embargo was put in place on the northern part of the aquifer under section 113A of the *Water Act 1912*. Then in June 2007 an embargo was placed on the rest of the aquifer to prevent additional commercial extraction. The groundwater source is now split into two management zones; Botany Management Zone 1 (covers the embargo area of 2003) and Botany Management Zone 2 (covers the embargo area of 2007). The project is mainly located in the Botany groundwater management – Zone 2. The Botany Sands Water Source has 11,156 ML of groundwater entitlement from an estimated 80 existing licences. The Botany Sands Water Source has a long-term average annual extraction limit of 14,684 ML/year of water potentially available that is not allocated.

2.1.3 *Water Management Regulation 2018*

ARTC as a rail authority is exempt from the requirement to hold a water access license or water use approval for on-going take of groundwater as per clauses 21(1), 34 (1) and clause 3 of Schedule 4 of the *Water Management Regulation 2018*, provided ARTC has assessed the environmental impacts and are satisfied that the activity is not likely to significantly affect the environment.

Further to this, any monitoring bores, installed in accordance with the minimum bore construction requirements for water bores in Australia, for the purposes of monitoring water levels or water quality is exempt from the requirement to obtain a water supply works approval if:

- it completed as part of a condition of an approval under division 5.2 Part 5, of the EP&A Act
- well installation details and bore log information is provided to water NSW within 60 days of completion of the water supply works.

Although a licence is not required for the project, ARTC must still satisfy the requirements of licensing set out in the Greater Metropolitan Region Water Sharing Plan and satisfy the approval requirements of the NSW Aquifer Interference Policy (refer to Section 2.2.1).

Water extraction monitoring may be required in accordance with the *NSW Water Extraction Monitoring Policy* (2007). It is up to the discretion of the licensing authority (NSW Department of Industry Water – DoI) to determine if water licensing is necessary under this policy.

2.2 Policies and guidelines

2.2.1 *NSW Aquifer Interference Policy*

The *NSW Aquifer Interference Policy* (AIP) was finalised in September 2012 (NOW, 2012) and clarifies the water licencing and approval requirements for aquifer interference activities in NSW. Many aspects of the AIP will be given legal effect in the future through an *Aquifer Interference Regulation* (2011). Stage 1 of the *Aquifer Interference Regulation* commenced on 30 June 2011.

The AIP indicates that activities with the potential to contaminate groundwater are considered to be an aquifer interference activity.

The AIP states that aquifer interference approval will not be granted unless the “Minister is satisfied that adequate arrangements are in force to ensure that no more than minimal harm will be done to any water source, or its dependent ecosystems, as a consequence of being interfered with” by the activities the approval relates to.

The minimal impact criteria for the groundwater source at the site are summarised below:

- With regard to the water table, impact is considered to be minimal where the water table change is less than 10 percent of the cumulative variation in the water table 40 metres from any high priority groundwater dependent ecosystem (GDE) or high priority culturally significant site listed in the water sharing plan. If an impact is greater than this it must be demonstrated to the Minister's satisfaction that the variation will not prevent the long term viability of a GDE of cultural significance. There are no high priority sites listed in the water sharing plan near to the site; however, site specific potential GDEs have been identified that are considered to be high priority and are considered in this report (see Section 4.12).
- With regard to the water table, impact is considered to be minimal where there is less than a cumulative 2.0 metre decline at any water supply work. If the impact is greater make good provisions apply.
- With regard to water pressure, impact is considered to be minimal where the cumulative decline in head is less than 2.0 metres at any water supply work. If the impact is greater than this, then further studies are required to satisfy the Minister that long term viability of the affected water supply works will not be affected. Otherwise make good provisions will apply.
- With regard to water quality, impact is considered to be minimal where the change in groundwater quality is within the current beneficial use category of the groundwater source beyond 40 metres from the activity. If this cannot be achieved studies will need to demonstrate that the change will not prevent the long term viability of the dependent ecosystem, or affected water supply works.

If the predicted impacts are less than the minimal impact considerations, then these impacts will be considered as acceptable.

Additional restrictions cover the interception of groundwater that underlies biophysical strategic agricultural land (BSAL), its dependent ecosystems or other water users. The project is not located within or near to BSAL.

The assessment considers the potential impacts identified against the criteria outlined above and the SEARs outlined in Section 2.3.

2.2.2 *NSW State Groundwater Policy Framework Document* (Department of Land and Water Conservation, 1997)

The objective of the *NSW State Groundwater Policy Framework Document* (NSW Government 1997) (DLWC) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. The NSW groundwater policy has three component parts:

- *NSW Groundwater Quantity Protection Policy* outlined in DLWC (1997).
- *NSW Groundwater Quality Protection Policy* (DLWC, 1998).
- *NSW Groundwater Dependent Ecosystems Policy* (DLWC, 2002).

These are discussed further below.

NSW Groundwater Quantity Protection Policy

The principles of this policy include:

- maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn
- groundwater extraction shall be managed to prevent unacceptable local impacts
- all groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

These principles are implemented under the WMA 2000 and the AIP, which have been discussed above.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- slow and halt, or reverse any degradation in groundwater resources
- direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater
- establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource
- establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

This guidance will be incorporated into the assessment by assessing the project against the requirements outlined in the water sharing plan and the AIP. This includes incorporating the environmental values (beneficial use category) and trigger values outlined in National Water Quality Management Strategy (NWQMS), presented below, into the impact assessment criteria outlined into the AIP.

NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

These criteria will be incorporated into the assessment by assessing the project against the requirements outlined in the water sharing plan and the AIP. This includes criteria to be protective of groundwater dependent ecosystems.

2.2.3 *National Water Quality Management Strategy* (NWQMS)

The *National Water Quality Management Strategy* (NWQMS) provides a national framework for improving water quality in Australia's waterways. The main policy objective of the NWQMS is to achieve sustainable use of the nation's water resources; protecting and enhancing their quality, while maintaining economic and social development. The NWQMS process involves community and government interaction, and implementation of a management plan for each catchment, aquifer, estuary, coastal water or other water body. This includes the use of national guidelines for local implementation.

The NWQMS *Policy and Principles* (ARMCANZ/ANZECC, April 1994) provides an overview of the principles for water quality management in Australia. The primary objective is:

"*to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development*."

The *Policy and Principles* (ARMCANZ/ANZECC, April 1994) document states that:

"the generally accepted mechanism for establishing in-stream or aquifer water quality requirements is a two-step process which involves:

- *establishing a set of environmental values*
- *establishing scientifically based water quality criteria corresponding to each environmental value*."

Environmental values are often interchanged with the term beneficial use (which is referred to in regard to minimum impact criteria set in the aquifer interference policy in Section 2.2.1) and are identified in the guidance to include:

- ecosystem protection
- recreation and aesthetics
- drinking water
- agricultural water (irrigation and stock water)
- industrial water.

Ecosystem protection, in this context, refers to aquatic ecosystems which depend at least in part on groundwater to maintain ecosystem health (groundwater-dependent ecosystems). Depending on the site setting, this may include surface water bodies such as wetlands, streams and rivers reliant on groundwater base flow, some estuarine and near-shore marine systems, as well as aquifer and cave ecosystems.

Criteria have been developed to characterise water quality relative to these environmental criteria and are outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and the Australian Drinking Water Guidelines (ADWG) and are discussed further below. The criteria specified in these documents will be used as the basis for assessing the current environmental values (beneficial use potential) for this assessment.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000/ ANZG, 2018)

For this project the national guidelines on water quality benchmarks within the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) (ANZECC 2000 guidelines) are applicable and provide default trigger values (DTVs) of various analytes for comparison with sampled values. Guideline water criteria are presented in the guidelines for:

- aquatic ecosystems
- primary industries (which includes agricultural and industrial water criteria).

There has been a revision to the ANZECC 2000 guidelines called the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018)[1]. The guideline values for varying toxicants are currently the same as ANZECC 2000 guidelines. It is recommended that future revisions of this report review developments in the default guidelines values (ANZG, 2018). ANZECC 2000 guidelines are recommended under current guidelines in the SEARs. This study will adopt the ANZECC 2000 guidelines default guideline values and analysis methodologies.

The ANZECC 2000 establishes a guide for setting water quality objectives for surface water resources required to sustain environmental values and the guideline values represent target concentrations within the surface water resource (or surface water body). The ANZECC 2000 guidelines have been considered as a conservative trigger value for groundwater. Alexandra Canal is the receiving surface water body for groundwater within the project, therefore criteria for an 80 per cent protection of marine water ecosystems has been considered.

Australian Drinking Water Guidelines

The *Australian Drinking Water Guidelines* (ADWG) (NHMRC 2011) provide a framework for the appropriate management of drinking water supplies to achieve a safe and appropriate point of supply. The guidelines provide a base standard for aesthetic and health water quality levels.

These guidelines would only be applied where the beneficial use potential of groundwater is suitable for drinking water or as a conservative value for human health where no other criteria is available. Given that there is an embargo on use of groundwater for domestic and potable from the Botany Sands aquifer in this area, these guidelines are not applicable to the project.

[1] *http://www.waterquality.gov.au/anz-guidelines*

2.2.4 Guidelines for Managing Risks in Recreational Water (NHMRC, 2008)

The Guidelines for Managing Risks in Recreational Water (NHMRC, 2008) provide a framework to protect the health of humans from threats posed by the recreational use of coastal, estuarine and fresh waters.

Botany Bay, Mill Stream (tidal areas) and Cooks River are used for a range of recreational purposes including boating, fishing and swimming (restricted to Botany Bay). Therefore the framework is considered in this assessment.

2.2.5 *PFAS National Environmental Management Plan*

Per- and poly-fluoroalkyl substances, also known as “PFAS”, are a group of manufactured chemicals that have been used since the 1950s in a range of common household products and specialty applications, including in the manufacture of non-stick cookware; fabric, furniture and carpet stain protection applications; food packaging; some industrial processes; and in some types of fire-fighting foams.

The *PFAS National Environmental Management Plan* (NEMP, 2018) provides a national approach to the environmental regulation of PFAS. The plan provides screening criteria applicable to this project for certain analytes for aquatic ecosystems for water and marine (interim). The plan also provides human health recreational criteria.

2.2.6 NSW Water Quality and River Flow Objectives

The NSW Water Quality and River Flow Objectives are the agreed environmental values and long-term goals for NSW’s surface waters. The water quality objectives align with the ANZECC 2000 guidelines. The objectives set out:

- the community’s values and uses for our rivers, creek, estuaries and lakes
- provide a range of water quality indicators to help assess whether the current conditions of our waterways support those values and uses.

This project sits within the Botany Bay Catchment and has a set of water quality objectives whereby the ANZECC 2000 guidelines provide technical guidance to assess the water quality needed to protect those values.

2.2.7 Botany Bay and Catchment Water Quality Improvement Plan

The plan is to set targets for pollutant load reductions required to protect the condition of Botany Bay, its estuaries and waterways. Target levels have been established for total nitrogen, total phosphorus and total suspended solids.

2.2.8 *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales*

The document *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales* (DEC, 2004) lists the sampling and analysis methods to be used when acquiring water samples for compliance with environmental protection legislation, a relevant licence or relevant notice.

Water quality sampling results discussed in this assessment have been collected by others (outlined in Section 1.1). It is assumed this data has been collected in accordance with this guidance.

2.2.9 *Risk Assessment Guidelines for Groundwater Dependent Ecosystems*

Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012) comprises four volumes and provides a conceptual framework for identifying and assessing ecosystems along with worked examples of assessments. The guidelines discuss the identification of high probability GDEs and also discuss the ecological value of Groundwater Dependent Ecosystems (GDEs). The results from the groundwater assessment will be used by ecological specialists to assess potential impacts on GDEs.

2.2.10 *Australian Groundwater Modelling Guidelines*

The *Australian Groundwater Modelling Guidelines* (Barnett et al, 2012) provide a framework for numerical modelling of groundwater systems in Australia. The guidelines state that:

"*These guidelines are a point of reference for best practice for all those involved in the development, application and review of groundwater models, and those who use the outputs from models. It is anticipated that the guidelines will be adopted by regulatory bodies, modellers, reviewers and proponents of groundwater models as a nationally consistent guide to groundwater modelling."*

The guidelines also state that:

"*These guidelines are not regulation or law, as they have not received endorsement from any jurisdiction. They should not be considered as de facto standards, as they are likely to evolve with modelling requirements and the sophistication of modelling approaches*."

Due to the limited interaction of the project with underlying groundwater, modelling was not considered necessary for this project and therefore these guidelines are not applicable to this assessment.

2.3 Secretary's environmental assessment requirements

The SEARs relevant to this groundwater impact assessment, together with a reference to where they are addressed in this report, are outlined in Table 2.1.

Table 2.1 SEARs relevant to this assessment

Requirements	Where addressed in this report
3. Assessment of Key Issues* (2) For each key issue the Proponent must:	
describe the biophysical and socio-economic environment, as far as it is relevant to that issue;	Section 4
describe the legislative and policy context, as far as it is relevant to the issue;	Section 2
identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts;	Sections 5 and 6
demonstrate how options within the project potentially affect the impacts relevant to the issue;	Sections 5 and 6
demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies);	Sections 5, 7 and 8
detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant); and	Sections 7 and 8
detail how any residual impacts will be managed or offset, and the approach and effectiveness of these measures.	Sections 7 and 8

Requirements	Where addressed in this report
7. Water – Hydrology	
7.1 The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders	Section 4
7.2 The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	Sections 5 and 6
(a) natural processes within rivers, wetlands, estuaries, marine waters, and floodplains, that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge.	Section 4
(b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	Sections 5 and 6
(c) minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Sections 5 and 6
(d) water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Sections 5.1.4 and 5.2.2
7.3 The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Section 8
7.4 The assessment must include details of proposed surface and groundwater monitoring	Section 8
8 Water quality	
(a) describe the background conditions for any surface and groundwater resources likely to be affected by the proposal;	Section 4
(b) state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values	Sections 2.2.3, 3.3 and 8
(c) identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of nontrivial harm to human health and the environment;	Sections 5.1.3 and 5.2.3
(d) identify the rainfall event that the water quality protection measures will be designed to cope with;	Refer to surface water assessment
(e) assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	Sections 5 and 6

Requirements	Where addressed in this report
(f) demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that; – where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and – where the NSW WQOs are not currently being met, activities will work toward their achievement over time; – justify, if required, why the WQOs cannot be maintained or achieved over time; – demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented; – identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments; and – identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Sections 7 to 8
8.2 The assessment should consider the results of any current water quality studies, as available, for the catchment areas traversed by the proposal	Section 4.14
9. Soils	
9.1 The Proponent must assess the potential for contamination and any impacts associated with the management of contaminated soils and water resources including, but not limited to: (a) a detailed assessment of the extent and nature of any contamination of the soil, groundwater and soil vapour;	Section 6 Also refer to the contamination report

3. Methodology

3.1 Key tasks

Key tasks for the assessment of potential impacts to groundwater included:

- Data review – This includes consideration of the groundwater management zones, SEARs, NSW legislative framework, concept design drawings and construction methodology, previous studies prepared for the project and surrounding proposals, existing hydrology, water quality data and publicly available databases. Further detail is provided in Section 3.2.
- Environmental setting – The data review has been used to establish the baseline groundwater conditions against which the project has been assessed.
- Assessment of groundwater impact – The information collated from the previous tasks were used to qualitatively characterise potential construction and infrastructure that is associated with groundwater impacts. Further detail is provided in Section 3.3.
- Mitigation measures and monitoring requirements have been recommended to manage any remaining potential impacts.

3.2 Data review

The desktop assessment included a review of available project documents. Table 3.1 provides a summary of the key documents informing this assessment and the key data sources collated from the report.

A preliminary design and document review was completed to identify potential groundwater risks for further characterisation.

Specific information considered in the assessment included:

- groundwater management zones imposed by the Department of Primary Industry. Groundwater extraction for domestic purposes is banned throughout Zone 2 (proposal areas: Tempe, Sydenham, St Peters) and Zone 3 (Botany). An Extraction Exclusion applies in Zone 1 (Botany, Banksmeadow)
- the Secretary's Environmental Assessment Requirements (SEARs) – as outlined in Section 2.3
- the NSW legislative framework for groundwater quality and availability, paying particular attention to the NSW aquifer interference policy, relevant water sharing plans (Botany Sands aquifer management plan), the NSW groundwater dependent ecosystems policy, and NSW and Australian groundwater quality guidance
- the design drawings and construction methodology
- previous studies prepared for the project and surrounding/connection projects
- existing hydrology/flooding, surface water quality, and groundwater monitoring data (i.e. data provided by relevant consultants, Sydney Airport, publicly available data)
- publicly available databases detailing the existing groundwater, soil, geological and hydrogeological environments.

Table 3.1 Key data sources

Report reference	Report/data description	Project data collated
Hatley (2004) *Hydrogeology of the Botany Basin*	A review of the geology, hydrogeology, and geotechnical characteristics of the Botany Basin	Geology and hydrogeology of the Botany Sands aquifer
Bureau of Meteorology (BoM) online database, accessed July 2018 (http://www.bom.gov.au/climate/data/)	Database of water, climate, and environmental data	Historical rainfall data
Silo Climate Data, The State of Queensland Department of Environment and Science (https://data.qld.gov.au/dataset/silo-climate-database)	Database of climate and evaporation data	Historical rainfall and evaporation data
WaterNSW online database, accessed July 2018 (https://www.waternsw.com.au/supply/regional-nsw/water-monitoring) and (https://realtimedata.waternsw.com.au/	Surface and groundwater monitoring data	Monitoring bore construction details Drillers logs Groundwater monitoring data
AECOM (2016) *WestConnex New M5 – Groundwater Monitoring Report*	Developed to provide groundwater data along the M5 Motorway corridor	Groundwater and surface water quality results Groundwater monitoring data
Golder (2018) *M5 East-Groundwater Baseline Report*	Developed to establish pre-construction groundwater conditions across the new M5 project	Groundwater monitoring data Groundwater quality test results
EES (2018) *Dewatering Feasibility Study – WestConnex Enabling Works – Airport East Project*	Developed to assess drawdown associated with service installation on the Airport East project	Groundwater elevations Geological logs for alluvial aquifer Groundwater and surface water quality results
AECOM (2015) *M4-M5 Link Environmental Impact Assessment*	EIS for the proposed tolled, multi-lane road link between M4 East at Haberfield and the new M5 at St. Peters	Groundwater and surface water quality results
AECOM (2017) *WestConnex New M5-Environmental Impact Assessment*	EIS for the new multi-lane twin motorway tunnels between the M5 East Motorway and St. Peters, a new road interchange, and upgrade of local roads at St. Peters to Mascot	Groundwater and surface water quality results Groundwater monitoring data
AECOM (multiple dates) Sydney Gateway – Monthly Baseline Surface Water Monitoring	Monthly surface water monitoring data	Surface water monitoring data
RMS (2018) *Sydney Gateway, State Significant Infrastructure Scoping Report*	Details the project and key environmental issues associated with the project	Key environmental issues
G2SJ, (2018) *Sydney Gateway – Factual Geotechnical Report*	Collated factual geotechnical investigation data for the Sydney Gateway project	Groundwater elevations Geotechnical bore logs
ARTC (2018) *Sydney Gateway, Stage 2 – Port Botany Rail Line Civil Works Concept Design*	Civil works layout plans and cross sections for the concept design of Botany Rail Line	Civil works design cross sections

3.3 Impact assessment method

3.3.1 Introduction

This impact assessment characterises the changes to the existing groundwater conditions associated with the project and the potential impacts to the range of beneficial uses or values of the receiving environments identified in Section 4. For the following reasons a desktop based qualitative approach was adopted for the assessment:

- the magnitude of impacts is expected to be localised and temporary (construction focused)
- any intersection of groundwater will be managed by adopting non-dewatering techniques, in line with normal construction practice
- any long-term impacts are expected to be negligible relative to existing conditions.

The data available for this assessment is limited to information from previous investigations and public databases. As such, a conservative approach identifying potential impacts is necessary due to gaps in hydrogeological understanding based on the limited data.

The impact assessment method has been developed by:

- establishment of a conceptual hydrogeological model for the project and surrounding areas
- characterising the existing local and regional hydrogeological conditions
- inferring and documenting the magnitude of potential changes in groundwater conditions and surface flow discharges from the conceptual model developed
- characterising the legislative criteria against which predicted changes in groundwater conditions can be compared to establish whether the groundwater changes represent acceptable or adverse impacts.

The following groundwater conditions were the focus of the impact assessment:

- groundwater recharge
- groundwater drawdown
- groundwater quality – beneficial use potential.

Groundwater recharge – An overall comparison of the change in capped areas relative to uncapped areas has been undertaken pre-, during and post-project development to assess the overall impacts on groundwater recharge. It is noted that the construction footprint (of which the operational footprint is smaller) approximates less than 0.3 per cent of the Botany Sands aquifer recharge area and there is already existing rail infrastructure present. As such the project is not expected to induce a measurable change in the existing recharge conditions.

Groundwater drawdown – Engagement with the project design team has been undertaken to identify subsurface infrastructure that could intersect groundwater. Interpreted groundwater elevations have then been plotted on the design cross-sections along the alignment of the project site to identify where groundwater is intersecting subsurface infrastructure. A safety factor has been added to the groundwater levels to allow for long-term wet weather conditions (natural variations in groundwater levels) and uncertainty in interpolation of groundwater elevation data. This has been used to identify where and what infrastructure works will require planning for the adoption of construction techniques that prevent groundwater drawdown (such as no dewatering) given that there is already a commitment on the project to adopt non-dewatering techniques, in line with normal construction practice.

Groundwater quality beneficial use potential – The current data indicates the beneficial use potential of the current groundwater system is limited to industrial water supplies and discharges to a moderately to highly impacted surface water systems. Acute and diffuse groundwater quality impacts associated with project construction and operation are therefore difficult to predict and may result in reduced beneficial use potential. As such, impacts have been assumed to have potential to occur during construction and operation. As such management and monitoring measures are considered.

3.3.2 Criteria for undertaking assessment

The AIP requires that potential impacts on groundwater sources, including their users and high priority GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the AIP. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable.

The Botany Sands aquifer is classified as a highly productive groundwater sources for coastal sand water sources. Predicted groundwater impacts have been assessed with reference to the minimal impact considerations for highly productive groundwater sources for coastal sand water sources. A highly productive (high yields and total dissolved solids less than 1,500 mg/L) system was selected based on the conceptual understanding of the hydrogeological conditions. These criteria are as follows:

- Water table – less than or equal to 10 per cent cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, at a distance of 40 metres from any high priority GDE or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum 2 metres water table decline cumulatively at any water supply work. EES (2018) measured a maximum fluctuation of the groundwater table of 2.5 metres and therefore a less than or equal to 0.25 metre variation in the groundwater table is allowed.
- Water pressure – a cumulative pressure head decline of not more than a 2.0 metre decline at any water supply work.
- Water quality – any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond a distance of 40 metres from the activity.

With regards to water quality criteria, Section 4 indicates that the Botany Sands aquifer system along the project site has been intermittently impacted by a range of historical industrial activities. This has resulted in existing groundwater quality often exceeding potable use criteria, recreation criteria and ecological criteria for the protection of slightly to moderately disturbed freshwater and marine water systems. Further to this there are a number of already contaminated groundwater sites in the vicinity of the project site that are known to have impacted groundwater, particularly at Sydney Airport (such as the domestic terminal taxi parking area and the Qantas jet base).

As a result of water quality impacts NSW DoI have placed a water use embargo on significant parts of the Botany Sands aquifer that intersect the project site (but not all areas) with regard to use of groundwater for domestic purposes such as gardening, bathing and drinking water.

Despite this the following receptors rely on, or are receiving water bodies for, the Botany Sands aquifer groundwater:

- industrial use is still permitted (subject to water quality monitoring conditions)
- the Botany Wetland system represents a high priority groundwater dependent ecosystem which is listed in the Water Sharing Plan for the Greater Metropolitan Groundwater Resources and crossed by the project
- Botany Bay, Cooks River and lower Mill Stream recreational users (fishing, swimming, boating, water sports) and marine/freshwater aquatic ecosystems.

These receptors represent the beneficial use potential of the aquifer, of which the current groundwater quality often exceeds, particularly with regard to recreational and aquatic ecosystems in receiving water bodies.

The AIP water criteria require that the beneficial use potential of these systems cannot change beyond 40 metres of the activity. A key aspect of this criteria is a 'change' in the beneficial use potential so, in this instance, so long as the current conditions do not change the beneficial use potential is being maintained. As such a focus on maintaining baseline water quality during construction and the operation has been the key focus of the water quality components of this assessment.

These criteria have been adopted to identify potentially adverse impacts, on which further investigations or mitigation measures are proposed in Section 7. These criteria need to be considerate of the changing conditions temporally and spatially in order to provide a comprehensive assessment of impacts.

It is noted that the NSW AIP does not apply within Sydney Airport land owned by the Commonwealth. However, there is currently no specific commonwealth groundwater impact assessment criteria and as such the NSW AIP has been adopted for commonwealth areas adjacent to the project.

4. Existing environment

4.1 Climate

Rainfall data have been obtained from the closest Bureau of Meteorology weather station at Sydney Airport (BOM site number 066037). Sydney airport has a complete rainfall record with complete data from 1898. This data was obtained from scientific information for land owners available from the Queensland Government website (https://data.qld.gov.au/dataset/silo-patched-point-datasets-for-queensland).

Most rainfall occurs in during the autumn season and the highest average rainfall occurs in June. The lowest rainfall occurs in the spring. The average annual rainfall is 1083.4 mm.

Figure 4.1 presents the long term monthly rainfall record for Sydney Airport Aeronautical Meteorological Office (AMO) (BOM Station 066037) along with the cumulative deviation from mean rainfall (cumulative rainfall deviation or CRD).

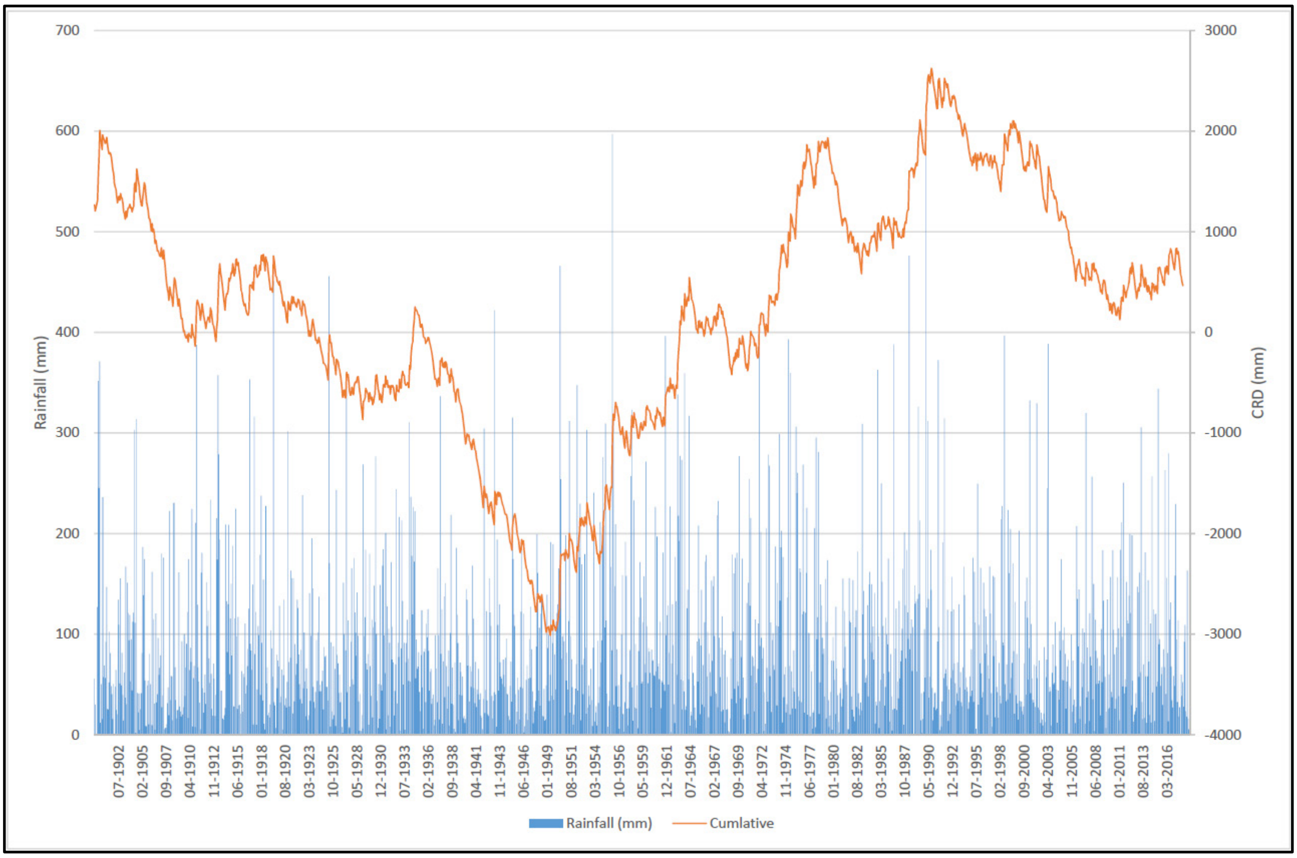


Figure 4.1 Rainfall and cumulative rainfall departure (CRD) for weather station Sydney Airport AMO (BOM site number 066037)

The cumulative deviation plot shows four distinct and large scale climatic trends over the 118 years of observation.

Two periods of above average rainfall occur; the first from 1900 to 1910, and then again from 1963 to 2018. There is a prolonged period of below average rainfall between 1935 and 1963. These large-scale trends include numerous small and intermediate scale fluctuations.

Different types of aquifers have different responses to climatic variation, generally referred to as the groundwater response time. Shallow unconfined aquifers often respond to a small-scale fluctuation including individual rainfall events, whereas deeper regional scale, and semi-confined aquifers such as the Hawkesbury Sandstone often show trends that are more aligned with larger scale variations.

The average annual rainfall from BOM station 066037 for the available 79 years is provided in Table 4.1. This data was obtained from the BOM website and only covers the last 79 years of data.

Table 4.1 Average rainfall (mm) at BOM station 066037

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
94.6	111.4	117.0	107.8	96.0	124.6	69.0	76.0	59.7	69.7	80.4	73.6	1083.4

Temperature and evapotranspiration data for Sydney Airport (BOM site number 066037) are provided on Table 4.2. Temperature is available for 79 years (1939 to present), while evapotranspiration data is available from 1889.

Mean daily evapotranspiration ranged from 0.4 millimetres on 23/06/1974 to 9.4 millimetres 01/01/2006. Average annual evapotranspiration for the monitoring period is 1200.7 millimetres per annum.

Table 4.2 Temperature and evapotranspiration, Sydney Airport AMO (BOM site number 066037)

Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Max Temp (°C)	26.6	26.5	25.4	23.0	20.1	17.6	17.1	18.4	20.7	22.7	24.1	25.9	22.3
Mean Min Temp (°C)	18.9	19.1	17.6	14.3	11.0	8.7	7.3	8.2	10.5	13.3	15.5	17.6	13.5
ET (mm)	146.5	120.5	110.7	82.2	62.4	47.7	55.0	74.0	95.9	122.2	134.9	150.0	1200.7

4.2 Topographical setting

The project is located predominantly within the existing rail corridor of the Botany Line within Mascot and Botany. It is located in a highly modified landscape that facilitates industrial development and transport. The project site is generally flat and at elevations less than 12 metres Australian height datum (AHD).

Regional topography generally slopes gently upwards from 0.0 metres AHD at Botany Bay in the south and Cooks River/Alexandra Canal to the west and north-west to elevations of 30 to 40 metres AHD to the north-east, east, and south-east of the project site. Higher elevations are present east of Sydney Central Business District (CBD), with a maximum of 110 metres AHD at Waverly Park in Bondi, before dropping to sea level at the coast.

4.3 Surface water features

4.3.1 Waterway overview

Surface water from the northern 1.4 kilometres of the project site flows in a north westerly direction to Alexandra Canal via existing drainage network and the Upper Mascot Open Channel.

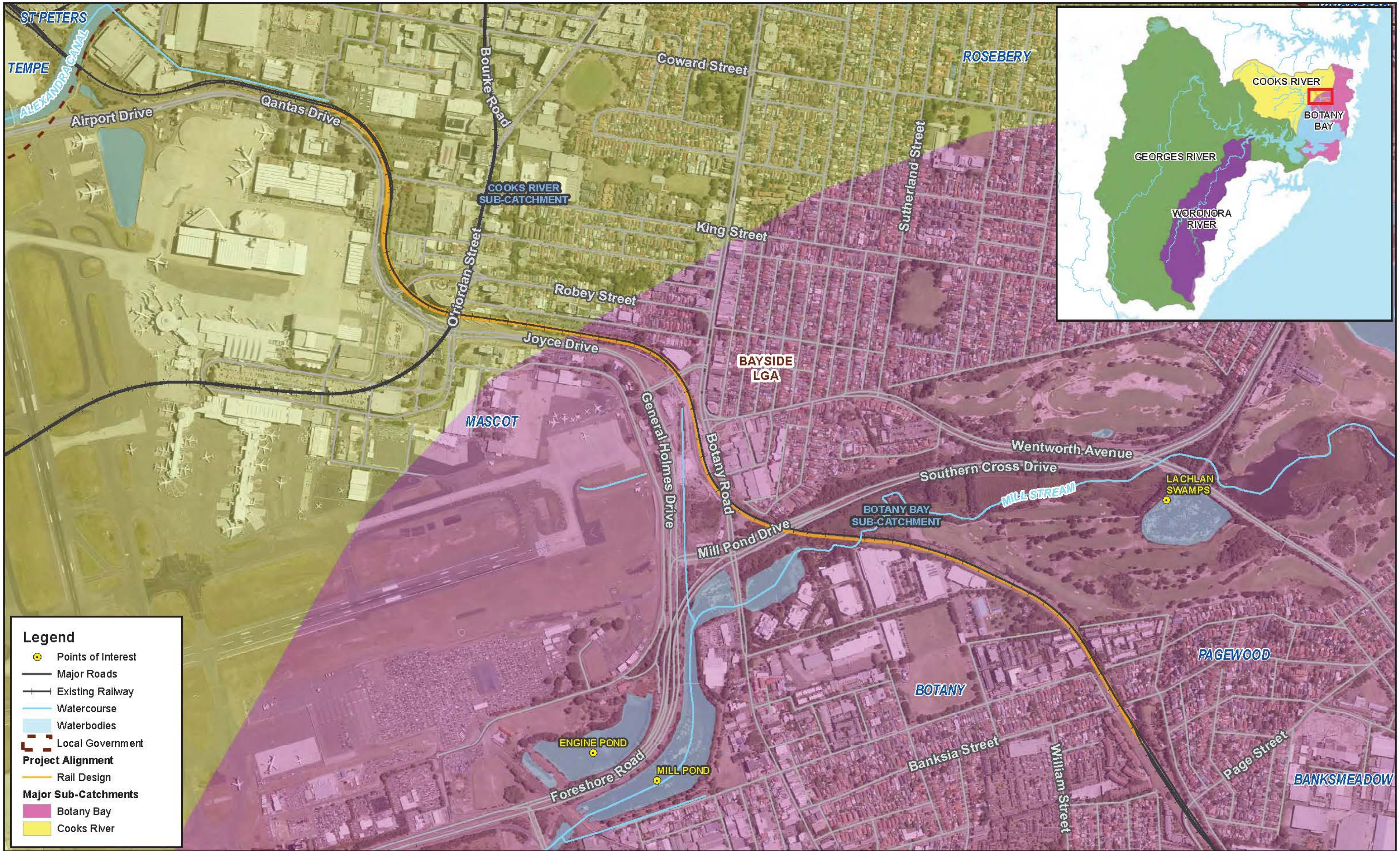
Surface water from the southern 1.6 kilometres of the project site flows to Mill Stream, directly via overland flow or through existing drainage networks.

4.3.2 Catchments

The project is located within the 'Direct to Botany Bay' sub-catchment of the larger Botany Bay catchment as per the Sydney Metropolitan Catchment Management Authority (SMCMA) *Botany Bay & Catchment Water Quality Improvement Plan* (SMCMA 2011). The Botany Bay catchment encompasses surface water features near and within the project site including Alexandra Canal, the Botany Wetlands (including Lachlan Swamps and Mill Stream, also known as Sydney freshwater wetlands) and Botany Bay to the south-east (Figure 4.2). There is a small wetland located to the west of Alexandra Canal and adjacent to South Street known as Tempe Wetlands. These wetlands are manmade and approximately 2.8 hectares in size.

Engine Pond and Mill Stream are located south of the Southern Cross Drive, and intersect the project site. Engine Pond acts as a sink for surface water runoff from the surrounding local area. While a locally and regionally significant surface water feature, it is not considered to be a pristine environment and is expected to be moderately disturbed by run-off from the surrounding urban environment. Engine Pond and Mill Stream are listed as Environmentally Significant Areas under a range of registers, including the directory of important wetlands in Australia (as listed in Sydney Airport Master Plan, 2039) and the national Wetlands Program. Further to this the water sharing plan for the greater metropolitan region groundwater sources 2011 lists Engine Pond, Mill Stream and Mill Pond as high priority groundwater dependent ecosystems. This is based on these features being part of Botany Wetlands (Sydney freshwater wetlands), which are listed as endangered ecological community in the *Biodiversity Conservation Act* 2016. It is noted that Engine Pond is on Commonwealth land. Consequently, it is not subject to environmental assessment or approvals under NSW environmental planning and assessment legislation. However, the EPBC Act requires protection of the environment from actions involving Commonwealth land, and it is therefore appropriate to consider threatened biota that are listed under NSW legislation and other aspects of the biodiversity in this area. In addition, the Botany Bay area provides summer habitat for a number of migratory wading birds that are listed under the EPBC Act, and the ponds may also be used on occasion by these species.

Botany Bay, which is not considered to be a pristine environment, is used for a range of beneficial purposes such as recreation and fishing (despite the DPI prohibition of commercial fishing in Botany Bay and Cooks River under the *Fisheries Management (General) Regulation, 2010*). Recreational fishing is prohibited in the area between the runways extending into Botany Bay but is not prohibited in and around Mill Stream and the broader Botany Bay area. There is a *Botany Bay Water Quality Improvement Plan* (SMCMA 2011) with the main objective to improve pollutant load reduction and suspended sediment through direction and on-ground implementation.



REFERENCE SOURCE: © Botany Bay & Catchment Water Quality Improvement Plan. Sydney: Botany Bay Water Quality Improvement Program, Sydney Metropolitan Catchment Management Authority 2011.

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A1	27/05/2019	Surface Water Features		

SCALES ON A1 SIZE DRAWING
0 100 200 m
1:10,000

CO-ORDINATE SYSTEM: MGA ZONE 56
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY
DRG No.

TITLE	NAME	DATE
DRAWN	D NAIKEN	27/05/2019
DRG CHECK	P.QUIMORA	27/05/2019

CLIENT
PREPARED FOR

BOTANY RAIL DUPLICATION A3

Groundwater Impact Assessment
Figure 4.2
Surface Water Features

RMS REGISTRATION No.
PART

ISSUE STATUS: FOR INFORMATION
EDMS No.
SHEET No.
ISSUE: A1

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4.4 Geology

4.4.1 Regional geology

The Permo-Triassic Sydney Basin is a convergent margin foreland sedimentary basin located along Australia's central eastern coast. It covers 64,000 square kilometres (km^2), with the onshore basin centred in Sydney, while the offshore basin extends eastward with 5,000 km^2 between the coast and the outer edge of the continental shelf (Stewart and Alder, 1995). It is characterised by a lower sequence of interbedded marine-deposited strata, followed by local Permian coal-bearing sequences, which are then finally overlain by additional marine and terrestrial strata. The Permo-Triassic sedimentary succession is intruded by igneous bodies of Jurassic to Tertiary in age, and overlain by unconsolidated Quaternary alluvium. The basement of the Sydney Basin includes the Lachlan Fold Belt and Late Carboniferous volcanoclastic sediments. The project site with regard to the regional geology is presented in Figure 4.3.

4.4.2 Site geology

The 1:100,000 Sydney Region Geological Map (Geological Survey of NSW 1983) states that the regional geology consists of Triassic Hawkesbury Sandstone and Ashfield Shale overlain by Quaternary sediments (unconsolidated sands with minor peat, silts and clays and hard iron-cemented layers known as waterloo rock). The Quaternary sediments infilled drowned river valleys that were incised into Hawkesbury Sandstone bedrock. These sediments, otherwise known as the Botany Sands, are composed of predominantly unconsolidated to semi-unconsolidated permeable sands. These are interspersed with lenses and layers of peat, peaty sands, silts and clays (low permeability), which become more common at greater depths. The stratigraphic units encountered in the project site are summarised below.

Hawkesbury Sandstone

The Hawkesbury Sandstone is composed of medium to coarse-grained quartz sandstone, with very minor shale and laminate lenses. It is divided into three intervals: a lower sequence of medium to coarse sandstones, a middle sequence of clayey sandstones, siltstones and shales, and an upper sequence of medium to coarse sandstones similar to the lower sequence. This unit is exposed about 1.0 kilometre north of the project site.

Ashfield Shale

The Ashfield Shale of the Wianamatta Group overlies the Hawkesbury Sandstone and was formed as prodelta and delta front deposits. This unit is composed of black to dark grey shale and laminates. The nearest exposure of the unit is located about 1.0 kilometre north of the project site.

Quaternary sediments

The sediments from the erosion of the underlying bedrock are transported by ancient and current waterways from the Quaternary sediments. The northern portion of the study area is underlain by alluvium composed of peat, sandy peat, and mud. This unit is deposited through fluvial processes in freshwater swamps. Medium to fine-grained marine sands with podsols comprise the area to the east of the project site.

Botany Sands are aeolian deposits comprising well-sorted, poorly cemented, and fine to medium-grained quartz sands. Lenses and bands of inter-dunal peat and organic clay are also present within the unit. The average thickness of the Botany Sands is 15 to 20 metres (Hatley, 2004). The depth to bedrock and indicative thickness of the Botany Sands along the project site is presented in Figure 4.3.

DATA SOURCE: Aerial Imagery ©AUSIMAGE - Jacobs Group (Australia) Pty Ltd 2018, © Department of Finance, Services & Innovation 2018

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BOTANY RAIL DUPLICATION

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Groundwater Impact Assessment
Figure 4.3
Regional Geology

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A1	27/05/2019	Regional Geology

WVR No. | APPROVAL

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CO-ORDINATE SYSTEM: MGA ZONE 56

HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: WSP, GHD

DRG No.

TITLE	NAME	DATE
DRAWN	D.NAIKEN	27/05/2019
DRG CHECK	P.QUIMORA	27/05/2019

PREPARED FOR

RMS REGISTRATION No.

PART

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SHEET No.

ISSUE: A1

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Fill

A thin layer of fill is commonly encountered in urban areas and is associated with infrastructure and roadworks. Areas of thicker filling are present in landfill sites north of the project site comprising dredged estuarine sand and mud, demolition gravels, and industrial and household waste. Sydney Airport located west of the project site is atop mixed Quaternary sediments and manmade fill.

Structural geology

There are a number of north-east to south-west faults cutting across the project site (WSP, 2010). The Woolloomooloo fault zone, consisting of a number of north-east trending unnamed faults, cuts across the Northern Lands (WSP, 2010). Pells (2015) suggests that the Woolloomooloo fault zone is a complex series of sub-vertical and low angle thrust structures (Golder, 2017). These fault lines are shown on Figure 4.3.

The structural geology is less significant for groundwater issues on this project due to infrastructure primarily intersecting shallow unconsolidated sediments.

4.4.3 Unconsolidated sediments

Unconsolidated sediments along the project site are up to about 20 metres in thickness, and bedrock is expected to be encountered from 10 metres to 15 metres below AHD (WSP, 2010). This is supported by previous investigations within and surrounding the project site, noting investigation points comprising layered sands, silts, and clays occur within these depths.

Soil landscape

Based on the Soil Landscapes of Sydney Sheet 9130 (Chapman and Murphy, 1989), the project is straddling along two types of soil landscapes – Aeolian Tuggerah (AEtg) to the east of the rail corridor, and Disturbed Terrain (DTX) extending across the airport to the west, along the Botany Wetlands, the lower reaches of the Cooks River and up Alexandra Canal to the north.

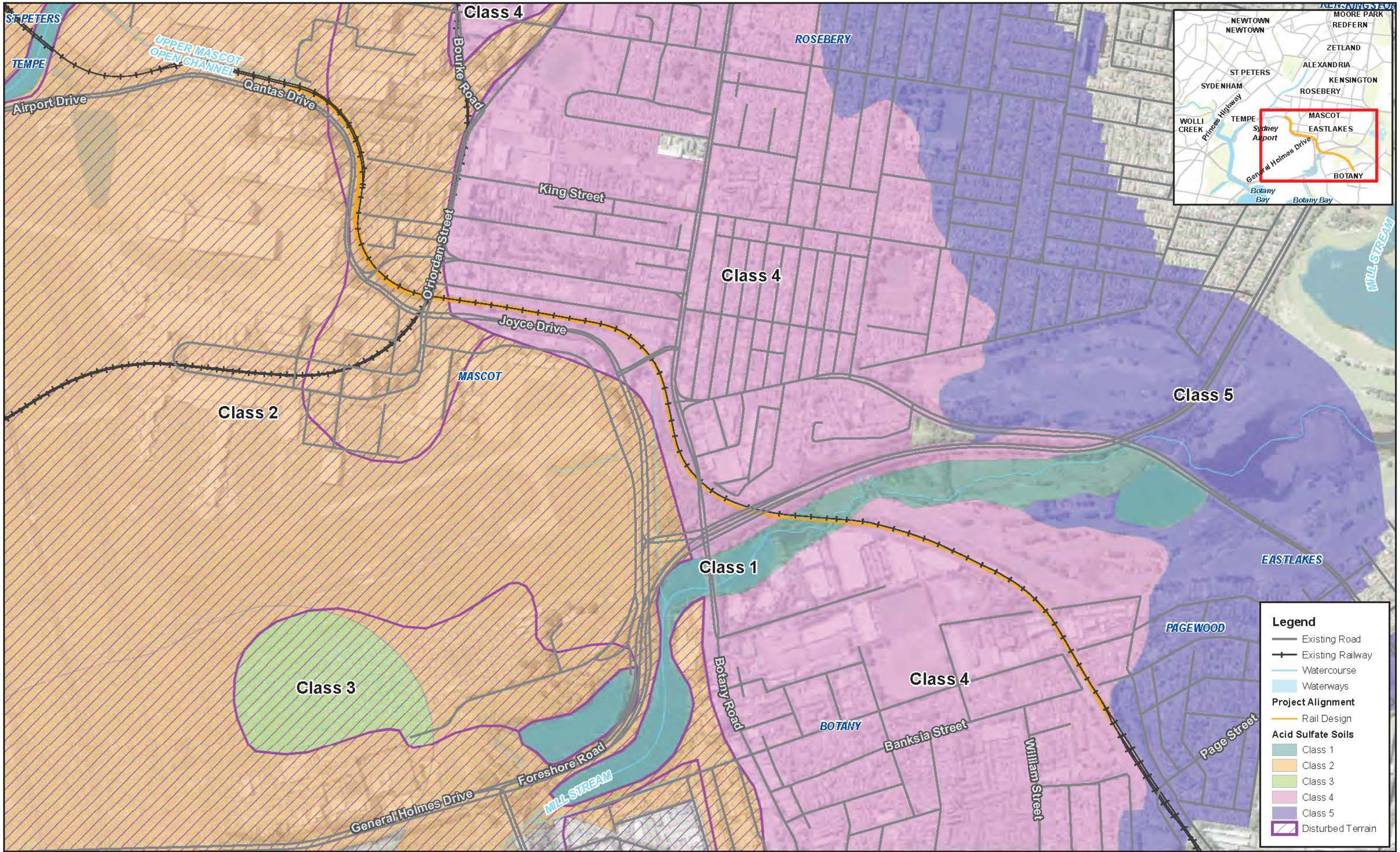
Soil salinity

Saline soils are typically present in areas along tidal waterways, such as Alexandra Canal. A soil salinity assessment completed by Golder (2016) for the new M5 classified the northern portion of the project site, located south of St. Peters as a low salinity potential area. The classification presented in Golder Associates (2016) was based on guidance provided in the NSW Department of Land and Water Conservation (2002) Site Investigations for Urban Salinity (DWLC, 2002). This may be attributed to the high permeability soils in the area that allow for rapid drainage and flushing of salts. This is expected to be similar to the conditions present within the rest of the project study area.

Acid sulfate soils

Acid sulfate soils (ASS) are naturally occurring soils containing iron sulfides. When exposed to air, these oxidise and produce sulfuric acid. These soils are common along coastal areas and inland waterways, wetlands, and drainage channels. The project is classified with a low probability of occurrence of ASS, with the exception of land adjacent to Mill Stream which is classified with a high probability of occurrence of ASS as shown in Figure 4.4 (NSW Office of Environment and Heritage, 2018).

There is the potential for ASS to present beneath the disturbed terrain and Tuggerah soils. Table 4.3 presents the acid sulfate classification of locations within the project site.



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BOTANY RAIL DUPLICATION

A3

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
A1	27/05/2019	Acid Sulfate Soils		

SCALES ON A1 SIZE DRAWING
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CO-ORDINATE SYSTEM: MGA ZONE 56
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: WSP, GHD

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Groundwater Impact Assessment
Figure 4.4
Acid Sulfate Soils

RMS REGISTRATION No.

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Table 4.3 Acid sulfate soil classifications

Location	Class	Work which would potentially expose acid sulfate soil	Potential ASS disturbance work expected to be conducted in project site
From Southern Cross Drive bridge to Mill Stream bridge	1	Any works below underside of ballast:	▪ Track excavation (~0.7 metres below the natural ground surface (mBGS)) ▪ Service upgrade trenches (~1 mBGS) ▪ Piling for Southern Cross bridge (~40 mBGS) ▪ Piling for Mill Stream bridge (~40 mBGS).
Western end of the duplication to the O'Riordan Street bridge	2	Works below natural ground surface and works by which the water table is likely to be lowered:	▪ Track excavation (~0.7 mBGS) ▪ Services upgrade trenches (~1 mBGS) ▪ Excavation for footings for retaining walls extending south of King Street to about 150 m south of O'Riordan bridge (footing depth of ~1 mBGS or more if piling is required) ▪ Piling for Robey Street bridge and O'Riordan Street bridge (~40 mBGS).
From the O'Riordan Street bridge to the western end of Southern Cross bridge From Mill Stream bridge to Banksia Street	4	Works 2 metres below natural ground surface and works by which the water table is likely to be lowered more than 2 metres below natural ground surface:	▪ Piling for Southern Cross Drive bridge (~40 mBGS) ▪ Excavation for footings for retaining walls between Botany Road bridge and Southern Cross Drive bridge (footing depth of ~1 mBGS likely to require piling at greater depths).
From Banksia Street to South-eastern end of the duplication	5	Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below 5 metres AHD and by which the water table is likely to be lowered below 1 metre AHD on adjacent Class 1, 2, 3 or 4 land	Not applicable.

4.5 Hydrogeological conditions

4.5.1 Introduction

The succeeding sections present the hydrogeological conditions of the underlying strata. However, it is expected that the project construction and operation will primarily intersect the shallow unconsolidated Botany Sands aquifer.

4.5.2 Aquifer parameters

Bedrock

Hawkesbury Sandstone

The Hawkesbury Sandstone is defined as a semi-confined dual porosity (fractured and porous) regional aquifer extending across Sydney Basin. Groundwater flow is through the porous layers (coarser sands and gravels) of the rock mass that has been dissolved at various depths intervals throughout the rock mass and is enhanced by open bedding planes and fractures. Reduced water quality within the upper portion of the sandstone unit may be due to the natural leakage of saline groundwater from the Ashfield Shales (Golder, 2017).

Ashfield Shale

Ashfield Shale is considered to be a low-yielding aquifer. Like the Hawkesbury Sandstone, its permeability is controlled by fracture intensity, persistence, and joint aperture. Groundwater within this unit is of high salinity, ranging from 5000–50000 mg/L (McNally, 2004). The Mittagong Formation is also considered to have the same hydraulic properties as the Ashfield Shale. Based on the New M5 hydrogeological design by Golder (2017), "*The Mittagong Formation has been conceptualised within the Ashfield Shale unit as they exhibit similar hydraulic properties and are both not understood to contain significant amounts of groundwater except in fracture networks*."

The hydraulic conductivities of the bedrock are presented in Table 4.4. From this it is apparent that despite the Ashfield Shale being considered an aquitard relative to the Hawkesbury Sandstone, the range of horizontal hydraulic conductivity values derived from testing is very similar between the two formations, and, as shown from the New M5 project and M4 East investigations, the Ashfield Shale and Hawkesbury Sandstone displayed identical median hydraulic conductivity values. From the M4-M5 Link, the maximum, and arithmetic mean hydraulic conductivity values of the Hawkesbury Sandstone were found to be an order of magnitude greater that the Ashfield Shale, while harmonic mean results had similar values.

Table 4.4 Hydraulic conductivity values derived from other investigations in metres per day (m/day)

Source	**Ashfield Shale (m/day)**	**Mittagong Formation (m/day)**	**Hawkesbury Sandstone** (m/day)	**Method**
WestConnex New M5 (AECOM, 2015)	<0.0001 to 0.07 Median = 0.003 n = 6	<0.0001 to 0.9 Median = 0.01 n = 10	<0.0001 to 4.3 Median = 0.003 n = 205	Packer tests (n=221) Depth range 10 to 80m
Sydney Metro EIS (Jacobs, 2016)	<0.0086 to 0.05 n = 3 Depth range 12 to 29 m	<0.0086 to 0.52 n = 15 Depth range 7 to 33 m	<0.0086 to >0.86 n = 53 Depth range 12 to 46 m	Packer tests (n=72)
North West Rail Link (ECRL) EIS (Hewitt, 2005)	No data	No data	Mean (near surface) = 0.1 Mean (50 m depth) = 0.002	Packer tests (n=363)
M4 East (GHD, 2015)	0.00022 to 0.73 Median = 0.011 n = 75 Depth range 10 to 40 m	No data	0.00043 to 1.7 Median = 0.011 n = 83 Depth range 10 to 50 m	Packer tests (n=158)
M4 – M5 Link (AECOM, 2017)	0.0086 to 0.12 Arithmetic Mean = 0.017 Harmonic mean = 0.010 n = 24	No data	0.0086 to 1.17 Arithmetic Mean = 0.1 Geometric mean = 0.012 N = 181	Packer tests (n = 205)

Geologic structures

Groundwater flow in the bedrock units within the project site are strongly influenced by geologic structures. Faults and intrusions generally provide secondary permeability as the fractures serve as conduits for groundwater flow.

Botany Sands and Quaternary sediments

The Botany Sands is considered to be an unconfined, highly permeability aquifer. Published data from 1937 to 1997 for the Botany Sands were compiled by Bish et al (2000), and further summarised by Hatley (2004). The aquifer characteristics of the Botany Sands are presented below in Table 4.5.

Table 4.5 Aquifer characteristics of the Botany Sands (Hatley, 2004)

Parameter	Range
Average thickness	15 to 20 m, up to 53 m in deeper paleochannels
Recharge (by rainfall infiltration)	6% (over estuarine sediments) to 37% (over sandy sediments)
Hydraulic gradient	0.003 to 0.01
Porosity	0.33 to 0.40
Variable storage coefficients	0.0004 to 0.26
Hydraulic conductivity (metres per day (m/day))	1.4 to 85
Transmissivity (m^3/day)	230 to 630
Specific yields	0.17 to 0.26

In coastal sand aquifers including the Botany Sands aquifer, groundwater is contained in the pore spaces in the unconsolidated sand sediments. Groundwater wells have a screen in them that intersects groundwater within the surrounding geology. The screen is made up of slots and is usually at a targeted depth. The remainder of the well is solid casing without slots.

The level of connection between surface water and groundwater is significant (tidal section only). There is a low impact on instream values as a connection with saline water. The estimated travel time between groundwater and an unregulated river is days to months.

The report *Dewatering Feasibility Study – WestConnex Enabling Works – Airport East Project* (EES, 2018) considered and area located along the project site. This report calculated groundwater velocities based on different screened depths within the Botany Sands aquifer. They calculated a site average of 1.1–1.3 m/day which equates to 396–480 metres per year (m/year).

Fill

There are intermittent areas of fill across the project associated with development/infrastructure in the area. A large portion of the rail corridor is constructed on engineered embankments that are elevated above adjoining ground level. The presence of such overlying the alluvium is expected to decrease infiltration rates and recharge to aquifers.

Previous studies also conclude that landfill sites surrounding the project site, have impacted on groundwater quality in the area.

Hydraulic conductivity data from previous investigations for boreholes screened within the Quaternary sediments and unconsolidated manmade fill are summarised in Table 4.6. The results suggest that the Botany Sands hydraulic conductivity values are variable, ranging from 0.6 to 26 metres per day.

Table 4.6 Hydraulic conductivity values for Quaternary sediments Botany Sands and fill

Source	Botany Sands (m/day)	Fill (m/day)	Method
WestConnex New M5- Alexandria Landfill Closure – Hydrogeological Assessment (AECOM, 2015)	0.605 to 0.904 n = 2 Average = 0.748	0.448 n = 1	Falling head test (n = 3) Depth range 6 to 34 m
Dewatering Feasibility Study – WestConnex Enabling Works – Airport East Project (EES, 2018)	19 to 26 n = 6	Not applicable	Falling head test (n = 3) Depth range 3 to 12 m Packer test n = 3 Depth range 6 to 12 m
Tempe Lands Remediation and Development – Groundwater Report (Coffey, 2003)	0.8 to 2.2 n = 6 0.002 to 0.003 n = 8	0.4 to 6.7 n = 11	Falling head test n = 17 Piezocone dissipation test n = 8

4.6 Groundwater recharge

Recharge to the Botany Sands aquifer is primarily through direct rainfall infiltration (Hatley, 2004) and ranges between 6 per cent over estuarine sediments to 37 per cent over sands (Bish et al, 2000). The main recharge for the Botany Sands aquifer is located about 6 kilometres north of the project at the Centennial Parklands. Other green areas like golf courses and the Botany Wetlands are also main recharge areas. The project site is mapped as an impervious surface (SMCMA, 2011), as urban developments such as roads and other man-made structures result in reduced surface infiltration. Therefore, it is expected that the project site will already have lower groundwater recharge from rainfall infiltration compared with open spaces overlying the same aquifer. However, leakage from supply and drainage networks generally compensate for decreased direct recharge in urban areas (Lerner, 2002).

4.7 Groundwater elevations

4.7.1 Temporal changes in groundwater elevations

Ongoing monitoring was undertaken by NSW DoI-Water from March 1999 through to March 2015 at ten wells primarily located within the Botany Sands aquifer. The screen lithology of GW042161 was unable to be identified from the available information. GW075025 is screened across the interface with the bedrock aquifer. The wells are located to the east of the project. The data was obtained from the WaterNSW real time data website[2]. The locations of these wells are presented on Figure 4.5. Plots of the groundwater elevations with rainfall data are in Figure 4.6, and groundwater elevations compared with the cumulative rainfall deviation (CRD) are in Figure 4.7.

[2] https://realtimedata.waternsw.com.au/

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CO-ORDINATE SYSTEM: MGA ZONE 56

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DRG CHECK	P.QUIMORA	28/05/2019

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PREPARED FOR

BOTANY RAIL DUPLICATION — A3

Groundwater Impact Assessment

Figure 4.5

DOI - Water Monitoring Bore Locations

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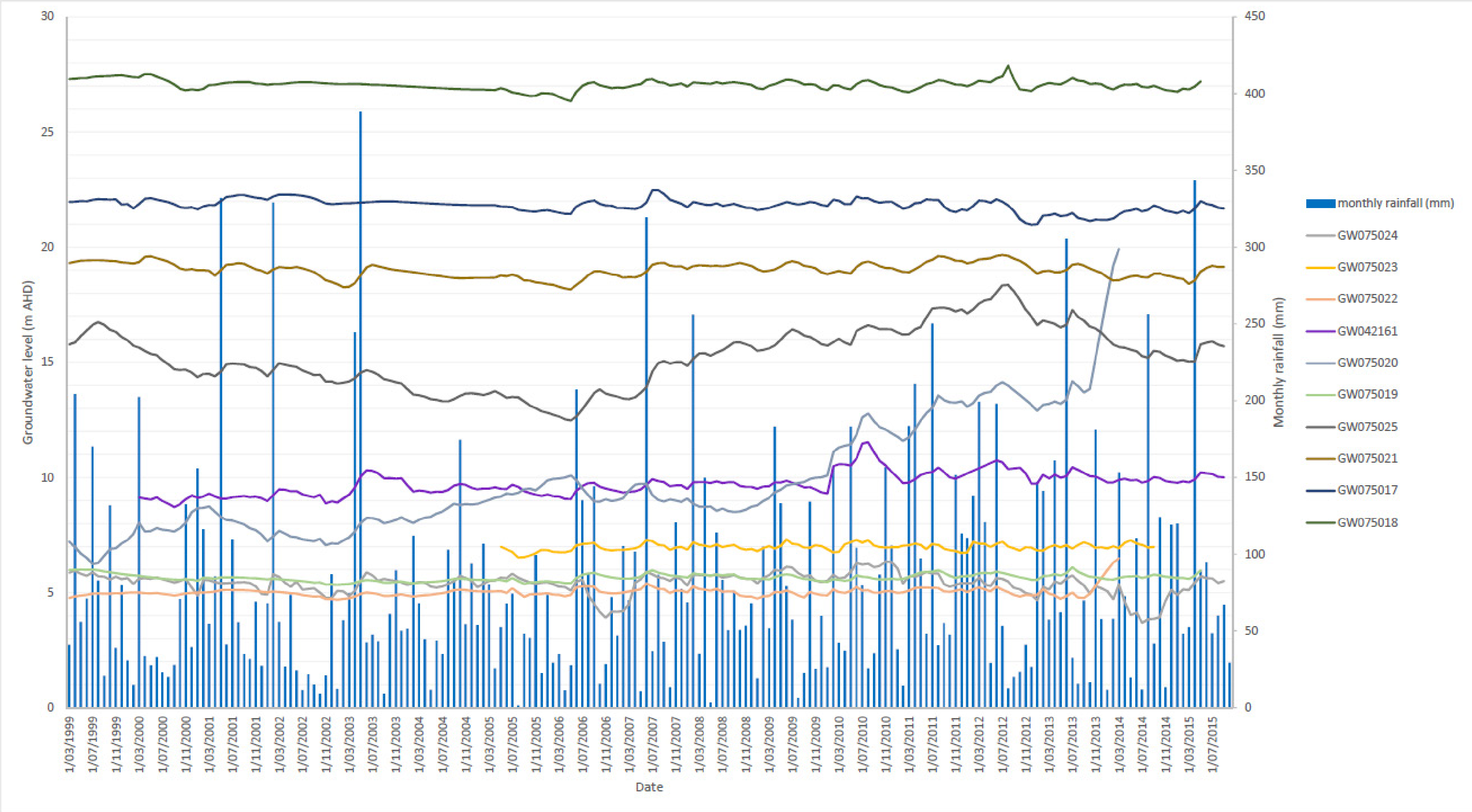


Figure 4.6 DOI-Water groundwater monitoring data for the Botany Sands aquifer

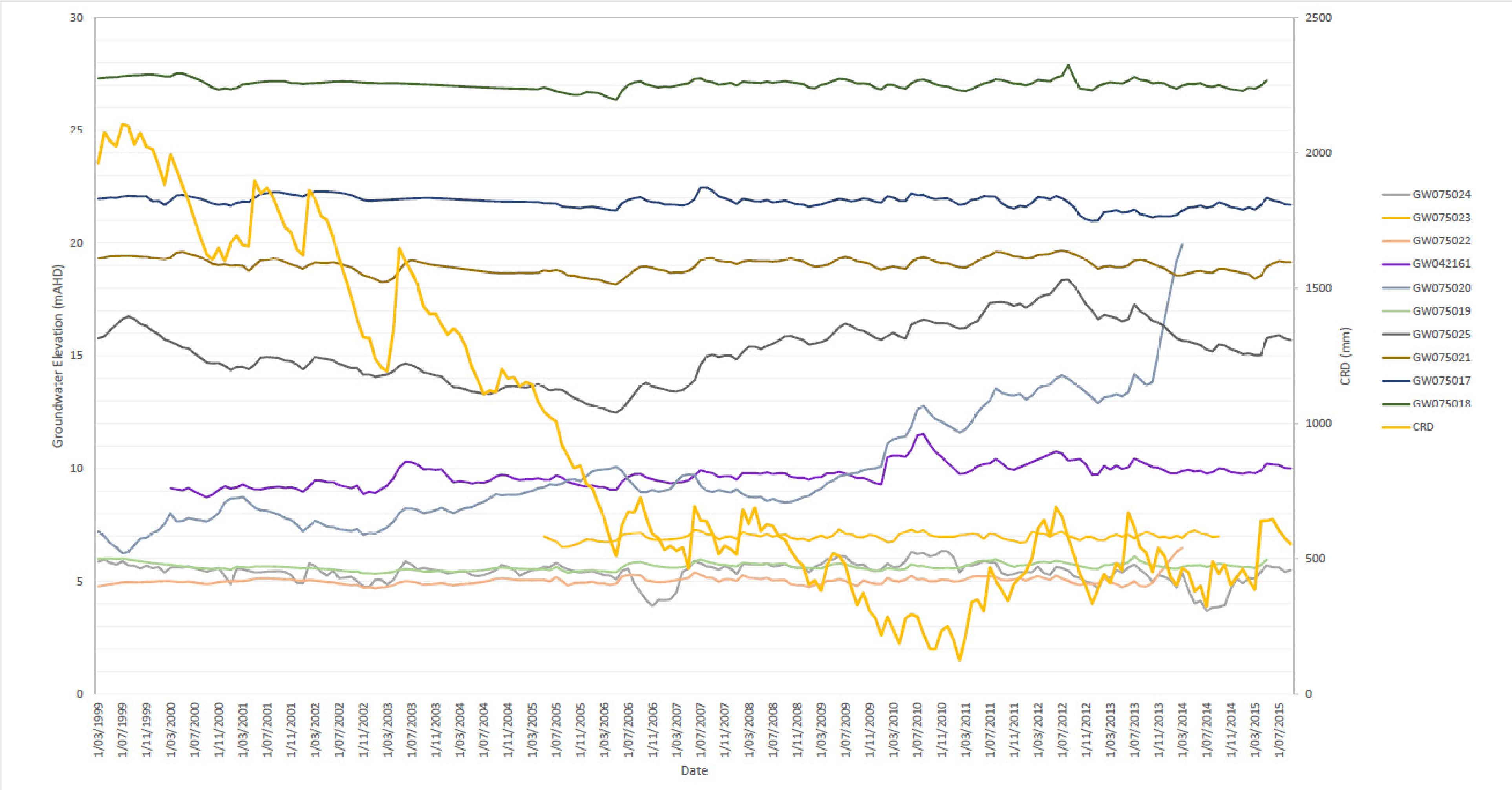


Figure 4.7 DOI-Water groundwater monitoring data and cumulative rainfall departure curves

The data are summarised below:

- Average variation in elevations – Following the topography of the area, groundwater is intercepted at higher elevations (27 metres AHD) in the north-west near Centennial Park, and at lower elevations (less than 5 metres AHD) to the south near Botany Bay.
- Response to rainfall characteristics – Monthly rainfall records for Sydney Airport AMO (BOM site number 066037) were plotted against groundwater levels. The available data shows that groundwater is generally stable, with spikes noted in periods with above average rainfall. However, the groundwater elevations show little response during periods of below average rainfall. Groundwater well GW075020 elevations steadily decrease towards the end of the dataset. This well is located at Heffron Park and may be due to irrigation of the parklands. The wells located with elevations between 5-10 metres AHD have more fluctuations in response to rainfall then the wells with elevations greater than 10 metres AHD. The groundwater elevations ranged from 1.035 metres (GW075019) to 6.113 metres (GW075025). To note, this data from these wells cannot be verified and the wells are located next to sporting fields that may extract groundwater for irrigation. Therefore these variations in groundwater may be induced by pumping of the aquifer for irrigation.
- Response to the CRD – The CRD for the date range is in a period of reduced rainfall. There is a decline until around 2011 where it slightly increases and stabilises. The groundwater elevations do not respond to this decrease in rainfall with the exception of GW075020 and GW075025. This suggests that groundwater elevations, especially in low lying areas where the project site is located, are generally less responsive to climatic conditions.

The *Dewatering Feasibility Study – WestConnex Enabling Works – Airport East Project* (EES 2018) reported water table natural variations ranging from 0.41 metre to 2.18 metres. This data came from a range of sources including on-site wells associated with the WestConnex enabling works airport east precinct, historical water-table fluctuation recorded in nearby registered groundwater bores (NSW DoI continuous monitoring wells) and continual data loggers of groundwater levels in a similar hydrogeological site near Newcastle.

The closest wells to the project are GW070522, GW075023, and GW075024. GW070522 is located about 240 metres to the south-west, GW075023 is located about 800 metres to the east and GW075024 is located about 720 metres to the north-east of the project site. The locations of these wells are shown in Figure 4.5.

An assessment of the closest NSW DoI monitoring wells to the project (GW075022 and GW075023) was completed. This suggested that groundwater elevations in this area generally do not have a significant response to long term climatic variations and that the variations tend to be associated with individual rainfall events. The range in these wells was estimated to be 1.04 metres at GW075023 and 1.98 metres at GW075022 although this well has an anomalous response of about 1.5 metres over the period July 2013 to March 2014, which has affected the interpreted range in this well.

4.7.2 Regional groundwater elevations

The flow directions within Botany Sands are generally controlled by topography associated with outcropping bedrock. From the recharge areas located at higher elevations northeast of the Botany basin, groundwater flows south and southwest towards rivers and other tributaries and into Botany Bay. Based on available bore monitoring data, groundwater is about 35 metres AHD near Centennial Park, with elevations gently declining south to Botany Bay. Flow gradients range from 0.003 to 0.01 (Hatley, 2004).

Interpreted regional groundwater elevations within the surficial (water table) aquifers (primarily the Botany Sand aquifer) along the rail corridor are presented in Figure 4.8 has been interpolated using the available historical data from:

- Long term DoI-Water monitoring wells - wells prefixed with ‘GW’.
- Short term groundwater elevation reported in *Dewatering Feasibility Study – WestConnex Enabling Works – Airport East Project* (EES, 2018) – wells MW2 to MW5.
- Groundwater elevation data from previous geotechnical investigations for the Sydney Gateway project – bores and CPT points prefixed with ‘SG’ and ‘WCX’.

Groundwater contours suggest that groundwater passing beneath the project site primarily discharges southwest to Botany Bay.

Relevant groundwater monitoring data from boreholes screened within the Botany Sands and alluvium are presented in Table 4.7 and Table 4.8, and groundwater measurements from geotechnical boreholes and cone penetration test (CPT) points are presented in Table 4.9. Average depth to groundwater is given in metres from top of casing (m/TOC) or below top of casing (m/BTOC).

Table 4.7 Key groundwater monitoring wells - continuous monitoring

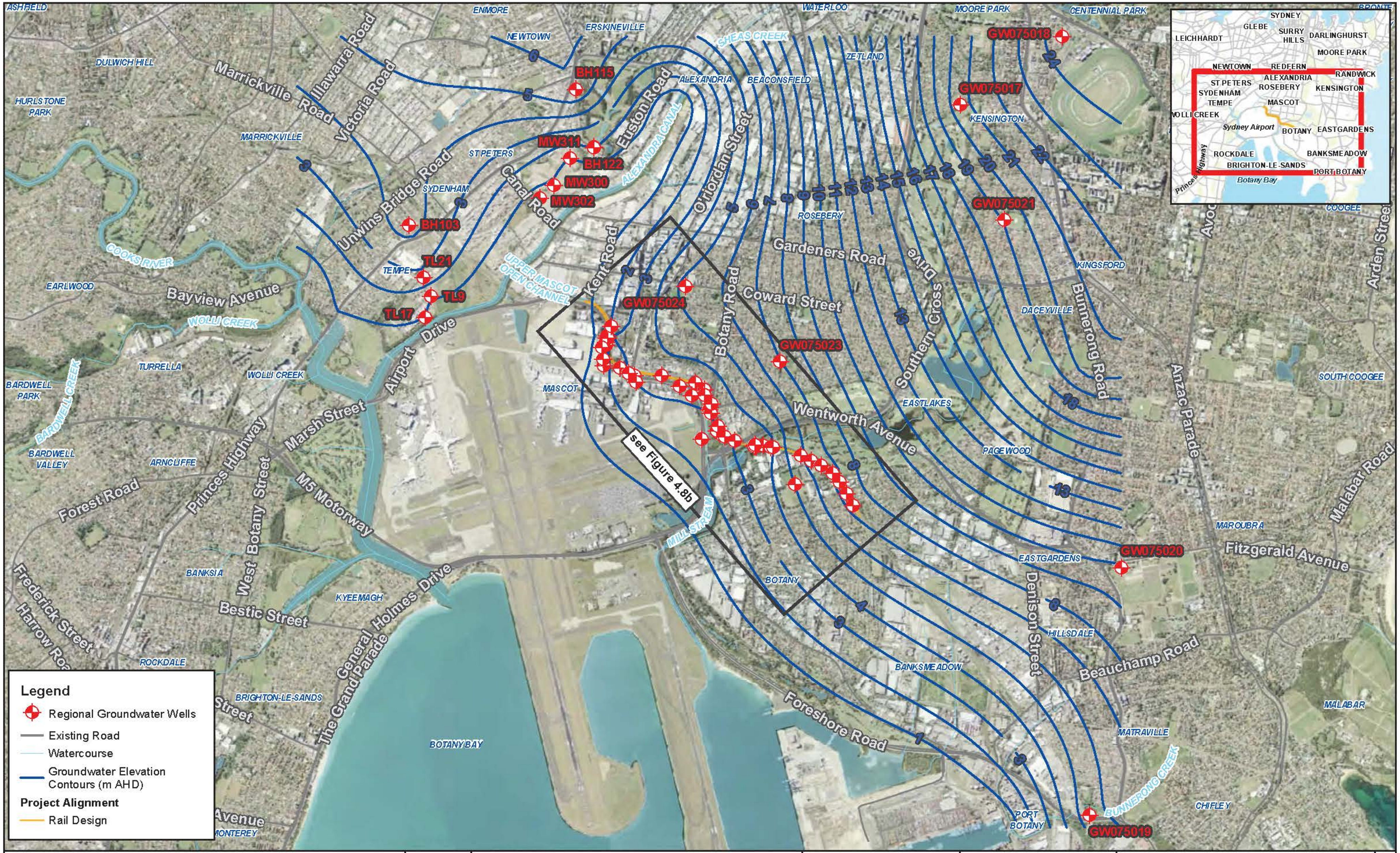
Source	Well ID	Monitoring Period	Screen depth metres below ground (from – to)	Average depth to groundwater m/TOC (min – max)	Average groundwater elevation (metres AHD)	Distance from the project site (m)
NSW DoI-Water	GW075024	01/03/1999 to 14/09/2015	12.0-15.0	(1.5 (0 – 3.8)	5.4	740 m, NE
	GW075023	01/05/2005 to 14/09/2015	15.5-18.5	0.5 (0 – 1.04)	6.9	700 m, E
	GW075022	11/03/1999 to 05/02/2014	11.25-14.25	1.5 (0 – 2.0)	5.0	260 m, SW
	GW042161	15/03/2000 to 14/09/2015	n/a	11.8 (9.9 – 12.9)	10.1	3090 m, E
	GW075020	05/03/1999 to 05/03/2014	24.5-27.5	10.3 (0 – 13.9)	9.8	2300 m, SE
	GW075019	05/03/1999 to 25/05/2015	16.50-19.50	8.4 (7.8 – 8.8)	5.7	2370 m, S
	GW075025	05/03/1999 to 14/09/2015	21.20-24.00	8.9 (5.7 – 11.8)	20.5	2390 m, SE
	GW075021	05/03/1999 to 14/09/2015	39.00-43.00	3.7 (3.1 – 4.6)	19.1	2700 m, SE
	GW075017	04/03/1999 to 14/09/2015	24.50-27.50	2.5 (1.5 – 3.4)	20.7	3390 m, E
	GW075018	04/03/1999 to 25/05/2015	40.00-43.00	1.3 (0.2 – 2.0)	24.6	5560 m, E

Table 4.8 Key groundwater monitoring wells screened within the Botany Sands and alluvium aquifers -spot recording

Source	**Well ID**	**Monitoring Period**	**Screen depth metres below ground (from – to)**	**Average depth to groundwater m/TOC (min – max)**	**Average groundwater elevation (m AHD)**	**Distance from the project site (m)**
EES, 2018	MW1-6	02/2017 to 08/2017	3.00-6.00	4.41	2.66	75 m, NW
	MW1-9	02/2017 to 08/2017	6.00-9.00	4.31	2.71	
	MW1-12	02/2017 to 08/2017	9.00-12.00	4.33	2.81	
	MW1-18	02/2017 to 08/2017	15.00-18.00	4.01	3.12	
	MW1-25	02/2017 to 08/2017	22.00-25.00	4.26	2.88	
	MW2	02/2017 to 08/2017	3.00-6.00	1.80	3.22	100 m, NW
	MW3	02/2017 to 08/2017	3.00-6.00	4.53	2.52	160 m, W
	MW4	02/2017 to 08/2017	3.00-6.00	3.76	3.35	17 m, E
	MW5	02/2017 to 08/2017	3.00-6.00	3.13	3.34	19 m, SE
	MW6	02/2017 to 08/2017	3.00-6.00	4.49	2.48	150 m, W
	EX1	02/2017 to 08/2017	--	3.43	3.38	44 m, W
	EX2	02/2017 to 08/2017	--	3.73	3.19	40 m, W

Table 4.9 Geotechnical boreholes and CPT points along the project site – spot recording

Source	Well ID	Date completed	Depth to groundwater (m/BTOC)	Groundwater elevation (m AHD)	Distance from the project site
RTA, 2009	1_G4014	4/03/2009	2.20	3.07	7 m, E
	3_G4014	6/03/2009	3.5	3.12	5 m, E
	6_G4014	18/03/2009	3.25	3.08	12 m, SW
	10_G4014	10/03/2009	3.15	4.65	3 m, SW
	11_G4014	16/03/2009	2.8	2.99	14 m, W
	12_G4014	12/03/2009	4.9	2.81	4 m, W
Coffey, 2015	WCX_GTY_BH_001	14/09/2015	2	3.22	57 m, W
	WCX_GTY_BH_002	21/09/2015	2.5	3.03	80 m, NW
	WCX_GTY_BH_003	1/10/2015	2.1	3.11	12 m, NW
	WCX_GTY_BH_004	17/10/2015	1.6	1.6	75 m, NW
	WCX_GTY_BH_005	23/10/2015	1	1.5	54 m, NW
	WCX_GTY_BH_006	28/10/2015	1	1.51	40 m, NW
	WCX_GTY_BH_034	29/07/2015	3.7	2.09	21 m, NE
AECOM, 2017	SG-BH055	22/04/2017	8.6	2.99	8 m, SE
	SG-BH058	25/02/2017	7.3	2.81	7 m, SE
	SG-BH059	28/03/2017	4.2	3.24	2 m, SW
	SG-BH064	26/02/2017	7.3	3.53	7 m, SE
	SG-CP012	08/05/2017	3.3	3.18	2 m, NE
	SG-CP013	08/05/2017	4	5.23	1 m, SW
	SG-CP015	08/05/2017	4.5	3.78	3 m, NE
	SG-CP017	08/05/2017	3	4.34	2 m, SW
	SG-CP018	08/05/2017	3	5.73	8 m, SW
	SG-CP019	08/05/2017	3	6.48	8 m, SW
	SG-CP020	08/05/2017	3.6	6.58	8 m, SW
	SG-CP021	08/05/2017	2.2	7.4	2 m, SW
	SG-CP022	08/05/2017	2.5	6.37	5 m, SW
	SG-CP023	08/05/2017	1.6	7.27	1 m, SW
	SG-CP024	08/05/2017	2.4	7.37	4 m, SW
	106	27/01/2010	2.25	3	12 m, SW
	110	09/12/2010	4.3	2.75	10 m, SW



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A1	28/05/2019	Interpreted Groundwater Elevations		
A2	03/06/2019	Interpreted Groundwater Elevations		
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A4	04/06/2019	Interpreted Groundwater Elevations		

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HEIGHT DATUM: AHD

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DRG CHECK	P.QUIMORA	4/06/2019

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PREPARED FOR

BOTANY RAIL DUPLICATION

A3

Groundwater Impact Assessment
Figure 4.8a
Interpreted Groundwater Table Elevations - Botany Rail Alignment

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ISSUE: A4

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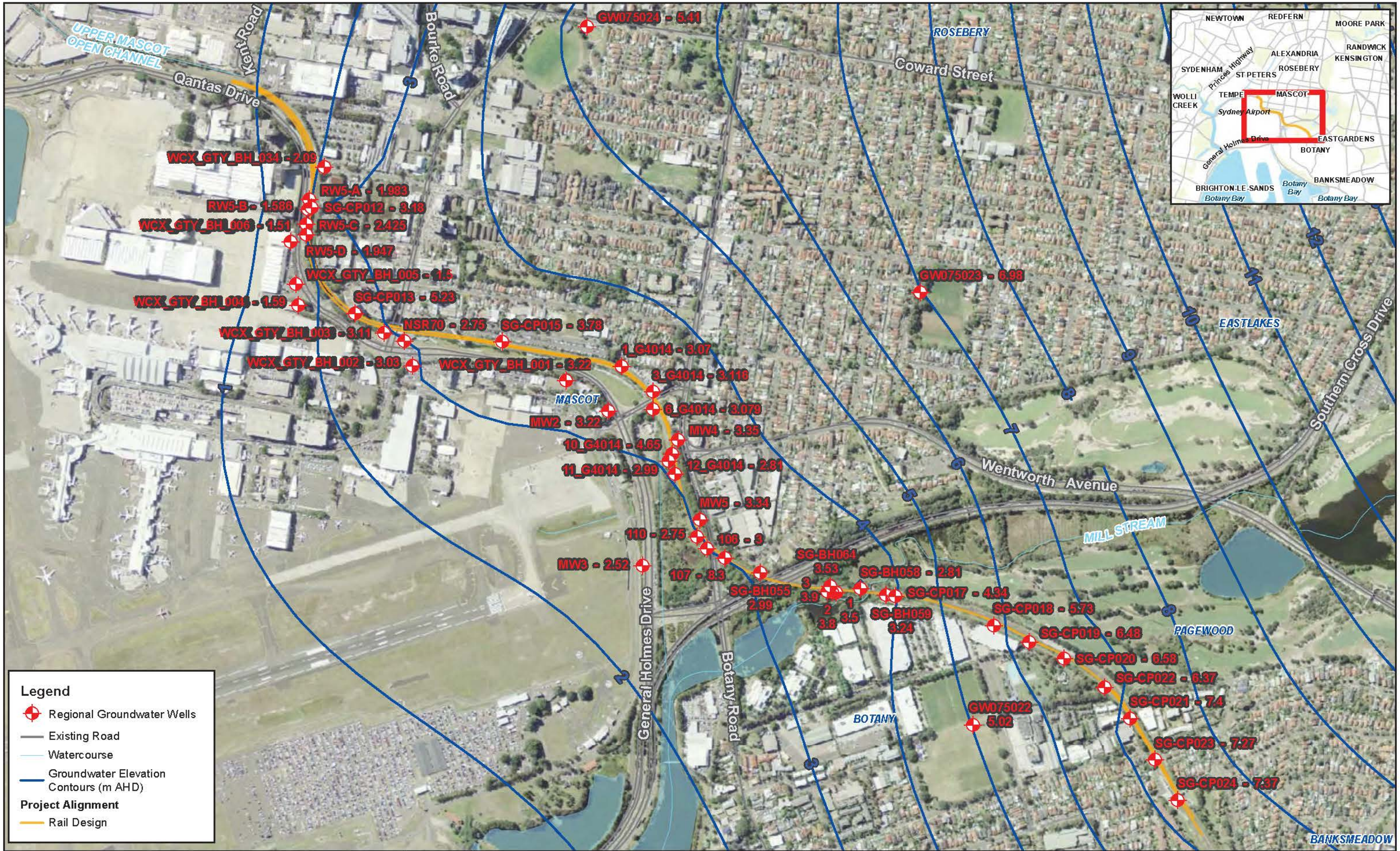

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A2	04/06/2019	Interpreted Groundwater Elevations		

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CO-ORDINATE SYSTEM: MGA ZONE 56 | HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: WSP, GHD

DRG No.

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DRG CHECK	P.QUIMORA	4/06/2019

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BOTANY RAIL DUPLICATION

A3

Groundwater Impact Assessment
Figure 4.8b
Interpreted Groundwater Table Elevations - Botany Rail Alignment

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4.8 Groundwater flow velocities

Groundwater flow velocities can be estimated by rearranging the Darcy flow equation as follows:

$$v = \frac{ki}{n}$$

Where:

k = Hydraulic conductivity (m/day)
i = Hydraulic gradient (m/m – dimensionless)
n = Effective porosity (m^3/m^3 – dimensionless)
v = Groundwater velocity (m/day)

The estimated regional flow velocities across the site using the data presented in Section 4.5 and Section 4.7 above are presented in Table 4.10.

Table 4.10 Estimated groundwater flow velocities

Input Parameter	Unit	Fill			Botany Sands			Source
		Low	Likely	High	Low	Likely	High	
Hydraulic conductivity (*k*)	m/day	0.4	2.7[a]	6.7	0.002	25[b]	85	Estimated range from data presented in Section 4.5
Gradient (*i*)	dimensionless	0.0025	0.005	0.005	0.002	0.005	0.01	Estimated range from Figure 4.7 and from data presented in Section 4.7
Effective porosity (*n*)	dimensionless	0.2	0.1	0.01	0.32	0.17	0.1	EES (2018) and Weight and Sonderegger (2001).
Groundwater velocity (v)	m/day	0.005	0.135	3.35	$1.3X10^{-5}$	0.7	9.5	Modified Darcy equation.

Table 4.10 suggests that groundwater flow velocities range from less than 1 cm/day to 9.5 m/day in the Botany Sands and from less than 1 cm/day to 3.4 m/day in areas of saturated fill.

The low end and high end values are expected to be conservative values that do not reflect bulk aquifer conditions and correlation between input parameters (i.e. high hydraulic conductivities are usually associated with lower gradient and higher effective porosities). Most likely groundwater flow velocities are expected to approximate 0.135 m/day for the fill aquifer and 0.7 m/day for the Botany Sands aquifer.

The *Dewatering Feasibility Study – WestConnex Enabling Works – Airport East Project* report (EES 2018) had an estimated range in average groundwater flow velocity for the Botany Sands of 1.1 – 1.3 m/day which is similar to the most likely estimate presented in Table 4.10, and is expected to be representative of the local conditions at the WestConnex Enabling Works – Airport East Precinct.

4.9 Water use restrictions

A ban on groundwater extraction was implemented by the NSW Government in 2006 on parts of Botany, which is underlain by the Botany Sands aquifer. Under the Temporary Water Restrictions Order (TWRO), groundwater extraction is prohibited for domestic use, and monitoring is required for industrial and irrigation purposes (NSW DPI, 2018). As shown in Figure 4.9, the project is mainly within Area 2 and therefore cannot be used for industrial or domestic purposes and can only be extracted for remediation, temporary construction dewatering, testing or monitoring purposes. Any extracted water used for licensed industrial purposes must be sampled, tested and treated (if required) in accordance with a testing plan certified by a consultant as being safe and suitable for its intended use. There is also an embargo on applications for new licences to extract water from the Botany Sands aquifer for domestic and commercial purposed.

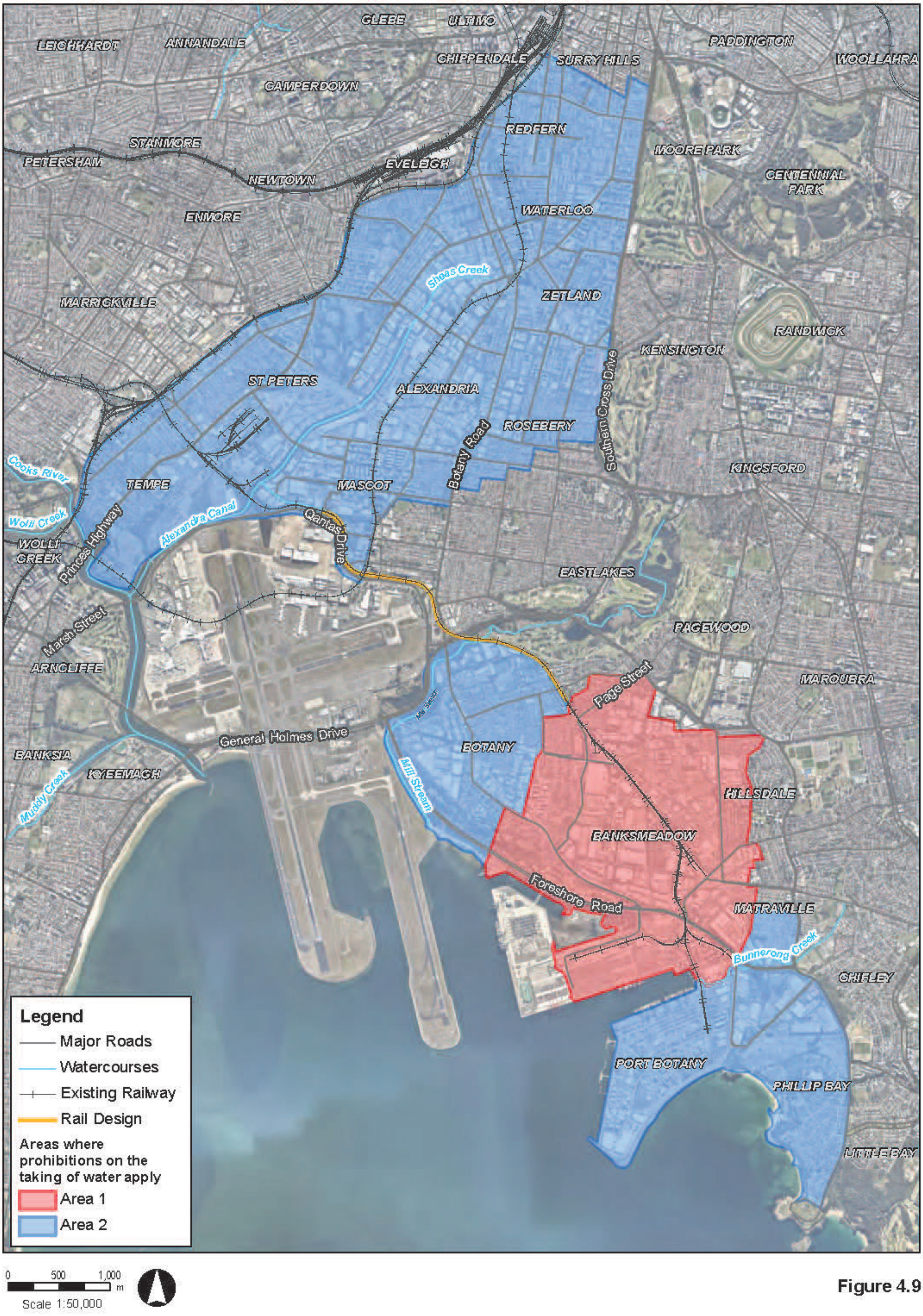

Figure 4.9

Temporary Water Restriction Order Areas

Author: David Naiken
Date: 11/07/2019
Map no: PS113386_GIS_071_A1

4.10 Groundwater users

Review of available data from the Bureau of Meteorology (BOM) identified fifty registered groundwater bores used for domestic, irrigation, monitoring and commercial purposes. These are located within 500 metre radius of the project. The majority of the bores are shallow (less than 15 metres in depth) and are screened within the Botany Sands and alluvium as presented in Figure 4.10.

Table 4.11 Registered groundwater users within 500 metres radius of the project (BOM – Australian Groundwater Explorer, 2018)

Bore ID	Purpose	Status	Status based on the TWRO	Distance from site (m)	Drilled depth (m below ground)	Standing water level	Salinity	Yield
GW017344	Commercial and Industrial	Unknown	Not applicable	131	13.8			
GW017352	Commercial and Industrial	Unknown	Not applicable	296	18.6			
GW017717	Commercial and Industrial	Unknown	Not applicable	267	16.1			
GW017718	Commercial and Industrial	Unknown	Not applicable	48	21.3			
GW017719	Commercial and Industrial	Unknown	Not applicable	463	18.2			
GW017720	Commercial and Industrial	Unknown	Not applicable	174	20.4			
GW017721	Commercial and Industrial	Unknown	Not applicable	482	14.3			
GW017722	Commercial and Industrial	Unknown	Not applicable	210	18.1			
GW020094	Commercial and Industrial	Unknown	Not applicable	138	45.7			
GW022240	Commercial and Industrial	Functioning	Not applicable	85	25.2			
GW023164	Irrigation	Unknown	Not applicable	362	3.6	1.8	Good	0.15
GW023429	Irrigation	Unknown	Not applicable	343	6	4.8	Good	0.35
GW023443	Irrigation	Unknown	Not applicable	387	7.6	6	Good	0.35
GW023525	Irrigation	Unknown	Not applicable	102	5.9		invalid code	
GW024036	Irrigation	Unknown	Not applicable	340	6			
GW024222	Commercial and Industrial	Unknown	Not applicable	219	23.7			
GW024655	Irrigation	Abandoned	Not applicable	60	9.1	1.9		1.01
GW025543	Monitoring	Unknown	Banned for domestic use	94	18.5			
GW025544	Irrigation	Functioning	Not applicable	221	4.8	3.3	Good	

Bore ID	Purpose	Status	Status based on the TWRO	Distance from site (m)	Drilled depth (m below ground)	Standing water level	Salinity	Yield
GW025553	Commercial and Industrial	Unknown	Not applicable	191	17			
GW025574	Irrigation	Functioning	Not applicable	45	4.8	3.6	Good	
GW025729	Commercial and Industrial	Unknown	Not applicable	37	21.3			
GW025994	Irrigation	Unknown	Not applicable	20	13.2	4.5	Good	3.09
GW026787	Commercial and Industrial	Unknown	Not applicable	5	24.8			
GW026788	Commercial and Industrial	Unknown	Not applicable	5	20.4			
GW027248	Commercial and Industrial	Unknown	Not applicable	351	4.8	-		
GW032339	Commercial and Industrial	Unknown	Not applicable	393	33.2			
GW033371	Commercial and Industrial	Unknown	Not applicable	27	11.8			
GW033372	Commercial and Industrial	Unknown	Not applicable	24	11.8			
GW038127	Commercial and Industrial	Unknown	Not applicable	498	33.2	14	Good	22.73
GW040222	Monitoring	Unknown	none	204	7			
GW065549	Commercial and Industrial	Unknown	Not applicable	478	22.5			
GW072461	Water Supply - Household	Functioning	Banned for domestic use	451	7			
GW100003	Water Supply - Household	Functioning	Banned for domestic use	187	5.8	2.14	Good	1
GW100754	Commercial and Industrial	Unknown	Not applicable	451	148	6		8.2
GW100989	Water Supply - Household	Functioning	Banned for domestic use	465	7.625	5.185		1
GW100996	Water Supply	Unknown	Banned for extraction	333	9.76	7.01	Good	0.75
GW101034	Water Supply	Unknown	none	56	5.185		Good	1
GW101136	Water Supply	Unknown	none	239	7.32	4.575	Good	1
GW101199	Water Supply - Household	Functioning	Banned for domestic use	464	5.49			1
GW101335	Monitoring	Unknown	Banned for extraction	295	10.67			
GW101546	Water Supply	Unknown	Banned for extraction	210	4.575	1.83	Good	1

Bore ID	Purpose	Status	Status based on the TWRO	Distance from site (m)	Drilled depth (m below ground)	Standing water level	Salinity	Yield
GW101711	Water Supply	Unknown	Banned for extraction	342	10			
GW101721	Water Supply	Unknown	Banned for extraction	321	6			
GW102616	Water Supply	Unknown	Banned for extraction	269	6			
GW102740	Water Supply	Unknown	Banned for extraction	458	10			
GW103745	Commercial and Industrial	Unknown	Not applicable	487	18.28			
GW104902	Water Supply	Functioning	none	298	7.1	1.83	Good	1
GW104930	Water Supply	Functioning	Banned for extraction	408	7	5.5		1
GW104990	Water Supply	Functioning	none	503	6	3.5		1

TWRO = Temporary water restrictions order (Feb 2018)

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BOTANY RAIL DUPLICATION

A3

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
A1	29/05/2019	Surrounding Groundwater Users		

SCALES ON A1 SIZE DRAWING

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CO-ORDINATE SYSTEM MGA ZONE 56

HEIGHT DATUM AHD

DRAWINGS / DESIGN PREPARED BY WSP GHD

DRG No.

TITLE	NAME	DATE
DRAWN	D NAIKEN	30/05/2019
DRG CHECK	P.QUIMORA	30/05/2019

Groundwater Impact Assessment
Figure 4.10
Surrounding Groundwater Users

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Groundwater Impact Assessment
Figure 4.10
Surrounding Groundwater Users

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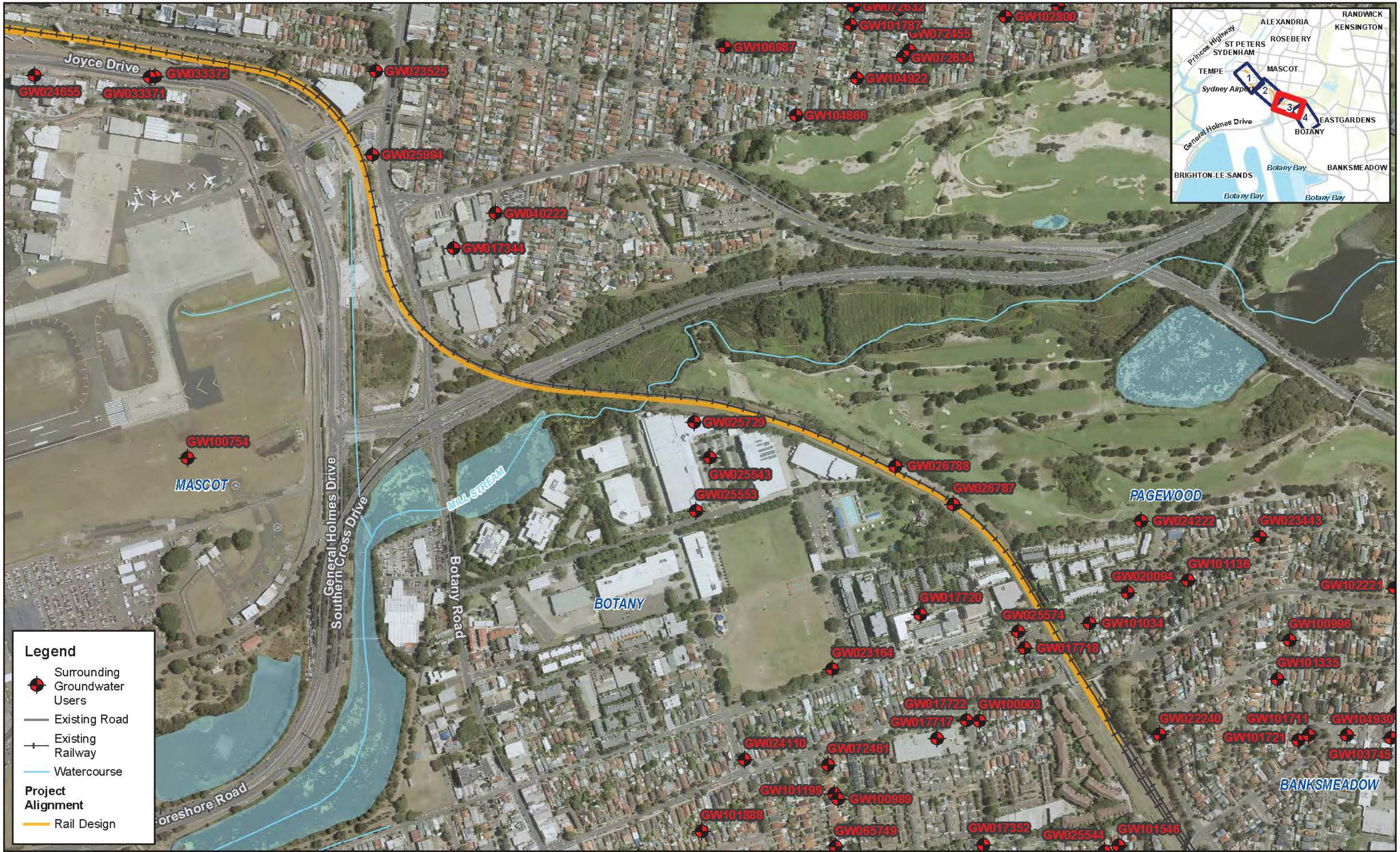

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BOTANY RAIL DUPLICATION

A3

REV	DATE	AMENDMENT / REVISION DESCRIPTION
A1	29/05/2019	Surrounding Groundwater Users

WVR No. | APPROVAL

SCALES ON A1 SIZE DRAWING: 0 50 100 m 1:6,000

CO-ORDINATE SYSTEM: MGA ZONE 56

HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: WSP GHD

DRG No.

TITLE	NAME	DATE
DRAWN	D NAIKEN	30/05/2019
DRG CHECK	P.QUIMORA	30/05/2019

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Groundwater Impact Assessment
Figure 4.10
Surrounding Groundwater Users

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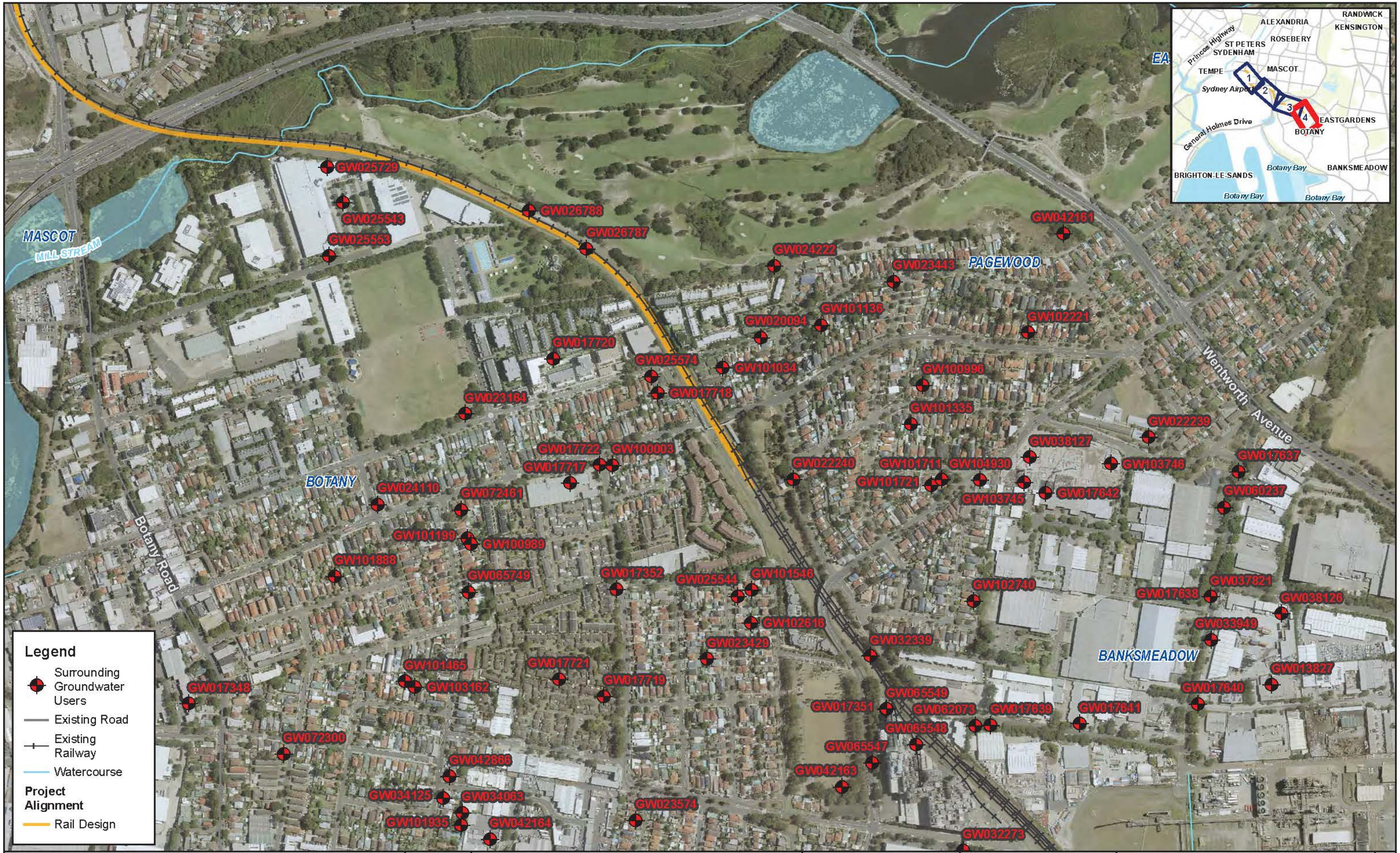

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CO-ORDINATE SYSTEM: MGA ZONE 56
HEIGHT DATUM: AHD

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BOTANY RAIL DUPLICATION — A3

Groundwater Impact Assessment
Figure 4.10
Surrounding Groundwater Users

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4.11 Existing water balance

Table 4.12 provides a general water balance for the Botany Sands aquifer to the north east of Cooks River. This water balance indicates that 34,815 m^3/day discharges from the aquifer to surface water features. Only a portion of the groundwater discharge to surface water passes beneath the project site to Alexandra Canal, Cooks River and Mill Stream/Botany Bay (primary discharge point). Based on the current understanding of the groundwater flow fields this is estimated to approximate 30 per cent of the total discharge to surface water or 10,445 m^3/day.

The most likely case groundwater velocities presented in Section 1.1 is for an average aquifer thickness of approximately 17 metres in areas along the alignment of the project site (Figure 4.3) and that the alignment perpendicular to groundwater flow approximates three kilometres (Figure 4.8). The groundwater discharge to surface water features is estimated to approximate 35,700 m^3/day. This is approximately four times higher than outlined above and is higher than the total estimated discharge to surface water for the Botany Sands aquifer, which is expected to be due to the adoption of conservative hydraulic conductivities and groundwater flow gradients for the estimation of groundwater flow velocities.

The construction footprint for the project occupies approximately 0.18 km^2, which is less than 0.3 per cent of the overall area of the Botany Sand aquifer (61.5 km^2). Subsequently it can be expected that the existing recharge volumes within the project site would be less than 0.3 per cent of the total rainfall recharge (i.e. less than 104 m^3/day).

Table 4.12 Existing water balance for the Botany Sands Aquifer (m^3/day)

Parameter	Inflow	Outflow	Source description
Rainfall Recharge	53,950		The water sharing plan for the greater metropolitan regions groundwater source background document (NOW, 2011) adopts an average daily rainfall recharge of 83,000 m^3/day for the Botany Sands. This data applies to all areas of the Botany Sands including western (Brighton-Le Sands / Ramsgate) and southern (Kurnell) areas of Botany Bay. Hatley (2004) indicated that the aquifer system to the north and east of Cooks River (on which, the project site is located) approximates 65 % of the surface area of the Botany Sands aquifer or 61.5 km^2.
Groundwater abstraction entitlement		19,135	The NSW water register indicates that there is currently 8,120.5 ML/annum (22,250 m^3/day) of water access license entitlement within the Botany Sands, which is primarily concentrated in the northern areas of the Botany Sands (as presented on the BOM – Australian Groundwater Insight website). It is assumed 86% of the entitlement is located in the northern Botany Sands area as indicated in Hatley (2004).
Surface water features		34,815	Surface water features include Botany Bay, Cooks River, Georges River, Alexandra Canal and lakes (although this would be a minor component in average or dry conditions when groundwater is less likely to discharge to lakes). Value is calculated as rainfall recharge less groundwater abstraction.
Groundwater Balance	53,950	53,950	Estimated as rainfall recharge less groundwater abstraction and groundwater discharge.

4.12 Groundwater dependent ecosystems

Communities of potential groundwater dependent ecosystems (GDEs) are identified based on a review of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (NOW 2011). One GDE is mapped around 1.0 kilometre from the project – the Freshwater Wetlands at Eastlakes, within the Lakes Golf Course, which is part of the Botany Wetlands. Stands of native vegetation (including Swamp Oak Forest) in the project site are likely to be terrestrial GDEs that are reliant on subsurface groundwater.

Mill Pond and Engine Pond are classified as environmentally significant areas and are managed under Sydney Airport's 'Wetland Enhancement Program' (Sydney Airport 2009).

4.13 Contaminated sites

The NSW EPA holds records of sites that have been notified under Section 60 of the CLM Act 1997 or otherwise reported to the EPA. The report notes seven sites within 500 metres of the project site and are presented in Table 4.13 and on Figure 4.11.

Table 4.13 Contaminated sites on the NSW EPA register within 500 metres of the project

Site name	Location	Contamination type	EPA assessment and management	Location in relation to the project site
Ing Industrial Fund	19–33 Kent Road, Mascot	Landfill	Regulation under the CLM Act not required	About 465 m north-east
Former Mascot Galvanising	336–348 King Street, Mascot	Zinc, lead, chromium and a low pH	Regulated under the CLM Act	About 145 m east
Sokol Corporation	50–56 Robey Street, Mascot	Other industry	Notified site – regulation under the CLM Act not required	About 60 m north
Telstra Exchange	904–922 Botany Road, Mascot	Other industry	Regulation under the CLM Act not required	420 m north-east
Former Email Site	Corner of Page St and Holloway St, Pagewood	Chlorinated hydrocarbons (TCE and PCE), and groundwater plume migrating offsite (to the south)	Regulated under the CLM Act	About 420 m east
Former Tannery	2 Daniel Street, Botany	Other industry	Regulation under CLM Act not required	About 390 m south-west
Roads and Maritime Services	5–9 Lord Street, Botany	Other industry	Regulation under CLM Act not required	About 280 m south

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A1	28/05/2019	Contaminated Sites

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DRG CHECK	P.QUIMORA	29/05/2019

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Groundwater Impact Assessment
Figure 4.11
Contaminated Sites (NSW EPA)

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4.14 Existing water quality

4.14.1 Overview of existing water quality

The groundwater quality within the project site has historically been of poor quality due to contamination. The suburbs within and surrounding the project site have been heavily industrialised that have included chemical manufacturing, fuel storage, tanneries, galvanising, petroleum distribution facilities, landfills, dry cleaners and wool scourers. This has led to the Botany Sands aquifer to be contaminated with a range of pollutants. These pollutants include:

- heavy metals
- nutrients
- PFAS
- pesticides
- petroleum hydrocarbons including VOCs, and PAHs
- phthalates and PCBs
- chlorinated hydrocarbons, dioxins and phenols
- light non-aqueous phase liquid.

Table 4.14 Summary of groundwater quality within the project site

Parameter	Botany Sands Aquifer
Electrical Conductivity	Variable ranging 335 µS/cm (freshwater)
pH	4.91 – 7.62
Major cations and major anions	Dominant calcium and sodium cations with bicarbonate, chlorides and sulfate anions
Heavy Metals	Iron, copper and lead above ANZECC 2000 guidelines. Mercury on the Sydney Airport site
Petroleum Hydrocarbons	Sydney Airport
PFAS	Throughout the Botany Sands Aquifer from numerous unknown sources
Electrical Conductivity	Variable ranging 335 µS/cm (freshwater)

4.14.2 Ground water quality data from other studies

Relevant groundwater quality data from previous studies are discussed below.

WestConnex New M5

Studies conducted by AECOM (2015-2016) and Golder (2016-2017) included groundwater quality data for the WestConnex Stage 2 M5 project. This included wells screened within the Botany Sands and alluvium and near to St. Peter's interchange located north of the project site:

- November 2015 groundwater quality for two wells screened within the Botany Sands indicate an average electrical conductivity of 556 microsiemens per centimetre, and pH of 6.8. For the alluvium, average electrical conductivity was 626 µS/cm with an average pH of 6.8.
- April 2016 laboratory results detectable concentrations of phenol, benzene, toluene, ethylbenzene and total xylenes (BTEX), polycyclic aromatic hydrocarbons (PAH), total recoverable hydrocarbons (TRH) were above detection limits.

- The groundwater quality data were compared against ANZECC 2000 guideline values for 95 per cent protection of freshwater species, and ANZECC 2000 guideline values for 95 per cent protection of marine species. Results reported exceedances of the criteria in the following:
  - ANZECC 2000 guidelines values for 95 per cent protection of marine species
  - Metals including cobalt and zinc in LDS-BH-3047
  - Manganese and nutrients (ammonia, total nitrogen, and total phosphorus) in MW063a and MW152s. The ammonia concentration in LDS-BH-3047 which is located near Alexandria Landfill exceeded 30,000 µg/L.

WestConnex Enabling Works – Airport East Project

A groundwater study was reported in the *Dewatering Feasibility Study – WestConnex Enabling Works – Airport East Project* (EES 2018). This included monitoring of twelve groundwater bores and six surface water locations from February to April, and August 2017. Key findings are summarised below:

- Groundwater field chemistry results show acidic to neutral pH ranging from 4.91 to 7.62, average electrical conductivity of 335 micro Siemens per centimetre, and highly variable oxygen reduction potential (ORP) values ranging from -215 millivolts to 265.5 millivolts. General hydrogeochemistry shows calcium, sodium, bicarbonate, chloride, and sulfate are the major chemical constituents.
- The groundwater quality data were compared against the following criteria:
  - ANZECC/ARMCANZ (2000) 95 per cent protection of aquatic freshwater species
  - NHMRC/NRMMC (2011) Drinking Water Quality
  - NHMRC/NRMMC (2008) Recreational Water Quality
  - groundwater health screening levels (HSLs) for vapour intrusion
  - Airports (Environmental Protection) Regulations (1997)- Schedule 2, freshwater criteria
  - DoE&E (2016) Commonwealth Environmental Management Guidance on Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) for a 99 per cent protection of freshwater species
  - DoH (2017) Health-based guidance values for PFAS, for use in site investigations in Australia
  - Airservices Australia June 2015 – Managing PFC Contamination at Airports.

Groundwater quality results reported the following exceedances:

- ANZECC/ARMCANZ (2000) 95 per cent protection of aquatic freshwater species:
  - metals including dissolved aluminium and iron in MW1_12 and MW2
  - nitrate in MW1_6, MW1_9, MW4, MW5 and EX1
  - AEPR (1997)-Schedule 2, freshwater criteria
  - metals including dissolved aluminium, iron, copper, lead, and zinc in MW1_6, MW1_9, MW1_12, MW1_18, MW1_25, MW2, MW3, MW4 and MW6)
  - nutrients including ammonia and phosphate across the whole site
  - total recoverable hydrocarbons (TRH) in MW1_25, however attributed to a differing background chemistry as this well is screened within the underlying clay layer
  - DoE&E (2016) 99 per cent protection of aquatic freshwater species and PFOS across the whole site
  - DoH (2017) Health based guidance values
  - PFOS+PFHxS in MW5 and MW6 with periodic exceedances in MW1_6, MW1_9 and MW1_25 (drinking water criteria)
  - PFOS+PFHxS in MW1_25 and MW2 exceeded criteria for drinking water and direct contact-recreational criteria.
- Groundwater sampled from the site was interpreted to be indicative of existing conditions within the surrounding Botany Sands aquifer.
- The identified contaminants of concern requiring ongoing monthly monitoring and management were PFAS, ammonium and dissolved metals (copper and zinc).

4.14.3 Surface water quality data from other studies

Relevant surface water quality data from previous studies are discussed below.

WestConnex M4-M5 Link

As part of the Environmental Impact Assessment for the M4-M5 Link, water samples were tested from Alexandra Canal. The surface water quality was compared against the following criteria:

- ANZECC (2000) 95 per cent protection of aquatic freshwater species.
- ANZECC (2000) 95 per cent protection of aquatic marine species.
- ANZECC (2000) estuaries -default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems.
- ANZECC (2000) lowland rivers -default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems.

Surface water quality results reported the following exceedances:

- ANZECC (2000) 95 per cent protection of aquatic freshwater and marine species:
  - field parameters including electrical conductivity, pH, turbidity
  - metals including arsenic, chromium, copper, lead, nickel, zinc
  - inorganics including nitrate and total nitrogen.
- ANZECC (2000) estuaries – default trigger values:
  - pH, phosphorus, and total nitrogen.
- ANZECC (2000) lowland rivers – default trigger values:
  - electrical conductivity (EC), pH, phosphorus and total nitrogen.

WestConnex New M5

Surface water quality assessment was conducted for the New M5 Environmental Impact Assessment. Results from previous studies done by GHD (2012) and AECOM (2015) were compared against the following criteria:

- ANZECC (2000) 80 per cent protection of aquatic marine species.
- ANZECC (2000) estuaries- default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems.

Surface water quality results for Alexandra Canal reported the following exceedances:

- ANZECC (2000) 80 per cent protection of aquatic marine species:
  - Metals including cadmium, chromium, lead, nickel, and mercury, and ammonia as N in the upper reaches of Alexandra Canal.
- ANZECC (2000) – estuaries:
  - Turbidity, and nutrients including nitrate, total nitrogen, and total phosphorus (in site 1- Alexandra Canal-via Alexandra Cycleway near Coward Street).

WestConnex Enabling Works Botany Road Rail Underpass

Results from the surface water sampling at six locations (SW1 to SW6) completed by EES (2018) along Mill Stream/Pond and Engine Pond are summarised below:

- The surface water quality data were compared against the following criteria:
  - ANZECC/ARMCANZ (2000) 95 per cent protection of aquatic freshwater species
  - NHMRC/NRMMC (2011) Drinking Water Quality
  - NHMRC/NRMMC (2008) Recreational Water Quality
  - Groundwater Health Screening Levels (HSLs) for vapour intrusion
  - Airports (Environmental Protection) Regulations (1997)- Schedule 2, freshwater criteria
  - DoE&E (2016) Commonwealth Environmental Management Guidance on Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) for a 99 per cent protection of freshwater species
  - DoH (2017) Health-based guidance values for PFAS, for use in site investigations in Australia
  - Airservices Australia June 2015 – Managing PFC Contamination at Airports.

Surface water quality results reported the following exceedances:

- DoE&E (2016) 99 per cent protection of freshwater species
  - PFOS at all locations across the site.
- DoH (2017) Health-based guidance values for PFAS
  - PFOS+PFHxS exceeding drinking water criteria at SW3, SW4, SW5, and SW6
  - PFOS+PFHxS exceeding drinking and recreational water criteria at SW2.
- AEPR (1997)-Schedule 2, freshwater criteria
  - Metals including copper and zinc, and ammonia at all locations across the site
  - Total petroleum hydrocarbons (C29-C36 fraction) at SW5.

Monthly baseline surface water monitoring – Sydney Gateway road project

AECOM has been sampling the surface water within the study area since December 2017. There were nine events undertaken from up to 11 locations. SW9 to SW11 relate to this project site and have been collected from Mill Stream. The locations of surface water monitoring points are shown on Figure 4.12.

The surface water quality data were compared against the following criteria:

- ANZECC (2000) 95 percent freshwater aquatic ecosystems
- ANZECC (2000) 95 percent marine aquatic ecosystems
- ANZECC (2000) Primary Contact Recreation
- FSANZ (2017) Recreational Water- Health based guidance values.

The results show that surface water in Mill Stream (SW10 and SW11) has chemical concentrations that exceed the following criteria:

- ANZECC (2000) 95 percent freshwater aquatic ecosystems
  - Metals including aluminium, copper (filtered and total), lead, and zinc (filtered and total)
  - Nutrients including phosphorus (persulfate digestion/ultra trace).
- ANZECC (2000) 95 percent marine aquatic ecosystems
  - Metals including copper (filtered and total), lead, and zinc (filtered and total)
  - Nutrients including phosphorus (persulfate digestion/ultra trace).

- ANZECC (2000) Primary contact – Recreation
  - pH
  - metals including total aluminium, iron, manganese
  - nutrients including ammonia as N, phosphorus (persulfate digestion/ultra trace)
  - benzo(a)pyrene
  - chlorinated hydrocarbons (1,1-dichloroethene, carbon tetrachloride).
- Detections above the laboratory limit of reporting were also reported for PFAS but were below the FSANZ (2017) recreational water guidance values. Comparison against ecological criteria was not completed for PFAS, however comparison against the NEMP (2018) criteria for ninety-five percent protection of marine and freshwater species suggests there is no reported exceedance.

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CLIENT: ARTC

REV	DATE	AMENDMENT / REVISION DESCRIPTION
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A2	03/06/2019	Water Sampling Locations
A3	04/06/2019	Water Sampling Locations

WVR No. | APPROVAL

SCALES ON A1 SIZE DRAWING

CO-ORDINATE SYSTEM: MGA ZONE 56

HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: WSP, GHD

DRG No.

TITLE	NAME	DATE
DRAWN	D NAIKEN	4/06/2019
DRG CHECK	P.QUIMORA	4/06/2019

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BOTANY RAIL DUPLICATION

A3

Groundwater Impact Assessment

Figure 4.12

Surface and groundwater Sampling Locations

RMS REGISTRATION No.

PART

ISSUE STATUS: FOR INFORMATION

EDMS No.

SHEET No.

ISSUE: A3

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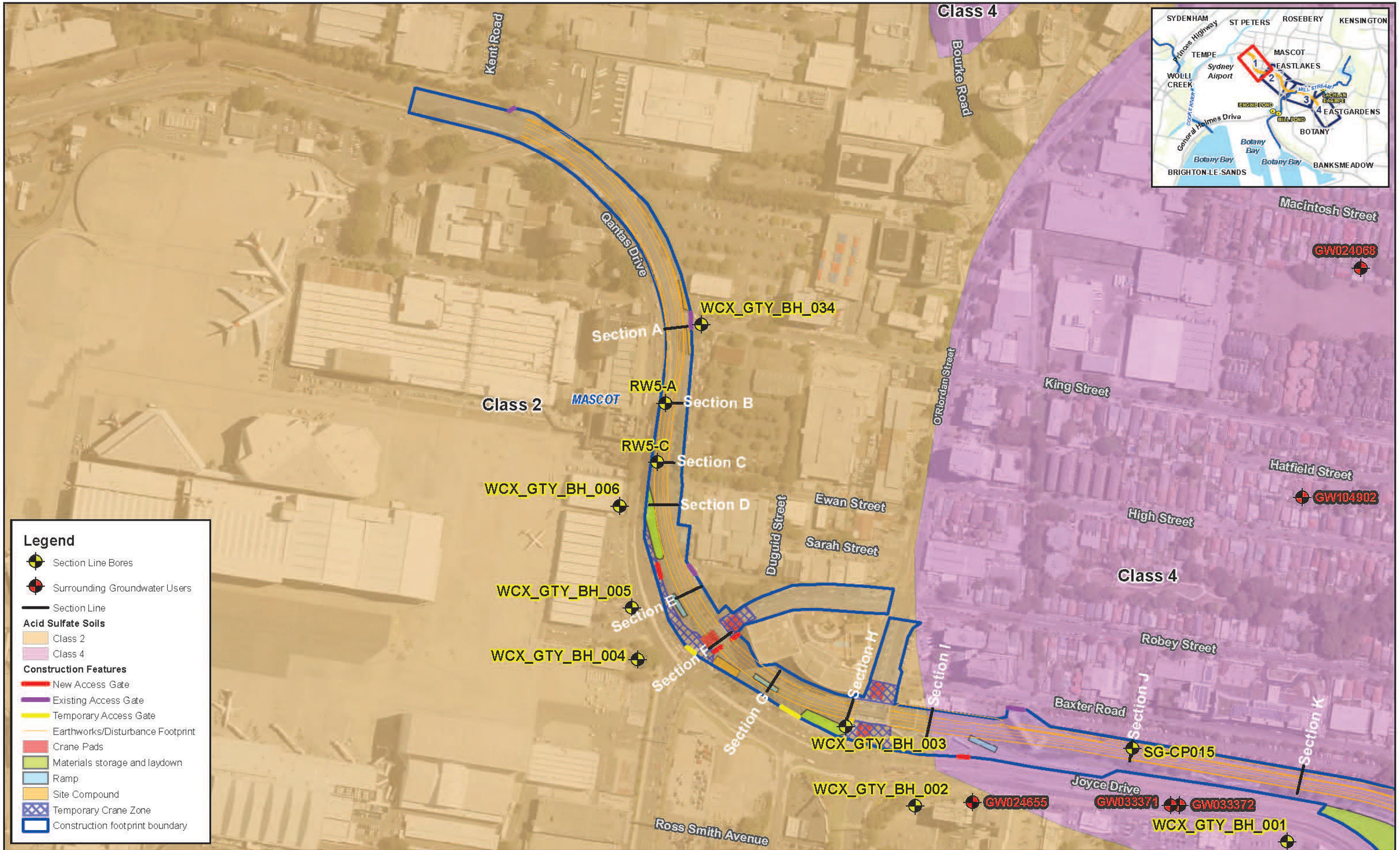
5. Assessment of impacts

Items of infrastructure that could potentially result in groundwater impacts relative to key receptors identified in Section 4 that could be impacted by the project are summarised in Figure 5.1 to Figure 5.4.

The aim of this section is to identify and discuss the key items of infrastructure associated with construction and operation that could potentially result in impacts and the magnitude of potential impacts. A more detailed discussion of the project infrastructure as a whole is provided in Chapter 6 and 7 of the main EIS document. As noted in Section 3, where data limitations prevent a detailed understanding of the actual impacts that may occur, a precautionary approach has been adopted for the identification of impacts and the associated magnitude of impact.



DATA SOURCE: Aerial Imagery © AUSIMAGE - Jacobs Group (Australia) Pty Ltd 2018

REV	DATE	AMENDMENT / REVISION DESCRIPTION
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A2	03/06/2019	Surrounding Receptors East and South of Mill Stream
A3	06/06/2019	Surrounding Receptors East and South of Mill Stream

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PLOT DATE / TIME: 7/06/2019 11:08:36 AM
PLOT BY: GK

TITLE	NAME	DATE
DRAWN	D.NAIKEN	7/06/2019
DRG CHECK	P.QUIMORA	7/06/2019

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BOTANY RAIL DUPLICATION — A3

Groundwater Impact Assessment
Figure 5.1
Surrounding Receptors - Area 1

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ISSUE STATUS: FOR INFORMATION
EDMS No.
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ISSUE A3

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	A2	03/06/2019	Surrounding Receptors East and South of Mill Stream		
	A3	06/06/2019	Surrounding Receptors East and South of Mill Stream		

WVR No. | APPROVAL

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CO-ORDINATE SYSTEM: MGA ZONE 56 | HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: WSP, GHD | DRG No.

TITLE	NAME	DATE
DRAWN	D.NAIKEN	7/06/2019
DRG CHECK	P.QUIMORA	7/06/2019

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A3

Groundwater Impact Assessment
Figure 5.2
Surrounding Receptors - Area 1

RMS REGISTRATION No. | PART

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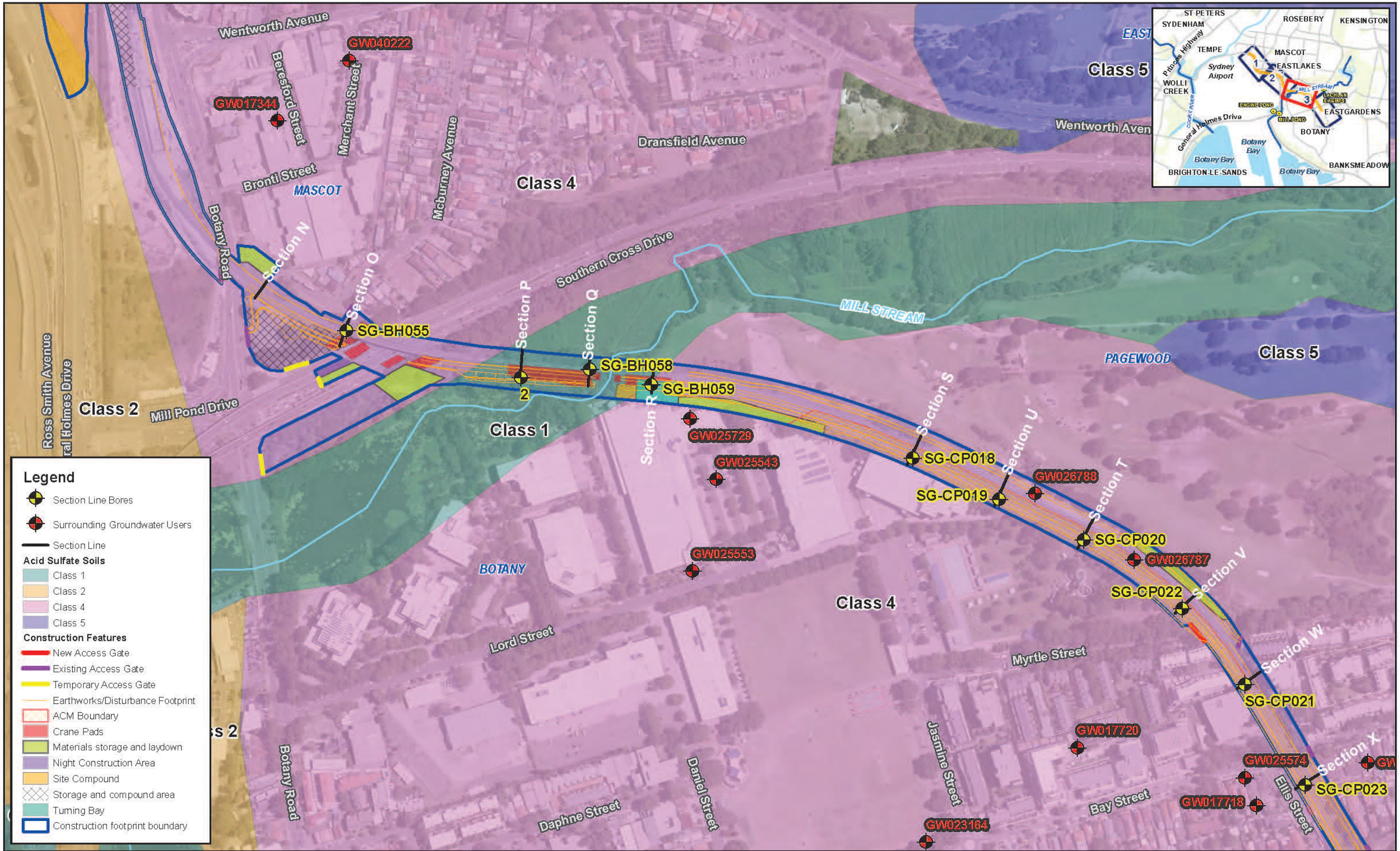

DATA SOURCE: Aerial Imagery ©AUSIMAGE - Jacobs Group (Australia) Pty Ltd 2018

REV	DATE	AMENDMENT / REVISION DESCRIPTION
A1	29/05/2019	Surrounding Receptors East of Mill Stream
A2	03/06/2019	Surrounding Receptors East and South of Mill Stream
A3	06/06/2019	Surrounding Receptors East and South of Mill Stream

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DRG No.

PLOT DATE / TIME: 7/06/2019 11:08:36 AM
PLOT BY: GK

TITLE	NAME	DATE
DRAWN	D.NAIKEN	7/06/2019
DRG CHECK	P.QUIMORA	7/06/2019

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BOTANY RAIL DUPLICATION — A3

Groundwater Impact Assessment
Figure 5.3
Surrounding Receptors - Area 2

RMS REGISTRATION No. | PART
ISSUE STATUS: FOR INFORMATION | EDMS No. | SHEET No. 3 | ISSUE: A3

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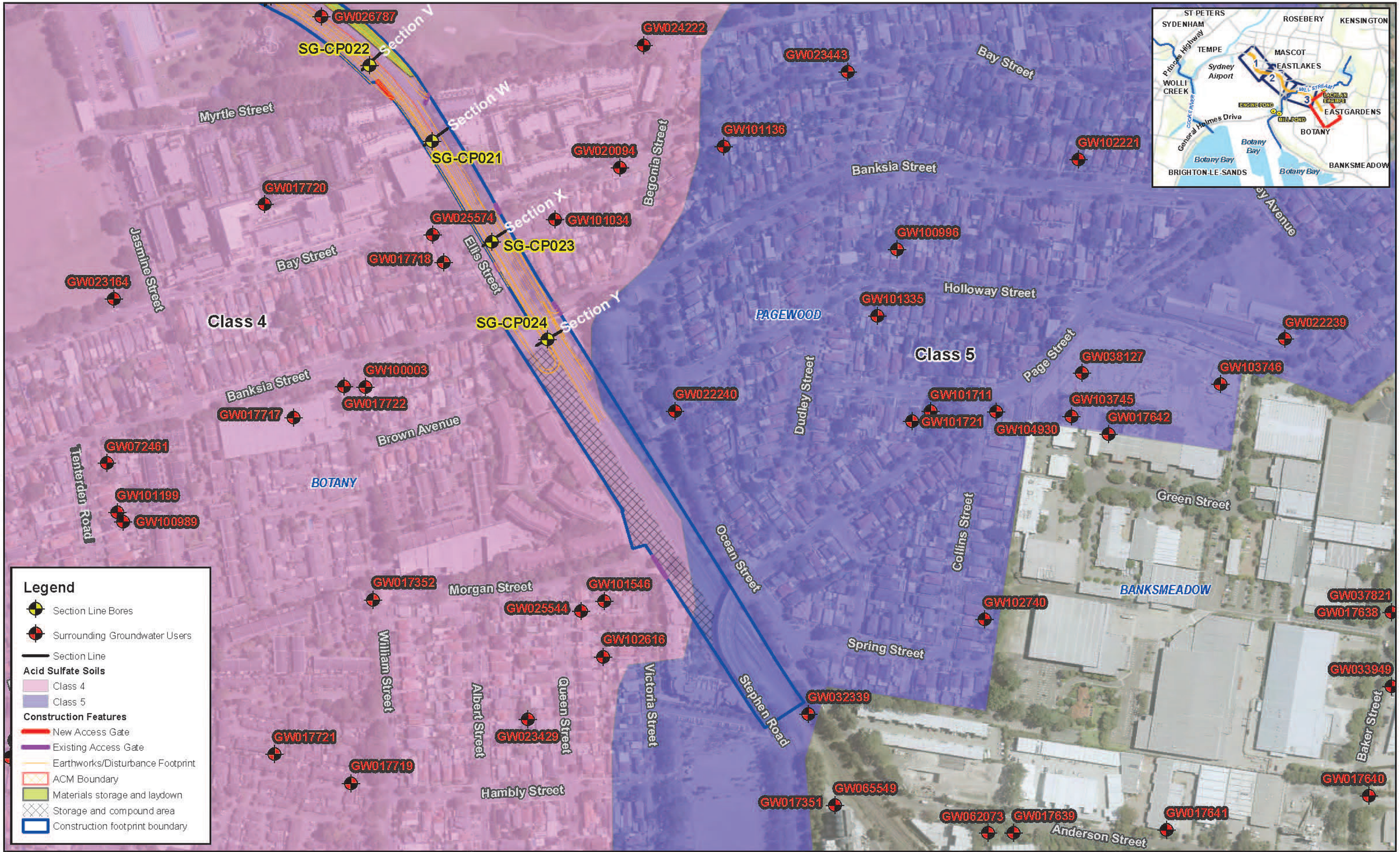

DATA SOURCE: Aerial Imagery ©AUSIMAGE - Jacobs Group (Australia) Pty Ltd 2018

REV	DATE	AMENDMENT / REVISION DESCRIPTION
A1	29/05/2019	Surrounding Receptors East of Mill Stream
A2	03/06/2019	Surrounding Receptors East and South of Mill Stream
A3	06/06/2019	Surrounding Receptors East and South of Mill Stream

DESIGN LOT CODE
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PLOT DATE / TIME: 7/06/2019 11:08:36 AM
PLOT BY: GK

TITLE	NAME	DATE
DRAWN	D.NAIKEN	7/06/2019
DRG CHECK	P.QUIMORA	7/06/2019

CLIENT: ARTC
PREPARED FOR

BOTANY RAIL DUPLICATION

A3

Groundwater Impact Assessment
Figure 5.4
Surrounding Receptors - Area 2

RMS REGISTRATION No.
PART
ISSUE STATUS: FOR INFORMATION
EDMS No.
SHEET No. 4
ISSUE: A3

Document Path: U:\Projects\PS113386_ARTC_Port_Botany\5_Shared\GIS\54_Production\Maps\PS113386_GIS_044_A3.mxd

5.1 Construction impacts

5.1.1 Changed groundwater recharge conditions

The key aspects of the rail duplication project that may limit or increase recharge are listed below:

- New rail track and movement (slewing) of the existing rail line to provide space for the rail duplication. This infrastructure is primarily surficial and any subsurface foundations will generally be closer than 1.0 metre from the existing ground surface. Re-alignment of the access track will result in the movement of the access track mound between sections W and X (south of the proposed Mill Stream bridge to Bay St – see Figure 5.1 to Figure 5.4), which will lower the existing ground surface by up to two metres, however the track in this section is elevated relative to the surrounding topography and will not result in intersection with the groundwater table. The removal of the surface is expected to expose more permeable sediments which will promote groundwater recharge events.
- Access tracks and the main line rail areas are proposed to be capped with lower permeability material than the underlying aquifer during construction. This represents a significant portion of the proposed operational project site. During construction existing infrastructure will be removed potentially exposing underlying materials. This will also increase the potential for groundwater recharge during rainfall events.

As noted in Section 1.1 the overall change in recharge areas is small relative to the overall recharge area for the Botany Sands aquifer (less than 0.3 per cent). Given this, any increases in recharge are not expected to have a measurable effect on groundwater elevations, especially given the relatively small climatic fluctuation in this area (Section 4.7.1), and the aquifer water balance. As such impacts to groundwater elevations are expected to be negligible relative to the AIP minimal impact criteria for water table changes and water pressure changes. Further to this, increases in recharge are also expected to represent positive impacts in regards to resource availability.

Based on the above, there will be negligible groundwater drawdown impacts on the following receptors:

- contaminated sites
- acid sulfate soils
- settlement of surrounding infrastructure
- surrounding groundwater supplies
- groundwater dependent ecosystems such aquatic ecology present in Mill Stream, Botany Bay and the Cooks River.

An increase in rainfall recharge will increase the potential for construction water quality impacts hence a potential for a change in the beneficial use potential of the aquifers in this area. If this occurred it would be considered to be more than a negligible impact as defined in the AIP and is discussed further in (Section 7).

Areas of expected higher risk of water quality impacts associated with general construction activities will include:

- storage and compound areas located near Section Y on Figure 5.4, between Section N and O on Figure 5.3, and near Section M on Figure 5.2
- material storage and laydown areas near Sections D and H on Figure 5.1, Sections L, N, O and P on Figure 5.2 and Sections R and V on Figure 5.3. Particularly those areas near to Mill Stream
- earthworks areas located along the entire project as presented in Figure 5.1 to Figure 5.4. Particularly those areas located near to Mill Stream. In this instance historical impact within subsurface soils may be exposed and released via rainfall infiltration
- areas where tracks are being slewed may liberate old impacts associated with a long history of active rail use such as historic lubricants
- areas of potential groundwater intersection where there will be a direct connection between potential construction activities and exposed groundwater.

The above activities may temporarily increase the potential for a change in beneficial use potential at the following down-gradient receptors:

- Industrial/irrigation users down-gradient of the project site including wells:
  - GW024036, which is a shallow well located on Sydney Airport that is registered as being used for irrigation purposes. It is noted that this well is already in the vicinity of the contamination remediation area at the Taxi car park. The groundwater in-take zone of the well (i.e. the bore screen) is expected to be positioned in the shallow unconsolidated aquifer that is either reworked/reclaimed Botany Sands or natural Botany Sands. Given the proximity to a remediation area, it is expected that this well is unlikely to be adversely impacted (by a change in beneficial use potential) by project construction activities.
  - GW024655 is registered as an abandoned irrigation well and is therefore no longer considered to be in use or potentially impacted by the project.
  - GW033371 and GW033372 are registered as commercial and industrial wells that may still be in use and could be impacted by the project. Given the depth of these wells they are expected to be screened in the Botany Sands aquifer. Given the proximity of these wells to the project, it is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW025994 is located in very close proximity to the project site although up-gradient and is registered as an irrigation well that may still be in use and therefore could be impacted. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. Given the proximity of this well to the project, it is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW100754 is located on the airport and is registered as a commercial and industrial well that could be in use. It has a depth of 148 metres and is screened within the underlying Hawkesbury Sandstone and is unlikely to be impacted by the project. As such this well is not considered further in this assessment.
  - GW025729 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. Given the proximity of this well to the project, it is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW025553 is registered as a commercial and industrial well that may still be in use and could be impacted the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. Given the proximity of this well to the project, it is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW026787 and GW026788 are registered as commercial and industrial wells that may still be in use and could be impacted by the project. Given the depth of these wells they are expected to be screened in the Botany Sands aquifer. Given the proximity of these wells to the project, it is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW017720 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. Given the proximity of these wells to the project, it is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW023164 is registered as an irrigation well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. It is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).

  - GW017722 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. It is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW017717 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. It is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
  - GW017718 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer. Given the proximity of these wells to the project, it is expected that this well would have a reasonable likelihood of being impacted by construction activities (by a change in beneficial use potential).
- Ecological and recreational users in Mill Stream, Botany Wetlands (including Lachlan Swamps), Cooks River and Botany Bay. The change in beneficial use would occur by the migration of impact groundwater down gradient with subsequent discharge to these surface water features. In areas near to Mill Stream the potential for impacts will be greater than in others where advection and dispersion of impacted groundwater would reduce the potential for a change in the beneficial use impacts. It is expected that impacts would be localised to the near shore ecology where groundwater has not been diluted.

At present, while it is acknowledged that the aquifer system in this area has water quality that is reflective of an industrial and urban setting, and is therefore unlikely to be subject to a change in beneficial use from construction it cannot be ruled out. Water quality impacts to down-gradient wells are therefore considered to be potentially significant and as such, environmental management measures will be required to minimise the potential for a change in beneficial use potential.

5.1.2 Groundwater drawdown impacts

A description of the potential for project infrastructure for reference design that intersect or avoid groundwater is provided below:

- New rail track and movement (slewing) of the existing rail line to provide space for the rail duplication. This infrastructure is primarily surficial and any subsurface foundations will generally be closer than one metre from the existing ground surface. Re-alignment of the access track will result in the movement of the access track mound between sections W and X (south of the proposed Mill Stream bridge to Bay Street) on Figure 5.4, which will lower the existing ground surface by up to two metres, however the track in this section is elevated relative to the surrounding topography and will not result in intersection with the groundwater table.
- New combined services routes for rail infrastructure (CSR). These are primarily located in between section V and the eastern end of the project site, in between sections O and S (east of Southern Cross Drive to Lord Street), in between sections N to O, and in between sections H and M. All of these will primarily be above ground structures with isolated locations below ground along Joyce Drive, in between sections I and J.
- Shallow concrete lined channels for capturing and managing rainfall run-off. These will be present in most areas of the project site and will generally be less than 0.5 metres deep and would not intersect groundwater.
- Retaining wall works on Mill Stream to Southern Cross Drive. These will be elevated relative to the surrounding topography and will be anchored horizontally removing the requirement for deep footings and any interaction with groundwater. In some instances foundations for the retaining walls may require piling works, however, similar techniques to that adopted for bridge pilings works would be adopted, which do not require groundwater dewatering (see bulleted points below).

- New deep drainage lines that will direct run-off to surface existing positive drainage systems– primarily between section S (invert 5.25 metre AHD) and Q (invert 4.4 metres AHD) and near section P, section L (invert 4.75 metres AHD), in between sections N and O, near sections F C, and B.
- Six new rail underbridges are to be built at four locations to replace or be adjacent existing underbridge structures. The exact construction of these underbridges has not been finalised. However, construction techniques will be adopted that prevent groundwater drawdown of the foundation excavations. For example, piling works are expected to adopt cast in situ techniques such as continuous flight auger. The cast insitu process would involve positive displacement of groundwater with concrete, while this is a form of dewatering it will not result in groundwater drawdown and the groundwater volumes displaced would be incidental and small.

Other existing utilities may be intersected or need to be relocated by the construction works and include:

- existing combined services routes that are to be removed or replaced. These are expected to include utilities owned by Sydney Water, Telstra and Ausgrid
- gas pipelines including:
  - Jemena high pressure gas pipelines (primary and secondary). This will not be relocated
  - a high pressure ethylene pipeline (referred to as the Qenos pipeline). This pipeline has been purged and contains inert Nitrogen. It is proposed that this pipeline would be relocated along section M (invert 4.5 metres AHD) to K (invert 3.0 metres AHD), in between sections I and J (invert 4.4 metres AHD) to F (invert 5.0 metres AHD). It is assumed that the old pipeline would be abandoned insitu and replaced by a new pipeline at the revised location
- Moomba to Sydney ethane pipeline (referred to as MSE). This pipeline may require protection at a number of locations along the project
- Ausgrid high voltage power
- drainage assets (Council).

Table 5.1 summarises the subsurface infrastructure by location, starting in Botany near Banksia Street, and whether the type of construction is occurring within that area. The sections are location on Figure 5.1 to Figure 5.4.

Table 5.1 Infrastructure with the potential to intersect groundwater along the alignment of the project site

Section	CSR – relocation and new	Retaining Wall	Bridge foundations	Earthworks	New Drainage	Qenos Pipeline relocation
Y to eastern end of the project site	X			X		
V to Y	X	X		X	X	
T to V	X					
R to T	X				X	
P to R	X	X	X		X	
N to P	X	X	X		X	
Botany Rd near Wentworth Avenue to P	X	X			X	
M to Botany Rd near Wentworth Avenue			X		X	
K to M	X	X	X	X	X	X

Section	CSR – relocation and new	Retaining Wall	Bridge foundations	Earthworks	New Drainage	Qenos Pipeline relocation
North of the IBIS budget hotel to K	X			X		
G to North of the IBIS budget hotel	X	X	X	X	X	X
D to G		X	X		X	X
King St to D		X		X	X	
Lancastrian Drive to Qantas Drive near King St				X		

Table 5.2 summarises the design inverts, observed groundwater elevations and reasonable worst case groundwater elevations at locations with groundwater data along the rail corridor. These locations are presented in Figure 5.1 to Figure 5.4. The reasonable worst case groundwater elevations are based on the observed groundwater elevations in 1999, which were associated with a period of expected higher groundwater elevations as reflected in the CRD curve on Figure 4.7 and/or a potential increase of 0.9 metres from existing groundwater elevations based on the variation in long term groundwater elevations at NSW DoI monitoring wells GW075022 and GW075023 located to the west and east of Mill Stream and near to the project.

Table 5.2 Summary of groundwater elevations and infrastructure invert elevations

Section	Invert level of lowest infrastructure (m AHD)	Infrastructure at lowest invert	Observed groundwater elevations (m AHD)	Reasonable worst case groundwater elevation (m AHD)	Depth from infrastructure to observed groundwater level (m)	Depth from infrastructure to RWC groundwater level (m)
A	5.339	Invert of track foundation	2.09	2.99	3.25	2.35
B	6.031	Invert of track foundation	1.98	2.88	4.05	3.15
C	6.544	Invert of track foundation	2.43	3.33	4.12	3.22
D	6.836	Invert of track foundation	1.51	2.41	5.33	4.43
E	7.389	Invert of track foundation	1.50	2.40	5.89	4.99
F	5	Qenos Pipeline	1.59	2.49	3.41	2.51
G	3.9	Qenos Pipeline	5.23	6.13	-1.33	-2.23
H	5.3	Qenos Pipeline	3.11	4.01	2.19	1.29
I	6.9	Qenos Pipeline	3.03	3.93	3.87	2.97
J	7.193	Invert of track foundation	3.78	4.68	3.41	2.51
K	5.185	Invert of track foundation	3.22	4.12	1.97	1.07
L	4.758	Invert of track foundation	3.07	3.97	1.69	0.79

Section	Invert level of lowest infrastructure (m AHD)	Infrastructure at lowest invert	Observed groundwater elevations (m AHD)	Reasonable worst case groundwater elevation (m AHD)	Depth from infrastructure to observed groundwater level (m)	Depth from infrastructure to RWC groundwater level (m)
M	5.88	Invert of track foundation	3.12	4.02	2.76	1.86
N	10.086	Invert of track foundation	8.30	9.20	1.79	0.89
O	10.715	Invert of track foundation	2.99	3.89	7.73	6.83
P	9.935	Invert of track foundation	3.80	4.70	6.14	5.24
Q	9.248	Invert of track foundation	2.81	3.71	6.44	5.54
R	4.7	Subsurface stormwater pipe	3.24	4.14	1.46	0.56
S	7.172	Invert of track foundation	5.73	6.63	1.44	0.54
T	7.364	Invert of track foundation	6.48	7.38	0.88	-0.02
U	7.449	Invert of track foundation	6.58	7.48	0.87	-0.03
V	7.543	Invert of track foundation	6.37	7.27	1.17	0.27
W	7.746	Invert of track foundation	7.40	8.30	0.35	-0.55
X	7.2	CSR	7.27	8.17	-0.07	-0.97
Y	8.519	Invert of track foundation	7.37	8.27	1.15	0.25

Notes:

Table excludes bridge piling works – which will be installed using cast insitu techniques that will not require dewatering but will intersect groundwater.

RWC = Reasonable worst case.

Table 5.2 indicates that the project infrastructure is intersected by groundwater at a small number of locations along the project site as summarised below:

- in the vicinity of Section G in Figure 5.1 to Figure 5.4 for relocation of the Qenos pipeline under worst case wet conditions and current groundwater conditions. It is noted however, that the groundwater elevations in this area are based on groundwater strike information at SG-CP013 (Table 4.9), which appear to be anomalously high
- in the vicinity of Sections T to W (excluding Section V) by the track foundations under reasonable worst case wet groundwater elevation conditions. There is no intersection under currently observed conditions
- in the vicinity of Section X on Figure 5.1 to Figure 5.4 by the new combined service route under worst case wet conditions (albeit slight) and current groundwater conditions.

The above summary indicates that there is a reasonable likelihood of intersection with groundwater at isolated locations along the alignment of the project site, particularly under wet conditions. In these areas if groundwater is intersected construction activities will be designed to prevent groundwater dewatering (and hence groundwater drawdown).

Bridge footings will intersect groundwater but as noted earlier cast insitu techniques will be adopted that do not require dewatering.

As such, impacts to groundwater elevations are expected to be negligible relative to the AIP minimal impact criteria for water table changes and water pressure changes. Further to this, increases in recharge (Section 5.1.1) are also expected to represent positive impacts in regards to resource availability.

With regard to receptors, the outcome of this approach will be that there will be no more than negligible drawdown impacts to:

- contaminated sites
- acid sulfate soils
- settlement of surrounding infrastructure
- surrounding groundwater supplies used for industrial purposes
- groundwater dependent ecosystems.

5.1.3 Groundwater quality

As outlined above, construction activities will involve moving the existing track and re-profiling of the existing surface to facilitate implementation of the proposed design. This will temporarily increase the potential for rainfall recharge and raise the potential for water quality impacts associated with construction activities.

Further to this, intensified construction activities relative to existing site use raise the potential for isolated spills and diffuse impacts. Chemicals of primary concern include hydrocarbons.

Impact is likely to occur through the infiltration of spilled pollutants onto the ground surface and/or liberated pollutants from disturbed fill/soils (see Section 5.1.1 for sources) and migration to underlying groundwater. Further detail on the contaminants present in soil that could be liberated by construction works is presented in the *Botany Rail Duplication EIS, Technical Report 5 – Contamination Assessment*.

Impacted groundwater from the above sources may then migrate to surface water features or other receptors (such as groundwater supply wells) where the beneficial use potential (environmental value) may be lowered.

The adoption of non-dewatering construction techniques, in line with normal construction practice, could result in direct contamination of exposed groundwater in excavations by construction activities, which would also migrate to down gradient receptors. These activities would include:

- increased potential for spills (fuels and hydraulics) from the construction machinery directly to exposed groundwater
- increased potential liberation of substances from tracks being removed and replaced such as historical rail lubricants and migration into open excavations with groundwater located in them
- disturbance of underlying contaminated materials and liberation of chemicals, via rainfall run-off into open excavations
- improper storage and handling of chemicals in and around the exposed groundwater in excavations.

As noted above groundwater intersection has potential to occur in the vicinity of Sections G and T- X (including Section V) which raises the potential for direct contamination of the aquifer system by construction activities.

With regard to receptors, the outcome of this will be a temporary increase in the potential for change in the beneficial use potential to down gradient receptors. While it is noted that the beneficial use potential of the existing aquifers in this area are low and there is an embargo on groundwater use for domestic purposes, the following receptors may still be impacted:

- Industrial/irrigation users down-gradient of the project site are presented below, all other wells located in this region are water supply wells subject to the Botany Sands aquifer water use embargo:
  - GW024036, which is a shallow well located on Sydney Airport that is registered as being used for irrigation purposes. It is noted that this well is already in the vicinity of the contamination remediation area at the Taxi car park. The well is expected to be screened in the shallow unconsolidated aquifer that is either reworked/reclaimed Botany Sands or natural Botany Sands.
  - GW033371 and GW033372 are registered as commercial and industrial wells that may still be in use and could be impacted by the project. Given the depth of these wells they are expected to be screened in the Botany Sands aquifer.
  - GW025994 is located in very close proximity to the project site although up-gradient and is registered as an irrigation well that may still be in use and therefore could be impacted. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
  - GW100754 is located on the airport and is registered as a commercial and industrial well that could be in use. It has a depth of 148 metres and is screened within the underlying Hawkesbury Sandstone and is unlikely to be impacted by the project. As such this well is not considered further in this assessment.
  - GW025729 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
  - GW025553 is registered as a commercial and industrial well that may still be in use and could be impacted the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
  - GW026787 and GW026788 are registered as commercial and industrial wells that may still be in use and could be impacted by the project. Given the depth of these wells they are expected to be screened in the Botany Sands aquifer.
  - GW017720 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
  - GW023164 is registered as an irrigation well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
  - GW017722 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
  - GW017717 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
  - GW017718 is registered as a commercial and industrial well that may still be in use and could be impacted by the project. Given the depth of this well it is expected to be screened in the Botany Sands aquifer.
- Ecological and recreational users in Mill Stream, Lachlan Swamps, Cooks River and Botany Bay.

Management measures will be required to limit the potential for a change in beneficial use potential.

5.1.4 Construction water balance

All water will be sourced from reticulated water supply, there will be no dewatering of the groundwater system by construction and there will be a temporary but negligible increase in groundwater recharge.

As such there will be a negligible change to the groundwater balance presented in Section 1.1.

5.1.5 Construction licensing

Due to the adoption of construction techniques that do not require dewatering, no licensing is expected to be required for the abstraction, management or discharge of groundwater from the site.

5.1.6 Summary of key findings

The following key points are made in regard to the impacts of construction activities on groundwater:

- Construction excavation activities may intersect groundwater at isolated locations during wet weather, but it is unlikely intersection will occur during dry conditions (other than at Section X). Bridge piling works will adopt cast insitu techniques that do not require groundwater dewatering and other non-dewatering techniques, in line with normal construction practice, will be adopted for other infrastructure such as the track foundations, the CSR and the Qenos pipeline if intersection occurs.
- There is a potential for a small increase in groundwater recharge during construction due to re-profiling works exposing more permeable materials.
- Based on the above, there will be no more than a negligible groundwater table impact relative to AIP groundwater table criteria.
- There will be an increased risk of water quality impacts associated with construction, which could change the beneficial use potential at a number of potentially sensitive groundwater receptors down gradient especially industrial water supply wells and Mill Stream. A change in water quality could represent a change in the beneficial use potential of the groundwater and surrounding receptors that is above the AIP minimal impact criteria for water quality. As such, management measures will be required.

5.2 Operational impacts

There would be additional tracks and increased train numbers during operation. However it is expected that there would be no more potential for impacts outside those that currently exist. In addition upgrades to the surface water drainage system would lower the potential for infiltration of any impacts to groundwater.

Other than increase train movements operational activities are expected to include:

- track lubrication using inert lubricants
- maintenance works, such as reconditions of the track, topping up of ballast, bridge and culvert inspections, rail grinding and track tamping
- any other major works would be completed in accordance with ARTC's environmental management system (EMS) which includes a procedure for completed a review of environmental factors when required.

Specific operational changes with regard to groundwater and their potential impacts are discussed further below.

5.2.1 Groundwater recharge

The main aspects of operation that will potentially impact on groundwater are expected to be:

- the new rail track and associated foundations will be constructed of material which has low permeability. As such it will reduce recharge to groundwater
- increased surface runoff associated with the new drainage structures and therefore better capture of rainfall will reduce rainfall infiltration to groundwater.

It is expected that the above applies to a small portion of the project site, and as such for the purposes of this assessment, if groundwater recharge was prevented in its entirety the overall impact on rainfall recharge to the Botany Sands aquifer would be less than 0.3 per cent (less than 104 m^3/day) of the overall groundwater balance.

Given this, any decreases in recharge are not expected to have a measurable effect on groundwater elevations, especially given the relatively small climatic fluctuation in this area associated with rainfall events (Section 4.7.1).

As such, operational groundwater recharge impacts are interpreted to be negligible and below the AIP minimal impact criteria for groundwater drawdown.

With regard to receptors, the outcome of these elements of construction will be no more than negligible recharge reduction (and hence drawdown) impacts to:

- contaminated sites
- acid sulfate soils
- settlement of surrounding infrastructure
- surrounding groundwater supplies
- groundwater dependent ecosystems such as aquatic ecology present in Mill Stream (Botany Wetlands), Botany Bay and the Cooks River.

5.2.2 Groundwater drawdown

Due to the nature of the works, and the existing known contamination within the Botany Sands aquifer, with management zones and embargos on groundwater take, all water required for operation would be sourced from non-groundwater sources. This will include reticulated water supplies.

Operational design will not require ongoing dewatering of groundwater, as such there will be no groundwater drawdown impacts during operation.

There may be permanent intersection of groundwater by new infrastructure as indicated in Table 5.2, however this will be negligible relative to overall aquifer thickness and as such there will be no change to groundwater elevations from subsurface barriers.

As such, operational groundwater drawdown impacts are interpreted to be negligible and below the AIP minimal impact criteria for drawdown.

With regard to receptors, there will be no more than negligible drawdown impacts to:

- contaminated sites
- acid sulfate soils
- settlement of surrounding infrastructure
- surrounding groundwater supplies used for industrial purposes.
- groundwater dependent ecosystems.

5.2.3 Groundwater quality

During operation groundwater impacts could result from infiltration of contaminants released by site activities or spilt or leaked chemicals during operation activities (such as via hydraulic leaks). The occurrence of this is expected to be low and no more than existing conditions.

The upgraded drainage system across the site further minimise the potential for infiltration of contaminants to groundwater and spills from accidents.

The revised capping material across the operational area will also reduce overall groundwater recharge and hence reduce the potential for negative groundwater quality impacts.

Groundwater quality in the Botany Sands aquifer is broadly impacted in this area by a range of ongoing industrial and commercial activities as well as the existing rail corridor (see Section 1.1).

Given the above, changes in water quality should not lower the beneficial use category of the groundwater source beyond 40 metres of the activity.

5.2.4 Operation water balance

Any water required for operational activities such as maintenance works will be sourced from reticulated water supply, there will be no dewatering of the groundwater system by operational activities and there will be minimal reduction in groundwater recharge.

As such there will be a negligible change to the groundwater balance presented in Section 1.1 and hence groundwater elevations.

5.2.5 Operation licensing

No groundwater licensing is expected to be required for the management of groundwater as no groundwater is expected to be abstracted or discharged from the site.

Any works outside of normal maintenance activities and requiring dewatering would be managed under the existing environmental management system and the requirement for licences would be determined at this time.

5.3 Summary of key findings

The key findings regarding impacts of operational activities on groundwater are:

- Operational activities are not expected to intersect groundwater or require ongoing dewatering.
- Groundwater recharge will slightly reduce in all areas of earthworks where new capping and foundation material has been emplaced but will result in a minimal reduction in the Botany Sands aquifer water balance. It will also result in a slightly reduced potential for groundwater quality impacts relative to existing conditions.
- Groundwater drawdown impacts relative to the AIP drawdown criteria will be no more than negligible.
- While there will be a slightly reduced potential for adverse impacts to groundwater quality and while existing water quality data indicates the Botany Sands aquifer is of limited value, there will be on going potential for impacts that could change the beneficial use potential and result in impacts greater than the AIP minimal impact criteria for water quality. The key potential impacts are spills and leaks from operational activities, however, these are expected to be no more than present day conditions. As such the potential for change in the beneficial use potential of down gradient groundwater is expected to be unlikely. Environmental management measures will be implemented to manage this.

6. Cumulative impacts

6.1 Introduction

Major developments currently under construction in the vicinity of the project include:

- M4–M5 Link and New M5. The interpreted zone of groundwater impact associated with this project is not interpreted to intersect the BRD project.
- Sydney Metro Southwest. The interpreted zone of groundwater impact associated with this project is not interpreted to intersect the BRD project.
- Airport North upgrades – O'Riordan Street. This project is expected to be largely completed in 2020 at which time BRD project is expected to have commenced as such cumulative construction based impacts may occur. However, it is noted that the construction works will be staged such that the progression of each project will not be hindered.
- Airport East upgrades – General Holmes Drive, Botany Road, Joyce Drive. This project will be completed prior to the commencement of the BRD project as such cumulative construction based impacts are not expected.

Other developments in the vicinity of the project that are proposed but not yet approved include the Sydney Gateway road project and F6 Stages 1 and 2. The F6, which will extend off from the new M5 is expected to have an interpreted zone of groundwater impact that does not intersect with the BRD project.

Further detail on the potential groundwater impacts of the Sydney Gateway road project projects are provided below.

6.2 Groundwater recharge

Recharge is expected to increase marginally during construction resulting in an increase in rainfall infiltration with no material impact to the groundwater balance and resource availability in this area. As such there is not expected to be any contribution to cumulative drawdown and water balance impacts potentially associated with other projects in this region.

There may a slight increase in the potential for infiltration of impacted groundwater that will overlap with construction works on the Sydney Gateway road project and the Airport North upgrades.

During operation, there will be marginally reduced recharge that is not expected to result in material change to groundwater elevations or the groundwater balance that currently exists. The Sydney Gateway Road project and the WestConnex enabling works airport north precincts are in close proximity to the BRD project close proximity to one another and any impacts would overlap. These projects are also expected to have negligible operational impacts on groundwater recharge compared to existing conditions as they will primarily be replacing existing sealed areas in the vicinity of the Botany Rail Duplication project.

6.3 Groundwater drawdown

Based on the information presented in Sections 1.1 and 5.2, there will not be construction or operational groundwater drawdown associated with the Botany Rail Duplication project and therefore the project will not contribute to ongoing cumulative groundwater drawdown impacts associated with other projects in the area. Any impacts associated with those projects will be assessed as part of the approvals process for those projects.

6.4 Groundwater quality

While the beneficial use potential of the groundwater system in this area is already impacted by existing industrial uses, there will be increased potential for infiltration of construction impacted rainfall to groundwater. The potential for this impact will also be associated with the Sydney Gateway road project and the WestConnex enabling works north precinct construction (in areas at and west of O'Riordan Street only), which will be occurring at a similar time. This will result in the potential for cumulative impacts, however, it is noted that the construction works will be staged such that the progression of each project will not be hindered. Construction works for the WestConnex enabling works east precinct is expected to be completed in 2019 and will not overlap with the construction works for the Botany Rail Duplication works.

During operation the existing land uses would remain the same albeit to support increased traffic volumes. The upgraded drainage and other operational infrastructure for all projects would also further reduce the potential for infiltration of contaminants to groundwater from leaks, spills, accidents and general operational activities.

The revised capping material across the operational area will also reduce overall groundwater recharge and hence the potential for adverse groundwater quality impacts by contaminant infiltration. This will reduce any contribution to cumulative water quality impacts from the BRD project.

Further to this, existing environmental management systems are in place to manage and maintain equipment and storage facilities that could be sources of hazardous chemicals and to respond appropriately to spills associated with accidents and leaks.

Based on this, cumulative impacts that could result in a change in the beneficial use potential criteria outlined in the AIP are not expected to occur however, this would need to be verified with monitoring.

7. Management of impacts

7.1 Approach

7.1.1 Overview

As a general guiding principle for major civil design and construction works, water quality mitigation and management measures will be implemented in accordance with the relevant requirements of NSW legislative framework for groundwater quality and availability, paying particular attention to the NSW aquifer interference policy, relevant water sharing plans (Botany Sands aquifer management plan), the NSW groundwater dependent ecosystems policy, and NSW and Australian groundwater quality guidance.

Mitigation measures would be managed through the following:

- ARTC's Site environmental management plans (EMPs) for enabling works
- project specific construction and environmental management plan (CEMP) for main construction works
- community and stakeholder engagement plan
- ARTC's environmental management system for operation of the project.

A Soil and Water Management Plan (SWMP) would be developed to manage soil and water risks during the main construction works. The SWMP would comply with the proposal conditions of approval and be in accordance with best on site practice, reflected in the Blue Book (Landcom, 2004).

7.1.2 Groundwater recharge

Groundwater recharge impacts relative to the AIP minimal impact criteria for groundwater elevation changes are considered to be negligible during construction and operation and therefore no mitigation measures are proposed.

7.1.3 Groundwater drawdown

There will be no construction or operational activities that will result in groundwater drawdown. As such no impacts are expected to occur.

The proposed construction approach of no dewatering would result in no greater than negligible impacts and as such no specific mitigation is proposed.

7.1.4 Groundwater quality

Construction

Construction activities are expected to have potential to increase the occurrence of contaminants infiltrating to groundwater and hence changing the beneficial use potential of underlying groundwater.

Given the existing groundwater conditions, which reflect historical urban and industrial activities, it is expected the likelihood of a change in the beneficial use potential of the underlying aquifer will be small, although this is uncertain.

Potential water quality impacts associated with the enabling works would be managed through the site environmental management plan. Potential water quality impacts associated with the main construction works would be managed by implementing environmental management measures within the a SWMP. This would include appropriate handling and management procedures for incidental groundwater ejected at the ground surface by bridge pile installation works.

As presented in the *Botany Rail Duplication EIS Technical Report 5 – Contamination Assessment*, the SWMP would include additional management plans to manage potential water quality impacts. These are:

- water quality objectives for the project
- an erosion and sediment control plan that allows for site-specific erosion and sediment controls at all work sites in accordance with the Blue Book
- an asbestos management plan (AMP) that would be prepared in accordance with NEPM 2013 and the *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (WA Department of Health, 2009)
- an acid sulfate soil management plan (ASSMP) that would be developed in accordance with the *Acid Sulfate Soils Manual* (ASSMAC, 1998).

Operation

The project would include capping and surface water capture systems that manage surface water and limit migration to the underlying groundwater system. Operation of the project would therefore, result in reduced potential for impacts to the beneficial use potential of the underlying groundwater system relative to existing conditions.

There would however, be an ongoing potential for groundwater quality impacts from isolated spills and leaks associated with operational and maintenance activities that could adversely impact groundwater quality. These would be no more than existing conditions and as such there is unlikely to be a change in the beneficial use potential of the underlying groundwater system.

The existing environmental management system would be continued to prevent ongoing groundwater quality impacts. This system includes a range of environmental procedures/protocols such as:

- a contaminated land database to inform intrusive maintenance works that could disturb and liberate contamination in subsurface soils
- material handling procedure
- spill prevent and response procedure
- emergency response procedures
- pesticide application and use
- project risk management protocols, which include consideration of risks to the environment.

7.2 List of mitigation measures

The mitigation measures that would be implemented to address potential groundwater impacts are listed in Table 7.1 and will be incorporated into the relevant management plans.

Table 7.1 Mitigation measures

Stage	Impact	Measure
Construction	Spills and leaks contaminating groundwater	Procedures to store, handle and use materials and equipment appropriately to prevent spills will be prepared and included in the Soil and Water Management Plan.
	Change in beneficial use potential of groundwater quality	Leakage of fuels, oils, chemicals and other hazardous liquids will be immediately cleaned up in accordance with the Safety Data Sheet and relevant emergency response procedure.
Operation	Spills and leaks contaminating groundwater	A groundwater construction monitoring program will be developed to verify the effectiveness of construction activities at preventing changes in the beneficial use potential of the aquifer system. This is detailed in Section 8.
	General maintenance activities	Potential spills and/or leaks will be managed in accordance with ARTC's pollution incident response procedure (under the Environment Management System) or in accordance with an Operator's Operational Management Environmental Management Plan (OEMP) prepared in accordance with ARTC's access agreement requirements (depending on the extent and natural of the spill).

8. Monitoring

Proposed monitoring to verify the effectiveness of construction and operation activities at limiting potential impacts to groundwater quality are presented below.

A groundwater monitoring program would be prepared and implemented to characterise baseline groundwater conditions and construction and operational impacts. A summary of the proposed monitoring program is provided below.

8.1 Baseline monitoring

A baseline monitoring program would be implemented to characterise baseline groundwater conditions.

The locations for groundwater monitoring should focus on the early detection of impacts and the potential for impacts at groundwater receptors. As such, the monitoring would include locations:

- up and down-gradient of the project site and at depths equivalent to the depth of construction and operational infrastructure (e.g. the shallow groundwater system of the Botany Sands aquifer)
- along the entire alignment of the project site, to understand the breadth of water quality characteristics on which impacts can be assessed
- near groundwater receptors including industrial groundwater supply wells and in between the project site and receiving surface water features (Botany Bay and Cooks River and Mill Stream).

An existing ongoing monitoring program has been implemented, from which baseline groundwater data could be used. The locations of existing groundwater monitoring locations are presented in Appendix A.

It is expected that the analytical suite used for water quality monitoring would focus on key contaminants associated with construction activities and the existing surrounding land use (to highlight pre-existing impacts associated with other industry in the area). As a minimum the analytical suite should include:

- total dissolved solids
- pH
- dissolved heavy metals, particularly cadmium, iron, lead, nickel, manganese and zinc
- chloride, sodium and sulfate
- nitrate, ammonia and phosphorus
- total recoverable hydrocarbons, benzene, toluene, ethylbenzene and xylene (BTEX) and polycyclic aromatic hydrocarbons (PAHs)
- PFAS.

The water quality results should be compared against criteria that facilitate the establishment of the current beneficial use potential of the groundwater system and receiving water bodies, on which any project related impacts can be assessed. This is expected to include:

- Criteria for the protection of aquatic species such as:
  - ANZG (2018) marine and freshwater criteria for the protection of 95 percent of aquatic species unless otherwise justified
  - the NEMP (2018) PFAS guidelines for marine and freshwater.
- Recreation criteria such as the NHMRC (2008) recreational guideline values. This would also be used as conservative criteria for assessing the suitability of the water for industrial purposes as well, assuming that industrial water supplies are not suitable for potable purposes without treatment (in accordance the Botany Sands embargo on domestic users).

A registered groundwater supply bore survey should be conducted to verify the use of the wells and or subsequently understand water quality criteria needed for the wells to maintain their viability. Any operational bores, could then be incorporated into the monitoring program or ‘fit for purpose’ water quality monitoring undertaken by the user in accordance with the Botany Sands groundwater source water restriction order 2018 could be used.

8.2 Construction monitoring

As there is an increased risk of a groundwater quality impacts (a change in beneficial use potential) relative to existing conditions, a construction base groundwater monitoring program is proposed.

The baseline groundwater monitoring program would be continued through construction for the purpose of identifying and responding to any groundwater quality impacts outside of those predicted. Quarterly monitoring is expected to be suitable to highlight the emergence of groundwater quality impacts relative to the baseline groundwater data. The construction monitoring period at each monitoring well would be completed once construction in the vicinity of each well was completed.

The emergence of groundwater impacts is expected to be relatively quick as groundwater flow velocities are estimated to be in the order of 255 m/year (Section 1.1) in the Botany Sands aquifer. As such quarterly monitoring is expected to be suitable to resolve the emergence of any construction based quality impacts. It is recommended that post-construction monitoring is continued for 1 year after the completion of each stage of the project to characterise the emergence of any construction impacts after completion.

Assessment of water quality impacts should focus on background (baseline) groundwater and surface water quality conditions where data is available to establish site specific criteria in accordance with ANZECC 2000 guidelines and ANZG (2018) while being cognisant of the NSW Water quality objectives and the Botany Bay and Catchment water quality improvement plan. Other criteria such as ANZG (2018) values, NEMP (2018) values and NHMRC (2008) values would be adopted where site specific data cannot be established.

Exceedance of these criteria would instigate further investigations and/or remedial response measures. These measures would be specified in the CEMP groundwater management plan.

8.3 Operation monitoring

As operational impacts are expected to be no more than existing conditions and that operational activities will be subject to the existing environmental management system to identify and manage environmental incidents, no ongoing groundwater quality monitoring is proposed.

9. Conclusion

A groundwater impact assessment has been completed to assess the impacts of the proposed project on the existing groundwater resources and down-gradient receptors.

The assessment has been desktop based, with the assessment of impacts and mitigation measures. The data available for this assessment is limited to information from previous investigations and public databases. As such, a conservative approach identifying potential impacts is necessary due to gaps in hydrogeological understanding based on the limited data to accommodate any uncertainty.

The characterisation of impacts has focused on comparing the impacts from the project against the AIP criteria for groundwater table changes and changes in beneficial use potential of the groundwater quality.

All potential groundwater impacts have been assessed to be manageable. The potential impacts and recommended mitigation measures are outlined below.

9.1 Groundwater drawdown impacts

The assessment has included establishing reasonable worst case groundwater elevations along the alignment of the project site and comparing those to the project design, particularly subsurface infrastructure. Further to this, consideration has been given to impacts of changed recharge conditions during construction and operation on groundwater drawdown and resource availability/water balance.

- The assessment of groundwater impacts during construction has relied on the adoption of non-dewatering techniques, in line with normal construction practice, where groundwater is encountered. Incidental and very localised displacement of groundwater for bridge and retaining piling works will occur but this will not result in groundwater drawdown.

Groundwater drawdown impacts during both construction and operation is considered negligible.

As such no mitigation measures are proposed.

9.2 Groundwater quality impacts

9.2.1 Construction impacts

The groundwater system is already typical for a historical urban and industrial use. The construction activities are however a change in use, albeit temporary, above an aquifer that supports industrial groundwater use and that discharges to wetland ecosystems of significance. There is uncertainty with regard to whether construction impacts will change the beneficial use potential (which would represent an adverse impacts under the AIP criteria), but given the presence of surface water systems of significance and potential down gradient industrial groundwater users, a precautionary approach has been adopted. This approach includes the adoption of the following mitigation measures:

- Potential water quality impacts would be managed by implementing environmental management measures within a relevant management plan. It also includes a number of target measures to manage contaminated soil and groundwater, including the development of a ASSMP.
- A baseline and construction monitoring program would be implemented to verify the effectiveness of the measures outlined in the SWMP to prevent groundwater quality impacts.

There may be an increased potential for cumulative groundwater quality impacts from increased rainfall infiltration during the combined construction of the Sydney Gateway Road Project and the Botany Rail Duplication project. This potential impact will be managed by implementing appropriate measures for each project separately.

9.2.2 Operation impacts

Impacts during operation are expected to be no more than existing conditions and with the ongoing implementation of the environmental management systems the potential for impacts is expected to be negligible.

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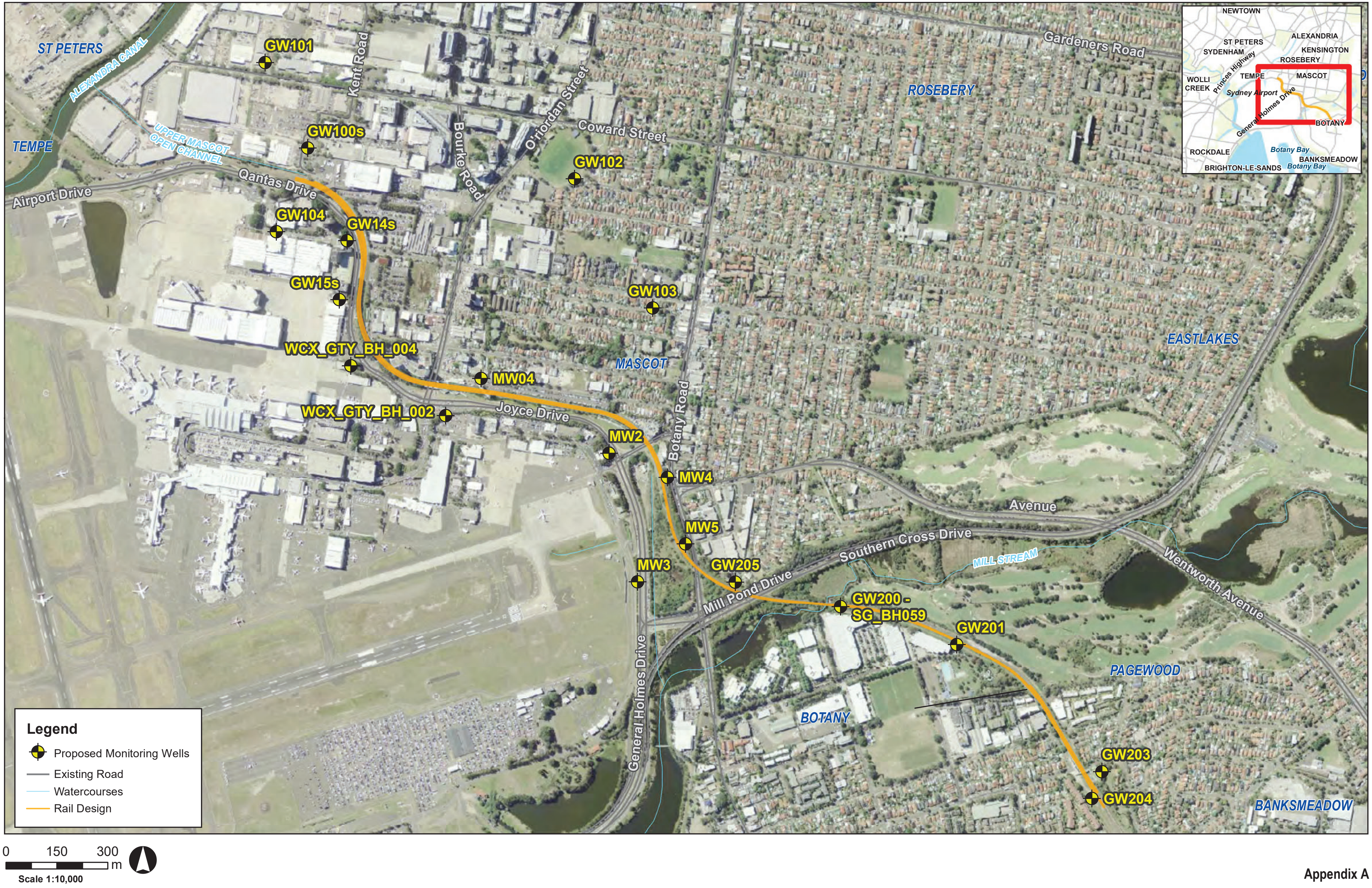
Appendix A
Proposed monitoring wells

Table A1 - Proposed wells for monitoring

Location ID	Easting	Northing	Existing Ground RL (m AHD)	Depth of well (m bgl)	Lithology	Ongoing baseline monitoring (as at April 2019)
GW14s	332104.69	6244353.19	4.10	6	Quaternary Sediments	Yes
GW15s	332081.84	6244179.48	3.25	6.02	Quaternary Sediments	Yes
WCX_GTY_BH_002	332395.54	6243838.78	5.63	3.96	Quaternary Sediments	Yes
WCX_GTY_BH_004	332115.79	6243985.37	3.30	3.97	Quaternary Sediments	Yes
MW04	332499.46	6243947.98	8.71	TBC	TBC	TBC
GW100s	331988.66	6244625.921	3.44	6.1	Fill / Quaternary Sediments	Yes
GW101	331863.565	6244877.462	2.19	6.1	Fill / Quaternary Sediments	Yes
GW102	332774.612	6244535.026	9.17	7.3	Fill / Quaternary Sediments	Yes
GW103	333004.73	6244155.16	8.14	5.98	Fill / Quaternary Sediments	Yes
GW104	331896.331	6244379.956	2.56	5.88	Fill / Quaternary Sediments	Yes
GW200-SG_BH059	333557.319	6243276.522	7.37	17.51	Fill / Quaternary Sediments	Yes
GW201	333899.745	6243165.058	9.30	6.51	Fill / Quaternary Sediments	Yes
GW203	334326.81	6242790.84	10.58	7.09	Fill / Quaternary Sediments	Yes
GW204	334297.052	6242711.503	9.89	5.2	Fill / Quaternary Sediments	Yes
GW205	333247.51	6243348.59	8.29	6.48	Fill / Quaternary Sediments	Yes
MW2	332876.5007	6243727.832	4.04	5.8	Fill / Quaternary Sediments	'
MW3	332959.6991	6243349.178	6.06	9	Fill / Quaternary Sediments	'
MW4	333047.8954	6243656.976	5.97	6	Fill / Quaternary Sediments	'
MW5	333101.1085	6243460.89	8.71	6	Fill / Quaternary Sediments	'

LEGEND

RL	Reduced level
mAHD	metres Australian Height Datum
mbgl	metres below ground level
TBC	To be confirmed
(10)	Brackets indicate approximation only.
DA	Data available (from previous investigation)
SWL	Standing water level
N/A	Not applicable
4.04	Historical survey or estimated data
'	Expected ongoing monitoring as part of Airport east project



Author: David Naiken
Date: 24/07/2019
Map no: PS113386_GIS_073_A1

Appendix A

Proposed Wells for Monitoring

G2SJV Gateway to Sydney Joint Venture
WSP Australia Pty Limited and GHD Pty Ltd

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