Australian Government

NSW GOVERNMENT | sydney METRO

Sydney Metro – Western Sydney Airport

Technical Paper 6

Flooding, hydrology and water quality

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Glossary and terms of abbreviation

Term	Definition
A	
AEP	Annual Exceedance Probability. The probability that a design event (rainfall or flood) has of occurring in any 1 year period.
Afflux	With reference to flooding, afflux refers to the predicted change, usually in flood levels, between two scenarios. It is frequently used as a measure of the change in flood levels, between an existing scenario and a proposal scenario.
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARR	Australian Rainfall and Runoff
Acid sulfate soils	Naturally occurring soils, sediments or organic substrates (e.g. peat) that are formed under waterlogged conditions. These soils contain iron sulfide minerals (predominantly as the mineral pyrite) or their oxidation products. In an undisturbed state below the water table, acid sulfate soils are benign. However, if the soils are drained, excavated or exposed to air by a lowering of the water table, the sulfides react with oxygen to form sulfuric acid.
Alignment	The geometric layout (eg of a road) in plan (horizontal) and elevation (vertical).
AIDR	Australian Institute for Disaster Resilience
B	
The Blue Book	The *Managing Urban Stormwater – Soils and Construction* (Landcom, 2004) series of handbooks, also known as the Blue Book, are an element of the NSW Government's urban stormwater program specifically applicable to the construction phase of developments. These provide guidance for managing soils in a manner that protects the health, ecology and amenity of urban streams, rivers estuaries and beaches through better management of stormwater quality.
BoM	Bureau of Meteorology
C	
Catchment	The area drainage by a stream or body of water or the area of land from which water is collected.
CEMP	Construction Environmental Management Plan
CSSI	critical State significant infrastructure
D	
DCP	Development Control Plan
DEM	Digital Elevation Model
DO	Dissolved oxygen
DRAINS	A multi-purpose software program for designing and analysing urban stormwater drainage systems and catchments

Term	Definition
E	
EC	Electrical conductivity
EY	Exceedances per year. Used to define the frequency of occurrence of more frequent rainfall or flood events. For example, a design event (rainfall or flood) that has a chance of occurring once during every 6 month period is expressed as having 2 Exceedances per Year (2EY).
ELVIS	Elevation Information System
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
Embankment	An earthen structure where the road (or other infrastructure) subgrade level is about the natural surface.
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
F	
FRMSP	Floodplain Risk Management Study and Plan
Flood prone land	Land susceptible to flooding by the probable maximum flood. Note that the flood prone land is also known as flood liable land.
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. It is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (ie flood prone land).
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the peak height of the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as 'greenhouse' and climate change. Freeboard is included in the Flood Planning Level.
G	
GDE	Groundwater dependent ecosystems (GDEs) are defined as ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services'.
GIS	Geographic information systems

Term	Definition
Groundwater	Water found in the saturated zone below the water table or piezometric surface
H	
Hydrology	Term given to the study of the rainfall and runoff process, including surface and groundwater interaction; with particular focus on the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
I	
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Infiltration	The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil. The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
J	
K	
km	kilometres
L	
LEP	Local Environmental Plan
LGA	Local government area
LiDAR	Light Detecting and Ranging
LUIIP	Land Use and Infrastructure Implementation Plan
M	
Mannings N	Mannings N is a measure of hydraulic roughness which relates to the amount of frictional resistance water experiences when passing over land and channel features.
m2	square metres
m3	cubic metres
m/s	metres per second
m3/s	cubic metres per second
mg/L	milligrams per litre
N	
N/A	Not applicable
NSW	New South Wales
O	
OEH	Office of Environment and Heritage (NSW Government)
OEMP	Operation Environment Management Plan
OSD	On site detention
OSO	Outer Sydney Orbital

Term	Definition
P	
PMF	Probable maximum flood. The flood that occurs as a result of the probable maximum precipitation on a study catchment. The probable maximum flood is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land (i.e. the floodplain).
PMP	Probable Maximum Precipitation
ppm	parts per million
Peak discharge	The maximum discharge occurring during a flood event.
Peak flood level	The maximum water level occurring during a flood event.
Pollutant	Any measured concentration of solid or liquid matter that is not naturally present in the environment.
Probability	A statistical measure of the expected chance or likelihood of occurrence
Proponent	The person or organisation that proposes to carry out the project or activity. For the purpose of the project, the proponent is Sydney Metro authority.
Q	
R	
Risk	Chance of something happening that will potentially have an undesirable effect. It is measured in terms of consequence and likelihood.
Runoff	The amount of rainfall that ends up as streamflow, also known as rainfall excess.
S	
SEARs	Planning Secretary's Environmental Assessment Requirements
SES	State Emergency Services
SMWSA	Sydney Metro - Western Sydney Airport (the project)
SSI	State significant infrastructure
Spoil	Surplus excavated material.
Staging	Refers to the division of the project into multiple contract packages for construction purposes, and/or the construction or operation of the overall project in discrete phases.
Stockpile	Temporary stored materials such as soil, sand, gravel, spoil/waste.
Stream order	A classification system which assigns an 'order' to waterways according to the number of additional tributaries associated with each waterway, to provide a measure of system complexity.
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape.
T	
TA	Technical Advisor

Term	Definition
TDS	Total dissolved solids
TfNSW	Transport for NSW
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
U	
V	
W	
WM Act	Water Management Act 2000 (NSW)
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent).
X	
Y	
Z	

Executive Summary

Project overview

The *Greater Sydney Region Plan* (Greater Sydney Commission, 2018a) sets the vision and strategy for Greater Sydney to become a global metropolis of three unique and connected cities; the Eastern Harbour City, the Central River City and the Western Parkland City.

Sydney Metro - Western Sydney Airport (the project) is identified in the *Greater Sydney Region Plan* as a key element to delivering an integrated transport system for the Western Parkland City. The project would traverse the Penrith and Liverpool local government areas (LGAs), providing a new metro railway between St Marys in the north and the Aerotropolis in the south, including passing through and providing access to Western Sydney International.

The project is characterised into components located outside Western Sydney International (off-airport) and components located within Western Sydney International (on-airport), to align with different planning approval pathways required under State and Commonwealth legislation.

Key features of the project include:

- around 4.3 kilometres of twin rail tunnels (generally located side by side) between St Marys (the northern extent of the project) and Orchard Hills
- a cut-and-cover tunnel around 350 metres long (including tunnel portal), transitioning to an in-cutting rail alignment south of the M4 Western Motorway at Orchard Hills
- around two kilometres of surface rail alignment within Western Sydney International
- around 3.3 kilometres of twin rail tunnels (including tunnel portal) within Western Sydney International
- around three kilometres of twin rail tunnels between Western Sydney International and the Aerotropolis Core
- six new metro stations, including four new metro stations outside Western Sydney International (off-airport) and two new metro stations within the Western Sydney International site (on-airport).
- grade separation of the track alignment at key locations.
- modifications to the existing Sydney Trains station and rail infrastructure at St Marys.
- a stabling and maintenance facility and operational control centre.
- new active transport links, commuter car parking facilities, public transport infrastructure, road infrastructure and landscaping as part of the station precincts.

This hydrology, flooding and water quality assessment

The Secretary's Environmental Assessment Requirements (SEARs) issued in February 2020 by the NSW Department of Planning, Industry and Environment (DPIE) and Commonwealth requirements issued on 29 January 2020 requires a hydrology, flooding and water quality assessment to support the Environmental Impact Statement being prepared for the project. This technical paper addresses the relevant flooding, hydrology and water quality requirements in the SEARs and will be used to support the assessment of on-airport works under Commonwealth requirements. As required by the SEARs, it provides an assessment of the predicted impacts to the catchment, flood behaviour, waterway conditions and water quality due to the project on the South Creek catchment during the construction and operational stages of the project.

This assessment has considered the full range of potential flood events, from frequent to the probable maximum flood and future climate predictions of changes to rainfall. Cumulative operational changes to the catchment were also assessed to capture the cumulative impacts that may result from the project occurring alongside other projects and projected future land use changes. Appropriate performance outcomes and proposed management and mitigation measures were identified, as required.

Assessment methodology

The project is located within the South Creek catchment. An understanding of baseline flood characteristics along the project alignment has been developed through review of existing catchment flood studies and development of a hydraulic model.

The project specific hydraulic model has also been used to develop an understanding of impacts that the project would have to flood behaviour and to ensure that project components such as cross drainage structures are designed to minimise flood impacts.

Existing literature and monitoring data carried out for the M12 Motorway and Western Sydney International has been compared to the ANZG/ANZECC guidelines to develop an understanding of the existing water quality within the study area. Potential pollutants from the construction and operation of the project have been identified to assess the potential water quality impacts as a result of the project and identify mitigation measure and their likely performance against water quality objectives

Existing conditions

The project footprint crosses approximately 3.6 km of floodplain which includes fast flowing creeks and flat floodplains. Flooding across the project area ranges from a few hours up to 18 hours in duration. High flood hazard areas are generally within the main creek channels. Flood modelling has identified up to 53 buildings potentially subject to inundation during a 1% Annual Exceedance Probability flood event. The existing watercourses intersected by the project corridor have moderate geomorphic fragility due to existing surface water and stormwater features in the catchment. But they have a high chance of maintaining their existing condition if catchment conditions remain the same.

Existing water quality in the water courses is generally poor and below current ANZG/ANZECC guidelines.

Potential construction impacts

The estimated changes to flood behaviour during construction are likely to be minimal due to the project largely being in tunnel. Impacts would be focused around the Cosgroves and Blaxland Creek viaduct crossings and the Stabling and Maintenance facility within the Blaxland and South Creek floodplains.

Changes to watercourses would potentially occur at all discharge points due to the local changes in surface conditions during construction.

The construction of the project has the potential to impact on the water quality of the surrounding environment. Potential impacts from the construction phase are largely associated with soil excavation and disturbance, which may result in increased sediment loads to the receiving waterways as well as potential erosion and release of contamination.

Potential operation impacts

For the operational phase of the project potential impacts would be confined to the viaduct sections which cross the floodplains of Cosgroves and Blaxland Creeks. These impacts are localised with minor changes to peak flood levels with no significant changes to duration of inundation or flood hazard. The project would not impact existing flood emergency response management for the wider Hawkesbury Nepean Valley.

The watercourses intersected by the project would be susceptible to change if the proposed water quantity and quality management measures are not implemented. Localised changes to velocity and peak flood levels would be managed to ensure the existing fragility of the watercourses is not exacerbated.

Potential impacts from the operation phase are predominantly related to increases in impervious surfaces at new stations and maintenance facilities. This would increase runoff volumes and velocities potentially increasing sediment loads and erosion in receiving waterways.

Proposed management and mitigation measures

Management and mitigation measures have been proposed for both construction and operation phases of the project. These should be documented in a project CEMF as well as site-specific ESCP. Ongoing design of the station precincts would incorporate WSUD principles and features, which would aim to protect watercourses and reduce pollutant loads from stormwater from the new stations. The design should be in line with the Penrith and Liverpool Council DCPs as well as relevant TfNSW, Water NSW and agency guidelines.

Application of design standards as well as management measures throughout the life of the construction and operation of the project would minimise impacts to the receiving waterways around the project.

1.0 Introduction

1.1 Project context and overview

The *Greater Sydney Region Plan* (Greater Sydney Commission, 2018a) sets the vision and strategy for Greater Sydney to become a global metropolis of three unique and connected cities; the Eastern Harbour City, the Central River City and the Western Parkland City. The Western Parkland City incorporates the future Western Sydney International (Nancy-Bird Walton) Airport (hereafter referred to as Western Sydney International) and Western Sydney Aerotropolis (hereafter referred to as the Aerotropolis).

Sydney Metro – Western Sydney Airport (the project) (see Figure 1-1) is identified in the *Greater Sydney Region Plan* as a key element to delivering an integrated transport system for the Western Parkland City. The project would be located within the Penrith and Liverpool Local Government Areas (LGAs) and would involve the construction and operation of a new metro railway line around 23 kilometres in length between the existing Sydney Trains suburban rail network at St Marys in the north and the Aerotropolis in the south. This would include a section of the alignment which passes through and provides access to Western Sydney International.

The project is characterised into components that are located outside Western Sydney International (off-airport) and components that are located within Western Sydney International (on-airport), to align with their different planning approval pathways required under State and Commonwealth legislation.

1.2 Key project features

Key operational features of the project are shown on Figure 1-1 and would include:

- around 4.3 kilometres of twin rail tunnels (generally located side by side) between St Marys (the northern extent of the project) and Orchard Hills
- a cut-and-cover tunnel around 350 metres long (including tunnel portal), transitioning to an in-cutting rail alignment south of the M4 Western Motorway at Orchard Hills
- around 10 kilometres of rail alignment between Orchard Hills and Western Sydney International, consisting of a combination of viaduct and surface rail alignment
- around two kilometres of surface rail alignment within Western Sydney International
- around 3.3 kilometres of twin rail tunnels (including tunnel portal) within Western Sydney International
- around three kilometres of twin rail tunnels between Western Sydney International and the Aerotropolis Core
- six new metro stations:
  - four off-airport stations:
    - St Marys (providing interchange with the existing Sydney Trains suburban rail network)
    - Orchard Hills
    - Luddenham Road
    - Aerotropolis Core
  - two on-airport stations:
    - Airport Business Park
    - Airport Terminal
- grade separation of the track alignment at key locations including:
  - where the alignment interfaces with existing infrastructure such as the Great Western Highway, M4 Western Motorway, Lansdowne Road, Patons Lane, the Warragamba to

Prospect Water Supply Pipelines, Luddenham Road, the future M12 Motorway, Elizabeth Drive, Derwent Road and Badgerys Creek Road

  - crossings of Blaxland Creek, Cosgroves Creek, Badgerys Creek and other small waterways to provide flood immunity for the project

- modifications to the existing Sydney Trains station and rail infrastructure at St Marys (where required) to support interchange and customer transfer between the new metro station and the existing Sydney Trains suburban rail network
- a stabling and maintenance facility and operational control centre located to the south of Blaxland Creek and east of the project alignment and to the north of Patons Lane
- new pedestrian, cycle, park-and-ride and kiss-and-ride facilities, public transport interchange infrastructure, road infrastructure and landscaping as part of the station precincts.

The project would also include:

- turnback track arrangements (turnbacks) at St Marys and Aerotropolis Core to allow trains to turn back and run in the opposite direction
- additional track stubs to the east of St Marys Station and south of Aerotropolis Core Station to allow for potential future extension of the line to the north and south respectively without impacting future metro operations
- an integrated tunnel ventilation system including services facilities at Claremont Meadows and at Bringelly
- all operational systems and infrastructure such as crossovers, rail sidings, signalling, communications, overhead wiring, power supply, lighting, fencing, security and access tracks/paths
- retaining walls at required locations along the alignment
- environmental protection measures such as noise barriers (if required), on-site water detention, water quality treatment basins and other drainage works.

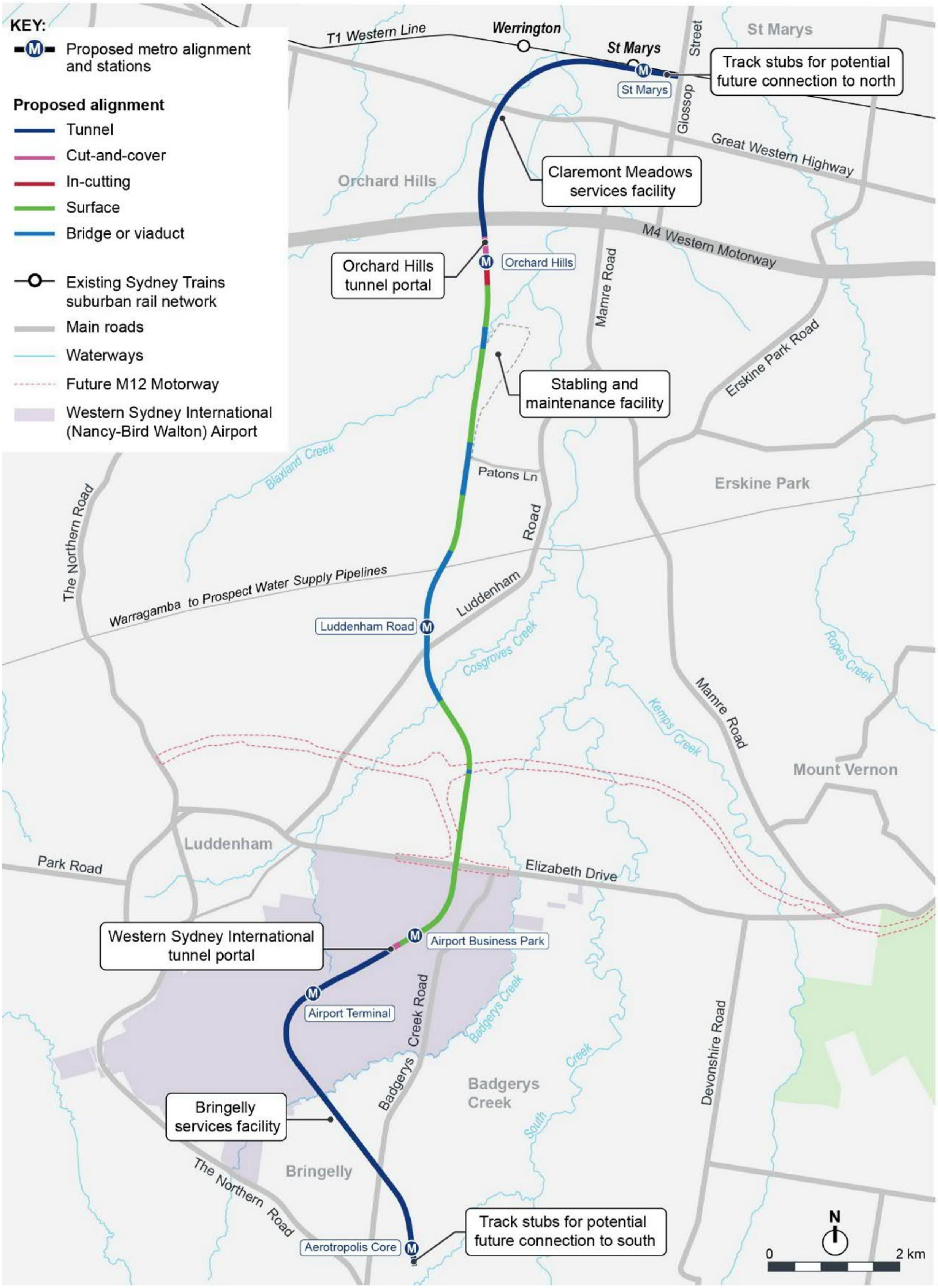
Off-airport project components

The off-airport components of the project would include the track alignment and associated operational systems and infrastructure north and south of Western Sydney International, four metro stations, the stabling and maintenance facility, two service facilities and a tunnel portal.

On-airport project components

The on-airport components of the project would include the track alignment and associated operational systems and infrastructure within Western Sydney International, two metro stations and a tunnel portal.

The key project features and the design development process are described in more detail in Chapter 7 (project description – operation) of the Environmental Impact Statement.



Note: Indicative design only, subject to design development

Figure 1-1 Project alignment and key features

1.3 Project need

Various State, regional and local policies and plans identify the need for an integrated transport solution that can respond to the needs of a growing Western Parkland City and that can support this growth in a sustainable manner to enhance the liveability and productivity of the area.

The project would be a key component in delivering an integrated transport system for the Western Parkland City. The new metro railway would become the city’s transport spine, linking residential areas with the Aerotropolis, other job hubs and the nationally significant Western Sydney International.

The project is needed to:

- service a growing population in the Western Parkland City.
- provide rail access to the Aerotropolis and Western Sydney International.
- deliver an efficient connection to the existing Sydney Trains suburban rail network (to provide a link to the Central River and Eastern Harbour cities).
- unlock access to jobs and increase potential for jobs growth in the Western Economic Corridor (including the Aerotropolis and Western Sydney International) and in the Penrith to Eastern Creek Growth Investigation Area.
- support and shape the sustainable growth of the Western Parkland City by optimising land use around station precincts.
- create opportunities for precinct planning that would improve liveability in and around station precincts.
- support access to urban renewal and new land release areas including the Penrith to Eastern Creek Growth Investigation Area and the Aerotropolis Land Use and Infrastructure Implementation Plan precincts.

1.4 Project construction

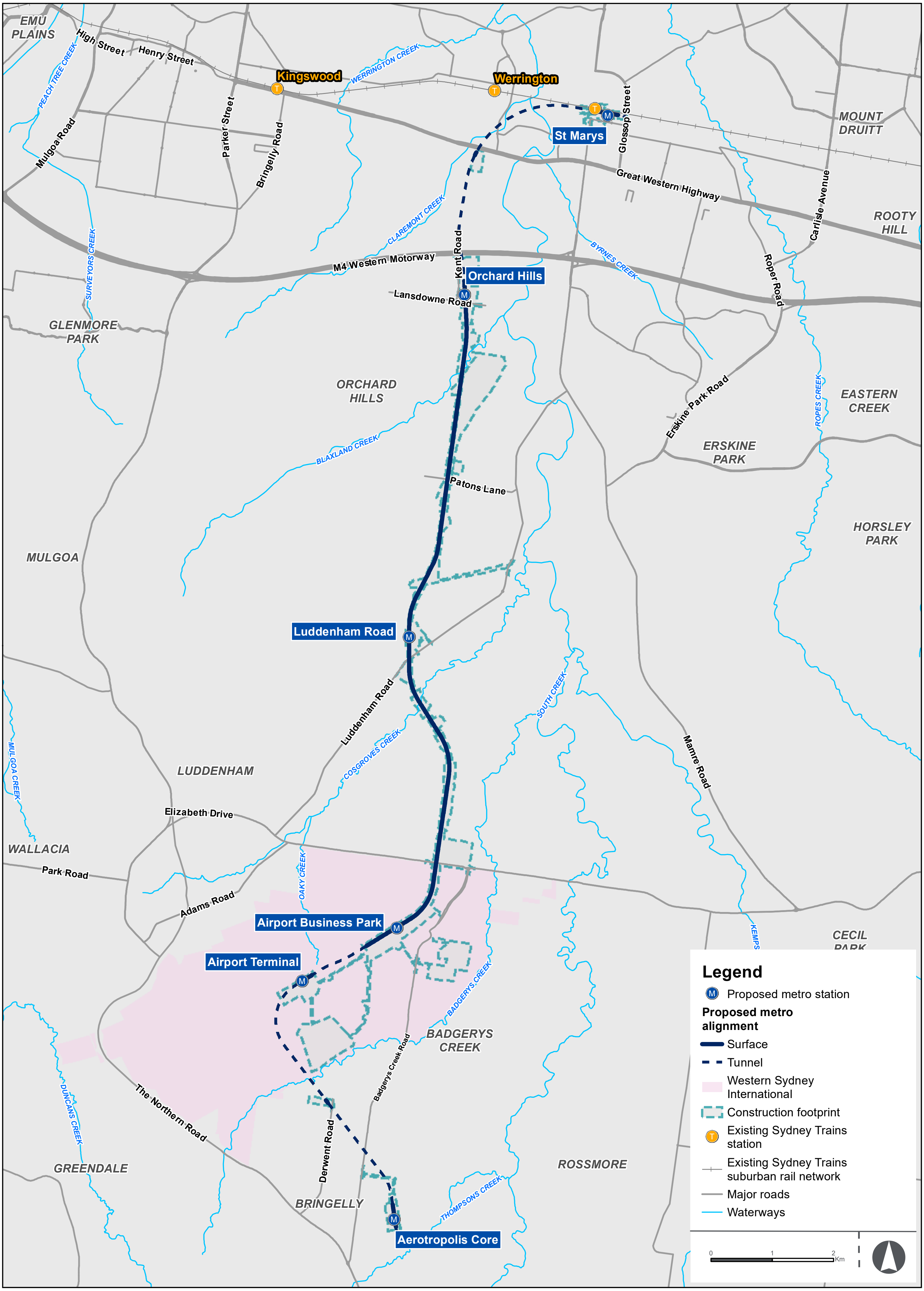
Construction of the project would involve:

- enabling works
- main construction works, including:
  - tunnelling and associated works
  - corridor and associated works
  - stations and associated works
  - ancillary facilities and associated works
  - construction of ancillary infrastructure including the stabling and maintenance facility
- rail systems fitout
- finishing works and testing and commissioning.

These activities are described in more detail in Chapter 8 (Project description – construction) of the Environmental Impact Statement.

The construction footprint for the project is shown on Figure 1-2.

Construction of the project is expected to commence in 2021, subject to planning approval, and take around five years to complete. An overview of the construction program is provided in Chapter 8 (Project description – construction) of the Environmental Impact Statement.



Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Construction footprint overview

Figure 1-2

1.5 Purpose of this Technical Paper

This technical paper, Technical Paper 6, is one of a number of technical documents that forms part of the Environmental Impact Statement. The purpose of this technical paper is to assess the potential hydrology, flooding and water quality surface water impacts and aims to address the requirements outlined in Section 1.5.1 and 1.5.2. Section 1.5.3 then provides an overview of the structure of this technical paper. Table 1.1 shows the relevant SEARs addressed in this assessment.

1.5.1 Assessment requirements

The Secretary's environmental assessment requirements (SEARs) relating to flooding, hydrology and water quality, and where these requirements are addressed in this technical paper, are outlined in Table 1.1.

Table 1.1 SEARS relevant to this assessment

SEARs requirements	Where addressed in this document
10. Flooding	
1. Flood behaviour during construction and operation for a range of modelled flood events up to the probable maximum flood (taking into account climate change) including:	Section 3.1
a. Any detrimental increases in the potential flood affectation of other properties, assets and infrastructure;	Section 5.1.1, 5.2.1, 6.1.1 and 6.2.1
b. Consistency (or inconsistency) with applicable Council floodplain risk management plans;	Section 6.1.1 and 6.2.1
c. compatibility with the flood hazard of the land;	Sections 4.1.4, 4.1.9, 4.2.2, 6.1.1 and 6.2.1
d. Compatibility with the hydraulic functions of flow conveyance in floodways and storage areas of the land;	Section 6.1.1 and Section 6.2.1
e. Downstream velocity and scour potential;	Section 4.1.10
f. impacts the development may have upon existing community emergency management arrangements for flooding;	Section 6.1.1 and 6.2.1
g. Any impacts the development many have on the social and economic costs to the community as consequence of flooding.	Section 6.1.1 and 6.2.1
11. Water - Hydrology	
1. Surface and groundwater resources (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Section, 4.1.10, 4.1.12, 4.1.13, 4.2.4 EIS Chapter 21 (Groundwater and geology) and *Technical Paper 7 (Groundwater)*
2. Surface and groundwater hydrology in accordance with the current guidelines, including:	Chapter 5.0 and 6.0 *Technical Paper 7 (Groundwater)*
a. Natural processes within rivers, wetlands, estuaries, and floodplains that affect the health of the fluvial, riparian, estuarine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Section 6.1.2, 6.2.2 and *Technical Paper 7 (Groundwater)*
b. Changes to environmental water availability and flows, both regulated/licenced and unregulated/rules-based sources;	Section 6.1.1 and *Technical Paper 7 (Groundwater)*

SEARs requirements	**Where addressed in this document**
c. Direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or waterways;	Section 6.1.2 and 6.2.2
d. Minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flows rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Chapter 8.0
e. Water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	*Technical Paper 7 (Groundwater)*
12. Water - Quality	
1. Water quality, including:	
a. identifying the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associates trigger values or criteria for the identified environmental values;	Section 3.4.1
b. 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 non-trivial harm to human health and the environment;	Section 5.1.2, 5.2, 5.2.2, 6.1.2 and 6.2.2 Note: quantity of pollutants has not been estimated due to the preliminary nature of proposed water quality management.
c. Identify the rainfall event that the water quality protection measures will be designed to cope with;	Section 8.2
d. Assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	Chapter 5.0, 6.0 and 7.0
e. Demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that: - where the NSW WQO for receiving waters are currently being met they will continue to be protected; and - where the NSQ WQOs are not being met, activities will work toward their achievement over time;	Chapter 8.0
f. Justify, if required, why the WQOs cannot be maintained or achieved over time;	Chapter 5.0 and 6.0
g. Demonstrate that all practical measures to avoid or minimise water pollution and protection human health and the environment from harm are investigated and implemented;	Section 6.1.2 and 6.2.2
h. Identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid to or minimise impacts on these environments; and	Section 4.1.4, 4.1.7, 4.1.2 and 8.0
i. Identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Section 8.3

SEARs requirements	Where addressed in this document
14. Sustainability and Climate Change Risk	
1. The risk and vulnerability of the project to **climate change** in accordance with the current guidelines.	Section 3.1.1

1.5.2 Commonwealth agency assessment requirements

The Minister for the Environment has advised that the on-airport aspects of the project would be assessed based on the provision of preliminary documentation. Further information was requested to guide the assessment of the on-airport components of the project. This information is included in Appendix J of the Environmental Impact Statement.

1.5.3 Structure of this report

This report uses the following structure:

- Chapter 1 Introduction – an introduction to the report.
- Chapter 2 Legislative and policy context – describes the legislative and policy context for the assessment, and relevant guidelines.
- Chapter 3 Methodology – describes the methods and assessment criteria adopted in this report to characterise and assess potential impacts on hydrology, flooding and surface water quality.
- Chapter 4 Existing environment – describes the existing surface water environment including catchment characteristics, groundwater, climate, water quality conditions and sensitive receptors.
- Chapter 5 Assessment of construction impacts – provides an assessment of the impacts of construction activities on flooding, watercourses and water quality.
- Chapter 6 Assessment of operation impacts - provides an assessment of the impacts of the project operation and operation activities and facilities on flooding, watercourses and water quality.
- Chapter 7 Potential cumulative impacts - provides an assessment of potential cumulative impacts to flooding, watercourses and water quality associated with other major projects in the study area.
- Chapter 8 Proposed Management and Mitigation measures – details existing management plans, performance outcomes to inform the next stages of design and mitigation measures to minimise the impact of the project.
- Chapter 9 Conclusion – overview of the key findings of the report.

1.6 Study area

The project is located within the Penrith and Liverpool Local Government Areas (LGAs), between the existing Sydney Trains suburban rail network in the north and the Western Sydney Aerotropolis (Aerotropolis) in the south.

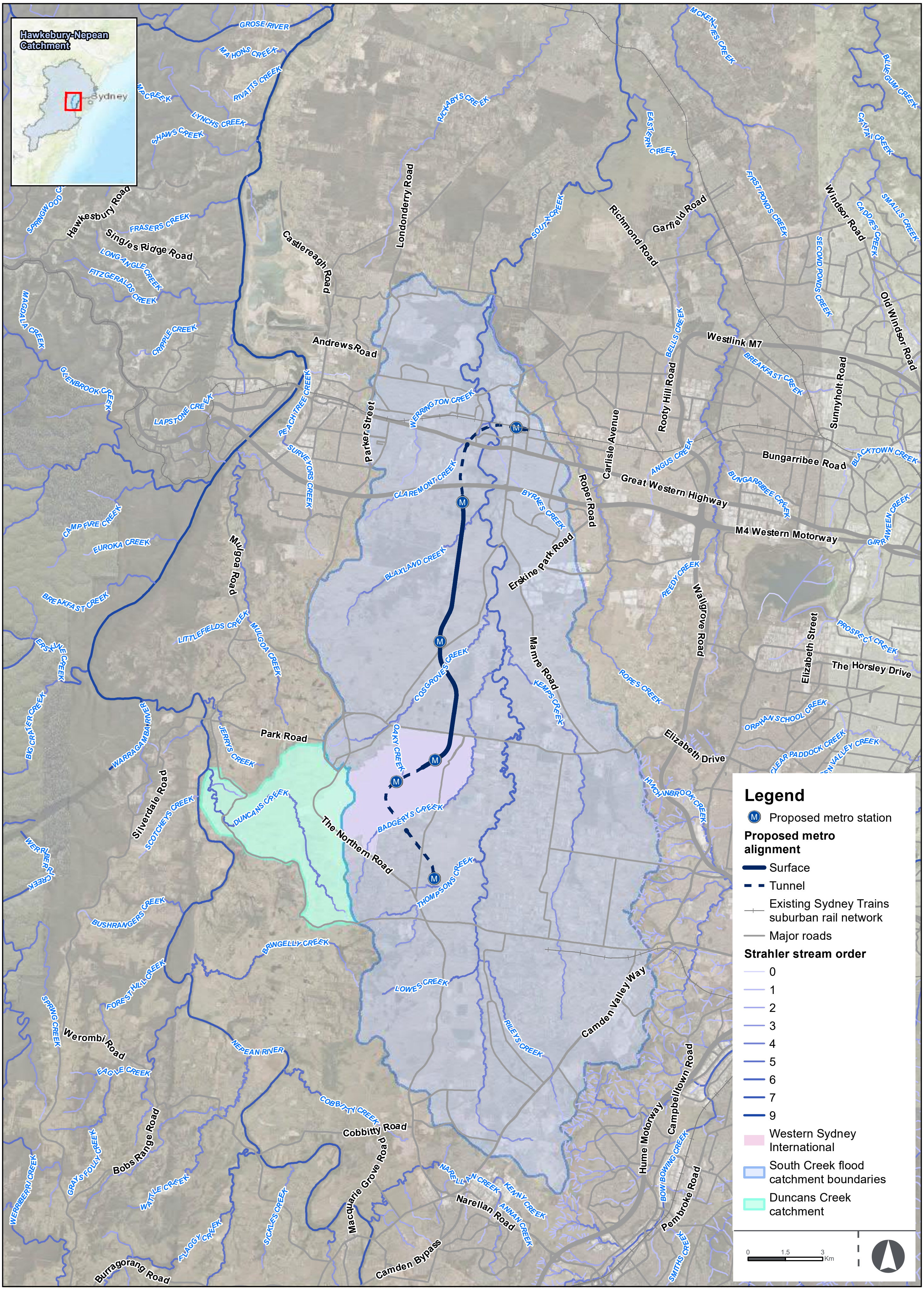
The project is characterised into components that are located outside Western Sydney International (off-airport) and components that are located within Western Sydney International (on-airport), to align with their different planning approval pathways required under Commonwealth and State legislation.

For the purposes of the hydrology, flooding and water quality assessment the study area extends beyond the project footprint to take all potential impacts into account.

Most of the study area is located in the South Creek catchment. The Duncans Creek catchment area is included for the on-airport study area. The study area is the same for both the flooding and water quality assessments and is shown on Figure 1-3.

South Creek is a major tributary of the Hawkesbury-Nepean Catchment. It flows in a generally northerly direction from its headwaters near Narellan through to Windsor where it joins the Hawkesbury River. The project alignment crosses a number of tributaries of South Creek including Badgerys Creek, Cosgroves Creek, Blaxland Creeks and lies within the catchments of Byrnes Creek, Moore Gully and Thompsons Creek as well as a number of unnamed tributaries (water course classifications (stream orders) are identified in Table 4.5). The study area considered within this report is inclusive of each waterway that the project intersects as well as their broader catchment areas between Christie Street, Werrington and Bringelly Road, Bringelly.

Duncans Creek is a tributary of the Nepean River and flows west then north away from Western Sydney International to join the Nepean River.



Sydney Metro – Western Sydney Airport

Study area

Figure 1-3

Indicative only, subject to design development

2.0 Legislative and policy context

The relevant legislation, policies and guidelines for hydrology, flooding and water quality matters that have been considered during the preparation of this report are outlined in the following sections. Additional supporting information is provided in Appendix A.

2.1 Off-airport legislation and policy context

2.1.1 Commonwealth policy

National Water Quality Management Strategy (ANZECC/ARMCANZ 2018)

The *National Water Quality Management Strategy* (NWQMS) establishes objectives to achieve sustainable use of water resources and provides guideline documents to assist water quality managers in achieving quality and supply of water that is fit for purpose. Values, targets and actions in these guidelines are not mandatory, but support a nationally-agreed framework for water quality planning and management.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) is a key guideline within the NWQMS that is used to identify catchment and waterway specific water quality management goals. These guidelines are an updated version of the previous guidelines referred to as the ANZECC 2000 guidelines.

The ANZG 2018 guidelines provide a process for assessing existing water quality condition and developing water quality objectives to sustain current or likely future environmental values for water resources. Guideline trigger values for water quality indicators are provided for different environmental values as generic starting points for assessing water quality where site specific information is not available. The guideline trigger values are used to evaluate the existing water quality conditions against long term water quality goals. It should be noted that the trigger values have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality.

These guideline trigger values are provided for various levels of protection of waterways which are considered when describing the existing water quality and key indicators of concern. The level of protection applied in this assessment when assessing ambient water quality is for slightly disturbed to moderately disturbed ecosystems. The ANZG guidelines provide updated databases to derive guideline values for toxicants and sediments in aquaculture and aquatic foods, physical and chemical stressors and for guideline values for agricultural water users. These databases and values have not been updated for all regions of Australia and in some regions, the values as used in the previous ANZECC 2000 guidelines still apply.

The project environmental values, based on ANZG 2018 guideline trigger values for the selected toxicants, would be for the protection of 95 percent of species in slightly disturbed to moderately disturbed freshwater systems. For physical and chemical stressors, the ANZG 2018 guidelines are the same as the ANZECC 2000 and provide guideline trigger values for slightly disturbed ecosystems in lowland rivers in south-east Australia as shown in Table 2.1.

Table 2.1 ANZG 2018 guideline water quality trigger values for physical and chemical stressors for slightly disturbed ecosystems in lowland rivers in south-east NSW

Parameter	Trigger value or criteria
Chlorophyll-a (mg/L)	0.005
Total Phosphorous (TP) (mg/L)	0.05
Filterable Reactive Phosphorus (FRP) (mg/L)	0.02
Total Nitrogen (TN) (mg/L)	0.5
Oxides of nitrogen (NO_x) (mg/L)	0.04
Ammonia (NH_4) (mg/L)	0.02
Dissolved Oxygen (DO)	85% - 110%
Turbidity (NTU)	6 to 50
pH	6.5-8
Salinity (µS/cm)	125 – 2200
Oils, petroleum and hydrocarbons	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour.

2.1.2 State legislation and policy

Water Management Act 2000 (WM Act)

The *Water Management Act 2000* (WM Act) recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with access to water. The main tool that the WM Act provides for managing the NSW water resources are water sharing plans. The WM Act focuses on protecting, enhancing and restoring water resources and encouraging best practice management and use of water.

A controlled activity approval under the WM Act is required for certain types of developments and activities that are carried out in or near waterfront land and that have the potential to affect water quality. However, under section 5.23 of the *Environmental Planning and Assessment Act 1979*, an activity approval (including a controlled activity approval) under section 91 of the WM Act is not required for State significant infrastructure. The design and construction of the project would take into account the former NSW Office of Water's guidelines for controlled activities on waterfront land to enable the mitigation of potential impacts to water quality.

A water use approval under section 89, a water management work approval under section 90, or an activity approval (other than an aquifer interference approval – refer to Technical Paper 7 (Groundwater) under section 91 of the WM Act may be required.

The Warragamba to Prospect Water Supply Pipelines infrastructure and corridors are classified as 'Controlled Areas' under the Act and WaterNSW are responsible for reviewing proposed developments and activities adjacent to or within the Controlled Areas.

Protection of the Environment Operations Act 1997

Section 120 of the *Protection of the Environment Operations Act 1997* (POEO Act) prohibits the pollution of waters by any person. Under section 122, holding an environment protection licence is a defence against accidental pollution of watercourses.

NSW Water Quality and River Flow Objectives

For each catchment in NSW, the NSW Government has endorsed the community's environmental values for water and identified water quality objectives. These are known as NSW Water Quality and River Flow Objectives (DECCW, 2006) and were adopted following extensive consultation with the community in 1998. The NSW Water Quality and River Flow Objectives are the agreed environmental values and long-term goals for NSW's surface waters and are consistent with the national framework in the ANZECC 2000 guidelines. They set out:

- the community's values and uses for NSW rivers, creeks, estuaries and lakes (i.e. healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water)
- a range of water quality indicators to help assess whether the current condition of waterways supports those values and uses.

Water quality objectives consist of three parts: environmental values, water quality indicators and associated guideline trigger values or criteria. At the time the NSW Water Quality and River Flow Objectives were approved by the government, the NSW Healthy Rivers Commission (HRC) was reviewing a number of catchments including the Hawkesbury-Nepean. As such the NSW Water Quality and River Flow Objectives do not provide environmental values for the Hawkesbury-Nepean catchment. Water quality objectives are instead recommended for this catchment in the *Independent Inquiry into the Hawkesbury Nepean River System* (HRC, 1998) and the associated *Lower Hawkesbury-Nepean nutrient management strategy* (HRC, 1998).

NSW Healthy Rivers Commission

In the late 1990s the NSW HRC carried out an inquiry into the Hawkesbury-Nepean catchment system. The result of this was a set of water quality objectives which would form the strategic framework for water quality improvement in the Hawkesbury-Nepean. The HRC was discontinued in 2004 and the Natural Resources Commission was established in its place. The Natural Resources Commission is tasked with considering outstanding HRC recommendations into Catchment Action Plans and government programs.

The HRC established the environmental values for the Hawkesbury-Nepean. The environmental values that have been identified as applying to all the lower Hawkesbury-Nepean catchment waterways are:

- protection of aquatic ecosystems.
- secondary contact recreation.
- visual amenity.
- water for irrigation and general use.
- livestock drinking.
- primary contact recreation.

While the HRC established the environmental values for the Hawkesbury-Nepean, the ANZECC guidelines provide the associated guideline water quality indicators and trigger values to protect the identified environmental values. Table 2.2 shows the ANZECC water quality trigger values for the project environmental values.

Table 2.2 Environmental values for the study area and associated water quality indicators, trigger values and criteria

Water quality objective	Indicator	Trigger value or criteria
Aquatic ecosystems		
Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	Total phosphorus	20 µg/L
	Total nitrogen	250 µg/L
	Chlorophyll-a	not applicable
	Turbidity	2–25 NTU
	Salinity (electrical conductivity)	30–350 µS/cm
	Dissolved oxygen	90–110%
	pH	6.5–7.5

Water quality objective	Indicator	Trigger value or criteria
Visual amenity		
Aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of the water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter.
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus.
Secondary contact recreation		
Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed	Faecal coliforms	Median bacterial content in fresh and marine waters of < 1000 faecal coliforms per 100 mL, with 4 out of 5 samples < 4000/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).
	Enterococci	Median bacterial content in fresh and marine waters of < 230 enterococci per 100 mL (maximum number in any one sample: 450-700 organisms/100 mL).
	Algae & blue-green algae	< 15 000 cells/mL
	Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed values in Tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines.
	Visual clarity and colour	Use visual amenity guidelines.
	Surface films	Use visual amenity guidelines.
Primary contact recreation		
Maintaining or improving water quality for activities such as swimming in which	Turbidity	A 200 mm diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 m (approximately 6 NTU).

Water quality objective	Indicator	Trigger value or criteria
there is a high probability of water being swallowed	Faecal coliforms	Beachwatch considers waters are unsuitable for swimming if: the median faecal coliform density exceeds 150 colony forming units per 100 millilitres (cfu/100 mL) for five samples taken at regular intervals not exceeding one month, or the second highest sample contains equal to or greater than 600 cfu/100 mL (faecal coliforms) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).
	Enterococci	Beachwatch considers waters are unsuitable for swimming if: the median enterococci density exceeds 35 cfu/100 mL for five samples taken at regular intervals not exceeding one month, or the second highest sample contains equal to or greater than 100 cfu/100 mL (enterococci) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60-100 organisms/100 mL).
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water. (Note, it is not necessary to analyse water for these pathogens unless temperature is greater than 24 degrees Celsius).
	Algae & blue-green algae	< 15 000 cells/mL
	Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
	pH	5.0-9.0 (see supporting information)
	Temperature	15°-35°C for prolonged exposure.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or

Water quality objective	Indicator	Trigger value or criteria
		mucus membranes are unsuitable for recreation. Toxic substances should not exceed the concentrations provided in tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines 2000.
	Visual clarity and colour	Use visual amenity guidelines
	Surface films	Use visual amenity guidelines
Livestock water supply		
Protecting water quality to maximise the production of healthy livestock	Algae & blue-green algae	An increasing risk to livestock health is likely when cell counts of microcystins exceed 11 500 cells/mL and/or concentrations of microcystins exceed 2.3 µg/L expressed as microcystin-LR toxicity equivalents.
	Salinity (electrical conductivity)	Recommended concentrations of total dissolved solids in drinking water for livestock are given in Table 4.3.1 (ANZECC 2000 Guidelines).
	Thermotolerant coliforms (faecal coliforms)	Drinking water for livestock should contain less than 100 thermotolerant coliforms per 100 mL (median value).
	Chemical contaminants	Refer to Table 4.3.2 (ANZECC 2000 Guidelines) for heavy metals and metalloids in livestock drinking water. Refer to Australian Drinking Water Guidelines (NHMRC and NRMMC 2004) for information regarding pesticides and other organic contaminants, using criteria for raw drinking water.
Irrigation water supply		
Protecting the quality of waters applied to crops and pasture	Algae & blue-green algae	Should not be visible. No more than low algal levels are desired to protect irrigation equipment.
	Salinity (electrical conductivity)	To assess the salinity and sodicity of water for irrigation use, a number of interactive factors must be considered including irrigation water quality, soil properties, plant salt tolerance, climate, landscape and water and soil management. For more information, refer to Chapter 4.2.4 of ANZECC 2000 Guidelines.
	Thermotolerant coliforms (faecal coliforms)	Trigger values for thermotolerant coliforms in irrigation water used for food and non-food crops are provided in Table 4.2.2 of the ANZECC Guidelines
	Heavy metals and metalloids	Long term trigger values (LTV) and short-term trigger values (STV) for

Water quality objective	Indicator	Trigger value or criteria
		heavy metals and metalloids in irrigation water are presented in Table 4.2.10 of the ANZECC 2000 Guidelines.
Homestead water supply		
Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	Blue-green algae	Recommend twice weekly inspections during danger period for storages with history of algal blooms. No guideline values are set for cyanobacteria in drinking water. In water storages, counts of < 1000 algal cells/mL are of no concern. >500 algal cells/mL - increase monitoring. >2000 algal cells/mL - immediate action indicated; seek expert advice. >6500 algal cells/mL - seek advice from health authority.
	Turbidity	5 NTU; <1 NTU desirable for effective disinfection; >1 NTU may shield some micro-organisms from disinfection. (see supporting information).
	Total dissolved solids	< 500 mg/L is regarded as good quality drinking water based on taste. 500-1000 mg/L is acceptable based on taste. >1000 mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste.
	Faecal coliforms	0 faecal coliforms per 100 mL (0/100 mL). If micro-organisms are detected in water, advice should be sought from the relevant health authority. See also the Guidelines for Microbiological Quality in relation to Monitoring, Monitoring Frequency and Assessing Performance in the Australian Drinking Water Guidelines (NHMRC & ARMCANZ 2004).
	pH	6.5-8.5 (see supporting information in NSW Water Quality Objectives)
	Chemical contaminants	See Guidelines for Inorganic Chemicals in the Australian Drinking Water Guidelines (NHMRC & NRMMC 2004).

2.2 On-airport legislative and policy context

2.2.1 Airports Act 1996

The *Airports Act 1996* (Cth) regulates certain Commonwealth owned airports, including the development of airport sites to the exclusion of state planning laws. The Airports Act contains a planning framework under which each airport is required to prepare a master plan for approval by the Commonwealth Infrastructure Minister. In addition, for major airport developments, a major development plan is required to be prepared and approved. For Western Sydney International, a transitional planning instrument called an Airport Plan has been developed to guide development on the site until a masterplan is put in place (Part 2) and also to authorise the first stage of airport development subject to conditions (Part 3).

The Airport Plan was determined by the Commonwealth Infrastructure Minister in December 2016 following preparation and finalisation of an Environmental Impact Statement, and incorporates the conditions specified by the Commonwealth Environment Minister. Those conditions include the requirement for preparation and approval of a Construction Plan and a number of Construction Environment Management Plans (CEMP), including a Soil and Water Management Plan, prior to commencement of main construction works. Initial versions of those plans were prepared and approved and main construction work on the airport commenced in September 2018. The plans have subsequently been varied and the current versions are available on the WSA website.

It is intended that the development of the project on the airport site would be authorised by the Commonwealth Infrastructure Minister varying the Airport Plan to include the rail development and any required conditions for the rail development taking account of any advice from the Commonwealth Environment Minister. If the existing conditions in the Airport Plan for the Stage 1 airport development require variation to accommodate the rail development, agreement from the Commonwealth Environment Minister would also be required. Separate approval of the on-airport rail development under Part 9 of the EPBC Act would not be required.

2.2.2 Airports (Environment Protection) Regulations 1997

The Airports (Environment Protection) Regulations (AEPR) 1997 provide regulation and accountability for activities at airports that generate or have a potential to generate pollution.

Schedule 2 lists accepted limits for water pollution which apply to on-airport lands to the exclusion of State laws. It is noted that these limits are more stringent than ANZG/ANZECC guidelines. The AEPR water quality pollutant limits are shown in Table 2.3.

It is noted that Part 5 of the AEPR allows for the development of local water quality standards. Local standards may be proposed by an airport lessee company and approved by the Commonwealth Infrastructure Minister following a period of consultation with relevant authorities, stakeholders and the broader public. Clause 5.02 (1) states that a substitute standard (local standard) may be proposed where it is considered that the limit of contamination specified in the AEPR is inappropriate. It is noted that no local standards have been proposed for the on-airport component of the project.

Table 2.3 Water quality limits for AEPR

Parameter	AEPR
pH	6.5-9.0
Salinity	>1000 mg/L or an increase of >5%.
Chlorophyll-a (mg/m3)	2
Total Phosphorous (TP) (mg/L)	<0.01
Faecal coliforms	The median faecal coliform count of test samples of the waters exceeds 150 faecal coliform organisms/100 ml
Total Nitrogen (TN) (mg/L)	<0.1
Dissolved Oxygen (DO) %	<6 mg/L OR 80% of average saturation level for normal 24hr period

Parameter	AEPR
Total Suspended solids (TSS) (mg/L)	Change of not more than 10% from the seasonal means TSS
Turbidity NTU	A reduction of 10% clarity in the euphotic zone from the seasonal mean
pH	6.5-9.0
Salinity	>1000 mg/L or an increase of >5%
Arsenic (µg/L)	50
Cadmium (µg/L)	0.2
Chromium (µg/L)	10
Copper (µg/L)	2
Lead (µg/L)	1
Nickel (µg/L)	15
Zinc (µg/L)	5
Mercury (µg/L) (except as provided in item methylmercury)	0.1
Mercury, occurring as methylmercury (µg/L)	0.012
Benzene	300
TPH C6-C9 fraction	150
TPH > C9 fraction	600

2.3 Guidelines

The following table summarises guidelines relevant to the design, assessment and management of hydrology, flooding and water quality for the project.

Table 2.4 Summary of relevant Guidelines

Authority	Name	Description
Commonwealth, Australian Institute for Disaster Resilience	Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, Handbook 7, 2017	This guide prepared by the Australian Institute for Disaster Resilience (AIDR) has been developed to provide guidance on the national principles supporting disaster reliance in Australian through the management and publication of this Handbook and others for other types of hazards. This Handbook is supported by six additional guidelines that cover specific aspects of flood risk management and a practice note to assist with land use planning. This Handbook has been considered when developing criteria for managing flood risk from the project and compliments the NSW Floodplain Development Manual (DIPNR 2005) by outlining current best practices for flood risk management.

Authority	Name	Description
NSW, Department of Natural Resources	NSW Government's Floodplain Development Manual, 2005	This is the NSW Government's Manual relating to the management of flood liable land in accordance with Section 733 of the *Local Government Act 1993*. The manual supports the NSW Government's Flood Prone Land Policy in providing for the development of sustainable strategies for managing human occupation and use of the floodplain. The manual applies to floodplains across NSW, in both urban and rural areas. It is also used to manage major drainage issues in local overland flooding areas.
NSW, Office of Environment and Heritage	Floodplain Risk Management Guide Incorporating 2016 ARR in studies, 2018	This guide provides advice on incorporating changes with recent updates to Australian Rainfall and Runoff (ARR) to flood risk management in NSW.
NSW, Department of Primary Industries	Guidelines for controlled activities on waterfront land, 2012	Provide guidance on development and activities on waterfront land.
NSW, Office of Environment and Heritage	Guidelines for developments adjoining land and water, 2013	Managed by the Department of Environment, Climate Change and Water it provides guidance on development and activities on waterfront land.
NSW State Emergency Service	Hawkesbury-Nepean Flood Plan, September 2015	The Hawkesbury-Nepean Flood Plan is a sub plan of the State Emergency Management Plan (EMPLAN) and covers the prevention and preparedness measures, the conduct of flood operations and the transition to recovery for floods in the Hawkesbury-Nepean Valley. This Plan is supported by the Penrith City Local Floodplain. This Plan has been considered because of the potential impact a flood emergency in the Hawkesbury-Nepean valley may have on operations of the project.
Water NSW	Guidelines for Development Adjacent to the Upper Canal and Warragamba Pipelines	These guidelines have been prepared for use by planning and consent authorities and proponents for development activities on land adjacent to or within the Upper Canal and Warragamba Pipelines corridors. The guidelines offer a range of solutions or options that are based on risk management principle.
Penrith City Council	Penrith Development Control Plan 2014	The purpose of the Penrith Development Control Plan 2014 (DCP) is to guide development within the Penrith LGA. Section C3 outlines development guidelines with respect to all aspects of the water cycle including, natural waterways, riparian corridors, wetlands and groundwater dependent ecosystems

3.0 Methodology

The methodology adopted to assess the impact of the project is outlined below with further details provided in Appendix B. This approach has been developed in line with relevant legislation and guidelines and with reference to the SEARs.

3.1 Flooding

The following methodology has been used to develop an understanding of existing flood behaviour in the study area and to assess potential construction phase flood impacts, operational phase flood impacts and potential cumulative flood impacts. Key steps in the flooding assessment methodology are shown in Figure 3-1.

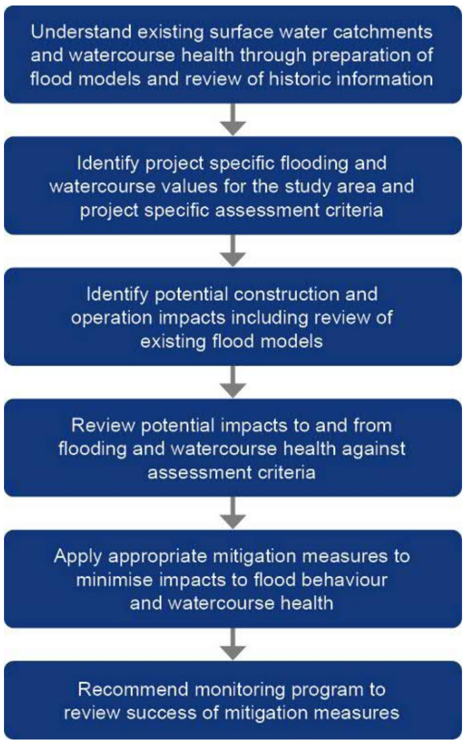


Figure 3-1 Flood assessment methodology

The flood assessment was undertaken based on the key tasks shown in Table 3.1.

Table 3.1 Flood assessment methodology

Key tasks in flood assessment methodology
Desktop review
Source and review historic information on flooding through research and liaison with Penrith and Liverpool City Councils. This identified previous studies covering flood assessments in the same study area. The studies identified aimed to define design flood behaviour and provide sustainable flood management strategies to support social and economic development within the catchment. Historic information also informed existing waterway health and flood risks across the study area. A summary of the principal findings and relevance to the project from the key reports is provided in Section 4.1.9.
Hydrologic modelling
Hydrologic modelling converts the design rainfall information into flow hydrographs that are utilised by the hydraulic model to understand flood heights, depths and velocities for a range of design storms.

Key tasks in flood assessment methodology
The hydrologic assessment used for the off-airport areas of the project was based on updating the historic hydrologic model developed (using XP-RAFTS) for the Updated South Creek Flood Study (WP, 2015). The available on-airport hydrology for the Western Sydney International (established through the development of a DRAINS model) was used to inform the hydrologic behaviour of the on-airport areas and connections to the off-airport hydrologic catchment. Based on guidance within Australian Rainfall and Runoff 2019 (referred to as ARR2019) (Ball et al 2019), the ensemble method was applied for both on-airport and off-airport hydrologic modelling, and median peak flows were extracted to apply within the hydraulic model.
Hydraulic modelling
Hydraulic modelling uses the flow hydrographs and the catchment and watercourse topography to predict flood behaviour including flood levels, flood extents, flood velocities and the duration of inundation in the catchment and watercourse. A TUFLOW one dimensional/two dimensional hydraulic model has been developed for the project to convert runoff rates into flow depths and velocities for both the base case (no project) and project design scenarios. The model has been prepared to assess the full range of probably flood events. This includes the 0.5 exceedances per year (EY) event (meaning an event which has a chance of occurring on average once every 2 years), the 0.2 EY (i.e. a chance of occurring once every 5 years), 5% Annual Exceedance Probability (AEP - indicating there is a 5% chance that this event could be exceeded in any one year), 1% AEP, 1% AEP including climate change and Probable maximum flood (PMF). Key features and assumptions used in development of the TUFLOW model are detailed in Appendix B. Calibration and validation A key phase of building a suitable hydraulic model for the project is the process of model calibration and validation. This is required to ensure the adopted model adequately predicts flood behaviour. Calibration involves utilising historic flood event data (referred to as observed data) to change model inputs to get the model to replicate the historic flood event. Validation then involves checking the model inputs against another historic event. Where historic data are available this is the recommended method for checking that the model inputs are suitable. The hydraulic model has been calibrated at two locations that correspond to existing NSW Water stream gauges, South Creek at Elizabeth Drive and South Creek at the Great Western Highway. Three historical flood events have been chosen to calibrate and validate the flood model. Details of these and the calibration achieved are provided in Appendix B. A comparison of modelled design flood extents was also made to the flood extents from Penrith City Council's adopted flood study (WP, 2015). Both models predict similar flood extents for the three design flood events presented (5%AEP, 1%AEP and PMF) along the main branch of South Creek. Differences in flood extents are most notably along minor tributaries to South Creek. The Council's flood study was developed with a focus on flood behaviour along the main branch of South Creek, Kemps Creek, Ropes Creek, part of Badgerys Creek and Thompsons Creek, while the project flood assessment has accounted for all tributaries that cross the project alignment. The discrepancies in peak flood levels are noted to be primarily due to the result of the application of different hydrologic design procedures been adopted notably with differences in design temporal patterns and rainfall depths between ARR1987 and ARR2019. Despite the differences noted, it was concluded that the flood model build was adequate for this assessment. Two flood modelling scenarios have been developed to inform the flood impact assessment for the project: • A base case scenario which provides a benchmark to assess the flood impacts for the project. Due to the proximity and intrinsic linkage between the designs for the project and Western

Key tasks in flood assessment methodology
Sydney International, the design for the project cannot be considered exclusive of Western Sydney International. The base case flood model therefore represents existing catchment conditions as well as incorporation of the Western Sydney International (stage 1) project works. Details of how this was incorporated are provided in Appendix B. • A project design scenario which is inclusive of the base case scenario and incorporates the preliminary design surface for the rail alignment and stabling/maintenance facility. Key assumptions and limitations of the flood model used for this impact assessment are detailed in Appendix B. Climate change Climate change effects were incorporated in the assessment in accordance with ARR2019 guidelines for rainfall intensity increase predicted for year 2090, which is considered a late century period. The 2090 interim climate change factor based upon a Representative Concentration Pathway (RCP) 8.5 (as recommended by ARR2019) adopts a 19.7% increase in rainfall intensity in the study area. Derivation of runoff for mainstream flooding therefore adopts a 1.197 rainfall intensity multiplier for design flood events in accordance to ARR2019 guidelines. In comparison, the NSW Governments projections for 2060 to 2079 predict an annual increase in rainfall intensity of 8.9% with a maximum for autumn of 13.6%. While there is no data for rainfall intensities, the adopted value of 19.7% is considered a conservative estimate and was adopted to understand the upper bounds of the potential implications of climate change on flooding and flood impacts as a result of the project.
Project Specific Criteria
The desktop review was used to develop a project specific set of criteria. The criteria were then used to inform the design and quantify the impact of the project. Refer to section 3.1.1 for the project specific criteria. Impact criteria for water quality is discussed in Section 3.4.2.
Impact Assessment
The available flood models were utilised to understand the impact of the project on flood behaviour and key criteria discussed in Section 3.1.1. The impact assessment also considered impacts beyond the project boundary including buildings and infrastructure such as roads. Construction impacts were assessed qualitatively using the existing 5%AEP flood behaviour as the basis of the assessment. The cumulative impact assessment has followed a qualitative approach based on a review of major developments proposed in the study area (refer to Section 7.0 for further details).
Proposed Management and Mitigation measures
The design development included design features to minimise impacts, however, where the design could not meet the project Specific Criteria, mitigation measures were developed that set performance measures for the final design and flooding, geomorphologic and water quality management of the project. Management plans are identified through the CEMF and industry guidelines to manage the impacts of the project and to set monitoring programs and have been developed and discussed in Section 8.

3.1.1 Operational impact flooding criteria

The operational impact assessment has been undertaken using the flood model as described above and comparisons made between the base case scenario model results and the project design scenario model results. The flooding criteria (refer to Table 3.2) have been established to inform iterations of the design, understand key flood behaviour characteristics for the study area and provide further project specific clarity to the requirements of the SEARs in relation to what is an impact on flood behaviour.

The project specific criteria have been established through a review of other linear infrastructure projects across greenfield sites and Penrith City Councils DCP (2014). These criteria have then been adapted for proposed use on the project. The land use is a mixture of rural agriculture, old urban areas at St Marys and major infrastructure such as the M4 Western Motorway, Great Western Highway and the Western Sydney International. The criteria are broken down into the following key flood parameters:

- Afflux - with reference to flooding, afflux refers to the predicted change, usually in flood levels, between two scenarios. The afflux criteria have been separated into the different land uses and identifies the need to protect existing structures and infrastructure from changes to peak flood levels.
- Velocity - this relates to how fast flood waters are moving. Areas subject to high velocities are more prone to scour and erosion.
- Hazard - Flood hazard is defined as the potential loss of life, injury and economic loss caused by future flood events. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, isolation, rate of rise of floodwaters, duration), topography and emergency management (AIDR, 2017).
- The proposed criteria are based on the preliminary flood hazard which is the velocity depth product and provides a preliminary understanding of flood hazard. The true flood hazard assessment considers other aspects including: rate of risk of floodwaters, time of day, effective warning time and isolation or distance to higher ground. The relative degree of flood hazard has implications to management of flood events, including evacuations.
- Duration - this refers to the time from start to finish that floodwaters are present on the surface. An understanding of the duration of inundation helps understand the existing flood risk such that the longer the duration of inundation the longer the increase in potential exposure to the flood risk for people, infrastructure, crops and wildlife.

Table 3.2 Flood impact criteria

Parameter	Location	Criteria (for events up to and including the 1%AEP)
Afflux	**Location**	**Maximum allowable afflux**
	Residential houses, commercial buildings and critical infrastructure	No change (maximum 10 millimetres (mm) increase) to buildings that are flood prone in existing conditions.
		No new above floor flooding
		50 mm at properties where flooding is below floor level
	Roads	50 mm
	Crown land open space, Farming, grazing and cropping land	200 mm
Flood velocity	**Location**	**Criteria**
	All areas	Velocities are to remain below 1 metre per second (m/s) where they are currently below this figure and that an increase of no more than 20 per cent should result from the project where existing velocities are above 1 m/s.
Flood hazard	**Location**	**Criteria**
	Residential and commercial buildings	No change in flood hazard vulnerability classification limits
	Roads	No change in flood hazard vulnerability classification limits.

Parameter	Location	Criteria (for events up to and including the 1%AEP)
Flood duration	**Location**	**Design criteria**
	Residential and commercial buildings	No increase to duration of above floor flooding
	Roads	No more than 10 per cent increase in flood duration
	Farm cropping	Dependent on the crop

3.2 Geomorphology

Geomorphology relates to the form, shape, size and structure (slopes, presence of rocks, locations of ponds, soil types) of watercourses. The geomorphic condition of a watercourse is dependent on the flows, vegetation, soil types, aquatic biodiversity etc and these can be affected by human induced changes to catchments and watercourses. Watercourses in good geomorphic condition are important for overall catchment health.

Geotechnical information, LiDAR data, aerial photographs and site visits have been used to inform the understanding of geomorphic conditions for waterways intersected by the project. A review of stream order classification based on Strahler system and flow paths identified through flood modelling has also informed the assessment. The NSW River Styles mapping (NSW Department of Industry, 2019) has also been used for this assessment. The geomorphic assessment has focussed on locations where the project footprint crosses waterways. Waterways included in this assessment are noted in Section 1.6 above and shown in Figure 1-3.

The geomorphology impact assessment has focused on a review of the flood depth, flood velocity and duration information to understand potential changes to the flows that influence geomorphic condition. The predicted change in hydraulic conditions (based on hydraulic modelling) at and around the waterways and drainage line crossings has also informed the assessment.

3.3 Catchment and watercourse health

To understand the existing hydrologic regime and existing watercourse health across the study area the available rainfall and flow gauge data has been reviewed, the existing geomorphic conditions (as described in Section 4.2) understood, connections to groundwater sources identified (in the Technical Paper 7 (Groundwater)) and existing surface water storages identified.

The project operation and construction water requirements have then been considered to understand the impact of the project on the catchment and waterway health. The flood modelling has also informed the potential changes to the existing hydrologic regime and geomorphic conditions.

3.4 Water quality

The following methodology has been used to understand the existing water quality environment in the study area and to assess potential construction phase, operation phase and cumulative water quality impacts. Key steps in the water quality assessment are shown in Figure 3-2.

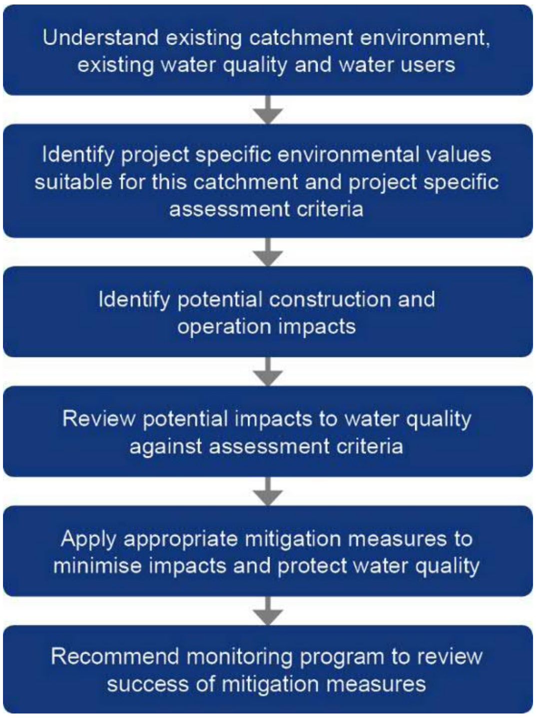


Figure 3-2 Water quality assessment methodology

3.4.1 Existing Water Quality Environment

To understand the existing environment and baseline surface water quality conditions in the study area, previous water quality studies and assessments were reviewed. A full discussion of the existing water quality studies and data is provided in Section 4.1.11 and Section 4.2.3.

Water quality assessment criteria

For parts of the project located off-airport land, the HRC inquiry provides the environmental values and the ANZG/ANZECC guidelines provide the associated water quality indicators and guideline trigger values (refer to Section 2.1.1 and Section 2.1.1).

For sections of the project located on-Airport land the assessment must consider the trigger values provided in the AEPR as shown in Table 2.3. However, local standards may be proposed where the AEPR limits are considered inappropriate.

Water quality monitoring has been carried out for the Western Sydney International both at the airport site and downstream. As discussed in Section 4.2.3, the existing water quality at the site was generally not compliant with the AEPR limits and enough monitoring data was available from the Western Sydney International project to allow for preparation of Interim site specific trigger values (see Section 4.2.3).

While the guideline trigger values are adopted for this assessment, site specific trigger values should be considered for the project based on monitoring carried out during pre-construction and construction of the project and further information from the Western Sydney International project.

3.4.2 Water Sensitive Urban Design

Ongoing design for station and ancillary infrastructure would be carried out in accordance with the applicable Penrith Council and Liverpool Council and TfNSW Water Sensitive Urban Design (WSUD) standards.

3.4.3 Impact assessment

A qualitative assessment of the potential water quality impacts from the project has been carried out and considers:

- the existing water quality environment (see Sections 4.1.11 and 4.2.3)

- the potential pollutants and impacts to the water quality environment from construction and operation activities
- the effectiveness of the identified mitigation measures
- any residual impacts post-mitigation and the likely performance against the water quality objectives.

The methodology for impact assessment is the same for both on-airport and off-airport land except where water quality impacts may result at on-airport land, this assessment considers the AEPR in addition to the ANZG/ANZECC guidelines.

The construction phase impact assessment aims to identify potential water quality impacts based on current understanding of the likely construction approach and construction methods.

The impact assessment identifies potential impacts to water quality during operation of the project. At this stage the design of water quality and drainage infrastructure at the stations is not adequately progressed to allow for quantitative assessment of potential water quality impacts. Further design of project infrastructure would be carried out in line with the relevant pollutant reduction targets as outlined in the Council, TfNSW, Commonwealth and State guidelines and legislation (refer to Chapter 2.0 (Legislative and policy context)). It is also noted that, based on monitoring carried out for the development of the Western Sydney International (see Section 4.2.3) the existing water quality of the project environment is currently not meeting the ANZG/ANZECC or AEPR trigger values. Application of the required WSUD standards to ongoing design would ensure that stormwater leaving the project site, particularly during operation of the completed proposal would be of similar or improved quality to the existing water quality environment.

3.4.4 Water Quality Mitigation Measures

In addition to design guidelines and requirements, other mitigation measures are identified for operation of the project to minimise and manage potential impacts to waterways. The mitigation measures focus on performance outcomes that should be used to inform future stages of the design.

3.4.5 Water Quality Monitoring

Section 8.2.3 outlines a monitoring program to assess the performance of the proposed design and mitigation measures to meet the project specific criteria. The monitoring program was developed to focus on the common pollutants and complement existing historic data and monitoring programs.

4.0 Existing environment

4.1 Existing environment (off-airport)

4.1.1 Catchment overview

The project footprint lies entirely within the South Creek catchment. South Creek, a major tributary of the Hawkesbury-Nepean catchment, flows in a generally northerly direction from its headwaters near Narellan through to Windsor where it joins the Hawkesbury River. The alignment crosses a number of tributaries of South Creek, including Badgerys Creek, Thompsons Creek, Cosgroves Creek, Blaxland Creek and Byrnes Creek. Figure 4-1 shows an overview of the South Creek catchment.

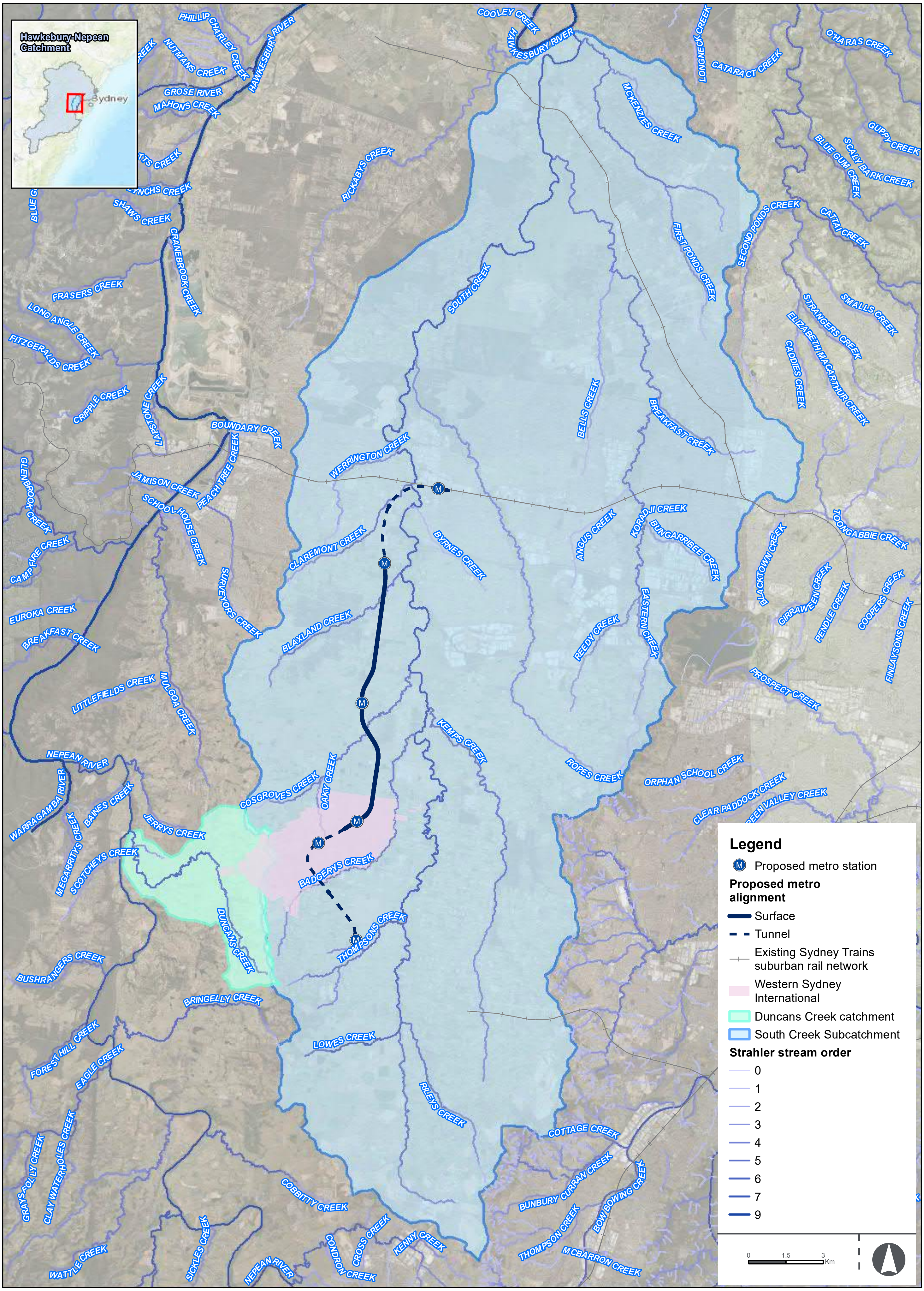
South Creek was dual-named as Wianamatta (based on the Indigenous name for this water course from the Dharug language meaning 'Mother Place') on 28 March 2003 by the Geographical Names Board of New South Wales. The South Creek corridor from Narellan to Hawkesbury has been identified as an important environmental spine for the Western Parkland City. It is estimated that by 2056, well over 1.5 million people would call the Western Parkland City home. The project crosses the following waterways:

- South Creek
- Claremont Creek
- Blaxland Creek
- Cosgroves Creek
- Badgerys Creek (located in the Western Sydney International site).

The study area for the project however, includes the catchment areas (but does not cross the main channel) for the following creeks:

- Byrnes Creek (at the northeast of the project)
- Oaky Creek (within the Western Sydney International site, to the west of the project)
- Moore Gully
- Thompsons Creek (at the southern end of the project)
- Duncans Creek (within the Western Sydney International site, to the southwest of the project).

South Creek is the receiving waterway for creeks within the project footprint. Figure 4-1 shows the waterways in the vicinity of the project.



Catchments and watercourses within the study area

Figure 4-1

Indicative only, subject to design development

4.1.2 Climate and rainfall

Rainfall gauges operated by the Bureau of Meteorology (BoM) are located at the Badgerys Creek airport site (station 067108) and Orchard Hills (station 67084). The average annual rainfall at Badgerys Creek was 671.6 mm between 1995 and 2019, and 821 mm at Orchard Hills between 1970 and 2018. Analysis done by BoM shows that heavy rainfall events with a probability of 1 Exceedance per Year (EY) and rarer rainfall events are more likely to occur between the months of November and March (BoM, 2005). The average monthly rainfall data as shown in Figure 4-2 shows that the wettest months tend to be January to March, while the driest months are July to September. The average annual potential evapotranspiration in the Badgerys Creek area is around 1200 mm based on data from between 1961 and 1990 (BoM, 2002).

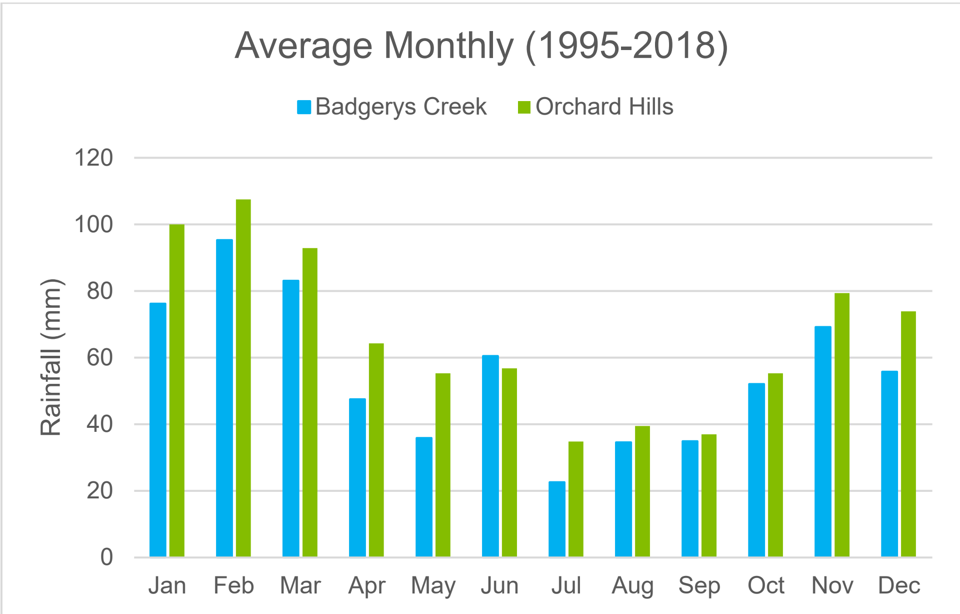


Figure 4-2 Average monthly rainfall in the study area

Climatic conditions in the area are moderate with a warm summer, cool to cold winter and reliable rainfall throughout the year. The mean monthly maximum temperature is 30.3 degrees Celsius (^{0}C) in summer and mean monthly minimum of around 4^{0}C in winter (BoM, station 067108).

4.1.3 Topography

LiDAR information has been used to understand the topographic conditions of the study area and the South Creek catchment. South Creek catchment's highest elevations occur at the southern catchment boundary at about 130 m Australian Height Datum (AHD) dividing the catchment from Narellan Creek to the south and the Nepean River to the west and drops to about 20 m AHD at St Mary's approximately 32 km away.

For the study area tributaries, heading north, the Badgerys Creek catchment divide is at an elevation of 110 m AHD and joins South Creek at an elevation of 40 m AHD, then Cosgroves Creek with a top elevation of 90 m AHD and joins South Creek at 32 m AHD and then Blaxland Creek at an elevation of 70 m AHD and joins South Creek at 30 m AHD. The overall catchment slope is less than 0.5 per cent with isolated steeper sections in the upper reaches but generally the catchment gently slopes to the north.

4.1.4 Land uses and catchment condition

Aerial photography was reviewed (Aerometrix, 2019) to understand the land use and catchment conditions for the study area. The catchment of South, Badgerys, Cosgrove and Blaxland Creeks consists of gently sloping rural residential land that is largely cleared.

Land use in the study area between the proposed Orchard Hills Station and St Marys Metro Station are low density residential areas, including schools and recreational infrastructure such as the

Kingsway sports fields. The density of development increases near St Marys and includes areas of higher density residential and mixed-use development.

Existing land use in the study area to the south of proposed Orchard Hills Station is predominantly cleared agricultural land, including grazing pastures, horticultural land and some rural residential land. There are some pockets of remnant vegetation, particularly surrounding the waterways. South of the Western Sydney International site at the south of the project footprint near Bringelly features a higher percentage of small rural residential lots.

There are small farm dams scattered across the catchment and the creek banks appear to be vegetated and there are a few areas of urban development that would impact catchment runoff characteristics. There are numerous farm dams and reservoirs within the study area. These are likely to be used for irrigation. Figure 4-3 shows the land uses around the project footprint.

4.1.5 Soils and geology

The soil landscapes across the study area include the alluvium through the floodplain areas with shale, sand and silt and slopes of zero to three per cent (similar to the surface topography) with no rocky outcrops. Soils include grey, yellow and brown chromosols (podzolic soils), black and brown dermosols (prairie soils) and tenosols (alluvium soils). The alluvium landscape has some saline areas where the water tables is close to the surface and streambank erosion has been observed (Bannerman, 1990).

For catchment areas away from the floodplain, the landscape classification is described as low hills and rises on Wianamatta Group Shale (shale, sandstone-lithic and sandstone quartz) in the Cumberland Plain with slopes of zero to nine per cent and no rock outcrops. Soils include red kurosols (red and brown podzolic soils), red and yellow sodosols (soloths) yellow chromosols (yellow podzolic soils) and red chromosols, red dermosols and red ferrosols (Krasnozems) on iron-rich parent material. (Bannerman, 1990). The NSW Environment, Energy and Science Group Soil and Land Information System (SALIS) indicates that these areas of the catchment are subject to localised sheet erosion that has potentially eroded the top layers of soil. (Blacktown SALIS report, 2019).

4.1.6 Acid sulfate soils

The Australian-wide Atlas of Australian Acid Sulfate Soils map (CSIRO, 2013) indicates that the probability of encountering acid sulfate soils along the reference alignment is “extremely low” to “low”. The NSW Acid Sulfate Soils Risk map (Naylor et al., 1998) indicates that the risk of acid sulfate soils is not reported along the alignment.

Potential acid sulfate soil testing has been undertaken at Western Sydney International as preliminary design investigations (GHD, 2018). A total of 97 soil samples were tested for possible acid sulfate soils which indicated that only two samples had a slight marginal presence of potential ASS, indicating that potential ASS are unlikely to be found within the study area.

4.1.7 Wetlands

There are no Ramsar or nationally important wetlands within the study area.

4.1.8 Groundwater interactions and groundwater dependent ecosystems

Technical Paper 7 (Groundwater) notes that groundwater within the alluvial deposits in the study area is likely to be in connection with the surface water within the creeks (when flowing). Alluvial groundwater is likely to provide some baseflow to local creeks in the area, particularly during periods of low rainfall and surface run off.

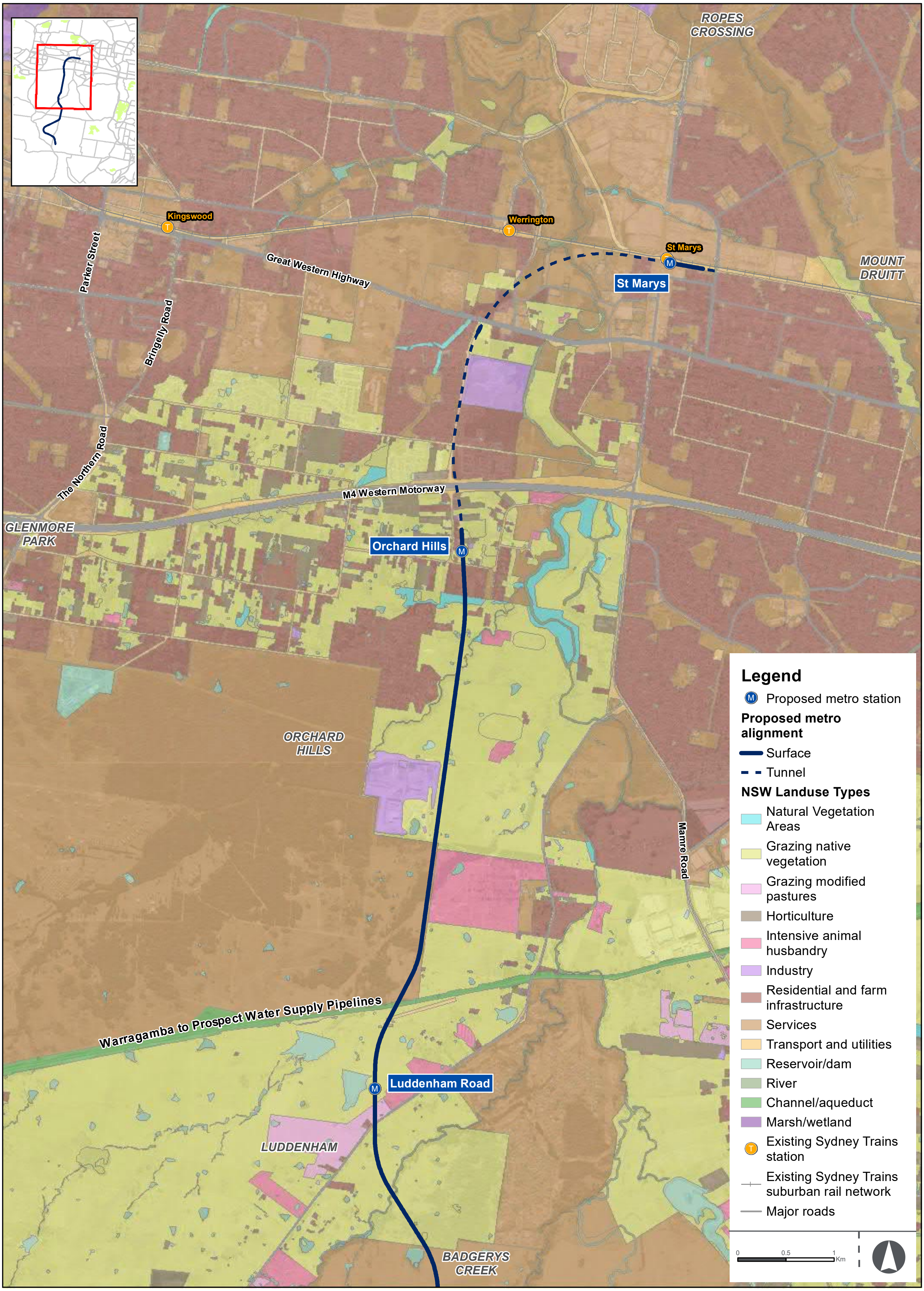
Creek lines are likely to be discharge areas for groundwater within the Bringelly shale groundwater catchments, however due to the low hydraulic conductivity of the Bringelly Shale and overlying soils, the total amount of groundwater discharge is likely to be small compared to the overall flow in the creeks and alluvial aquifers.

Groundwater levels within Western Sydney International indicates that water levels within the alluvial deposits may be higher than the underlying Bringelly Shale (GHD, 2016). This may be indicative of units which have limited hydraulic connection. Based on these groundwater levels it is plausible that surface waters could be losing streams (i.e. recharging underlying shale). It is often the case that the same creek is gaining and losing in different section of its course. Further assessment of groundwater levels is detailed in Technical Paper 7 (Groundwater).

Technical Paper 7 (Groundwater) indicates there may be some groundwater dependent communities present along creek lines where Cumberland River Flat Forest occurs. It is more likely that where vegetation communities use groundwater, it is likely to be from fresher/brackish groundwater from within the shallower soil zones, which may be temporal following rainfall recharge.

Technical Paper 7 (Groundwater) also notes there are no high priority aquatic or karst Groundwater dependent ecosystems (GDEs) listed in the Water Sharing Plan located within the study area.

The Water Sharing Plan for the Sydney Metropolitan Region Groundwater Sources (OEH, 2011) indicates that there are high priority GDE in the study area but the dependence as indicated above it not clear.



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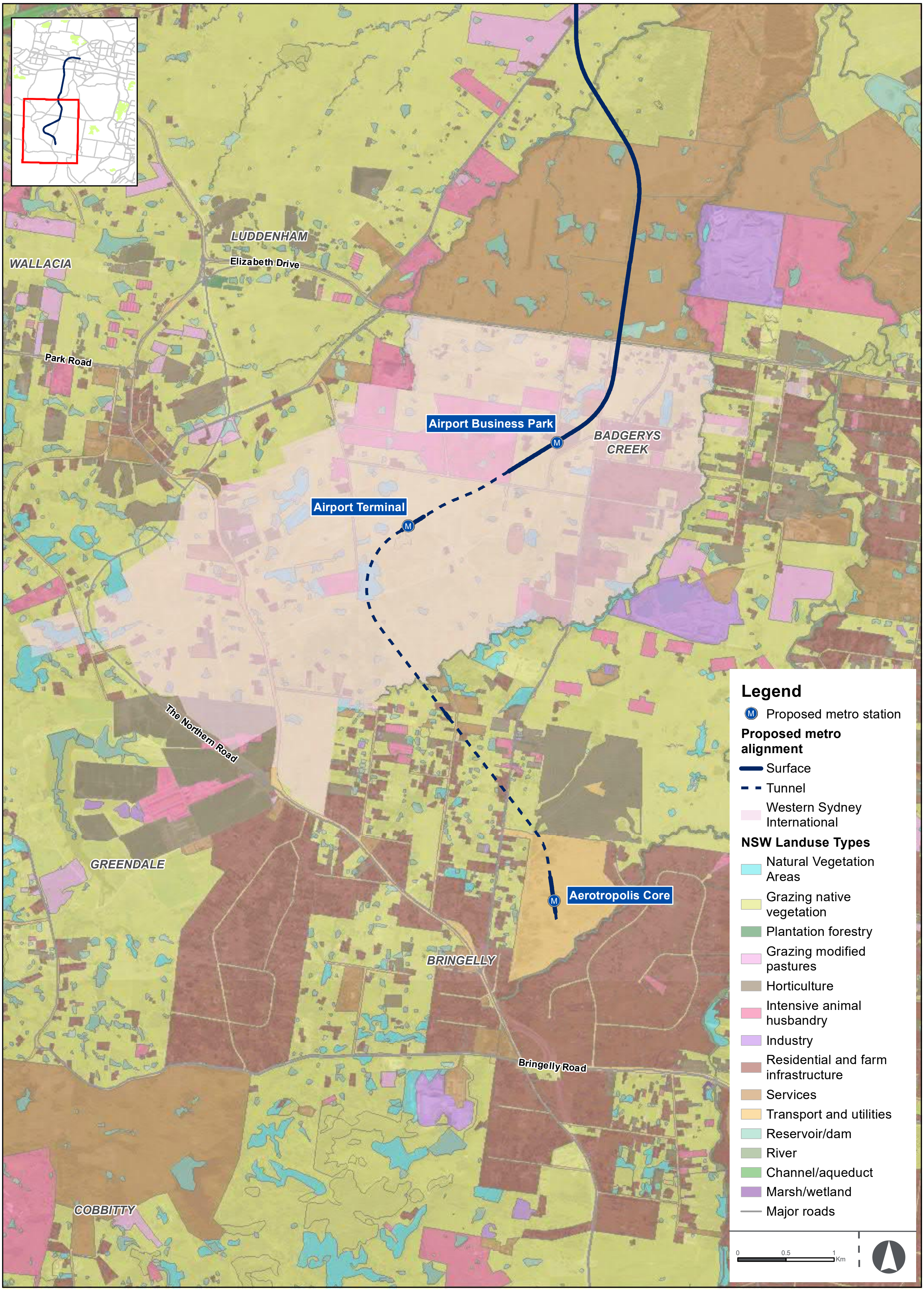
Land uses in the study area

Figure 4-3a



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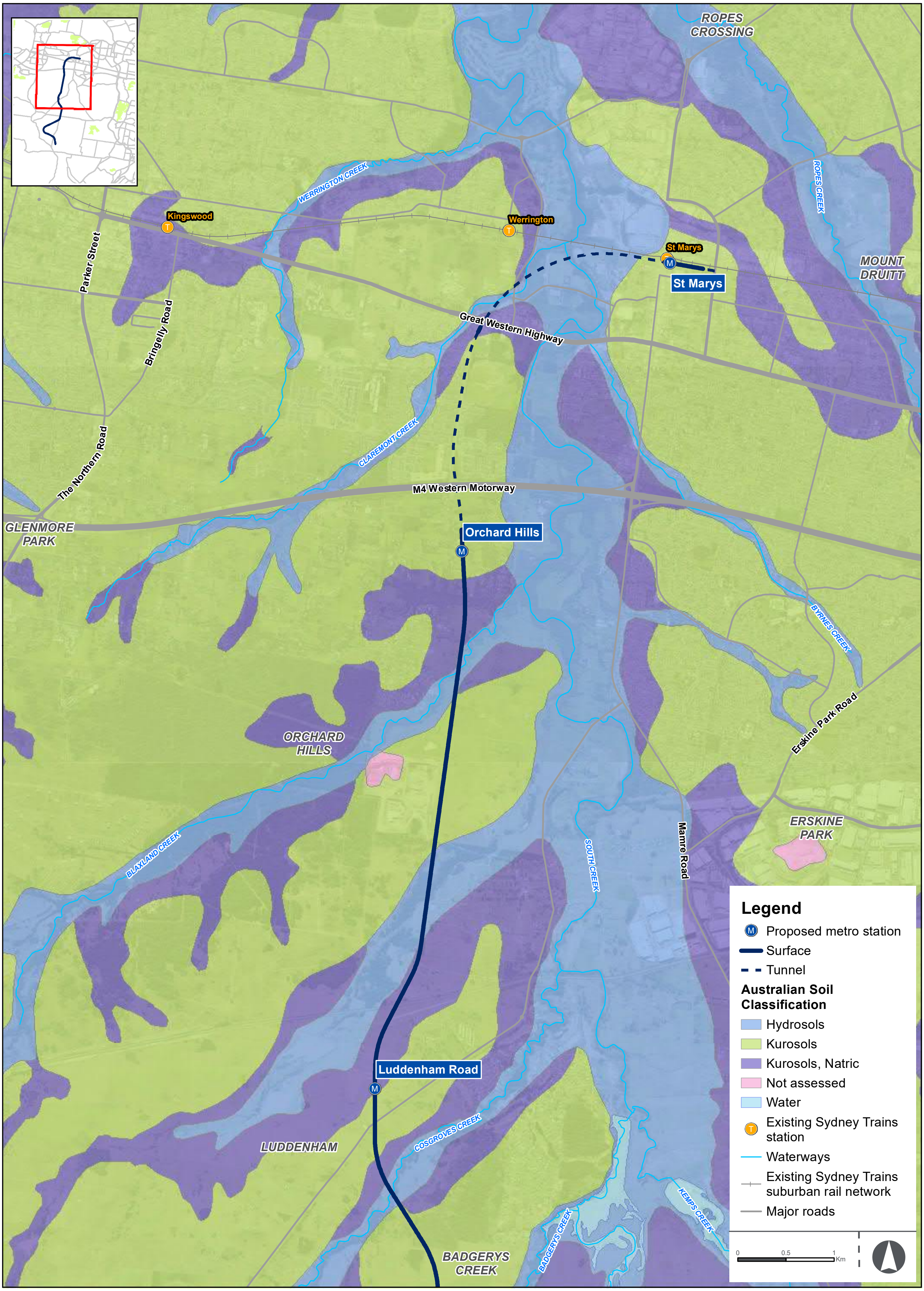
Land uses in the study area

Figure 4-3b



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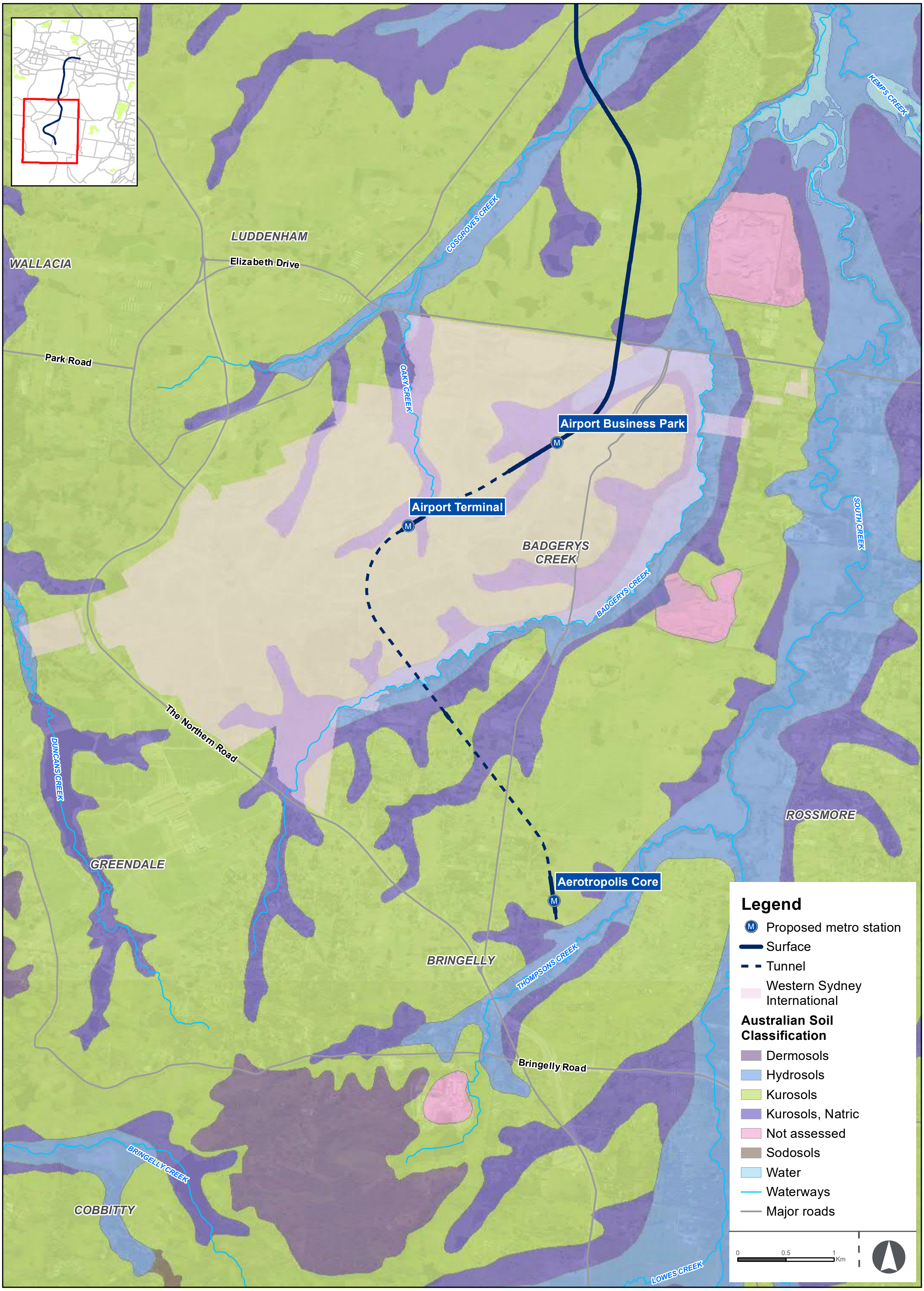
Soil landscapes in the study area

Figure 4-4a



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Soil landscapes in the study area

Figure 4-4b

4.1.9 Existing flood conditions

Previous reports

A number of flood studies and floodplain management studies have been carried out since the 1990s within the South Creek catchment. These studies aimed to define design flood behaviour and provide sustainable flood management strategies to support social and economic development within the catchment.

An overview of the key studies that have informed this assessment is provided in Table 4.1. It is noted that the hydrology used by all of the projects described below (except the Western Sydney International) is based on the original Department of Water Resources 1990 South Creek Flood Study XP-RAFTS model. This model also forms the basis of the hydrologic modelling for this project (as described in Section 3.1 and detailed in Appendix B).

Table 4.1 Previous flood reports

Report	Relevance to project
Western Sydney Aerotropolis South Creek Flood Study - Preliminary results for PPO (Sydney Water, July 2019)	This study developed updated flood modelling for South Creek to inform strategic land use planning for the Western Sydney Aerotropolis Land Use and Infrastructure Implementation Plan (LUIIP). The modelling was based on models developed as part of the South Creek Flood Study (Worley Parsons, 2015) with updates including recent topographic, land use and drainage changes in the catchment as well as revision to ARR 2016 methodology. The model includes South Creek, as well as tributaries of Blaxland Creek, Cosgroves Creek, Badgerys Creek, Thompsons Creek and Kemps Creek so cover the study area for this project. They also incorporate allowance for proposed M12 Motorway and M9 roads. This model was not available for use to inform design and assessment for this project.
Updated South Creek Flood Study, Worley Parsons (Penrith City Council, Final Report, 2015)	Presents modelling that Penrith City Council currently adopts for planning within the South Creek Catchment. The study results are based on a two-dimensional hydrodynamic model (RMA-2) of the South Creek catchment that was established to define design flood behaviour along the floodplain. The topography of the hydrodynamic model was established with LiDAR data gathered between 2002 and 2006. The full range of design flood events were simulated to derive flow, flood level, velocity, provisional flood hazard and hydraulic categories. The modelling was developed based on ARR1987 approaches. It is acknowledged that significant effort was invested in the flood study to develop a modelling tool that could be used from a regional context to assess future development and proposed flood mitigation measures to alleviate flood risk resulting from such projects. However as detailed in Appendix B, this model was not used for this project for a number of reasons, including that the flood study was based on ARR1987, that updated LiDAR information is now available and the flood study RMA2 model did not incorporate all tributaries that traverse the project alignment.

Report	Relevance to project
South Creek Floodplain Risk Management Study and Plan, Worley Parsons (Penrith City Council, 2019)	The objective of the South Creek Floodplain Risk Management Study and Plan is to understand the flood risks to people and property and develop a set of management measures to reduce the flood risk. The Study and Plan are based on the flood study results (2015) but include an assessment of property flood affectation and flood hazard. The flood study has then been utilised to assess the effectiveness of floodplain risk management measures in reducing the flood risk across the South Creek catchment. The models have not been updated to consider the latest rainfall information as outlined in ARR2019 but the results of the modelling represent the most up to date catchment wide information for South Creek. Assessment for this project has utilised the XP-RAFTS hydrologic model but did not the RMA-2 hydraulic model (refer to Appendix B for further information.)
Hawkesbury-Nepean Flood Plan, NSW State Emergency Service, September 2015	This plan informs the understanding of current flood risk in the South Creek catchment as it relates to emergency management arrangements. The interaction of the wider Hawkesbury-Nepean system is understood to extend into the South Creek floodplain to the M4. Beyond this (to the south) flooding is as a result of local catchment runoff and therefore the plan does not cover specific emergency management arrangements for the project. The M4 is identified as a flood evacuation route within the South Creek catchment. No other roads are identified as designated evacuation routes.

Other flood studies

Other flood studies prepared previously that are relevant to the study area but have not informed the assessment of the project are:

- Hawkesbury Nepean Regional Flood Study July 2019
- St Marys Byrnes Creek Catchment Floodplain Risk Management Study and Plan Oct 2019
- Flood Study Report, South Creek (Department of Water Resources, 1990)
- South Creek Floodplain Management Study (Willing and Partners Pty Ltd, 1991)
- Austral Floodplain Risk Management Study and Plan (Perrens Consultants, 2003)
- South Creek Floodplain Risk Management Study and Plan (Bewsher Consulting, 2004).

4.1.10 Project flood modelling

The current flood modelling as described in Section 3.1 has determined existing flood behaviour for the study area (off-airport). The key flood behaviour characteristics include flood depth, flood level, flood hazard, flood flow distribution, velocity and duration of inundation. Preliminary flood hazard is the flood velocity depth product with the full flood hazard taking into consideration a number of other factors including duration of inundation, access to high ground and flood warning time. For the project the preliminary hazard has been determined using the information from the flood model.

Flood maps showing baseline flooding within the catchment are presented in Figures C.1 to C.21 in Appendix C to illustrate the peak flood depths and extents, peak velocity, flood hazard and duration of inundation considered to be representative of base case catchment conditions (i.e. without consideration of this project).

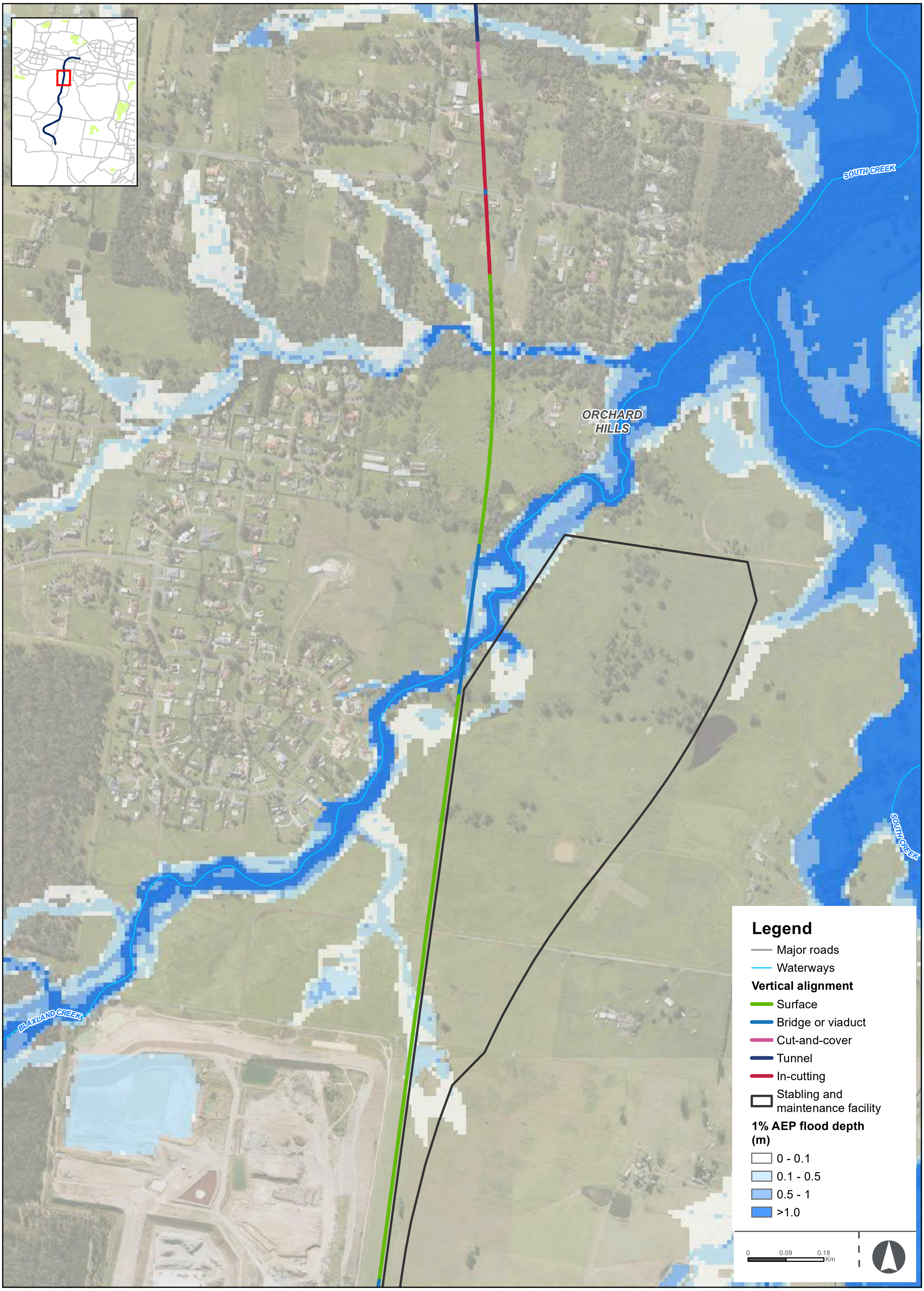
The modelling indicates that the project footprint crosses approximately 3.6 km of flood liable land where flood liable land is defined by the extent of the PMF. This includes the main South Creek floodplain of 1.5 km in width at the project crossing (note that the project is in tunnel through this crossing), numerous minor overland flow paths and Blaxland Creek and Cosgrove Creek make up the other floodplains intersected by the project. The project is in tunnel under the Badgerys Creek floodplain. There are many agricultural dams across the study area and within close proximity to the project and as a conservative approach these dams have been considered full at the start of the flood events.

Peak flood levels and depths

Existing flooding through the study area is characterised by numerous flow paths within the established tributaries of South Creek and Badgerys Creek. There are a number of agricultural dams which contain flood depths ranging from approximately 0.3 m to 2.0 m under the 1% AEP event in existing conditions.

The main creek channels consistently have flood depths greater than 1 m from the 0.2EY through to the PMF. The peak flood levels in the main South Creek channel indicate the flood surface has a gentle slope but the tributaries of Cosgroves Creek, Blaxland Creek and Badgerys Creek have steeper flood surfaces before they reach the floodplain of South Creek. The PMF flood modelling indicates that peak flood depths of greater than 1 m are experienced across the whole floodplain width of 1.5 km at the M4 Western Motorway crossing of South Creek.

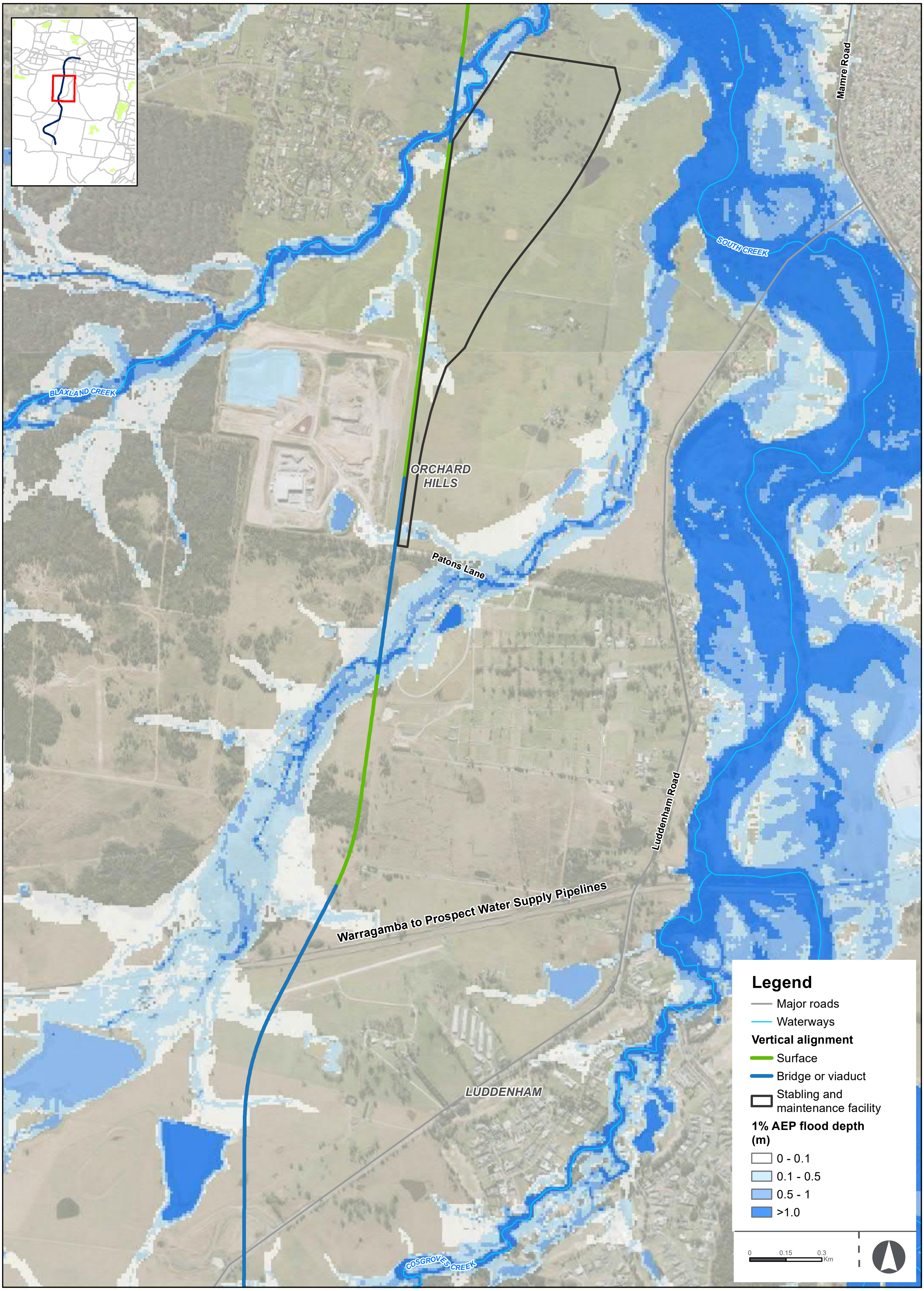
The project is within tunnel for large sections in the north of the study area where it crosses the South Creek floodplain and in the section to the south east of the Western Sydney International where it crosses Badgerys Creek. The 1%AEP flood extent and depth at floodplain crossings where the project is at ground level or on viaduct structures are illustrated in Figure 4-5a to Figure 4-5d. These figures show a closer view of the 1% AEP flood extent with broader information presented in Appendix C. These areas are the key focus for this flood assessment as they are the locations where the project interacts with the floodplain. Figures C.1 to C.6 of Appendix C presents the existing flood levels and depths across the study area for the 0.2EY, 0.5EY,5% AEP, 1%AEP, 1%AEP with climate change considerations and PMF events.



1%AEP base case flood extent at Blaxland Creek and a tributary of Blaxland Creek

Figure 4-5a

Indicative only, subject to design development



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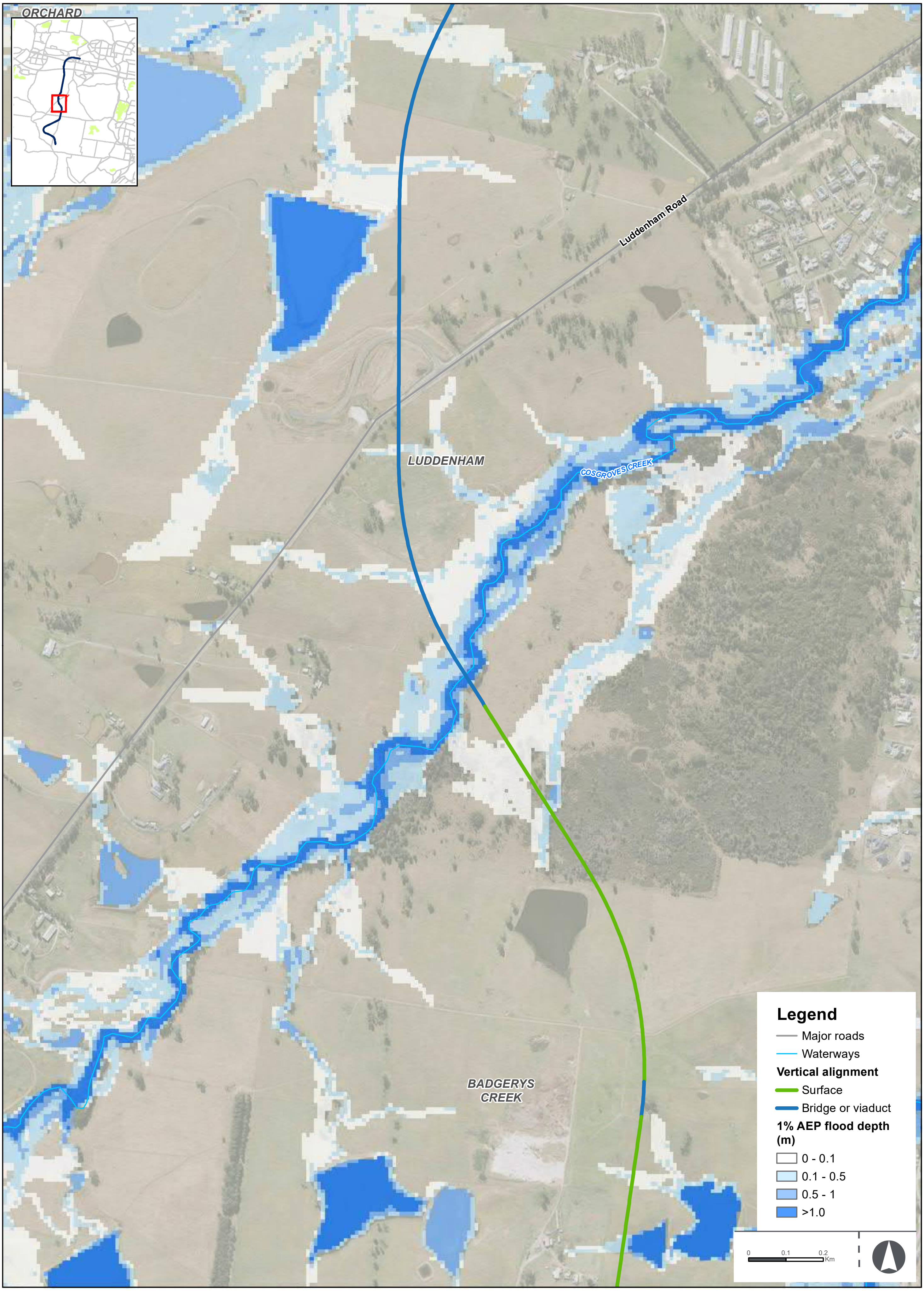
1%AEP base case flood extent at unnamed tributary of South Creek

Figure 4-5b

Indicative only, subject to design development

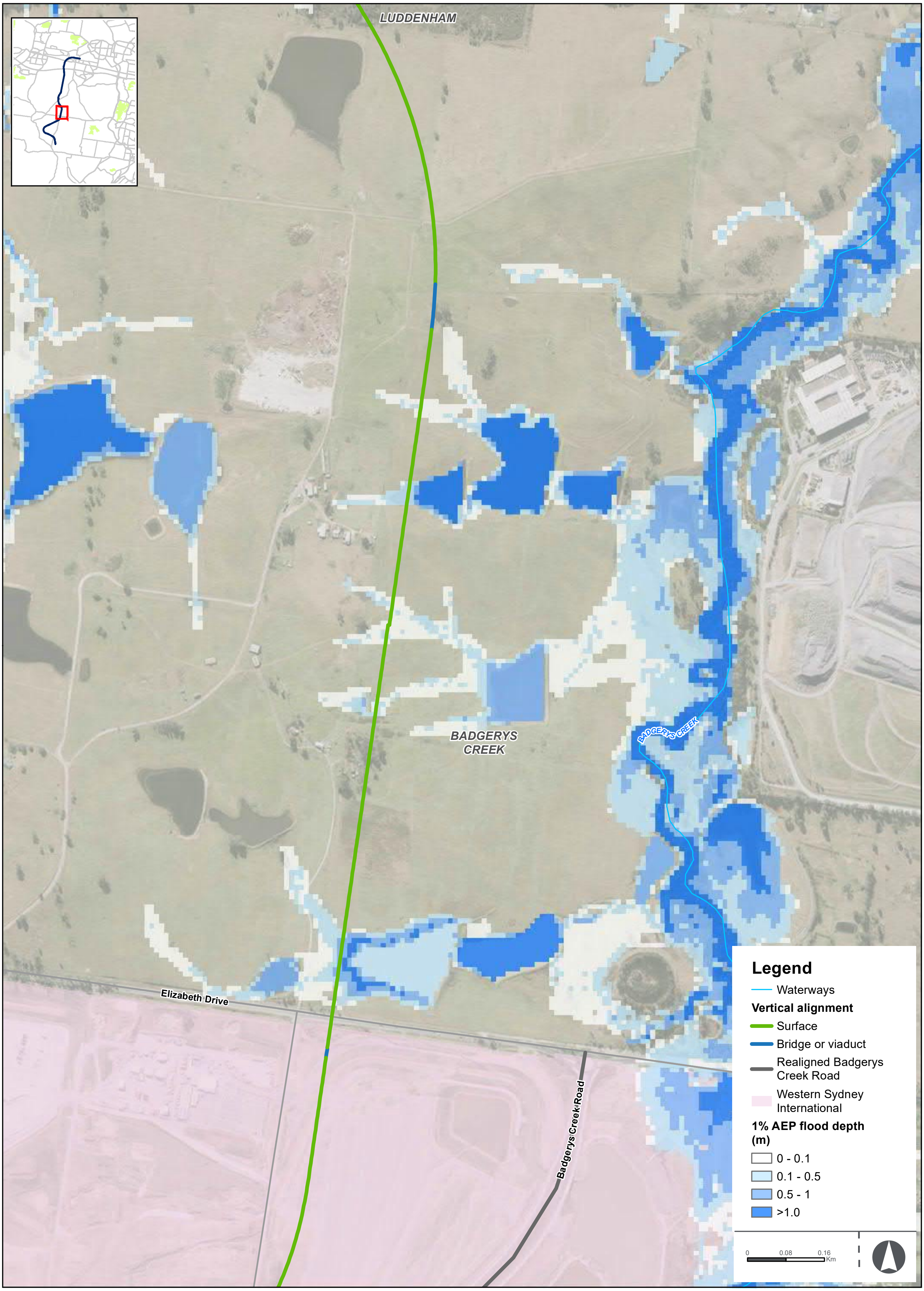


Sydney Metro – Western Sydney Airport

1%AEP base case flood extent at Cosgroves Creek

Figure 4-5c

Indicative only, subject to design development



1%AEP base case flood extent at tributaries of Badgerys Creek

Indicative only, subject to design development

Figure 4-5d

Peak flood velocities

Within the study area the peak velocities are generally less than 0.5 m/s for the 0.2EY floodplain areas and up to 1 m/s in the main channels and there are isolated sections of South Creek, Badgerys Creek, Cosgroves Creek and Blaxland Creek with velocities over 2 m/s. For the 1% AEP, velocities of approximately 0.5 m/s are still predicted across the floodplain area but for South Creek higher velocities of up to 1 m/s are predicted to occur out of the main channel and across the floodplain. Also for the 1% AEP the main South Creek channel has velocities greater than 2 m/s consistently through the study area.

For the PMF event the flood modelling has predicted floodplain peak velocities are between 1 and 2 m/s. Peak velocities in section of the channel of South Creek and in the tributary channels in the study area are greater than 2 m/s. Refer to Appendix C, Figures C.7 to C.11 for mapping of baseline peak velocities across the study area.

Flood duration

The duration of flood inundation across the study area refers to the time from start to finish that floodwaters are present on the surface. The duration of inundation helps to provide an understanding of the existing flood risk such that the longer the duration of inundation the longer the increase in potential exposure to the flood risk for people, infrastructure, crops and wildlife.

The existing land uses across the study area, as described in Section 4.1.4 are largely agricultural which affects the runoff rates and subsequently the duration of inundation. The presence of farm dams across the study area and within overland flow paths also impacts the duration of inundation as they can store runoff and interrupt the natural runoff processes but for the purposes of this assessment the actual impact of these dams has not been assessed. The flood modelling has assumed they are full and therefore do not act to retain any water during flood events.

For the regular events, the 0.2EY and 0.5EY, the duration of inundation in the creek channels is between 18-24 hours, with durations of 1-18 hours across the floodplains.

For the 1% AEP flood event, the duration of inundation in the channels is between 12-18 hours and across the floodplains it is between 6-12 hours. In the PMF the duration is largely between 12-18 hours across the floodplain with no difference in the channels. Refer to Appendix C (Figures A.13 to A.16) for mapping of the duration of inundation across the study area.

Property flood affectation

Building survey was obtained for this assessment containing building outlines and height attributes derived from the SMWSA Lidar Data Capture of June 2019. This survey covered an approximately one kilometre corridor either side of the project and was reviewed against base case flood levels results to identify properties within the area that are subject to inundation during the 1% AEP event. This assessment has noted 53 properties that have above ground level inundation at buildings during a 1%AEP event. This assessment is based on ground levels from lidar data, detailed flood level survey of these properties would be required to assess if above floor flooding occurs. It is noted that there are additional buildings located within the South Creek floodplain, further away from the project alignment, that have not been picked up in this survey.

Hazard

Flood hazard is assessed through consideration of a combination of flood depth and velocity. This is referred to as the preliminary flood hazard as the true flood hazard assessment considers other aspects including rate of rise of floodwaters, time of day, effective warning time and isolation or distance to higher ground. The relative degree of flood hazard has implications to management of flood events, including evacuations. Flood hazard categories (based on general vulnerability thresholds within Australian Disaster Resilience Handbook Collection Guideline 7-3 Technical flood risk management guideline: Flood hazard (Commonwealth of Australia, 2012)) have been used to understand the general flood risk within the project footprint and across the study area.

The 1% AEP flood hazard is presented in Figure C.20 of Appendix C and shows the results classified by categories defined in the Table 4.2. The mapping indicates that the main South Creek channel is classified as H6 and should be avoided during a flood event with large areas of the South Creek floodplain H5 and the remainder H4 or less. The tributaries of Cosgrove, Badgerys and Blaxland creeks have H4 to H3 in the main channels and H3 to H1 in their floodplains.

Table 4.2 Hazard vulnerability classification

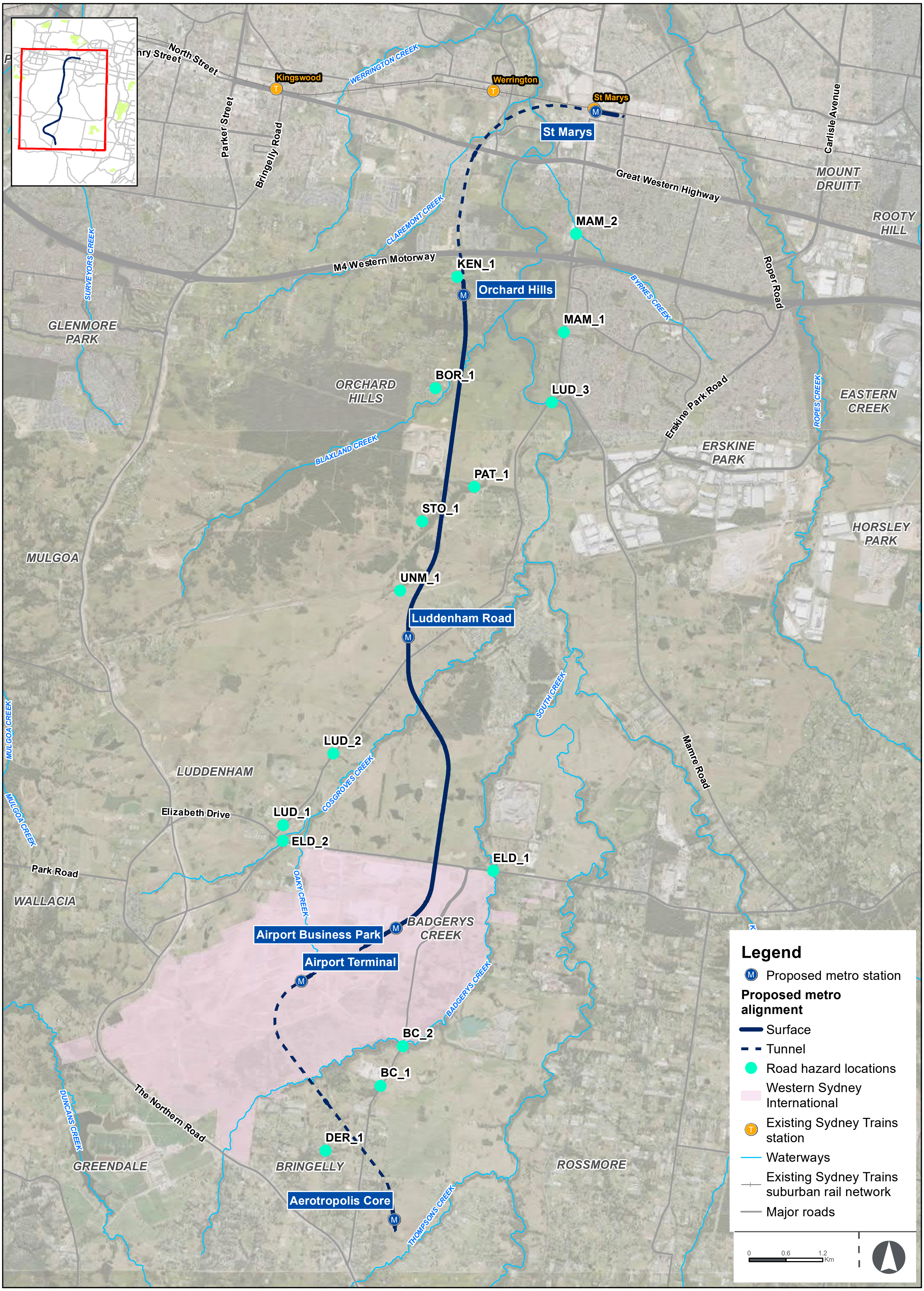
Hazard vulnerability classification	Description	Classification limit (D and V in combination) m^2 /s	Limiting still water depth (D) m	Limiting velocity (V) m/s
H1	Generally safe for vehicles, people and buildings.	D*V ≤ 0.3	0.3	2.0
H2	Unsafe for small vehicles	D*V ≤ 0.6	0.5	2.0
H3	Unsafe for vehicles, children and the elderly.	D*V ≤ 0.6	1.2	2.0
H4	Unsafe for vehicles and people.	D*V ≤ 1.0	2.0	2.0
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure	D*V ≤ 4.0	4.0	4.0
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure	D*V ≤ 4.0	-	-

Large areas of the study area are rural landscape. To understand the how existing flood hazard may affect the community, the preliminary flood hazard at selected road crossings has been documented in Table 4.3, with the locations shown in Figure 4-6. It is noted that based on the flood hazard categories in Table 4.2, a road is considered unsafe (non-trafficable) for small passenger vehicles when the flood hazard exceeds 0.3 m^2/s. The roads estimated to be currently unsafe, with flood hazard above 0.3 m^2/s are highlighted in bold.

Table 4.3 Flood hazard for selected roads for existing and design scenarios.

Road	Existing Case Hazard (m^2/s)			
	0.5EY	0.2EY	5%AEP	1%AEP
Stockdale Road (STO_1)	0.01	0.02	0.03	0.05
Patons Lane (PAT_1)	0.03	0.14	**0.32**	**0.53**
Mamre Road (location 1) (MAM_1)	-	-	0.03	0.07
Mamre Road (location 2) (MAM_2)	-	-	-	0.08
Luddenham Road (1) (LUD_1)	0.02	0.02	0.03	0.03
Luddenham Road (2) (LUD_2)	**0.32**	**0.36**	**0.42**	**0.53**
Luddenham Road (3) (LUD_3	0.16	**0.97**	**1.84**	**2.42**
Kent Road (KEN_1)	0.07	0.09	0.15	**0.32**
Elisabeth Drive (1) (ELD_1)	0.00	0.01	0.08	0.16
Elisabeth Drive (2) (ELD_2)	0.02	0.04	0.06	0.16
Unnamed Road (UNM_1)	**0.44**	**0.45**	**0.62**	**0.81**
Derwent Road (DER_1)	0.01	0.04	0.08	0.14
Bordeaux Place (BOR_1)	-	-	-	-
Badgerys Creek Road (1) (BC_1)	0.08	0.1	0.11	0.12
Badgerys Creek Road (2) (BC_2)	-	-	**0.71**	**1.68**

Note: Bold values indicate locations roads are estimated to be unsafe, with flood hazard above 0.3 m^2/s



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Reporting locations for road hazard assessment

Figure 4-6

4.1.11 Water quality

Several catchment condition and water quality studies have been carried out in the Hawkesbury-Nepean. The Hawkesbury-Nepean River Health Strategy (Hawkesbury-Nepean Catchment Management Authority, 2007) and the Cooperative Research Centre for Irrigation Futures Report (2007) described the South Creek catchment as one of the most degraded in the Hawkesbury-Nepean. The hydrological and sediment regimes have been dramatically altered by vegetation clearing and increasing urbanisation in the catchment. Both reports noted that the recovery potential of the catchments were considered low but that the existing waterways form important corridors for remnants of endangered riparian vegetation.

The major water quality issues in South Creek are related to high nutrient concentrations derived from both point and diffuse pollution sources and subsequent algal and aquatic weed growth. Historically point pollution sources that impact South Creek's water quality include effluent released from five sewage treatment plants in the lower parts of the catchment. These plants are generally located downstream of the project footprint. The Sewage Treatment System Impact Monitoring Program (Sydney Water, 2017) noted that site-specific total nitrogen from these plants was not significantly correlated with nitrogen levels in South Creek but that total phosphorus loads from the plants was positively correlated with phosphorus levels in South Creek.

Diffuse pollution sources are often more difficult to quantify and manage than point sources, but in the Hawkesbury-Nepean catchment it has been established that diffuse sources such as urban and agricultural runoff have just as great if not greater effect on water quality than point sources. Diffuse sources of pollutants include market gardens, cattle and sheep grazing intensive agriculture such as poultry farming as well as both urban and industrial land uses (Sydney Water, 2017).

Remedial actions that have been undertaken in South Creek catchment in relation to water quality have demonstrated improvements, however it is noted that the condition of the system was poor to start with and that there is forecast to be continuing pressure on these systems as population growth and urbanisation continue.

Water quality monitoring

Water quality monitoring was carried out for the future M12 Motorway project. Five of the monitoring locations used for the future M12 Motorway project are relevant to the project, however only one sampling event was carried out and there was water present at only two of the five locations during sampling. Table 4.4 shows the data from these locations compared to the ANZECC values. Values highlighted in red indicate exceedances of the ANZECC guidelines.

Table 4.4 Water quality monitoring data from the M12 Motorway project compared to ANZECC guideline values

	DO %s	EC (□S/cm)	pH	Turbidity NTU	TN mg/L	TP mg/L
ANZECC	85-110%	125-2200	6.5-8	6-50	0.5	0.05
M12_2 Cosgroves Creek	**62.7%**	**3510**	**8.03**	16	**2.3**	<0.05*
M12_6 South Creek	**80.1%**	**2640**	**8.47**	14.3	**1.4**	<0.05*

*Values lower than the laboratory limit of detection

Bold values outside ANZECC limits

The sample at Cosgroves Creek failed to comply with dissolved oxygen, total nitrogen and electrical conductivity targets in this sampling event. Dissolved oxygen was low and total nitrogen was high Electrical conductivity was also high, likely due to groundwater intrusion and low flows (Transport for NSW, 2019). The sample from South Creek shows dissolved oxygen values slightly lower than the ANZECC guideline values. Total nitrogen values were two to four times higher than the ANZECC guideline values and Electrical conductivity and pH were also higher than the ANZECC guideline values.

As such the existing water quality in the area is generally not meeting the recommended ANZECC values. The existing water quality is considered poor and degraded due to high nutrient concentrations and low dissolved oxygen concentrations.

4.1.12 Catchment and watercourse health

The study area is dominated by surface runoff from rainfall which concentrates into defined watercourse catchments as described in Section 4.1.1. Many of the watercourses are interrupted by storages used for grazing and cropping which is a reflection of the current land uses across the study area. Section 4.1.1 describes the existing geomorphic conditions across the study area including stream order. The flood modelling of the regular rainfall events indicates that these regular events are confined to the main channels and relatively quickly flow away to the lower portions of the South Creek catchment.

The urbanised areas of the study area (predominantly north of the M4 Western Motorway) have more formalised drainage systems that discharge into the main watercourses intersected by the project.

As described in Section 4.1.8 surface watercourses are likely to be discharge areas for groundwater, however due to the low hydraulic conductivity of the Bringelly Shale and overlying soils, the total amount of groundwater discharge is likely to be small compared to the overall flow in the creeks and alluvial aquifers. The climate conditions indicate a summer dominant rainfall pattern.

The existing catchment and watercourse health south of the M4 Western Motorway could be considered adequate for the existing land uses such that all surface water available is utilised for grazing and cropping and flood events across the floodplain provide additional surface water at opportunistic times. Rainfall runoff and some groundwater baseflows are likely to contribute to flows within the watercourses particularly during periods of low rainfall. There are also large areas of riparian vegetation that help contribute to the overall catchment and watercourse health.

Considering the existing health, water quality (Section 4.1.11) and geomorphic recovery potential (Section 4.1.13) the sensitive environments include Badgerys, Cosgroves, Blaxland and South Creeks.

North of The M4 Western Motorway were the land use becomes more urbanised the catchment is highly affected by development of the land such that rainfall does not infiltrate into the ground and all surface runoff is concentrated into channels that are directed to the nearest watercourse. The main South Creek channel however still has riparian vegetation which helps protect the watercourse but flows within the creek are affected by the land uses in the catchments.

4.1.13 Geomorphology

As described above, the project lies within the South Creek catchment. Within the study area, the catchment is characterised by gently undulating topography and meandering waterways. South Creek and its major tributaries have well vegetated riparian zones.

The project footprint crosses a number of tributaries of South Creek (refer to Figure 4-1). A desktop assessment of the existing geomorphic conditions is presented below.

Table 4.5 Geomorphology of watercourses within the study area

Watercourse	Stream order	NSW River Style	Existing condition[1]	Recovery potential	Description
South Creek	3rd	2 - Low sinuosity, fine grained	Moderate condition Moderate fragility	High	There is evidence of erosion in South Creek downstream of Luddenham Road bridge and at Orchard Hills at a bend in the creek for a reach of 50 -100 m (refer Photograph 4.1). This shows exposed and steep banks which indicates erosion. Downstream of this the creek does not appear to be affected by erosion, as the banks are more gently sloped and grassed down to the water surface (Photograph 4.2).
Badgerys Creek	1st	6 – Chain of ponds	Moderate condition High fragility	High	This section of Badgerys Creek has no permanent tributaries and is the main permanent watercourse in its part of the catchment. High fragility means this section of creek is vulnerable to changes in flow regime.
Cosgroves Creek	2nd	2 - Low sinuosity, fine grained	Moderate condition Moderate fragility	High	Moderate fragility means this section of creek is susceptible to change but has sufficient vegetation and consistency in flows to maintain its current form.
Blaxland Creek	1st	2 - Low sinuosity, fine grained	Moderate condition Moderate fragility	High	Moderate fragility means this section of creek is susceptible to change but has sufficient vegetation and consistency in flows to maintain its current form.
Byrnes Creek	1st	2 - Low sinuosity, fine grained	Moderate condition Moderate fragility	Low	Moderate fragility means this section of creek is susceptible to change but has sufficient vegetation and consistency in flows to maintain its current form.
Moore Gully	1st	6 – Valley fill, fine grained	Moderate condition High fragility	High	High fragility means this section of creek is vulnerable to changes in flow regime.
Thompsons Creek	1st	2 - Low sinuosity, fine grained	Moderate condition Moderate fragility	Moderate	Moderate fragility means this section of creek is susceptible to change but has sufficient vegetation and consistency in flows to maintain its current form.

1.Existing condition of the creek where impacted by the project

Photograph 4.1 South Creek immediately downstream of Luddenham Road

Photograph 4.2 South Creek downstream of Luddenham Road bridge looking north

4.2 Existing environment (on-airport)

4.2.1 Catchment overview

The Western Sydney International is located in the upper reaches of the catchments of Badgerys Creek, Cosgroves Creek, Oaky Creek (a tributary of Cosgroves Creek) and Duncans Creek.

Badgerys Creek passes through the Western Sydney International starting at the southern extent and continues for approximately 1.2 km in a northeast direction before its coarse returns to the Western Sydney International boundary. The creek forms the southeastern boundary of the Western Sydney International to Elizabeth Drive.

The headwaters of Oaky Creek are located in Western Sydney International and it flows in a northwesterly direction for around 2 km before it reaches the western boundary of the Western Sydney International.

A number of unnamed tributaries of Duncans Creek are located in the Western Sydney International site and flow in a westerly direction. Duncans Creek is a tributary of the Nepean River. The project does not directly impact the Duncans Creek catchment and as such is not discussed further.

The Stage 1 Western Sydney International works would result in major modification to the existing flow paths and catchment boundaries within the site. Western Sydney International I design incorporates a number of detention basins to mitigate increases in peak runoff across the site and addition of low flow culvert outlets underneath Elizabeth Drive to maintain low flow in Badgerys Creek.

4.2.2 Flooding behaviour

Flood modelling has been completed to understand flood behaviour within Western Sydney International. This understanding of flood behaviour is based on the modelling completed for the Western Sydney Airport Environmental Impact Statement (DIRD, 2016b) and the project. Key flood behaviour characteristics are discussed below.

Peak flood levels and depths

The flood modelling indicates that the Badgerys Creek floodplain is both within and outside of the Western Sydney International boundary. Figure 4-7 shows the base case 1%AEP flood extent and depth across Western Sydney International in relation to the project. There are several overland flow paths with multiple basins within the Western Sydney International boundary that contribute flows to Badgerys Creek.

For the 0.2EY event these overland flows paths have depths less than 0.1 m, but the basins are deeper with up to 0.5 m predicted. The main channel is predicted to have depths of 1 m with overbank areas up to 0.5 m deep. Refer to mapping shown in Figures C.1 to C.6 of Appendix C with the boundary of the Western Sydney International. For the larger events, such as the 1% AEP, these overland flow paths are still shallow and close to 0.1 m deep but the basin depths are over 0.5 m. Badgerys Creek overbank areas in the 1% AEP between 0.5 and 1 m in depth and the main channel greater than 1 m in depth. In the PMF event all flood liable land is inundated by over 1 m as predicted by the flood models.

Peak flood velocities

The flood modelling indicates that across the floodplains and within the overland flow paths the peak velocities are less than 0.5 m/s for the 0.2EY event. The main Badgerys Creek channel is the only watercourse with velocities greater than 0.5 m/s and up to 1 m/s. For the 1% AEP flood event, the floodplain and flood extents are wider but the peak velocities are no greater than 0.5 m/s and up to 2 m/s in the main Badgerys Creek channel.

For the PMF event, some of the upper reaches of the overland flow paths still have peak velocities of 0.5 m/s but the remainder of the floodplain has velocities between 0.5 and 1.0 m/s with up to 2.0 m/s in the main channel. Refer to mapping shown in Figures C.7 to C.11 of Appendix C which show modelled peak velocities.

Flood duration

The presence of the large storages within the Western Sydney International site are likely to affect the duration of inundation for the overland flow paths and minor tributaries. The main Badgerys Creek channel has a duration of inundation between 18-24 hours for the full range of flood events with the overland flow paths being less than 6 hours. The storage basins are predicted to have durations between 12 and 24 hours. Figures C.12 to C.16 of Appendix C which show modelled duration of inundation.

Property flood affectation

The Western Sydney Airport Environmental Impact Statement (DIRD, 2016b) did not identify any flood affected properties within the project footprint.

Hazard

For the Western Sydney International site, the predicted flood hazard is categorised as H1, indicating areas a generally safe for people, vehicles and buildings (refer to Table 4.2 for detailed definition of hazard categories) for all flood liable areas except the basins where the deep water results in higher hazard and unsafe classification (H3 with small areas categorised H4).

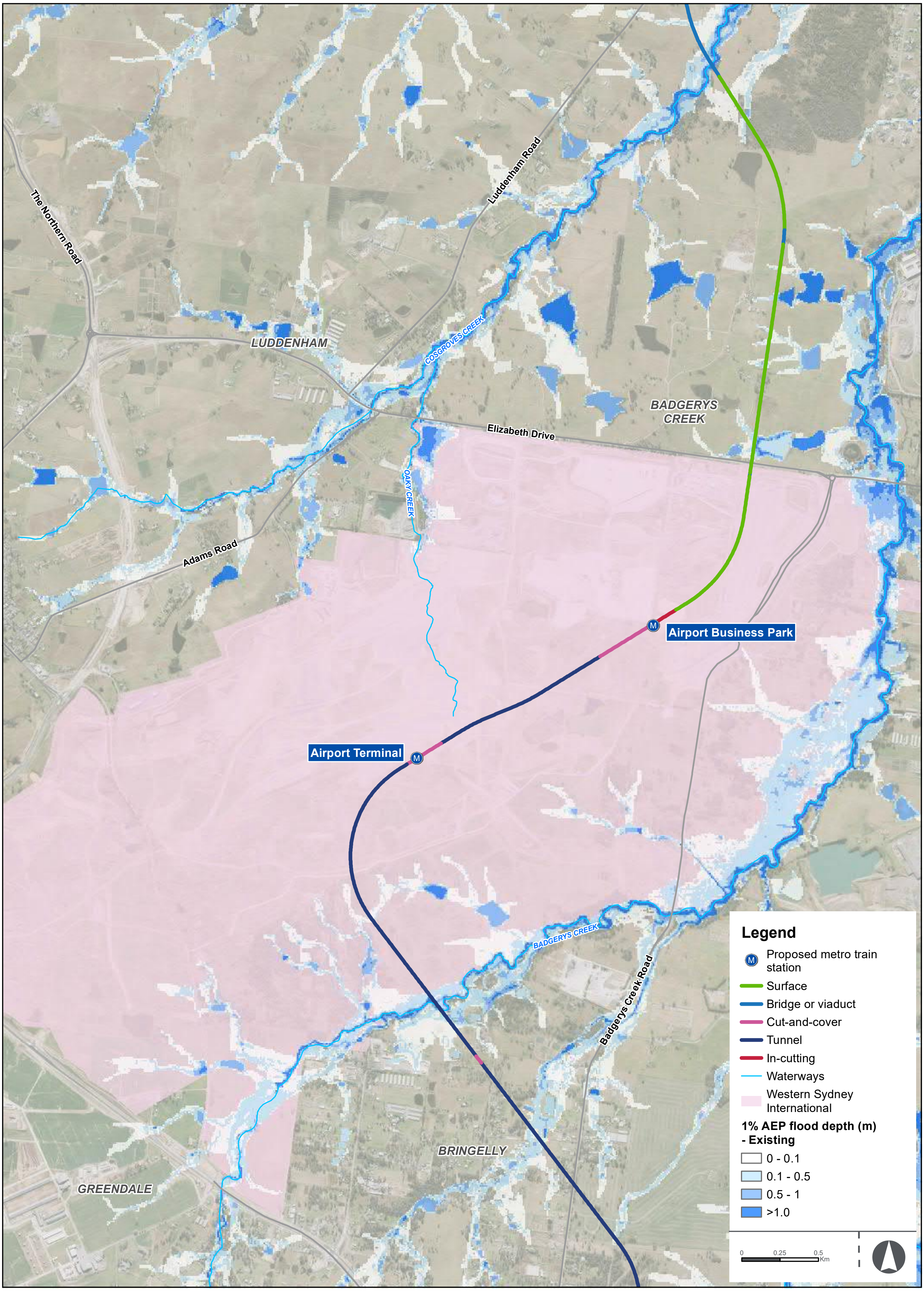

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Figure 4-10 1%AEP flood extent along Badgerys Creek at Western Sydney International

Figure 4-7

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4.2.3 Water quality

Water quality monitoring in the vicinity of the project site on-airport land has previously been carried out for a number of assessments at the future Western Sydney International site including:

- Western Sydney Airport - Surface Water Quality Assessment, GHD, 2016
- Environmental Field Survey of Commonwealth Land at Badgerys Creek, SMEC, 2014,
- Geology, Soils and Water Technical Paper – Proposal for a Second Sydney Airport at Badgerys Creek or Holsworthy Military Area, PPK, 1997

Table 4.6 shows the data from these studies. The items in bold indicate exceedances of the criteria. Monitoring locations are shown on Figure 4-8.

Table 4.6 Water quality data from previous studies at the Western Sydney International

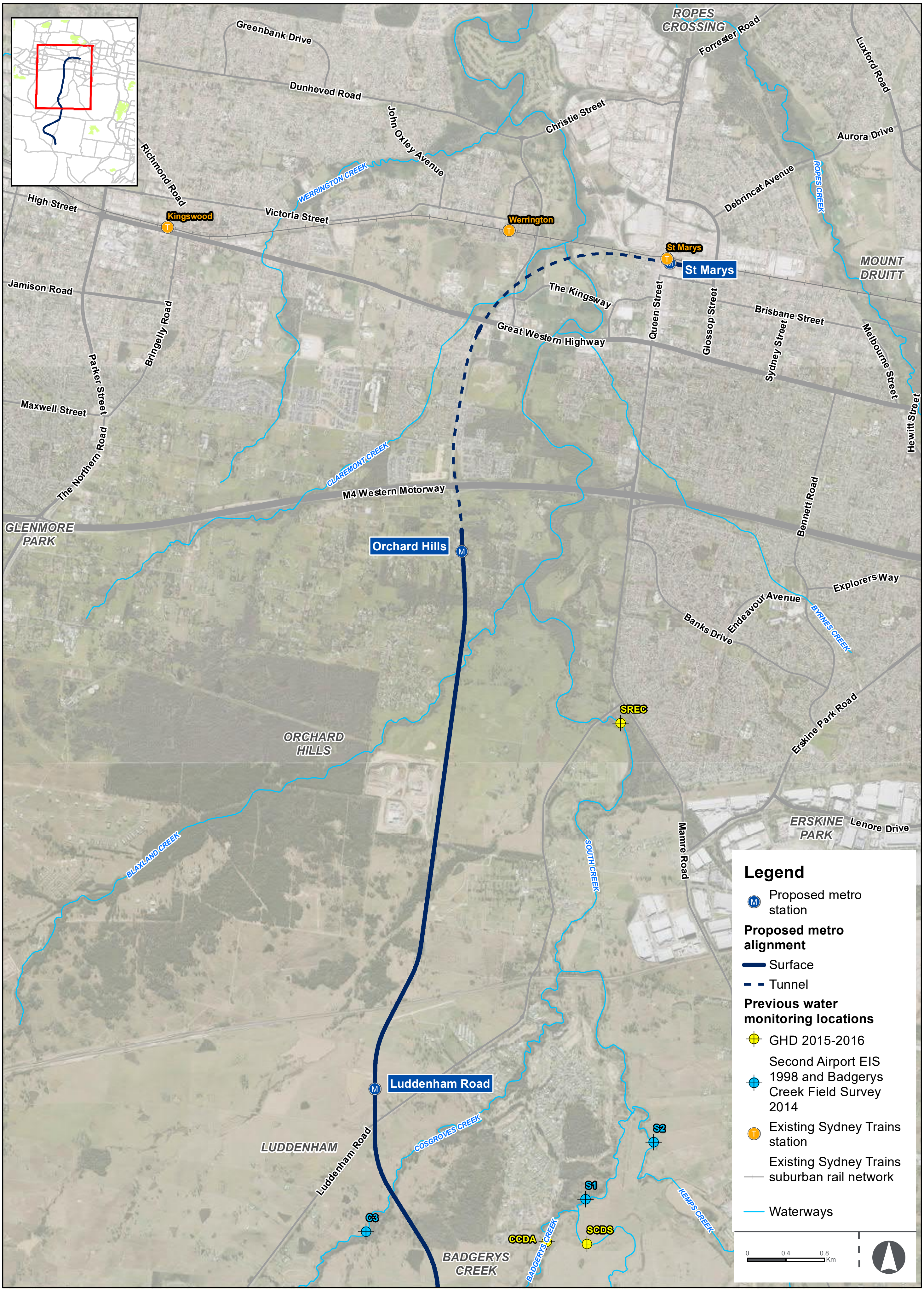
Location	DO %s	EC (µS/cm)	pH	Turbidity NTU	TSS mg/L	TN mg/L	TP mg/L
AEPR Limits	80%	-	6.5-9	<10%	<10%	0.1	0.01
ANZECC	85-110%	-	6.5-8	6-50	<40	0.5	0.05
Second Airport EIS (PPK 1997-1999)							
Badgerys Creek (B1 1996)	63	-	6.9	1.1	2	-	<0.02
Badgerys Creek (B2, 1996)	**150**	-	7.3	7	33	-	**1.2**
Badgerys Creek (B3, 1996/1998)	13-107	-	6.7-7.2	5.1-46	9-24	**0.12-2.3**	**0.26-0.47**
Cosgroves Creek (C1, 1996)	25	-	6.7	2.9	5	-	<0.02
Cosgroves Creek (C3, 1996/1998)	2-65	-	6.7-7.4	2.9-16	5-12	**1.23-1.7**	0.02-**0.07**
Duncans Creek (D1, 1996/1998)	15-50	-	6.7-7.1	5.2-12	6-13	0.02-**1.3**	0.02-0.04
South Creek (S1, 1998)	83-105	-	7-7.2	15-65	9-**56**	0.49-**1.6**	0.01-**0.14**
South Creek (S2, 1998)	60-87	-	6.8-6.9	7-82	5-19	0.44-**1.5**	0.01-**0.11**
South Creek (S3, 1998)	39-79	-	6.9-7.4	12-40	4-14	0.8-**1.52**	0.05-**0.5**
Thompsons Creek (T1, 1996/1998)	15-50	-	6.4-7.3	4.9-14	5-11	0.02-**1.14**	0.01-0.04
Badgerys Creek Environmental Field Survey (SMEC 2014)							
Cosgroves Creek (C1)	-	-	-	11	32	**0.8**	**0.09**
Badgerys Creek (B1)	-	-	-	3.2	10	**2.8**	**1.6**
Badgerys Creek (B2)	-	-	-	14	17	**2.5**	**0.5**
Badgerys Creek (B3)	-	-	-	11	16	**2.6**	**0.5**
Thompsons Creek (T1)	-	-	-	17	31	**0.7**	**0.07**
Duncans Creek (DN1)	-	-	-	35	30	**1.5**	**0.1**
Western Sydney International EIS WQ monitoring (GHD 2015, 2016)							
Badgerys BCUS	21.3	2710	-	12	23	**6.2**	**0.42**
Badgerys BCMS	36	3100	-	7.71	5	**18.5**	**0.31**

Location	DO %s	EC (µS/cm)	pH	Turbidity NTU	TSS mg/L	TN mg/L	TP mg/L
Badgerys BCDS	8.6	3050	-	13	5	**2.3**	**1**
Cosgroves OCDS (CCUS)	55.4 (73.6)	4320 (5020)	38.1 (4.25)	19 (5)	1.2 (0.8)	0.05 (0.03)	-
Duncans DCDS	52.5	847		**89.2**	14	**0.9**	**0.06**
GHD (Nov 2015 to July 2016, average monthly data)							
L1 (DS Basin 1)	44.4	1486	-	39.9	14.2	**3.7**	**0.4**
L2 (DS Basin 2)	45.7	1646	-	19.1	15.6	**3.2**	**0.4**
L3 (DS Basin 3)	57.1	6933	-	**55.1**	20.7	**5.6**	**0.8**
L4 (DS Bain 4)	45.8	1825	-	**70.2**	26.3	**9.3**	**1.6**
L5 (DS Basin 6)	54.5	2370	-	28.2	8.4	**2.4**	**0.1**
L6 (DS Basin 7)	41.2	770	-	31.9	8.8	**1.1**	**0.1**
L7 (DS Basin 8)	58.8	1502	-	20.3	11.7	**1.1**	**0.1**
L8 (Greendale Rd)	48.1	1534	-	33.6	10.5	**1.1**	**0.1**
L9 (Northern Rd)	17.8	2736	-	**251.2**	**80.1**	**36.3**	**5.9**

The data has been collected over greater than 20 years and shows exceedances throughout the 20-year period. The data collected as part of the most recent water quality monitoring for the development of the Western Sydney Airport Environmental Impact Statement (DIRD, 2016b) indicated that values were generally above the AEPR limits and the ANZECC default guideline values for nutrient loads and below for dissolved oxygen. However, the data showed total suspended solids loads were generally low and achieved the ANZG 2018 guideline default values. These results were consistent with the 2014 and 1997 studies and were considered consistent with the dominant cleared agricultural land uses in the area.

The data also showed that conductivity levels were above those for typical lowland rivers. Heavy metals, hydrocarbons and pesticides were also sampled. The results for pesticides organochlorines (OC), organophosphates (OP), total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbon (PAH), benzene, toluene and xylene (BTX) from fuels and phenols were negative for all samples. Arsenic, cadmium, lead, nickel and mercury were found to be below the detectable limits of below the ANZECC guideline levels. Some exceedances were observed for chromium, copper and zinc.

Overall, the data showed that both the Western Sydney International site and downstream catchments are degraded, particularly in terms of nutrients. The existing water quality is not compliant with the AEPR limits or the ANZECC default guideline values for protection of aquatic ecosystems, primary and secondary contact recreation and irrigation water used for food and non-food crops.



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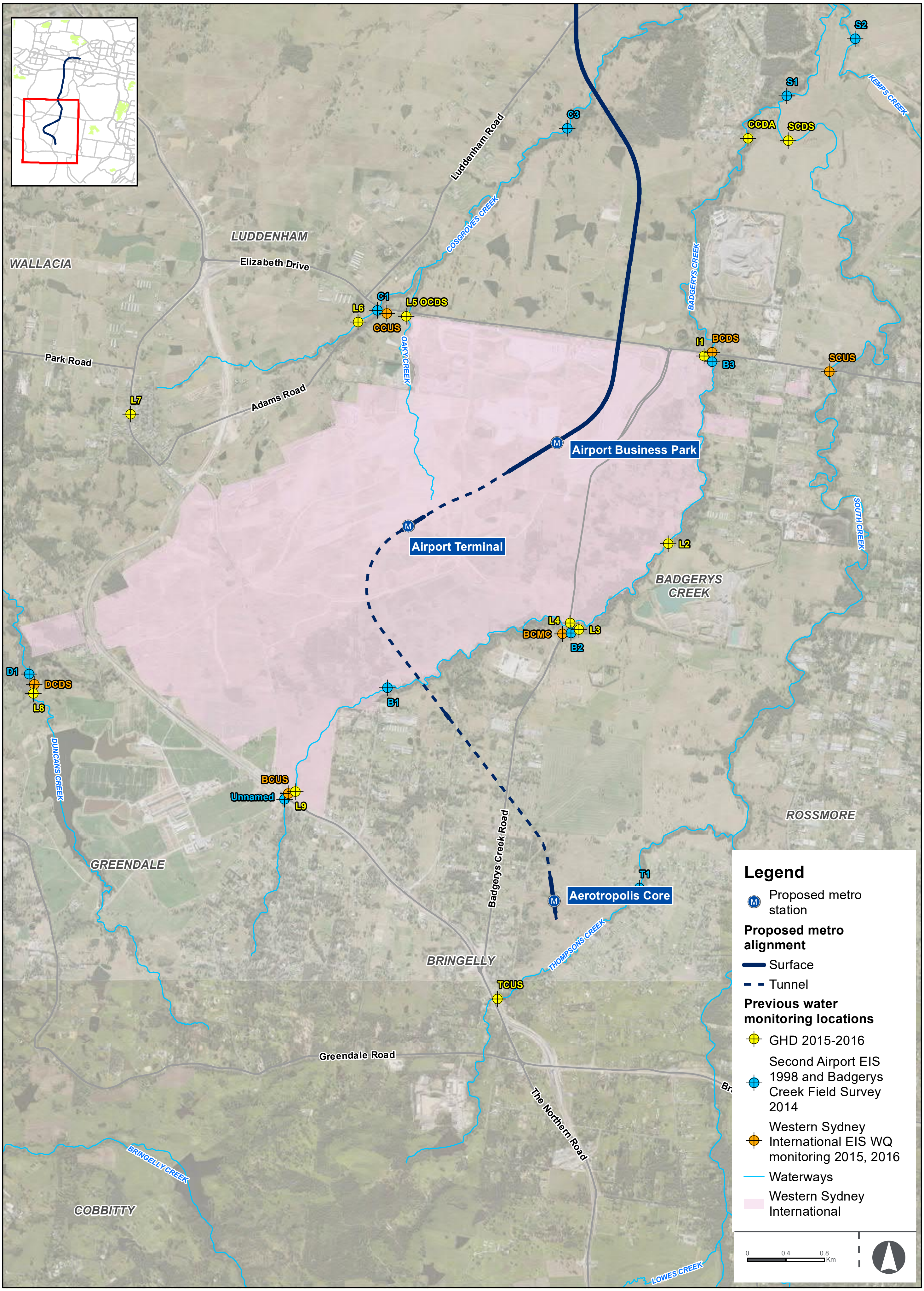
Previous surface water monitoring locations

Figure 4-8a



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Previous surface water monitoring locations

Figure 4-8b

As a result, interim site specific trigger values were prepared for Western Sydney International based on nine months of data and are shown in Table 4.7. These interim values were considered to provide an early indication of the likely range of results of water quality monitoring during construction of Western Sydney International and broader water quality of the project catchment.

Table 4.7 Western Sydney International Interim Site Trigger Levels

	TSS (mg/L)	TP (mg/L)	TN (mg/L)
Interim Site Trigger Levels	23.2	0.92	6.2
ANZECC default guideline trigger levels	40	0.05	0.5
AEPR Limits	Change of not more than 10% from seasonal mean	0.01	0.1

4.2.4 Geomorphology

Through Western Sydney International, Badgerys Creek, Oaky Creek and Duncans Creek display evidence of path and ongoing bed degradation (GHD, 2015). The creeks have a vegetated riparian zone and are considered to be in a moderate geomorphic condition. As a result of past clearing, the construction of farm dams along the watercourses and ongoing agricultural activities, tributaries of Badgerys Creek and Cosgroves Creek across the Western Sydney International site are also considered to be in a moderate state of geomorphic condition. A desktop assessment of Duncans Creek is presented in Table 4.8.

Table 4.8 Geomorphic Assessment (on-Airport)

Watercourse	Stream order	NSW River Style	Existing condition	Recovery potential	Description
Duncans Creek	1st	2 - Low sinuosity, fine grained	Moderate condition Moderate fragility	Moderate	Moderate fragility means this section of creek is susceptible to change but has sufficient vegetation and consistency in flows to maintain its current form.

5.0 Assessment of construction impacts

5.1 Construction impacts (off-airport)

5.1.1 Flooding

Construction of the project has the potential to cause flood impacts and/or be impacted by flooding. Modelling of construction activities and staging has not been carried out, but potential impacts include:

- inundation and damage to construction sites, machinery, plant and equipment
- safety risks associated with high flow velocities and/or deep water, potentially restricting access to construction areas and constituting a hazard to construction workers and personnel
- temporary blockage of flow paths causing afflux beyond the construction footprint due to stockpiling, location of construction works or equipment, fencing, temporary waterway crossings and works to prepare the viaduct footings
- increased flow rates in receiving drainage lines, downstream of the construction footprint due to vegetation clearing and increased hardstand areas
- changes to flow paths downstream of the construction footprint due to removal and/or infilling of dams as part of construction activities, construction of culverts, construction of civil works required for rail embankments, permanent and temporary roads, possible widening of the waterways through processes of scour and bank erosion.

The likelihood and magnitude of risks would vary depending on the stage of construction and timing of high rainfall events in relation to the stage of constructions activities. Given the project has a construction timeline of about five years, the construction phase is likely to experience variation in weather events. Rainfall and water levels would be monitored within key watercourses to identify potential flooding events during the constructions phase.

An assessment of potential impacts associated with project construction activities is provided below. This assessment has been based on a review of proposed construction works against the 5%AEP flood extent (refer to Figure 5-1).

Viaduct structures

The project would cross Blaxland Creek and associated tributaries, an unnamed Creek north of Warragamba to Prospect Water Supply Pipeline/south of Patons lane, Cosgroves Creek with viaduct structures. Construction work would involve clearing of riparian vegetation and topsoil stripping of up to 60 m for a standard construction footprint for viaduct construction. Work would also include creation of temporary roads (including temporary creek crossings), hardstand areas, work set down areas and crane pads. Clearing of vegetation has potential to increase flow rates and cause scour. Construction works also have the potential to temporarily block floodplain flows with temporary crossings and works to prepare the viaduct footings. The potential impacts at each viaduct crossing are not considered to be substantial and would be localised with minimal impacts beyond the immediate construction footprint. As such, limited, if any, afflux impacts are expected to upstream infrastructure or properties, but localised changes in velocities are expected to occur around the footings with potential for scour at these sites.

Works around the Warragamba to Prospect Water Supply Pipelines would as best as possible remain outside of the pipelines corridor to minimise impacts. All surface water around the viaduct structures would be managed to ensure water is not directed into the corridor.

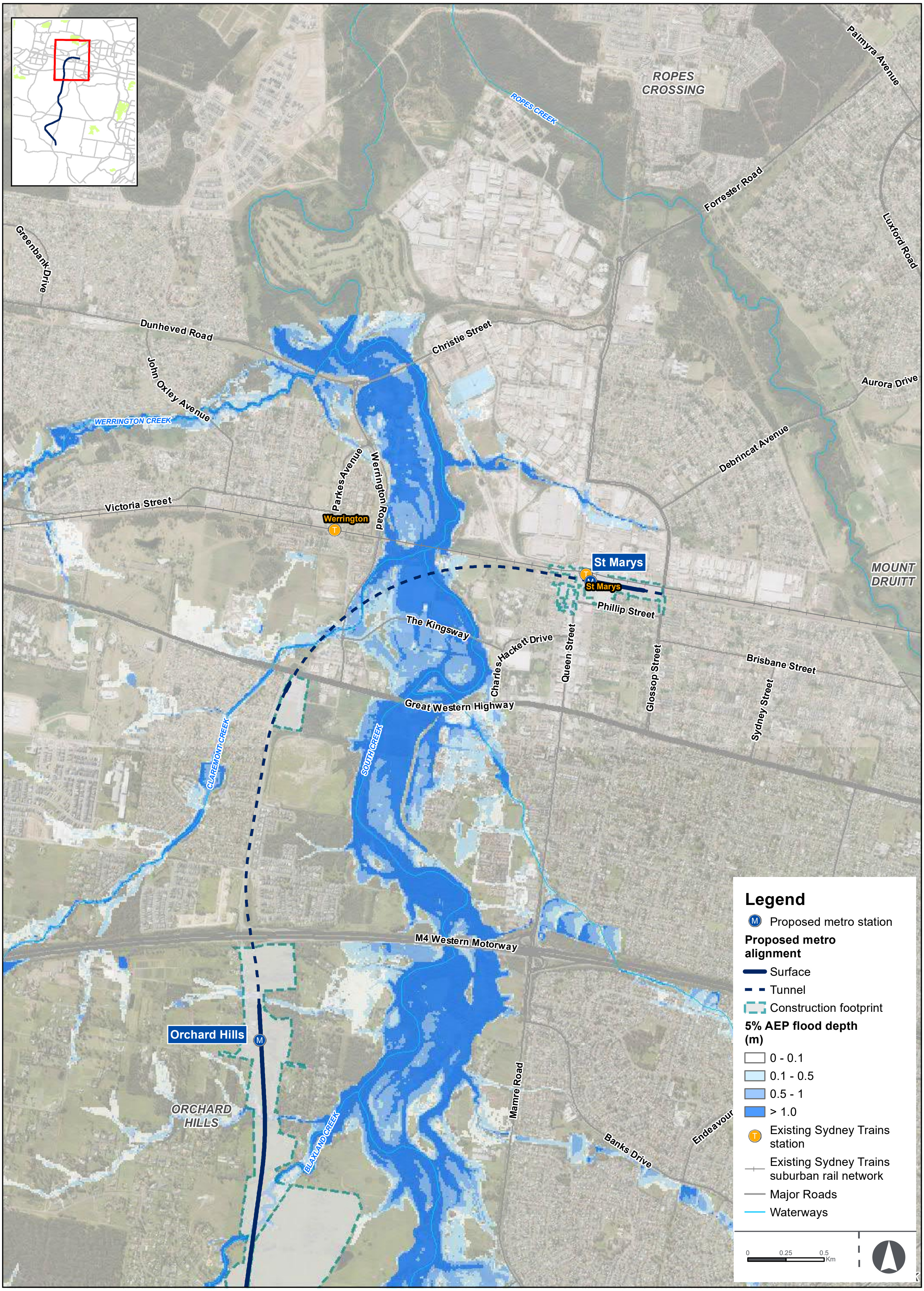
Tunnelling and associated works

The tunnelling support site for the St Marys to Orchard Hills tunnelled section of the project would be located adjacent to Kent Road in Orchard Hills and would also provide for construction of the tunnel portal and dive structure. This site is not flood prone in a 5%AEP. As this is the design event being considered for assessment of construction impacts there would therefore be no impacts to or from flooding at the tunnelling support site.

A service facility will be located at Bringelly off Derwent Road which will involve a cut and cover type construction with most facilities below ground. Part of the site is flood prone in the 5% AEP with depths up to 50 mm and there is an existing farm dam with great depths predicted. There is likely to be some minor redistribution of overland flows across the site due to the construction of the facility but these will be localised and managed during construction.

Station construction

Six stations are proposed as part of the project. The stations (and therefore associated construction sites) are all located outside flood prone areas and therefore would not result in impacts to or from flooding.



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5% AEP flood extent across construction footprint

Figure 5-1a

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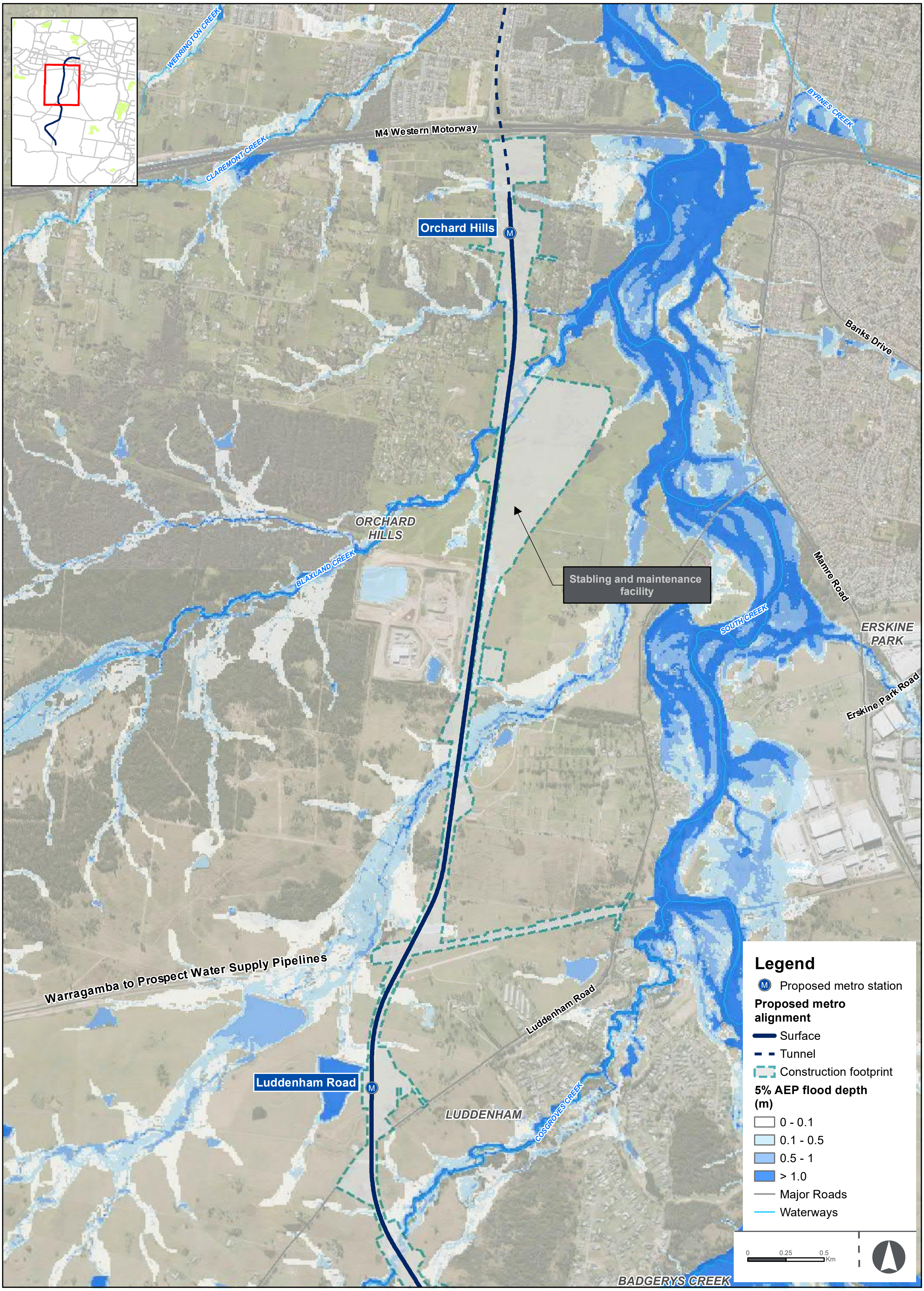

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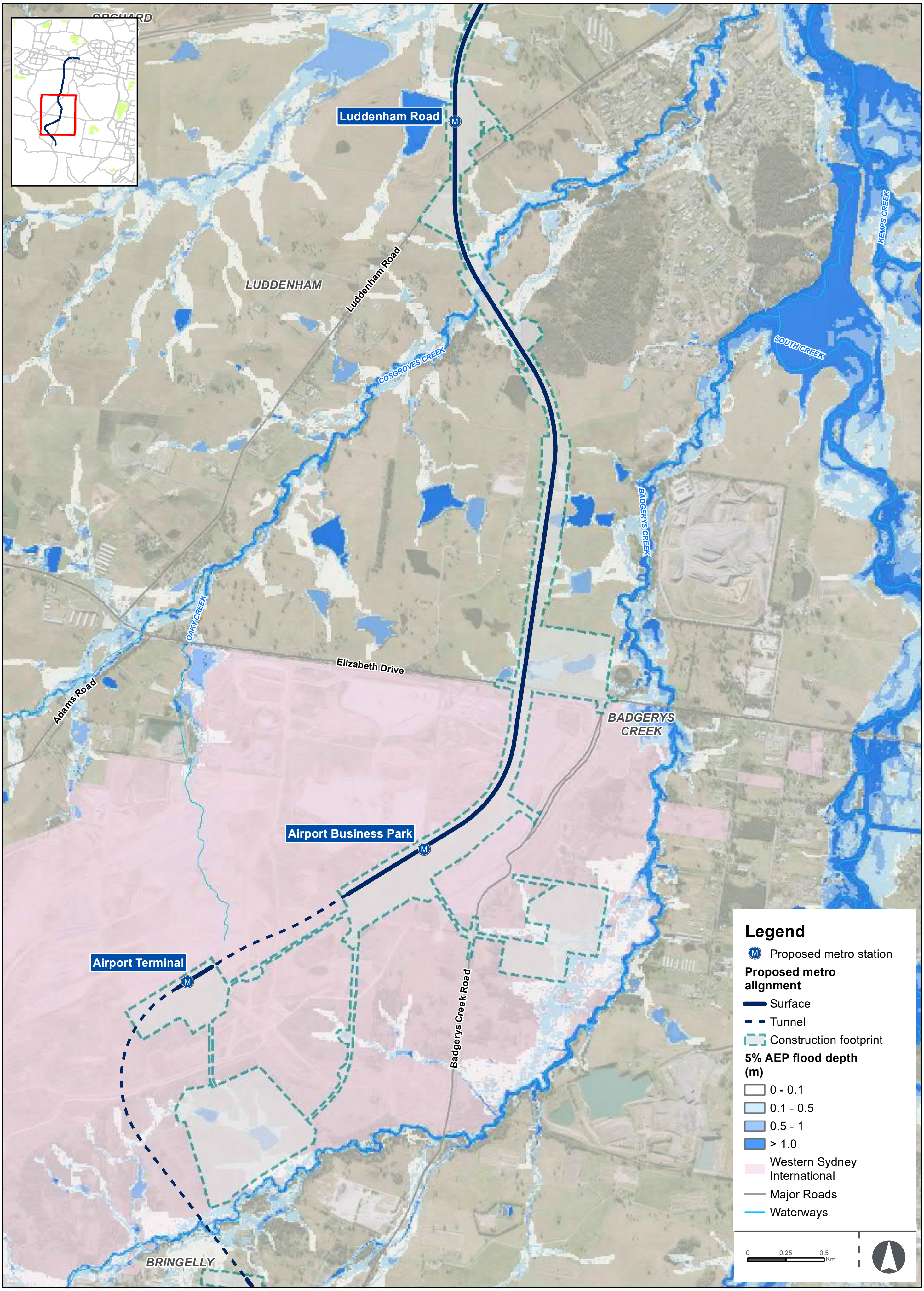
5% AEP flood extent across construction footprint

Figure 5-1b



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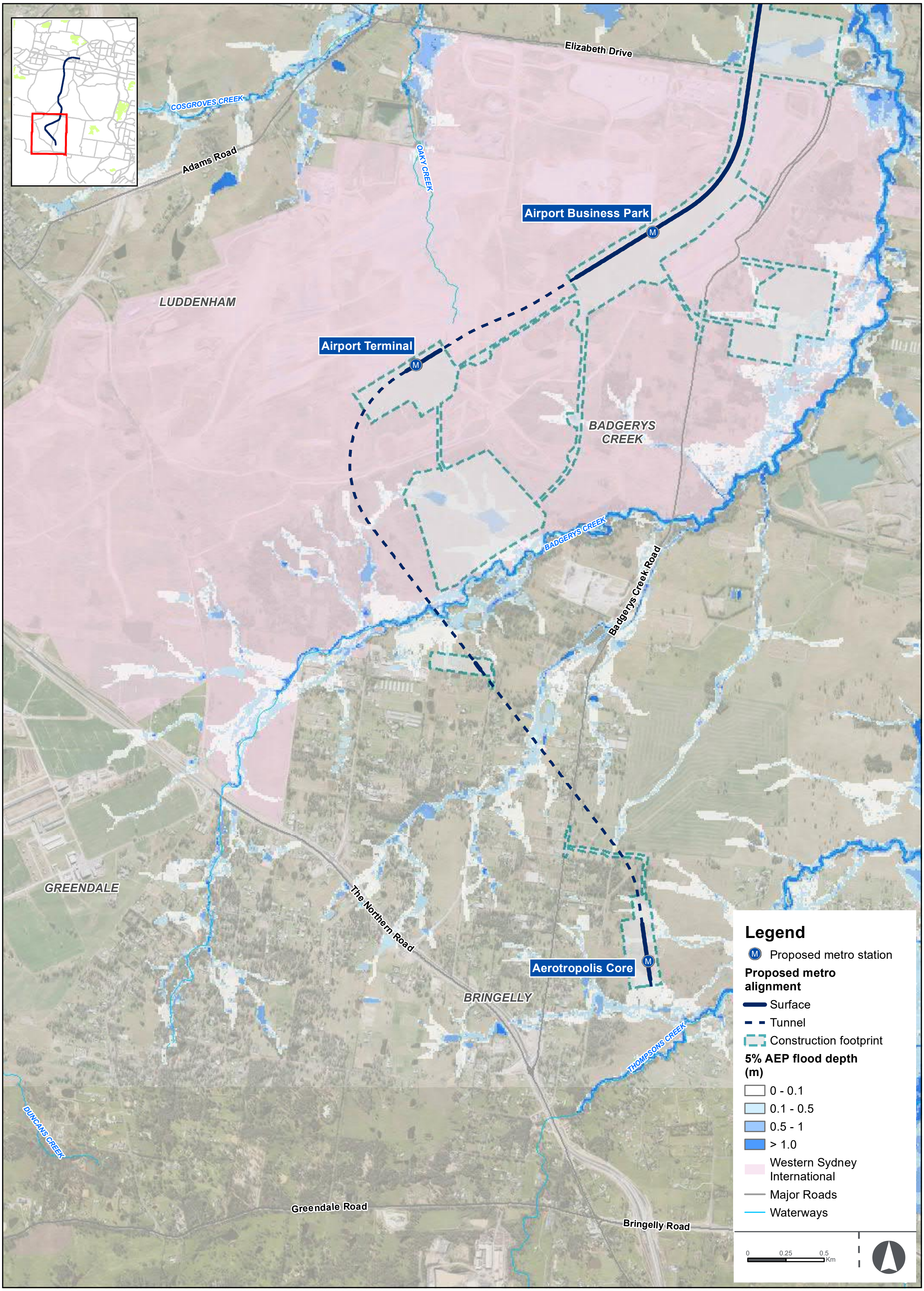
5% AEP flood extent across construction footprint

Figure 5-1c



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5% AEP flood extent across construction footprint

Figure 5-1d

Stabling and maintenance facility

The stabling and maintenance facility is located north of Patons Lane and south of Blaxland Creek and this site is partially within the PMF flood extent for Blaxland Creek/South Creek. Works at this facility are largely located outside the extent of the 5%AEP. Works associated with construction of the facility intersect the 5%AEP floodplain on upstream extents of minor tributaries of Blaxland Creek. It is therefore expected that any flood impacts associated with construction of this facility would be minimal.

There is potential for inundation and damage to occur during construction should a large flood event occur. Site planning, layout and management would be carried out in accordance with the Blue Book to minimise potential flooding impacts. The site planning would seek to keep all major construction sites outside the 5%AEP flood extent and therefore not impact land beyond the construction footprint. For larger events, the site layout would consider the PMF flood extent but potentially result in an increase in flood extent at the confluence of Blaxland and South Creeks. This impact would be temporary and unlikely to be substantial as the construction works would not completely block the floodplain with the facility.

5.1.2 Water quality

The construction of the project has the potential to further degrade the water quality of the waterways within the study area and areas downstream of the project. Construction of the project may lead to increases of the following pollutants into waterways:

- nutrients (nitrogen and phosphorus) – commonly present in agricultural areas that may become mobilised from disturbance of agricultural land for construction work
- sediment from vegetation and top soil clearing, soil excavation, movement and storage and stormwater runoff through disturbed sites
- chemicals, fuels and hydrocarbons from use, refuelling and maintenance of equipment and construction machinery
- concrete slurry and wastewater – from mobile concrete batching plants
- contaminants of concern related to previous land uses - heavy metals, TRH, BTEX, PAHs, OCPs and OPPs
- heavy metals such as zinc, lead, copper, nickel, cadmium and chromium from disturbance of contamination and use and maintenance of vehicles and plants
- gross pollutants such as paper and plastic packaging and materials from material use on construction sites and general construction staff litter.

Without mitigation activities, there is potential for water quality impacts from construction sites at all stations (St Marys, Orchard Hills, Luddenham Road, Aerotropolis Core), the services facilities at Claremont Meadows and Bringelly, the stabling and maintenance facility and the length of the project corridor.

While it has been noted that the quality of the existing environment is already degraded, the construction of the project may further degrade water quality if not properly managed. The likelihood and magnitude of risks would vary depending on the stage of construction, the area of disturbance and presence of high rainfall or wind weather events. In accordance with the Construction Environmental Management Framework, soil and water mitigation and management measures would be implemented at all construction sites and this would limit the impact of the project. These would be soil and water measures which are commonly applied and well understood and are discussed in further detail in Chapter 8.0.

An assessment of potential impacts associated with project construction activities and specific locations is provided below.

Erosion and sedimentation

There would be extensive earthworks required for the project, particularly at tunnel and station construction sites but also for all general civil works required for rail embankments, permanent and temporary roads and site offices and ancillary facilities. Significant earthwork activities would include cut and fill to achieve design levels, excavation for station sites and tunnel boring. Land would also be required for construction compounds to support tunnel excavation and viaduct construction. This would require the movement of large quantities of material (refer to Section 8.6 of the EIS)

Activities that directly disturb soils such as vegetation clearing, top soil clearing and earthworks, as well as other activities like vehicle movements and changes to natural drainage lines may lead to increased erosion and export of sediment to waterways during construction. These risks would be ongoing throughout the life of the construction phase and would be highest at locations with a slope of greater than 2.5%, that are near waterways and that are frequently disturbed. Risks of sediment transport and erosion would also increase during high rainfall and wind weather events.

Earthworks would increase the amount of disturbed and exposed soil available, which may impact the surface water quality of the environment through:

- changes to surface water run-off or evaporation due to clearing vegetation coverage. This may increase run-off volumes at both the temporary or long-term time scale
- increased surface water run-off due to soil stabilisation earthworks. Soil stabilisation may result in change to the permeability of the natural soils
- increased turbidity, lowered dissolved oxygen levels and increased nutrients in water ways
- reduction in channel habitat from sediment transport and deposition.

These potential impacts would be accounted for in the Project Construction Environmental Management Framework and associated Soil and Water Management Plan (SWMP) and Progressive Erosion and Sediment Control (PESC) and on site management protocols. Site specific PESCs would be required at each major construction site to manage and minimise the risks of impacts to water quality.

The SWMP and site specific PESC would include sediment and erosion controls such as sediment fences, silt traps and bunds and controls, as detailed in Chapter 8.0 (Management and mitigation measures).

Correct implementation of site management protocols and controls as described the SWMP would minimise potential impacts to the surface water quality.

Stockpiling and spoil handling

The construction of the project would generate spoil and other wastes that would be stored in stockpiles. Materials that may be generated through the construction phase would include vegetation waste, general construction and demolition waste and excess spoil from tunnelling excavations, bulk earthworks for embankments and piling. Stockpiling is common practice given the volume of material likely to be moved and its timing cannot typically be done in a manner that facilities transport and final placement.

Stockpiling of earthwork materials poses a risk to water quality in receiving environments through the increased likelihood of movement of sediment. Stockpiling of mulched vegetation from clearing of trees and shrubs poses a risk of tannins leaching into watercourses, and increased loads of organics in watercourses. The discharge of water that is high in tannins may increase the biological oxygen demand of the receiving environment, which may in turn result in a decrease in available dissolved oxygen. Once discharged to the environment, tannins may also reduce visibility and light penetration, and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

This material would be minimised and reused where possible. Excess spoil is stockpiled in locations that are open to rainfall or runoff would include appropriate management measures such as sediment fences and diversion drains to mitigate the impact of sediment movement offsite. Correct implementation of stockpile management protocols would mitigate and mange impacts to the receiving environments water quality.

Viaduct construction

Construction of viaduct structures over Blaxland Creek, a tributary of Blaxland Creek (south of Lansdowne Road), the Warragamba to Prospect Water Supply Pipeline and Cosgroves Creek have the potential to cause water quality impacts to sensitive areas. Construction work would involve riparian vegetation clearing and topsoil stripping of up to 60 m for a standard construction footprint for viaduct construction. Work would also include creation of temporary roads temporary creek crossings, hardstand areas, work set down areas and crane pads. Exposure and disturbance of soils for these areas would increase the risk of sediment erosion and transport to the waterways, particularly on sloped sites.

Site specific management plans would be developed for each location and would aim to minimise disturbance of sediment in the waterways and any sediment of pollutant laden runoff from adjacent construction sites. They would be prepared in line with best practice measures as outlined in the Blue Book.

Viaduct works in the vicinity of the Warragamba to Prospect Water Supply Pipelines would be carried out in accordance with Water NSW Guidelines for development adjacent to the Warragamba pipelines (Water NSW, 2020) to ensure no stormwater runoff into the pipelines corridor.

Potential for spills and litter

The following activities may result in release of contaminants, oils, fuels, grease, chemicals and gross pollutants into the waterways in and surrounding the project:

- machinery and equipment operation, refuelling, maintenance and wash down
- spills and failure of machinery
- concrete batching, treatment and curing
- disturbance of contaminated soils
- inadequate management of chemicals, spoil, material stockpiles and litter from construction sites
- litter generating activities from staff at office and construction areas.

Pollutants from these activities may be picked up in runoff from the site and enter the waterways and be transported downstream of the project footprint. Water quality and ecological impacts may result from release of these contaminants into the catchment. Mitigation and management measures would be implemented as part of the design and planning of the construction phases. This would reduce the potential for release of chemicals from construction sites and into waterways.

Water treatment plant discharges

Runoff from construction activities is the main vector through which pollutants from the site would enter receiving waterways. Release of untreated runoff from the construction areas would transport physical and chemical pollutants into the waterways which would have negative impacts to the receiving environment. To mitigate impacts from untreated runoff, water from general construction activities and water from construction activities that intercept groundwater, such as excavation of tunnels, stations and shafts, will be captured, treated and then reused or discharged. Any water that could not be reused would be discharged from the sites via construction water treatment plants

Wastewater would be treated at construction water treatment plants as shown in Table 5.1. This would include stormwater captured at the surface and groundwater captured in tunnels that would be pumped to the surface. The water treatment plant would use clarifiers, tanks, filters and chemicals to treat the water until it meets the requirements for discharge (or reuse). Water quality and ecological impacts may result from the release of the untreated stormwater and groundwater into the catchments but with appropriate treatment impacts can be minimised. Table 5.1 shows the locations, nominated discharge points and indicative discharge volumes from the plants. Locations of the discharge points during construction are shown in Figure 5-2.

Table 5.1 Treated water discharge from construction water treatment plants

Location	Discharge point	Indicative discharge volume when discharging (litres per second)
Off-airport		
St Marys	• Existing stormwater system	• 10
Claremont Meadows services facility	• Existing stormwater system	• 10
Orchard Hills	• South Creek via existing M4 Motorway drainage infrastructure • Existing stormwater system	• 10 • 10
Bringelly services facility	• Unnamed drainage line	• 2
Aerotropolis Core	• Thompsons Creek	• 10

At Aerotropolis Core, treated water surplus to reuse requirements would be discharged to Thompsons Creek. A connection would be required to transfer treated water from the water treatment plant to Thompsons Creek.. The location of the connection and discharge point would be identified during design development and be subject to the performance outcomes described in Section 8.2. If the works are not consistent with the performance outcomes described in Section 8.2, the works would be subject to separate assessment and approval.

5.1.3 Geomorphology

As described in Section 4.1.13 there are four watercourse crossings. Some watercourses are permanent and well defined and some only flow after rainfall runoff has occurred and can just be considered overland flow paths. The construction of viaducts and culverts within these watercourses would have a short term impact on the geomorphology of the watercourses and overland flow paths.

The potential impacts have been assessed qualitatively and should be considered when developing the construction plan and staging of works in and around watercourse crossings. The impacts include:

- changes in low flow channel shape due to temporary works changing local runoff behaviour
- increased sediment load due to clearing the site for construction
- loss of riparian vegetation and aquatic vegetation during construction which may increase the vulnerability of the channel to erosion
- removal of local levee banks or farm dams would change flood behaviour and therefore change flows in the channel.

Additionally, construction of power supply routes would require the crossing of both South Creek and Badgerys Creek. It is proposed that horizontal directional drilling would be carried out to install the cables underground. This would enable surface impacts to riparian vegetation at watercourse crossings and geomorphological impacts to be avoided.

5.1.4 Water balance

The excavation of the tunnels, stations, in-cutting sections and shafts is likely to intercept groundwater, resulting in the need to capture, treat and reuse or discharge water. Treated water would be re-circulated to the tunnel cutting face and also used for surface dust suppression.

Treated water that could not be recirculated would be discharged from the sites via construction water treatment plants (refer to Table 5.1). The reuse of treated water would be maximised during the construction works. Where surplus treated water required discharge from the sites, it would likely be discharged to the local stormwater system or directly to the surrounding landscape to evaporate. Other reuse options including Sydney Water trade waste agreement(s) and use of treated water at nearby projects (such as Western Sydney International and future M12 Motorway) would be investigated during detailed design.

Surface water management at the construction sites would be managed through the implementation of standard erosion and sediment control mitigation measures in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008).

5.2 Construction impacts (on-airport)

5.2.1 Flooding

An assessment of potential impacts associated with on-airport project construction activities has been based on a review of proposed construction works against the 5%AEP flood extent (refer to Figure 5-1 above).

The project is in tunnel for most of its length through Western Sydney International and generally located away from flood-prone land. The potential on-airport flood impacts during construction would be focused around the viaduct segment casting facility, the tunnel segment casting facility and the spoil dump area. Impacts associated with the spoil dump area are discussed in Section 6.2.1 below. The viaduct and tunnel segment casting facility is on the edge of the 5%AEP flood extent. Any flood impact at these locations would be temporary and would be managed through flood sensitive construction planning.

5.2.2 Water quality

Potential water quality impacts during on-airport construction work would involve similar pollutants, sources and quantities as described in Section 5.1.2. Construction works would interface with the work being carried out for the Western Sydney International. The alignment would be at grade until Airport Business Park Station and then would be in tunnel through the airport site, past Badgerys Creek Road. Other components of the project located on-airport land include tunnel dive structures, two cut and cover stations and an access road from the Northern Road (refer to Figure 8-16 In Chapter 8 of the EIS). Water quality impacts on-airport land would be related to construction of this infrastructure as well as the permanent spoil placement area, haul and access roads between worksites, a viaduct segment precast yard and office and site parking areas.

Key activities that would be likely to cause impacts include vegetation clearing and all earthworks for project sites. Activities that directly disturb soils such as vegetation clearing, top soil clearing and earthworks, as well as other activities like vehicle movements may lead to increased export of sediment and pollutants through run-off to waterways. These risks would be ongoing throughout the life of the construction phase and would be highest at locations with a slope of greater than 2.5%, that are near waterways and that are frequently disturbed. Risks of sediment transport and erosion would also increase during high rainfall and wind weather events.

The construction support site which includes the permanent spoil placement area, tunnel lining segment precast facility and a viaduct segment precast facility will be located in the Western Sydney International area. The permanent spoil placement area forms part of the airport construction support site. The exact location for placement of the spoil would be confirmed during design development in consultation with Western Sydney Airport. The area for the placement of spoil would be outside the Environmental Conservation Zone along Badgerys Creek. Correct implementation of soil and water management protocols at the permanent spoil site, as described in Section 8.0 would mitigate and mange impacts to the receiving environments water quality. The managed, the permanent spoil placement area would pose minimal risk of runoff of pollutants and sediments entering Badgerys Creek following implementation of soil and water management protocols. Stockpiling of earthwork and vegetation materials poses a risk to receiving water quality environments through the increased likelihood of movement of sediment and organic laden run-off. Discharge of water that is high in sediment or organic material may increase turbidity or the biological oxygen demand of the receiving environment which would may affect aquatic ecosystems in receiving environments. All drainage and hydraulic elements of the stockpile areas would be designed and managed to minimise hydraulic scour and erosion.

The viaduct segment precast yard would require an approximate 136,000 m^2 area which would include a concrete batching plant, segment and viaduct parapet fabrication areas, material delivery and laydown area and access roads. In addition to sediment and erosion risks during the construction of these sites, there is potential risk of discharge of highly alkaline wastewater from concrete batching plants to surrounding watercourses if not controlled properly. While the main sources of wastewater would be concrete batching and staff facilities use of vehicle washdown areas could also result in the discharge of wastewater containing oil and petroleum hydrocarbons if not managed properly. Discharge of these pollutants to the surrounding environment is likely to cause impacts. All wastewater would need to be captured and recycled or disposed of off-site at an appropriately licensed facility which would mitigate impacts to surrounding water quality environments.

A swale constructed as part of the Western Sydney International Stage 1 project would be impacted by construction of the cut-and-cover tunnel and would be temporarily diverted along the western side of the cut-and-cover section to a detention basin adjacent to Badgerys Creek. Correct implementation of exposed surfaces management would mitigate and mange impacts to the receiving environments water quality.

Management of potential pollutants such as sediment, construction waste and excess materials, chemical and oils from construction activities on-airport land would be in line with the Project CEMP and the identified mitigation and management measures as outlined in Section 8. As such the risk of water quality impacts from the construction of the project on-airport land is anticipated to be adequately managed and have residually low impacts to the water quality environment of the project.

Water treatment plant discharges

Use of water in construction activities and the excavation of the tunnels, stations and shafts which is likely to intercept groundwater, would result in the need to capture, treat and reuse or discharge water. Treated water would be re-circulated to the tunnel cutting face and also used for surface dust suppression. Groundwater in the tunnels during construction would be removed by pumping to the surface. At the surface, water would be treated by construction water treatment plants as shown in Table 5.2. Water quality and ecological impacts may result from release of untreated stormwater and groundwater into the catchment but with appropriate treatment these impacts during construction would be minimised. The water treatment plant uses clarifiers, tanks, filters and chemicals to treat the water until it meets the requirements for being discharged (or reused). Table 5.2 shows the locations, nominated discharge points and indicative discharge volumes from the plants.

Table 5.2 Treated water discharge from construction water treatment plants

Location	Discharge point	Indicative discharge volume when discharging (litres per second)
On-airport		
Western Sydney International tunnel portal	• Badgerys Creek via Western Sydney International swale	• 10
Airport Terminal	• Badgerys Creek via Western Sydney International swale	• 10

5.2.3 Geomorphology

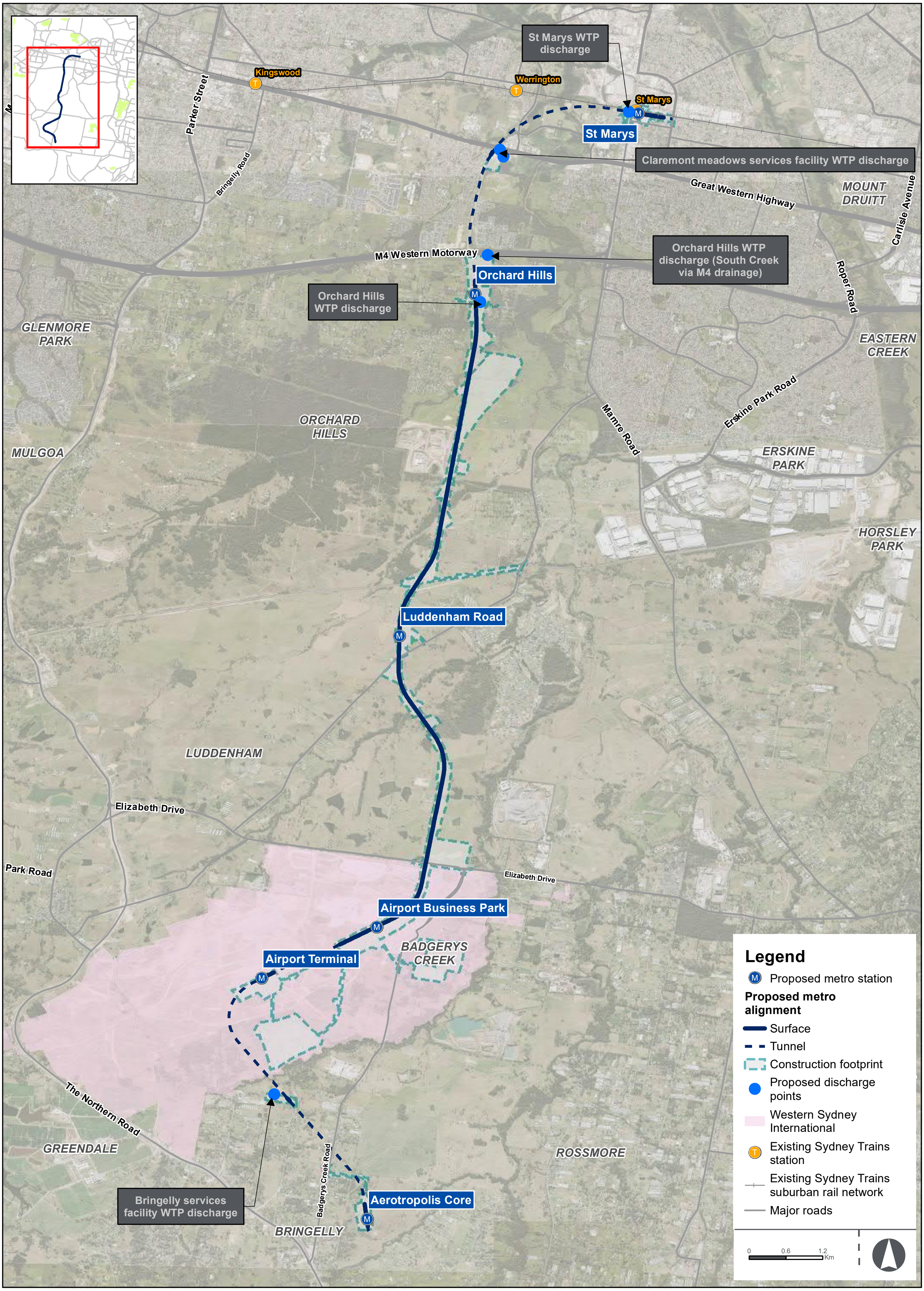
The on-airport watercourses are largely tributaries and overland flow paths with farm dams currently interrupting flows. The project would not impact Badgerys Creek as it is tunnelled under Badgerys Creek. The project would not impact Duncans Creek as the construction footprint does not intersect the creek or its catchment.

A permanent stockpile would be created within the Western Sydney International for the project. The stockpile would include diversions of overland flows paths and removal of farm dams which may impact the banks of Badgerys Creek due to changes in the discharge location. Other potential impacts to geomorphology from construction of the project may include:

- changes in low flow channel shape due to temporary works changing local runoff behaviour
- increased sediment load due to clearing the site for construction
- loss of riparian vegetation and aquatic vegetation during construction which may increase the vulnerability of the channel to erosion

- removal of local levee banks or farm dams would change flood behaviour and therefore change flows in the channel.

Appropriate management of the diversions in line with the soil and water management plan as outlined in Chapter 8.0 would minimise these impacts but the final stockpile design and management would be the responsibility of the Western Sydney International.



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Indicative only, subject to design development

Proposed discharge points from water treatment plants

Figure 5-2

6.0 Assessment of operation impacts

6.1 Operation impacts (off-airport)

6.1.1 Flooding

Flooding impacts presented below are based on flood modelling completed for the project. The existing flood behaviour is described in detail in Section 4.1.10. Flood impact criteria were defined for the project and hence enable assessment against the SEARs in relation to operational flood impacts (see Section 3.1.1).

Features such as tunnels and viaduct structures have been incorporated into the design to minimise interruption to flood flows within the major watercourses and ensure the existing floodplain storage and floodway areas are maintained. Required project earthworks and location of the project in relation to existing floodplain features has the potential to cause impacts to flooding. Further, the stabling and maintenance facility is located on land that is partially inundated during a PMF. Specific operational flood impacts associated with the project are described below.

Afflux

The change in flood level and extent (afflux) resulting from the project is shown in maps presented in Figures D.22 to D.27 of Appendix D. These show the full range of flood events considered for this assessment. The preparation of the maps and description of impacts have been developed in accordance with the flood impact criteria defined for the project (refer to Table 3.2).

Afflux impacts (changes to flood impacts greater than the project flood impact criteria listed in Section 3.1.1) for all events up to and including the 1%AEP are negligible and any changes to flood levels greater than the flood impact criteria are contained within the project corridor.

The flood model results indicate that there is a change to flood extents around the stabling and maintenance facility, with small open space areas newly inundated upstream of the alignment at Blaxland Creek (refer to Figure D.25 in Appendix D). The flood extents are of low depth, do not encroach into existing urban areas and are within the project flood impact criteria. The stabling and maintenance facility has been designed to be immune to the PMF event by raising the existing ground level. The earthworks to raise ground levels are located within the extent of the PMF and afflux impacts are noted within the floodplain surrounding this facility during a PMF event. The introduction of the stabling and maintenance facility also causes afflux during a PMF of up to 50 mm across South Creek and up to 20 mm across properties (discussed in Section 4.1.10 located to the east of Mamre Road within the suburb of St Clair (see Figure D.26 Appendix D). Floor level survey of the properties in this area is required to fully understand the impact of this afflux.

The flood model results indicate no change to flood extents or levels at the Bringelly Service facility off Derwent Road or the Claremont Meadows service facility.

In summary, the project meets the afflux criteria for all events up to and including the 1%AEP event.

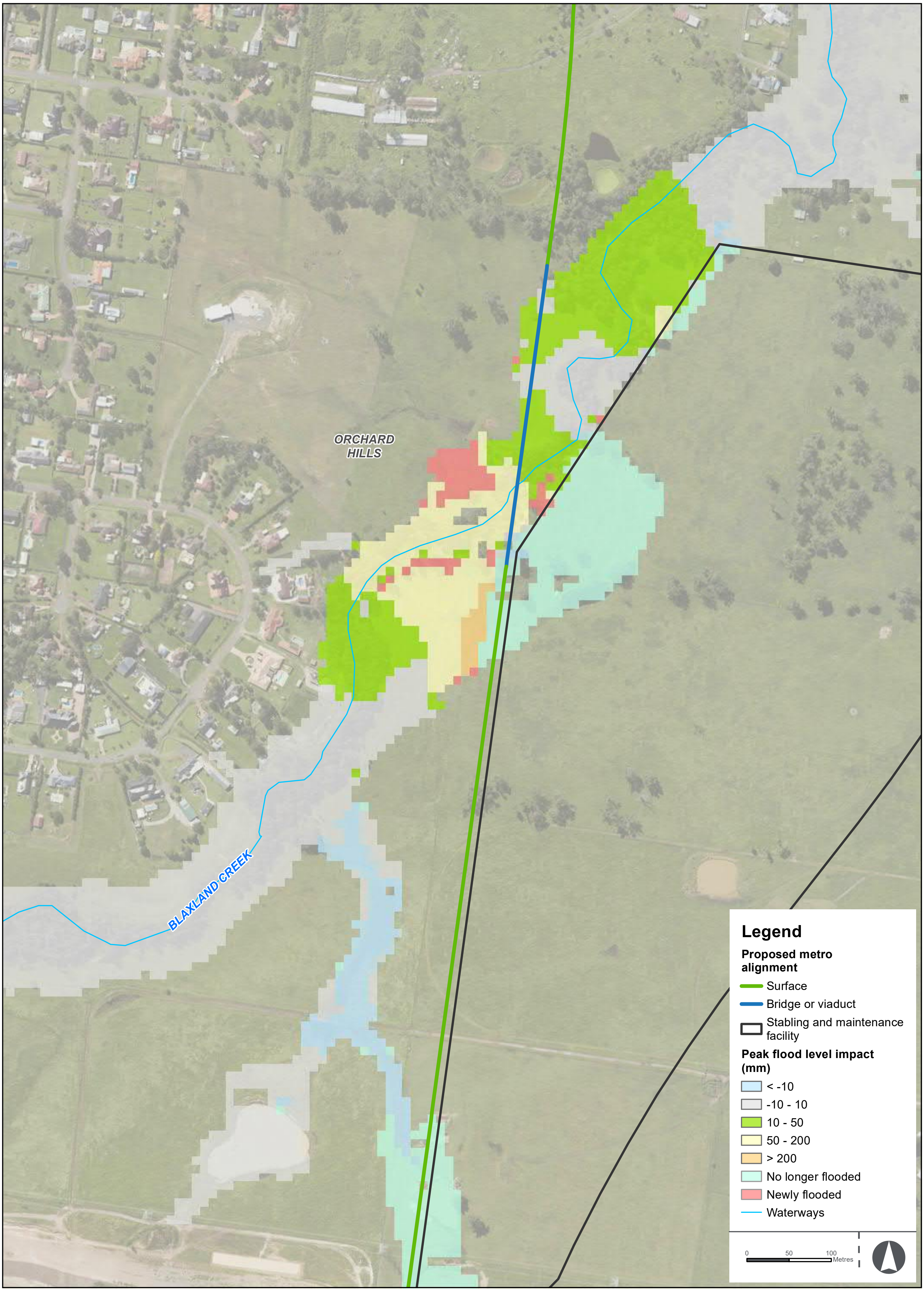
Property flood Impacts

Building survey was obtained for this assessment containing building outlines and height attributes derived from the SMWSA Lidar Data Capture of June 2019. As noted in section 4.1.10, 53 properties were identified within the Study Area that have above ground level inundation at buildings during a 1%AEP event. Of these properties, an assessment has been completed to identify if any of these buildings experience any increase in flood level (afflux) greater than 10 mm. This assessment has shown that there are no buildings that experience afflux of 10 mm or more for events up to and including the 1%AEP event.

Climate change impacts

The project has been designed with consideration of future climate change. The track levels have been designed to achieve flood immunity during a 1% AEP event inclusive of climate change. The project generally meets the flood impact criteria (refer to Section 3.1.1) for the 1%AEP event inclusive of climate change.

However, there is one isolated location where a change in peak water level is predicted to be greater than 200 mm within open areas close to the project alignment. This area is within the Blaxland Creek floodplain, near the stabling and maintenance facility. (see Figure 6-1). There is also a change to the area that is inundated with newly flooded areas also noted. The change in flooded area does not encroach into existing urban areas. The area where afflux is greater than 200 mm is open space and covers a distance of about 100 m adjacent to the project corridor. The maximum afflux in this area is 238 mm. This impact may be resolved through further design refinement to the viaduct at this crossing either through additional earthworks or providing additional flow widths. It is also noted that the stabling and maintenance facility (which is designed to be immune to the PMF event), contributes to the afflux seen at this location.



Sydney Metro – Western Sydney Airport

1% AEP with climate change afflux at Blaxland Creek crossing

Figure 6-1

Indicative only, subject to design development

Flood Velocity

The change in peak flood velocities across all modelled events between ‘no project’ and the project case are shown in Figures D.28 to D.32 in Appendix D. Increases in velocities can lead to increased potential for scour and erosion and need to be managed.

The predicted changes in peak velocities meet the design criteria (refer to Table 3.1) for storm events up to and including the 1% AEP event across the study area.

Scour protection in the form of rock protection is incorporated within the design of proposed culvert crossings to reduce localised increase in velocities. The peak 1% AEP velocities have been used to inform the preliminary scour protection design which is detailed in Table 6.1.

Table 6.1 Scour Protection Requirements at Culvert locations

Culvert location	HEIGHT OR DIAMETER (MM)	Number of culverts	1%AEP culvert velocity (m/s)	Minimum d50 rock size (mm)	Minimum length of apron (m)
Unnamed tributary of South Creek, near Kent Rd just south of the M4 Western Motorway*	1500	1	1.1	200	5.4
Unnamed tributary of South Creek, near Kent Rd just south of Western Motorway	1800	6	0.8		
Unnamed tributary of Blaxland Creek, South of Lansdowne Rd	750	3	2.4	200	2.25
Tributary of Cosgroves Creek (approx 400 m South East of where project crosses Cosgroves Creek)	750	4	2.4	200	2.25
Tributary of Badgerys Creek (approx. 1.4 km north of Elizabeth Drive)	750	1	2.3	200	2.25
Tributary of Badgerys Creek (approx. 1.2 km north of Elizabeth Drive)	1050	2	1.1	100	3.15
Tributary of Badgerys Creek (approx. 940 m north of Elizabeth Drive)	750	2	1.8	200	2.25
Tributary of Badgerys Creek (approx. 900 m north of Elizabeth Drive)	750	1	2.0	200	2.25
Tributary of Badgerys Creek (approx. 700 m north of Elizabeth Drive)	750	1	2.7	200	2.25
Tributary of Badgerys Creek (approx. 200 m north of Elizabeth Drive)	750	2	2.4	200	2.25
Tributary of Badgerys Creek (approx. 100 m north of Elizabeth Drive)	900	2	2.0	200	2.7

*Fauna culvert

Duration

Changes to duration of inundation across all modelled events between 'no project' and project case are presented in Figures D.33 to D.37 of Appendix D. The predicted changes in duration of inundation are generally minimal and comply with the design criteria (of limiting the change to no more than 10%) for storm events up to and including the 1% AEP event across the study area. There are several localised areas which are noted to occur in isolation for which duration of inundation would increase by greater than 10%. These areas are immediately upstream of the embankment, at localised areas constricted by farm dams, or within waterway areas. Duration of inundation has not increased substantially at any of these locations.

The increase in duration increases the flood risk to people and property, such that they are isolated for longer periods of time or the ponding of water against a building can impact the integrity of the structure and foundations. Since the increases are small (in the order of hours rather than days) and the overall duration of flooding is less than a day these minor increases do not change the flood risk or impact the integrity of structures.

This assessment has not identified any locations of high quality farming land where there are changes to flood duration. An increase in duration for crops can decrease the quality of the crop yield but the increase in duration estimated from the project is unlikely and would not have any impact to crop yields across the study area as the localised areas of change are in the order of hours different not days. However, the acceptability of changes to duration of inundation would need to be discussed further with stakeholders to understand the full impact and develop site mitigation measures where necessary.

Hazard

Changes to flood hazard between base case and project case are presented in Figures D.38 to D.42 of Appendix D. There are no considerable differences in flood hazard regime for storm events up to and including the 1% AEP event within the study area. Several localised areas are noted where flood hazard has increased in isolation, usually immediately upstream of the embankment or at localised areas constricted by farm dams. Flood hazard has not increased substantially at any of these locations and measures to reduce afflux impacts would also assist in reducing the duration impacts noted.

The flood hazard (velocity depth product) has been checked for key roads across the study area. The results for key roads are presented in Table 6.2. The roads estimated to currently be unsafe, with flood hazard above 0.3 m^2/s are highlighted in bold. Note that a road is considered unsafe (non-trafficable) for small passenger vehicles when the flood hazard exceeds 0.3 m^2/s. Comparing the results to the assessment against existing conditions (Table 4.3), the project can be seen to have negligible increases to preliminary flood hazard. There is one location, Unnamed Road (UNM_1) where the 0.5EY preliminary hazard is predicted to slightly reduce and otherwise flood hazard at key road location would remain unchanged (locations of roads in Table 6.2 are shown in Figure 4-6).

Table 6.2 Design conditions flood hazard at key roads.

Road	Project Case Hazard (m^2/s)			
	0.5EY	0.2EY	5% AEP	1% AEP
Stockdale Road (STO_1)	0.01	0.02	0.03	0.05
Patons Lane (PAT_1)	0.03	0.14	**0.32**	**0.53**
Mamre Road (location 1) (MAM_1)	-	-	0.03	0.07
Mamre Road (location 2) (MAM_2)	-	-	-	0.08
Luddenham Road (1) (LUD_1)	0.02	0.02	0.03	0.03
Luddenham Road (2) (LUD_2)	**0.32**	**0.36**	**0.42**	**0.53**
Luddenham Road (3) (LUD_2)	0.16	**0.97**	**1.84**	**2.42**

Road	Project Case Hazard (m^2/s)			
	0.5EY	0.2EY	5% AEP	1% AEP
Kent Road (KEN_1)	0.07	0.09	0.15	**0.32**
Elisabeth Drive (1) (ELD_1)	0.00	0.01	0.08	0.16
Elisabeth Drive (2) (ELD_2)	0.02	0.04	0.06	0.16
Unnamed Road (UNM_1)	**0.43**	**0.45**	**0.62**	**0.81**
Derwent Road (DER_1)	0.01	0.04	0.08	0.14
Bordeaux Place (BOR_1_	-	-	-	-
Badgerys Creek Road (1) (BC_1)	0.08	0.1	0.11	0.12
Badgerys Creek Road (2) (BC_2)	-	-	**0.71**	**1.68**

Notes:

(1) **Bold** values indicate locations where roads are estimated to be unsafe, with flood hazard above 0.3 m^2/s

(2) Light blue shading indicates value has reduced in comparison to existing conditions.

(3) Locations are shown in Figure 4-9

The Penrith and Liverpool Local Flood plans and the Hawkesbury-Nepean Flood Plan, September 2015 do not identify any of these roads as being flood evacuation routes. Within the project area the M4 Motorway is a defined flood evacuation route but the project would be in tunnel at this location and would not impact flood behaviour and therefore not affect the use of the M4 during a flood emergency. The negligible change in flood hazard would indicate that existing (not documented) flood evacuation planning would not be impacted by the project.

Road flood immunity impacts

Based on aerial imagery information available at time of study no roads are impacted by increases in peak flood levels of more than 50 mm. Flood hazard has been evaluated at key road locations shown in Figure 4.12 and was found to have negligible impact to the trafficability of the roads.

In addition to the hazard check, the peak flood levels for the 1%AEP were checked at the roads identified in Table 6.2. The definition design results in no change to peak flood levels at these roads.

Catchment and watercourse health Impact

The project is not predicted to change the existing hydrologic regime as the project footprint is minimal on the surface compared to the wider South Creek catchment and therefore existing rainfall runoff processes would continue similarly to existing conditions.

The project has been designed to include cross drainage structures (viaducts and culverts) to allow flood flows to be maintained which would minimise interruption to flows within the watercourses. The potential changes to baseflow contribution from groundwater would influence the creek geomorphic condition. Refer to Technical Paper 7 (Groundwater) for further information.

While the proposed Metro stations along the project alignment are located outside the predicted extent of the mainstream PMF event, it is noted that local overland flows have the potential to impact two of the proposed stations, namely St Marys and Aerotropolis Core. Localised stormwater management plans would need to be developed to ensure these stations are protected from local flood flow.

The project would require the removal and or relocation of several farm dams. The flood modelling has indicated that the removal of these farm dams would not have a significant impact on afflux. Their removal may impact the duration but the availability of surface water for downstream catchments would not be impacted.

The impact of the project on catchment and watercourse health is deemed minimal but some localised changes may occur due to viaducts, culverts and baseflow contributions.

Local policy agreement

The predicted impacts from the project as outlined in Section 6.1.1.1 to 6.1.1.6 show that the project would have minimal impact to flood behaviour. These minimal changes to flood behaviour indicate that the flood risk to land outside the project footprint is not significant. It is therefore concluded that Penrith and Liverpool City Council flood management objectives (included in Appendix A) for development are met.

6.1.2 Water quality

The operation of the project has the potential to impact and potentially degrade the water quality of the waterways within the study area and downstream. Contaminants of concern during operation of the project would include:

- suspended and dissolved solids from concentration flows from impervious areas
- gross pollutants such as rubbish and litter from station and ancillary facilities
- oils, grease and TPH from use and transfer of fuels on trains and other vehicles.

The most likely source of pollutants from completion of the project would be the concentrated flows from impervious surfaces that were previously pervious. An increase in impervious surfaces such as roofs and paved areas would have the potential to cause impacts to the water quality of the receiving waterways through increased runoff volumes and increased sedimentation or erosion. Additionally, station areas would include pedestrian and vehicle traffic which would generate pollutants. A more detailed assessment of key potential impacts associated with impervious operational areas is provided below.

While it has been noted that the quality of the existing environment is already degraded, further impacts from the operation of the project would be likely to further degrade the water quality if not properly managed.

Track and tunnel infrastructure

The potential for pollutant generation along the rail tracks mainly relate to sediments (including brake dust particulate matter) and chemicals from fuels and lubricants used in operation of the project. There is potential for increased volumes of chemical and vehicle brake dust to enter the surface water environment from at-grade track areas. Along the rail tracks, all at-grade section of the project would be drained. Water quality treatment for drainage would be provided through surface bioretention basins located within the On Site Detention (OSD) basins.

Tunnelled sections of track present lower risk of runoff generation given they would be covered and stormwater would be captured at the station entrances and tunnel portals. However some pollutants may still be generated in the form of station litter and sediment from station washdowns (refer Chapter 8.0 and Operational environmental management plan or system for management of potential operational impacts). Water captured from the mined and driven tunnels and cut-and-cover tunnels would be pumped to the water treatment plants for treatment and discharge. The water quality treatment plants would treat wastewater pumped from the tunnels and other below ground facilities as a result of stormwater entering the tunnel portals or ingress of groundwater.

There are three tunnel portals in the project design. There are located north of Orchard Hills Station, south of the Airport Terminal Station and north of Badgerys Creek. Water from the tunnel portals would be captured, pumped and treated in a surface basin.

WSUD principles would be incorporated into the ongoing design of the project for all track infrastructure. WSUD features would include swales, and water quality basins to treat captured drainage from track infrastructure. The adopted water quality measures would be integrated into a holistic approach to water management that is tailored to the specific requirements of the project and the potential for pollutant generation.

Station and ancillary facilities

Station sites in the off-airport section of the project include St Marys Station, Orchard Hills Station, Luddenham Road Station and Aerotropolis Core Station. These sites would feature increased impervious surfaces for station entrances, plazas and platform facilities as well as large increases in pedestrian and vehicle traffic once operational. This change in catchment affects the types and volumes of pollutants generated compared to existing conditions. The potential pollutants include litter, oils, sediments and potentially chemicals from station cleaning activities. The volume of the potential pollutants from station precinct areas would impact waterways if discharged to the environment. Water quality treatment for the station sites through ongoing design and water quality treatment plants is discussed below.

Additionally, maintenance activities such as the wash down and general maintenance of trains at ancillary facilities have the potential to generate considerable volumes of pollutants. However, these activities would be carried out in covered buildings and wash down water would be collected in a separate system for treatment and reuse, thus avoiding any potential for such pollutants to enter the local drainage system.

Ongoing design for station and ancillary infrastructure would be carried out in accordance with the TfNSW, Penrith and Liverpool Council standards. WSUD features at stations may include gross pollutant traps, filter pits, grassed swales and bioretention tranches and raingardens that would treat stormwater runoff to required levels prior to discharge into the environment.

Water quality treatment

Water quality treatment for stormwater runoff from the station sites would be provided through:

- bioretention treatment within proposed OSD basins - approximately two per cent of total contributing catchment areas has been included as water quality treatment in the project footprint. Figure 6-2 shows the locations of proposed water quality basins.
- Water treatment plants at St Marys Station and the Bringelly service facility.

The water quality treatment plants would treat wastewater and groundwater ingress pumped from the stations, tunnels and other below ground facilities. The water treatment plant building would include chemical treatment tanks, water storage tanks, and filters which would treat collected water to a standard in line with the performance outcomes as outlined in Section 8.2 prior to discharge from the site. Treatment of collected wastewater and groundwater from the project facilities would minimise impacts from entry of pollutants such as sediment and fuel to the receiving water quality environment. Discharge points for the two water treatment plants which will see continued use through project operation are in the same locations as during construction and are shown on Figure 5-2. There is potential for scour and erosion impacts from these discharge points, however impacts would be mitigated through inclusion of appropriate scour protection at all drainage and final outfalls that are installed as part of the project.

Viaducts

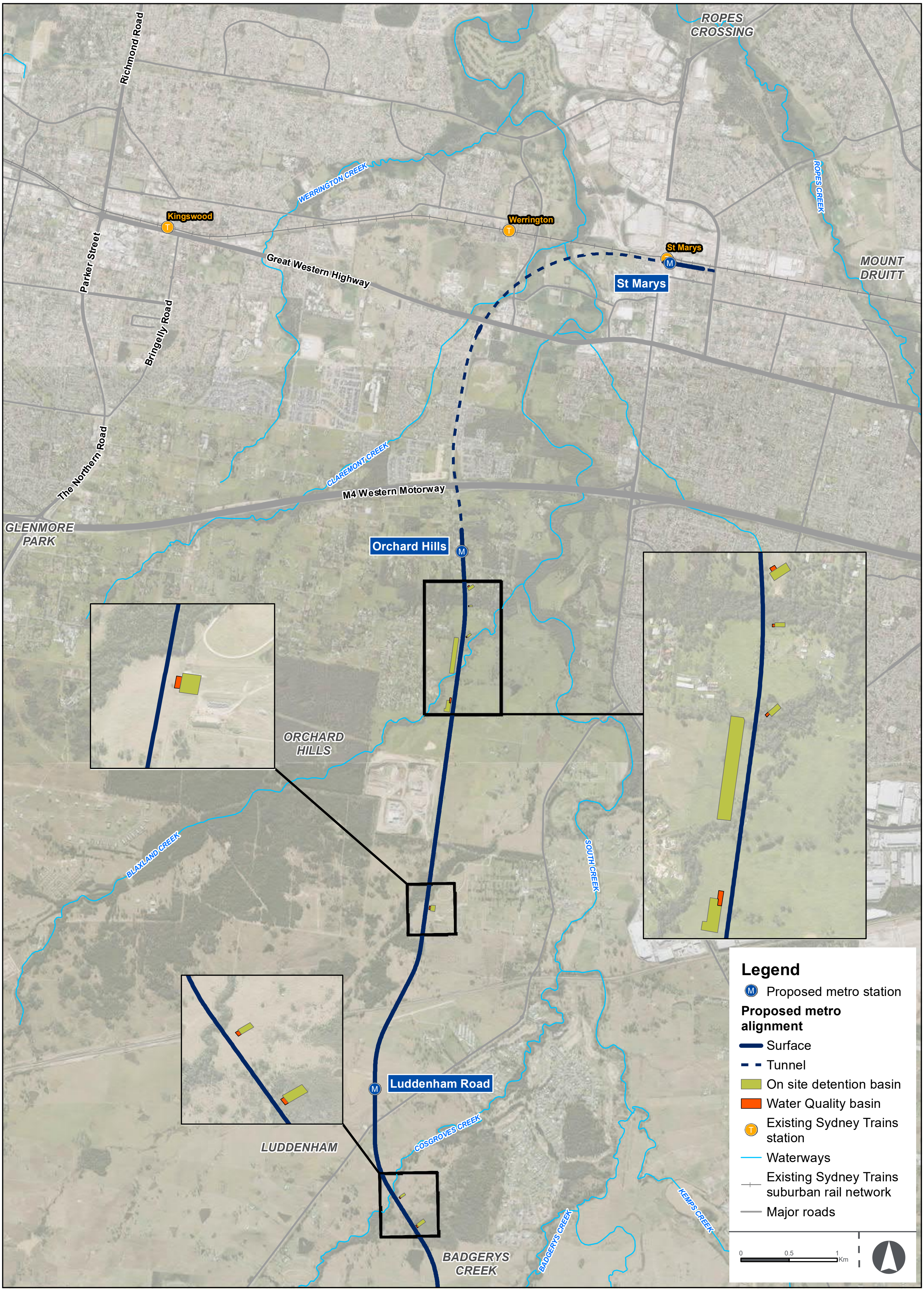
Viaduct structures over Blaxland Creek and Cosgroves Creek have the potential to cause localised changes in flow behaviour. Changes to flow velocity and distribution may cause changes to scour and sedimentation characteristics of waterways. Ongoing design for viaducts would aim to minimise required structures within mean water flow areas to minimise scour and erosion potential.

The presence of viaduct structures would not create an increase in impervious surface as an equivalent area of permeable land would be located below viaduct structures. Runoff generated by viaducts would be controlled in discrete locations by the construction of grass swales. Water quality treatment measures would be included in each downpipe from viaducts. Where a viaduct crosses a major creek or the Warragamba to Prospect Water Supply Pipelines, water quality treatment has been included in the adjacent detention basins.

6.1.3 Geomorphology

Geomorphic impacts are predicted to be negligible because there would be minimal change to contributing catchment areas and therefore no change to flood flows. The piers have been located out of the main flow paths for each watercourse and the impact would not propagate downstream.

The removal of several farm dams to construct the project is likely to result in a change to the frequency of low flow events. These changes may be counteracted by the inclusion of on-site detention basins which have been designed to Penrith Council requirements and therefore would be designed to match existing runoff characteristics. Overall the change to storage across the study area is predicted to not be significant.

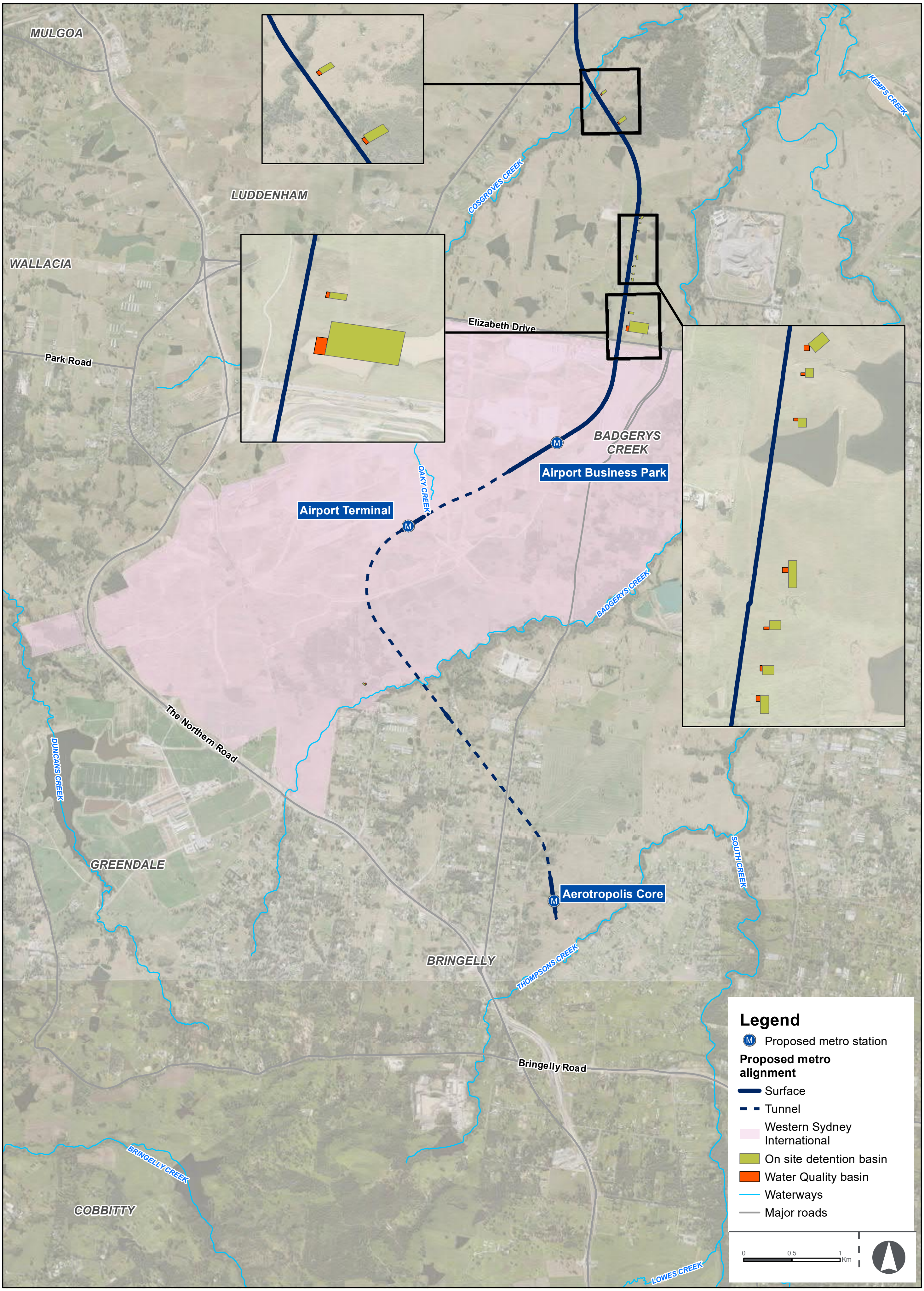


Sydney Metro – Western Sydney Airport

Proposed on site detention basins and water quality basins along the Project alignment

Figure 6-2a

Indicative only, subject to design development



Proposed on site detention basins and water quality basins along the Project alignment

Figure 6-2b

Indicative only, subject to design development

6.2 Operation impacts (on-Airport)

6.2.1 Flooding

Afflux

The change in flood level and extent (afflux) on-airport resulting from the project is shown in maps presented in Figures D.22 to D.27 of Appendix D and show results of modelling for the full range of flood events considered for this assessment. This mapping and discussion below has been developed in relation to the flood impact criteria defined for the project (see Table 3.1).

The project design features, including the tunnel results in no substantial change in peak flood levels, such that afflux is not predicted to increase above the project flood impact criteria listed in Section 3.1.1).

For all flood events up to and including the 1%AEP event, the project meets the flood impact criteria within Western Sydney International.

The permanent spoil placement area is located across a main overland flow path through the Western Sydney International to Badgerys Creek, causing changes to flood behaviour in Badgerys Creek through redistribution of floodwaters. project flood modelling identified areas near the stockpile as being newly inundated due to the stockpile redistributing the floodwaters away from this flow path. It is noted however that flood depths in a 1%AEP event remain below 200 mm in the newly inundated areas. These areas are within land that forms part of the Environment Conservation Zone for the Western Sydney International, bordering the existing Badgerys Creek flood extent, and as such this new inundation is not considered a substantial impact.

Climate change impacts

For the 1% AEP flood event inclusive of climate change, the project generally meets the flood impact criteria (refer to Figure D.27 of Appendix D. As per the 1% AEP flood event described above, the permanent spoil placement area causes a redistribution of floodwaters flowing to Badgerys Creek leading to creation of newly inundated areas along the edge of the existing flood extent. As flood depths in these newly inundated areas do not exceed 200 mm and they are on land forming part of the Environment Conservation Zone for the airport, this new inundation is not considered a substantial impact.

Velocity

Change in peak velocities across all modelled events between base case and project case are shown in Figures D.28 to D.32 in Appendix D. The predicted changes in peak velocities within the Western Sydney International site comply with the design criteria for all storm events up to and including the 1% AEP event.

Duration

Changes to duration of inundation within Western Sydney International across all modelled events between base case and project case are presented in Figures D.33 to D.37 of Appendix D. The predicted changes in duration of inundation are minimal and comply with the design criteria for storm events up to and including the 1% AEP event across Western Sydney International. There are localised areas along Badgerys Creek where durations have increased, but these are small areas that correlate with the newly inundated areas and are not considered a significant impact.

Hazard

Changes to flood hazard between base case and project case are presented in Figures D.38 to D.42Appendix D. There are no material differences in flood hazard regime for storm events up to and including the 1% AEP event within the Western Sydney International.

6.2.2 Water quality

Potential impacts to water quality on-airport land during the operational phase would be similar to those discussed in Section 6.1.2.

The most likely source of pollutants from completion of the project would be the transformation of pervious areas to impervious surfaces. An increase in impervious surfaces such as roofs, footpaths and paved areas would potentially cause impacts to the water quality of the receiving waterways through increased runoff volumes and increased pollutant loads, sedimentation or erosion. Additionally, station areas would feature areas of increased pedestrian and vehicle traffic which would generate pollutants. A more detailed assessment of key potential impacts associated with operation is provided below.

Track and tunnel infrastructure

Particulates such as brake dust would be the major pollutant expected in run-off from track areas. The potential for pollutant generation along the rail tracks is relatively low and would be mainly relate to sediments (including brake dust particulate matter). All at-grade sections of the project would be drained to bioretention basins located along the project footprint to treat stormwater and remove sediment and nutrients prior to discharge to the receiving environment.

The remainder of the track on-airport land would be tunnelled. Pollutants in runoff collected from tunnels would be expected to be sediment from wash-down activities at station platforms, brake dust and litter from station platforms. There would be minimal flows expected from tunnelled areas of the project and as such there would be anticipated to be minimal impact from the tunnelled section of the project. Potential water quality impacts from these pollutants in this section of the project would be mitigated through inclusion of operational water treatment plants to treat stormwater and groundwater within the proposed tunnels, tunnel portals and cutting sections of the project.

Station and ancillary facilities

The Airport Business Park Station would be located at surface level in an at-grade (shallow cutting) configuration. The station site would feature increases in impervious surfaces for station entrances, plazas and platform facilities. Once operational there would be large increases in pedestrian and vehicle traffic. This would have the potential to generate pollutants including litter, oils, sediments and potentially chemicals from station cleaning activities. The volume of the potential pollutants from station precinct areas would impact waterways if discharged to the environment. The Airport Terminal Station would be an underground cut-and-cover station but would include new above ground impervious areas in the form of a new station entrance plaza and access platforms.

Ongoing design for station and ancillary infrastructure would be carried out in accordance with the applicable TfNSW, Penrith and Liverpool Council standards. WSUD features at stations may include gross pollutant traps, filter pits, grassed swales and bioretention trenches and raingardens that would treat stormwater runoff to required levels prior to discharge into the environment.

Water quality treatment

Water quality treatment for the project in on-airport land would be provided through:

- bioretention treatment within the existing Western Sydney International Stage 1 Construction Impact Zone. This is documented in the Western Sydney Airport EIS – Surface Water Quality Assessment (GHD, 2016)
- a water quality treatment plant at the Western Sydney International tunnel portal.

The water quality treatment plants would treat wastewater and groundwater ingress pumped from the stations, tunnels and other below ground facilities. The water treatment plant building would include chemical treatment tanks, water storage tanks, and filters which would treated collected water to a standard in line with the performance outcomes as outlined in Section 8.2 prior to discharge from the site. Treatment of collected wastewater and groundwater from the project facilities would minimise impacts from entry of pollutants such as sediment and fuel to the receiving water quality environment. Discharge points for the water treatment plants are shown on Figure 5-2. There is potential for scour and erosion impacts from these discharge points, however impacts would be mitigated through inclusion of appropriate scour protection at all drainage and final outfalls that are installed as part of the project.

6.2.3 Geomorphology

The project does not interfere with many of the overland flow paths or watercourses within Western Sydney International as it would be located below ground in an open cut trough and cut-and-cover tunnel. At the southern extent of the Western Sydney International, the tunnel passes under and emerges past Badgerys Creek Road and would therefore not have any impacts to the geomorphology of Badgerys Creek.

As noted in section 6.2.1, the permanent spoil placement area intersects the main overland flow path to Badgerys Creek through the area. This would cause a redistribution of the floodwaters away from the current location, impacting the peak levels and timing of flows in Badgerys Creek, and impacting the geomorphic conditions in Badgerys Creek.

7.0 Cumulative impacts

There is the potential for cumulative impacts to flooding, geomorphology and water quality to occur from the project and other proposed developments within the South Creek catchment. The projects that have the potential to have a cumulative impact with the project were considered and screened in Chapter 27 of the Environmental Impact Statement. The projects considered to be relevant for the flooding, hydrology and water quality assessment include:

- the Western Sydney International
- M12 Motorway
- The Northern Road
- St Marys Intermodal Facility
- Future development proposals.

A brief description of these projects and qualitative assessment of associated potential cumulative impacts during construction and operation is provided below.

It is noted that the Western Sydney International Stage 1 works have commenced and, as described in Section 3.1, it has been included in the baseline existing conditions flood model because it was determined that the Western Sydney International Stage 1 works would be in place before the project and therefore should be considered within the baseline conditions.

The potential cumulative impact of these projects to the surface water environment of the project footprint are discussed below.

7.1 Western Sydney International

Western Sydney International covers an approximately 1780 hectare area that is being developed to service the Greater Western Sydney region and the continued need for aviation services. Stage 1 of Western Sydney International would include a single runway, terminal and other relevant facilities for an operational capacity of approximately 10 million passengers annually, as well as freight traffic. Other facilities would include a business park to provide offices for government agencies, service providers and airport-related businesses.

Construction activities for Stage 1 are occurring in two major phases:

- site preparation activities including clearing and earthworks (currently underway)
- aviation infrastructure activities such as construction of the runway, internal road network, terminal, air traffic control tower and maintenance facilities.
- Site commissioning activities involving testing and commissioning of all facilities in readiness for operation.

Stage 1 is expected to be constructed from 2018 to 2026 with operations commencing in 2026.

Construction of the project is being planned to occur at the same time as construction of Western Sydney International and it is expected that the project would be operational in time for the commencement of airport operations. Given construction planning of the project would align with construction planning of Western Sydney International, potential impacts on water quality associated with the Western Sydney International during construction would be managed in coordination with Western Sydney Airport.

The Stage 1 works are included in the baseline flood assessment which means the impact of the project is effectively a cumulative impact assessment for the Western Sydney International and the project. The key changes to flood behaviour as a result of both projects would include changes to runoff volumes and direction of runoff across the Western Sydney International site. The flood modelling carried out for this project includes Western Sydney International stormwater management measures which are intended to internally manage these changes. The operation impacts (on-airport) are discussed in section 6.2 and indicate insignificant impacts as a result of the project and the Stage 1 Western Sydney International.

Impacts to geomorphic conditions from both projects would be limited to the Western Sydney International Stage 1 works as the project would independently manage stormwater runoff from the trench.

Bioretention basins and drainage swales are included in the Western Sydney International design to provide water quality treatment for stormwater runoff prior to discharge to Badgerys Creek, Oaky Creek, Cosgroves Creek and Duncans Creek. There would be minor cumulative impact to water quality on airport land as the project would be drained cut-and-cover tunnel or open trough through the Western Sydney International. It is anticipated that the inclusion of water quality treatment measures would help improve currently degraded water quality conditions at watercourses within Western Sydney International. When these measures are included in the project design is it estimated that the cumulative impacts to water quality would be minor.

7.2 M12 Motorway

A new motorway is being delivered between the M7 Motorway, Cecil Hills and The Northern Road in Luddenham over a distance of about 16 kilometres. Construction of the M12 Motorway project is expected to start in 2022 and be open to traffic before the opening of the Western Sydney International Airport in 2026

The M12 Motorway will cross Badgerys Creek and South Creek approximately 800 m to the east of the project (north of Western Sydney International) and Cosgroves Creek approximately 1.2 km to the west of the project.

At the time of preparation of the design for the project, details of the M12 were not available to be included in the flood modelling but the EIS released in October 2019 has been reviewed to estimate potential cumulative impacts.

The M12 Motorway is predicted to have local flooding impacts at Cosgroves and Badgerys Creek but the impact at both crossings not predicted to extend beyond the M12 Motorway project boundary and therefore would not impact the project. The cumulative impact on flooding is considered insignificant for peak flood levels, but may change the duration of inundation and the peak velocities at the crossing points.

No construction machinery or structures would be placed in waterways during construction that would cause blockage and change to scour in Cosgroves and Badgerys Creeks. However, as the M12 Motorway includes works at the creek crossings and changed catchment conditions from rural to impervious surfaces there is potential for cumulative impact to the geomorphic conditions in both creeks as a result of construction of both projects.

Road drainage would typically include gross pollutant and sediment traps to remove these particles, as well as design measures and scour protection to prevent changes erosion and sedimentation within waterways. It would be anticipated that the road would be designed in line with best practice as outlined by Transport for NSW and the WSUD requirements of the relevant local councils. As such the risk of cumulative water quality impact to the receiving waterways in the area is low.

Cumulative water quality impacts are likely to occur during construction of the M12 Motorway connection to Western Sydney International if they coincide with the construction of the project in this location. Staging of the project construction could consider combining construction water quality mitigation measures to reduce footprint and ensure a consistent approach to minimising water quality impacts in the downstream catchment.

7.3 The Northern Road

The Northern Road upgrade will consist of a 35-kilometre section of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway in Glenmore Park. The Northern Road upgrades are being delivered in stages with some stages completed and the final stages having started construction in 2019

The upgrade of the Northern Road will cross Badgerys Creek approximately 1.5 km upstream of the project and will traverse the upper catchment of Duncan's Creek. It will have no cumulative impact on flooding as it currently crosses Badgerys Creek and but it could alter flows in the Duncans Creek catchment. However, the project would have no impact on flooding in Duncans Creek so there would be no cumulative flood impacts.

There is low potential for the cumulative impact on geomorphic changes in Badgerys Creek as a result of both projects. The widening of The Northern Road crossing of Badgerys Creek and the project crossing of Badgerys Creek will create areas of local increases in velocities which may change the flow regime between the crossings and impact the geomorphic characteristics of the channel.

Similarly, to the M12, the cumulative impacts to water quality will be low.

While the works for the Northern Road are over a kilometre away from the project, both projects are within the Badgerys Creek catchments. During construction, there is the potential of cumulative impacts on local water quality from clearing, earthworks, materials handling and from exposed surfaces and stockpiles. Staging of the project construction would be necessary to consider the Northern Road construction activities. Cumulative impact to flooding will be insignificant during construction.

7.4 St Marys Intermodal

Pacific National is proposing the staged construction and operation of an intermodal terminal (road and rail) and container park near St Marys. The facility will facilitate the introduction of a new container rail shuttle service between Port Botany and Greater Western Sydney, increasing the volume of import and export freight moved via rail. A maximum of five 600 m trains will run per day and the facility will have an ultimate operating capacity of 300,000 twenty-foot equivalent units (TEU) (shipping containers).

St Marys Intermodal is a State Significant Development for the construction and operation of an Inland Container Terminal and associated container handling operations. An application for the development (Application Number SSD-7308) was lodged with Department of Planning and Environment (DP&E). The project EIS was lodged in September 2018 and response to submissions is currently being prepared.

The overall construction timeframe for the Intermodal is expected to take five months to complete. Timing of construction however is currently unknown. During construction, there is the potential of cumulative impacts on local water quality from clearing, earthworks, materials handling and from exposed surfaces and stockpiles. Staging of the project construction would be necessary to consider the Intermodal construction activities. Cumulative impact to flooding will be insignificant during construction.

The flood impact assessment that was completed as part of the EIS for the St Marys Intermodal found that there would be no significant increases in flood level outside the land owned by Pacific National for the full range of flood events assessed (BG&E, 2019). The project is underground in the area near St Marys Intermodal and therefore there is no increased cumulative flood risk for the project as a result of the St Marys Intermodal.

The Intermodal Stormwater Management Plan has been designed to meet the WSUD objectives in the *Penrith Development Control Plan and the WSUD Technical Guidelines*. The St Marys Intermodal Environmental Impact Statement concluded that the proposed intermodal would improve the water quality of the runoff generated from the site by removal of gross pollutants and treatment of stormwater from the site prior to discharge. As such the stormwater discharge from the site is expected to be an improvement compared to the existing water quality in the area and there are not expected to be any cumulative impacts as a result of the development of the Intermodal and the project.

7.5 Future development considerations

In addition to the specific projects identified above, the Western Sydney Aerotropolis Plan (NSW Government, 2020) outlines the future potential development for significant areas of the Badgerys Creek and South Creek catchments. At the local government scale, Draft Penrith Local Strategic Planning Statement, (Penrith City Council, 2019) and Draft Liverpool Local Strategic Planning Statement (Connected Liverpool 2050), Liverpool City Council (2019) identify changes to planning controls to manage the impact of future development. The theme of all these documents and supporting information indicates the future catchment conditions for the South Creek catchment upstream and in the immediate vicinity of the project would be changed from predominantly open space rural residential uses to support economic centres focussed around defence and aerospace industries.

The dominant changes to these areas and the catchment include an increase in hard stand areas, increase in urban sourced pollutants and potentially loss of overland flow paths (formalisation of overland flow paths). The increase in hard stand areas reduces infiltration and increases runoff for all rainfall events from the regular (0.5EY) to the rare (1% AEP). This can potentially impact flood behaviour as the increased runoff volumes enter the waterways at a faster rate which can also cause higher flood levels. The increased runoff volumes impact the existing natural creek changes causing erosion at the entry point and changes to channel shape due to changes in the regular flows entering the waterway. Urban sourced pollutants are more easily washed off hard stand surfaces and transported to the nearest creek. These pollutants will impact suspended solids, nutrients and aquatic flora and fauna within the creeks.

However, the Penrith City Council and Liverpool City Council’s current planning controls outline stormwater quality and quantity requirements, flood management principles and environmental objectives to ensure the impacts of urban development are minimised and/or mitigated. While the exact composition of land use changes is not yet understood, the cumulative impact of these changes together with the project should be able to be managed through appropriate design of stormwater quality and quantity controls with consideration of the hydrologic processes within the wider South Creek catchment. As such, there are not expected to be any cumulative impacts as a result of future development within the catchment and the project.

7.6 Summary of cumulative impact

All environmental impact assessments for the other relevant projects have concluded that the projects would have no flood impacts outside the project areas and that they would discharge stormwater of neutral or improved quality as compared to the baseline conditions of the area. Planning controls within Penrith City Council and Liverpool City Council would ensure impacts of future land use development within the catchment are minimised and/or mitigated.

The addition of more viaduct crossings through the South Creek catchment may have long term impacts on geomorphology due to the channelling of flood flows. Therefore, the cumulative impacts of all these projects needs to carefully consider management of velocity and duration across a range of flood events to minimise geomorphic changes to Badgerys and Cosgroves Creek. The flood model for the project includes Western Sydney International and therefore there is an inherent understanding of potential cumulative impacts within the flood assessment process.

If mitigation measures are applied across projects, no adverse cumulative surface water impacts are anticipated. There is opportunity to include water quality treatment devices in the development of the projects and that this may improve the water quality of runoff from the sites as compared to the existing conditions. As such the residual risk of impacts to the surface water environment of the project footprint is expected to be low.

8.0 Proposed management and mitigation measures

8.1 Approach to the management and mitigation

This chapter describes the environmental management approach for the project for hydrology, flooding and water quality during construction and operation. Further details on the environmental management approach for the project are provided in Chapter 26 of the Environmental Impact Statement.

A Construction Environmental Management Framework (CEMF) (Appendix E of the Environmental Impact Statement) describes the approach to environmental management, monitoring and reporting during construction. Specifically, it lists the requirements to be addressed by the construction contractor in developing the CEMP, sub-plans, and other supporting documentation for each specific environmental aspect.

Specific subplans from the CEMF that will be developed include:

- Soil and Water Management Plan
- Stormwater and Flooding Management Plan
- Progressive Erosion and Sediment Control Plan.
- Key supporting guidelines to inform the development of these plans include:
- Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, Handbook 7, Australian Institute for Disaster Resilience, 2017,
- *Managing Urban Stormwater – Soils and Construction*, Landcom, 2004

The chapter includes the performance outcomes which the project would be designed, constructed and operated to, as well as mitigation measures, including those that would be included in the SWMP.

8.2 Performance outcomes

Performance outcomes have been developed consistent with the requirements of the SEARs for the project. The performance outcomes for the project are summarised below in Table 8.1 and identify measurable, performance-based standards for environmental management.

Table 8.1 Performance outcomes for the project in relation to Hydrology and Flooding

SEARS desired performance outcome	Project performance outcome	Timing
Flooding, hydrology and water quality		
The project minimises adverse impacts on flooding characteristics Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding	Land and property beyond the construction footprint would not be impacted by construction for the 0.5 Exceedances per Year (EY) storm event	Construction
	No aspect of construction to materially adversely affect existing water quality in receiving waters to a minimum 0.5 EY storm event, or in line with the 'Blue Book' (Managing Urban Stormwater: Soils & Construction Volume 1 (Landcom, 2004))	Construction

SEARS desired performance outcome	Project performance outcome	Timing
hazards, or dam failure Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved) Sustainable use of water resources The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine	No material change to channel shape within the construction footprint for the 0.5 EY storm event for streams classified first order and higher	Construction
	Water discharged from the project, including runoff from hardstand areas, surface and ground water storages would: • contribute towards achieving ANZECC guideline water quality trigger values for physical and chemical stressors for slightly disturbed ecosystems in lowland rivers in southeast NSW, or • meet any water quality criteria determined in consultation with the NSW Environment Protection Authority (off-airport) where an EPL is required or in consultation with Western Sydney Airport in accordance with the Airports (Environmental Protection) Regulations 1997 (on-airport)	Construction and operation
	Drainage from the project (including the stabling and maintenance facility, service facilities and stations) designed in accordance with local council requirements for managing urban stormwater quality and quantity	Operation
	For all land currently flooded up to the one per cent annual exceedance probability event, no change to peak flood levels up to the following limits, unless otherwise agreed with the affected property owner: • residential, commercial, critical infrastructure – no new above floor flooding, maximum change of 10 millimetres for existing flooded buildings and maximum of 50 millimetres for properties where flooding is below floor level. • roads – maximum change of 50 millimetres • Crown land open space, farming, grazing and cropping land – maximum change of 200 millimetres	Operation
	Where flood water velocities are currently below one metre per second (m/s), the project is designed and operated to ensure they remain below one metre per second. Where velocities are above one m/s, an increase of no more than 20 per cent is permitted.	Operation
	No change to flood hazard vulnerability classification limits for residential and commercial buildings or roads	Operation
	No change to flood hazard vulnerability classification limits for all land types as a result of the placement of the permanent spoil stockpile site at Western Sydney International	Operation
	No change to the one per cent annual exceedance probability duration of inundation up to the following limits: • residential, commercial, critical infrastructure – no increase for above floor flooding • roads – maximum change of 10 per cent increase in duration	Operation

SEARS desired performance outcome	Project performance outcome	Timing
and marine waters (if applicable)	• agricultural land for cropping – dependant on cropping type	
	For moderate and high fragility watercourses impacted by the project (as defined by the NSW River Styles mapping (NSW, Department of Planning, Industry and Environment 2019)), maintain existing flow regimes and velocities as best as possible to preserve and minimise changes to the watercourses	Operation
	Critical infrastructure (including stations entries and tunnel portals) to have immunity against the probable maximum flood event	Operation

8.3 Proposed mitigation measures

In addition to the development and implementation of the management plans described in the CEMF, specific mitigation measures have been identified. These are included in Table 8.2.

Table 8.2 Project management and mitigation measures

Ref	Mitigation measures	Applicable location(s)
Construction		
HYD1	Construction planning would consider flood related mitigation, including: • staging construction works to reduce the duration of works within the floodplain • daily and continuous monitoring of weather forecasts and storm events, rainfall levels and water levels in key watercourses to identify potential flooding events and related flood emergency response • consultation with NSW State Emergency Services and relevant local councils to ensure consistent approaches to the management of flood events (off-airport only) • provide flood-proofing to excavations at risk of flooding during construction, where reasonable and feasible, such as raised entry into shafts and/or pump-out facilities to minimise ingress of floodwaters into shafts and the dive structure • review of site layout and staging of construction works to avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required.	Orchard Hills construction site Off-airport construction corridor On-airport construction corridor.
HYD2	Minimise works in the main creek channels (at Blaxland Creek, unnamed watercourse south of Patons Lane and Cosgroves Creek) where possible and avoid works in the channel during rainfall events.	Off-airport construction corridor

Ref	Mitigation measures	Applicable location(s)
WQ1	A surface water quality monitoring program would be implemented to monitor water quality during construction. The program would be developed in consultation with (as relevant) Western Sydney Airport, NSW Environment Protection Authority, relevant sections of Department of Planning, Industry and Environment and relevant local councils. The program would consider monitoring being undertaken as part of other infrastructure projects such as the M12 Motorway and Western Sydney International. On-airport, the water quality monitoring program would ensure that works meet the requirements under Schedule 2 of the Airports (Environment Protection) Regulations 1997. The program would monitor all construction discharge locations including South Creek at St Marys, South Creek at the M4 Western Motorway, South Creek at Longleys Road, Cosgroves Creek at Twin Creeks Drive, Thompsons Creek and Badgerys Creek at Elizabeth Drive.	Claremont Meadows services facility construction site Orchard Hills construction site Off-airport construction corridor Airport construction support site Airport Terminal construction site On-airport construction corridor Bringelly services facility construction site.
Operation		
HYD3	The flood model for the project would be updated with regard to flood modelling undertaken for the South Creek Sector Review (anticipated to be released in 2020). The updated flood modelling would be used to inform design development	All
HYD4	Develop localised stormwater management plans at St Marys Station and Aerotropolis Core Station to ensure these stations are protected from localised flooding	St Marys Station Aerotropolis Core Station.
HYD5	Flood compatible design would need to be demonstrated for the permanent spoil placement area to ensure compliance with applicable land use criteria	On-airport.
WQ2	Design batter slope gradients and surface treatments to minimise erosion risk	All
WQ3	Drainage and water treatment design to be undertaken in accordance with Water Sensitive Urban Design requirements specified in local council, Transport for NSW and on-airport standards	All
WQ4	Suitably designed scour and erosion controls should be included at drainage and sedimentation basin outlet discharge points	All
WQ5	Detailed design of viaducts across waterways would aim to minimise infrastructure within the bed and banks of existing waterways and minimise changes to flood behaviour across the floodplain	All
WQ6	Where feasible, on-site detention of stormwater would be introduced where stormwater runoff rates are increased. Where there is insufficient space for the provision of on-site detention, the upgrade of downstream infrastructure would be implemented where feasible and reasonable	All

Ref	Mitigation measures	Applicable location(s)
WQ7	At all locations where stormwater is discharged, water quality measures such as gross pollutant traps, bio-retention swales and Water Sensitive Urban Design features would be investigated and implemented where feasible and reasonable	All
WQ8	Water quality monitoring of all discharges from water quality treatment plants to be undertaken to contribute towards achievement of the ANZECC guideline water quality trigger values	St Marys Station Bringelly services facility.

8.4 Residual Impacts

The residual impacts include all those locations where the flood behaviour criteria has not been met through the current design. It is understood further design iterations would look to solve all residual impacts and provide a complying design. These locations are discussed in detail in Section 6.1 and Table 8.3 with proposed further design measures identified.

Table 8.3 Residual flood impacts

Location	Residual Impact	FLOOD IMPACT CRITERIA NOT MET	Recommended design iteration/Mitigation Measure
Blaxland Creek	Afflux greater than 200 mm in open space areas upstream of viaduct/Stabling and Maintenance facility (see Figure 6-1)	No more than 200 mm afflux on crown land open space	Change viaduct and/or earthworks arrangement to minimise works in the floodplain.
Stabling and maintenance facility	Afflux of up to 50 mm across South Creek and up to 20 mm across properties located to the east of Mamre Road within the suburb of St Clair during a PMF event	Residential houses, commercial buildings and critical infrastructure afflux criteria • No change (max 10 mm) to flood levels at buildings that are flood prone in existing conditions • No new above floor flooding • Max 50 mm at properties where flooding is below floor level	Consider changes to earthworks arrangements in area affected by PMF.

9.0 Conclusion

This report documents the flooding, hydrology and water quality assessment carried out for the project. It will be used to inform project design, environmental assessment, regulators, stakeholders and community about potential impacts on flood behaviour, watercourse health and water quality and to identify recommended mitigation and management measures.

The project is located within the South Creek catchment and impacts are minimised due to incorporation of tunnels within the design. Incorporation of tunnels, troughs and viaducts into the design minimise interruption to flood flows within the major watercourses and ensures the existing floodplain storage and floodway areas are maintained. As such the project flood assessment, has found that afflux, velocity, flood duration and flood hazard impacts are not significant and are isolated to a few locations.

Impacts to flood behaviour during construction will be minimal with construction site layouts considering existing flood extents and minimising use of flood prone land for extended periods of time. This will also minimise impacts to land and property beyond the construction footprint. Monitoring of rainfall events and development of a flood emergency management plan (FEMP) for the construction phase will also reduce flood risks to the project construction works.

With regard to water quality, the assessment has reviewed the existing conditions of the South Creek catchment and water quality monitoring data carried out for the M12 Motorway and at the Western Sydney International site. The data showed that the existing water quality environment of the study area is generally not compliant with the ANZG/ANZECC guideline values. The water quality assessment has identified potential on-airport and off-airport impacts during construction and operation and identified mitigation measures to reduce and mitigate potential impacts.

Both the construction and operation phases of the project have the potential to impact on the water quality of the surrounding environment. Potential impacts from the construction phase are largely associated with soil excavation and disturbance for construction of the tunnelled and cut-and-cover sections of the project, which may result in increased sediment loads to the receiving waterways as well as potential erosion and release of contamination. Potential impacts from the operation phase are predominantly related to increases in impervious surfaces at new stations and maintenance facilities. This would increase runoff volumes and velocities potentially increasing sediment loads and erosion in receiving waterways. Other likely impacts would be from increased pedestrian and vehicle traffic in the area which may result in release of gross pollutants or chemicals and fuels in to the receiving environment.

Performance outcomes and mitigation measures have been identified for both construction and operation phases of the project. These should be documented in a Project SWMP and CEMP as well as site-specific ESCP. Ongoing design of the station precincts would incorporate WSUD principles and features, which would aim to protect watercourses and reduce pollutant loads from stormwater from the new stations. The design should be in line with the Penrith and Liverpool Council DCPs as well as relevant TfNSW and agency guidelines.

Application of design standards as well as management measures throughout the life of the construction and operation of the project would minimise impacts to the receiving waterways around the project.

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