Australian Government

BUILDING OUR FUTURE

NSW GOVERNMENT

M12 Motorway Environmental Impact Statement

Appendix M Surface water quality and hydrology assessment

Roads and Maritime Services | October 2019

BLANK PAGE

Contents

Tables

Figures

Annexures

Glossary of terms and abbreviations

Term	Meaning
AHD	Australian Height Datum
Ammonia	The most reduced form of inorganic nitrogen available, and is preferentially utilised by plants and aquatic micro-organisms
ANZECC	Australian and New Zealand Environment and Conservation Council
Aquatic Ecology	Flora and fauna that live in or on water for all or a substantial part of the lifespan (generally restricted to fresh/inland waters)
ARI	Average Recurrence Interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASRIS	Australian Soil Resource Information System's
ASS	Acid Sulfate Soils
AWS	All Weather Station
BAM	Biodiversity Assessment Method
Biota	All organisms in a given area (including flora and fauna), considered as a unit
Blue Book	*Managing Urban Stormwater, Soils and Construction, Volume 1 4th Edition, March 2004* (Landcom, 2004) and *Managing Urban Stormwater, Volume 2D-Main road construction* (Department of Environment and Climate Change (DECC, 2008)
BOD	Biological oxygen demand
BOM	Bureau of Meteorology
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location
CEMP	Construction Environmental Management Plan
Chlorophyll-*a*	A measure of the amount of algae growing in a waterway
Coastal Management SEPP	State Environmental Planning Policy (Coastal Management) 2018
Culvert	An enclosed channel for conveying water below a road
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
DLWC	Department of Land and Water Conservation
DPI	NSW Department of Primary Industries
Ecosystem	A functional unit of energy transfer and nutrient cycling in a given place. It includes all relationships within the biotic community and between the biotic components of the system
EIS	Environmental Impact Statement
Electrical conductivity	The measure of a material's ability to accommodate the transport of an electric charge
Embankment	An earthern structure where the road (or other infrastructure) subgrade level is above the natural surface

Term	Meaning
Environmental value	Particular values or uses of the environment that are important for a healthy ecosystem or for public benefit or health.
EPA	NSW Environment Protection Authority
EPBC	Environment Protection and Biodiversity Conservation Act (Commonwealth)
Ephemeral Creek	A creek that only exists for a short duration of time following rainfall
EPL	Environmental Protection License
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle
FBA	Framework for Biodiversity Assessment
Fill	The material placed in an embankment
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami
Floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (ie flood prone land)
FM	Fisheries Management Act (NSW)
Geomorphology	The study of shaping of the landscape by water, wind and other processes. Commonly used to describe the condition of streams as they are shaped by erosion and/or accretion of sediments
GRCCC	Georges River Combined Councils Committee
Groundwater	Water that is held in the rocks and soils beneath the earth's surface
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally). Habitats are measurable and can be described by flora and physical components
HNCMA	Hawkesbury-Nepean Catchment Management Authority
HRC	Healthy Rivers Commission
Hydrology	The study of rainfall and surface water runoff processes
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways
LCC	Liverpool City Council
Median (wrt road)	The central reservation which separates carriageways from traffic travelling in the opposite direction
Median (wrt data)	The middle value
Metals	Occur naturally at trace levels in the environment. This category includes the elements arsenic, cadmium, copper, chromium, iron, lead, manganese, mercury, nickel, selenium and zinc
mg/L	Milligrams per litre
MNES	Matters of National Environmental Significance

Term	Meaning
MUSIC	eWater Model for Urban Stormwater Improvement Conceptualisation
NHMRC	National Health and Medical Research
NSW	New South Wales
NTU	Nephelometric Turbidity Unit
Nutrients	Nutrients in aquatic environments promote the growth of algae and increase turbidity which in turn reduces light and may affect plant growth. Generally excessive nutrient inputs lead to excessive algal growth and formation of nuisance blooms. Nutrients consist of nitrogen (including total nitrogen, oxidised nitrogen and ammonia) and phosphorus (including total phosphorus and filterable reactive phosphorus (FRP))
OEH	Office of Environment and Heritage
Oxidised nitrogen	Represents the level of free nitrogen within the water column that is readily available to plants.
pH	A measure of the acidity or alkalinity of a waterway
POEO	Protection of the Environment Operations Act (NSW)
Project	Refers to the construction and operation of the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network.
Project footprint	The land required to construct and operate the project. This includes permanent operational infrastructure and land required temporarily for construction.
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them
RL	Reduced Level
RMS	Roads and Maritime Services
Roads and Maritime	Roads and Maritime Services
RTA	Roads and Traffic Authority
Runoff	The part of the rainfall on a catchment which flows as surface discharge past a specified point
RUSLE	Revised Universal Soil Loss Equation
Scour	The erosion of material by the action of flowing water
SEAR	Secretary's Environmental Assessment Requirements
SEARs	Secretary's Environmental Assessment Requirements and specifications for an environmental assessment prepared by the Secretary of the NSW Department of Planning and Environment under section 115Y of the Environmental Planning and Assessment Act 1979 (NSW)
Sediment	Material, both mineral and organic, that is being or has been moved from its site of origin by the action of wind, water or gravity and comes to rest either above or below water level
Sedimentation	Deposition of sediment usually by water
Spoil	Surplus excavated material
SSTV	Site Specific Trigger Value
SRE	Sensitive Receiving Environments

Term	Meaning
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 sections
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste
STP	Sewage Treatment Plant
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
Swale	A shallow, grass-lined drainage channel
Terrestrial	Living or growing on land (ie terrestrial flora or fauna)
TfNSW	Transport for NSW
Threatened	As defined under the Threatened Species Conservation Act 1995 (NSW), a species, population or ecological community that is likely to become extinct or is in immediate danger of extinction
TN	Total nitrogen - A measure of all the nitrogen species found in a waterway including oxidised nitrogen, ammonia and total organic nitrogen
TP	Total phosphorus - A measure of both biologically available species (known as filterable reactive phosphorus) and the unavailable species.
Tributary	A river or stream flowing into a larger river or lake
TSC	Threatened Species Conservation Act (NSW)
TSS	Total Suspended Solids
Turbidity	A measure of light penetration through a water column containing particles of matter in suspension
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent)
Wetland	Wetlands are areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle. They include areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water, which is generally still or slow moving except in distributary channels such as tidal creeks which may have higher peak flows. Wetlands may be constructed for the purposes of removing pollutants from runoff
WQO	Water Quality Objective

Executive summary

Background

Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network (the project). The project has been determined to be a controlled action under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) (EPBC 2018/8286) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires assessment and approval from the Commonwealth Government.

The M12 Motorway would run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 kilometres and would be opened to traffic prior to opening of the Western Sydney Airport.

Purpose of this report

This report has been prepared to support the environmental impact statement (EIS) for the M12 Motorway project (the project). The EIS has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project (SSI 9364) and to enable the Minister for Planning and Public Spaces and the Commonwealth Minister for the Environment to make a determination on whether the project can proceed. The report presents an assessment of the construction and operational activities for the project that have the potential to impact on surface water quality and hydrology.

Existing water quality

The water quality of creeks within the project area is poor and representative of a catchment that has been impacted by urbanisation and land clearing. They main waterways have low flow and are typically high in nutrients with low in dissolved oxygen. They currently do not meet the requirements for protection of nominated environmental values for slightly to moderately disturbed ecosystems. Other drainage lines and unnamed tributaries were dry and overgrown with vegetation at the time of inspection.

Overview of potential impacts

Construction impacts

Construction of the project would involve a range of activities including the establishment of ancillary facilities and access tracks, demolition of existing buildings, vegetation clearing and subsequent mulching, earthwork including cut and fill, construction of bridges, culverts and adjustment of three waterways (Kemps Creek, South Creek and Badgerys Creek) within the construction footprint. These construction activities have the potential to impact on various aspects of the surface water quality and hydrology including:

- Erosion of soils and sedimentation of waterways
- Reduced water quality from elevated turbidity, increased nutrients and other contaminants
- Smothering of aquatic organisms from increased sediments and associated low dissolved oxygen levels
- Potential growth of weeds and algal blooms associated with reduced water quality

- Accidental leaks or spills of chemicals and fuels
- The introduction of gross pollutants (rubbish) into the waterways
- Adjustment of Badgerys Creek, South Creek and Kemps Creek
- Changes to flow rates, volumes and flow paths within waterways and drainage lines
- Temporary watercourse crossings and construction of bridges altering flow and water quality.

The potential impacts are common on major road projects and with the application of the standard mitigation measures outlined herein, the potential impacts on surface water quality, hydrology and geomorphology are considered minor and manageable.

Operational impacts

Operation of the M12 Motorway, which largely comprises of a new dual carriageway located within a predominately greenfield area, has the potential to impact on surface water quality and hydrology. The potential impacts to water quality and hydrology from the project would include:

- Increased road runoff volumes and/or velocity resulting in potential increase in scouring and erosion
- Accidental leaks or spills of chemicals and fuels
- The introduction of gross pollutants (rubbish) into the waterways
- Reduced water quality from elevated turbidity, nutrients and other contaminants
- Changes to flow rates, volumes and flow paths within waterways and drainage lines
- Altered hydrology and geomorphology from the creation of impermeable surfaces and the proposed minor creek adjustments at Badgerys Creek, South Creek and Kemps Creek.

The potential impacts are common on major road projects and with the application of the standard mitigation measures outlined herein, the potential impacts on surface water quality and hydrology are considered minor and manageable. In addition, the design of the project includes operational water quality basins at sensitive receiving environments which are expected to improve existing water quality in these locations.

Summary of environmental management measures

The key water quality objective is to ensure downstream waterways and identified sensitive receiving environments are protected against the potential impacts from surface runoff generated by the project. Construction methods would be in accordance with Roads and Maritimes' Code of Practice for Water Management and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a) (referred to herein as the ANZECC Water Quality Guidelines). There are a number of physical-chemical and toxicant parameters that need to be controlled during the construction and operation of the project to maintain or strive to achieve the required level of protection for nominated environmental values.

A detailed Soil and Water Management Plan (SWMP) would be prepared as part of the Construction Environmental Management Plan (CEMP) to manage erosion and sediment impacts associated with land disturbance and creek adjustments so that impacts to soil and water quality are minimised throughout the construction phase. Construction drainage and discharge outlet infrastructure will direct flows downstream and energy dissipation and scour protection will be implemented to minimise alterations of the bed and banks.

Management measures implemented during the operational phase to protect water quality would include procedural controls such as stormwater management plan that would include:

- Water management controls and a maintenance and inspection program for these controls
- Physical controls to treat and contain rainfall runoff and accidental spills
- Scour protection measures at culvert discharge outlets and downstream of creek adjustments
- A monitoring program to assess and manage impacts on receiving water ways while the site restabilises.

Conclusions

The activities associated with the construction and operation of the project have the potential to impact on surface water quality, hydrology and the geomorphology of the surrounding waterways. With the implementation of management measures and appropriate design and sizing of water quality controls, the project would have a minimal impact on surface water quality, hydrology and geomorphology, provided the identified risks are managed in accordance with the establish protocols and standards

1. Introduction

1.1 Background

Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network (the project). In addition, the project has been determined to be a controlled action under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) (EPBC 2018/8286) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires assessment and approval from the Commonwealth Government.

The M12 Motorway would run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 kilometres and would be opened to traffic prior to opening of the Western Sydney Airport. The project would commence about 30 kilometres west of the Sydney central business district, at its connection with the M7 Motorway. The project traverses the local government areas of Fairfield, Liverpool and Penrith. The suburbs of Cecil Park and Cecil Hills are found to the east of the M12 Motorway, with Luddenham to the west.

The project is predominately located in greenfield areas. The topography in and around the project comprises rolling hills and small valleys between generally north–south ridge lines. The existing land uses are semi-rural residential, recreational, agricultural, commercial and industrial. The main residential areas are Kemps Creek, Mount Vernon and Cecil Hills.

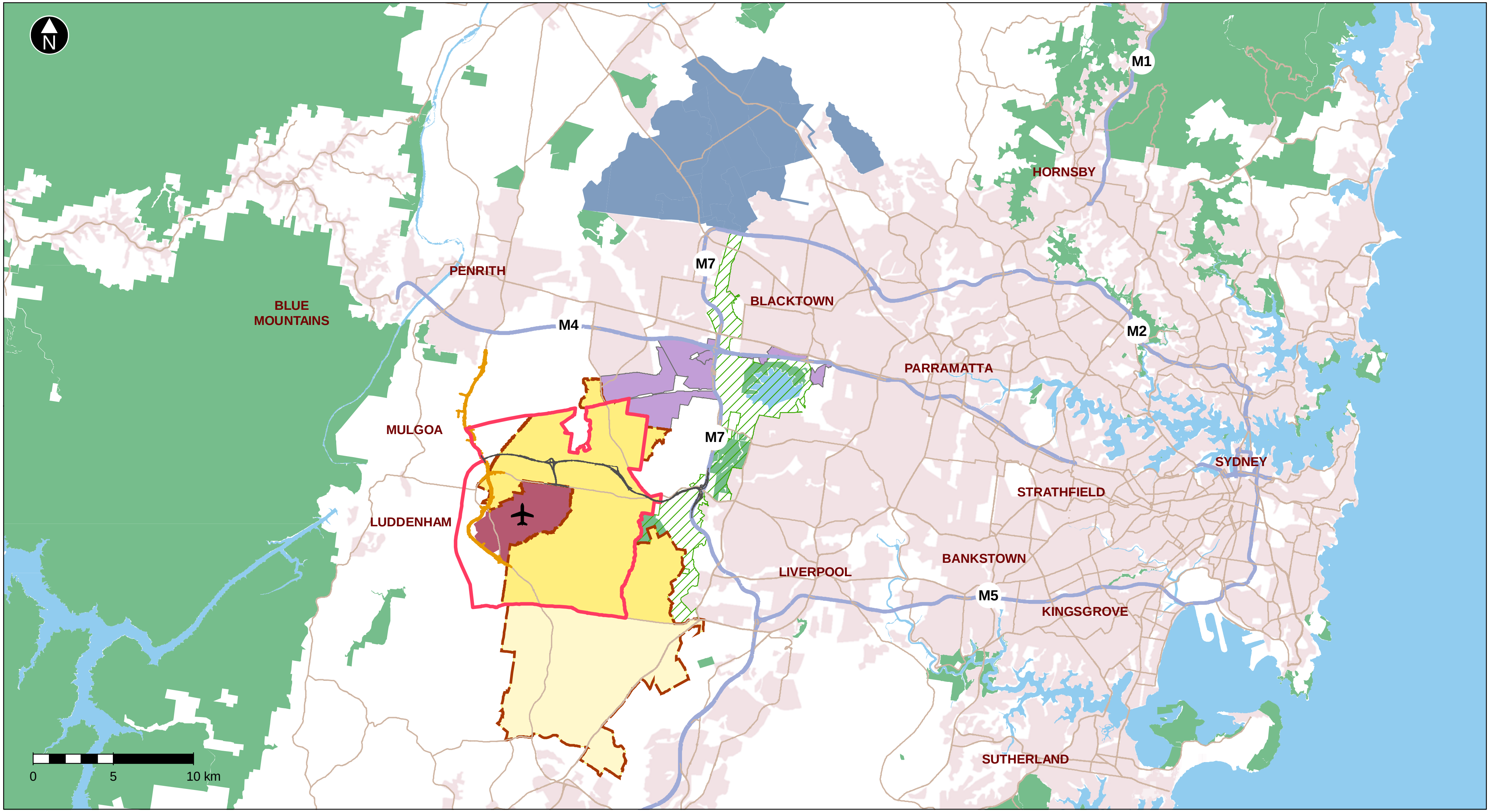
The project is required to support the opening of the Western Sydney Airport by connecting Sydney's motorway network to the airport. The project would also serve and facilitate the growth and development of the Western Sydney which is expected to undergo significant development and land use change over the coming decades. The motorway would provide increased road capacity and reduce congestion and travel times in the future and would also improve the movement of freight in and through western Sydney.

The project location is shown in **Figure 1-1** in relation to its regional context.

1.2 Project overview

The project would include the following key features:

- A new dual-carriageway motorway between the M7 Motorway and The Northern Road with two lanes in each direction with a central median allowing future expansion to six lanes
- Motorway access via three interchanges/intersections:
  - A motorway-to-motorway interchange at the M7 Motorway and associated works (extending about four kilometres within the existing M7 Motorway corridor)
  - A grade separated interchange referred to as the Western Sydney Airport interchange, including a dual-carriageway four lane airport access road (two lanes in each direction for about 1.5 kilometres) connecting with the Western Sydney Airport Main Access Road
  - A signalised intersection at The Northern Road with provision for grade separation in the future
- Bridge structures across Ropes Creek, Kemps Creek, South Creek, Badgerys Creek and Cosgroves Creek



- The project
- Motorways
- Existing main roads
- The Northern Road upgrade (currently under construction)
- Western Sydney Parklands
- NPWS estate / reserve
- Urban areas
- Main waterbodies

Growth areas

- Western Sydney Priority Growth Area
- South West Priority Growth Area
- South West Growth Area
- Western Sydney Airport
- Western Sydney Aerotropolis
- Western Sydney Employment Area
- North West Growth Area

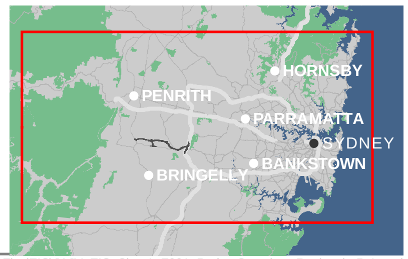


Figure 1-1 Project location (regional context)

Date: 18/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\Chapters\Chapter1_Introduction\FinalEIS\JAJV_EIS_Chap1_F001_ProjectOverview_Regional_r5v1.mxd
Created by : AA | QA by : NS

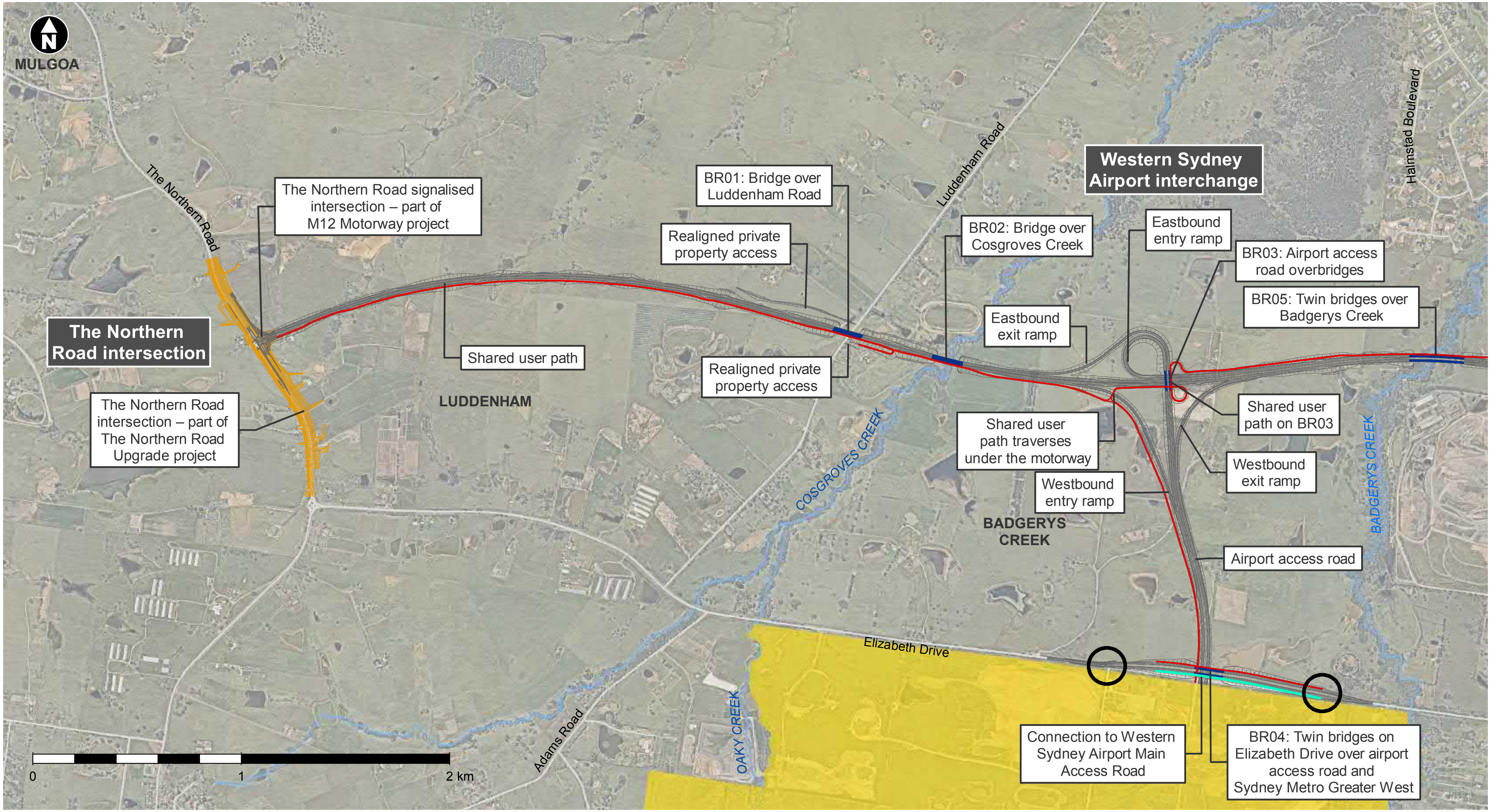
- Bridge structure across the M12 Motorway into Western Sydney Parklands to maintain access to the existing water tower and mobile telephone/other service towers on the ridgeline in the vicinity of Cecil Hills, to the west of the M7 Motorway
- Bridge structures at interchanges and at Clifton Avenue, Elizabeth Drive, Luddenham Road and other local roads to maintain local access and connectivity
- Inclusion of active transport (pedestrian and cyclist) facilities through provision of pedestrian bridges and an off-road shared user path including connections to existing and future shared user path networks
- Modifications to the local road network, as required, to facilitate connections across and around the M12 Motorway including:
  - Realignment of Elizabeth Drive at the Western Sydney Airport, with Elizabeth Drive bridging over the airport access road and future passenger rail line to the airport
  - A realignment of Clifton Avenue over the M12 Motorway, with associated adjustments to nearby property access
  - Relocation of Salisbury Avenue cul-de-sac, on the southern side of the M12 Motorway
  - Realignment of Wallgrove Road north of its intersection with Elizabeth Drive to accommodate the M7 Motorway northbound entry ramp
- Adjustment, protection or relocation of existing utilities
- Ancillary facilities to support motorway operations, smart motorways operation in the future and the existing M7 Motorway operation, including gantries, electronic signage and ramp metering
- Other roadside furniture including safety barriers, signage and street lighting
- Adjustments of waterways, where required, including Kemps Creek, South Creek and Badgerys Creek
- Permanent water quality management measures including swales and basins
- Establishment and use of temporary ancillary facilities, temporary construction sedimentation basins, access tracks and haul roads during construction
- Permanent and temporary property adjustments and property access refinements as required.

The project overview presented in this document represents the proposed concept design. If the project is approved, a further detailed design process would follow, which may include variations to the concept design. Flexibility has been provided in the concept design to allow for refinement of the project during detailed design, in response to any submissions received following the exhibition of the environmental impact statement (EIS), or if opportunities arise to further minimise potential environmental impacts.

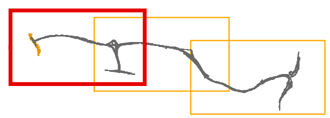
The key features of the project are shown on **Figure 1-2**.

1.3 Purpose and scope of this report

This report has been prepared to support the EIS for the project. The EIS has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project (SSI 9364) and to enable the Minister for Planning to make a determination on whether the project can proceed. The report presents an assessment of the construction and operational activities for the project that have the potential to impact surface water quality and hydrology.

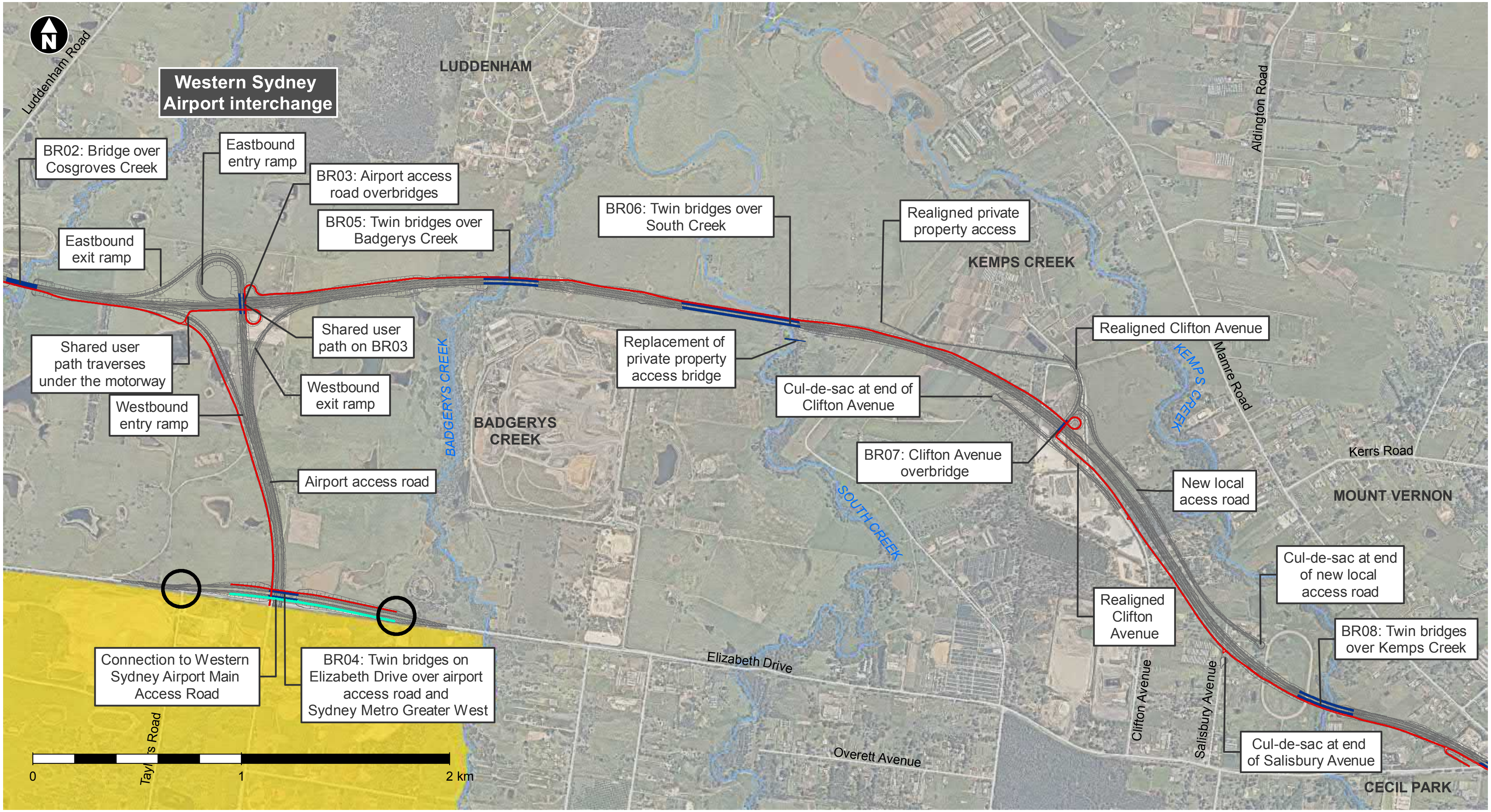


- The project
- Part of The Northern Road upgrade project
- Shared user path
- Future shared user path (by others)
- Existing roads
- Waterways
- Bridges
- Western Sydney Airport
  Note. The roads within this zone are being removed as part of airport construction.
- Potential future intersections (by others)
  Note: Locations to be confirmed



Page 1 of 3

Figure 1-2 Key features of the project



The project

Part of The Northern Road upgrade project

Shared user path

Future shared user path (by others)

Existing roads

Waterways

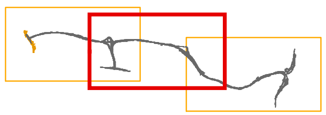
Bridges

Western Sydney Airport

Note. The roads within this zone are being removed as part of airport construction.

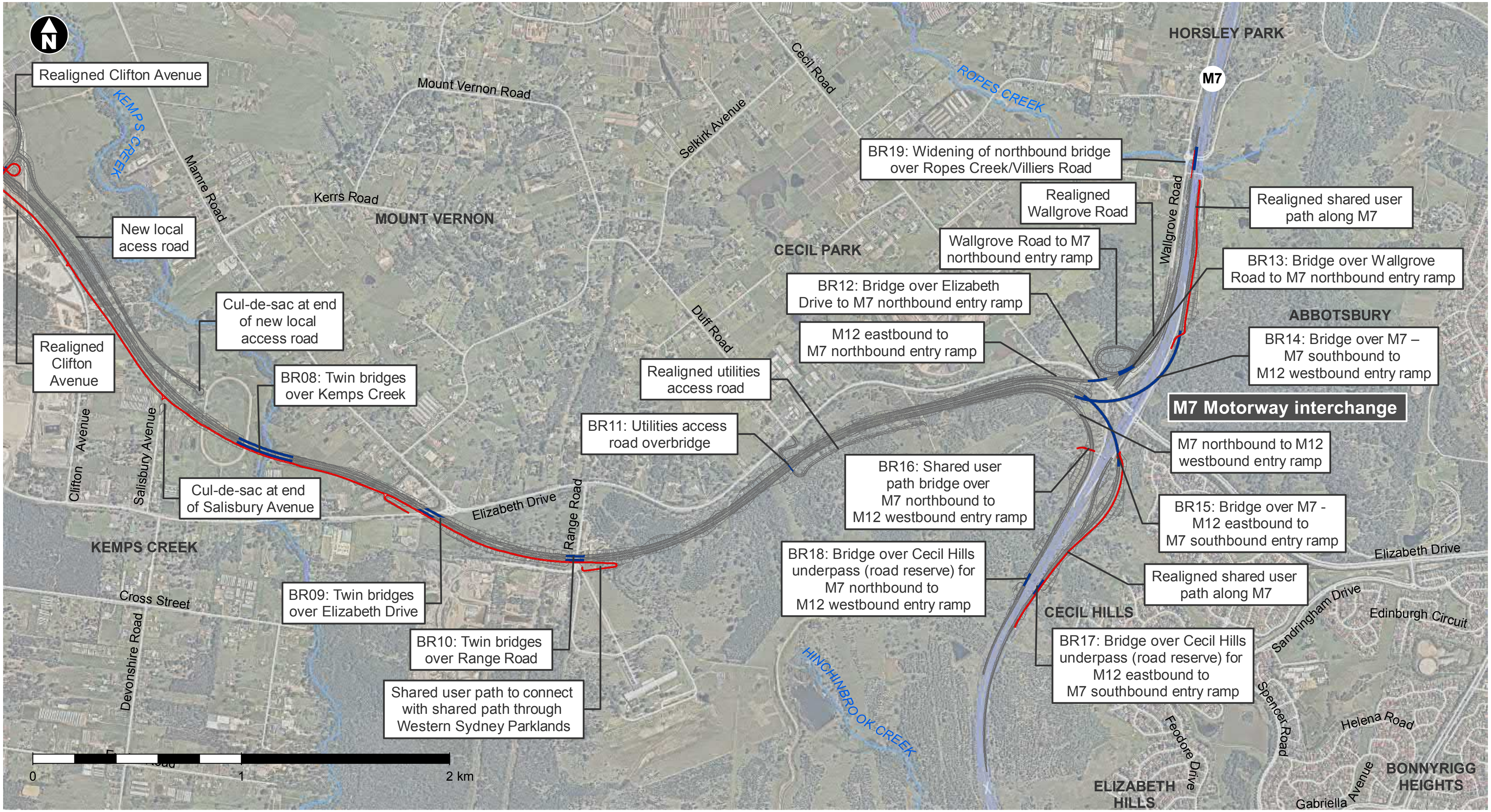
Potential future intersections (by others)

Note: Locations to be confirmed

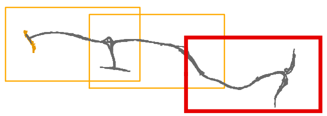


Page 2 of 3

Figure 1-2 Key features of the project



The project
Part of The Northern Road upgrade project
Shared user path
Future shared user path (by others)
Existing roads
Waterways
Bridges



Page 3 of 3

Figure 1-2 Key features of the project

1.4 SEARs

On 18 June 2018, the Secretary of the NSW Department of Planning and Environment issued to Roads and Maritime the draft Secretary's environmental assessment requirements (SEARs) for the M12 Motorway EIS. The SEARS were finalised and reissued on 12 July 2018. The project was then determined to be a controlled action under the EPBC Act, and updated SEARs were issued on 30 October 2018 that include the Commonwealth assessment requirements under the EPBC Act.

Table 1-1 lists those requirements relating specifically to the assessment of the project's potential impacts on surface water quality and hydrology, with a reference to the chapter or section of this report where each requirement is addressed.

Table 1-1 SEARs (surface water quality and hydrology)

Secretary's requirement	Where addressed
14. Water - Hydrology	
1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	**Chapter 4** specifically including **Section 4.2.** Also see Appendix N of the EIS (Groundwater quality and hydrology assessment)
2. The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration.	**Section 5.1.2**
3. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including: a. natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	**Section 5.1** (in particular **Section 5.1.6** and **Section 5.1.7**) and **Section 5.2** (in particular **Section 5.2.3**) Also see Appendix E of the EIS (Biodiversity assessment report) and Appendix N of the EIS (Groundwater quality and hydrology assessment)
b. impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	Appendix N of the EIS (Groundwater quality and hydrology assessment)
c. changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	**Section 5.1.2** **Section 5.1.6** **Section 5.1.7** **Section 5.2.3**
d. direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	**Section 5.1.5** **Section 5.1.6** **Section 5.2.3**

Secretary's requirement	Where addressed
e. minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	**Section 5.1.6** **Section 5.2.3** **Section 5.1.3** **Section 6**
f. water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	**Section 5.1.2** **Section 5.1.7**
4. The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	**Chapter 8**. Also see Appendix N of the EIS (Groundwater quality and hydrology assessment)
15. Water – quality	
1. The Proponent must: a. state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	**Section 2.3**
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;	**Chapter 6**
c. identify the rainfall event that the water quality protection measures will be designed to cope with;	**Section 5.1.2** **Section 5.1.5** **Chapter 6**
d. assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	**Section 0** **Chapter 6**
e. demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that: • where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and	**Section 3.5** **Section 5.1.8** **Section 0** **Chapter 6**
• where the NSW WQOs are not currently being met, activities will work toward their achievement over time;	**Section 3.5** **Section 5.1.8** **Section 0** **Chapter 6**
f. justify, if required, why the WQOs cannot be maintained or achieved over time;	**Section 5.1.8** **Section 0**

Secretary's requirement	Where addressed
	Chapter 8
g. demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	**Section 5.1.1** **Chapter 6**
h. identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments; and	**Section 4.4** **Section 5.2** **Chapter 6**
i. identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	**Chapter 8**
16. Protected and sensitive lands	
1. The Proponent must assess the impacts of the project on environmentally sensitive land and processes (and the impact of processes on the project) including, but not limited to: a. Key Fish Habitat as mapped and defined in accordance with the Fisheries Management Act 1994 (FM Act);	**Chapter 4** Also see Appendix E of the EIS (Biodiversity assessment report)
b. waterfront land as defined in the Water Management Act 2000;	**Section 5.2.3** **Chapter 9** Appendix E of the EIS (Biodiversity assessment report)
c. land or waters identified as Critical Habitat under the TSC Act, FM Act or EPBC Act; and	Appendix E of the EIS (Biodiversity assessment report)
d. biobank sites, private conservation lands and other lands identified as offsets.	Appendix E of the EIS (Biodiversity assessment report)

2. Policy and planning setting

2.1 NSW legislation

2.1.1 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) is administered by the Office of Environment and Heritage (OEH). The POEO Act regulates air and water pollution, noise control and waste management. Provision of environmental protection licences are core strategies under the POEO Act. The owner or occupier of the premises engaged in scheduled activities is required to hold an environmental protection licence and comply with conditions of that licence. The project would be a scheduled activity as it meets relevant criteria for road construction and extractive activities (under Items 35 and 19 respectively) of Schedule 1 of the POEO Act. Environmental protection licences may be issued to authorise carrying out the scheduled activities and to regulate water pollution resulting to such activities.

Under the POEO Act, there is a legal responsibility to ensure that runoff leaving a site meets an agreed water quality standard, including water being discharged from sedimentation ponds after storm events.

2.1.2 Protection of the Environment Administration Act 1991

The *Protection of the Environment Administration Act 1991* (NSW) establishes the EPA, Board of the EPA, and community consultation forums. The objectives of the Act are to protect, restore and enhance the quality of the environment and to reduce risks to human health. It sets out obligations and responsibilities for managing activities that may cause environmental harm. The Act allows the Board to determine whether the EPA should institute proceedings for serious environmental protection offences and advises the Minister on any matter relating to the protection of the environment. Under the Act, the RMS should ensure that any discharges into water of substances likely to cause harm to the environment must be reduced to harmless levels.

2.1.3 Water Act 1912, Water Management Act 2000 and Water Management (General) Regulation 2011

The *Water Act 1912* (NSW) and the *Water Management Act 2000* (NSW) (WM Act) are the two key pieces of legislation for the management of water in NSW and contain provisions for the licensing of water access and use. The *Water Act 1912* (NSW) is being progressively phased out and replaced by the WM Act.

The aims of the WM Act are to provide for the sustainable and integrated management of the State's water sources for the benefit of both present and future generations. The WM Act implicitly recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The WM Act enables the State's water resources to be managed under water sharing plans, which establish the rules for the sharing of water in a particular water source between water users and the environment, and rules for the trading of water in a particular water source.

The project is located within the Hawkesbury-Nepean water management area and is therefore covered by the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources (NSW Department of Primary Industries (DPI), 2011). This plan applies to surface water sources and includes rules for protecting the environment, water extraction, managing licence holders' water accounts, and water trading within the plan area. Under Schedule 5, Part 1, clause 2 of the Water Management (General) Regulation 2011 (NSW), roads authorities are exempt from the requirement to hold a water access licence to take water for road construction and road maintenance.

2.1.4 NSW Fisheries Management Act 1994

The *Fisheries Management Act 1994* (NSW) (FM Act) provides for the protection of threatened fish and marine vegetation and is administered by the Department of Primary Industries. The FM Act, in conjunction with the *Biodiversity Conservation Act 2016,* aims to conserve, develop and share fishery resources and conserve marine species, habitats and diversity. The proposed alignment would cross Cosgroves Creek, Badgerys Creek, South Creek, Kemps Creek and Ropes Creek.

Waterway crossings have been designed where possible according to NSW Fisheries (part of the NSW DPI) guidelines (*Why do Fish need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (DPI, 2003)) and in consultation with NSW Fisheries staff to ensure minimum impact to aquatic habitats and species protected under the Act.

Under section 199 of the FM Act, Roads and Maritime as a public authority has a duty to notify the Minister responsible under that Act, before it carries out or authorises any dredging or reclamation work. The Minister may within 21 days of receiving that notification, raise any matters concerning the proposed work. Roads and Maritime must consider any matter raised by the Minister before it carries out the proposed work.

2.1.5 Threatened Species Conservation Act (1995)

Biodiversity matters in NSW are currently assessed under the *Biodiversity Conservation Act 2016* (NSW) (BC Act) which came into effect in August 2017. Roads and Maritime applied to have the project defined as a ‘pending or interim planning application’ under Clause 27(1) of the Biodiversity Conservation (Savings and Transitional) Regulation 2017 based on having undertaken ‘substantial environmental assessment’ prior to the commencement of that Act. This application was granted by a delegate of the Secretary of the Department of Planning, Industry and Environment (DPIE) on 5 April 2018. Accordingly, the former planning provisions, including the *Threatened Species Conservation Act 1995* (NSW) (TSC Act, continue to apply to the project.

The TSC Act aims to conserve threatened species, populations and ecological communities through ensuring appropriate assessment, management and regulation of actions that may damage critical or other habitat for a listed threatened species, or may otherwise significantly affect a threatened species, population or ecological community. The design of waterway crossings will ensure that there are minimal impacts on aquatic species and habitats protected under the TSC Act.

2.1.6 Sydney Regional Environmental Plan No. 20 – Hawkesbury-Nepean River (No 2-1997)

The purpose of the *Sydney Regional Environment Plan No. 20 – Hawkesbury-Nepean River – (No2-1997)* (NSW) (SREP20) is to "protect the environment of the Hawkesbury-Nepean River system by ensuring that the impacts of future land uses are considered in a regional context". It covers environmentally sensitive areas, water quality and quantity and controls development that has the potential to impact on the river environment.

The project is located within the South Creek catchment which ultimately drains to the Hawkesbury River. The Local Government Areas (LGAs) of Penrith, Liverpool and Fairfield are identified as three of the 15 LGAs to which the SREP20 – Hawkesbury-Nepean River applies and specific planning policies and recommended strategies for consideration in this project are detailed in Clause 6 of SREP 20. The recommended clauses of SREP 20 and how they have been addressed in the context of the M12 project are provided in **Table 2-1**.

Table 2-1 Strategies for consideration under Clause 6 of SREP 20

Clause	Policy	Project consideration
6(1)	**Total catchment management** Is to be integrated with environmental planning for the catchment	The project has been designed to ensure that the water quality of downstream waterways is protected against the potential impacts from construction and operation of the project through consideration of erosion and sedimentation risk and increased surface flows.
6(2)	**Environmentally sensitive areas** Must be protected and enhanced through careful control of future land use changes and through management and (where necessary) remediation of existing uses	The project is not expected to have a major impact on environmentally sensitive areas. Water quality controls and mitigation measures have been specifically designed to protect sensitive receiving environments as discussed in **Section 6**
6(3)	**Water quality** Future development must not prejudice the achievement of the goals for use of the river for primary contact recreational and aquatic ecosystem protection in the river system. If the quality of the receiving water does not currently allow these uses, the current water quality must be maintained, or improved, so as to not jeopardise the achievement of the goals in the future. When water quality goals are set by the Government these are to be the goals to be achieved under this policy.	The project has been designed so as to have minimal impact on water quality on waterways in the project area so as to not jeopardise achieving the long environmental values and uses of the Hawkesbury Nepean catchment as discussed in **Sections 5.1.8** and **0**.
6(4)	**Water quantity** Aquatic ecosystems must not be adversely affected by development which changes the flow characteristics of surface or groundwater in the catchment.	Potential changes to flow characteristics and runoff of surface water as a result of the project area are discussed in **Sections 5.1.6** and **5.2.3**. Where there is potential for changes in surface flow to impact on aquatic ecosystems appropriate hydrological controls have been recommended (refer **Sections 6.1.3** and **6.2.6**.

2.2 Commonwealth legislation

2.2.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) provides a legal framework to protect and manage Matters of National Environmental Significance (MNES) including the following biodiversity-related matters (as relevant to the project area):

- Listed migratory birds
- Listed threatened species and ecological communities.

Where a project is likely to have a significant impact on a MNES, the project is referred to the Australian Environment Minister. The referral process involves a decision on whether or not the project is a 'controlled action'. When a project is declared a controlled action, approval from the Minister is required. The project has been declared a controlled action and approval under the EPBC Act is required.

2.3 Relevant guidelines

2.3.1 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) was formulated with the objective of achieving sustainable use of the nation's water resources by protecting and enhancing water quality whilst maintaining economic and social development.

The NWQMS contains guidelines for setting water quality objectives to sustain current or likely future environmental values for water resources. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a) (referred to herein as the ANZECC Water Quality Guidelines) are part of the NWQMS and are relevant to the project as discussed below.

2.3.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Water Quality Guidelines)

The ANZECC Water Quality Guidelines provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters and list a range of environmental values assigned to that waterbody. The ANZECC Water Quality Guidelines have been applied with guidance from the *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DECC, 2006) booklet to understand the current health of the waterways in the vicinity of the project and the ability to support nominated environmental values, particularly the protection of aquatic ecosystems. The ANZECC Water Quality Guidelines provide recommended trigger values for various levels of protection which have been 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 to moderately disturbed ecosystems.

It should be noted that as per Section 2.2.1.9 of the ANZECC (2000) guidelines; "the guidelines have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality, nor should they be used in this way. They have been derived to apply to the ambient waters that receive effluent or stormwater discharges, and protect the environmental values they support."

2.3.3 NSW Water Quality Objectives

The NSW Water Quality Objectives (WQOs) are the agreed environmental values and long-term goals for NSW's surface water (DECCW, 2006). They set out:

- The communities values and uses (ie healthy aquatic ecosystem, water suitable for recreation or drinking water etc) for our waterways (rivers, creeks, lakes and estuaries)
- A range of water quality indicators to assess whether the current condition of the waterway supports these values and uses.

At the time that WQOs were approved by the government (September 1999) for catchments across NSW, the Hawkesbury-Nepean was subject to an independent inquiry by the Healthy Rivers Commission (HRC).

The HRC inquiry into the Hawkesbury-Nepean system in the late 1990s determined water quality objectives that recognise the communities 'environmental values' and uses of the waterways. These water quality objectives were agreed to by the NSW Government through a statement of Joint Intent in 2001.

The water quality objectives consist of three parts: environmental values, water quality indicators and recommended guideline levels. The HRC water quality objectives (discussed further in **Section 2.3.4**) have been adopted as the relevant water quality objectives for the project, along with the environmental values from the ANZECC Water Quality Guidelines (discussed further in **Section 2.3.2**). As the water quality criteria provided in the HRC guidelines were established in the 1990s, the ANZECC water quality guidelines developed in 2000 have superseded these. The ANZECC Water Quality Guidelines have been used as the basis for the surface water quality and hydrology assessment presented it his report.

2.3.4 Healthy Rivers Commission Inquiry

The HRC was established in 1995 by the NSW Government to make recommendations on:

- Suitable objectives for water quality, flows and other goals central to achieving ecologically sustainable development in a realistic time frame
- The known or likely views of stakeholder groups on the recommended objectives
- The economic and environmental consequences of the recommended objectives
- Strategies, instruments and changes in management practices that are needed to implement the recommended objectives (DECCW, 2006).

The HRC Inquiry is relevant to the project as it established environmental values for different regions of the Hawkesbury-Nepean River, into which the project drains (referred to herein as the HRC guidelines). As stated in **Section 2.3.3**, the ANZECC Water Quality Guidelines have been used as the basis for the surface water quality and hydrology assessment. The HRC guidelines, however, have been adopted to identify the environmental values to be protected .

2.3.5 Environmental values

As stated in **Section 2.3.3**, the ANZECC Water Quality Guidelines have been used as the basis for the surface water quality and hydrology assessment. In addition, the HRC has been used to determine water quality guidelines for the protection of water quality in the Hawkesbury-Nepean River (HRC, 1998).

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit or health. They are values that require protection from the effects of pollution and waste discharges and provide goals that help in the selection of the most appropriate management options (ANZECC/ARMCANZ, 2000a).

Water quality objectives and environmental values were determined under the HRC Inquiry into the Hawkesbury-Nepean system (HRC, 1998). In 2001 the NSW Government agreed to these through a Statement of Joint Intent.

The project lies largely within the lower Hawkesbury-Nepean Catchment within the regions classified as 'mixed-use rural' and 'predominantly urban'. The nominated environmental values applying to waterways within the study area are:

- **Protection of aquatic ecosystems —** Aquatic ecosystems comprise the animals, plants and micro-organisms that live in water and the physical and chemical environment in which they interact. Aquatic ecosystems have historically been impacted upon by multiple pressures including changes in flow regime, modification and destruction of key habitats, development and poor water quality.
- **Visual amenity** — The aesthetic appearance of a waterbody is an important aspect with respect to recreation. As such the water should be free from noticeable pollution, floating debris, oil, scum and other matter. Substances that produce objectionable colour, odour, taste or turbidity and substances and conditions that produce undesirable aquatic life should not be apparent (NHMRC, 2008). The key aesthetic indicators are transparency, odour and colour.
- **Primary contact recreation —** Primary contact refers to where the body can be fully immersed and there is the potential to swallow water. You are in direct contact with the water. This includes water skiing, diving and swimming
- **Secondary contact recreation —** This refers to activities such as paddling, wading, boating and fishing in which there is direct contact but the chance of swallowing water is unlikely.
- **Irrigation water supply —** This refers to the suitability of water supply for irrigation, for example irrigation of crops, pastures, parks, gardens and recreational areas
- **Homestead water supply —** The objective applies to all homesteads that draw water from surface water for domestic needs, including drinking water. Suitability of domestic farm water supply, other than drinking water. For example water used for laundry and produce preparation.

The environmental values have been considered in the assessment of existing water quality and potential impacts as a result of the project.

Key water quality indicators and related numerical criteria have been nominated for each environmental value using the ANZECC Water Quality Guidelines. These values and indicators are provided in **Table 2-2**.

Table 2-2 Environmental values for waterways in the project area and associated indicators and guideline values

Environmental value	Indicator	Guideline value
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and riparian zones over the long term	Total phosphorus	25µg/L
	Total nitrogen	350µg/L
	Chlorophyll-a	3µg/L
	Turbidity	6-50 Nephelometric Turbidity Unit (NTU)
	Salinity (electrical conductivity)	125-2200µS/cm
	Dissolved oxygen	85-110% saturation
	pH	6.5-8.5

Environmental value	Indicator	Guideline value
	Toxicants	As per table 3.4.1 ANZECC/ARMCANZ (2000a) (95% level of protection for slightly to moderately disturbed ecosystems and 99% level of protection for toxicants that bioaccumulate)
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of 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 matter. 250 µg/L
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts n/a (no quantitative value specified)
Secondary contact recreation – maintaining or improving water quality of activities such as boating and wading, where there is a low probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the NHMRC 2008 Guidelines for managing risks in recreational water
	Nuisance organisms	As per the visual amenity guidelines. Large numbers of midges and aquatic works are undesirable.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable of recreation. Toxic substances should not exceed values in table 9.3 of NHMRC (2008) guidelines.
	Visual clarity and colour	As per the visual amenity guidelines.
	Surface films	As per the visual amenity guidelines.
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the NHMRC 2008 Guidelines for managing risks in recreational water
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values in table 9.3 of the NHMRC (2008) guidelines.

Environmental value	Indicator	Guideline value
	Visual clarity and colour	As per the visual amenity guidelines.
	Temperature	15°-35°C for prolonged exposure.
Irrigation water supply – protecting the quality of waters applied to crops and pastures	Algae and 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, landscapes 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 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	Recommended 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 cells/mL – seek advice from health authority
	Turbidity	5 NTU; <1NTU desirable for effective disinfection; >1 NTU may shield some micro-organisms from disinfection
	Total dissolved solids	• <500mg/L is regarded as good quality drinking water based on taste • 500-1000mg/L is acceptable based on taste • >1000mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste

Environmental value	Indicator	Guideline value
	Faecal coliforms	0 faecal coliforms per 100mL (0/100mL). 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
	Chemical contaminants	See Guidelines for Inorganic Chemicals in the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 2004).

2.3.6 Construction phase mitigation guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures that would be implemented during the construction phase of the project:

- NSW DECC (2008), *Managing Urban Stormwater – Volume 2D Main Road Construction*, NSW Department of Environment, Climate Change and Water (known as the Blue Book Volume 2): Sydney
- Landcom (2004), *Managing Urban Stormwater – Soils and Construction*, Volume 1, 4th Edition (known as the Blue Book Volume 1): Sydney
- RTA (2003a), Road Design Guideline: Section 8 Erosion and Sediment, Roads and Traffic Authority of NSW: Sydney
- RTA (2003b), Guideline for Construction Water Quality Monitoring, Roads and Traffic Authority of NSW: Sydney
- RTA (2009), Erosion and Sediment Management Procedure, Oct 2009, Roads and Traffic Authority of NSW: Sydney
- RTA (1999), Code of Practice for Water Management - Road Development and Management, Roads and Traffic Authority of NSW: Sydney
- RMS (2012), Environmental Direction: Management of Tannins from Vegetation Mulch, Roads and Maritime Services: Sydney
- RTA (2005), Guidelines for the Management of Acid Sulphate Materials: Acid Sulphate Soils, Acid Sulphate Rock and Monosulfidic Black Ooze, Roads and Traffic Authority of NSW: Sydney
- RTA (2001), Stockpile Site Management Procedures, Roads and Traffic Authority of NSW: Sydney
- RMS (2011), Technical Guideline: Temporary Stormwater Drainage for Road Construction, Roads and Maritime Services: Sydney
- RMS (2011), Technical Guideline – Environmental Management of Construction Site Dewatering, Roads and Maritime Services: Sydney
- TfNSW, 2013 NSW Sustainable Design Guidelines Version 3.0, Transport for NSW.
- DPI, 2012 Guidelines for controlled activities on waterfront land, Department of Primary Industries.

These guidelines seek to minimise land degradation and water pollution from road construction sites in NSW. The guidelines have been used to identify appropriate management procedures for construction including physical controls to minimised erosion and to prevent sediment moving off site.

2.3.7 Operational phase mitigation guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures to be implemented during the operational phase of the project:

- RTA (2003c) Procedures for Selecting Treatment Strategies to Control Road Runoff, Roads and Traffic Authority of NSW: Sydney
- RTA (1999) RTA Code of Practice for Water Management, Roads and Traffic Authority of NSW: Sydney
- RTA (1997) RTA Water Policy, Roads and Traffic Authority of NSW, Sydney
- NSW EPA (1997) Managing Urban Stormwater: Council Handbook, NSW Environmental Protection Authority: Sydney
- Austroads (2001) Road Runoff and Drainage: Environmental Impacts and Management Options, Austroads AP-R180
- Austroads (2003) Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure, Austroads AP-R232
- Austroads (2010) Guide to Road Design, Part 5: Drainage Design, Sydney
- DECCW (2007) Managing Urban Stormwater, Environmental Targets Consultation Draft, Department of Environment, Climate Change and Water: Sydney
- Penrith City Council, Water Sensitive Urban Design Policy December 2013, updated in December 2017
- Fairfield City Council, Stormwater Management Policy, September 2017
- Liverpool City Council, Liverpool Development Control Plan 2008. General controls for all development, Updated in April 2019
- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DECC, 2000).

The objective of these documents is to provide guidance on water management practices, water quality, quantity and water conservation issues related to the design, operation and maintenance of the roads and traffic systems. This is in order to protect waterways and water quality where practicable and feasible. They provide guidance on the process of designing permanent water quality treatment in a consistent and practicable manner. The design for the project would address the sensitivity of receiving waters and local environment within and directly outside the project area.

The guidelines on water quality design criteria for the operational phase of development projects have been obtained from the NSW EPA Managing Urban Stormwater – Council Handbook (NSW EPA, 1997) and recommend pollutant load reductions.

Penrith, Fairfield and Liverpool City Councils have guidelines and policies on stormwater quality management and Water Sensitive Urban Design. The requirements for pollutant load reductions for total suspended solids and nutrients as shown in **Table 2-3**. These are percentage reductions requirements for the developed conditions.

Table 2-3 Councils pollutant load reductions requirements (as a percentage)

Indicator	Penrith City Council	Liverpool City Council	Fairfield City Council
Total Suspended Solids	85%	85%	80%
Total Phosphorus	60%	45%	55%
Total Nitrogen	45%	45%	40%

3. Assessment methodology

3.1 Overview

The methodology for the assessment of surface water quality and hydrology is outlined in the following sections and has included:

- Undertaking a desktop review and analysis of existing surface water quality and hydrology information to determine potential receptors, describe the existing environment and identify potential issues
- A site visit and water quality monitoring event to support and enhance the findings of the desktop analysis and refine the understanding of potential issues
- Assessment of the impact of construction and operation activities on water quality and hydrology with reference to the ANZECC Water Quality Guidelines with regard to the relevant environmental values
- Identification of appropriate measures to mitigate the potential impacts to water quality and hydrology resulting from construction and operation of the project.

3.2 Study area

The study area for the water quality and hydrology assessment is the area directly affected by the development and any additional areas likely to be affected by the development, either directly or indirectly. The study area generally comprises the construction and operational footprints and a 500 metre buffer around the M12 Motorway alignment (**Figure 3-1**).

3.3 Desktop assessment

The desktop assessment involved a review of the existing surface water and hydrological conditions across the study area to assess the likely and potential impacts of the project on surface water quality and hydrology during construction and operation. The review of information has included:

- Review of available literature, water quality data, hydrological data and background information on catchment history and land use to aid in interpreting the existing conditions. Literature sources included:
  - GHD (2016) Western Sydney Airport EIS - Surface Water Hydrology and Geomorphology
  - HNCMA (2007) Hawkesbury-Nepean River Health Strategy
  - Liverpool City Council (2003). Austral Floodplain Risk Management Study and Plan. Review and Finalisation
  - Rae, D.J. (2007) Water management in South Creek Catchment. Current state, issues and challenges. Technical report No. 12/07
  - Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings
  - RMS/Aurecon (2016) M12 Motorway Strategic Route Options Analysis, Hydrology Working Paper
  - Water quality data collected by Sydney Water, Liverpool City Council, Western Sydney Airport and the Georges River Keeper
- Assessment of the impact of construction and operation activities on water quality and hydrology with reference to the ANZECC Water Quality Guidelines and the HRC Inquiry with regard to the relevant environmental values of aquatic ecosystems, visual amenity, primary and secondary contact recreation, homestead water supplies and irrigation supplies.

- Identification of water quality and hydrology treatment measures to mitigate the impact of construction on water quality, following the principles of *Managing Urban Stormwater–Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater–Soils and Construction Volume 2D* (DECC, 2008), collectively referred to as the Blue Book.
- Identification of water quality treatment measures to mitigate the impact of the operation of the project on water quality following the principle of *Procedure for Selecting Treatment Strategies to Control Road Runoff* (RTA, 2003c), *Roads and Maritime Water Policy* (RTA, 1997) and *Roads and Maritime Code of Practice, Water Management* (RTA, 1999).
- Consideration and recommendation of erosion and scour protection measures for changes in hydrology during the operation of the project.

There are several guidelines and management procedures relevant to the assessment of surface water quality and hydrology. These guidelines and procedures have been used to determine existing water conditions along the project and identify the appropriate water quality and hydrology management and mitigations measures for implementation during the construction and operational phases of the project (refer **Section 2.3**).

3.4 Identification of sensitive receiving environments

Sensitive receiving environments (SREs) are environments that have a high conservation or community value or support ecosystems/human uses of water that are particularly sensitive to pollution or degradation of water quality. SREs were identified within 500m of the M12 Motorway alignment based on the following considerations:

- Key fish habitat field assessment in accordance with (DPI, 2013)
- Waterway classification (Fairfull and Witheridge, 2003)
- Key fish habitat mapping (DPI, 2018a)
- Threatened aquatic species under FM Act, TSC Act and EPBC Act
- Groundwater and surface water dependent vegetation and fauna communities listed under the BC Act and EPBC Act
- Proximity to a drinking water catchment
- Areas that contribute to aquaculture and commercial fishing

In addition, areas mapped as Coastal Wetlands within the vicinity of the project under the State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP) are also considered within this assessment to be SREs due to their environmental significance and sensitivity. Under the Coastal Management SEPP, an activity cannot impact on the biophysical, hydrological and ecological integrity of the wetland and its catchment. While the SEPP does not apply to the project because of its declared status as State Significant Infrastructure, the sensitivity of areas mapped under the SEPP has been taken into account in this assessment.

The locations identified as SREs are identified in **Section 4.4** and are mapped on **Figure 3-2**. The strategy to minimise impacts on the water quality of the SRE's is discussed in **Chapter 6**.

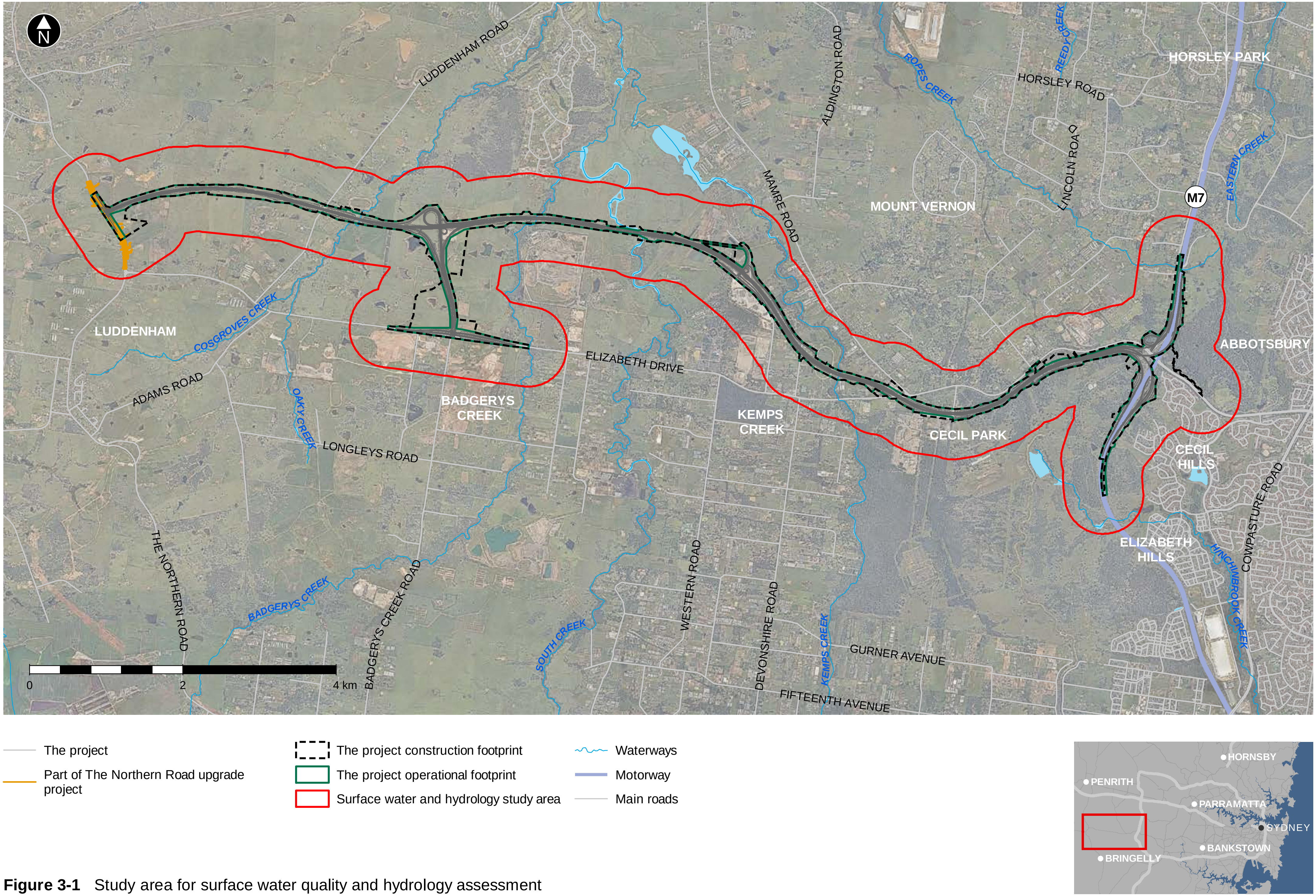


Figure 3-1 Study area for surface water quality and hydrology assessment

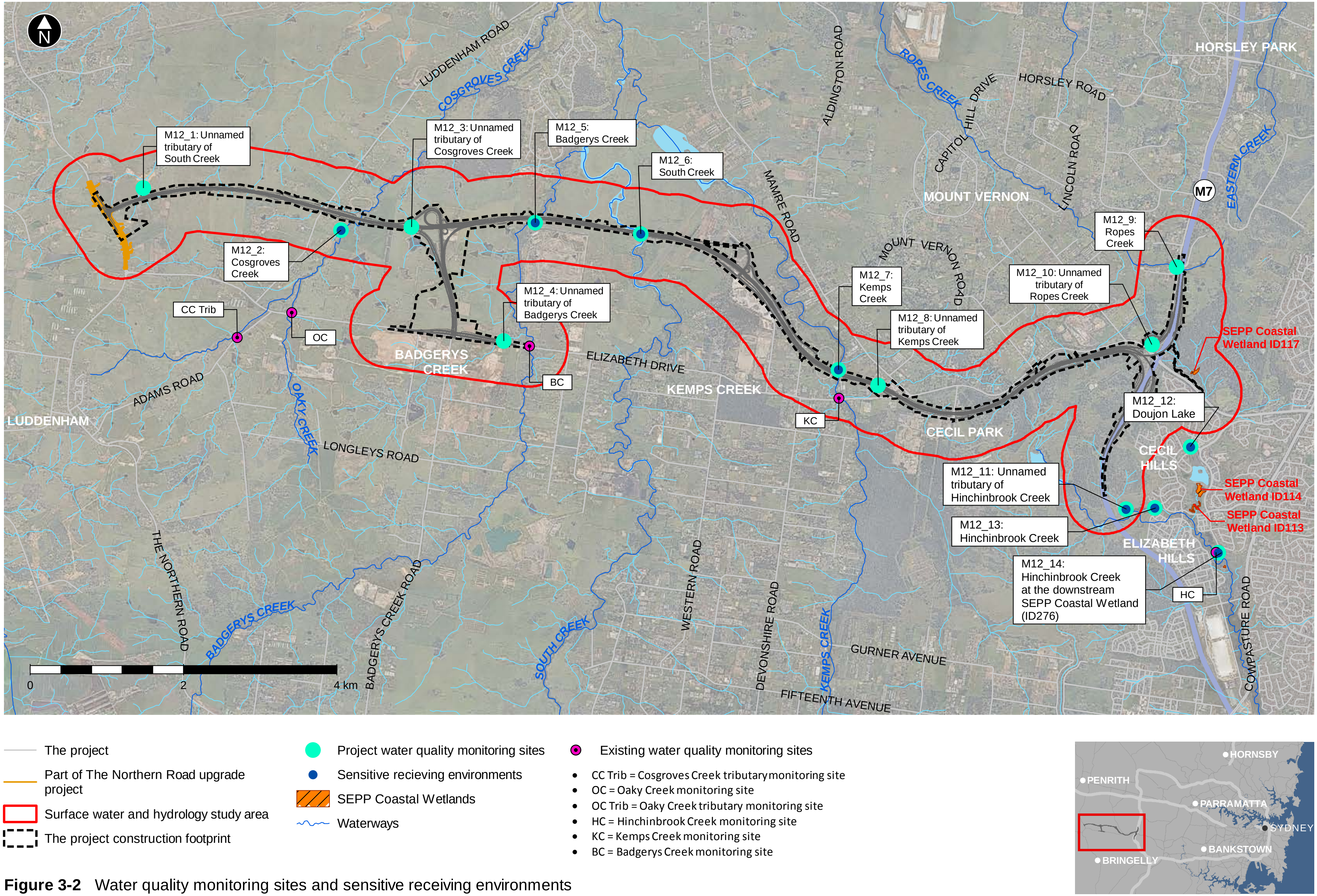


Figure 3-2 Water quality monitoring sites and sensitive receiving environments

3.5 Water quality criteria

As identified in the SEARS, the desired performance outcome for the project in relation to water quality is that:

“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 and marine waters (if applicable)”.

The assessment included consideration of the project’s performance against the agreed water quality objectives (for protection of slightly to moderately disturbed ecosystems) outlined in **Section 2.3**. The performance against these objectives during the construction phase and operation is presented in **Section 5.1.8** and **Section 0** respectively.

3.6 Site investigations

A site visit of the study area was undertaken on Monday 18 and Tuesday 19 June 2018, to undertake water quality monitoring and to visually assess the condition of waterways traversed by the project. No rain had fallen in the week prior to the monitoring event according to the Badgerys Creek All Weather Station (AWS) #067108 (BOM, 2018). While water quality monitoring would ideally include monitoring in wet weather, there were a number of extended dry periods in 2018 during preparation of this assessment which meant this was not feasible.

An additional monitoring event was undertaken on 11 March 2019 at four locations within the Hinchinbrook Creek and Doujon Lake catchment. As a result of the limited water quality, additional water quality monitoring is currently occurring (during dry and wet weather) that will assist in future assessments that may be required during the detailed design stage of the project.

A total of 14 locations within the study area were visited as described in **Table 3-1** overleaf and shown in **Figure 3-2**. **Figure 3-2** also shows a number of existing water quality monitoring locations were sampling has been undertaken by others (including by Liverpool Council, Sydney Water, Western Sydney Airport and the Georges River Keepers). Monitoring sites were generally located at the project crossing of the waterway, with the exception of the unnamed tributary of Badgerys Creek which due to access issues was visited slightly upstream of the proposed crossing.

Water quality sampling included *in-situ* monitoring and collection of grab samples. *In-situ* water quality parameters included temperature, conductivity, salinity, pH and dissolved oxygen and were measured using a calibrated YSI Pro Plus multi-parameter water quality meter. Turbidity was also measured *in-situ* using a Hach turbidimeter.

Measurements were generally collected between 15 and 30 centimetres below the surface depending on the depth of water. Sampling depth was recorded in the field. For each parameter measured *in-situ*, three replicate measurements were recorded about 10 metres apart. Each parameter was then reported as the average (arithmetic mean) of the three measurements.

A single grab samples were collected at each site and sent to the laboratory for analysis. The analytical suite for laboratory analysis included:

- Total suspended solids
- Total nitrogen
- Total phosphorus.

Table 3-1 Waterway monitoring sites

Site number	Watercourse	Details of sampling
M12_1	Unnamed tributary of South Creek	No sample collected^
M12_2	Cosgroves Creek	Replicate (3) *in-situ* and 1 grab sample
M12_3	Unnamed tributary of Cosgroves Creek	No sample collected^
M12_4	Unnamed tributary of Badgerys Creek	No sample collected^
M12_5	Badgerys Creek	No sample collected^
M12_6	South Creek	Replicate (3) *in-situ* and 1 grab sample
M12_7	Kemps Creek	Replicate (3) *in-situ* and 1 grab sample
M12_8	Unnamed tributary of Kemps Creek	No sample collected^
M12_9	Ropes Creek	No sample collected^
M12_10	Unnamed tributary of Ropes Creek	No sample collected^
M12_11	Unnamed tributary of Hinchinbrook Creek	No sample collected^
M12_12	Doujon Lake	Replicate (3) *in-situ* and 1 grab sample
M12_13	Hinchinbrook Creek	Replicate (3) *in-situ* and 1 grab sample
M12_14	Hinchinbrook Creek at the downstream SEPP Coastal Wetland	Replicate (3) *in-situ* and 1 grab sample
^ insufficient water to collect samples		

In conjunction with the water quality sampling, a geomorphological assessment was also undertaken. This included a site visit of all waterways traversed by the project and an assessment of the existing watercourse geomorphology as it relates to the setting within the floodplain, the condition of the bank vegetation and the type of watercourse.

3.7 Approach for assessment of potential impacts

Due to the dry weather conditions only a small number of waterways had sufficient water for sampling. Therefore, water quality data collected by external stakeholders (refer **Section 3.3**) within the project areas were collated to supplement the monitoring data. This combined data (whilst limited) was used to provide a qualitative assessment of impacts from the construction phase of the project and from the operation of the project to waterways not considered sensitive. A quantitative assessment of operational impacts to sensitive receiving environments has been undertaken using modelled data. Additional monitoring is recommended prior to construction to confirm if the project would maintain or improve water quality.

3.7.1 Assessment of construction impacts

The assessment of potential impacts during construction involved:

- Identifying potential risks to surface water quality, hydrology and geomorphology from construction activities
- Identifying potential impacts to downstream waterways, SREs and the Western Sydney Regional Park

- Assessment of potential impacts to the relevant environmental values of aquatic ecosystems, visual amenity, primary and secondary contact recreation, homestead water supply and irrigation water supplies with consideration to the ANZECC Water Quality Guidelines
- Identification of water quality treatment measures to mitigate the impacts of construction in line with the **Blue Book.**

3.7.2 Assessment of operational impacts

The assessment of potential impacts during operation involved:

- Identifying potential risks to surface water quality, hydrology and geomorphology from the operation of the project
- Identifying potential impacts to downstream waterways, SREs and the Western Sydney Regional Park
- Assessment of the flow and velocities within creeks using information from the TUFLOW flood modelling undertaken for the project. This modelling focussed on the four main floodplain creeks and the proposed bridge over Luddenham Road and considered flood conditions under the existing (pre-development) and proposed conditions (post-development). Operational modelling accounted for creek adjustments, and other design elements related to cross drainage and longitudinal drainage. Operational impacts on hydrology for the remainder of the project with the exception of the abovementioned sites was assessed qualitatively.
- While the hydrology of Ropes Creek has been assessed, flooding impacts were not modelled at Ropes Creek as the design of the bridge at this location has been developed to match the existing bridge . As part of the design process, the existing M7 Motorway bridges over Ropes Creek were investigated to understand their form and function, including their hydraulic and hydrologic performance. The existing bridges while spanning Ropes Creek, are not primarily waterway bridges. Their span width and vertical clearance are governed by road design requirements (clearance above Villiers Road and the adjacent property access road). Hence the bridge decks are above the 2000 year ARI flood level, and the total opening and flood conveyance beneath the bridges provides capacity in excess of the 100 year ARI flood immunity requirement. Further, the flooding conditions and hydraulics in this area are controlled by the Wallgrove Road embankment and the existing culvert crossing under Wallgrove Road. The proposed bridge widening would maintain the same span widths and therefore the total opening for flood conveyance would be the same. Based on this investigation, flooding impacts at this location are not expected.
- Operational impacts on hydrology for minor receiving drainage lines (overland flow paths, intermittent creek channels) downstream of the project were assessed quantitatively using DRAINS software. Modelling of catchments of the minor drainage lines under the existing (pre-development) and proposed conditions (post-development) were implemented for 2, 10 and 100 year storm events. The modelling factored in changes to these catchments that would be caused by the project's longitudinal profile and pavement drainage, and the expected change in pervious and impervious surface areas. For each drainage line, the assessment measured the approximate change in peak flow rate at the project's operational boundary. Where the flow rate increased by more than 10 per cent (being a threshold value giving a reasonable representation of the change in catchment hydrology that would have a noticeable impact) at the operational boundary, further analysis was applied to the catchment to determine the point downstream where the measured increase in flow rate dropped below 10 per cent. For those reaches of the drainage lines where the measured increase was greater than 10 per cent, the assessment looked at whether this resulted in any hydrological impact on existing infrastructure such as farm dams, houses and structures or whether there would be any increased risk of flooding or scour and erosion.
- The assessment of minor drainage lines also assessed impacts where the changes in hydrology were shown to result in reduced flows to farm dams.

- Mitigation measures were identified for each drainage line on a case by case basis to manage and mitigate the potential adverse impacts.
- The assessment did not examine in detail the project's potential impacts on farm dam yields. Precise impact on farm dam yields is dependent on the final road design including alignment, geometry and drainage design and would be further investigated at the detailed design phase.
- This assessment also did not examine the project's potential impacts on the existing detention basins that were built as part of original M7 Motorway works, due to the lack of survey data or as-built information in regard to these existing basins. The existing basins would be assessed as part of detailed design and potential adverse impacts would be addressed through design solutions.
- Assessment of the potential impacts of the quality and volume of proposed discharges from stormwater runoff by modelling using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC model). The MUSIC model was used to determine surface water pollutant loading from project surface roads, with a focus on three key indicators; Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN).
- Quantitative water quality assessment was informed by modelling using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC model). The MUSIC model uses an iterative process to find the basin volume needed to achieve the required water quality treatment for the road catchment. The MUSIC model was used to determine surface water pollutant loading from project surface roads at the identified SREs. Operational water quality impacts across the remainder of the project have been assessed qualitatively.
- Assessment of increased runoff volumes at each of the SREs by considering the increase in impervious surface within each of their catchments. Operational water quality impacts across the remainder of the project have been assessed qualitatively. Impacts associated with increased runoff across the remainder of the project have been assessed qualitatively.
- Identification of appropriate treatment measures to mitigate the impact of the operational phase.

3.7.3 Assessment of cumulative impacts

The assessment of cumulative surface water impacts involved:

- Identifying major projects with a construction program that is likely to overlap with the project construction and/or in within the same surface water catchment as the project (both upstream and downstream)
- For these collective projects, identify common sensitive receptors, qualitatively assess likely cumulative impacts and identify mitigation measures during the construction and operation of the project.

3.7.4 Sediment basin design

The preliminary design of the water management system for the construction phase was undertaken with consideration to landform design and likely discharge locations. The locations of the sediment basins were selected to provide for the maximum runoff captured from catchments throughout the construction process whilst minimising environmental impacts. The sedimentation basins have been sized in accordance with Blue Book Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008).

4. Existing environment

4.1 Rainfall and climate

Review of the Bureau of Meteorology (BOM) rainfall and temperature data for the Badgerys Creek observation station indicated that the average yearly rainfall for the general study area ranges from 22.6 millimetres in July to 98.5 millimetres in February, with an average annual rainfall of approximately 681 millimetres. Average maximum temperatures range from 17.5 degrees Celsius in July to 30.1 degrees Celsius in January, and average minimum temperatures range from 4.1 degrees Celsius in July to 17.1 degrees Celsius in January and February. This information was used to help inform sediment basin design.

4.2 Surface water hydrology

4.2.1 Topography

The topography in and around the study area is rolling hills and small valleys between generally north to south ridge lines. In the east and west of the study area the topography is gently undulating terrain becoming flat in the middle of the study area where it passes through the floodplains associated with Cosgrove Creek, Oaky Creek, Badgerys Creek, South Creek and Kemps Creek (RMS/Aurecon 2016).

Within the Rolling Hills Terrain, the topography typically comprises rounded hills with slopes of five degrees to 20 degrees, ie around 10 per cent to 35 per cent grade, and local relief of typically up to 10 metres to 30 metres. Within this general terrain type, the ground surface levels along the alignment range from about Reduced Level (RL) 70 metres Australian Height Datum (AHD) to RL115 metres AHD.

The topography of the Flat to Gently Undulating Terrain in the central portion of the alignment typically comprises gentle rises and undulations with broad rounded crests with slopes of zero degrees to five degrees, ie up to around eight per cent grade, and local relief of up to about 15 metres. Ground surface levels along the central portion of the alignment range from about RL 35 metres AHD to RL 70 metres AHD. The Flat to Gently Undulating Terrain type is dissected by the Creek Channel/Alluvial Floodplain Terrain type by four meandering creeks, Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek, with each creek flowing to the north.

The topography of the alluvial floodplains adjacent to the creeks comprises low slopes of about zero to two degrees, which extend from the creek channels out to a maximum distance of about 500 metres.

4.2.2 Catchment description

The majority of the project is located within the Hawkesbury-Nepean catchment, a catchment covering more than 22,000 square kilometres which provides drinking water, recreational opportunities, agricultural and fisheries produce, and tourism resources for the Sydney Metropolitan area. The Hawkesbury-Nepean Catchment is of national significance, being the longest coastal catchment in NSW flowing 470 kilometres from the headwaters of the Nepean River in Goulburn before joining the Hawkesbury River in Sydney’s west and draining to Broken Bay. There are many major drainage features flowing in this catchment including the Hawkesbury, Nepean, Wingecarribee, Wollondilly, Mulwaree, Tarlo, Nattai, Coxs, Kowmung, Grose, Capertee, Colo and Macdonald Rivers. There are also several creeks including Berowra, Mangrove, Cattai, South and Mooney creeks. The catchment contains a variety of landscapes including rainforest, open woodlands, heathlands, wetlands and highland freshwater streams.

The south eastern end of the project drains to Hinchinbrook Creek which is located in the Georges River catchment. The Georges River catchment covers an area of 960 square kilometres and is one of the most highly urbanised catchments in Australia (GRCCC, 2019).

The majority of the project lies within the Lower Nepean River Management Zone of the Hawkesbury-Nepean Catchment. While almost half the Hawkesbury-Nepean Catchment is protected in national parks and water catchment reserves, the project lies within the South Creek sub-catchment which has been extensively modified and disturbed due to increasing urbanisation and associated land clearing. The Hawkesbury River is the ultimate downstream receiving environment and is located about 29 kilometres from the project at the closest point.

Land uses within the study area are predominately semi-rural and include residential, agricultural, commercial and industrial. The largest residential areas are the suburbs of Kemps Creek, Mount Vernon and Horsley Park. Agricultural land uses include poultry farms, farms producing tomatoes and cucumbers, a Christmas tree farm and wholesale nurseries. Commercial uses are generally located within the Kemps Creek village and include service stations, food stores, hardware and maintenance shops. Industrial uses include the Elizabeth Drive landfill and quarry site (RMS/Aurecon, 2016).

Within the study area there are a number of existing transport and utilities infrastructure including the M7 Motorway, Elizabeth Drive, the Sydney Water Upper Canal system and major electrical infrastructure (Roads and Maritime/Aurecon 2016).

The project intersects Cosgroves Creek, Badgerys Creek, South Creek, Kemps Creek and Ropes Creek and drains to Hinchinbrook Creek, as shown on **Figure 4-1**. The majority of these creeks drain into South Creek which then flow north to join the Hawkesbury River at Windsor. The South Creek sub-catchment covers around 490 square kilometres and generally flows from south to north. The confluence of Kemps Creek and Badgerys Creek into South Creek is about three kilometres north of Elizabeth Drive. There are also numerous farm dams in the area.

The creeks intersected or potentially impacted by the project are themselves fed by numerous minor drainage lines, most of which are dry but which would likely become active during and after heavy and/or sustained rainfall events. In the rural lands many of these channels have been dammed at intervals to create small farm storage dams. All of the impacted minor drainage lines flow into either of the six creeks referred to above, and catchments exhibit the same characteristics in terms of topography and morphology.

The South Creek sub-catchment is one of the most degraded sub-catchments of the Hawkesbury-Nepean. Vegetation clearing within the catchment and increasing urbanisation has dramatically altered the hydrological and sediment regimes. The hydrology of the catchment has been significantly altered due to increasing impervious surfaces which has in turn altered the geomorphology and ecology of the watercourses. Additional flow is also derived from a number of major Sewerage Treatment Plants (STPs) which discharge into the catchment (HNCMA, 2007).

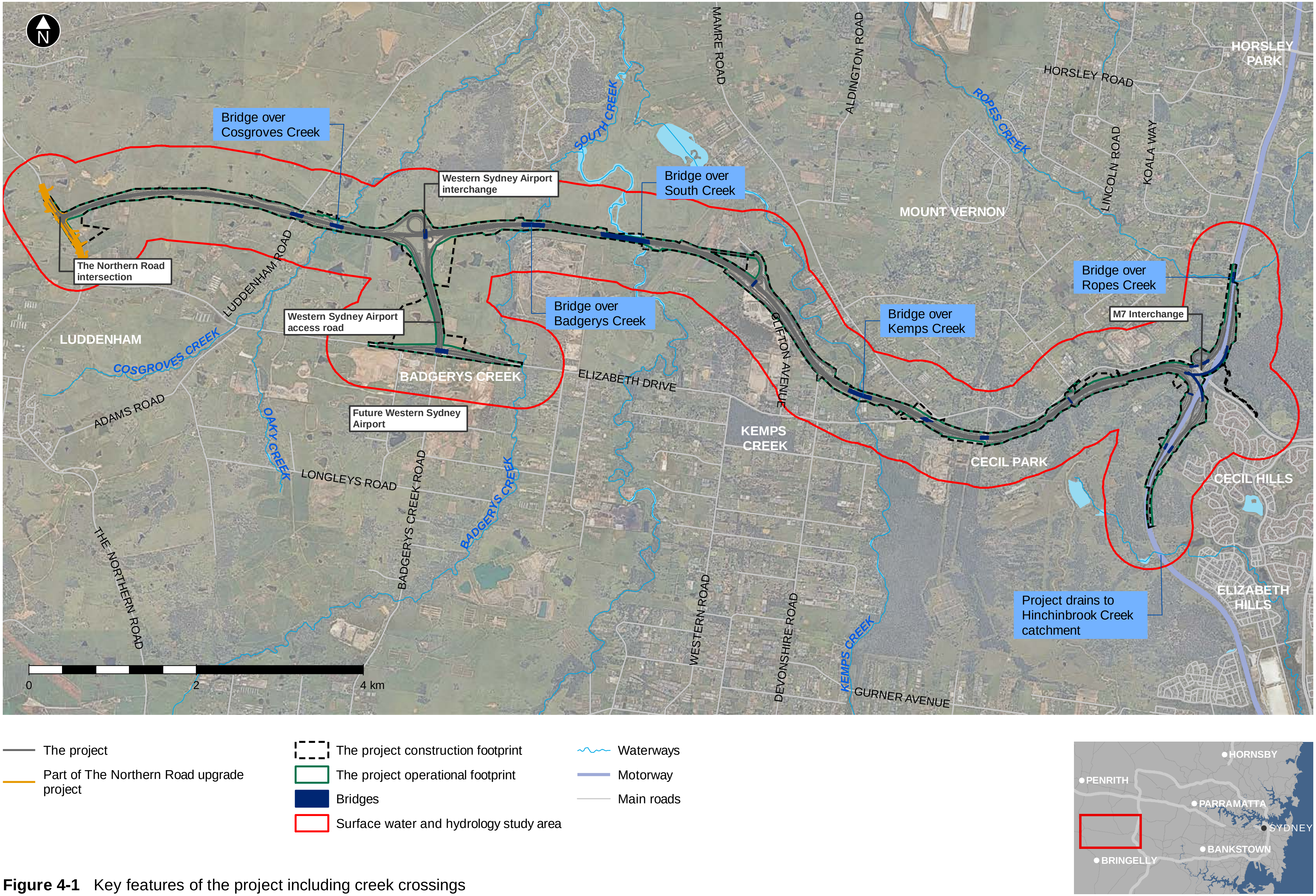


Figure 4-1 Key features of the project including creek crossings

4.2.3 Key watercourses

Watercourses within the project area have been classified according to the Strahler stream classification system and the Framework for Biodiversity Assessment (FBA) where waterways are given an order according to the number of additional tributaries associated with each waterway (Strahler, 1952 and OEH, 2014). A first order stream, otherwise known as headwater stream, begins at the top of a catchment. They are generally the smaller tributaries that carry water from the upper reaches of the catchment to the main channel of the river and are rarely named. Where two first order streams join, the section downstream of the junction is referred to as a second order stream. Additionally, where two second order streams join, the waterway downstream is classified third order and so on. Where a lower order stream (eg first) joins a higher order stream (eg third) the area downstream of the junction retains the higher order. These key watercourses are shown on **Figure 4-1**.

Cosgroves Creek

Cosgroves Creek, at the location it would be crossed by the project, is an ephemeral fourth order stream with a series of disconnected pools and named and unnamed tributaries including Oaky Creek. Cosgroves Creek originates in Luddenham and flows for about 8.5 kilometres until it drains into South Creek. The catchment is largely rural with some residential estates (Twin Creek Golf and Country Club).

The hydrological subcatchment of Cosgroves Creek (draining to South Creek) is about 2165 hectares, of which 15 per cent (325 hectares) is classified as impervious surfaces (GHD, 2016). As outlined in **Section 4.4**, Cosgroves Creek is considered to be a SRE.

Badgerys Creek

Badgerys Creek, at the location it would be crossed by the project, is a fourth order stream of about 16 kilometres in length, originating near Bringelly. The creek then flows north and then north east before its confluence with South Creek in the suburb of Badgerys Creek. Land use within the Badgerys Creek catchment consists of agricultural (grazing of naturalised and modified pastures) and rural residential. Ecologically sensitive riparian vegetation also exists within the catchment (GHD, 2015) as do small areas of landfill and native forest.

The hydrological sub-catchment of Badgerys Creek (draining to South Creek) is about 2800 hectares of which 12 per cent (335 hectares) is classified as impervious surfaces (GHD, 2016). Badgerys Creek is the largest tributary of South Creek in the study area. As outlined in **Section 4.4**, **Section 4.4**, Badgerys Creek is considered to be a SRE.

South Creek

South Creek, at the location it would be crossed by the project, is a major fifth order tributary of the Hawkesbury-Nepean River. It originates in the low hills near Narellan and runs for over 64 kilometres in a northerly direction through the Western Cumberland Plain to Windsor where it flows into the Hawkesbury River. The South Creek catchment is a shale-based catchment that encompasses most of the Cumberland Plain of western Sydney. South Creek is tidal in its lower reaches. South Creek drains a catchment of 414 square kilometres and is joined by 17 tributaries including Badgerys, Cosgroves, Kemps, Ropes and Eastern Creek.

The South Creek Catchment is currently regarded as one of the most seriously degraded sub-catchments in the Sydney region, largely due to long term clearing of vegetation and increased impervious areas due to urbanisation. This has resulted in dramatic alterations to the hydrology, geomorphology and ecology of the watercourse (Rae 2007). The water quality of South Creek is influenced by discharge from a number of wastewater plants and runoff from stormwater and agriculture areas. As outlined in **Section 4.4**, South Creek is considered to be a SRE.

Kemps Creek

Kemps Creek, at the location it would be crossed by the project, is a tributary of South Creek and is a fourth order stream which flows into the Hawkesbury-Nepean River. The creek originates about two kilometres east of Catherine Fields and flows for about 17 kilometres through the suburbs of Rossmore, Bringelly, Austral and Kemps Creek before entering South Creek north of Elizabeth Drive. The creek flows through a predominately semi-rural setting, although urbanisation has increased in recent years (Liverpool City Council (LCC), 2003).

Kemps Creek catchment is known to suffer from flooding and associated drainage problems (eg overtopping of creeks), due to limited hydraulic capacity in the creek channels, filling activities on the floodplain and inadequate hydraulic capacity at culverts and bridges (LCC, 2003). As a result of drainage problems there have been considerable earthworks to control water including construction of dams to store water, construction of channels or banks to divert flow of water and enlarging the creek channel to reduce flood levels (LCC, 2003). Land use within the Kemps Creek sub-catchment largely includes agriculture (grazing, market gardens, poultry), residential, commercial and extractive industry. As outlined in **Section 4.4**, Kemps Creek is considered to be a SRE.

Ropes Creek

Ropes Creek, at the location it would be crossed by the project, is an ephemeral first order tributary of South Creek. Ropes Creek originates in south western Sydney near Fairfield and generally flows in a northerly direction for about 23 kilometres before reaching its confluence with South Creek. Ropes Creek catchment has been extensively cleared of vegetation, other than around the waterways, for agricultural activities to take place. The catchment has a long history of flooding (BMT, 2013). The Ropes Creek catchment also contains two well defined open channel tributaries.

Ropes Creek is already traversed by several major roads including the M7 Motorway at Cecil Park, the M4 Western Motorway between Erskine Park and Colyton and the Great Western Highway and Main Western Railway Line east of Oxley Park. As outlined in **Section 4.4**, Ropes Creek is not considered to be a SRE.

Hinchinbrook Creek

Hinchinbrook Creek would not be crossed by the project however the project would drain to this creek. At its closest point to the project, Hinchinbrook Creek is a fourth order stream. It drains to the sub-catchment of Cabramatta Creek which lies within the Georges River catchment. The creek originates in Cecil Hills and flows through the suburbs of Elizabeth Hills and Hinchinbrook before it enters Cabramatta Creek at Hoxton Park. The health of Hinchinbrook Creek has been measured using the ecological indicators of water quality, vegetation and macroinvertebrates by the Georges River Combined Councils Committee (GRCCC). The overall health rating (2014-15) for Hinchinbrook Creek was poor due to the poor condition or lack of riparian vegetation and the low diversity of macroinvertebrates which were dominated by pollutant tolerant animals. Water quality however was as good. As outlined in **Section 4.4**, Hinchinbrook Creek is considered to be a SRE.

4.2.4 Watercourse geomorphology

The stability of bed and banks of watercourse crossed by, or receiving drainage from, the project have the potential to be impacted by the project. To assess these potential impacts, a brief geomorphological assessment of all water courses within the study area was undertaken in conjunction with water quality sampling. All channels within the study area are situated in a broad valley on low relief floodplain. A summary of the geomorphological assessment is provided in **Table 4-1.**

Table 4-1 Watercourse morphology summary

Watercourse	Geomorphological description
Unnamed tributary of South Creek	This tributary consists of a single meandering channel which is modified and narrow, averaging one metre wide, with a shallow channel gradient. The substrate is a silty clay. Bank undercutting has occurred in sections of the channel. The channel was completely dry upon inspection.
Cosgroves Creek	Cosgroves Creek is a discontinuous channel with steep channel gradient, a depth of about two metres and an average channel width of about five metres. The substrate consists of silty clay. Significant undercutting occurs at meander bends, suggesting a high potential for erosion at this site.
Unnamed tributary of Cosgroves Creek	This tributary is a minor infilled drainage line between farm dams. The channel is shallow with no bank definition along most of its length. The channel was completely dry at the time of inspection. The substrate is sandy clay with no areas of active erosion and is unlikely to have received recent flows.
Unnamed tributary of Badgerys Creek	The tributary contains irregular bank morphology. Undercutting has occurred at meanders. The channel was completely dry at the time of inspection. The channel gradient is shallow transitioning to steep due to sediment accumulation. The substrate consists of silty clays.
Badgerys Creek	Badgerys Creek is an incised meandering channel with irregular bank morphology due to abundant riparian vegetation and woody debris. Significant undercutting occurs along the length of the channel. The channel has a steep gradient with a channel depth greater than three metres and average channel width of about five metres.
South Creek	South Creek has a moderate gradient and a discontinuous channel which lies within a largely un-vegetated floodplain. Some bank undercutting occurs along the exposed right bank. The depth of the channel appears shallow and channel width is about seven metres.
Kemps Creek	Kemps Creek has a moderate gradient and a discontinuous channel with irregular bank morphology. The creek is laterally unconfined and significant undercutting occurs at creek bends. The channel depth appears shallow with a silty clay substrate. The channel width averages about three metres.
Unnamed tributary of Kemps Creek	This tributary is a shallow gradient channel and was completely dry upon inspection. The channel width is about one metre and channel depth less than one metre. No undercutting or erosion is apparent due to vegetation overgrowth.
Ropes Creek	Ropes Creek is a highly modified drainage channel transitioning to a laterally confined low gradient channel. The channel was completely dry upon inspection with minimal bank definition. No undercutting is apparent due to vegetation overgrowth and shallow depth.
Unnamed tributary of Ropes Creek	This tributary is a minor drainage channel, laterally unconfined with a shallow gradient. No apparent bank definition as there is no evidence of recent flows and the channel is overgrown with terrestrial vegetation.
Hinchinbrook Creek	Hinchinbrook Creek is a highly modified drainage channel consisting of a series of large disconnected pools. This section of the creek contains an artificial rock wall barrier downstream. The natural substrate consists of silty clays, with isolated sections of channel erosion and bank undercutting occurring at the channel meanders. The channel depth is greater than two metres.

Watercourse	Geomorphological description
Unnamed tributary of Hinchinbrook Creek	This tributary is a shallow gradient, meandering channel which was completely dry and densely vegetated. The channel was widest at the confluence with the Hinchinbrook Creek pool, reducing to less than one metre upstream. Isolated sections of undercut bank occurred on the channel meanders. The substrate consists of silty clays.

Due to a history of clearing, construction of dams along the watercourses and ongoing agricultural activities the waterways in the study area are considered to be in moderate geomorphic condition despite sections of well vegetated riparian zones.

4.3 Existing surface water quality

This section discusses the existing surface water quality at the five main creeks where water quality data was available: Badgerys, Cosgroves, South, Kemps and Hinchinbrook Creek. Ropes Creek was dry at the time of monitoring and no other water quality data is currently available at this location.

The data presented herein was obtained from Liverpool City Council, Sydney Water and Western Sydney Airport and was collected at varying frequencies between 2015 and 2018.

This section also includes water quality data collected for the project as part of the site investigations discussed in **Section 3.6**.

Additional water quality monitoring would be undertaken prior to construction, during construction and during operation to observe any changes to water quality potentially generated by the project and inform appropriate management responses. Further information on the water quality monitoring program is provided in **Chapter 8**.

The existing water quality is discussed in relation to the ANZECC Water Quality Guidelines recommended trigger values for the protection of aquatic ecosystems for slightly to moderately disturbed ecosystems. The protection of this value provides the most conservative water quality criteria of all nominated environmental values (for indicators relevant to the proposed works). Therefore by meeting the protection of aquatic ecosystems, all other environmental values will be protected.

4.3.1 Cosgroves Creek

The water quality of Cosgroves Creek has been monitored near Adams Road downstream of a water quality basin by Western Sydney Airport between November 2015 and September 2018. The Cosgrove Creek tributary demonstrated poor water quality failing to meet relevant ANZECC Water Quality Guidelines for protection of aquatic ecosystems. Key indicators of concern were dissolved oxygen, nutrients and some metals. Dissolved oxygen concentrations were very low (median 40 percent saturation) which can place stress on aquatic organisms. Nutrient concentrations (ammonia, total nitrogen and total phosphorus) were elevated with median concentrations exceeding recommended guidelines. Concentrations of total metals, chromium, copper and zinc were all greater than the recommended guidelines. Median results are provided in **Table 4-2** with results outside the recommended guidelines shown in bold.

A single water quality sample was collected at Cosgroves Creek during project specific site inspections in June 2018. Results are shown in **Table 4-2** with results outside the recommended guidelines shown in bold. The creek itself was predominantly dry and the sample was collected from a shallow residual pool. Algae was present along the edges of the waterbody and there was a slight film on the surface. Four of the seven water quality indicators measures complied with relevant guidelines. Dissolved oxygen, total nitrogen and electrical conductivity all failed to comply on that sampling event. Dissolved oxygen was low, at approximately 62 per cent saturation and total nitrogen was high (2.3 milligrams per litre). Electrical conductivity was elevated and exceeded the relevant guidelines, likely due to groundwater intrusion and low flow.

Table 4-2 Median water quality results from Western Sydney Airport monitoring and project specific monitoring at site M12_2

Indicator	Western Sydney Airport (2015-2018) water quality results	M12_2 (June 2018) water quality results	ANZECC Water Quality Guidelines for protection of aquatic ecosystems
Conductivity (µs/cm)	480	**3510**	125-2200
pH	7.69	8.03	6.5-8.5
Dissolved oxygen (% saturation)	**40.8**	**62.7**	85-110
Turbidity (NTU)	20.1	18.6	6-50
Total suspended solids (mg/L)	11	16	40
Ammonia (mg/L)	**0.05**	No data	0.02
Oxidised nitrogen (mg/L)	0.04	No data	0.04
Total nitrogen (mg/L)	**1.1**	**2.3**	0.35
Total Phosphorus (mg/L)	**0.05**	**<0.05***	0.025
Filterable phosphorus (mg/L)	No data	No data	0.02
Chlorophyll-a (µg/L)	2	No data	3
Arsenic (mg/L)	0.0015	No data	0.013
Cadmium (mg/L)	0.0002	No data	0.0002
Chromium (II + VI) (mg/L)	**0.002**	No data	0.001
Copper (mg/L)	**0.006**	No data	0.0014
Lead (mg/L)	0.002	No data	0.0034
Mercury (mg/L)	<0.0001	No data	0.0006⁺
Nickel (mg/L)	0.0025	No data	0.011
Zinc (mg/L)	**0.011**	No data	0.008
Bolded value denotes exceedance of guidelines for slightly to moderately disturbed ecosystems * represents less than the minimal level the laboratory can detect. ⁺ represents the 99% trigger values as this chemical bioaccumulates			

4.3.2 Badgerys Creek

The water quality of Badgerys Creek has been monitored near Elizabeth Drive downstream of a water quality basin by Western Sydney Airport between November 2015 and September 2018. Overall the quality of the water in Badgerys Creek was poor and did not meet the ANZECC Water Quality Guideline for protection of slightly to moderately disturbed aquatic ecosystems. While pH and turbidity were within the recommended range, electrical conductivity was slightly above the trigger value and dissolved oxygen concentrations were very low suggesting that groundwater intrusions may contribute a large proportion of baseflow within the creek. Nutrient concentrations were elevated exceeding recommended trigger values. Similarly, chlorophyll-*a* concentrations were also elevated which could suggest that the creek is eutrophic and may suffer from algal blooms. Total metal concentrations for chromium, copper, cadmium and zinc were above the recommended guidelines while the other metals; arsenic, and nickel were below the guideline and mercury was not detected.

Median water quality results are provided in **Table 4-3** with results outside the recommended guidelines shown in bold. Badgerys Creek and a tributary of Badgerys Creek were both visited at the alignment in June 2018. At the time of sampling the creek and tributary was dry and no water quality sample was available to be taken for the project.

Table 4-3 Median water quality results for Badgerys Creek from Western Sydney Airport

Indicator	Western Sydney Airport (2015-2018) water quality results	ANZECC Water Quality Guidelines
Conductivity (µs/cm)	**2372**	125-2200
pH	7.36	6.5-8.5
Dissolved oxygen (% saturation)	**46.7**	85-110
Turbidity (NTU)	23.8	6-50
Total suspended solids (mg/L)	14	40
Ammonia (mg/L)	**0.08**	0.02
Oxidised nitrogen (mg/L)	**0.11**	0.04
Total nitrogen (mg/L)	**1.7**	0.35
Total Phosphorus (mg/L)	**0.19**	0.025
Filterable phosphorus (mg/L)	No data	0.02
Chlorophyll-a (µg/L)	**8**	3
Arsenic (mg/L)	0.002	0.013
Cadmium (mg/L)	**0.00055**	0.0002
Chromium (II + VI) (mg/L)	**0.002**	0.001
Copper (mg/L)	**0.005**	0.0014
Lead (mg/L)	0.002	0.0034
Mercury (mg/L)	<0.0001*	0.0006^{+}
Nickel (mg/L)	0.003	0.011
Zinc (mg/L)	**0.01**	0.008
Bolded value denotes exceedance of guidelines for slightly to moderately disturbed ecosystems * represents less than the minimal level the laboratory can detect $^{+}$ represents the 99% trigger values as this chemical bioaccumulates		

4.3.3 South Creek

South Creek was also monitored as part of this water quality assessment with a single water quality sample collected during the site visit in June 2018. Results are presented in **Table 4-4** with results outside the recommended guidelines shown in bold. The water level was low consisting of a series of large disconnected pools. Algae was present on the substrate at the creek edge and the water appearance was cloudy. Dissolved oxygen concentrations were slightly below the lower recommended ANZECC Water

Quality Guidelines of 85 per cent saturation. Total phosphorus concentrations were below the limit of reporting (0.05 milligrams per litre) and total nitrogen was elevated and four times the ANZECC guideline of 0. 0.35 milligrams per litre. Electrical conductivity was also higher than expected for freshwater systems according to the ANZECC Water Quality Guidelines. High conductivity levels are likely due to the prevailing dry weather conditions which may have resulted in groundwater intrusion. Groundwater is generally more saline than surface water and during prolonged dry weather conditions, groundwater can comprise a large proportion of creek base flows thereby resulting in elevated conductivity.

Table 4-4 Project specific monitoring at site M12_6

Indicator	M12_6 (June 2018) water quality results	ANZECC Water Quality Guidelines
Conductivity (µs/cm)	**2640**	125-2200
pH	8.47	6.5-8.5
Dissolved oxygen (% saturation)	**80.1**	85-110
Turbidity (NTU)	14.3	6-50
Total suspended solids (mg/L)	16	<40
Total nitrogen (mg/L)	**1.4**	0.35
Total Phosphorus (mg/L)	<0.05*	0.025
Bolded value denotes exceedance of guidelines for slightly to moderately disturbed ecosystems * represents less than the minimal level the laboratory can detect.		

4.3.4 Kemps Creek

Kemps Creek has been monitored by Liverpool City Council between October 2017 and August 2018 near Elizabeth Drive. Over this time period the quality of the water in Kemps creek was poor when compared to the ANZECC Water Quality Guidelines for aquatic ecosystems. Dissolved oxygen concentrations were low, ranging from 21 percent saturation to 78 percent saturation, noting the minimum recommended level is 85 percent saturation for a healthy aquatic ecosystem. Nutrients phosphorus and nitrogen did not comply with the recommended trigger values for the protection of aquatic ecosystems, with some nutrients reaching up to thirty times greater than the recommended maximum levels. Median results are provided in **Table 4-5** with results outside the recommended guidelines shown in bold.

Kemps Creek was also monitored as part of this water quality assessment with a single water quality sample collected during the site visit in June 2018. Water levels were low at the time of inspection, but not stagnant. Dissolved oxygen levels were very low (35 per cent saturation). Nutrients were elevated exceeding the guidelines for protection of aquatic ecosystems. Total nitrogen concentrations of 6.6 milligrams per litre in Kemps Creek were the highest recorded in the study area and were almost 19 times the recommended ANZECC guideline. Total phosphorus was also highest in Kemps Creek with a recorded concentration 0.6 milligrams per litre which is 24 times the recommended ANZECC guideline. All other parameters tested were within the recommended ANZECC Water Quality Guidelines limits for protection of aquatic ecosystems. Results from this monitoring event are provided in **Table 4-5**.

Table 4-5 Median water quality results from Liverpool City Council monitoring and project specific monitoring at site M12_7

Indicator	Liverpool City Council (2017-2018) water quality results	M12_7 (June 2018) water quality results	ANZECC Water Quality Guidelines
Conductivity (µs/cm)	1889	1500	125-2200
pH	7.66	7.28	6.5-8.5
Dissolved oxygen (% saturation)	**31.1**	**35.9**	85-110
Turbidity (NTU)	10.7	12.1	6-50
Total suspended solids (mg/L)	No data	10	<40
Ammonia (mg/L)	**0.065**	No data	0.02
Oxidised nitrogen (mg/L)	**0.115**	No data	0.04
Total nitrogen (mg/L)	**4.5**	**6.6**	0.35
Total Phosphorus (mg/L)	**0.75**	**0.6**	0.025
Filterable phosphorus (mg/L)	**0.56**	No data	0.02
Bolded value denotes exceedance of guidelines for slightly to moderately disturbed ecosystems			

4.3.5 Ropes Creek

Ropes Creek was dry at the time that water quality monitoring was undertaken for the project and currently is not monitored by Council or other stakeholders. Additional water quality monitoring would be undertaken at this location as part of the water quality monitoring program for the project as discussed in **Chapter 8**.

4.3.6 Hinchinbrook Creek

Hinchinbrook Creek has been monitored by the Georges River Keeper group for the past 10 years in autumn and spring. Monitoring occurred 1.8 kilometres downstream of the existing M7 Motorway. Data from the past five years generally shows that the water quality within the creek is of average water quality with most of the indicators complying with relevant guidelines. Similar to other waterways in the project area, dissolved oxygen levels were very low (31.8 per cent saturation) failing to meet the minimum level of protection for aquatic ecosystems. Ammonia, total nitrogen and total phosphorus concentrations were elevated and exceeded the ANZECC Water Quality Guidelines, as was total phosphorus which exceeded the ANZECC (2000) guidelines of 0.025 milligrams per litre. Unlike other catchment streams, total nitrogen and oxidised nitrogen and total reactive phosphorus concentrations were noticeably lower, complying with relevant guideline limits for protection of the aquatic ecosystems.

Four sites were also visited in the Hinchinbrook Creek catchment as part of the water quality monitoring undertaken for the project. These sites are shows as M12_12, M12_13 and M12_14, however only three had sufficient water for sampling. Hinchinbrook Creek site M12_13 was sampled within a large pool immediately downstream of the M7 Motorway. Additionally, a SEPP Coastal wetland on Hinchinbrook Creek (ID276) downstream of the alignment (M12_14) and Doujon Lake (M12_12) were monitored. Doujon Lake (M12_12) is immediately upstream of SEPP coastal wetland ID113 and ID114.

The water quality of Hinchinbrook Creek itself was poor and generally did not comply with the ANZECC Water Quality Guidelines due to elevated pH and total nitrogen and phosphorus. Dissolved oxygen concentrations also failed to comply falling below the lower limit of 85 per cent saturation. The water quality of Doujon Lake and Hinchinbrook Creek at the wetland was also poor due to elevated nutrients, total suspended solids and low dissolved oxygen.

Doujon Lake exhibited the poorest water quality with very high turbidity and total suspended solids and nutrient concentrations more than 35 times the recommended limit for protection of aquatic ecosystems. At the time sampling, the Lake was highly turbid which with thick films and scums present at the lakes edge. Water quality results are provided in **Table 4-6** with results outside the recommended guidelines shown in bold.

Table 4-6 Median water quality results from Georges River Keeper monitoring and project specific monitoring sites

Indicator	Georges River Keeper (2013-2018) water quality results	M12_12 (March 2019) water quality results	M12_13 (March 2019) water quality results	M12_14 (March 2019) water quality results	ANZECC Water Quality Guidelines
Conductivity (µs/cm)	610	470	850	200	125-2200
pH	7.09	7.31	**9.27**	7.82	6.5-8.5
Dissolved oxygen (% saturation)	**31.8**	**39.7**	**77.3**	**58.9**	85-110
Turbidity (NTU)	13.21	**110.7**	21.27	18.60	6-50
Total suspended solids (mg/L)	No data	**410**	29	**45**	<40
Ammonia (mg/L)	**0.04**	No data	No data	No data	0.02
Oxidised nitrogen (mg/L)	0.025	No data	No data	No data	0.04
Total nitrogen (mg/L)	0.59	**13**	**1.8**	**0.8**	0.35
Total Phosphorus (mg/L)	**0.041**	**0.9**	**0.2**	**0.049**	0.025
Filterable phosphorus (mg/L)	0.0085	No data	No data	No data	0.02
Bolded value denotes exceedance of guidelines for slightly to moderately disturbed ecosystems					

4.3.7 Summary

Overall the water quality of creeks within the study area is classified as poor and degraded due to low dissolved oxygen concentrations and elevated nutrients. Additionally, metal concentrations were elevated for some creeks. Kemps Creek generally had the highest nutrient concentrations of waterways within the study area, followed by Badgerys Creek, which also exhibited elevated concentrations of some heavy metals.

4.4 Sensitive receiving environments

Waterways and other surface water features within the vicinity of the project were considered to be potential SREs and therefore were assessed against the SRE considerations outlined in **Section 3.4.** This assessment is documented in **Table 4-7** and the locations which were identified as SREs are mapped on **Figure 3-2**.

Table 4-7 Sensitive receiving environments

Surface water feature	Assessment against SRE considerations outlined in Section 3.4	Sensitive receiving environment
Cosgroves Creek	Type 2' moderately sensitive key fish habitat (DPI, 2013). The creek is also currently mapped by DPI as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge, 2003).	Yes
Badgerys Creek	Type 2' moderately sensitive key fish habitat due to the presence of large woody debris providing significant fish refuge during wetter seasons (DPI, 2013). The creek is also mapped as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge, 2003).	Yes
South Creek	Type 1' highly sensitive key fish habitat. The creek is a fifth order watercourse, containing semi-permanent pools for fish refuge and large woody snags (DPI, 2013). DPI mapping also identifies the creek as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge, 2003)	Yes
Kemps Creek	Type 1' highly sensitive key fish habitat. The creek is a fourth order watercourse, containing semi-permanent pools for fish refuge, and a variety of aquatic habitats including large woody snags (DPI, 2013). DPI mapping also identifies the creek as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge, 2003).	Yes
Ropes Creek and unnamed tributaries of South Creek, Cosgrove Creek Badgerys Creek, Kemps Creek and Ropes Creek	No adequate fish habitat and limited to no water.	No
Hinchinbrook Creek	Type 1' highly sensitive key fish habitat. The creek is a fourth order stream consists of a series of disconnected pools and a rock wall which forms a significant barrier to creek connectivity. It contains a variety of aquatic habitat and is located approximately 1.1 kilometres upstream of a SEPP Coastal Wetland. With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge, 2003).	Yes
Unnamed tributary of Hinchinbrook Creek	Type 3 minimal key fish habitat. The tributary is a second order ephemeral drainage line with no water and limited aquatic habitat. The site has been identified as a sensitive receiving environment due to the requirement not to significantly impact surface water quality or quantity within a SEPP Coastal Wetland catchment. It is classified Type 3 minimally sensitive key fish habitat (Fairfull and Witheridge 2003).	Yes

Surface water feature	Assessment against SRE considerations outlined in Section 3.4	Sensitive receiving environment
Doujon Lake	Type 2 moderately sensitive key fish habitat as it provides fish refuge and a variety of aquatic habitats (DPI 2013). Doujon lake contains a variety of aquatic habitat including overhanging vegetation, undercut banks and a small patch of aquatic macrophytes. With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge, 2003).	Yes
SEPP Coastal Wetlands (ID113 and ID114)	The site has been identified as a sensitive receiving environment due to its listing as a SEPP Coastal Wetland.	Yes
Hinchinbrook Creek at the downstream SEPP coastal wetland ID276	Type 1' highly sensitive key fish habitat. The creek drains to SEPP Coastal Wetland (ID276) and is a fourth order stream made up of a series of disconnected pools. Aquatic habitats include overhanging vegetation, undercut banks and dense macrophytes. DPI mapping also identifies the creek as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 1 highly sensitive key fish habitat (Fairfull and Witheridge, 2003)	Yes
SEPP Coastal Wetland ID117	The site has been identified as a sensitive receiving environment due to its listing as a SEPP Coastal Wetland. Type 2 moderately sensitive key fish habitat as during wet periods it provides a variety of aquatic habitats (DPI, 2013). The SEPP Coastal wetland is fed by four minor unnamed drainage lines. These are first or second order waterways which are not Key Fish Habitat (DPI 2007) and have minimal channel definition. With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge, 2003).	Yes

4.5 Soils

4.5.1 Soil landscapes

Based on a review of the 1:100,000 scale Soil Landscape Map for Penrith, the study area is underlain by four soil landscapes (OEH, 2018). These are presented in **Table 4-8**.

Table 4-8 Soil landscapes

Soil landscape	Characteristics	Limitations	Sediment type
South Creek	Fluvial deposits which are located at Badgerys, Cosgroves, South and Kemps Creeks where the project crosses these waterways. It is described as Quaternary alluvium derived from Wianamatta Group shales that comprise deep sandy, sandy clay and clay soils that were deposited as part of the current active South Creek drainage network.	High erodibility, shrink-swell potential, salinity, low fertility and localised areas of permanently high- water tables or seasonal waterlogging.	D, for fine and dispersible Western Sydney soils
Blacktown	Residual soils which are located in the flat to gently undulating terrain between creek channels. It is described as shallow to moderately deep clays and silty clays derived from the Bringelly Shales.	Strongly acidic, low fertility, high shrink-swell soils, with low permeability potential for salinity and high erodibility.	D, for fine and dispersible Western Sydney soils

Soil landscape	Characteristics	Limitations	Sediment type
Luddenham	Residual soils which are located on the low rolling hills at both ends of the alignment. It is derived from Bringelly Shales and is described as shallow to moderately deep, typically comprising clay, and sandy clays where Minchinbury Sandstone may be present.	Moderately inclined slopes of 10-20 percent are the dominant landform and as a result of development limitations included high erosion hazards, together with a high shrink-swell potential and low permeability and low fertility.	D, for fine and dispersible Western Sydney soils
Picton	Residual and colluvial soils located at the eastern end of the alignment. This soil landscape occurs on steep side slopes over Wianamatta Group shales usually with a southern aspect and where there are slope gradients more than 20 per cent. Picton soils are described as shallow to deep residual and colluvial clays	There is potential for mass movement and slope instability, ie land sliding.	D, for fine and dispersible Western Sydney soils

4.5.2 Salinity

Salinity in urban areas is a combination of dryland and irrigation salinity processes and is largely caused by rising groundwater bringing salts to the land surface. Rises in groundwater are largely due to changes in natural drainage paths from clearing of vegetation, irrigation and other activities. Salinity is often associated with prolonged wetness and lack of surface cover and therefore can increase the vulnerability of soils to erosion.

Areas of moderate salinity potential are defined as where Wianamatta Group Shales or tertiary alluvial terraces are present. Additional saline areas may be present which have not yet been identified or may occur if site conditions change adversely.

Areas of high salinity potential are defined as those areas where expected soil, geology, topography and groundwater conditions predispose a site to salinity. These areas are most commonly drainage systems or low lying/flat grounds where there is a high potential for the ground to become waterlogged.

Areas of known salinity are defined as those areas where saline soils have been identified or air photo interpretation and field observations have identified visual indicators of land salinity such as bare earth or waterlogging.

The *Salinity Potential in Western Sydney 2002 Map* (DLWC, 2002) shows the soils along the alignment have a moderate salinity potential aside from several locations with high salinity potential:

- Cosgroves Creek
- In low lying levels immediately to the east and west of Cosgroves Creek
- Kemps Creek.

Soil salinity within the vicinity of the project is shown in **Figure 4-2**.

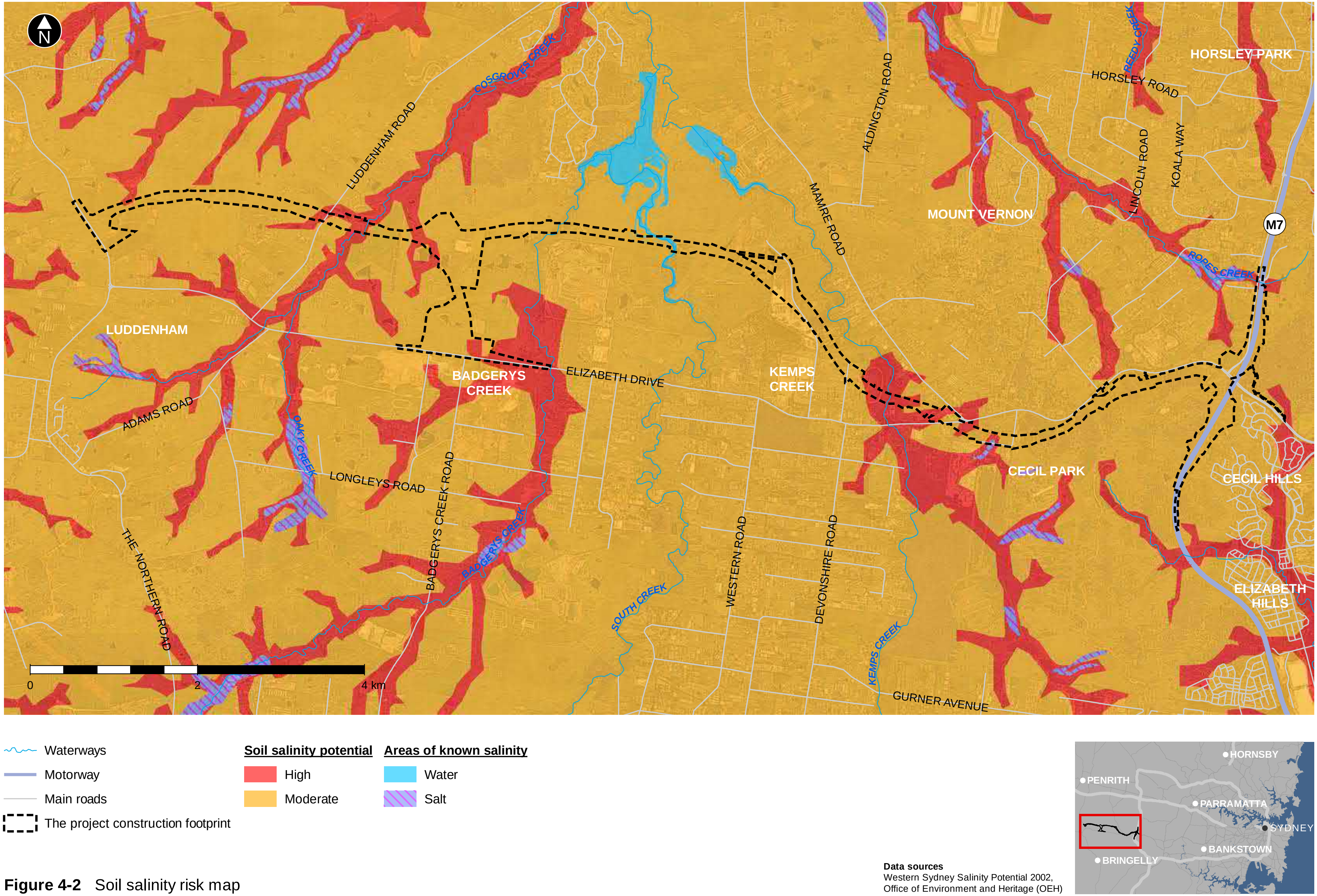


Figure 4-2 Soil salinity risk map

Data sources
Western Sydney Salinity Potential 2002,
Office of Environment and Heritage (OEH)

4.5.3 Acid sulfate soils

Acid sulfate soils (ASS) is the common term for naturally occurring sediments and soils containing iron sulphides. The exposure of these soils to oxygen by drainage or excavation, oxidises the iron sulphides and generates sulfuric acid. The sulfuric acid can be readily released into the environment, with potential adverse effects on the natural and built environments. The majority of ASS are formed when available sulfate (which occurs widely in seawater, marine sediment, or saturated decaying organic material) reacts with dissolved iron and iron minerals forming iron sulfide minerals, the most common being pyrite. This generally limits the occurrence of ASS to deeper marine sediments and low-lying sections of coastal floodplains, rivers and creeks where surface elevations are less than about RL five metres AHD.

The Australian Soil Resource Information System's (ASRIS, 2018) online ASS risk map indicates the project is mapped within an area considered to have an extremely low probability of ASS occurrence, indicating that there is no known or expected occurrence of ASS within the construction footprint.

Acid rock is defined as rock that contains sulfide or sulfate minerals (commonly pyrite) which has the potential to oxidise when exposed and produce sulfuric acid. Acid rock is potentially an issue where the sulfide bearing rock that has previously been protected from weathering, or is below the water table, becomes exposed such as in deep cuttings.

Sedimentary pyrite is a common constituent of organic rich, typically fine-grained marine and anoxic terrestrial sediments. Coal measures and carbonaceous mudstones are typically where sedimentary pyrite would be anticipated.

To date, no occurrences of acid rock have been documented within Bringelly Shales. On this basis the potential for encountering acid rock along the construction footprint is considered to be extremely low.

4.5.4 Contamination

The construction footprint encompasses large areas of historical and current potentially contaminating activities which may require management or further investigation during the construction phase of the project. Historical and current potentially contaminating activities within the construction footprint include agricultural and rural land use, service stations, landfilling and waste recycling, quarries, potential areas of fill material and industrial land use. Areas of potential contamination along the study area are discussed in detail in Appendix O of the EIS.

5. Assessment of impacts

5.1 Construction impacts

Construction of the project would involve a range of activities including the establishment of ancillary facilities and access tracks, demolition of existing buildings, vegetation clearing and subsequent mulching, earthwork including cut and fill, construction of bridges and adjustments of three waterways within the project footprint. Detailed construction information is provided in Chapter 5 of the EIS. These construction activities present a potential risk to downstream water quality if management measures are not implemented, monitored and maintained throughout the construction phase. Construction phase impacts are discussed in **Section 5.1.1**.

5.1.1 Surface water quality

The potential impacts to water quality associated with construction are presented in **Table 5-2**, overleaf.

Potential impacts to surface water quality would be reduced through the implementation of adequate mitigation and management measures discussed in **Section 6.1** and **Section 6.2**. An assessment of residual risk to surface water quality associated with construction of the project is provided in **Section 6**.

5.1.2 Water balance

Water would be used for a range of purposes during construction including dust suppression, earthworks compaction, concrete batching for roads and bridges, wheel washing, machinery and for amenities (toilets, sinks, showers, drinking). This section provides a preliminary assessment of the water balance for the project, as required by the SEARs.

The water balance is limited to the construction phase of the project as there would be no ongoing water supply requirement during the operational phase. The water balance excludes consideration of groundwater as groundwater would not be used during construction of the project, as discussed further below. Estimated construction water use for each of the relevant construction activities is provided in **Table 5-1**.

Table 5-1 Project water balance

Construction activity	Total water demand (ML)	Annual average water demand (ML)
Dust suppression	270	90
Earthworks compaction	270	90
Concrete pavements	38	12.6
Potable water at main ancillary facility	10	2.86
Potable water at outpost sites (eight sites)	16	4.57
Concrete bridges	63	21
Wheel washing (nine sites)	9	3
Total	676	224.03

Table 5-2 Potential construction impacts on surface water quality

Construction activity / Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Earthworks, cuttings, stockpiling Erosion and exposure of sediments and contaminated soils from exposed areas, open cuts and stockpiles due to wind and stormwater runoff leaving to sedimentation and contamination of downstream waterways	Sediment, nutrients, hydrocarbons, metal Contaminants and gross pollutants.	Increased sedimentation can alter the geomorphology of waterways and smother and reduce biological productivity of aquatic systems through reduced light penetration decreasing available plant material for fish to feed on. Increased sediments result in increased nutrients in waterways which can lead to algal blooms. This reduces the environmental value of water by limiting its potential uses.	All waterways within the study area have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Demolition Dust, litter and other pollutants from building materials associated with demolition which can enter downstream waterways due to wind and stormwater runoff.	Sediments, gross pollutants.	Increased turbidity and rubbish reducing visual amenity of waterway.	• Ropes Creek • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Pollution – leakage or spills Leakage or spills of petroleum, oils and other toxicants from construction machinery, plant equipment, refuelling and vehicles traveling to and from site. Spills and leakages could potentially be transported to downstream waterways.	Hydrocarbons, oil and grease, hydraulic fluids, high pH, zinc and other hazardous chemicals.	Oily films on surface water reducing the visual amenity. Decreased biodiversity, loss of habitat and fish kills from increased concentrations of toxicants	All waterways within the study area have the potential to be impacted. Waterways at high risk (within 50 metres of ancillary facilities) include: • Unnamed tributary of South Creek (and the South Creek downstream receiving environment), • Unnamed tributary of Kemps Creek (and the Kemps Creek downstream receiving environment).

Construction activity / Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Concreting Concrete dust, concrete slurries or washout water discharged to downstream waterways or where the existing bridge crossing South Creek is proposed to be demolished.	High pH, chromium, solids.	Increased alkalinity and pH of downstream waterways which can be harmful to aquatic life. Water contaminated with chromium can accumulate in the gills of fish affecting the health of aquatic animals. Solids that are improperly disposed of can clog stormwater pipes and cause flooding.	All waterways within the project areas have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Vegetation clearing and mulching Soil and bank erosion and mobilisation of sediments to waterways via direct disturbance of waterway (due to installation of culverts, clearing of riparian vegetation etc) or via stormwater runoff and wind. Tannin leachate from clearing and mulching entering downstream waterways.	Sediment, nutrients, heavy metals (bound to sediments or resuspended in instream works), high Biological Oxygen Demand (BOD) and tannins.	Increased BOD resulting in decreased available dissolved oxygen which can impact on aquatic ecosystems and lead to fish kills. Tannins can also result in dark coloured water being discharged from construction sites into downstream waterways. This affects the visual amenity of the waterway, can alter the pH, reduce visibility and light penetration.	All waterways within the project areas have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Cut and Fill Sediment runoff from excavation and excess spoil storage to downstream waterways. Water pollution from dust generated from stockpiles or inappropriate storage, handling and disposal of spoils. Contaminants associated with previously landuses could be exposed and transported downstream	Sediment, hydrocarbons, metals, and nutrients.	Increased turbidity, lower dissolved oxygen levels and increased nutrient concentrations which could result in algal blooms and aquatic weed growth. Increased metal and toxicant concentrations which can impact the health of aquatic organisms and result in fish kills. Reduced visual amenity.	Filling at: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek. Cuttings at: • Badgerys Creek • Kemps Creek.

Construction activity / Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Drainage and surface road works Soil and bank erosion and mobilisation of sediments into receiving waterway during the direct disturbance of waterway bed and/or banks as a result of the construction of instream structures and associated earthworks.	Sediments, nutrients and heavy metals stored in bed sediments.	Increased turbidity, lower dissolved oxygen levels and increased nutrient concentrations which could result in algal blooms and aquatic weed growth. Permanent in-stream structures and new culverts may change the characteristics of waterways by altering flow rates and flow paths, leading to scour and deposition of sediment. Disturbance and exposure of contaminated soils which could result in release of heavy metals and toxicants to surface water. Changes to geomorphology from installation of culverts and changes to flow.	All waterways within the project areas have the potential to be impacted.
Bridges Elevated concentrations of sediments entering and polluting the waters from disturbance and erosion of bed and banks. Pollutants from construction machinery or concrete spills entering waterways.	Sediments and nutrients, high pH, fuels, chemicals, oils, grease and petroleum hydrocarbons.	Increased turbidity levels from suspension of solids smothering aquatic ecosystems and reducing visual amenity. Increased alkalinity and pH impacting aquatic organisms. Permanent in-stream structures could change the characteristics of these waterways due to changes in flow rates and flow paths leading to scour and deposition of sediments.	• Cosgroves Creek (BR02) • Badgerys Creek (BR05) • South Creek (BR06 and BR20) • Kemps Creek (BR08)

Construction activity / Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Adjustment of waterway Bed and bank disturbance causing soil and streambank erosion which in turn can result in sediments being transported to downstream waterways.	Sediments, nutrients, metals.	Elevated turbidity, nutrients and other contaminants and low dissolved oxygen levels could result in algal blooms and aquatic weed growth. Changes to geomorphology and flow velocities within waterways due to increased sedimentation and alteration to channel morphology. Decline in aquatic life, vegetation and ecosystem function downstream due to habitat removal and alteration/fill materials into existing waterways. If inappropriately designed or managed adjustment can increase flow velocity and scour potentially causing stream bed and bank stability issues.	• Badgerys Creek • South Creek • Kemps Creek.
Temporary watercourse crossings Increased sediments to downstream water courses due to scour and disturbance of creek banks. Spills from construction machinery and vehicles hauling material over crossings.	Sediment, nutrients, chemicals, heavy metal, oil and grease and petroleum hydrocarbon	Increased turbidity, lower dissolved oxygen levels and increased nutrient concentrations which could result in algal blooms and aquatic weed growth. Increased metal and toxicant concentrations which can impact the health of aquatic organisms and result in fish kills.	• Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Other unnamed/minor drainage lines.
Dewatering Dewatering and infilling for farm dams. Discharges from sediment basins to downstream waterways.	Sediments, nutrients.	Increased suspended sediments resulting in high turbidity and poor water clarity impacting on visual amenity. Elevated nutrients and sediments can reduce dissolved oxygen resulting in proliferation of weeds and fish kills. Dewatering activities during construction may mobilise sediments and contaminants and increase the turbidity of the receiving environments along the project, potentially having an impact on water quality.	All waterways within the project areas have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.

Overall an estimated 676 megalitres of water is required for construction over the life of the project. There is not expected to be any extraction of water from local waterways for construction of the project. The project's potable water demand of about 7.43 megalitres per year would be met through metered connections to the Sydney Water network.

The potential for sourcing groundwater was investigated. One cut was assessed to have potential to be below the water table. The maximum inflow rate into this cut that was assessed for a range of parameters sets was 6.75 kilolitres per day, which if exposed would be subjected to an average evaporation rate of about 1.45 kilolitres per day. However, the majority of parameter sets adopted for the sensitivity analysis resulted in estimated groundwater inflow rates less than one kilolitre per day, which if subjected to evaporation, would result in the entire seepage inflow being evaporated. Based on the very low predicted groundwater inflow rates, groundwater was not considered a viable source of water to supply project water demands with.

The concept design incorporates about 82 proposed temporary sediment basins which are spread out along the project area. Average basin volume would be approximately $500m^3$. Basins were sized based on the five day 85^{th} percentile rainfall depth. At the current design volumes, the project's sediment basins are not considered a viable secure water source since associated environmental protection licences typically require that they are emptied within five days of a rain event. However, it is noted that surface water basins could be used for opportunistic supply during the five days following rainfall. While not currently proposed, it is possible that water for construction of the project could be provided by increasing the size of the sediment basins above the five day 85^{th} percentile rainfall event or through dewatering of the sediment basins into dedicated storage dams. This option could be investigated during detailed design.

Where non-potable demand cannot be met through project opportunistic use of sediment basins or farms dams within the construction footprint, the demand would need to be supplemented with potable water either via the Sydney Water network or via water tankers.

5.1.3 Impacts to SEPP Coastal Wetlands

Background

As identified in **Section 4.4** and shown on **Figure 3-2**, there are four wetlands in the vicinity of the project which are identified as Coastal Wetlands under the Coastal Management SEPP (ID113, ID 114, ID117 and ID 276). Construction of the project is upstream and within the surface water catchment of these wetlands and therefore altered surface water quality and/or hydrology from the project has the potential to impact these wetlands. In addition, construction works would be within the mapped 'proximity area' of wetland ID117.

Under the Coastal Management SEPP, even if no works are undertaken within the wetland itself, works undertaken within the proximity area, should be designed so as not to significantly impact on the biophysical, hydrological or ecological integrity wetland.

Impacts

SEPP Coastal Wetlands ID113 and ID114 are located about 1.2 kilometres downstream of the construction footprint at the nearest point. No direct impacts would occur within the wetlands or within the proximity area for these wetlands. The wetlands are fed by ephemeral, minor first order, unmapped and unnamed drainage lines from a predominantly residential catchment. These are first or second order waterways which are not Key Fish Habitat (DPI 2007) and have minimal channel definition. Impact to these drainage lines is restricted to earth works and potential accidental spills within the uppermost extents of these drainage lines.

The areas receive minimal upstream catchment flows. Due to the limited upstream catchment areas, the potential impact to the surface water quality and quantity within the Coastal Wetlands ID113 and ID114 is expected to be negligible with the application of the water quality treatments that have been incorporated into the design of the project (see **Section 6**) and the management measures outlined in **Chapter 8**.

Costal Wetland ID117 is located in the north eastern portion of the construction footprint between the M7 Motorway and Elizabeth Drive. A temporary access track is required to be constructed within the 'proximity area' of this wetland during construction (for construction vehicles to access via Elizabeth Drive). As an informal access track already exists within the proximity area, construction of the formalised access track would utilise this pre-existing clearing, requiring minimal tree removal and earth works. Further details on the potential impacts to the ecological integrity of the wetland (such as vegetation removal) and associated mitigation measures are discussed in Appendix E of the EIS (Biodiversity assessment report). The wetland is fed by four minor unnamed drainage lines. These are first or second order waterways which are not Key Fish Habitat (DPI 2007) and have minimal channel definition. The proposed access track crosses the uppermost extents of three of these drainage lines. These ephemeral drainage lines are crossed at the ridgeline and receive minimal upstream catchment flows and therefore the potential impacts to surface water quality and hydrology within the Coastal Wetland during construction are negligible and would be adequately managed through the application of the management measures outlined in **Chapter 8**.

Coastal Wetland ID276 is located approximately 1.8 kilometres downstream of the construction footprint, at the nearest point, along Hinchinbrook Creek. No direct impacts occur within the wetland or within the proximity area for this wetland, however construction would occur in the upstream catchment. Upstream, Hinchinbrook Creek consists of a series of disconnected pools, which would limit the potential water quality and quantity impacts to the Coastal Wetland allowing any potential poor water quality such as TSS to settle out prior to discharging downstream to the wetland. Additionally, the potential impact to the surface water quality and quantity are expected to be negligible with the application of the water quality treatments that have been incorporated into the design of the project (see **Section 6**) and the management measures outlined in **Chapter 8**.

5.1.4 Construction discharges

There are two potential sources of water discharges during construction; discharge of water from construction sediment basins and dewatering of farm dams.

Surface runoff from the construction sites would be managed in accordance with Blue Book. The requirements of the Blue Book are that local erosion and sediment controls be provided within the construction catchment area and adequately sized temporary sediment basins at the discharge points of all outlets from the construction area. As per the Blue Book, the pollutants of concern during the construction process are total suspended solids, pH and oil and grease. The treatment of these pollutants would be in accordance with typical licence conditions for road projects. Often nutrients and metals are bound to sediments in a dissolved (and often harmful) state and transported from the construction site. The capture of the sediments via the construction sediment basins would subsequently result in the capture of nutrients and toxicants thereby reducing risks to downstream water quality.

Should dewatering of farm dams be required, discharge of water would be particularly turbid. To minimise impacts, discharge would occur away from any flow paths to downstream waterways.

5.1.5 Erosion and sedimentation

Highly erodible soils have been identified within the project area (refer **Section 4.5**). There are a number of construction activities that have the potential to impact on the soil environment:

- Vegetation removal – vegetation would be removed as part of the project as discussed in Appendix E of the EIS (Biodiversity assessment report). Vegetation removal would expose soils to weathering processes, increasing the risk of erosion and sedimentation.
- Cut and fill earthworks – cut and fill earthworks over the project area could affect the topography, geology and soils. The topography would change in elevation and gradient. In areas of cut, underlying geology layers would be exposed due to the removal of the topsoil layer and proportion of the surficial geology. In areas of fill, the existing topsoil layer would be removed prior to placing material excavated during cutting on top.

Fill requirements have the potential to impact on soils and landform as loose fill could be eroded during rainfall events by runoff. This can result in sedimentation of downstream drainage lines through mass movement of soils and change soil surface characteristics.

In areas of cut, the earthworks have the potential to destabilise the landform. To reduce the risk of this, the design of cuts has considered appropriate batter slopes to avoid and/or minimise potential destabilisation.

Key activities during construction that can directly or indirectly increase erosion and siltation include:

- Stockpiling – excavated material would require stockpiling before being reused on the project. If stockpiles are not adequately stabilised, material could erode away during high rainfall or windy events.
- Construction of new roads – there is the risk of soil compaction during the construction of new roads from the operation and movement of heavy machinery. This heavy machinery can disturb soil surface, increasing the potential for erosion.
- Construction of bridges – the construction of bridges requires piles which supports the bridge foundations. Piling requires excavation and can result in moderate impacts to soils due to disturbance.
- Relocation of utilities – the relocation of water mains and telecommunication facilities underground would involve soil disturbance from trenching and underboring. The disturbance of soil by machinery could increase the potential for soil erosion.
- Landscaping – minor earthwork are required during landscaping activities that could result in the erosion of disturbed soils that have not stabilised. These impacts would be temporary as stabilisation and revegetation would act to resist future soil erosion.

5.1.6 Hydrology and geomorphology

Project construction has the potential to impact on waterway form and geomorphic processes. Geomorphic and/or hydrological impacts could arise from:

- Temporary changes in flows and velocities in minor drainage lines and creeks across the project’s construction footprint including within Kemps Creek, South Creek and Badgerys Creek downstream of the project while the creeks are adjusted. Adjustment works would be staged to ensure creek flows and velocities are not significantly changed and to avoid downstream erosion and bed and bank stability impacts.
- Build-up of mobilised sediment in streams within the study area.
- Increases in the volume and rate of runoff from impermeable surfaces created from the project which could cause erosion within the instream channel.

- Impacts to geomorphology as a result of increased mobilised sediment or increased surface runoff (volume and/or velocity) could occur where activities are near watercourses. Those watercourses where evidence of erosion and bank undercutting have a higher potential to be impacted, including Cosgroves and Badgerys Creeks.
- Changes in localised flow paths along minor drainage lines during construction leading to increased scour and erosion potential. These changes also have the potential to modify/redirect flows to farm dams (eg either increase or decrease flows) and impact their embankments (eg increases in the frequency and rate of flow surcharging their spillways). Conversely, a reduction in flow associated with inter-catchment transfer of flow can also result in detrimental environmental effects. These impacts are discussed further in the operational impacts section and impacts from altered drainage would be further investigated during detailed design.

During construction, all runoff and localised flows within the construction footprint would be controlled by erosion and sediment control measures such as temporary sediment basins, temporary drainage and sediment fencing, to reduce the potential for scour and erosion.

5.1.7 Environmental water availability and flows

The construction of the project would cause soil compaction through the operation of construction machinery. This has the potential to change the distribution of flow as the compacted soils become less pervious and thereby could increase the quantity of water in the local catchment.

No water extraction directly from creek is proposed during construction of the project. Some water extraction from sediment basins and farm dams within the construction footprint would occur during construction. However, the total volume of water to be used is relatively low (see **Section 5.1.2)** and would have a minor impact on environmental water availability and flows. Additionally, no construction machinery or structures would be place in waterways that would cease or block flow. Therefore the project is unlikely to reduce the quantity of water in nearby waterways and drainage lines and would have no impact on environmental flows.

5.1.8 Performance against NSW water quality objectives

There are a number of potential pollutants associated with the construction of the project including contaminated soils, fuels from machinery, tannins from cleared and mulched vegetation and sediment laden runoff. Each of these have the potential to impact on the water quality and subsequent environmental values of the downstream environment.

The proposed management measures including erosion and sediment controls are designed to minimise pollutant loading to downstream waterways during the construction of the project. Runoff from the construction phase of the project is designed to meet standards outlined in the Blue Book. These require that the treated runoff from the construction site through the sediment basins be less than 50 milligrams per litre for total suspended solids and have a pH of 6.5 to 8.5. Further water quality assessment would be undertaken during detailed design to establish site specific discharge criteria for sediment basins. Areas identified as potentially containing contaminated soils are addressed through mitigation measures provided in **Appendix O** of the EIS (Soils and Contamination Assessment Report). These mitigation measures will be implemented along with those provided in **Table 8-1** of this report.

Due to limited water quality data, it cannot be confirmed if this discharge would be similar or better than existing water quality and may be higher than the required limit for the protection of environmental values under the relevant water quality objectives for the project (ie meeting the ANZECC Water Quality Guidelines). The key pollutants of concern from unsealed construction areas would be sediment, oil and grease and pH. Other pollutants (such as nutrients), however, may also be bound to the sediment or present in dissolved form.

It is expected that, with the implementation of the management measures (namely sediment basins), pollutant loading to the receiving waterways would be less when compared to pollutant loading from the wider respective catchments. The project pollutant loading is considered to pose a low risk to human health and the surface water environment. No further measures would need to be investigated, therefore, to further minimise water pollution and protect human health and the environment from harm.

Sediment basins would be designed to ensure that levels of TSS in the discharge would be less than 50 milligrams per litre and have a pH of 6.5 to 8.5. The ANZECC (2000) guidelines state that ranges for turbidity and TSS are similar. By limiting TSS to less than 50 milligrams per litre the project would generally meet the recommended trigger value for protection of aquatic ecosystems.

There is no data available currently on the expected toxicant levels with the project. It is, therefore, unknown at this stage if the water quality objectives will be met by the project. Whilst there is limited data to inform existing water quality, additional monitoring that is currently underway would be available during the detailed design phase and will assist in determining if water quality objectives will be met.

The results from the current monitoring program would be available during detailed design to further refine the water quality and hydrology controls for the construction of the project. This supplementary data, with particular consideration given to the potential for implementation of additional treatment measures, where reasonable and feasible, will be investigated to provide further improvements to water quality. These may further minimise water pollution and protect human health and the environment from harm.

The water quality objectives, as defined in **Table 2-2,** are not currently being met and would not be met during the construction of the project. The construction of the project would, to the extent possible, aim to contribute to achieving the objectives during the operational phase, as far as practical, through implementation of controls discussed in **Chapter 6**.

5.2 Operational impacts

During the operational phase of the project all roads and bridges would be sealed, cleared areas would be landscaped and scour protection would be installed. There would be no exposed topsoil and therefore little or no risk of soil erosion and subsequent transport of sediment into nearby receiving waterways. Water quality risks during the operation would instead be associated with runoff of pollutants from new road surfaces and increased vehicular traffic, accidental spills, increased impervious areas, changes to longitudinal and introduction of permanent structures within waterways.

5.2.1 Surface water quality

The potential impacts to surface water quality associated with operation are presented in **Table 5-3**.

Potential impacts to surface water quality would be reduced through the implementation of mitigation and management measures discussed in **Chapter 8**. An assessment of residual risk to surface water quality associated with operation of the project is provided in **Section 6**.

Table 5-3 Summary of potential operational impacts within the operational footprint on surface water quality

Operational element / source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Spill events Discharge of spill directly into waterways (should spill event happen on a bridge) or via runoff into the drainage system.	Oil and grease, fuel and various hazardous chemicals transported by vehicles.	Increased toxicant concentrations may be toxic to aquatic biota and fish. Oily surface films reduce the visual amenity of the waterway.	All waterways
Stormwater runoff Untreated stormwater from impervious surfaces which are not conveyed to treatment systems.	Gross pollutants and litter, sediments, total suspended solids, nutrients, BOD, heavy metals and hydrocarbons, oil and grease	Increased sediment loads and nutrients reduce light penetration through the water column or can smother aquatic flora and fauna. Decay of organic matter and some hydrocarbons can decrease dissolved oxygen levels resulting in fish kills, and can increase concentrations of heavy metals (including aluminium and iron) which are toxic to aquatic biota. Conversely, increased nutrients from sediments can result in excessive plant growth, resulting in algal blooms.	All waterways

Stormwater quality

The project includes a new dual carriageway located within what is currently a largely greenfield area. As such this would lead to a change in catchment hydrology, with the most obvious effect being an increase in stormwater flow events. Stormwater from impervious surfaces is typically of poorer quality than runoff from a greenfield catchment and may result in a progressive deterioration of the environmental values of downstream waterways. Additionally, stormwater runoff contains pollutants that are not typically found in runoff from rural catchments (**Table 5-4**).

Table 5-4 Key pollutants of concern in typical road runoff (Gunawardena, 2012)

Pollutant	Sources
Litter/gross pollutant	Soil, plant debris, rubbish.
Rubber	Tyre wear.
Suspended solids	Bitumen wear, vehicles, atmospheric deposition, maintenance.
Nitrogen and phosphorus	Atmospheric deposition, fertiliser application, dead plant material, sediments, vehicle exhausts.
Oil and grease	Spills, lubricants, hydraulic fluids, asphalt.
Hydrocarbons	Vehicle exhausts.
Petroleum	Spills, leaks, hydraulic fluids, asphalt surfaces.
Lead	Atmospheric deposition, tyre wear, bearing wear.
Zinc	Engine oil and grease, tyre wear.
Iron	Auto body rush, road structures (bridges, guard rails), moving engine parts.
Copper	Engine wear, brake lining wear, moving engine parts.
Cadmium	Tyre wear, lubricants.

Pollutant	Sources
Chromium	Metal plating, brake lining wear, moving engine parts.
Nickel	Lubrication oil, diesel fuel and petrol, metal plating, asphalt paving, brake lining wear.
Manganese	Moving engine parts.
Pesticides and herbicides	Atmospheric deposition, spraying, soils.

The predicted water quality impacts during the operational phase of the project were modelled at the five main creeks which were identified as SREs: Badgerys; Cosgroves; South; Kemps and Hinchinbrook Creeks. The results of the water quality modelling are summarised in **Table 5-5**. The modelling for Hinchinbrook Creek reflects the impacts at the downstream SEPP Coastal Wetlands ID113, ID114 and ID276. SEPP Coastal Wetland ID117 would not receive road runoff from the project during operation and therefore no water quality impacts are expected/reported in this table.

While the modelling focussed on the five main creeks identified as SREs in **Section 4.4**, it is noted that the qualitative assessment of potential surface water quality impacts (above) and hydrological impacts (below) relate to the entire operational footprint area.

The water quality impacts are based on the results of the water quality modelling undertaken as part of concept design development and reflect the predicted quality of discharges following treatment in the permanent sediment basins (discussed in **Section 6.2**).

MUSIC modelling of the annual pollutant loads generated from the five catchments with downstream SREs was undertaken for key indicators TSS, TP and TN to ensure minimal impact with the implementation of controls. Modelling of both the existing loads (ie pre-development) and post-development loads (with and without water quality controls) was undertaken. Pollutant loads for all indicators reduced during operation (with water quality controls) compared to the existing (pre-development) conditions, with the greatest percentage reduction in loads for TSS and TP.

The MUSIC modelling has demonstrated that the total pollutant load for the five combined catchments is reduced with the operation of the project provided the water quality controls recommended in **Chapter 6** are implemented.

The treatment strategy would be finalised at detailed design and would incorporate further considerations for water quality improvements.

It is noted that the proposed permanent water quality treatment measures for the project include permanent basins. The proposed permanent basins are wet basins. The presence of wet basins within a 13 kilometre zone of the Western Sydney Airport presents a potential risk for aeroplane bird strike. The International Civil Aviation Organisation and World Birdstrike Association (ICAOWBA) recommends identifying, and where necessary managing, potential wildlife attractants within 13 kilometres of runways (Avisure, 2016). As such, the type and design of permanent water quality basins for the project should be further investigated during detailed design to confirm the suitability of the basins and develop appropriate mitigation measures (eg implementation of deterrents to potential wildlife and/or potential conversion of the basins to dry biofiltration basins).The potential for bird strike and relevant mitigation measures are discussed in Section 8.4 of the EIS (Health and safety) and Chapter 9 of the EIS (Environmental management measures).

Table 5-5 Operational water quality impacts – pollutant loads from water quality basins at the sensitive receiving environments

Location and catchment area*+		Indicator			Comment
		TSS (kg/yr)	Total nitrogen (kg/yr)	Total phosphorus (kg/yr)	
Badgerys Creek (13.27 ha)	Pre-development	1570	33.3	4.44	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	1250	32.8	3.56	
Cosgroves Creek (5.23 ha)	Pre-development	639	12.9	1.81	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	439	12	1.24	
Kemps Creek (13.55 ha)	Pre-development	1573	34.4	4.38	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	1470	32.7	3.96	
South Creek (15.45 ha)	Pre-development	1970	37.6	5.35	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	1680	36.2	4.23	
Hinchinbrook Creek (26.95 ha)	Pre-development	29,600	220	52.5	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	3,450	49	7.26	

Notes: *The water quality results presented for the Hinchinbrook Creek catchment are relevant to the downstream SREs including SEPP Coastal Wetlands ID113, ID114 and ID276. +As discussed above, SEPP Coastal Wetland ID117 would not receive road runoff from the project during operation and therefore no water quality impacts are expected/reported in this table.

Spills

There is potential for accidental spillage of hazardous materials during the operational stage of the project. Spills of oils, lubricants, hydraulic fluids and chemicals can potentially occur due to vehicle or plant and equipment leakages or vehicle crashes. Without satisfactory means of containment, the spillage of contaminants could pass rapidly into the drainage system and impact downstream ecosystems. Spills of chemicals or petrol in accidents can impact the ecology of waterways and terrestrial ecosystems.

It is considered that there would be sufficient opportunity for any spill event to be contained near the project within the drainage system or immediate surrounds. The risk associated with accidental spills within the project are considered comparable to those of similar roads, including others surrounding the study area.

The proposed design would provide spill containment upstream of all sensitive receiving environments. Spill containment should be provided at all proposed water quality basins shown in **Table 6-6**, including the proposed basins on Hinchinbrook Creek. The minimum spill containment volumes should be 20,000 litres. For the proposed swales, it may not be possible to contain such a large spill volume and there is the potential for the spill to runoff to downstream waterways. In these instances the spill would be managed in accordance with standard operational emergency spill response procedures.

5.2.2 Performance against NSW Water Quality Objectives

The operational water quality modelling undertaken as part of this assessment indicates that the existing (ie pre-development) water quality in Cosgroves, Badgerys, South and Kemps Creeks does not meet the ANZECC Water Quality Guidelines .

With the implementation of erosion and sediment controls and water quality controls as part of this project (as outlined in **Section 6.2**), the pollutant loading to these creeks would be reduced compared to existing conditions. Therefore, the project is unlikely to have a material impact on the ambient water quality of sensitive receiving waterways.

The water quality objectives are currently being met for all environmental values, with the exception of aquatic ecosystems (see **Table 5-6**). During operation, the project would, to the extent possible, continue to protect the receiving waters where the water quality objectives are currently being met. Where the objectives are not being met, the project would contribute to achieving the objectives over time, as far as practical, through implementation of controls discussed in **Chapter 6**.

The operation of the project would result in an improvement in overall water quality at the SREs (defined in **Table 4-7**) with a reduction in total suspended solids and nutrient loads to downstream waterways. Whilst an improvement on existing water quality is anticipated, water quality remains unlikely to meet the ANZECC water quality guidelines in the short term. The operation of the project is not expected to impact on achieving the environmental values of primary and secondary contact recreation, as the key indicators of concern relevant are pathogens, algae and toxicants.

The operation of the project would not result in an increase in bacteriological indicators. In addition, the project is not likely to result in increased algae as there would be a reduction in sediment laden runoff and thereby a reduction in nutrients. This reduction in sediment laden runoff will also reduce the level of toxicants entering downstream waterways which could have posed a risk to human health. The operation of the project, therefore, would not pose a significant risk to human health and the environment.

The results from the current monitoring program would be available during detailed design to further refine the water quality and hydrology controls for the project. This supplementary data together with additional MUSIC modelling, with particular consideration given to the potential for implementation of additional treatment measures, where reasonable and feasible, will be investigated to provide further improvements to water quality. These may further minimise water pollution and protect human health and the environment from harm.

Table 5-6 Project performance against environmental values

Environmental value	Project performance against values
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and riparian zones over the long term	None of the indicator values are currently being mat at any of the crossings. The total phosphorus and total nitrogen would be met with project controls, however, only at Hinchinbrook Creek.
	Note that toxicants have not been modelled. Toxicants are represented indirectly by TSS, however TSS is not a parameter on the NSW WQ objectives and is normally correlated to Turbidity. The results of the TSS would provide an indication of the toxicants. The desirable range of 6 to 50 NTU recommended by ANZECC (2000) for protection of aquatic ecosystems has been representative by an indicative only range of 20 to 75 milligrams per litre for TSS. TSS guideline levels would not be met but they would be reduced by the project.
Visual amenity – aesthetic qualities of waters	Visual amenity values are currently being met at all water crossings and would continue to be met with the project.
Secondary contact recreation – maintaining or improving water quality of activities such as boating and wading, where there is a low probability of water being swallowed	Secondary contact recreation values are currently being met at all water crossings and would continue to be met with the project.
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Primary contact recreation values are currently being met at all water crossings and would continue to be met with the project.
Irrigation water supply – protecting the quality of waters applied to crops and pastures	Irrigation water supply values are currently being met at all water crossings and would continue to be met with the project.
Homestead water supply – protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	Homestead water supply values are currently being met at all water crossings and would continue to be met with the project.

5.2.3 Hydrology and geomorphology

The potential impacts to hydrology during operation of the project relate to the increase in impervious surface from introduction of a road into an otherwise predominantly greenfield area, a change in surface flow paths within minor drainage lines across the project and from creek adjustments.

The drainage design including the bridge sizing, cross drainage culverts and longitudinal drainage system has been developed to avoid drainage lines catchment diversion as far as practicable to minimise hydrology impacts. Overall there is unlikely to be a significant change in hydrology and flow distribution across the broader catchment. However, there is the potential for localised changes in flow from one subcatchment to the next.

Potential impacts are summarised in **Table 5-7** and are discussed below.

Table 5-7 Operational surface water hydrology and geomorphology impacts

Operational element	Potential impact	Affected waterways
Increased stormwater runoff volumes, decreased infiltration and changes to surface drainage.	Increased velocity of water runoff and potential flooding or scour of creeks.	All major and minor waterways receiving drainage from the operational footprint including Badgerys Creek, Cosgroves Creek, South Creek, Kemps Creek and Hinchinbrook Creek.
Increased impervious areas where the project alignment runs along existing greenfield areas.	Increased runoff and peak flow velocities.	All major and minor waterways receiving drainage from the operational footprint including Badgerys Creek, Cosgroves Creek, South Creek, Kemps Creek and Hinchinbrook Creek.
Adjustment of creeks	Increased erosion or sedimentation Decline in ecosystem function (due to habitat removal and alteration of existing waterways).	Badgerys Creek South Creek Kemps Creek

Major watercourses

The existing (pre-development) catchment is mainly greenfield with some scattered urban developments. The change in land-use from greenfield to road pavement under post development conditions may impact on the natural hydrological attributes due to the increase in impervious areas with the introduction of the road pavement. **Table 5-8** presents the percentage of impervious areas pre and post development, and summarises the increase in impervious area, within each of the four major drainage catchments.

Table 5-8 Percentage change in impervious surface pre- and post-development – major creeks

Major drainage lines	% of impervious catchment – pre development	% of impervious catchment - post development	% increase between pre and post development
Cosgroves Creek+	1.3%	4.4%	3.1%
Badgerys Creek+	1.6%	2.8%	1.2%
South Creek+	0.9%	1.3%	0.4%
Kemps Creek+	2.9%	3.9%	1.0%
Hinchinbrook Creek*	25.1%	26.0%	0.9%
Notes: + Based on comparing the pre- and post-project conditions of each of the catchments draining to the M12 Motorway crossing of these creeks. Note that the percentage of imperviousness of the existing conditions are obtained from the South Creek Flood Study XP-RAFTS model and the adopted values are considered appropriate according to the available aerial photo imagery. * Based on comparing the pre- and post-project conditions of the catchment draining to Hinchinbrook Creek near SEPP Coastal Wetland ID 276 using aerial photography.			

The comparison between the percentage of impervious areas pre- and post- development at the four creeks demonstrates that the post developed road pavement contributes only a minor increase in catchment imperviousness. It is anticipated that the minor increase in catchment imperviousness would translate to negligible impact to the natural hydrological attributes including volumes and duration.

Potential flood impacts from the project are discussed in Appendix L of the EIS (Flooding assessment report). The project achieves a high level of flood immunity, with the levels of the main carriageways designed to be above the 100 Year Average Recurrence Interval (ARI) flood levels. The study area for the flooding assessment focused on the five key areas where the project would influence, or be influenced by, flooding including: Cosgroves, Badgerys, South and Kemps Creeks and the minor waterway next to Luddenham Road that would be bridged by the project. Ropes Creek was not modelled as the bridge crossing has been designed to match the existing structure and therefore no flood impacts are expected and hydrological impacts would be managed through standard design measures incorporated at detailed design.

Figure 5-1 to **Figure 5-4** shows the comparison of peak velocities at Badgerys Creek, Cosgroves Creek, South Creek and Kemps Creek (ie the bridges near the identified SREs) under pre- and post M12 Motorway conditions. Flood modelling results indicate that there are some very small and localised areas of velocity increase above 20% where velocities are above 1.0 metres per second under post-M12 Motorway conditions, but these are localised at the proposed bridges and generally contained within the project's operational footprint. Suitable scour protection measures would be provided where required to protect the geomorphology and water quality of the receiving waterway. The changes in volume and velocity are unlikely to impact on aquatic connectivity and habitat as discussed in Appendix E of the EIS (Biodiversity assessment report).

The impacts on peak flood velocities outside of the project's operational footprint are considered negligible because the increase in flood velocities are minor and the magnitude of the peak flood velocities under post-M12 Motorway conditions are low, less than 1.0 metres per second, which is considered within the scour or erosion threshold of bare ground.

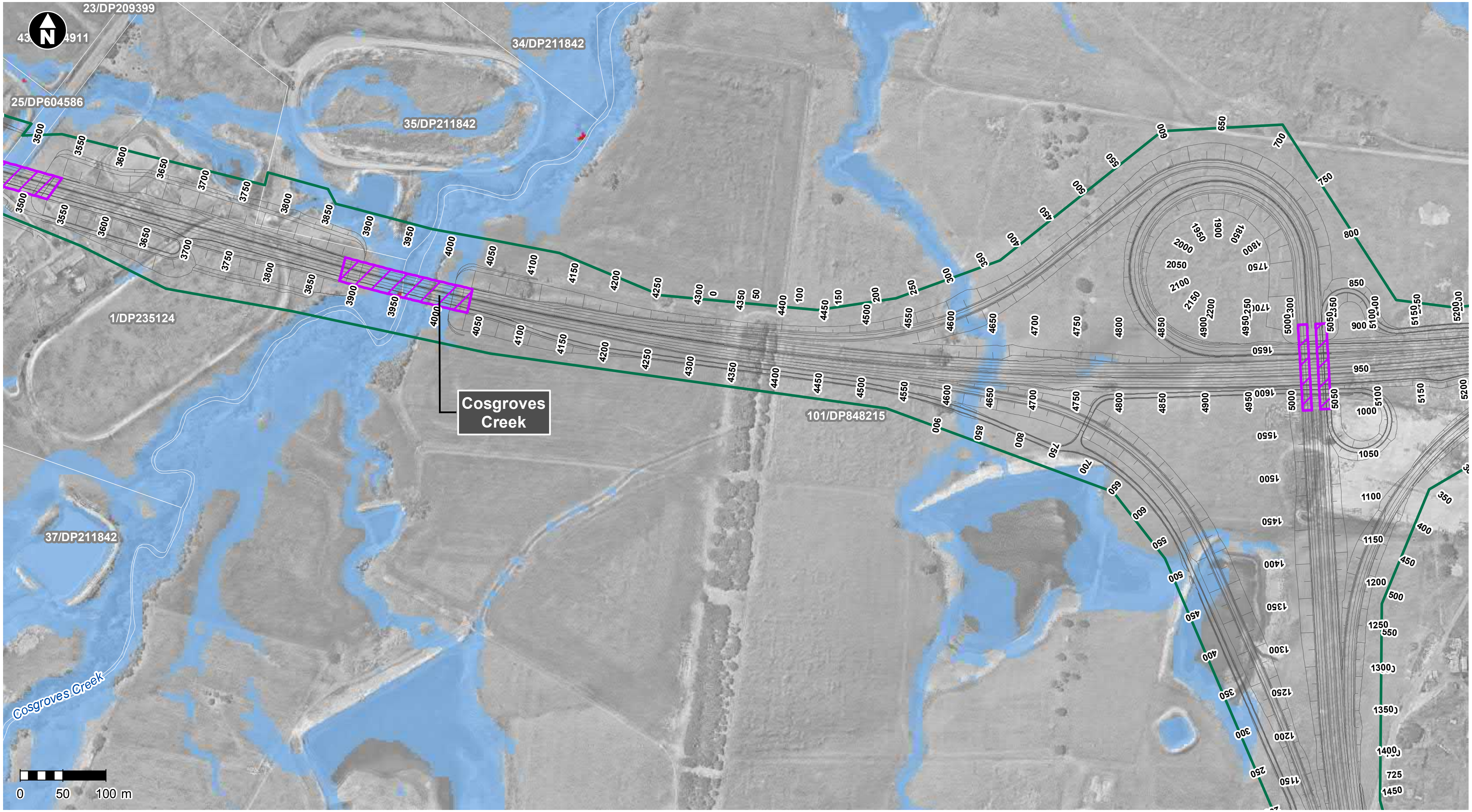
Management of scour at bridges has been accounted for in the design through setting the width of the bridges and embankments to avoid scour where possible, design of minor and localised creek adjustments where required (see section below on creek adjustments) and would be further considered during detailed design.

Creek adjustments

Badgerys Creek, South Creek and Kemps Creek would be permanently adjusted over a distance of 61 metres, 200 metres and 86 metres respectively. The adjustments are required within the creek to ensure that bridge piers are not located within the waterway, to avoid encroachment of the structure into the environmental flows, to minimise bridge lengths, reduce risk of erosion around bridge piers, provide suitable flood conveyance, to minimise creek disturbance during construction, and to minimise shading of the creeks. The adjustments have been designed for the shortest lengths practicable.

The proposed creek adjustments would have a similar capacity to the existing creek channels and would be designed as far as practicable to mimic natural flow conditions. The creek corridors would be revegetated with native riparian vegetation suitable for the local area, in accordance with the requirements of the Policy and guidelines for fish habitat conservation and management (DPI, 2013) and Guidelines for instream works on waterfront land (DPI, 2012a). The creek channels would be rehabilitated following active construction works in accordance with the landscape plans for the project.

The extent and design of any creek adjustments would be refined during detailed design taking into account potential environmental benefits from minimising adjustments to the creeks' natural alignment and form. Any refinement of creek adjustments would take place in conjunction with detailed design of the bridges, with a particular focus on the placement of bridge piers to achieve an acceptable balance between the functionality of the bridges and the potential hydraulic, hydrological and ecological impacts of any creek adjustments.



Legend

- The project
- The project operational footprint
- Bridges
- Cadastre

Velocity increase

- Less than 20% increase and proposed velocity less than 1.0m/s
- More than 20% increase and proposed velocity more than 1.0m/s

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:6,000 at A4

Coordinate System: GDA 1994 MGA Zone 56

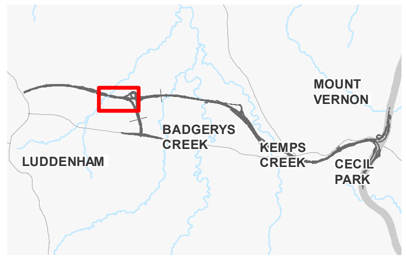
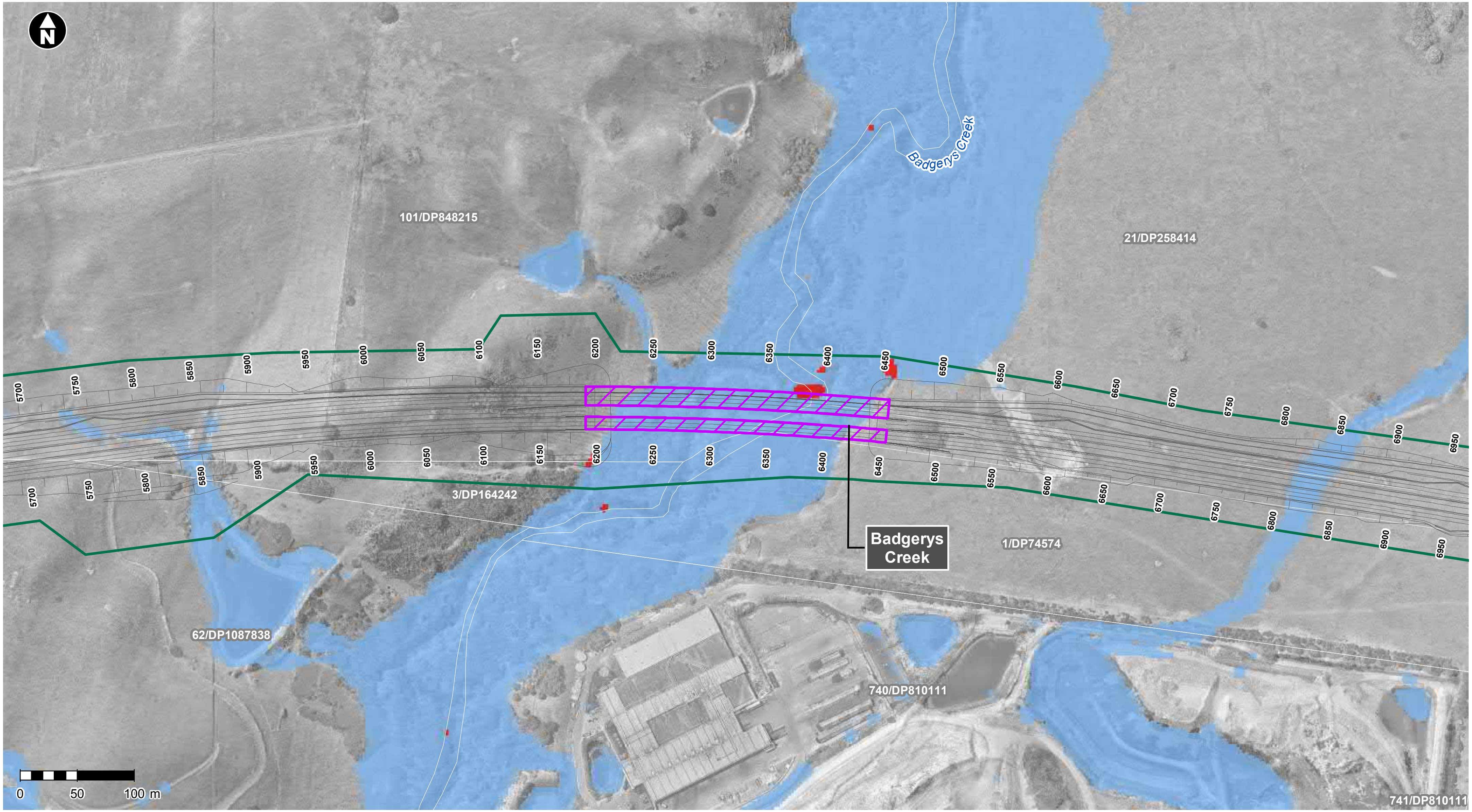


Figure 5-1 100 year ARI velocity impact at Cosgroves Creek



Legend

- The project
- The project operational footprint
- Bridges
- Cadastre

Velocity increase

- Less than 20% increase and proposed velocity less than 1.0m/s
- More than 20% increase and proposed velocity more than 1.0m/s

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

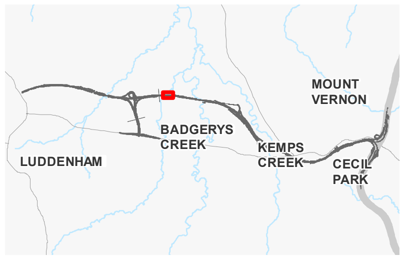
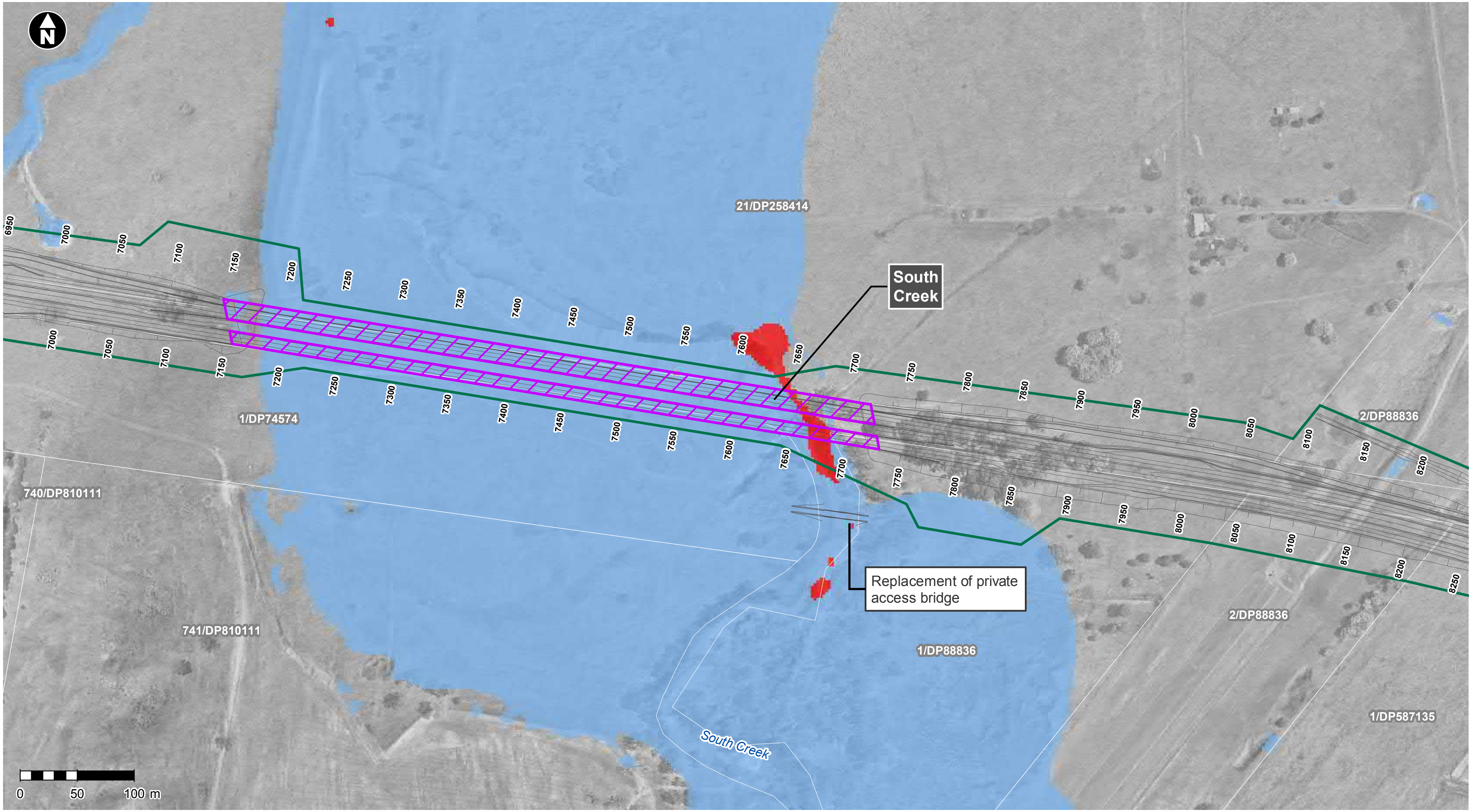


Figure 5-2 100 year ARI velocity impact at Badgerys Creek



Legend

- The project
- The project operational footprint
- Bridges
- Cadastre

Velocity increase

- Less than 20% increase and proposed velocity less than 1.0m/s
- More than 20% increase and proposed velocity more than 1.0m/s

*Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

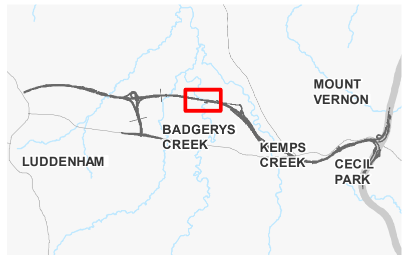
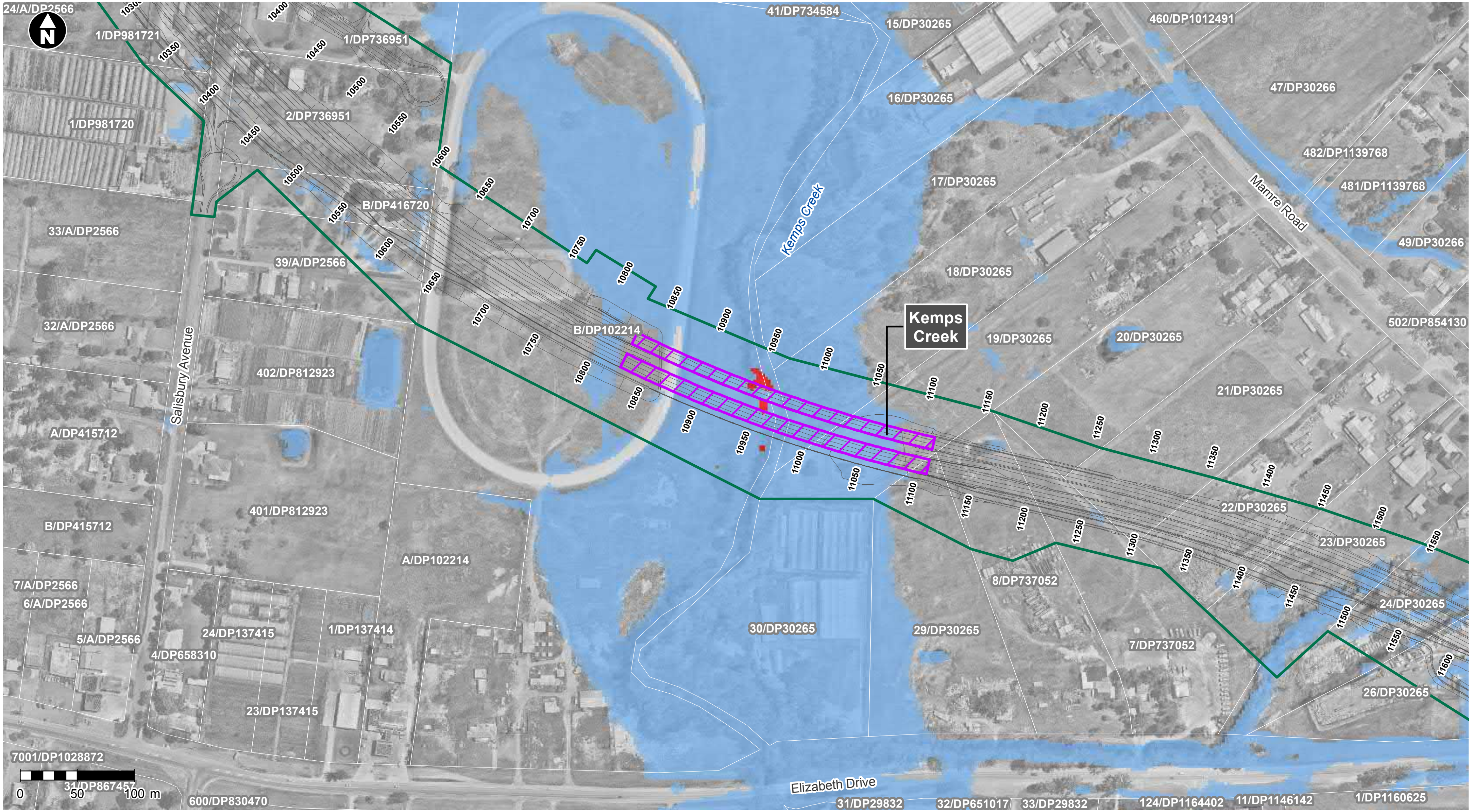


Figure 5-3 100 year ARI velocity impact at South Creek



Legend

- The project
- Bridges
- Cadastre
- The project operational footprint

Velocity increase

- Less than 20% increase and proposed velocity less than 1.0m/s
- More than 20% increase and proposed velocity more than 1.0m/s

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

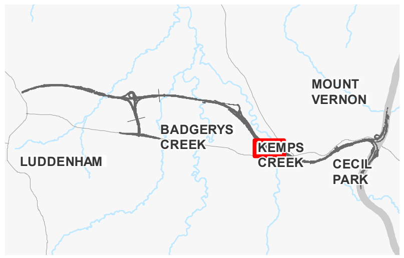


Figure 5-4 100 year ARI velocity impact at Kemps Creek

Date: 8/07/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_VelocityImpact\JAJV_FLD_All_100pc_F001_100yrARIFloodVDiff_DDP_A4L_v1.mxd
Created by : EM | QA by : RB

Culverts

Culverts are a more sensitive influencer on flow and velocity changes, though the area of influence remains localised at the inlet and outlet of the culverts. The culverts would be located on existing flow paths have been designed so as to not restrict the free flow of water. The design methodology adopted has minimised changes to peak flows and velocity as much as practical, and wherever localised changes would still occur, scour protection would be provided to prevent erosion.

Culverts have been designed with as low gradient as practical and sized so that headwater levels are no higher than existing. Even so, outlet velocities would be higher than existing. Scour protection would be provided at all culvert outlets, and in some cases an energy dissipation device would be required. catch drains (open channels) where flow velocities could result in scour.

Further detail about the project's potential hydrological impact on minor drainage lines downstream of proposed culvert outlets is provided below.

Minor receiving drainage lines

The M12 Motorway would traverse through a number of minor natural receiving drainage lines. These are overland flow paths, usually dry, that typically receive stormwater flows from upstream rural catchments and convey the flow through downstream properties to major creeks.

The project's alignment, longitudinal drainage and culvert designs may result in changes to the catchment characteristics and the catchment boundaries of these minor drainage lines.

The project could increase the imperviousness of a catchment, which would lead to increased stormwater runoff. An increase in the catchment area could also occur which would also increase the peak flow rates and volume of runoff to the minor drainage lines. An increase in flows could result in additional water supply and more frequent overtopping of some farm dams, and potentially increase the risk of flooding, scour and erosion. Conversely, a decrease in flow due to changed flow paths could result in a reduced water supply to some farm dams.

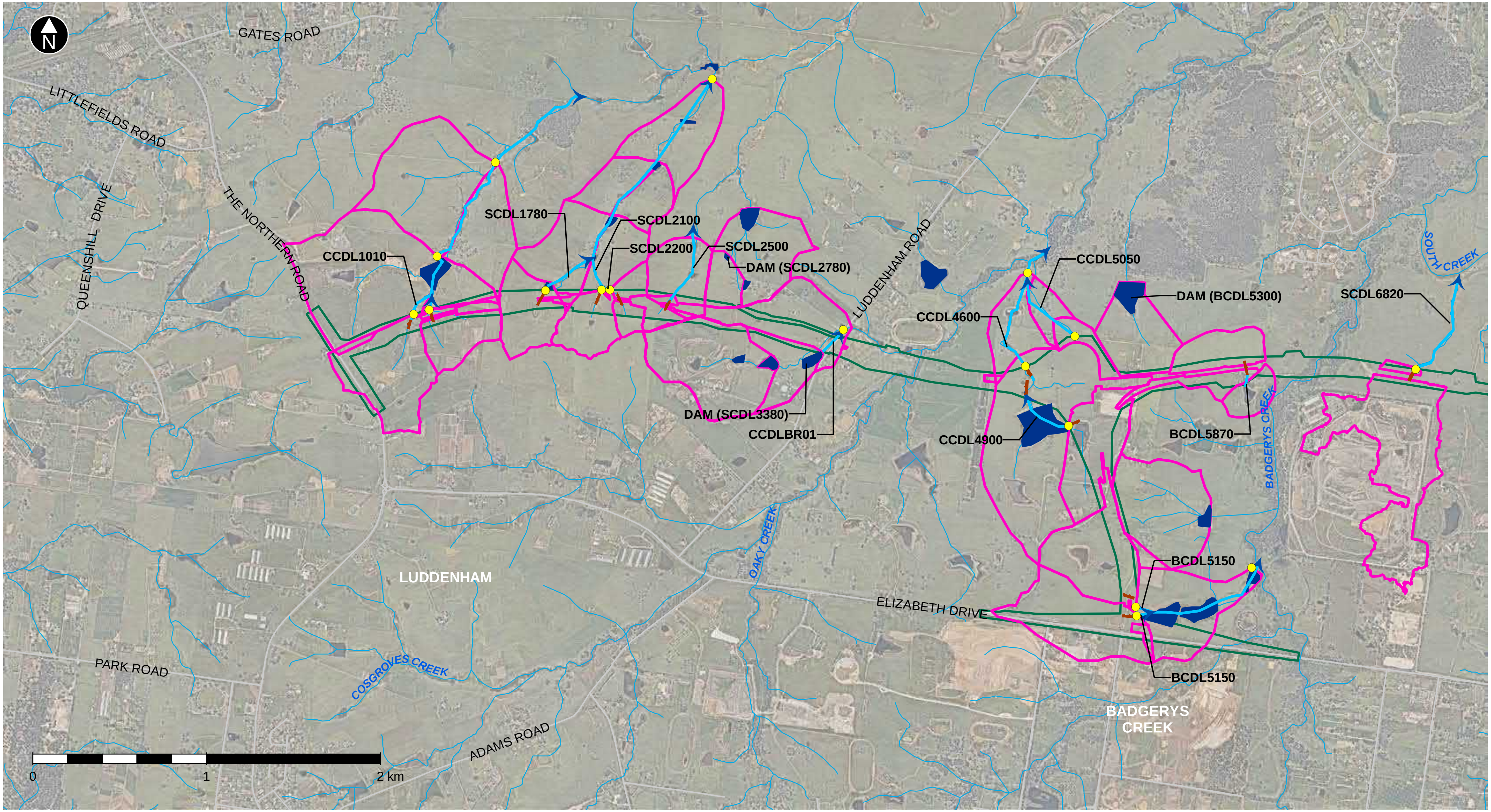
A detailed analysis has therefore been undertaken of all minor drainage lines intersected by the project to understand the impacts the project would have on the hydrology and flooding behaviour downstream of the project's operational footprint.

The analysis focused on changes in volume and peak flow rate for the 2-year, 10 year and 100 year ARI storm events at each minor drainage line, and involved the following key steps:

- Identification of minor drainage lines and catchments, and estimation of the percentage increase in impervious area in the catchment as a result of the project
- Identification of 'points of interest', at the project's operational boundary and the downstream location that defines the limit of impact, being where any measured increase in volume and peak flow rate is less than 10 per cent above the existing.

The detailed analysis for all of the minor drainage lines and catchments is shown in **Annexure 1**. Where the initial modelling results showed no change to the peak flow rate or volume, or where the change (increase or decrease) at the project's operational boundary was less than 10 per cent, no further analysis was applied and it has been concluded that the impact on that drainage line (and any downstream infrastructure) is negligible, with no increase in the risk of flooding, scour or erosion.

Where the initial modelling results showed a change (increase or decrease) in peak flow rate or volume of more than 10 per cent at the project's operational boundary, further analysis was applied to determine the downstream impact, and the point downstream where the measured change in flow rate dropped below 10 per cent. This impact has been assessed and the results included in **Annexure 1**, and all of the assessed drainage lines are illustrated in **Figure 5-5**.



Waterways

Main roads

The project operational footprint

Points of interest

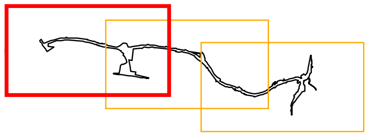
Minor drainage lines that have been assessed

Direction of flow

Farm Dams that have been assessed

Cross drainage culverts

Minor drainage channel catchments - with project



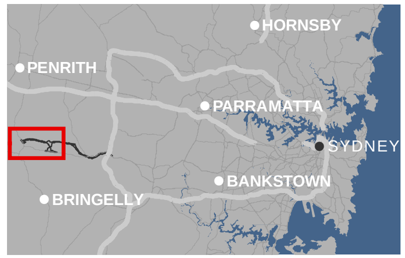
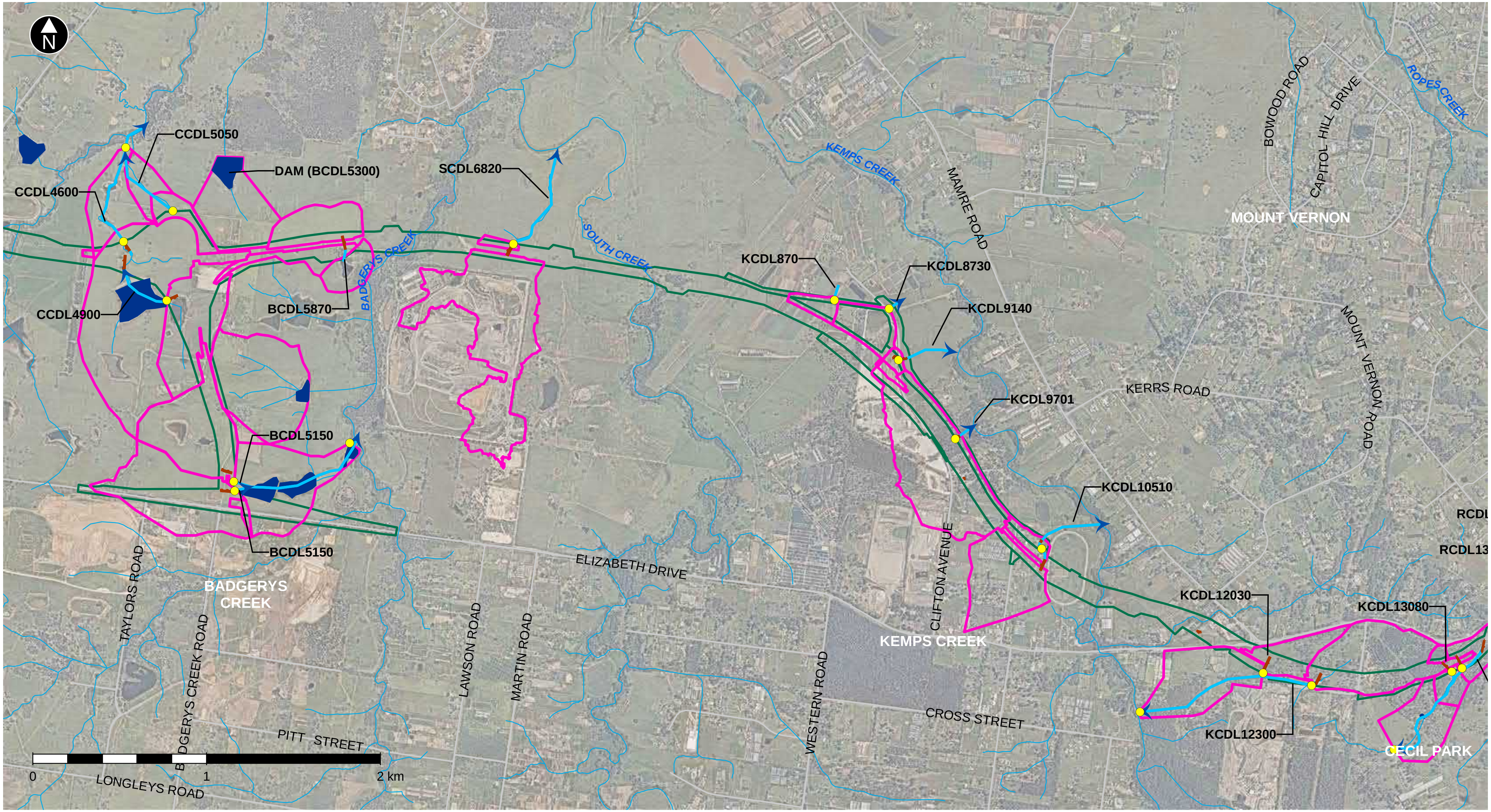


Figure 5-5 Minor drainage lines and farm dams

Date: 23/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F012_DrainageAssessed_r1v1.mxd
Created by : HK | QA by : AA



- Waterways
- Main roads
- The project operational footprint
- Points of interest
- Minor drainage lines that have been assessed
- Direction of flow
- Farm Dams that have been assessed
- Cross drainage culverts
- Minor drainage channel catchments - with project

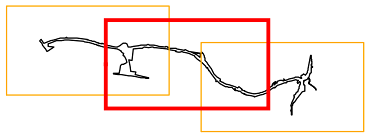


Figure 5-5 Minor drainage lines and farm dams

Date: 23/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F012_DrainageAssessed_r1v1.mxd
Created by : HK | QA by : AA

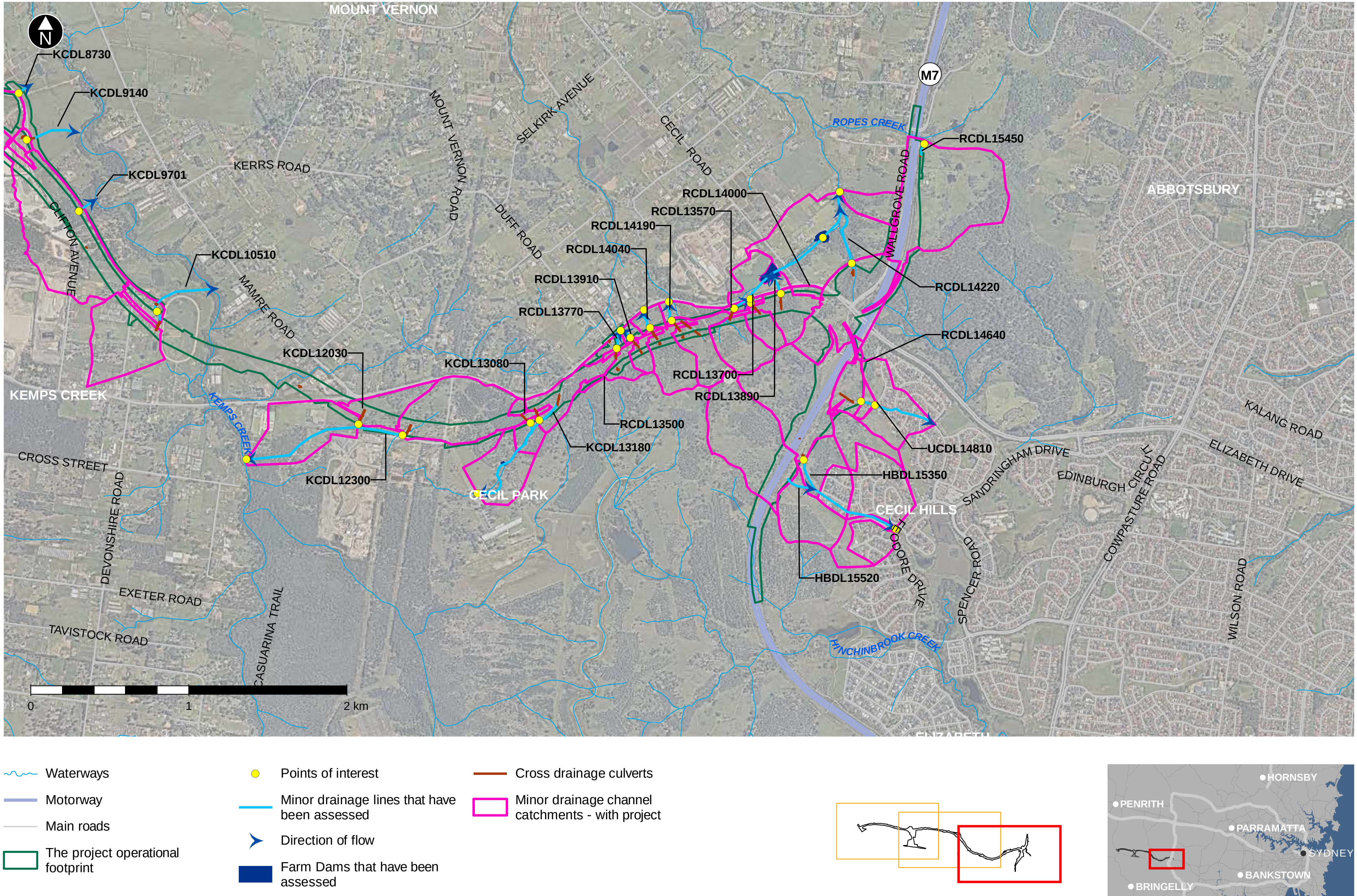


Figure 5-5 Minor drainage lines and farm dams

The analysis summarised in **Table 5-9** showed that increases in peak flow rate and volume of stormwater runoff are likely to impact on minor drainage lines and the downstream farm dams at a number of locations. Without implementing any mitigation measures, downstream farm dams (in catchments that are increasing in size, or impervious area, or both) would be at increased risk of overtopping after a 10 year ARI or 100 year ARI storm event. In addition, some drainage lines would receive increased concentration of flows with prolonged duration of higher peak flow rate and volume. For example, Kemps Creek drainage line DL9701 is shown in the table as potentially experiencing an increase in peak flow of up to about 150 per cent over existing (at the project's operational boundary), depending on the intensity of the storm event. This increase is mostly attributable to the large increase in the catchment area and the impervious component of the catchment that would result from the project's concept design, which would lead to increased concentration of stormwater flows within this minor drainage line.

Where there are more highly developed urban land uses situated in or close to minor drainage lines downstream of the project, such as near Elizabeth Drive between Mamre Road and the M7 Motorway, there are some locations where the project may result in increased flows with the potential to impact on downstream land use or on the flood immunity of Elizabeth Drive. In particular, **Table 5-9** and **Figure 5-5** show drainage lines flowing across Elizabeth Drive between Duff Road and Cecil Road (Ropes Creek catchment, drainage lines DL13910, DL14040, DL14190 and DL13890) where the modelled increases in peak flow rate and volume are potentially large. Similarly, there is one drainage line flowing south from the project's footprint into Kemps Creek (DL12300, south of the Kemps Creek Sporting and Bowling Club), where the modelled increase in peak flow rate and volume of stormwater runoff is also potentially large. At these locations, because of the nature of nearby and downstream land use, consideration of stormwater detention basins may be warranted, subject to further analysis during detailed design.

As discussed in **Table 5-9**, with the implementation of recommended management measures, the impacts of increased peak flow rates and volume on land and infrastructure downstream would be minimal. Further, the analysis showed that for each minor drainage line, the impacts diminish with distance downstream until the channel either joins with one of the major creeks, or the peak flow rate declines until it is almost the same as for the existing or pre-developed conditions.

During the project's detailed design, further modelling would be conducted to verify the project's impacts on minor drainage lines and to confirm the mitigation strategies being committed to by Roads and Maritime under this assessment. In particular this would apply to measures designed to mitigate impacts downstream and outside of the project's operational boundary. These measures would also be subject to negotiation and agreement with individual affected property owners.

The assessment did not examine in detail the project's potential impacts on farm dam yields. Precise impact on farm dam yields is dependent on the final road design including alignment, geometry and drainage design and would be further investigated at the detailed design phase.

This assessment also did not examine the project's potential impacts on the existing water quality detention basins that were built as part of original M7 Motorway works, due to the lack of survey data or as-built information in regard to these existing basins. The M12 Motorway would result in increased pavement area along the M7 Motorway at the northbound entry ramp and southbound exit ramp in the vicinity of Ropes Creek. The mitigation strategy for the project therefore would be to ensure that the existing treatment capability of existing basins are maintained during detailed design, taking into account any additional runoff from the widened M7 Motorway pavement.

Table 5-9 Summary impacts and suggested mitigations at minor drainage lines

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
Cosgroves Creek	CC DL 1010	Private	+12 to +58	• Afflux of 20 millimetres at the downstream project (operational) boundary. • Increased flows to the farm dam (about 9%) would adversely impact on the performance of the existing spillway and its scour protection. • There would be increased outflow from the farm dam which is likely to cause increased depth of flow across the property access road to the dam. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner. • If updated modelling undertaken during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins	• There would be a minor increase in the rate and volume of runoff discharging to the existing dam that is located a short distance to the north of the project operational footprint. • The affected dam is likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
Cosgroves Creek	CC DL 1110	Private	-9 to -10	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measures are proposed at this location.	• There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line confluences with the drainage line CC DL1010 a short distance downstream of the project operational footprint.
Cosgroves Creek (Luddenham Road)	CC DL BR01	Local Council	+3 to +4	• Increase in the peak flow rate is considered to be minor. However, this minor increase could adversely impact on the flood immunity of Luddenham Road. • The culverts would overtop Luddenham Road more frequently due to the increase in the peak flow rate.	• During detailed design Roads and Maritime would carry out further modelling to confirm the impact, and the design of appropriate mitigation measures, which could include detention basin(s) and culvert upgrade(s)	• There would be minor increase in the peak flow rate to the culverts on Luddenham Road and the property access road.
South Creek	SC DL 1780	Private	+0 to +3%	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measures are proposed at this location.	• There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project corridor before the drainage line confluences with the drainage line SC DL2100 a short distance downstream of the project operational footprint.
South Creek	SC DL 2100	Private	+8 to +13	• Afflux of 20 millimetres at the downstream project (operational) boundary.	• Further modelling would be undertaken during detailed design to verify the project impacts on the	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located on the

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
				• Increase in the peak flow rate would not cause scour of the downstream drainage line.	characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner.	downstream drainage line north of the project operational footprint. • The affected dam is likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
South Creek	SC DL 2200	Private	-10 to -12	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measures are proposed at this location.	• There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line joins with the drainage line SC DL2100 a short distance downstream of the project operational footprint.
Cosgroves Creek	CC DL 4600	Private	+3 to +28	• The flow to the tributary of Cosgroves Creek would increase by up to 1% in the 100 year ARI event. • The existing farm dam located about 300 m from	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway	• There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • There would be a minor increase in the rate and volume of runoff discharging to the existing dam that is located a short

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
				the project (operational) boundary, would be subjected to increased flow. This may have adverse impact on the performance of the spillway and its scour protection. • Increase in the peak flow rate would not cause scour of the downstream drainage line.	and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner.	distance to the north of the project operational footprint. • The affected dam is likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
South Creek	SC DL 2500	Private	+21 to +34	• Afflux of 20 millimetres at the downstream project (operational) boundary. • Increase in the peak flow rate would not cause scour of the downstream drainage line	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. All potential management measures would be considered in consultation with the affected property owner.	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located on the downstream drainage line north of the project operational footprint. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
South Creek	SC DL 2780	Private	-11	• Runoff to the farm dam at this location would be reduced by about 12%.	• Further modelling would be undertaken during detailed design to verify the project impacts on flows to this receiving drainage line. • All potential management measures would be considered in consultation with the affected property owner	• There would be a reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff.
South Creek	SC DL 3380	Private	-4	• Runoff to the farm dam at this location would be reduced by about 4%.	• No mitigation measures are proposed on the receiving drainage line.	• There would be a minor reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff.
Cosgroves Creek	CC DL 4900	Private	+5 to +20	• Increased flow may impact adversely on the performance of the spillway to the farm dam at this location. • The dam footprint would be partly impacted by the motorway road/drainage works.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap.	• There would be a minor increase in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop more frequently due to the increase in the volume of runoff.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
					• All potential management measures would be considered in consultation with the affected property owner.	
Cosgroves Creek	CC DL 5050	Private	-22 to -26	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measures are proposed on the receiving drainage line.	• There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line joins with the drainage line CC DL 4600 a short distance downstream of the project operational footprint.
Badgerys Creek	BC DL 5150	Private	+12 to +61	• Afflux of 20 millimetres at the project (operational) boundary • Overall there would be increased flow to the farm dams at this location. This is likely to impact adversely on the performance of the dams and their spillways • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. All potential management measures would be considered in consultation with the affected property owner.	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located short distances to the west of the project operational footprint. • The affected dams are likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • There would be minor increase in the peak flow rate to Badgerys Creek, but this is not likely to cause any adverse impacts to the mainstream flooding.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
					• If updated modelling undertaken during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins	• Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.
Badgerys Creek	BC DL 5160	Private	-2 to +1	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is proposed at this location.	• There would be a minor change in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line joins with the drainage line BC DL 5150 a short distance downstream of the project operational footprint.
Badgerys Creek	BC DL 5300	Private	-10	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• Further modelling would be undertaken during detailed design to verify the project impacts on flows to this receiving drainage line. • All potential management measures would be considered in consultation with the affected property owner	• There would be a minor reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
Badgerys Creek	BC DL 5870	Private	-3 to +3	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is proposed at this location.	• There would be a very minor reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff. • There would be very minor change in the peak flow rate and volume of runoff to the receiving downstream drainage line.
South Creek	SC DL 6820	Private	-2 to -3	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line downstream of the project operational footprint.
Kemps Creek	KC DL 8700	Private	-27 to -32	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.
Kemps Creek	KC DL 8930	Private	+2 to +7	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is proposed at this location.	• There would be a minor increase in the rate and volume of runoff into receiving drainage line.
Kemps Creek	KC DL 9140	Private	-25 to -50	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
Kemps Creek	KC DL 9701	Private	+90 to +156	• Afflux of 160 millimetres at the downstream project (operational) boundary. • Increased flow to Kemps Creek from this drainage line which could impact adversely on the mainstream flooding. • Increase in the peak flow rate would not cause scour of the downstream drainage line. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line. • Based on the available lidar data, the scour assessment did not identify any significant increase in flow velocities although the peak flow rates would double in the 100 year ARI event and almost triple in the 2 year ARI event.	• Further modelling would be undertaken during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection such as rip rap lining • Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	• There would be a substantial increase in the peak flow rate and volume of runoff to the receiving drainage line downstream of the project operational footprint. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.
Kemps Creek	KC DL 10510	Private	-2	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
Kemps Creek	KC DL 12030	Private	+17 to +85	• Afflux of 20 millimetres at the downstream project (operational) boundary. • There would be increased flow to Kemps Creek from the motorway works. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be undertaken during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection such as rip rap lining. • Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	• There would be a substantial increase in the rate and volume of runoff into the receiving drainage line if no detention basin is provided as a mitigation measure. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.
Kemps Creek	KC DL 12300	Private	+19 to +47	• Afflux of 30 millimetres at the downstream project (operational) boundary adjacent to quarry access road. • There would be increased flow to Kemps Creek from the motorway works. • The increase in the peak flow rate attributable to the project has the potential to	• Further modelling would be undertaken during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection such as rip rap lining.	• There would be a substantial increase in the rate and volume of runoff into receiving drainage line if no detention basin is provided as a mitigation measure. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
				increase the scour potential in the receiving downstream drainage line.	• Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	
Kemps Creek	KC DL 13180	Private	+52 to +113	• Afflux of 50 millimetres at the downstream project (operational) boundary • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flows in the culvert across the property access road. Subject to modelled verification and confirmation of impacts, a	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located a short distance to the south of the project operational footprint. • The affected dam are likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
					detention basin and culvert upgrade may be required • All potential management measures would be considered in consultation with the affected property owner. • If updated modelling undertaken during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins.	
Kemps Creek	KC DL 13080	Private	-31 to -35	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.
Ropes Creek	RC DL 13500	Private	-67 to -70	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.
Ropes Creek	RC DL 13790	Private	-2 to +11	• The project would not have an adverse impact on the	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line before the drainage line

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
				receiving drainage line due to the minor change in flow.		confluences with drainage line RC DL 13910,
Ropes Creek	RC DL 13910	Private	+9 to +20	• Afflux of 10 millimetres at the downstream project (operational) boundary. • Increase in the peak flow rate does not cause scour of the downstream drainage line.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow in the existing culverts across Elizabeth Drive. Provision of a detention basin and scour protection within the project operational footprint, as part of an integrated approach with future widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts to the existing culverts.	• There would not be any increase in the rate and volume of runoff into receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Ropes Creek	RC sDL 14040	Private	+4 to +5	• Reduction in flood immunity to the existing culvert beneath Elizabeth Drive.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow in the existing culverts across Elizabeth Drive. Provision of a detention basin and scour protection within the project operational footprint, as part of an integrated approach with	• There would not be any increase in the rate and volume of runoff into receiving drainage line downstream of Elizabeth Drive. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
					future widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts to the existing culverts.	
Ropes Creek	RC DL 14190	Private	+14 to +16	• Afflux of 20 millimetres at the downstream project (operational) boundary. • Increase in the peak flow rate does not cause scour of the downstream drainage line.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow in the existing culverts across Elizabeth Drive. Provision of a detention basin and scour protection within the project operational footprint, as part of an integrated approach with future widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts to the existing culverts.	• There would not be any increase in the rate and volume of runoff into receiving drainage line downstream of Elizabeth Drive. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Ropes Creek	RC DL 13570	Private	-2 to -3	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff in the drainage line before it joins with drainage line RC DL 13700 at the inlet of the existing culvert beneath Elizabeth Drive.
Ropes Creek	RC DL 13700	Private	-7 to -8	• The project would not have an adverse impact on the	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff in the drainage line before it confluences with drainage

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
				receiving drainage line due to the minor change in flow.		line RC DL 13890 at the farm dam on the northern side of Elizabeth Drive.
Ropes Creek	RC DL 13890	Private	+62 to +160	• Potential for impact on the capacity of the existing culvert beneath Elizabeth Drive causing flooding. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flow over the spillway of the affected dam and capacity of the existing culvert beneath Cecil Road • Subject to modelling and verification of project impacts, adjustments may be made to the spillway of the dam that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner. • Modelling during detailed design would also verify the project impact on the existing culverts across Elizabeth Drive. Provision of a detention basin within the project operational footprint, as part of an integrated approach with future	• There would be a minor increase in the rate and volume of runoff discharging to the existing dam that is located in the private property a short distance north of Elizabeth Drive. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
					widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts to the existing culverts. • If updated modelling undertaken during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins	
Ropes Creek	RC DL 14000	Private	-50 to -67	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.
Ropes Creek	RC DL 14220	Private	-4 to +25	• The increase in the 2 to 10 year ARI flow may impact adversely on the existing culverts beneath Wallgrove Road/Elizabeth Drive intersection. This may cause flooding at the intersection for these storm events.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flows in the culverts beneath the Wallgrove Road/Elizabeth Drive intersection	• There would be a minor increase in the rate and volume of runoff into receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
					• Subject to modelling and verification of the project impacts, mitigation could include provision of a detention basin within the project operational footprint to minimise the potential adverse impacts to the existing culverts. • The modelling would also be used to demonstrate that the proposed mitigation measures will be effective based on the design as modelled.	
Ropes Creek	RC DL 14640	Private	-20 to 0	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Unknown catchment	UC DL 14810	Private	+33 to +75	• Afflux 40 millimetres at the project (operational) boundary. • Velocity of flow in the downstream drainage line would increase. • The 10 year ARI flow would increase by 44%, which would impact adversely on	• Further modelling would be undertaken during detailed design to verify the project impacts on the existing pipe drainage in Jaquetta Close. • Further modelling would be undertaken in respect of the capacity of existing pipe drainage in Jaquetta Close, to verify impacts on this	• There would not be an increase in the rate and volume of runoff into receiving drainage line. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
				the downstream pipe drainage system through the existing development. • Overland flow through the Jaquetta Close in the existing housing development would increase which could cause road overland flooding. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	infrastructure and confirm mitigation measures. • Subject to outcomes of modelling, provision of a detention basin and scour protection (such as rip rap lining) within the project operational footprint could be considered to minimise the potential adverse impacts on receiving drainage lines and existing drainage.	
Hinchinbrook Creek	HB DL 15350	Private	-19 to +23	• No increase in peak flow rates for storm events from 10 year ARI to 100 year ARI. • Peak flow rate would increase in the 2 year ARI storm event, increasing risk of scour potential in the downstream receiving drainage line.	• Further modelling would be undertaken during detailed design to verify the project impacts on the characteristics of flows in this receiving drainage line. • Subject to modelling outcomes and verification of project impacts, mitigation could include provision of scour protection and a detention basin within the project operational footprint.	• There would be a minor increase in the rate and volume of runoff into receiving drainage line in the frequent rain events. However, there would be a significant reduction in the rate and volume of runoff into the receiving drainage line in the major storms. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at project Operational Boundary (%)	Potential Impacts	Proposed Mitigation Measures	Residual Impacts
Ropes Creek	RC DL 15450	Private	+11 to +53	• Afflux 10 millimetres on the existing watercourse in the private property at the project (operational) boundary. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be undertaken during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection. • Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	• There would be a minor increase in the rate and volume of runoff into receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Hinchinbrook Creek	HB DL 15520	Private	-8 to -18	• The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line before it confluences with drainage line HB DL 15350 a short distance downstream of the project operational footprint. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

5.2.4 Impacts to SEPP Coastal Wetlands

Potential water quality and hydrology impacts to SEPP Coastal wetlands 113, 114 and 236 associated with the operation of the M12 Motorway are expected to be negligible with the implementation of the proposed water quality controls included in the design of the project where it drains to Hinchinbrook Creek.

The construction access track adjacent to SEPP Coastal Wetland 117 would remain in place during the operational phase of the project. Very limited traffic is expected to access the track and impacts to water quality and quantity would be negligible. As outlined in the environmental management measures in **Chapter 8**, further consideration would be given to potential operational water quality management measures in this location during detailed design.

6. Water quality and hydrology controls

As discussed in **Chapter 4.5.3**, construction and operation of the project has the potential to impact the water quality of receiving environments. This section provides a discussion of measures that have been incorporated into the concept design for the project. The locations and details of these water quality controls are subject to change during design development when the proposed water quality controls would be sized and checked against any previously unknown site constraints.

6.1 Construction phase

6.1.1 Proposed sediment basins

The main strategy to minimise any impacts to water quality during construction, in particular to SREs, is the construction of sediment basins. There are 82 sediment basins proposed for the construction phase of the project as presented in **Table 6-1** and **Figure 6-2**.

Table 6-1 M12 temporary sediment basins for the construction phase

Sediment basin Name	Receiving waterway	Sediment basin Name	Receiving waterway^
B980EB	South Creek	B9710EB	Kemps Creek
B950WB	South Creek	B10550EB	Kemps Creek
B1110EB	South Creek	B10600EB	Kemps Creek
B1770EB	South Creek	B10850EB	Kemps Creek
B1790EB	South Creek	B11150EB	Kemps Creek
B2100EB	South Creek	B12050WB	Kemps Creek
B2110EB	South Creek	B12060WB	Kemps Creek
B2200EB	South Creek	B12350WB	Kemps Creek
B2500EB	South Creek	B12600WB	Kemps Creek
B2510EB	South Creek	B13050WB	Kemps Creek
B3350WB	Cosgroves Creek	B13060WB	Kemps Creek
B3890EB	Cosgroves Creek	B13150WB	Kemps Creek
B4080EB	Cosgroves Creek	B13300WB	Kemps Creek
B4590EB	Cosgroves Creek	B13800EB	Ropes Creek
B4660EB	Cosgroves Creek	B13810EB	Ropes Creek
B5840WB	Badgerys Creek	B13910EB	Ropes Creek
B5850WB	Badgerys Creek	B14050EB	Ropes Creek
B6200WB	Badgerys Creek	B14060EB	Ropes Creek
B6840EB	South Creek	B14210EB	Ropes Creek
B6850EB	South Creek	B14650EB	Ropes Creek
B7170WB	South Creek	B3750EB	Ropes Creek

Sediment basin Name	Receiving waterway	Sediment basin Name	Receiving waterway^
B7800WB	South Creek	B13610EB	Ropes Creek
B8770EB	Kemps Creek	B13710EB	Ropes Creek
B9700EB	Kemps Creek	B13940EB	Ropes Creek
B300EB	Cosgroves Creek	B13950EB	Ropes Creek
B580EB	Cosgroves Creek	B14095EB	Ropes Creek
B1200WB	Cosgroves Creek	B14220EB	Ropes Creek
B1250WB	Cosgroves Creek	B15300EB	Hinchinbrook Creek
B1710EB	Badgerys Creek	B14820EB	Hinchinbrook Creek
B2150WB	Badgerys Creek	B14810EB	Hinchinbrook Creek
B2300EB	Badgerys Creek	B14800EB	Hinchinbrook Creek
B1130EB	Badgerys Creek	B2025WB	Ropes Creek
B1130WB	Badgerys Creek	B1860WB	Hinchinbrook Creek
B1900EB	Badgerys Creek	B1450EB	Hinchinbrook Creek
B1900WB	Badgerys Creek	B1275WB	Hinchinbrook Creek
B460WB	Kemps Creek	B1260EB	Hinchinbrook Creek
B910WB	Kemps Creek	B1310EB	Hinchinbrook Creek
B230WB	Kemps Creek	B1300EB	Hinchinbrook Creek
B423EB	Ropes Creek	B15400EB	Ropes Creek

^ temporary sediment basins located within the Hinchinbrook Creek catchment would provide protection to downstream SEPP Coastal wetlands ID113,114 and 276.

The locations of the sediment basins are indicative only and are subject to change during detailed design. The locations were selected to provide the best chance of capturing all runoff before it enters natural waterways, using gravity to divert maximum runoff from disturbed areas within the construction areas to the basins. The locations for sediment basins also considered site constraints such as major utility services and environmentally sensitive areas.

6.1.2 Sediment basin sizing

The design criteria for sizing construction phase sediment basins aimed to minimise changes to the existing water quality to the greatest extent practicable, and was based on the requirements of:

- Managing Urban Stormwater, Soils and Construction guidelines, Volumes 1 (Landcom, 2004) (known as the Blue Book)
- Managing Urban Stormwater, Volume 2D: Main Road Construction (DECC, 2008) (along with the document above, also known as the Blue Book)
- Roads and Maritime General Specifications; Guide to QA Specification 36 Environmental Protection and G38 (Soil and Water Management)
- Expected requirements of an Environmental Protection License (EPL) and section 120 of the POEO Act, as discussed below.

In addition to the requirements of the abovementioned guidelines, the number, location and size of the basins will be further refined during the detailed design with consideration of the NSW EPA relevant Environment Protection Licence application requirements and the environmental values of the downstream receiving waterway. Practical measures to prevent water pollution and control, abate or mitigation impacts to the environment will be investigated at the detailed design stages of the project. Such measures may include larger or high efficiency temporary basins and alternative dry bio-retention operational basins.

Temporary sediment basins provided for the construction phase have been sized according to the requirement of the Blue Book. The 85th percentile, five-day rainfall depth design criteria has been applied for basins upstream of the SREs (as nominated in **Section 4.4**), and the 80th percentile at all other locations (as outlined in **Table 6-2**).

The three key design elements that were used at concept design for the individual sizing of each sediment basin were:

- Catchment areas contributing to the sediment basins (disturbed and undisturbed areas).
- The percentage of the total contributing sub catchment area that is either "cut" or "fill". These are batters/ embankment areas. These sub catchments generate greater soil losses.
- Whether the basin is located upstream of a "sensitive" receiving environment, thus requiring the 85th percentile, five-day rainfall depth design criteria.

Other design input parameters included soil type, rainfall erosivity (which is a function of local rainfall intensity), soil hydrologic group, volumetric runoff coefficients and soil erodibility. The key site-specific design parameters that should be used at the concept design stage to size the sediment basins are listed in **Table 6-2**.

Table 6-2 M12 Design criteria for sizing the temporary sediment basins at concept design

Parameter	Value	Comment
Rainfall parameters		
Rainfall depth duration (days)	5 day	5 day to be adopted as standard duration used in the EPA EPL
Rainfall percentile	80th and 85th	85th to be adopted for Sensitive areas only. 80th for all other locations
Rainfall depth (mm) – 5 day	80th -27.4 mm 85th - 35.0 mm	For Penrith as derived from the Blue Book. The selection of the Penrith site to the west of the study area is a conservative measure
Volumetric Runoff Coefficient, cv	Varies (0.51 to 0.64)	0.64 has to be adopted for Group D hydrologic Soils of high runoff potential for under 35 millimetres rainfall depth
Rainfall intensity for 2 year ARI, 6 hr duration	9.88 mm/hr using the 2016 BOM data, and 9.48 mm/hr using the previous 1987 BOM data	9.88 mm/hr to be adopted from Rainfall Intensity IFD tables which is slightly conservative Refer to derived rainfall erosivity in this table
RUSLE Parameters (Revised Universal Soil Loss Equation)		
Soil/Sediment Type	C, D, or F	Varies along the alignment. Mainly type F, type D and small localised pockets of type C. Type D for deeper subsoils
Erodibility, k	Varies k=0.02 to k=0.06	K = 0.05 as a reasonable value for the typical soils found in this area, however this selection can be further improved at detailed design stage through site specific soil testing for erodibility

Parameter	Value	Comment
Rainfall Erosivity, R	2164	R= 2496 based on the Bureau of Meteorology rainfall intensities for the site.
Hydrologic Soil Group	D	For high runoff potential, Reference: Appendix F of the Blue Book
Soil Cover, C	1	Corresponding to expected type of activities on site
Soil Conservation Practices P	1.3	Corresponding to expected type of activities on site
Length Slope Factors, LS	Variable	To be determined separately for Main roadway; and Steeper embankment areas (cut and fill)
Sediment Yield Time Period (months)	2 to 6 months	4 months period that accounts for the likely maintenance frequency during construction for the removal of captured sediments

The sediment basins have been sized to ensure sufficient volume for settling and storage of sediments by using catchment areas and the appropriate design rainfall depth and the Revised Universal Soil Loss Equation (RUSLE). The sediment basins would capture sediments from soil losses that are generated in the construction area and would need to remain in operation until all disturbed surfaces have been covered with pavement or vegetation. The basins would also include accidental spill management such as hydrocarbons through the proposed underflow baffle arrangement located at the outlet of all basins. These basins would require maintenance for the removal of sediments when the sediment depth reaches approximately 300 millimetres in depth. The runoff in these basins would need to be emptied within 5 days of a storm event in anticipation for the next storm event.

Following the review of the NSW EPA licence conditions for the basins, further consideration would need to be given to alternatives such as high performance sediment basins that could include the use of highly effective flocculants other than Gypsum.

A typical design for a sediment basin is provided in **Figure 6-1** from the Blue Book. Sediment basin design would be subject to detailed design.

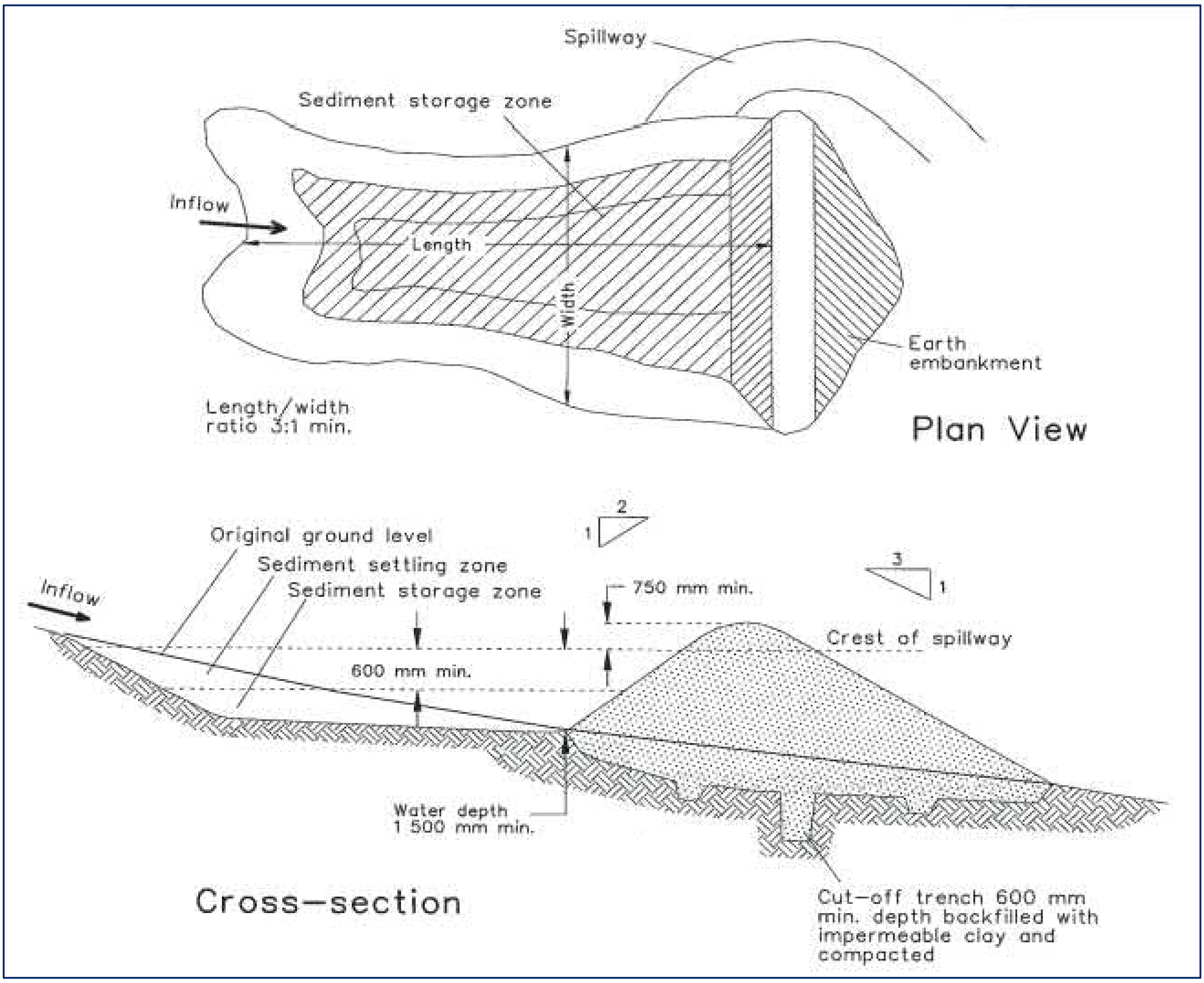
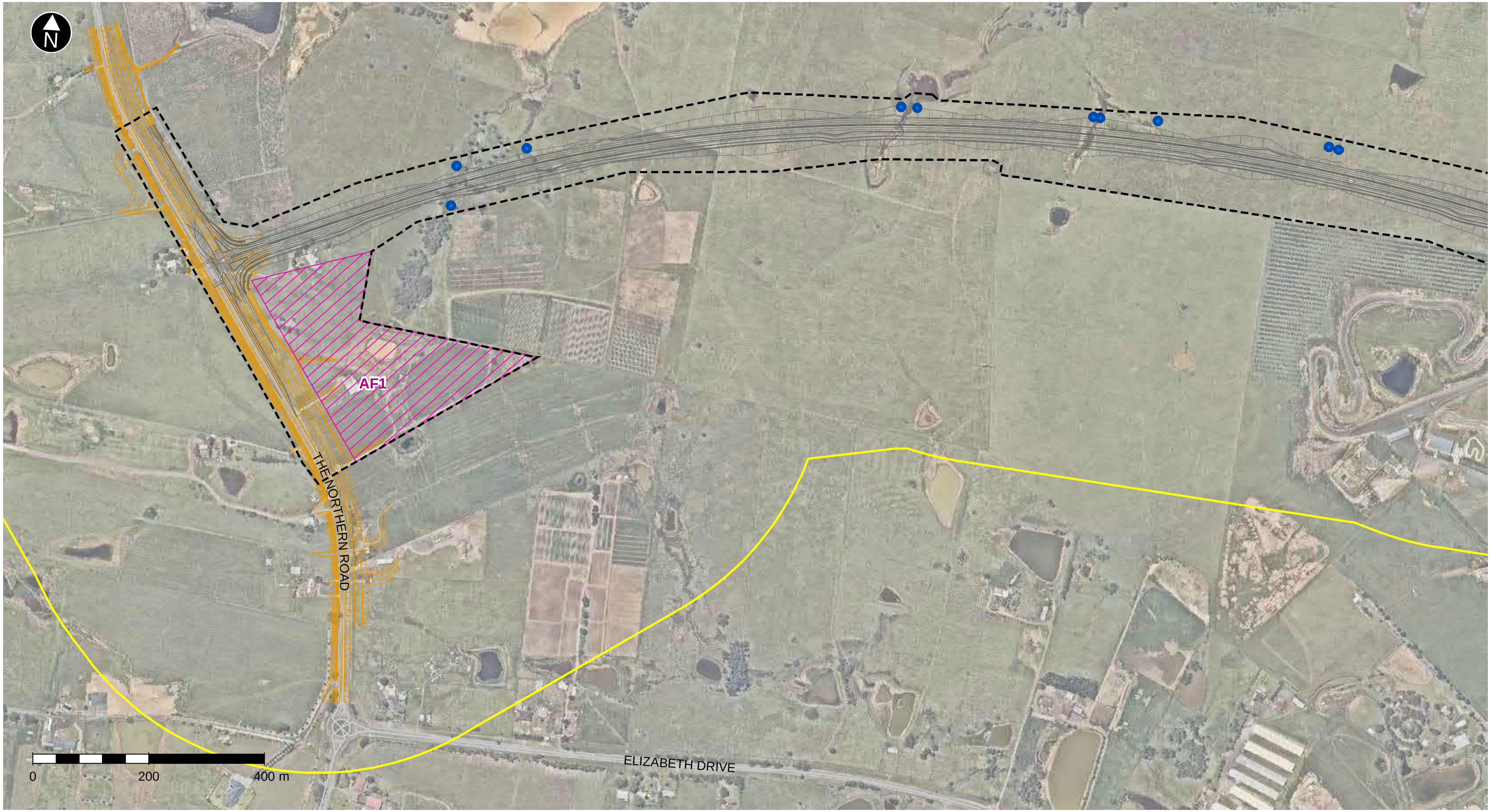


Figure 6-1 Typical sediment basin design (Source: Blue Book).



The project

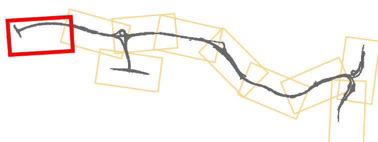
Part of The Northern Road Upgrade project

The project construction footprint

Temporary sediment basins (construction phase)

Surface water and hydrology study area

Ancillary facilities



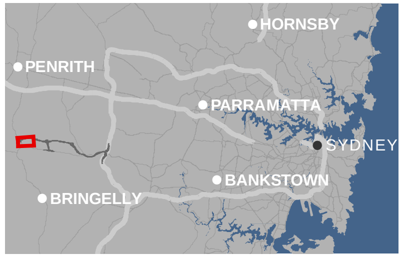
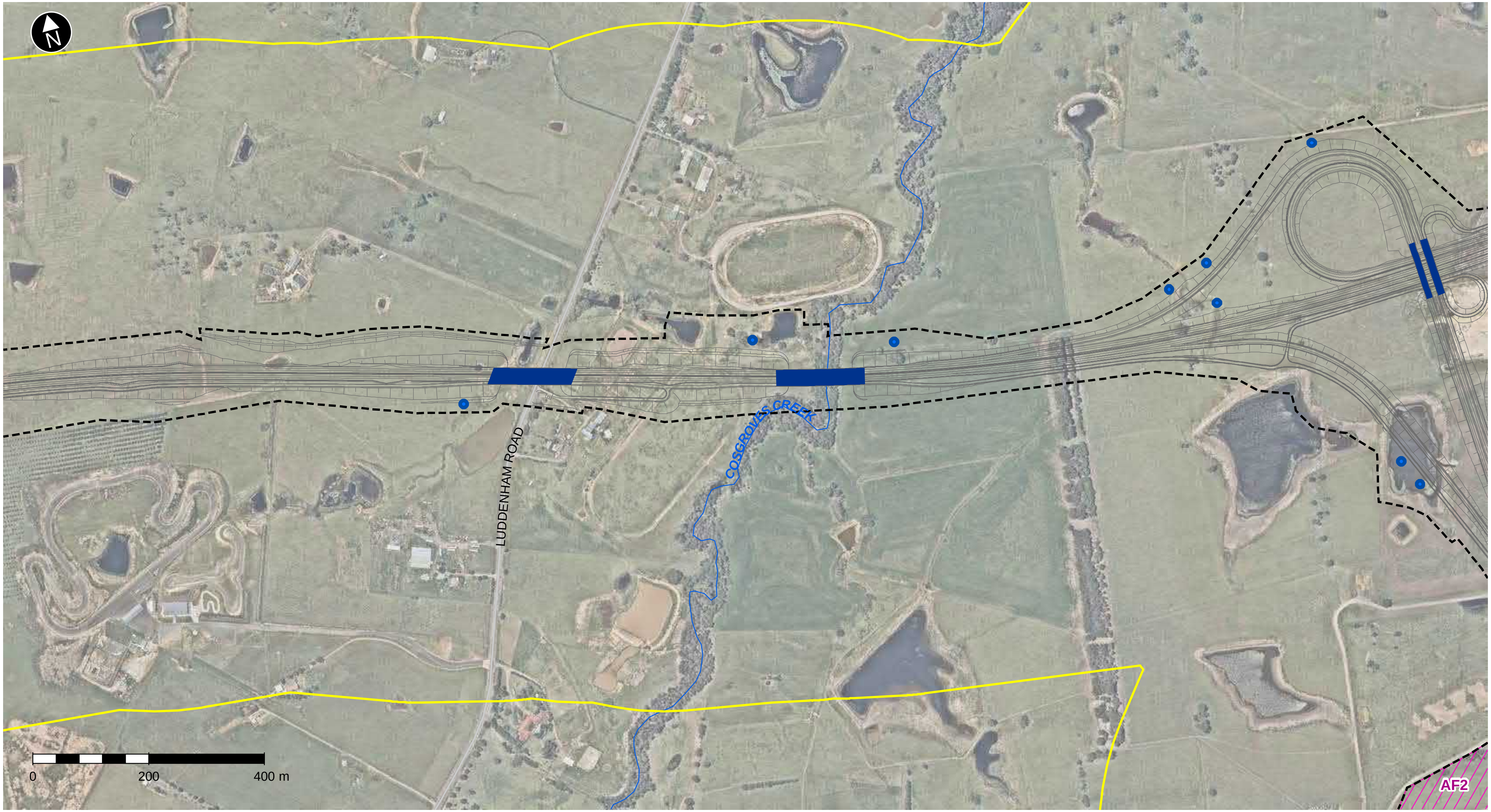
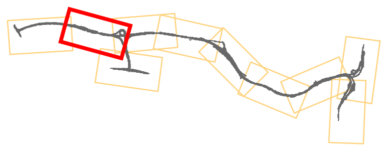


Figure 6-2 Temporary sediment basins (Construction phase)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F009_TempSedBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project construction footprint
Waterways
Temporary sediment basins (construction phase)
Surface water and hydrology study area
Ancillary facilities



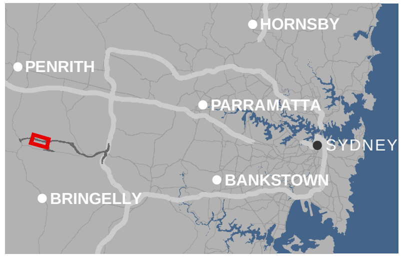
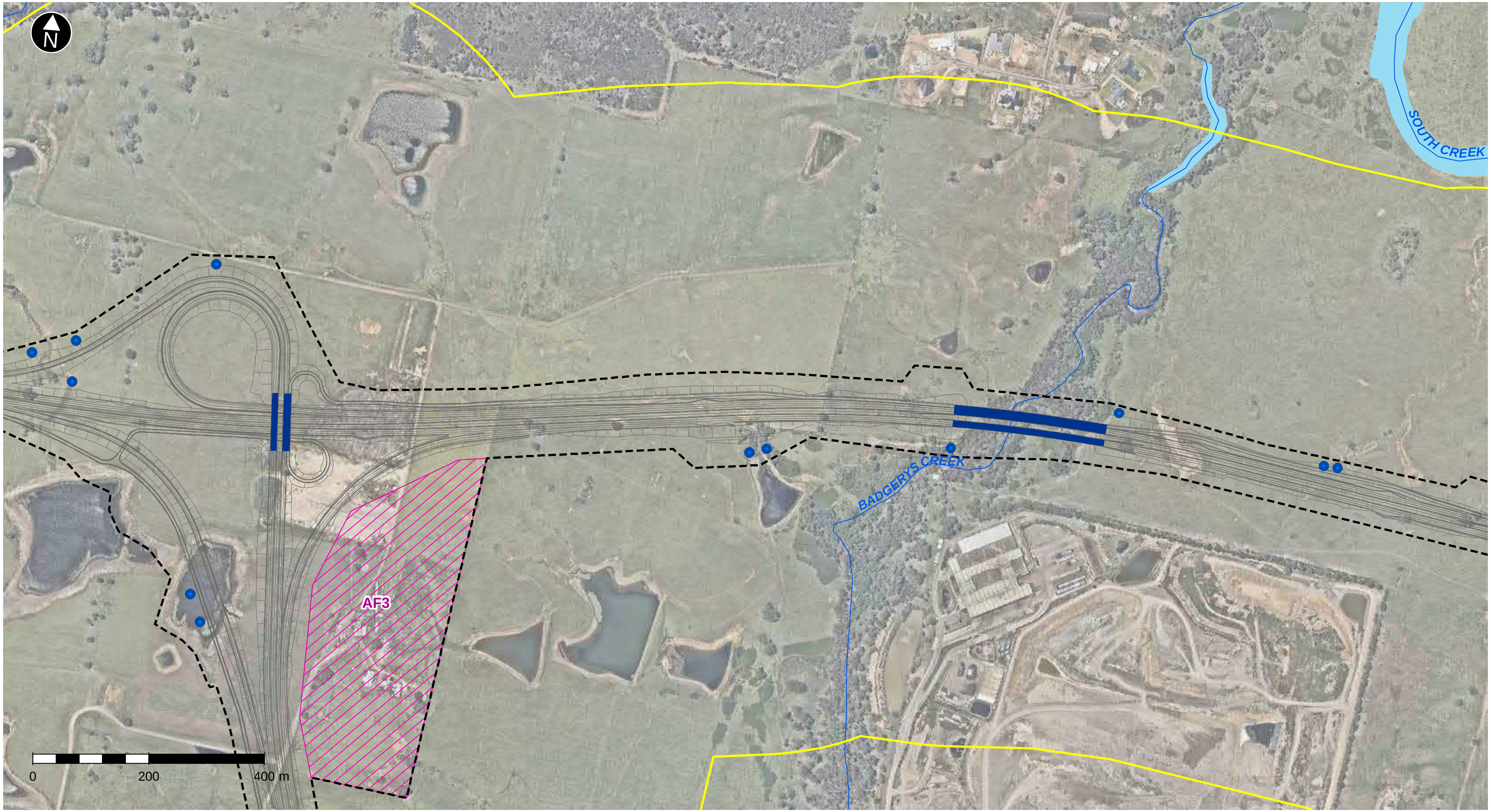
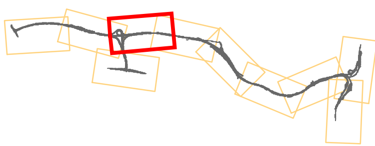


Figure 6-2 Temporary sediment basins (Construction phase)



The project
Bridges
The project construction footprint
Waterways
Temporary sediment basins (construction phase)
Surface water and hydrology study area
Ancillary facilities



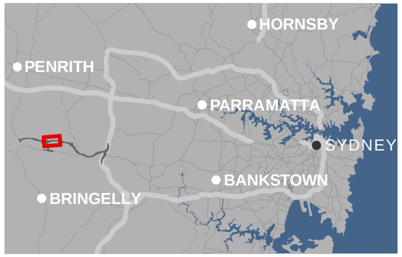
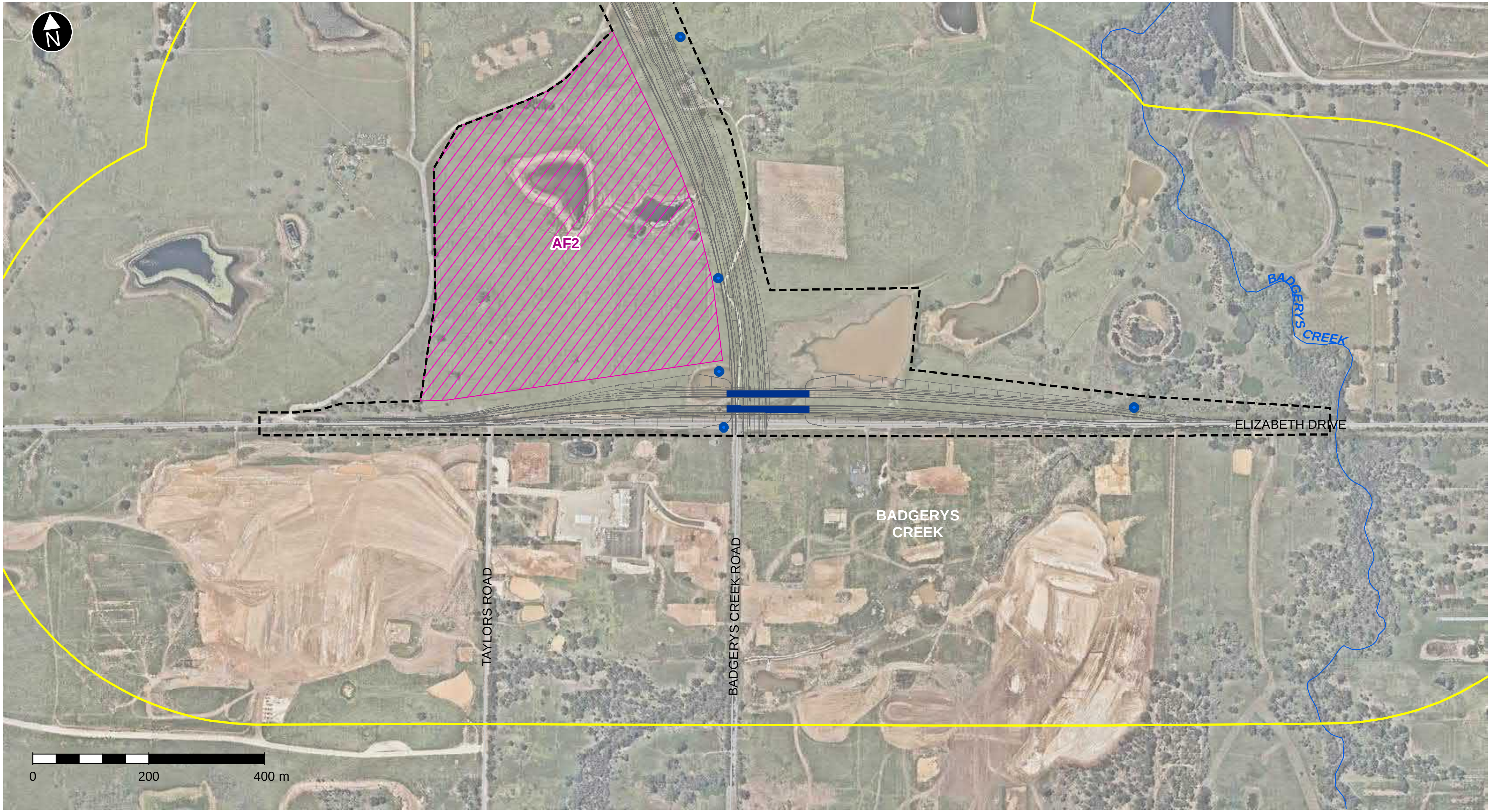
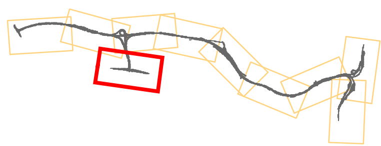


Figure 6-2 Temporary sediment basins (Construction phase)



The project
Bridges
The project construction footprint
Waterways
Temporary sediment basins (construction phase)
Surface water and hydrology study area
Ancillary facilities



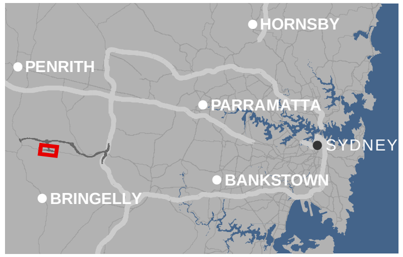
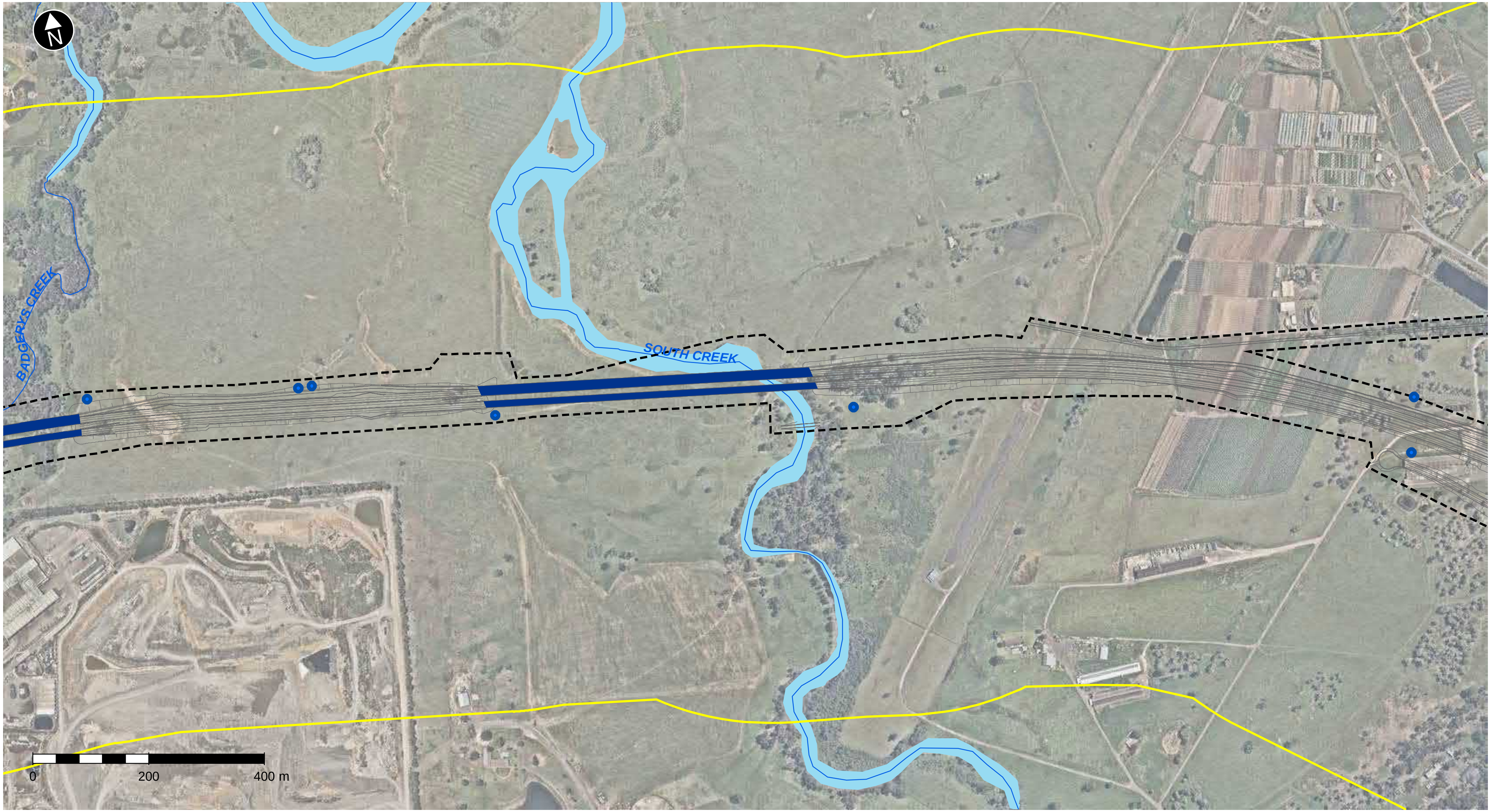
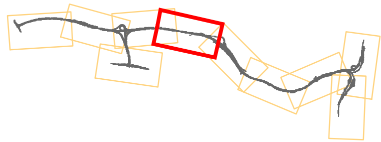


Figure 6-2 Temporary sediment basins (Construction phase)



The project
Bridges
The project construction footprint
Waterways
Temporary sediment basins (construction phase)
Surface water and hydrology study area



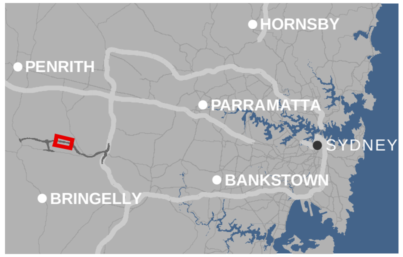
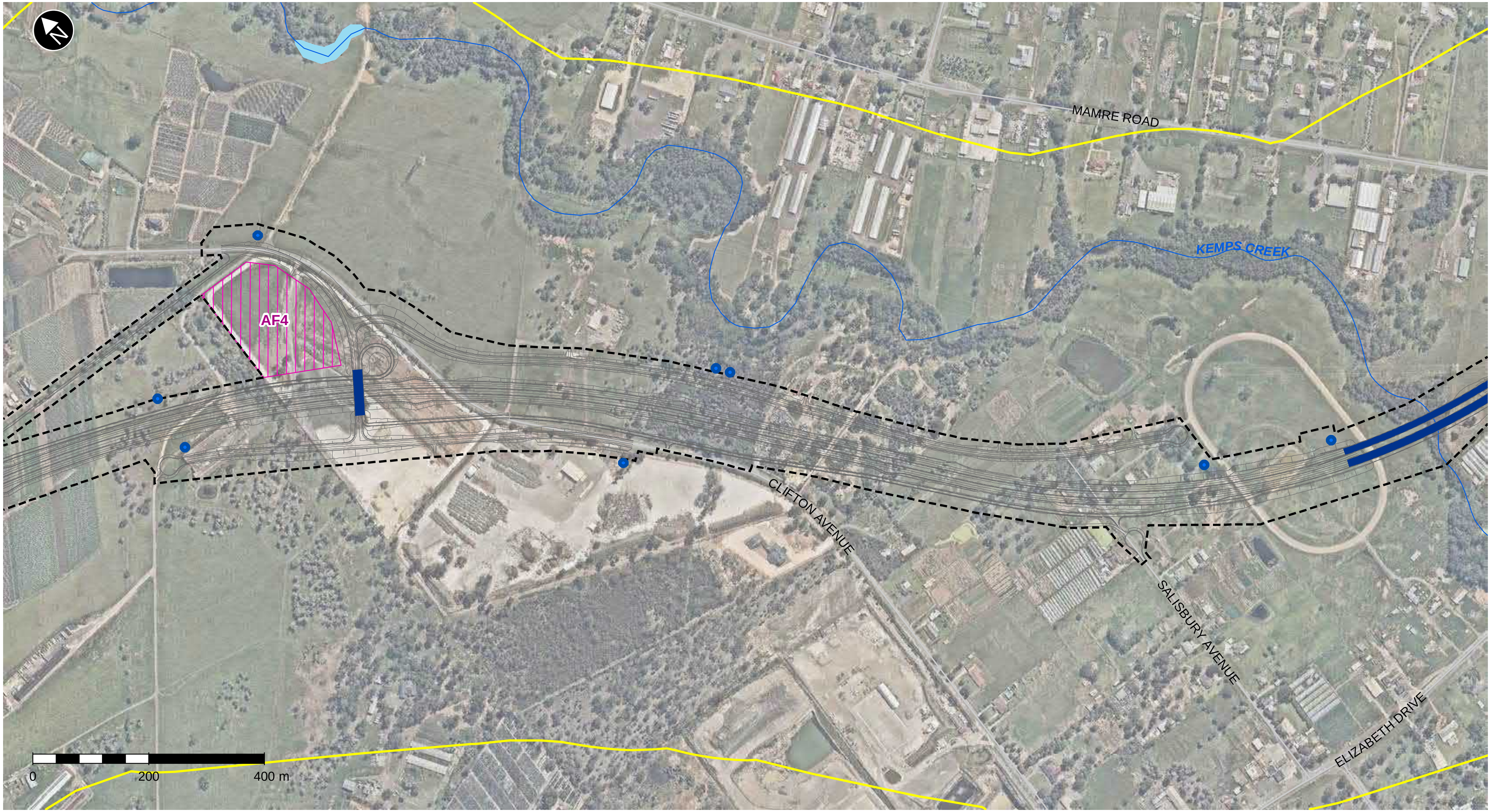


Figure 6-2 Temporary sediment basins (Construction phase)

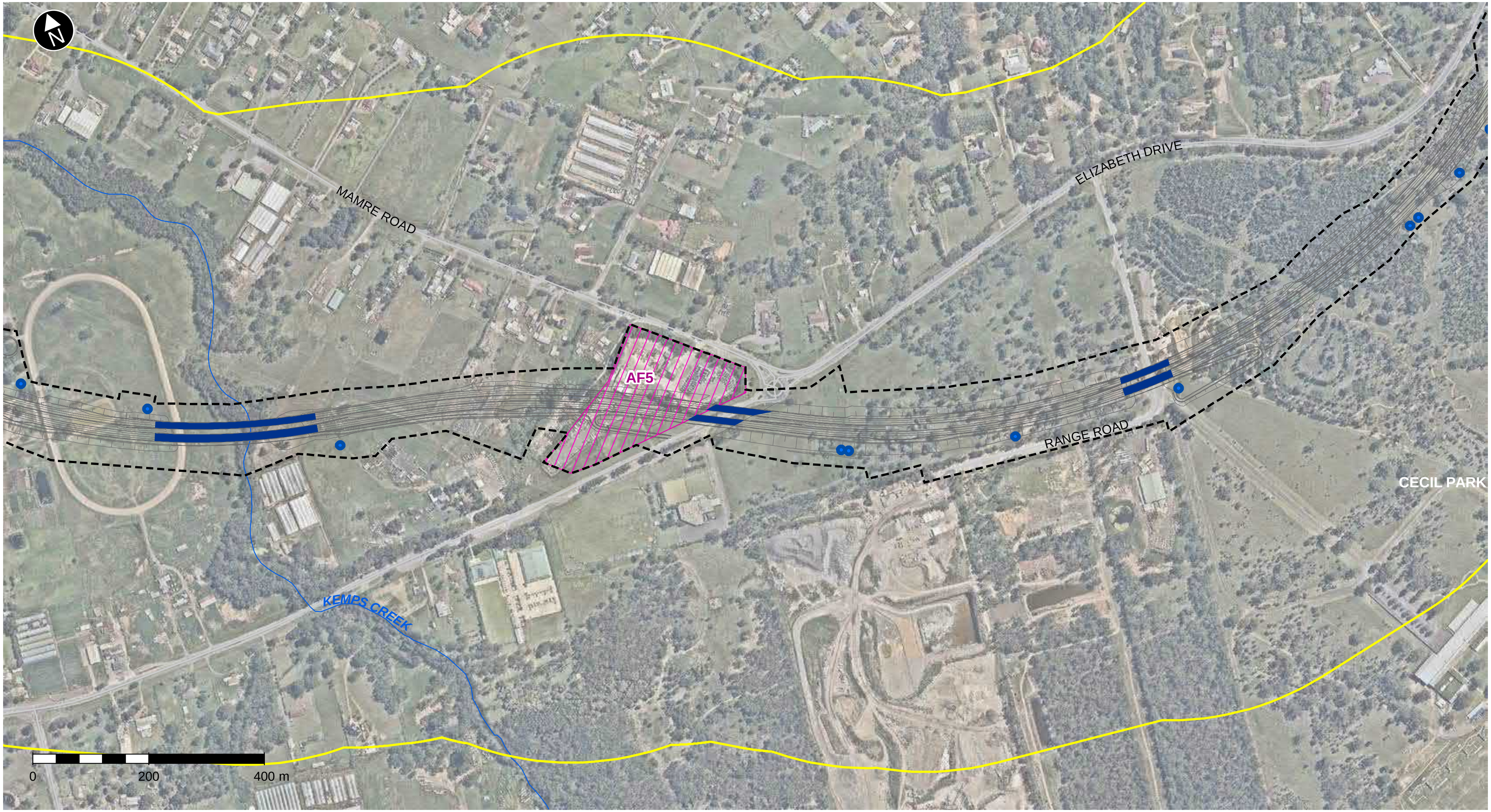
Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F009_TempSedBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



- The project
- Bridges
- The project construction footprint
- Waterways
- Temporary sediment basins (construction phase)
- Surface water and hydrology study area
- Ancillary facilities

Figure 6-2 Temporary sediment basins (Construction phase)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F009_TempSedBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project construction footprint
Waterways
Temporary sediment basins (construction phase)
Surface water and hydrology study area
Ancillary facilities

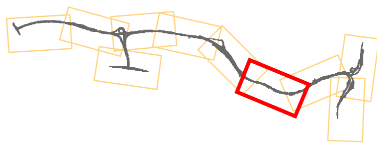
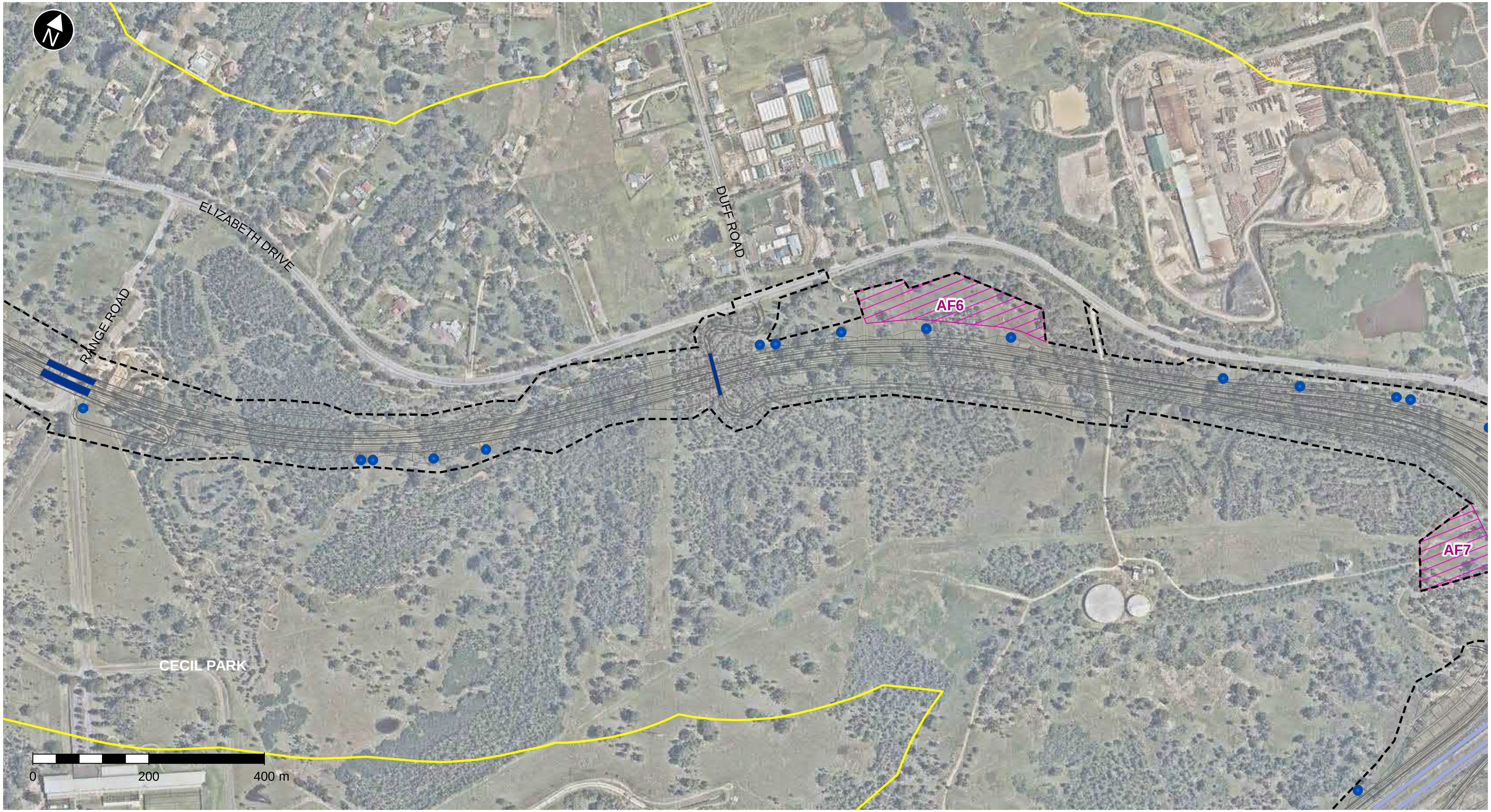
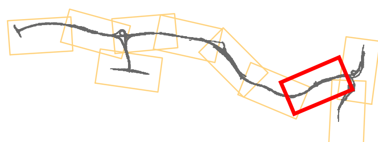


Figure 6-2 Temporary sediment basins (Construction phase)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F009_TempSedBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project construction footprint
Temporary sediment basins (construction phase)
Surface water and hydrology study area
Ancillary facilities



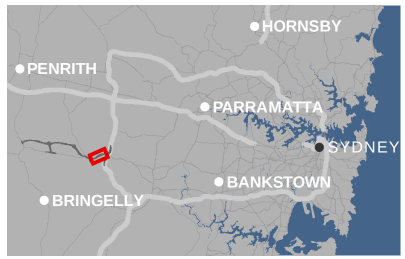


Figure 6-2 Temporary sediment basins (Construction phase)

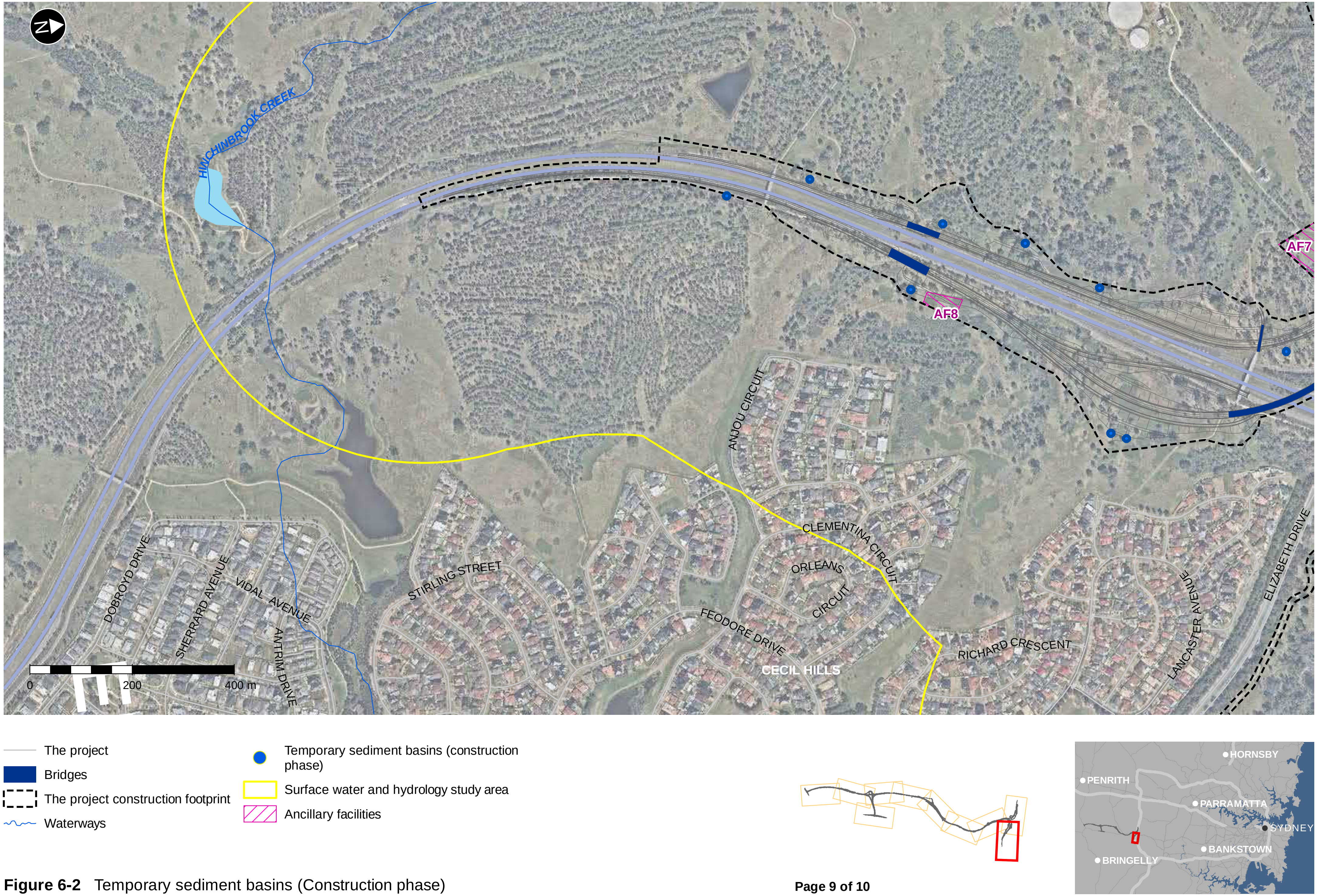
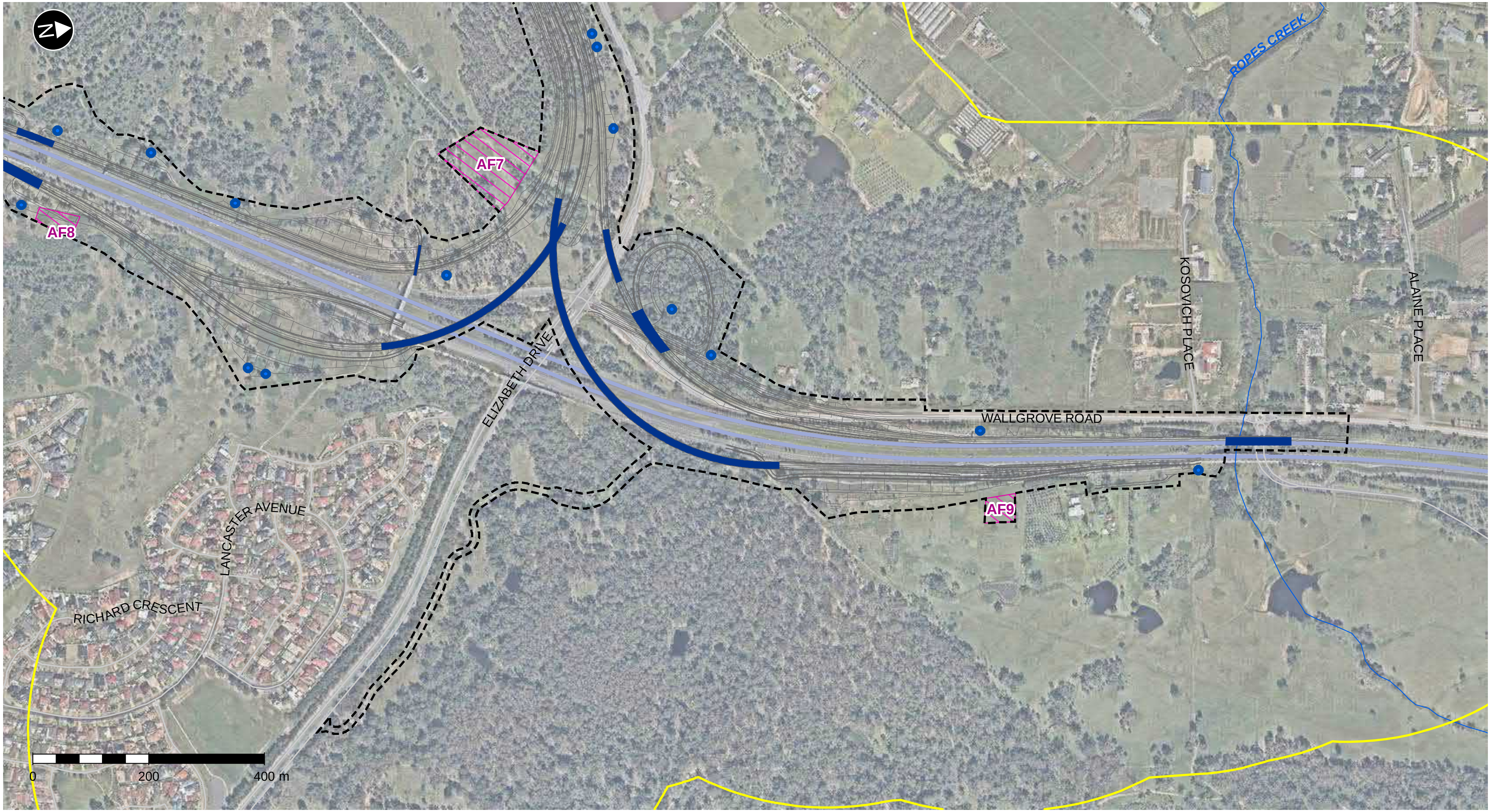


Figure 6-2 Temporary sediment basins (Construction phase)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F009_TempSedBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project construction footprint
Waterways
Temporary sediment basins (construction phase)
Surface water and hydrology study area
Ancillary facilities

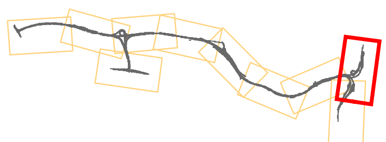


Figure 6-2 Temporary sediment basins (Construction phase)

6.1.3 Hydrological controls

There are a number of construction activities that have to potential to result in hydrological impacts without appropriate controls. The activities which have the potential to impact and appropriate controls include:

- Waterway based construction activities. Waterway based construction activities including bridge construction and installation of culverts (to mitigate the impact of the project on flooding and scour potential) would be carried out in accordance with the RMS Technical guidelines, *Temporary Stormwater Drainage for Road Construction, December 2011 and* include:
- Measures to ensure no release of dirty water into drainage lines and/or waterways
- Erosion and sediment control measures to prevent materials (eg concrete, grout, sediment etc) entering waterways
- Visual monitoring of local water quality (ie turbidity, hydrocarbon spills/slicks on a regular basis to identify any potential spills or deficient controls).
- Temporary creek crossings and work platforms*.* Temporary crossings may be required at some watercourses for construction of haul roads and temporary construction access tracks. Temporary crossings are likely to comprise a temporary causeway built with rock and geotextile and pipe culverts to maintain flow and they would likely be maintained for the duration of construction at that location. The temporary crossings would remain dry during normal creek flow conditions when the water is low, but could become covered by water in times of floods. This type of crossing, whilst being occasionally impassable, is suitable for construction activities. The temporary creek crossings will: be constructed in a manner that mimics the natural creek bed shape; would be certified by the road designer to confirm no additional flooding impacts would occur during design flood events; and would be removed in full following the completion of construction and the area rehabilitated.
- Temporary working platforms would be required at bridge sites to provide a working area for bridge pier and abutment construction including piling. These platforms would be located in a construction work zone and would extend from the existing banks into the waterway to enable stable and safe access. Temporary work platforms can disrupt flow, detain water and increase inundation and disturb creek beds resulting in sedimentation downstream. The location and design of the working platforms would be detailed in the CEMP, but as a minimum would remain in the waterway for as least time as possible, be designed to facilitate water flow and allow fish passage and include silt curtains and anti-pollution booms.

The abovementioned RMS Guidelines provide the construction procedures for new culverts, for extension or replacement of culverts, for upstream diversion of external upstream surface runoff and for the management of onsite runoff.

6.2 Operational phase

The ANZECC Water Quality Guidelines indicate that several physical-chemical and toxicant parameters need to be controlled to maintain the required protection level for aquatic ecosystems during the operational phase of the proposed M12. Some of these parameters include nutrients (total phosphorus and nitrogen), suspended solids, oils and greases, petroleum hydrocarbons and several heavy metals including copper, lead, zinc, cadmium and chromium which are commonly found in stormwater runoff from roads.

The operation of the M12 would result in increased traffic volumes in an area that is currently largely farming land. With the increase in traffic would be a corresponding increase in nutrients and heavy metals, however a large proportion of these pollutants are bound to particles and can be controlled by water quality basins and grassed swales along the project that intercept stormwater flows.

The design criteria are described in **Section 6.2.3**.

6.2.1 Operational water quality treatment

The main strategy to minimise impacts to water quality during operation, in particular to SREs, is the provision of a water quality treatment sequence consisting of grassed swales (see **Section 6.2.3**) and water quality basins (see **Section 6.2.5**). Rainfall runoff and accidental spills would be treated and contained through these swales and basins and this would be supplemented by a water quality monitoring program (see **Section 8.1**).

The swales would be used in preference to operational water quality basins to meet the design criteria and to reduce the project footprint. however when the design criteria cannot be met with swales alone, then operational basins would be added to meet the criteria of the project. The proposed water quality controls would be located upstream of the sensitive receiving environments identified in **Section 4.4** and provide treatment to road pavement runoff before it is discharged into these environments.

The treatments would be designed to meet the water quality requirements outlined in the design criteria in **Section 0** and **Table 6-5**.

The detailed design would include mitigation in against scour in areas where scour is possible such as downstream of water quality ponds or around pier locations for bridge construction.

6.2.2 Soil permeability

There are no site specific soil permeability test results at the proposed locations of swales and basins. For the purposes of the concept design MUSIC model, it has been assumed that all basins are in medium clays and a value of one millimetre an hour has been adopted. This has been based on estimated hydraulic conductivity at BH217 which indicated a value of 0.023m/d. During detailed design, site specific soil permeability data would be obtained and the values changed as required for individual swales and basins.

6.2.3 Proposed swales

Swales have been proposed at 12 locations along the major crossings as a form of water quality treatment during the operation of the project. The proposed swales are shown in **Figure 6-3** and are generally located at the lower end of the batter (where the proposed fill generally meets existing ground level) and convey road pavement runoff to downstream creeks. They are open trapezoidal channels with relatively shallow longitudinal grades ranging from 0.5 per cent up to two percent and side slopes of one (vertical) to two (horizontal).

The swale lengths shown in **Table 6-3** are based on the early concept design and these operational phase water quality controls would need to be updated during detailed design.

Table 6-3 Proposed water quality swales

Swale name	Swale length (m)	Receiving creek
Sw1	251	Cosgroves Creek
Sw3	260	Cosgroves Creek
Sw6-1	209	Badgerys Creek
Sw6-2	262	Badgerys Creek
Sw6-3	196	South Creek
Sw6-4	96	South Creek
Sw6-5	311	Badgerys Creek

Swale name	Swale length (m)	Receiving creek
Sw7	484	South Creek
Sw8	366	Kemps Creek
Sw9	519	Kemps Creek
Sw10	374	Kemps Creek
Sw12	156	Kemps Creek
Sw13	311	Kemps Creek

Table 6-4 lists the location and length of swales upstream of the minor crossings. These swales would provide a reasonable level of water quality treatment for TSS and TP. Their dimensions according to the concept design are:

- Minimum depth of 300 millimetres
- Minimum base width of 500 millimetres with side slopes of 1:4 (vertical: horizontal).

These channels could be made wider if required at the detailed design stages.

Table 6-4 Swales upstream of the M12 minor culvert crossings

Receiving Culvert ID	Swale Length (m)	Receiving Culvert ID	Swale Length (m)
C1110 L	51	C4600 L	165
C1010 L	38	C4900 R	160
C12030 L	103	C4900 R	246
C12030 L	223	C4900 R	498
C12300 L	77	C4900 R	398
C12300 L	105	C5150 R	508
C1110 L	131	C4900 R	98
C13180 L	72	C4900 R	156
C13790 R	17	C5160 R	112
C13910 R	27	C5160 R	54
C13910 R	30	C5160 R	120
C14040 R	67	C4900 R	191
C14040 R	55	C5150 R	39
C14040 L	88	C5870 R	262
C14190 R	33	C6820 R	195
C14190 R	60	C6820 R	207
C14220 L	55	C1010 R	38
C14220 R	22	C1010 L	47
C1780 R	78	C14220 L	157
C1780 L	102	C14220 L	176

Receiving Culvert ID	Swale Length (m)	Receiving Culvert ID	Swale Length (m)
C1780 L	143	C14220 L	210
C2100 R	57	C14220 L	204
C2100 L	95	C13570 R	33
C2100 L	64	C13570 L	38
C2200 L	74	C13570 R	98
C2500 R	33	C13700 R	91
C2500 L	35	C13570 L	45
C2500 R	47	C13700 L	30
C2500 L	34	C13700 R	20
C4600 L	246	C13700 L	72
C4600 L	72	C13890 L	108
C5160 R	543	C13890 R	28
C4640 R	140	C13890 L	73
C4600 L	194	C13890 R	181
C4600 L	59	C14220 R	54
C4600 L	208	C14220 R	82
C4640 R	135	C14810 R	191
C4900 R	57	C14810 R	69
C4640 L	204	C15350 R	75
C4600 L	286	C15350 R	83
C4900 R	92	C15520 R	59

Notes: The culvert ID generally corresponds to the concept design road chainageR and L indicate that the swale is located at the right or left side in the increasing chainage direction.

6.2.4 Design criteria

In order to meet the project's water quality objective for the operational phase (ie no reduction to existing water quality), the NSW Office of Environment and Heritage total suspended solids design target for water quality, as described in *Managing Urban Stormwater – Council Handbook* (EPA, 1997) has been adopted as the project design target for the sizing of water quality treatment controls.

Total suspended solids are considered the key indicator for management during the operational phase. Pollutants are expected to primarily be generated by vehicular traffic and build-up of contaminants from tyre and pavement wear in addition to atmospheric deposition of particles. As such, the emphasis in stormwater quality management for road runoff during operation should focus on the export of suspended solids and associated particle bound pollutants (Austroads, 2001). Pollutants such as heavy metals, hydrocarbons and other toxicants in particulate form (ie not dissolved) are usually attached to fine sediments (RTA, 2003c). Therefore, trapping suspended solids must be the primary focus of the water quality management strategy for the operational phase of the M12 Motorway. The abovementioned NSW EPA design targets prescribe an 80 per cent pollutant load reductions for total suspended solids (TSS). This design target has been adopted for the project as shown in **Table 6-5**.

In addition to meeting the design criteria of **Table 6-4**, the proposed mitigated annual average pollutant loads need to be below the existing conditions annual average pollutant loads. This additional criterion has been adopted to satisfy the SEARs requirements.

Table 6-5 Operational water quality design targets

Pollutant	Minimum reduction of the annual average pollutant loads
Total suspended solids (TSS)	80%

The NSW Water Quality Objectives for various downstream environmental values and ANZECC Water Quality Guidelines have also been considered as part of the design criteria.

6.2.5 Proposed water quality basins

Twenty four water quality basins are proposed as outlined in **Table 6-6**. These basins would also incorporate a mechanism for capturing accidental spill containments. This is achieved through the underflow baffle arrangement at the outlet that retains floating hydrocarbons upstream of the baffle. Permanent water quality basins are designed to contain a 20,000 litre spill.

Table 6-6 Proposed water quality operational basins

Basin name	Receiving waterway ^
B3890	Cosgroves Creek
B4080	Cosgroves Creek
B5800	Badgerys Creek
B6200	Badgerys Creek
B1351	Badgerys Creek
B7150	South Creek
B7800	South Creek
B9700	Kemps Creek
B9701	Kemps Creek
B9711	Kemps Creek
B10600	Kemps Creek
B11100	Kemps Creek
B14880	Hinchinbrook Creek (Doujon Lake)
B14881	Hinchinbrook Creek (Doujon Lake)
B15300	Hinchinbrook Creek (Doujon Lake)
B15100*	Hinchinbrook Creek (Doujon Lake)
B01230*	Hinchinbrook Creek (Doujon Lake)
B01050*	Hinchinbrook Creek (Doujon Lake)
B15580*	Hinchinbrook Creek (Doujon Lake)

Basin name	Receiving waterway ^
B16000*	Hinchinbrook Creek
B16001*	Hinchinbrook Creek
B16184*	Hinchinbrook Creek
B16185	Hinchinbrook Creek
B16900*	Hinchinbrook Creek

* Indicates that the basin is an existing basin that would need to be augmented
^ Operational water quality basins within the Hinchinbrook Creek catchment would provide protection to downstream SEPP Coastal wetlands ID113,114 and 236

6.2.6 Hydrological controls

To ensure that operation of the project does not have a hydrological impact on the downstream waterways a number of hydrological controls have been incorporated into the concept design including:

- Permanent crossings of Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek would be via bridge and not culverts
- Low-flow channels that would have piers have had localised creek re-alignments so that piers are outside the channels
- All service roads and shared paths would be at motorway level and not creek level
- Changes to velocity whilst minimal, would result in localised changes at piers. However, they are located outside the low flow channels on the floodplain so as to not directly impact on the hydrology of the waterway
- Measures to protect against scour and/or to control the velocity of flows at culvert outlets would be implemented within the project's operational boundary. Subject to engineering at the detailed design phase, these measures could include rock armouring of culvert inlets and outlets, check dams, vegetated swales and detention basins.

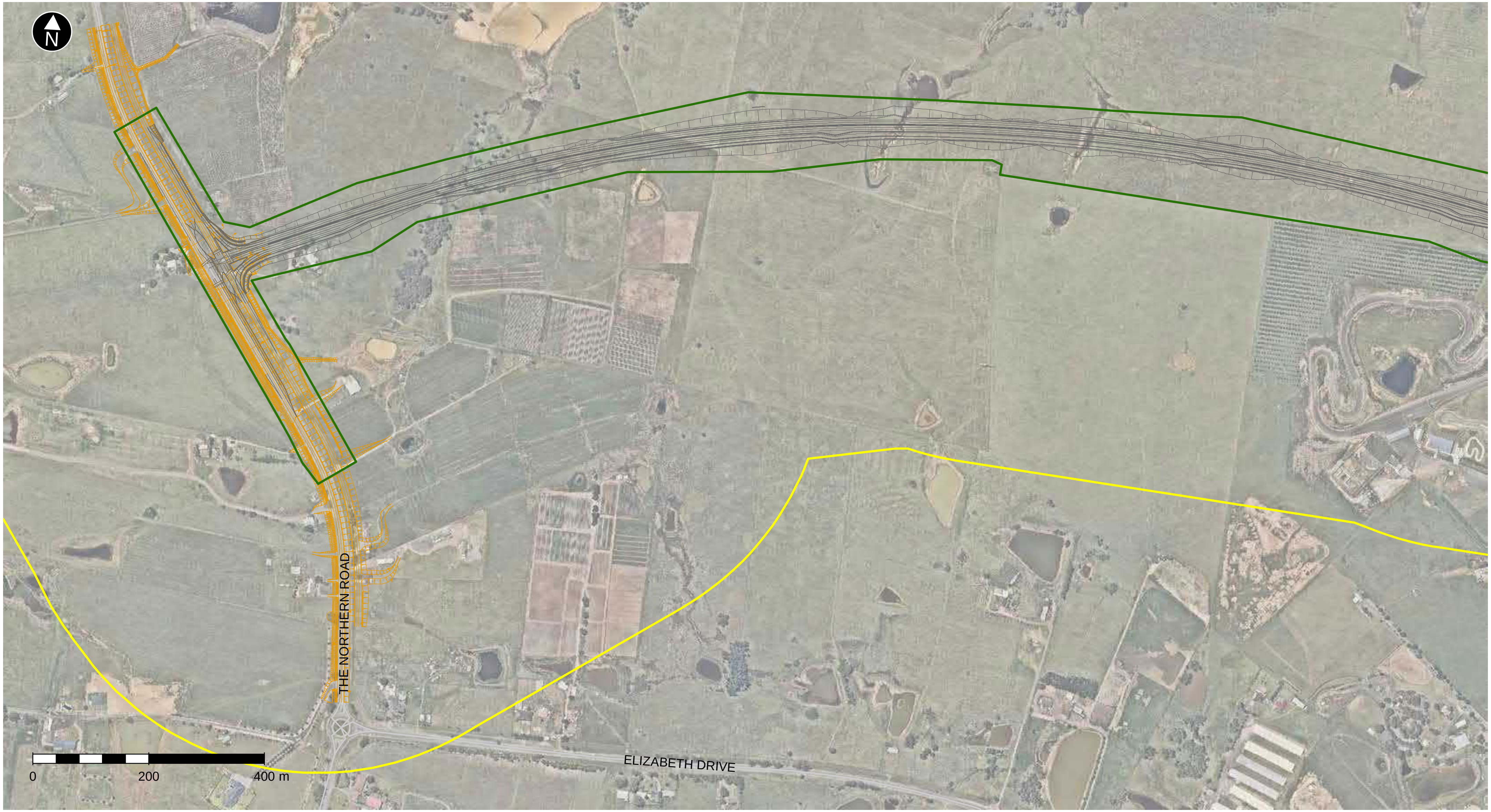
Where there are changes in peak flow rates and volumes of stormwater runoff downstream and outside of the project's construction and operational footprint, and where there are potential hydrological impacts on minor drainage lines or infrastructure such as farm dams (see **Section 5.2.3**), further investigations would be undertaken during detailed design, including further detailed modelling of hydrological impacts, to determine the nature and extent of the actual impact. Subject to the findings of those investigations during detailed design, Roads and Maritime would determine the appropriate environmental management measures in consultation with individual landowners.

6.2.7 Water quality modelling

The eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC model) is the industry standard model that is used to quantify pollutant loads for existing and proposed conditions. The MUSIC model has been applied during the concept design to determine the sizes of the permanent water quality controls and ensure the water quality complies with the water quality objectives outlines herein.

When undertaking the MUSIC modelling, the catchment draining to an individual control measure was identified by considering the formation of the proposed carriageway and the proposed pipe drainage network. The total catchment area was then divided into sub catchments according to the different land use characteristics of the 'impervious road catchment' area, and the batter slope or 'pervious road side' area.

Appropriate rainfall and other key input parameters such as event mean concentrations and soil permeability were then used.



The project

Part of The Northern Road Upgrade project

The project operational footprint

Surface water and hydrology study area

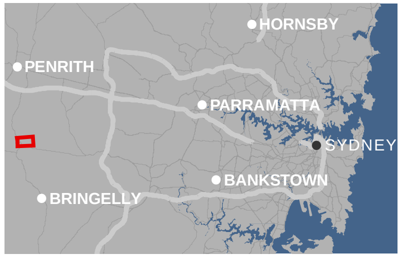


Figure 6-3 Proposed swales and water quality basins (operational)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F010_WQSwalesBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA

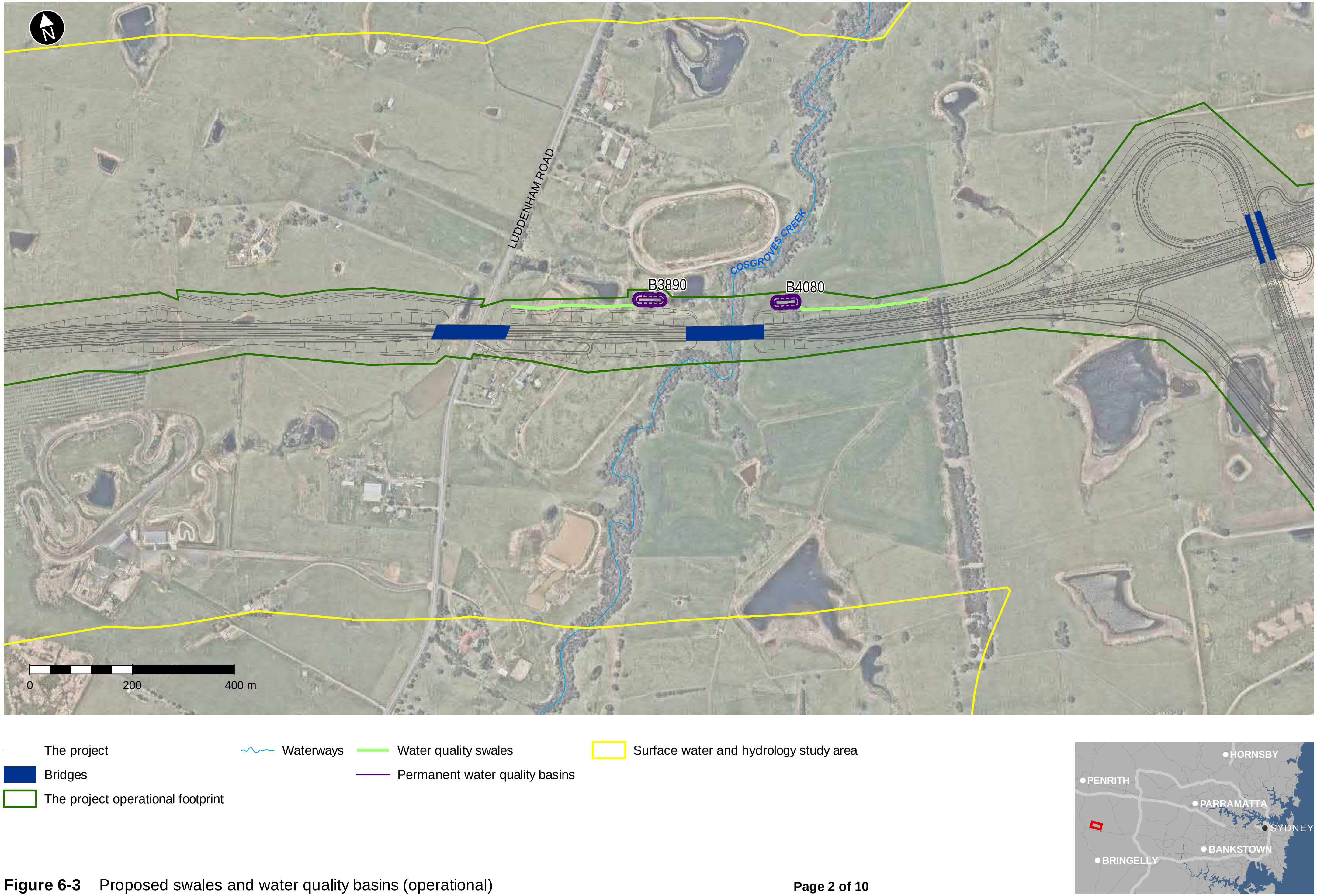
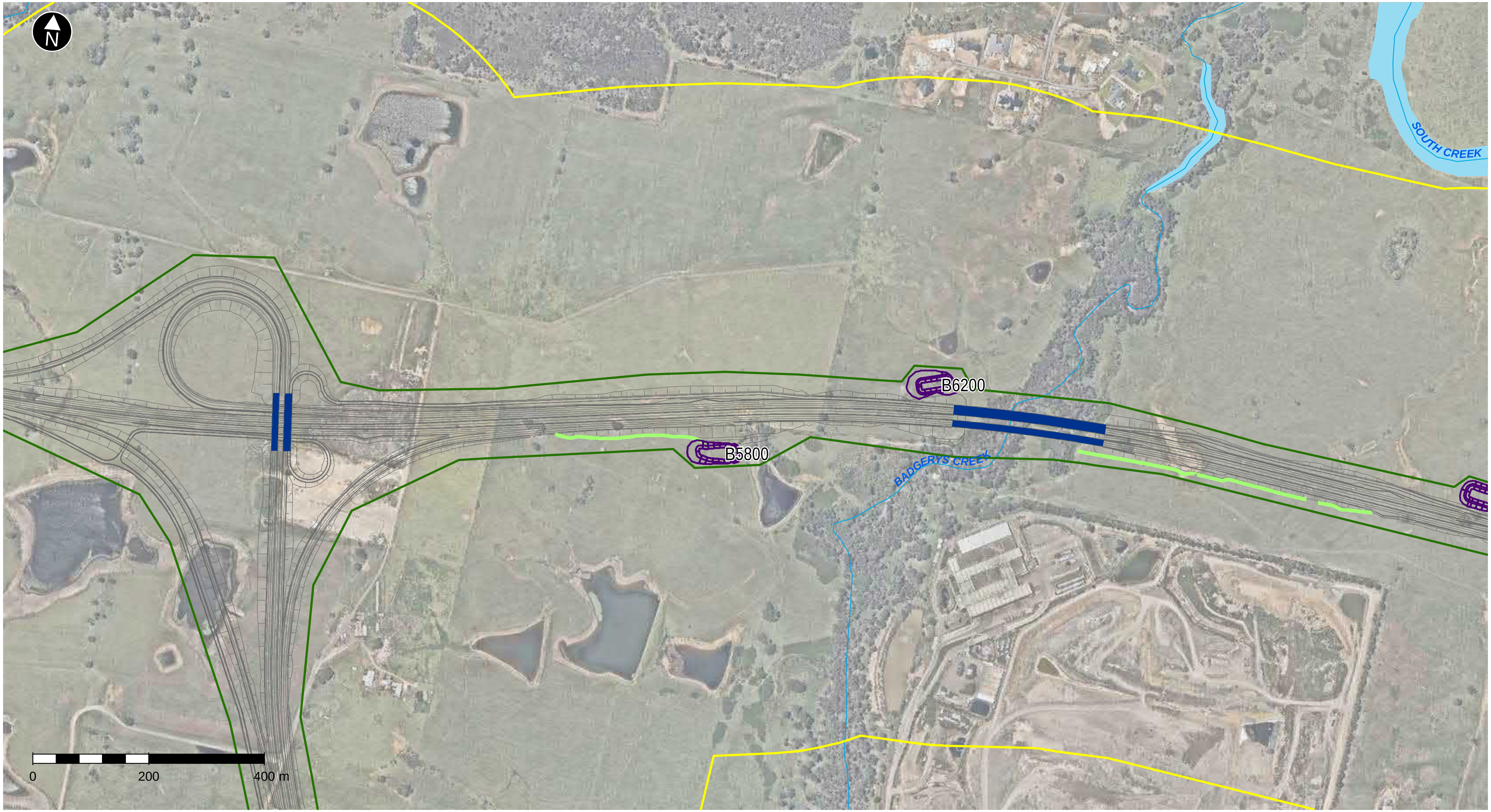


Figure 6-3 Proposed swales and water quality basins (operational)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F010_WQSwalesBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project operational footprint
Waterways
Water quality swales
Permanent water quality basins
Surface water and hydrology study area

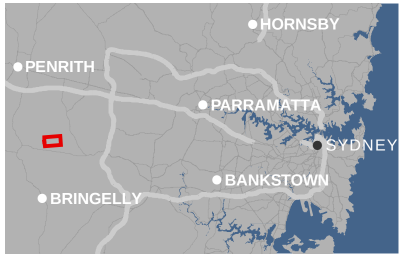


Figure 6-3 Proposed swales and water quality basins (operational)

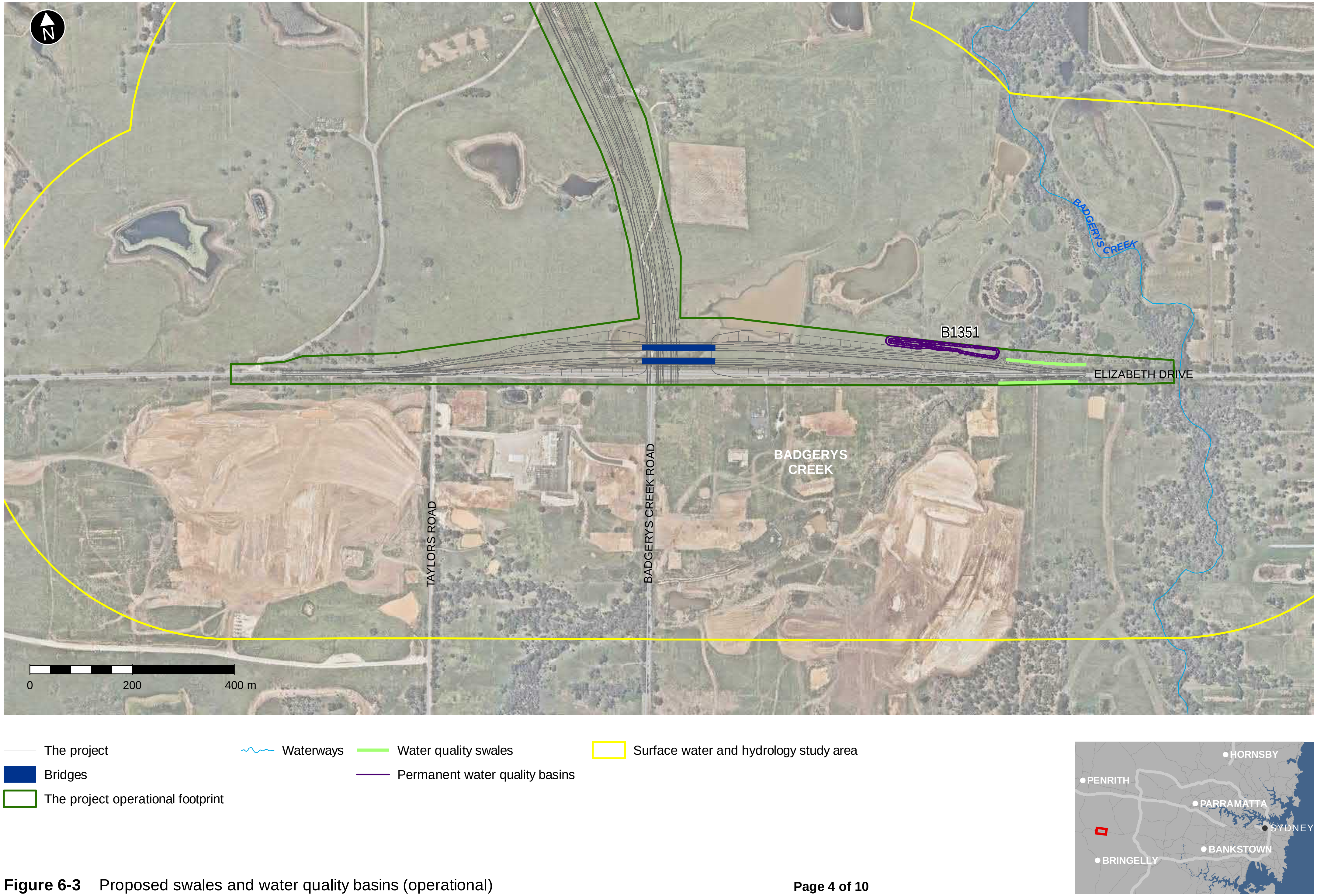


Figure 6-3 Proposed swales and water quality basins (operational)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F010_WQSwalesBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA

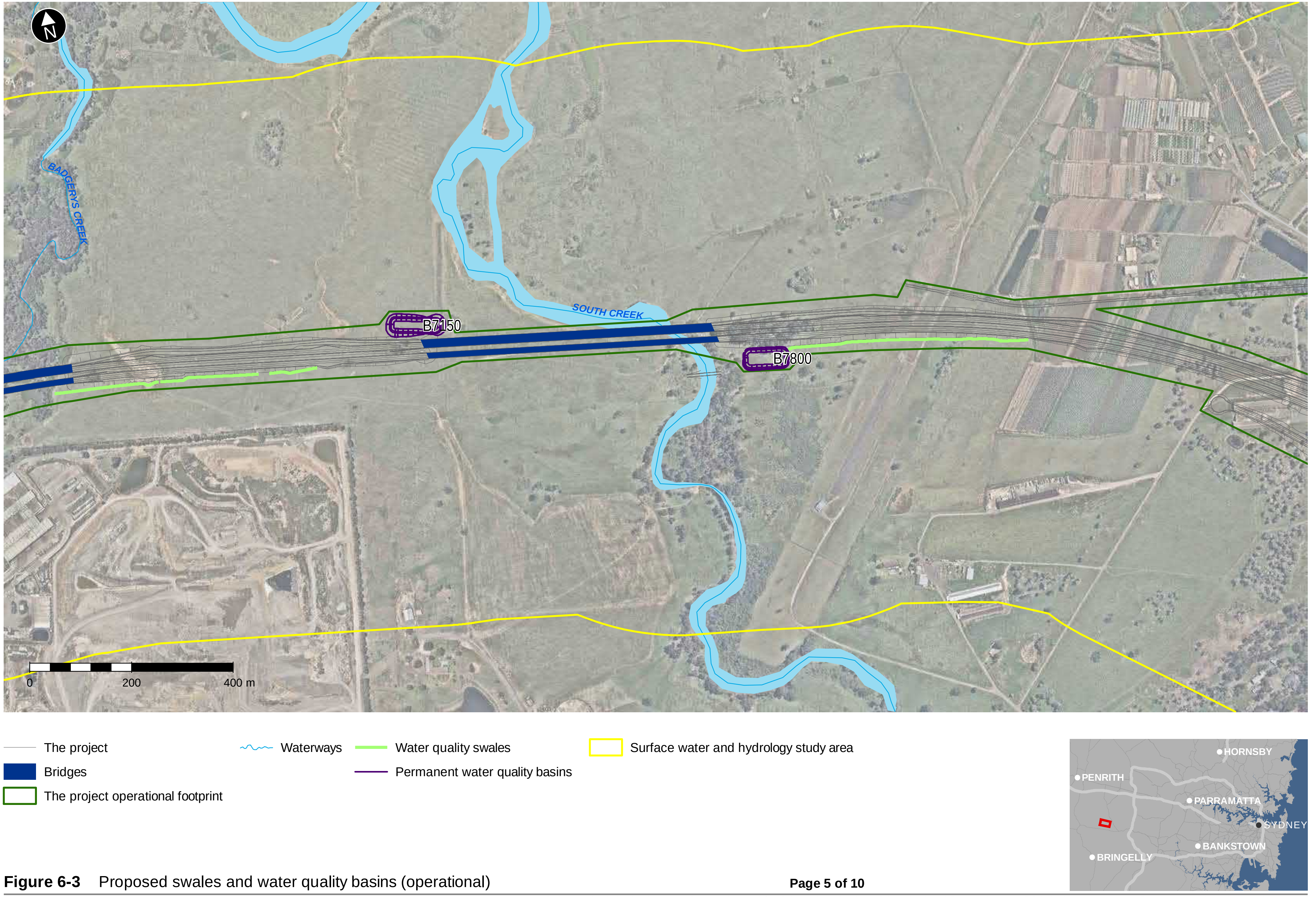
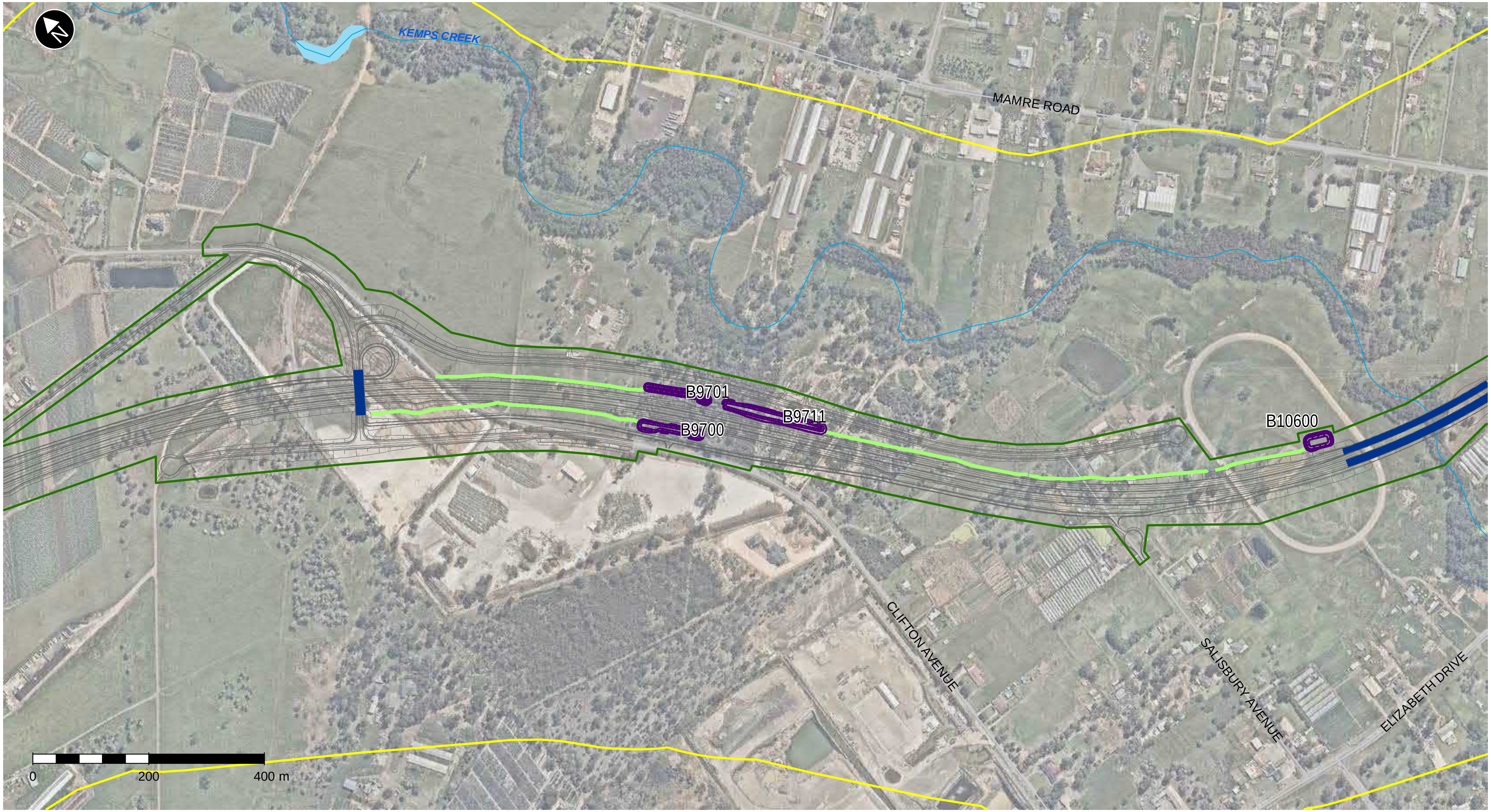


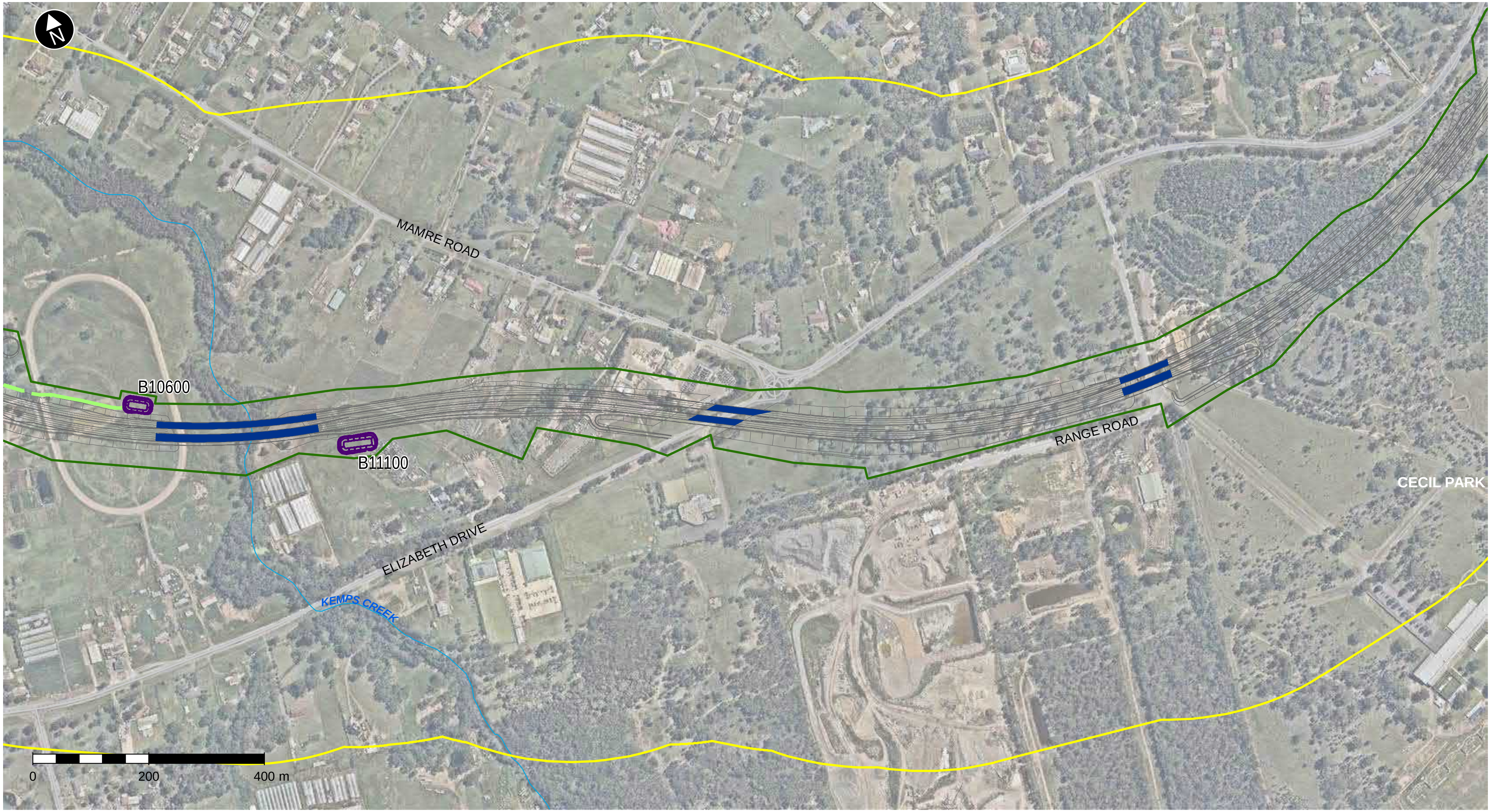
Figure 6-3 Proposed swales and water quality basins (operational)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F010_WQSwalesBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project operational footprint
Waterways
Water quality swales
Permanent water quality basins
Surface water and hydrology study area

Figure 6-3 Proposed swales and water quality basins (operational)



The project
Bridges
The project operational footprint
Waterways
Water quality swales
Permanent water quality basins
Surface water and hydrology study area

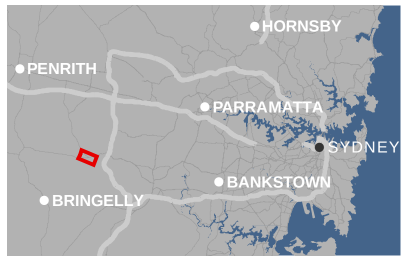
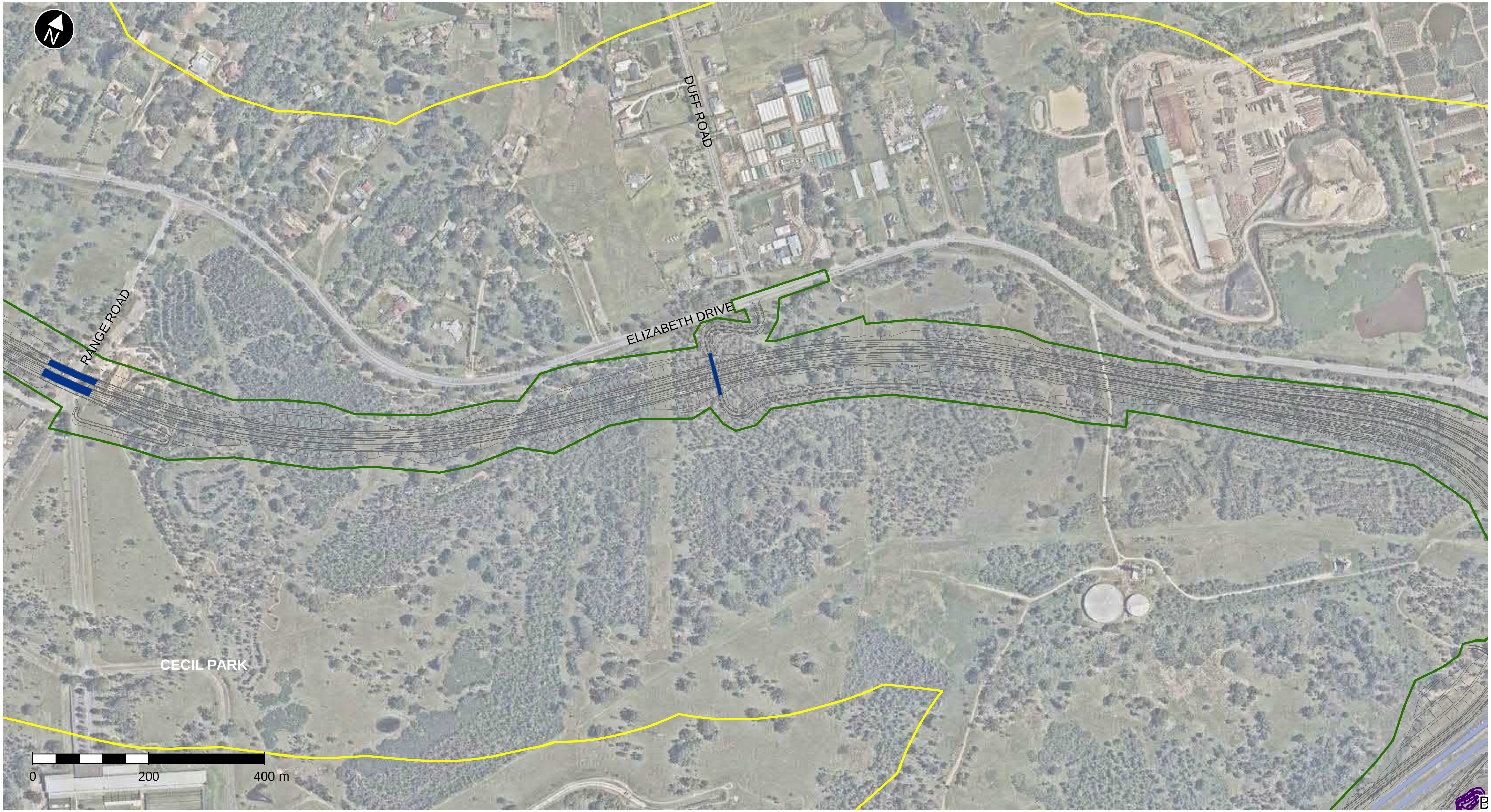


Figure 6-3 Proposed swales and water quality basins (operational)



The project
Bridges
The project operational footprint
Permanent water quality basins
Surface water and hydrology study area

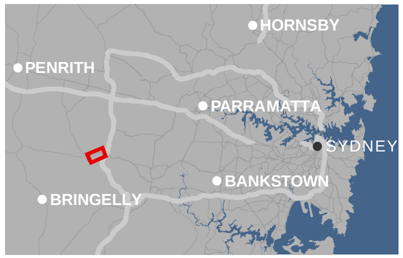
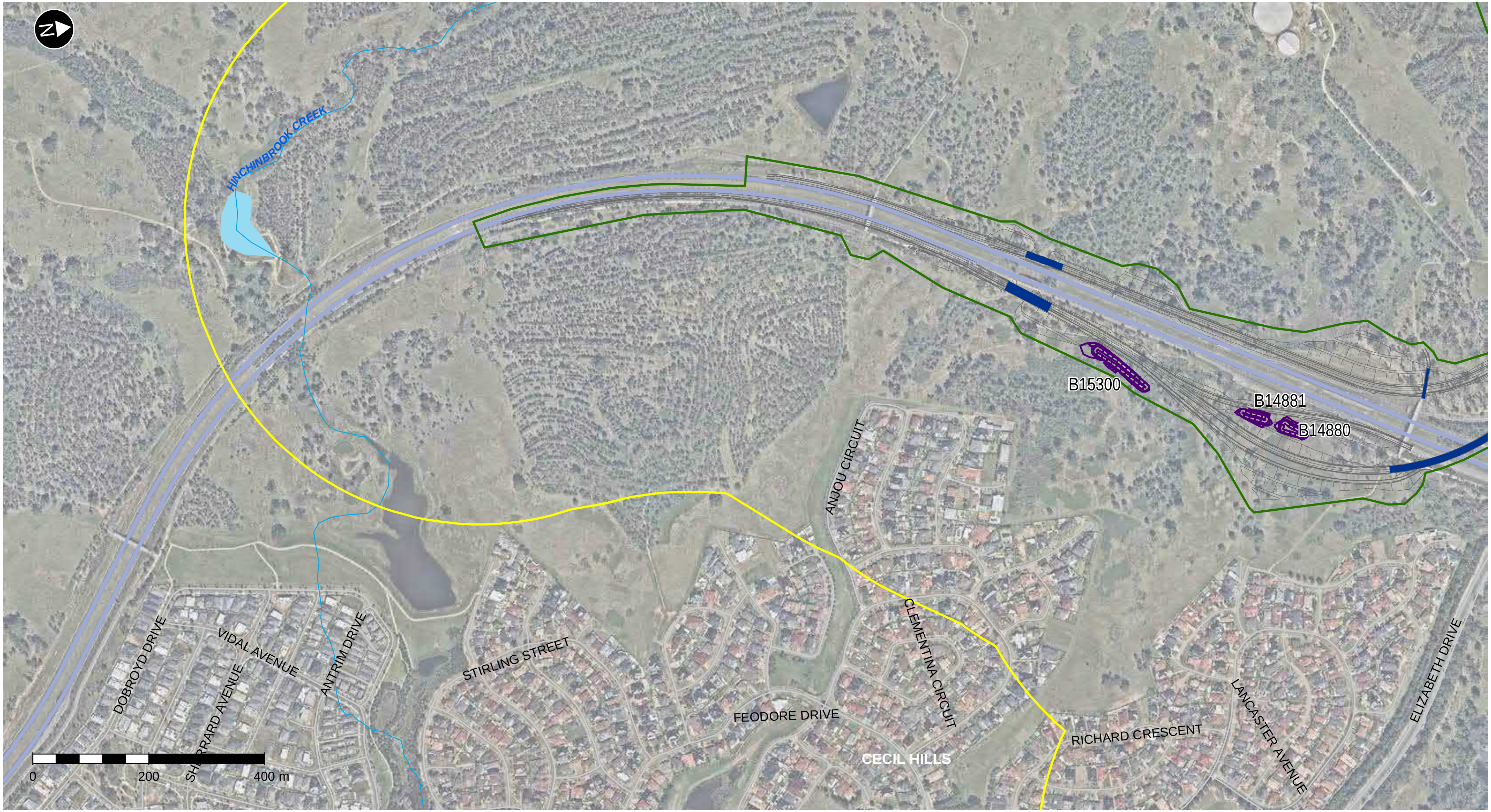


Figure 6-3 Proposed swales and water quality basins (operational)

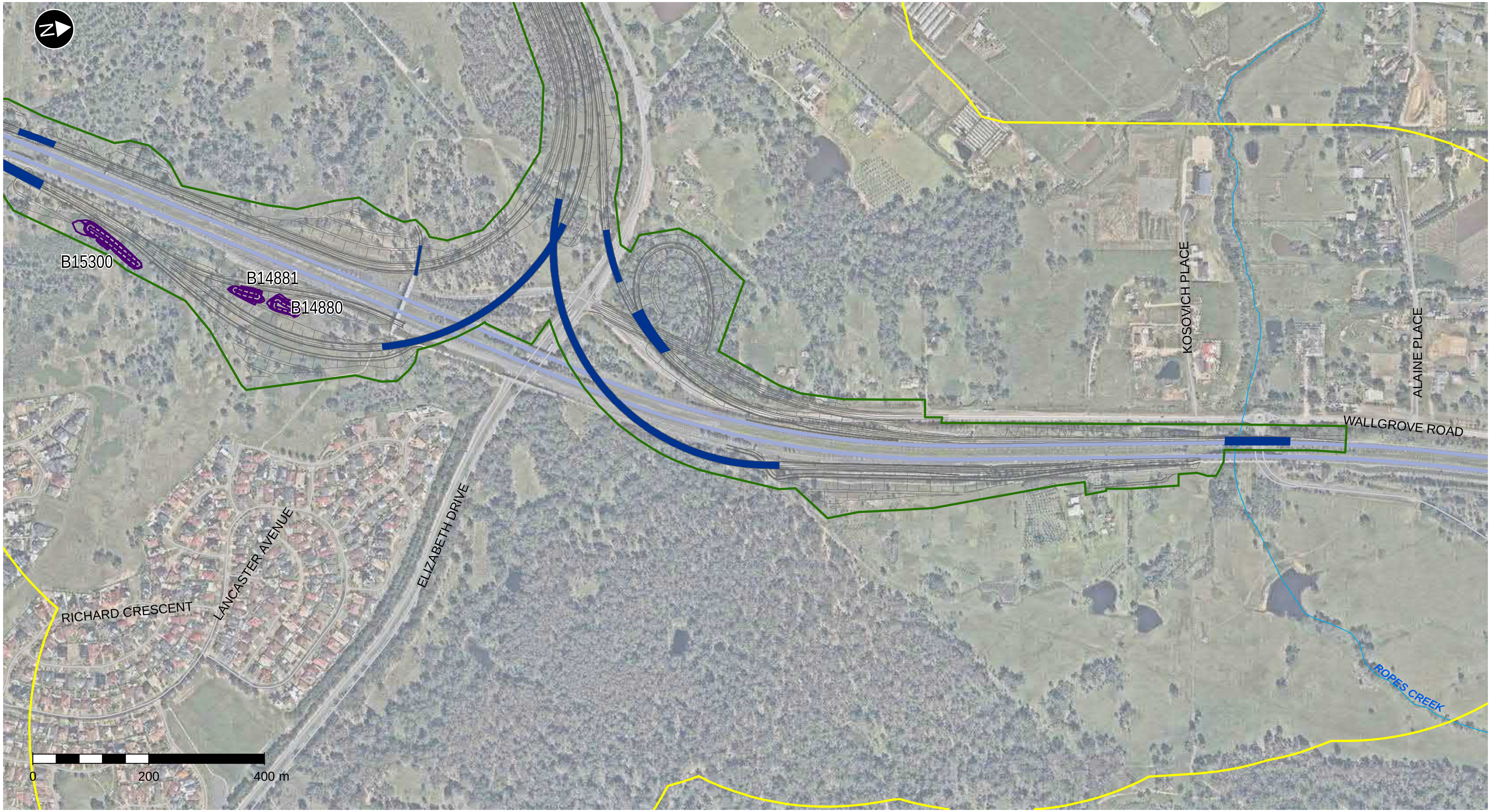
Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F010_WQSwalesBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project operational footprint
Waterways
Permanent water quality basins
Surface water and hydrology study area

Figure 6-3 Proposed swales and water quality basins (operational)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F010_WQSwalesBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA



The project
Bridges
The project operational footprint
Waterways
Permanent water quality basins
Surface water and hydrology study area

Figure 6-3 Proposed swales and water quality basins (operational)

Date: 1/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\WaterQuality\FinalEIS\JAJV_EIS_WaterQuality_F010_WQSwalesBasinsMapseries_r2v1.mxd
Created by : HK | QA by : AA

Water quality modelling methodology

MUSIC water quality modelling was undertaken to determine volumes of the permanent water quality controls that comply with the project design targets. The pollutants modelled were Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP).

The catchment draining to an individual control measure was delineated by considering the formation of the proposed carriageway and the proposed pipe drainage network. The total catchment area was divided into two sub-catchments according to the different land use characteristics of the 'impervious road catchment' area, and the batter slope or 'pervious road side' area.

Models of the basins were created adopting the sub-catchment areas estimated in the catchment analysis. The MUSIC models of the water quality basins were run to determine the minimum basin volumes required for a two metre maximum depth basin, with an average depth of 1.5 metres (water volume/ water surface area).

Rainfall inputs

The MUSIC model uses pluviograph data (six minutes rainfall data) and user-defined event mean concentrations (EMCs) to estimate pollutant loads. Pluviograph data was obtained from the Bureau of Meteorology for Station 067020 called Liverpool which is the most appropriate pluviograph station to the project. The data was available for the period 5/12/2001 to 31/8/2010. The model was run at six minutes time steps for the available duration.

Event mean concentrations

A literature review was undertaken to determine the event mean concentrations for the proposed road pavement areas for TSS, TN and TP to use in the MUSIC model. The following references were used to assess the typical concentrations:

- RTA (2003) Procedure for Selecting Treatment Strategies to Control Road Runoff (Version 1.1)
- CRC for Catchment Hydrology (1997) Best Practice Environmental Management Guidelines for Urban Stormwater
- CSIRO (1997) Metals and Hydrocarbons in Stormwater Runoff from Urban Roads.
- CRC for Catchment Hydrology (2000) Water Sensitive Road Design, Design Options for Improving Stormwater Quality of Road Runoff
- CRC for Catchment Hydrology (1999) Urban Stormwater Quality, A Statistical Overview
- Austroads (2001) Road Runoff and Drainage: Environmental Impacts and Management Options
- CRC for Catchment Hydrology and Monash University (2004) Stormwater Flow and Quality and the Effectiveness of Non-Proprietary Stormwater Treatment Measures, A review and Gap Analysis.

The event mean concentrations that are given in the Music model for "*Sealed Road*" were compared to the literature review data. These event mean concentrations were similar, therefore the adopted event mean concentrations were those that were given in the Music model for "*Sealed Road*". These concentrations are outlined in **Table 6-7**.

Table 6-7 Stormwater runoff event mean concentrations for operational phase in milligrams per litre

Pollutant concentration (mg/L)	TSS		TP		TN	
	Event (wet)	Base (dry)	Event (wet)	Base (dry)	Event (wet)	Base (dry)
Road pavement	269	15.8	0.5	0.14	2.19	1.29

Outputs of the modelling

In order to compare against environmental values and their concentration targets and desirable long term concentrations from catchment discharges, the model upstream was run to obtain outputs expressed in mean and 90th percentile concentrations for the following:

- The catchment upstream of the project
- The project road pavement resultant treated concentrations immediately downstream of the proposed permanent water quality controls
- The combined resultant and upstream catchment, ie downstream of the project.

This was done for all the major crossings and results are presented below. The major crossings are water bodies defined as SREs (see **Section 4.4**) that the project would pass over, specifically:

- Cosgroves Creek
- Badgerys Creek
- South Creek
- Kemps Creek
- Hinchinbrook Creek
- Unnamed tributary of Hinchinbrook Creek.

Water quality models have also been set up and run for each minor crossings, which are those that have not been identified as SREs, to obtain concentrations similar to the above scenario. Twenty-nine minor crossings have been included in the modelling and consist of unnamed creeks within the study area.

A comparison of the estimated pollutant concentrations from the project study area against the ANZECC guideline limits for the more conservative environmental value of protection of slightly to moderately disturbed aquatic ecosystems was made. Further comparisons were made between estimated concentrations in the streams immediately upstream and immediately downstream of the project discharge points. This would provide an indication of any impacts of the existing background concentrations and also enable a comparison against the ANZECC guideline limits.

Mean concentration for TSS, TP and TN were extracted from the water quality model at all the major creek crossings and all the minor cross drainage and road pavement discharge points. These are presented as graphs in the sub-sections below, where:

- The orange line represents the estimated concentrations immediately upstream of the project, being the upstream catchment (u/s of M12)
- The yellow line represents the estimated concentrations immediately downstream the proposed project water quality controls before the resulting water re-enters the receiving waterway (d/s of M12 water controls)
- The green line represents the estimated concentrations immediately downstream of the project, including the treated run-off from the proposed project water quality (d/s of M12)
- The dashed blue lines represent the recommended limit for protection of aquatic ecosystems.

The desirable range of 6 to 50 NTU recommended by ANZECC (2000) for protection of aquatic ecosystems has been representative by an indicative only range of 20 to 75 milligrams per litre for TSS.

Water quality modelling results

Major crossings

The major crossings are all located upstream of areas that have been identified as sensitive receiving waterways, as such impacts on water quality from the project would not be desirable. Mean concentration for TSS, TP and TN results and comparisons for all the major crossings against recommended limits for protection of aquatic ecosystems are summarised in **Figure 6-4** to **Figure 6-6**. Overall the results show that there is a noticeable reduction in nutrients and TSS for the major crossings, all classified as SREs, for runoff treated by proposed project water quality controls.

Note that TSS is not a parameter on the NSW water quality objectives and is normally correlated to turbidity. Also, toxicants have not been modelled. Toxicants are represented indirectly by TSS, however, and hence the results of the TSS below provide an indication of the toxicants.

TSS has been modelled against both water quality design targets (**Table 6-5**) and environmental values for waterways in the project area (**Table 2-2**).

The results of the modelling indicate that the design targets would be met upstream of all the major crossings. This would be achieved as a result of the proposed project swales and basins that would reduce the annual average pollutant loads of TSS by more than 80 per cent.

Figure 6-4 presents the results for TSS against the environmental values. At all major crossings, the mean concentration of discharges upstream and downstream of the project would be around the upper recommended guideline limit of 50 milligrams per litre. The treated runoff from the project would be significantly better, however, with reduced concentrations of TSS that would comply with the lower guideline limit of 20 milligrams per litre. Overall the concentrations downstream of the project would be very slightly improved due to the mixing with the improved treated water quality from the project that will result in dilution. While; this improvement is not significant, it works towards meeting the nominated environmental values.

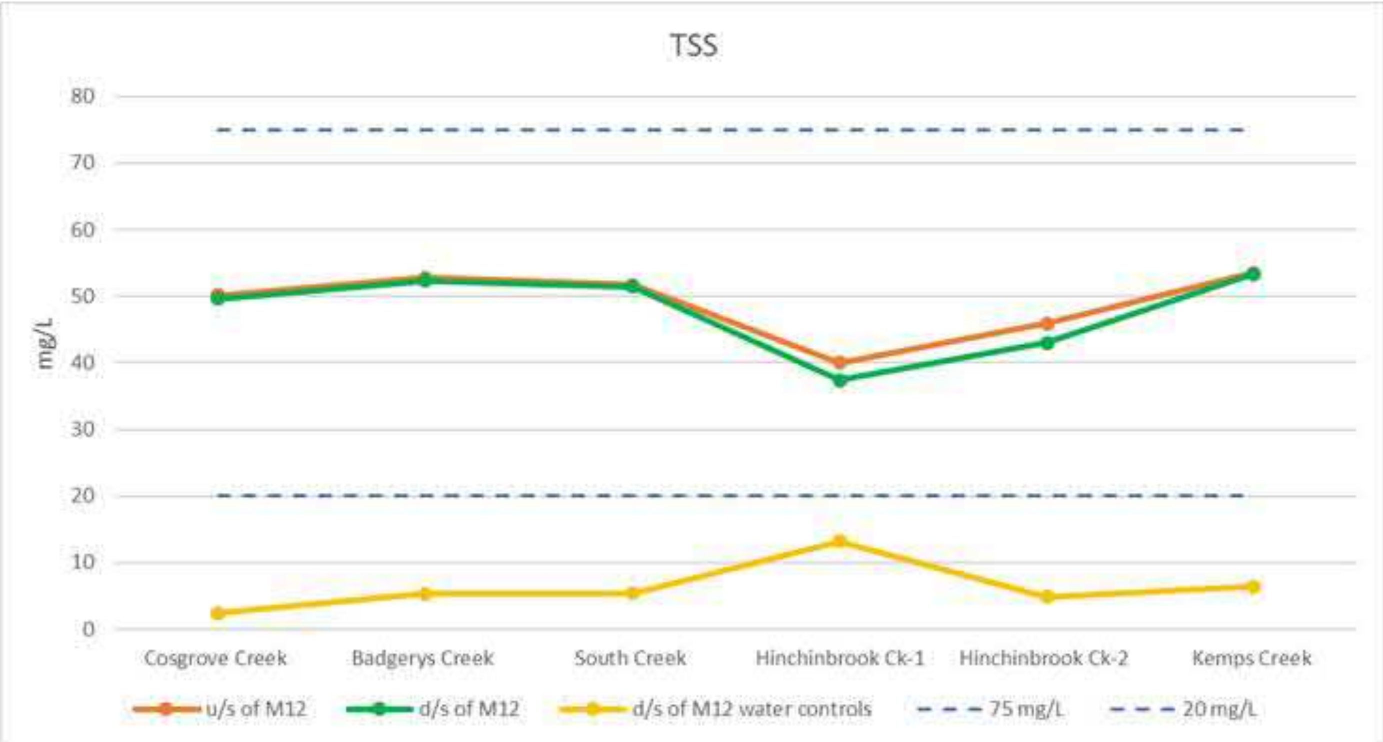


Figure 6-4 Mean total suspended solids concentrations and ANZECC guideline limits – Major crossings

Figure 6-5 presents the results for TP. At all major crossings, the mean concentrations upstream and downstream of the project would be significantly higher than the acceptable limit of 0.025 milligrams per litre. The treated runoff from the project, however, would contain significantly lower concentrations that would be just above the recommended limit. The concentrations downstream of the project would be very slightly improved due to the mixing with the improved treated water quality from the project. While still unlikely to meet the protection of aquatic ecosystems criteria, the results indicate that the project would contribute towards protecting environmental values.

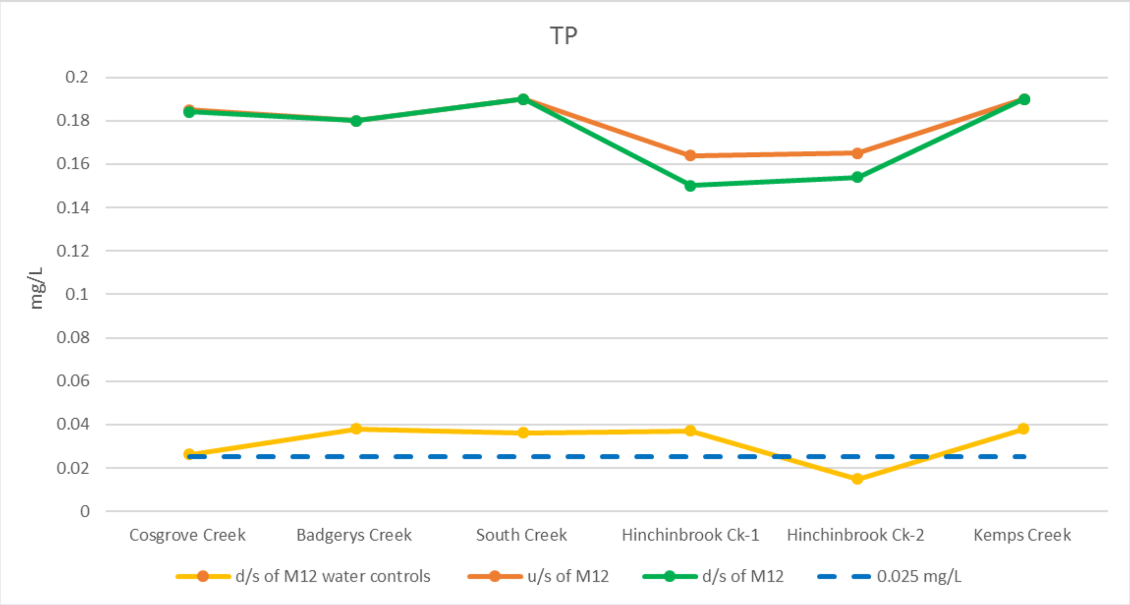


Figure 6-5 Mean total phosphorus concentrations and ANZECC guideline value – Major crossings

Figure 6-6 presents the results for TN. At all major crossings, the mean concentrations upstream and downstream of the project would be significantly higher than the acceptable limit of 0.35 milligrams per litre. the treated runoff from the project, however, would contain significantly lower concentrations that would be just above the recommended limit. The concentrations downstream of the project would be very slightly improved due to the mixing with the improved treated water quality from the project that will result in dilution; and whilst still unlikely to meet the protection of aquatic ecosystems criteria, the results indicate the project would contribute towards protecting environmental values.

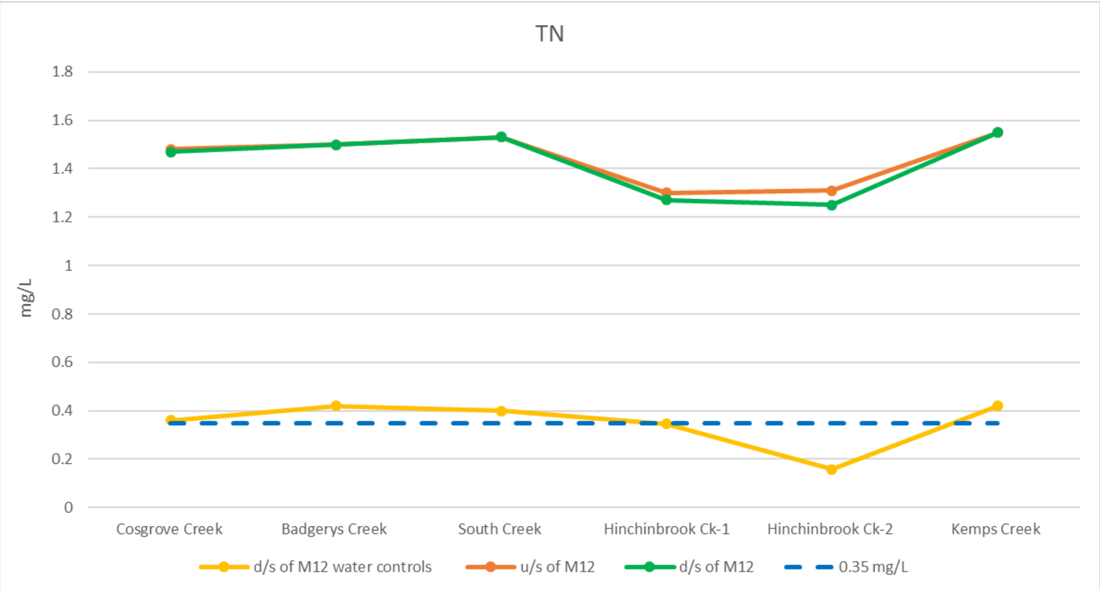


Figure 6-6 Mean total nitrogen concentrations and ANZECC guideline limits – Major crossings

Minor crossings

The minor crossings are all located upstream of areas that have been identified as non-sensitive receiving waterways. Overall, the water quality from the project at minor crossings that are located upstream of non-sensitive aquatic environments continues to exceed the recommended guideline limit for protection of aquatic ecosystems, however, concentrations for TN and TP are somewhat reduced. As such, impacts on water quality from the project would not be desirable but would be unlikely to have a major impact on the environment. Mean concentration for TSS, TP and TN results of all the minor crossings are shown on **Figure 6-7** to **Figure 6-9**.

TSS has only been modelled against environmental values for waterways in the project area (**Table 2-2**). The water quality design targets (**Table 6-5**) are not applicable to the minor crossings as the project design criteria states that there is no need to provide permanent water quality controls for non-sensitive receiving environments.

Figure 6-7 presents the results for TSS. At all minor crossings, the mean concentrations upstream and downstream of the project and from the project road pavement would be around the middle range of acceptable limits. The concentrations downstream of the project road pavement would be slightly higher.

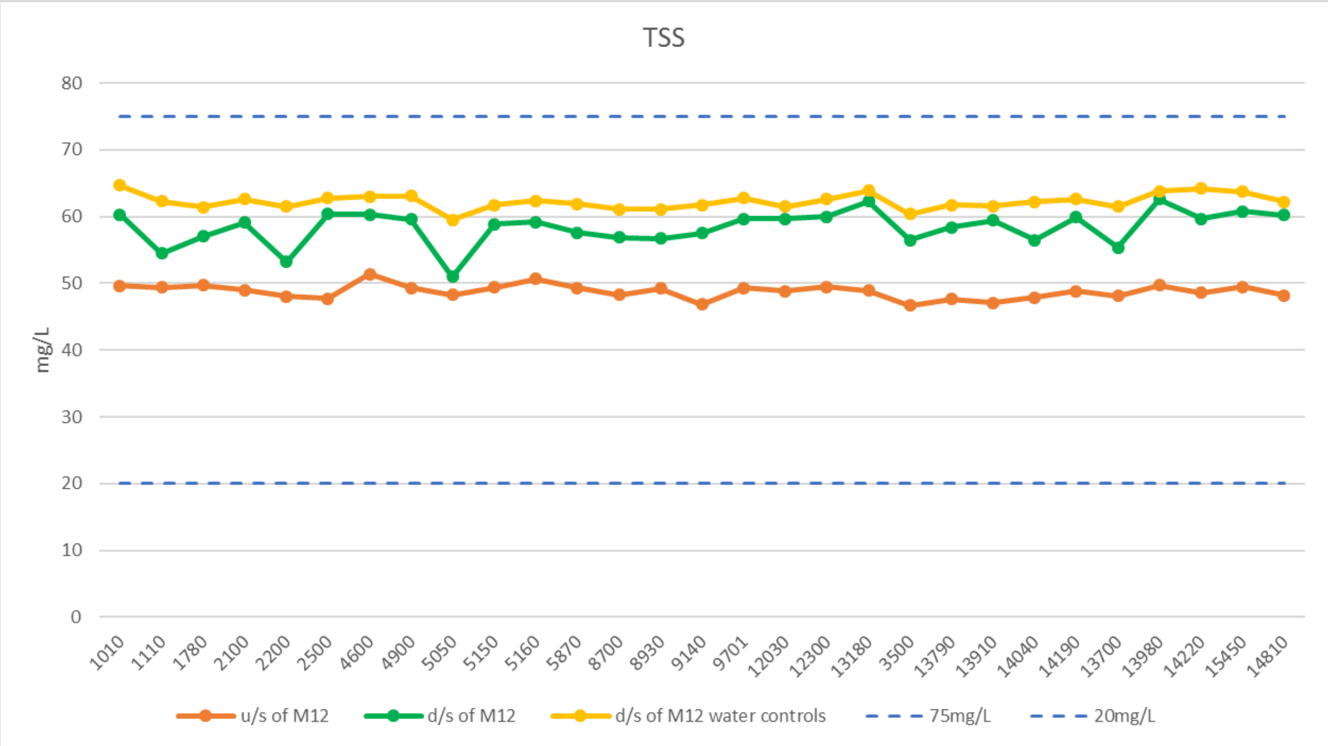


Figure 6-7 Mean total suspended solids concentrations and ANZECC guideline limits – Minor crossings

Figure 6-8 presents the results for TP. At all minor crossings, the mean concentrations upstream and downstream of the project and from the project would be much higher than the recommended limit. The concentrations downstream of the project road pavement would be slightly higher than the guidelines for protection of aquatic ecosystems but would be lower than existing conditions.

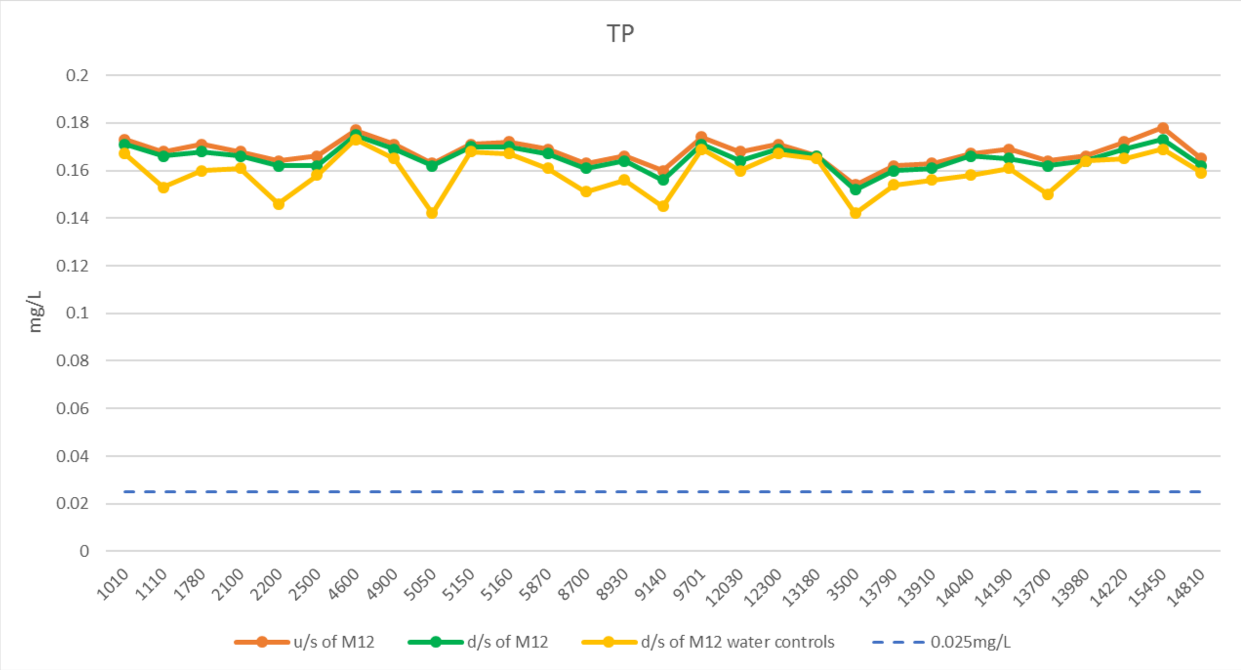


Figure 6-8 Mean total phosphorus concentrations and ANZECC guideline limit – Minor crossings

Figure 6-9 presents the results for TN. At all minor crossings, the mean concentrations upstream and downstream of the project and from the project would be much higher than the recommended limit. The concentrations downstream of the project road pavement would be slightly higher than the guidelines for protection of aquatic ecosystems but would be lower than existing conditions.

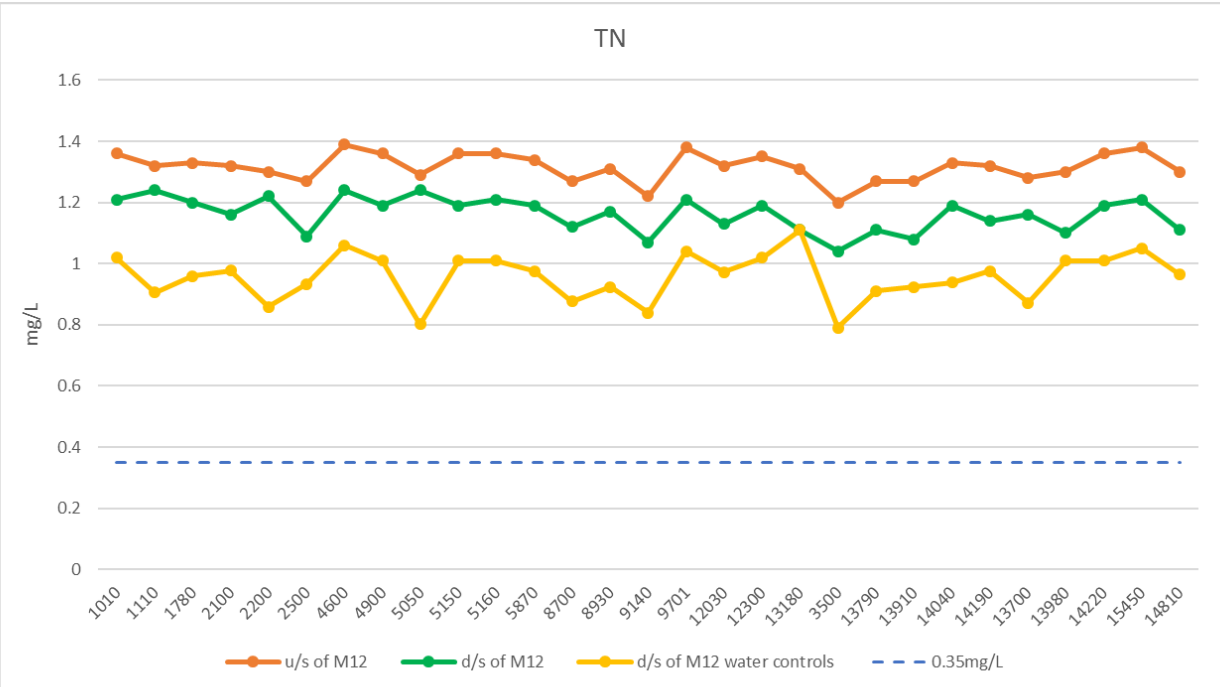


Figure 6-9 Mean total nitrogen concentrations and ANZECC guideline limit – Minor crossings

The results for the minor crossings indicate that there would be a small impact on the water quality, however, the results for downstream of the project road pavement are conservative as they have not taken into consideration the default swales that would provide reasonable treatment for TSS and TP. As such, the impact not would be significant. This would not be true for TN as the default swales would not provide any treatment and therefore the TN results in **Figure 6-9** are considered to be more applicable.

Combined results

Overall it is believed that any surface runoff from these minor crossing travelling through non-sensitive areas would receive natural assimilation and improvements in water quality before reaching any downstream sensitive waterways with an identified environmental value. Therefore, the overall results of the combined major and minor crossings is considered to be an acceptable outcome for the protection of the nominated environmental values for downstream waterways.

7. Cumulative impacts

7.1 Review of relevant projects

Cumulative surface water quality and hydrology impacts may arise from the interaction of construction and operation activities of the project and other approved or proposed projects in the area. When considered in isolation, specific project impacts may be considered minor. These minor impacts may be more substantial, however, when the impact of multiple projects on the same receivers is considered. As such, the surface water quality and hydrology impacts discussed in **Chapter 4.5.3**, were assessed in consideration of the recently completed, ongoing and proposed projects described in **Table 7-1**.

The identified projects are in varying stages of delivery and planning. This section provides an assessment of cumulative surface water quality and hydrology impacts based on the most current and publicly available information on the nominated projects. In many instances this is a high-level qualitative assessment. The assessment of cumulative impacts per project is discussed in **Section 7.2** and **Table 7-1.**

7.2 Assessment of cumulative impact

Since potential surface water quality and hydrology of the M12 Motorway are expected to be minor with the implementation of appropriate environmental management measures, the project is expected to have a minor contribution to cumulative surface water quality and hydrological impacts. As the project is not expected to generate significant water quality or hydrological impacts during construction or operation, outside of the potential for minor erosion and sedimentation, accidental spills and increased stormwater runoff, the M12 Motorway would have a minor contribution to cumulative surface water quality and hydrological impacts associated with the project and other identified projects in the vicinity.

Overall, the M12 Motorway would have minor cumulative water quality and hydrology impacts associated with the construction; and minor cumulative water quality and hydrology impacts associated with operation of the M12 Motorway and the other ongoing and planned developments in the area. Where any minor impacts occur, they are likely to be either highly localised, temporary and/or readily assimilated into the existing waterway.

Table 7-1 Projects considered in the cumulative impact assessment

Project	Relevance of the identified project to consideration of cumulative surface water quality and hydrology impacts on the M12 project	Commentary
Western Sydney Airport (approved)	Temporal and spatial relevance, due to the following characteristics: • Located directly adjacent to the project (overlapping areas of potential influence) • Within the same hydrological catchment • Concurrent (simultaneous) construction and operation.	The Western Sydney Airport EIS surface water quality assessment (GHD, 2016) and surface water hydrology and geomorphology assessment (GHD, 2016b) concluded that: • The site preparation works, particularly the clearing of vegetation and earthworks would lead to extensive disturbance of existing soils. This can result in erosion and sedimentation and subsequently the release of pollutants including suspended solids, nutrients and other toxicants to downstream waterways deteriorating the quality of water and altering the geomorphology • The construction of aviation infrastructure works could also impact on the surface quality as there would be an increased risk of chemical and hydrocarbons spills • With the implementation of a SWMP and CEMP that construction is unlikely to have a significant impact on downstream water quality and that any potential impacts are likely to be localised and short term • Upon completion of construction, water quality discharged from the airport site to the downstream waterways is expected to improve compared to existing conditions for total phosphorus, total nitrogen and suspended solids • The proposed airport would result in a major modification to the land use and surface water runoff generated and would result in the removal of a large number of watercourses and farm dams from the airport site • The proposed detention basin strategy would be effective at limiting the downstream impacts such that any increases in flood level would not worsen flooding to surrounding roads and dwellings, and the risks to changes in creek geomorphology would be low • Minor changes in water level is predicted immediately downstream of the airport site • There would be an increase in impervious surfaces and therefore increased pollutants (suspended and dissolved solids, nutrients, gross pollutants, heavy metals and total petroleum hydrocarbons) and litter entering downstream waterways Erosion and sedimentation is expected during construction of the M12 Motorway, with sediment basins located to best capture runoff before it enters the waterway. The locations and basins would be further refined during the detailed design to ensure minimal impact to water quality. Whilst increased runoff is expected to occur during operation of the project the associated pollutants transported in runoff are expected to decrease with the implementation of appropriate water quality controls outlined herein. Therefore, it is expected that there would be minor cumulative water quality and hydrological impacts associated with the construction and operation of the project and the Western Sydney Airport.

Project	Relevance of the identified project to consideration of cumulative surface water quality and hydrology impacts on the M12 project	Commentary
Sydney Metro Greater West	Temporal and spatial relevance, due to the following characteristics: • Located directly adjacent to the project (overlapping areas of potential influence) • Within the same hydrological catchment • Likely to be concurrent (simultaneous) construction and operation.	Construction of the Sydney Metro Greater West is likely to have some overlap with the construction of the M12 Motorway. During timeframes where construction activities are concurrent, increased water quality and hydrological impacts are likely. The magnitude of cumulative construction impacts would be dependent on the specific construction locations, activities and impacts which are yet to be determined for the Sydney Metro – Greater West. As the Sydney Metro Greater West would need to incorporate water sensitive urban design measures to meet water quality objectives. Additionally, the as planning provisions require that future development cannot result in significant hydrological changes, it is expected that cumulative impacts to surface water quality and hydrology would be minor.
The Northern Road Upgrade • Stage 5 (Littlefield Road to Glenmore Park) • Stage 6 (Littlefields Road to Eaton Road)	Temporal and spatial relevance, due to the following characteristics: • Located directly adjacent to the project • Within the same hydrological catchment • Likely to be consecutive (back to back) construction and concurrent (simultaneous) operation.	Stages 1 through 4 of The Northern Road upgrade will be completed by the time construction of the M12 Motorway project commences. The construction for Stage 5 is scheduled for early 2019 to end of 2022 and Stage 6 is scheduled for mid-2019 to end of 2021 and may overlap with the M12 Motorway construction. As the construction periods for the project and The Northern Road Upgrade will overlap, there is the potential for increased likelihood of erosion and sedimentation from the project if the sites from the Northern Road Upgrade have not completely stabilised. Potential to impact on water quality and hydrology from operation would be due to increased runoff (carrying pollutants), accidental leaks or spills of chemicals and fuels, and increased stormwater runoff from the change in land use to impervious areas. Implementation of standard stormwater practices and adherence to industry standards to meet water quality objectives, will result in minor cumulative impacts.
Other existing road network upgrades and potential road projects, including: • Elizabeth Drive Upgrade • Mamre Road Upgrade • Outer Sydney Orbital	Temporal and spatial relevance, due to the following characteristics: • Located directly adjacent to the project • Within the same hydrological catchment • Likely to be consecutive (back to back) construction and concurrent (simultaneous) operation.	The timing for construction and operation of the existing and potential road upgrade projects has not yet been announced, however, there is potential for overlaps between the M12 Motorway and some of these road upgrade works. The future development would be designed to minimise impacts to hydrology and geomorphology as much as possible during construction. Water quality impacts during construction and operation would be typical of large infrastructure projects and mitigated by the implementation of standard stormwater practices and adherence to industry standards. Therefore, there would be minor cumulative water quality and hydrology impacts associated with the construction and operation of the M12 Motorway and other road projects.

Project	Relevance of the identified project to consideration of cumulative surface water quality and hydrology impacts on the M12 project	Commentary
Major land releases, including: • Western Sydney Aerotropolis • Sydney West Growth Area • Western Sydney Employment Area	• Temporal and spatial relevance, due to the following characteristics: • Located directly adjacent to the project • Within the same hydrological catchment • Potential future context of the M12 project (operation).	The timing for construction of surrounding urban developments (growth areas) has not yet been announced. However, there is potential for overlaps between the M12 Motorway and surrounding projects located within the same hydrological catchment. Impacts will be dependent on the specific construction locations, activities and impacts which are yet to be determined for these projects. The future development would be designed to consider water sensitive urban design principles and to minimise impacts to hydrology and geomorphology as much as possible. It is expected that water quality impacts would be typical of large developments and mitigated by the implementation of standard stormwater practices and adherence to industry standards, there would be minor cumulative water quality and hydrology impacts. The operation of the growth areas would increase runoff volumes due to the transformation of the existing greenfield sites into predominantly impervious sites. The growth areas would likely provide water sensitive urban design solutions and incorporate detention basins to manage flows out of the sites, however there is still the potential for changes to existing hydrology with development occurring within Western Sydney. Increased flows also have the potential to impact on water quality. The cumulative impact of the increased area of impervious surfaces between the growth areas and the M12 Motorway could result in a moderate increase in runoff within the and stormwater network and downstream waterways. While the implementation of standard stormwater practices and adherence to industry standards would somewhat reduce runoff, the cumulative hydrological impact (via stormwater to downstream waterways) could be moderate.

8. Environmental management measures

The key water quality objective for the project is to ensure downstream waterways are protected against the potential impacts from construction and operation of the project. Measures to avoid, minimise or manage surface water and hydrology impacts as a result of the project are detailed in **Table 8-1**. These measures include preparation of a soil and water management plan, erosion and sediment control plan, an emergency spill response procedure and a water quality monitoring program to monitor the performance of these measures. The environmental management measures include a surface water quality monitoring program which will include collection of baseline data for comparison to construction and operational monitoring data as outlined in **Section 8.1**.

The environmental management measures listed in the table below should be read in conjunction with those outlined in Appendix L of the EIS (Flooding assessment report), Appendix N of the EIS (Groundwater quality and hydrology assessment report), Appendix O of the EIS (Soil and contamination assessment report) and Chapter 9 of the EIS.

Table 8-1 Environment management measures (surface water quality and hydrology)

Impact	Reference	Environmental management measure	Responsibility	Timing
General	SWH01	A Construction Soil and Water Management Plan (CSWMP) will be prepared for the project. The plan will outline measures to manage soil and water impacts associated with the construction works, including contaminated land. The CSWMP will provide: • Measures to minimise/manage erosion and sediment transport both within the construction footprint and offsite including requirements for the preparation of erosion and sediment control plans (ESCP) for all progressive stages of construction • Measures to manage waste including the classification and handling of spoil • Procedures to manage unexpected contaminated finds including asbestos which would be outlined in the Contaminated Land Management Plan and Asbestos Management Plan to be prepared for the project • Measures to manage stockpiles including locations, separation of waste types, sediment controls and stabilisation • Measures to manage groundwater dewatering and impacts including mitigation required • Processes for dewatering of water that has accumulated on site and from sediment basins, including relevant discharge criteria • Measures to manage potential tannin leachate	Contractor	Prior to construction

Impact	Reference	Environmental management measure	Responsibility	Timing

		• Measures to manage accidental spills including the requirement to maintain materials such as spill kits
		• Measures to manage potential saline soils
		• Details of surface water and groundwater quality monitoring to be undertaken prior to, throughout, and following construction
		• Controls for sensitive receiving environments including SEPP Coastal Wetlands which may include but not be limited to:
		  – Designation of 'no go' zones for construction plant and equipment
		  – Creation of catch/diversion drains and sediment fences at the downstream boundary of construction activities where practicable to ensure containment of sediment-laden runoff and diversion toward sediment sump treatment areas (not sediment basins) to prevent flow of runoff to the SEPP Coastal Wetland.
		• Erosion and sediment control measures will be implemented and maintained at all work sites in accordance with the principles and requirements in Managing Urban Stormwater – Soils and Construction, Volume 1 (Landcom 2004) and Volume 2D (NSW Department of Environment, Climate Change and Water 2008), commonly referred to as the "Blue Book", as well as relevant Roads and Maritime Guidelines.		

	SWH02	A soil conservation specialist will be engaged for the duration of construction of the project to provide advice on the planning and implementation of erosion and sediment control including review of ESCPs.	Roads and Maritime/ Contractor	Prior to construction and during construction
	SWH03	A water reuse strategy will be developed for both construction and operational phases of the project to reduce reliance on potable water. This strategy will be prepared during the detailed design stage and implemented throughout the project and will outline the construction and operational water requirements and potential water sources to supply the water demand in consultation with Sydney Water. Alternative water supply options to potable water will be investigated, with the aim of reusing water using recycled water where feasible.	Contractor	Detailed design, prior to construction, and throughout construction and operation

Impact	Reference	Environmental management measure	Responsibility	Timing
Impacts of stockpiles	SWH04	Stockpiles will be managed to minimise the potential for mobilisation and transport of dust and sediment in runoff in accordance with Roads and Maritime Stockpile Site Management Guideline (Roads and Maritime, 2015). This will include: • Minimising the number of stockpiles, area used for stockpiles, and time that they are left exposed • Locating stockpiles away from drainage lines, waterways and areas where they may be susceptible to wind erosion • Stabilising stockpiles, establishing appropriate sediment controls and suppressing dust as required.	Contractor	Construction
Surface water quality impacts	SWH05	A construction water quality monitoring program will be developed and included in the CSWMP for the project to establish baseline conditions, observe any changes in surface water and groundwater during construction, and inform appropriate management responses. The program will be based on the water quality monitoring methodology water quality indicators and the monitoring locations identified in the Surface water and hydrology assessment report (this report), and Groundwater quality and hydrology assessment report (Appendix N of EIS). Baseline monitoring will be undertaken monthly for a minimum of 12 months prior to the commencement of construction. As a minimum this will include three wet weather sampling events over six months where feasible. Sampling locations and monitoring methodology to be undertaken during construction will be further developed in detailed design in accordance with the Guidelines for Construction Water Quality Monitoring (RTA 2003) and the 'ANZECC water quality guidelines' (ANZECC/ARMCANZ (2000). It will include collection of samples for analysis from sedimentation basin discharge points, visual monitoring of other points of release of construction waters and monitoring of downstream waterways. The monitoring frequency during construction will be confirmed during detailed design however will include at least monthly construction monitoring at all monitoring sites	Roads and Maritime/ Contractor	Prior to construction, and during construction and operation

Impact	Reference	Environmental management measure	Responsibility	Timing
		which will preferentially monitor following wet weather events. Should the results of monitoring identify that the water quality management measures are not effective in adequately mitigating water quality impacts, additional mitigation measures will be identified and implemented as required.		
	SWH06	An operational water quality monitoring program will be developed and implemented following the completion of construction to observe any changes in surface water and groundwater following construction, and inform appropriate management responses. The program will be based on the water quality monitoring methodology, water quality indicators, and the monitoring locations presented in the Surface water and hydrology assessment report (this report), and Groundwater quality and hydrology assessment report (Appendix N). The monitoring program will be undertaken monthly and will preferentially monitor following wet weather events when rainfall results in discharge from control sites or is greater than a nominated rainfall threshold which will be identified in detailed design. Monitoring will be undertaken for a minimum of 12 months following the completion of construction, or until the affected waterways are certified by a suitably qualified and experienced independent expert as being rehabilitated to an acceptable condition and/or the permanent water quality structures are deemed to be operating satisfactorily. Should the results of monitoring identify that the water quality management measures are not effective in adequately mitigating water quality impacts, additional mitigation measures will be identified and implemented as required.	Roads and Maritime / Contractor	Prior to operation and during operation
	SWH07	The performance water quality controls developed for the design set out in the EIS document (including but not limited to temporary and permanent sediment basins) will be verified as the detailed design develops for the project to ensure the objectives of the project are achieved. In the instance that during detailed design it cannot be demonstrated that the water quality controls would be effective in mitigation potential impacts, additional mitigation	Contractor	Detailed design

Impact	Reference	Environmental management measure	Responsibility	Timing
		measures would be identified and implemented.		
	SWH08	Further water quality assessment will be undertaken during detailed design to establish site specific discharge criteria for construction sediment basins. Based on this, the number, location and size of the basins will be further refined during the detailed design with consideration to the relevant NSW EPA Environment Protection Licence application requirements and the environmental values of the downstream receiving waterway.	Roads and Maritime/ Contractor	Detailed design
	SWH09	Practical measures to prevent water pollution and control, abate or mitigate impacts to the environment will be investigated at the detailed design stages of the project with the aim to make improvements to the currently proposed water quality controls. Such measures may include: • Larger or high efficiency temporary basins • Alternative dry bioretention operational basins.	Roads and Maritime/ Contractor	Detailed design
Impacts of dewatering	SWH10	A dewatering management plan will be prepared as part of the CSWMP which will outline the dewatering methodology, supervision requirements, staff responsibilities and training, and approvals required before any dewatering activity commences.	Contractor	During construction
Impacts on water bodies	SWH11	The following measures will be undertaken to manage activities within watercourses or on waterfront land: • Implementing practices to minimise disturbance of banks • Undertaking bank stabilisation and installing instream structures • Maintaining minimum flows to assist in maintaining the viability of aquatic communities and preventing barriers to fish passage • Constructing instream crossings during low flows and design so that drainage off crossing doesn't contribute sediment load to the stream • All drainage feature crossings (permanent and temporary watercourse crossings and stream diversions), drainage swales and depressions will be designed by a suitably	Contractor	Prior to construction and during construction

Impact	Reference	Environmental management measure	Responsibility	Timing
		qualified and experienced professional and will be designed and constructed in accordance with relevant guidelines.		
	SWH12	A set of hydrologic and hydraulic models will be developed, which are to be used to define the nature of both main stream flooding and major overland flow along the full length of the project operational footprint under pre- and post-project conditions. The hydraulic model is to extend a sufficient distance upstream and downstream of the project operational footprint, to negate any boundary effects and to define the full extent of any impact that the project will have on patterns of both main stream flooding and major overland flow. The hydraulic model(s) is to be based on the TUFLOW (or equivalent) two-dimensional (in plan) hydraulic modelling software. The models will be used to verify the nature and extent of impacts and to confirm the type of mitigation measures required. The models will also be used during detailed design to describe the interaction between the project and flows particularly with respect to culverts and to assist in refining the design for flows arriving at and travelling through culverts.	Contractor	Detailed design
Impacts on SEPP Coastal Wetlands	SWH13	Consideration will be given to the design of operational water quality erosion and sediment controls incorporated into the design of the construction access track being left in place upstream from the SEPP wetland, and within the proximity area of, the SEPP Coastal Wetland ID117.	Contractor	Detailed design

8.1 Surface water quality monitoring program

8.1.1 Purpose

A surface water monitoring program will be implemented as an environmental management measure to observe any changes in surface water quality that may be attributable to the project and inform appropriate management responses.

The monitoring program will include collection of baseline data for comparison to construction and operational monitoring data to understand, and respond to, any impacts from the project. An outline of each stage of the monitoring program (baseline, construction, operational) is provided in **Sections 8.1.3, 8.1.4** and **8.1.5** (respectively) and describes the location and frequency of monitoring during these period.

Site specific trigger values (SSTVs) will be developed based on the baseline water quality monitoring program and will be used to define existing conditions and confirm whether the proposed water quality controls and management measures will meet the water quality objectives.

The surface water quality indicators to be monitored are common to all stages of the monitoring program and are outlined in **Section 8.1.6**. Surface water monitoring locations are described in **Section 8.1.2**.

The frequency, locations and indicators to be sampled would be confirmed during detailed design.

Monitoring would be undertaken in accordance with the following guidelines:

- Guideline for Construction Water Quality Monitoring (RTA, 2003b)
- Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000b).

8.1.2 Monitoring locations

Current monitoring locations for surface water quality are listed in **Table 8-2** and shown in **Figure 3-2**. Additional sites, reference and control sites (ie up and downstream of the project) will be identified prior to commencement of construction. These sites are useful in determining impacts of a disturbance or pollution event.

Table 8-2 Proposed water quality monitoring locations

Site number	Site name	Coordinates	Description and locations details
M12_1	Unnamed tributary of South Creek	287282.71 m E 6251632.72 m S	Road bridge on Elizabeth Drive over South Creek. U/S of alignment
M12_2	Cosgroves Creek	289864.51 m E 6251080.48 m S	Road bridge on Twin Creeks Drive over Cosgroves Creek. D/S of alignment
M12_3	Unnamed tributary of Cosgroves Creek	290783.22 m E 6251120.36 m S	Road bridge on Elizabeth Drive over Cosgroves Creek. U/S of alignment
M12_4	Unnamed tributary of Badgerys Creek	291989.97 m E 6249633.41 m S	Road bridge on Elizabeth Drive over Badgerys Creek. U/S of alignment, and east of connecting road to Elizabeth Drive.
M12_5	Badgerys Creek	292402.94 m E 6251178.92 m S	Residential development area on Humewood Place, borders Badgerys Creek. D/S of alignment
M12_6	South Creek	293776.85 m E 6251029.82 m S	Residential development area on Humewood Place, borders South Creek. D/S of alignment
M12_7	Kemps Creek	296359.62 m E 6249256.72 m S	Industrial site K&N Mechanical 917 Mamre Road, borders on Kemps Creek. D/S of alignment
M12_8	Unnamed tributary of Kemps Creek	296876.16 m E 6249052.47 m S	Road bridge on Elizabeth Drive over Kemps Creek. U/S of alignment
M12_9	Ropes Creek	300775.63 m E 6250599.30 m S	Road bridge on Capitol Hill Drive over Ropes Creek. D/S of alignment
M12_10	Unnamed tributary of Ropes Creek	300453.12 m E 6249586.05 m S	Roundabout on Wallgrove Road over Ropes Creek. U/S of alignment? Was Site M12_9 for Jacobs work
M12_11	Unnamed tributary of Hinchinbrook Creek	298956.6 m E 6248415.48 m S	Hinchinbrook Creek tributary to Liverpool Offtake Reservoir. U/S of alignment. Access via locked road gate to the south.
M12_13	Hinchinbrook Creek	300407.62 m E 6247267.18 m S	Hinchinbrook Creek. Access via Kensington Close. D/S of alignment. Jacobs have accessed this site previously.

8.1.3 Baseline data

The baseline data collected to date is presented in **Section 4.3**. Additional baseline surface water quality data will be collected for a minimum of twelve months prior to commencement of construction. Sampling frequency would be monthly plus following wet weather events for at least 12 months. As a minimum this should include three wet weather sampling events over six months. Wet weather monitoring events are defined as 22 millimetres or more of rain within 24 hours recorded at the Badgerys Creek AWS Bureau of Meteorology (BoM) gauge (#067108). Sampling will occur within the following 24 hours of the rain event. If rainfall events are regularly less than 22mm, opportunistic wet weather monitoring would be undertaken to ensure that some wet weather data is collected. Following the completion of six months of baseline monitoring the EPA will be consulted to discuss the current monitoring program and any refinements to the study design.

8.1.4 Construction phase surface water monitoring

Surface water monitoring during the construction phase will be undertaken at all monitoring sites on a monthly basis plus following wet weather events. Monitoring should also be undertaken when discharge from a point source such as a controlled sediment basin occurs. Visual monitoring of other points of release and monitoring of downstream waterways will also be undertaken during construction.

8.1.5 Operational phase surface water monitoring

Monthly monitoring will occur for a minimum of 12 months during operation of the project. Additional wet weather monitoring will occur when rainfall results in any discharge from control sites (or greater than a nominated rainfall threshold). The operational surface water monitoring period shall continue following the completion of construction until the affected waterways are certified by an independent expert as being rehabilitated to an acceptable condition and/or the permanent water quality structures are deemed to be operating satisfactorily.

8.1.6 Surface water monitoring indicators

The surface water monitoring program will include both field parameters and laboratory analysis of the following indicators:

- Field parameters (electrical conductivity, pH, turbidity, dissolved oxygen and temperature)
- Heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, iron and manganese)
- Nutrients (including ammonia, NO2, NO3, TKN, total nitrogen, total phosphorus, SRP)
- Chlorophyll-a
- Oil and grease
- Major urban pollutants (ultra-trace Polynuclear Biphenyls, organochlorine and organo-phosphorus pesticides, fumigants, halogenated aliphatic and aromatic compounds)
- Benzene, toluene, xylene, naphthalene (BTXN)
- Phenols and poly-aromatic hydrocarbons (PAHs)
- Total dissolved solids (TDS)
- Total suspended solids (TSS).

9. Conclusions

The project lies primarily within the Hawkesbury-Nepean Catchment with a small portion at the eastern end of the project within the Georges River Catchment. More specifically the project falls within the South Creek sub catchment, a heavily modified and disturbed area due to increasing urbanisation and land clearing.

The assessment of existing water quality data and project specific monitoring of waterways relevant to the project (including Badgerys Creek, Cosgroves Creek, South Creek, Kemps Creek, Ropes Creek and Hinchinbrook Creek) found that they exhibit poor water quality with elevated nutrient levels and low dissolved oxygen and heavy metals. They currently do not meet the ANZECC Water Quality Guidelines for protection of nominated environmental values.

The construction and the operation of the project has the potential to impacts these waterways. Potential impacts to surface water and hydrology could result from:

- Erosion of soils and sedimentation of waterways
- Reduced water quality from elevated turbidity, increased nutrients and other contaminants
- Smothering of aquatic organisms from increased sediments and associated low dissolved oxygen levels
- Potential growth of weeds and algal blooms associated with reduced water quality
- Accidental leaks or spills of chemicals and fuels
- The introduction of gross pollutants (rubbish) into the waterways
- Changes to flow rates, volumes and flow paths within waterways and drainage lines
- Increased road runoff volumes and/or velocity resulting in potential increase in scouring and erosion
- Altered hydrology and geomorphology from the creation of impermeable surfaces and the proposed minor creek adjustments at Badgerys Creek, South Creek and Kemps Creek
- Temporary and permanent watercourse crossings and construction of bridges altering flow and water quality.

To minimise impacts to surface water quality and hydrology a range of measures wold be implemented during the detailed design, construction and operational phases of the project including:

- A detailed Soil and Water Management Plan (SWMP) would be prepared as part of the Construction Environmental Management Plan (CEMP) to manage erosion and sediment impacts associated with land disturbance and creek adjustments so that impacts to soil and water quality are minimised throughout the construction phase.
- Management of stockpiles
- Emergency spill response procedures
- Water quality monitoring
- Installation and management of permanent water quality treatment measures including grassed swales and water quality basins
- Further investigation of potential hydrological impacts and proposed design during detailed design to minimise impacts.

Overall with the implementation of the proposed mitigation measures, the project is expected to have minimal impacts on existing water quality and environmental values during the construction phase. Additional monitoring is recommended to occur prior to construction to confirm existing water quality and if implementation of the Blue Book is adequate in maintaining and improving water quality so that the project can work towards achieving water quality objectives.

During the operation of the project, modelled pollutant loads to SREs are expected to decrease (with the implementation of water quality controls) and this is likely to result in an improvement in water quality, however other waterways within the operational footprint may experience a deterioration in water quality. Additional baseline water quality monitoring will provide additional information to support the selection and performance of the final water quality management measures for both the construction and operational phases of the project.

10. References

ANZECC/ARMCANZ (2000a) *National Water Quality Management Strategy - Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZECC/ARMCANZ (2000b) *National Water Quality Management Strategy* - Australian Guidelines for Water Quality Monitoring and Reporting. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Austroads (2001) *Road Runoff and Drainage: Environmental Impacts and Management Options*. Austroads AP-R-180.

Austroads (2003) *Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure*, Austroads AP-R232.

Austroads (2010) *Guide to Road Design, Part 5: Drainage Design*, Sydney.

Avisure (2016) *Western Sydney Airport Environmental Impact Statement: Preliminary Bird and Bat Strike Risk Assessment,* August 2016.

BMT (2013) *Rural Area Flood Study Ropes, Reedy & Eastern Creeks Final Report*. Prepared for Fairfield City Council, November 2013.

BOM (2018) *Climate statistics for Australian locations*. Australian Bureau of Meteorology available at *http://www.bom.gov.au/climate/averages/tables/cw_061078.shtml*

DECCW (2006) *NSW Water Quality and River Flow Objectives – Sydney Harbour and Parramatta River*. Department of Environment, Climate Change and Water. 1 May 2006.

DECCW (2008) *Managing Urban Stormwater-Volume 2D Main Road Construction*, NSW Department of Environment, Climate Change and Water (known as the Blue Book Volume 2): Sydney.

DEC (2004) *Approved methods for Sampling and Analysis of Water Pollutants in NSW.* Department of Environment and Conservation NSW.

DEC (2006) *Using the ANZECC Guidelines and Water Quality Objectives in NSW.* Department of Environment and Conservation NSWDPI (2012) *Guidelines for controlled activities on waterfront land*. Department of Primary Industries.

DPI (2013) *Industries Policy and Guidelines for Fish Habitat Conservation and Management.* NSW Department of Primary Industries, June 2013.

EPA (1997) *Managing Urban Stormwater: Council Handbook*, NSW Environmental Protection Authority: Sydney.

Fairfull, S. and Witheridge, G. (2003) *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings.* NSW DPI Cronulla.

GHD (2016) *Western Sydney Airport EIS - Surface Water Quality*. Department of Infrastructure and Regional Development.

GHD (2016b) *Western Sydney Airport EIS - Surface Water Hydrology and Geomorphology*. Department of Infrastructure and Regional Development.

GRCCC (2019) *Georges River Catchment*. Georges River Combined Councils' Committee (***http://www.georgesriver.org.au/Catchment.html*** accessed 13 March 2019)

Gunawardena, J.M.A. (2012) *relating Vehicle Generated Pollutants to Urban Stormwater Quality.* Science and Engineering Faculty Queensland University of Technology.

HNCMA (2007) *Hawkesbury-Nepean River Health Strategy*. Hawkesbury-Nepean Catchment Management Authority. March 2007.

HRC (1998) *Independent inquiry into the Hawkesbury-Nepean River System*. Healthy Rivers Commission of New South Wales, August 1998.

Landcom (2004) *Managing Urban Stormwater - Soils and Construction*, Volume 1, 4th Edition (known as the Blue Book Volume 1): Sydney.

Liverpool City Council (LCC) (2003) *Austral Floodplain Risk Management Study and Plan*. Review and Finalisation. Prepared by Perrens Consultants. September 2003.

NSW EPA (1997) *Managing Urban Stormwater – Council Handbook.* NSW Environmental Protection Agency.

NSW OEH (2014) *Framework for Biodiversity Assessment. NSW Biodiversity Offsets Policy for Major Projects.* NSW Office of Environment and Heritage.

Rae, D.J. (2007) *Water management in South Creek Catchment. Current state, issues and challenges*. Technical report No. 12/07. Cooperative Research Centre for Irrigation Futures.

RMS/Aurecon (2016) *M12 Motorway Strategic Route Options Analysis, Hydrology Working Paper.*

RMS (2011) Technical guideline: *Temporary stormwater drainage for road construction.* Roads and Maritime Services, Sydney.

RTA (2003a) Road Design Guideline: Section 8 Erosion and Sediment, Roads and Traffic Authority of NSW: Sydney

RTA (2003b) *Guideline for Construction Water Quality Monitoring*, Roads and Traffic Authority of NSW, Sydney.

RTA (2003c) *Procedures for Selecting Treatment Strategies to Control Road Runoff*, Roads and Traffic Authority of NSW, Sydney.

Strahler, A.N. (1952) *Hypsometric (area-altitude) analysis of erosional topography.* Bull. Geol. Soc. Am., 63, 1117-1142

TfNSW (2013) *NSW Sustainable Design Guidelines Version 3.0*, Transport for NSW.

Annexure 1

Minor drainage lines: hydrological analysis

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
1010	23.8	26.7	2.9	12%	0.1%	13%	13%	0.69	0.94	0.40	58%	1.82	2.04	0.22	12%	3.28	3.70	0.42	13%	Drainage lines 1010 and 1110 discharge into a farm dam within the private property about 200m downstream of project boundary. The drainage line then continues to run along the existing natural watercourse through downstream private properties.	Yes	From the project boundary to about 1000m north along the existing watercourse
1110	12.9	11.4	-1.5	-12%	0.1%	4%	4%	0.49	0.45	-0.04	-9%	1.10	0.99	-0.12	-10%	2.58	2.33	-0.25	-10%		No	
d/s 1010/1110								3.76	3.79	0.03	1%	9.70	9.79	0.09	1%	18.10	18.40	0.30	2%	The increase in the peak flow rate will become 2% in the 100 year ARI about 1000m downstream of the project boundary.	Yes	
1780	14.3	14.3	0	0%	0.1%	9%	9%	0.54	0.55	0.02	3%	1.21	1.21	0.00	0%	2.80	2.80	0.00	0%	Drainage Line 1780 discharges into a farm dam adjacent to the project boundary. This dam is not impacted by the M12 flows. After the dam, drainage line 1780 then joins with drainage lines 2100/2200 into a farm dam approximately 200m downstream of the project. The combined drainage lines 1780/2100/2200 then run through downstream properties that consist of a series of four farm dams. The increase in flow rate will become 2% approximately in the 100 year ARI about 1500m downstream of the project up to the junction of an unnamed tributary of South Creek.	No	From the project boundary to about 1500m north along the existing watercourse
2100	10.2	11.1	0.9	9%	0.1%	14%	13%	0.43	0.49	0.06	13%	0.92	1.00	0.08	8%	2.27	2.50	0.23	10%		Yes	
2200	6.6	5.7	-0.9	-14%	0.1%	4%	4%	0.31	0.27	-0.04	-12%	0.65	0.57	-0.07	-11%	1.67	1.50	-0.17	-10%		No	
d/s 1780								1.26	1.31	0.05	4%	2.72	2.71	-0.01	0%	6.58	6.67	0.09	1%		No	
d/s 1780								1.72	1.77	0.05	3%	3.80	3.80	0.00	0%	8.59	8.80	0.21	2%		No	
d/s 1780								2.18	2.22	0.04	2%	4.89	4.88	-0.01	0%	10.60	11.00	0.40	4%		No	
d/s 1780								2.67	2.71	0.04	1%	6.12	6.12	0.00	0%	12.60	13.10	0.50	4%		No	
d/s 1780								3.03	3.10	0.07	2%	7.17	7.15	-0.02	0%	14.40	14.80	0.40	3%		No	
2500	3.7	4.2	0.5	14%	0.1%	22%	22%	0.18	0.25	0.06	34%	0.41	0.48	0.07	17%	1.13	1.37	0.24	21%	Farm Dam is about 250m downstream of project	Yes	250m from the project boundary
d/s 2500								0.57	0.58	0.02	3%	1.35	1.32	-0.03	-2%	3.01	3.12	0.11	4%	The increase will become negligible at the farm dam approximately 250m downstream of the project.	No	

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
1010	0.522	0.543	0.02	0.87	0.90	0.03	1) Afflux of 20mm at the downstream project boundary. 2) Increased flows to the farm dam (about 9%) would adversely impact on the performance of the existing spillway and its scour protection. 3) There will be Increased outflow from the farm dam which is likely to cause increased depth of flow across the property access road to the dam.	No local infrastructure, culverts or house en route of the drainage line. No further assessment is required in terms of the potential impacts to these elements. However, the existing farm dam should be inspected/surveyed at detail design to confirm the scope for the potential mitigation measures.	1) Upgrade the existing dam spillway including scour protection. 2) EIS to recommend 20mm afflux acceptable through the drainage line given that the afflux would be contained within the existing watercourse and that there are no houses or structures that could be impacted. 3) May need to provide a low flow culvert or cause way across the property access road subject to further analysis at detail design and agreement with the affected property owner.	Project Boundary
1110										
d/s 1010/1110	1.346	1.353	0.01	0.25	0.25	0.00	1) Afflux of 10mm.		1) EIS to recommend 20mm afflux acceptable through the drainage line from the project boundary to about 1000m from the project boundary. Given that the afflux would be contained within the existing watercourse and that there are no houses or structures that could be impacted, it is considered reasonable to accept the afflux.	About 1000m d/s of the project boundary
1780										
2100	0.380	0.398	0.02	0.85	0.86	0.00	Afflux of 20mm at the downstream project boundary.		2) EIS to recommend 20mm afflux acceptable through the drainage line given that the afflux would be contained within the existing watercourse and that there are no houses or structures that could be impacted.	Project boundary
2200										
d/s 1780							There will be minor increase in flows to all local farm dams.	Survey and inspect the local farm dams at detail design.	1)Upgrade to the dam spillway and scour protection may be required after consultation with the affected property owners.	Dam 200m from project boundary
d/s 1780										Dam 500m from project boundary
d/s 1780										Dam 900m from project boundary
d/s 1780										Dam 1250m from project boundary
d/s 1780										At 1500m d/s of project boundary
2500	0.299	0.322	0.02	0.87	0.92	0.05	Afflux of 20mm at the downstream project boundary.	No local infrastructure, culverts or house exist en route of the drainage line.	1) EIS to recommend 20mm afflux acceptable through downstream drainage line given that the afflux would be contained within the existing watercourse and that there are no houses or structures that could be impacted.	Project Boundary
d/s 2500										

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
2780	6.48	5.71	-0.77	-12%	0.0%	0%	0%	0.73	0.65	-0.08										Dam on the northern side of M12 alignment located about 250m from the project boundary. Motorway pavement drainage or culverts do not discharge into the dam.	Yes	NA
3380	41.52	39.83	-1.69	-4%	0.0%	0%	0%	2.17	2.09	-0.08										Farm dam at approximate CH 3380 located adjacent to the project boundary on the southern side of the alignment. Motorway pavement drainage or culverts do not discharge into the dam.	Yes	NA
BR01	58.5	60.3	1.8	3%	0.1%	6%	6%	1.55	1.61	0.06	4%	4.16	4.33	0.17	4%	7.54	7.78	0.24	3%	Flow increase is considered within acceptable limit.	Yes	NA
4600	72.4	74.6	2.2	3%	0.1%	13%	13%	2.25	2.88	0.63	28%	5.93	6.34	0.41	7%	11.20	11.50	0.30	3%	Confluence of drainage line 4600 and Cosgroves Creek is about 650m downstream of project	No	
4900	19.8	20.6	0.8	4%	0.1%	14%	13%	0.61	0.73	0.12	20%	1.54	1.61	0.07	5%	2.95	3.13	0.18	6%	Farm Dam is immediately downstream of culvert discharge and part of catchment of drainage line 4600	No	
5050	6.9	5	-1.9	-28%	0.1%	2%	2%	0.24	0.18	-0.06	-24%	0.56	0.42	-0.15	-26%	1.21	0.94	-0.27	-22%	Drainage line 5050 joins line 4600 immediately upstream of the confluence with Cosgroves Creek	No	

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
2780	652.7 cu. m (2 year ARI runoff volume)	575 cu m (2 year ARI runoff volume)	-77.7 cu.m (2 year ARI reduction in runoff volume)				Yield of the dam reduced by 12%.		Compensate the land owner as the reduction in the yield is more than 10%.	Dam on the northern side of M12 alignment located about 250m from the project boundary
3380	4070 cu.m (2 year ARI runoff volume)	3905 cu.m (2 year ARI runoff volume)	-165 cu.m (2 year ARI reduction in runoff volume)				Yield of the dam reduced by 4%.		4% reduction in the runoff to the dam due to the motorway works. No mitigation measure is considered necessary.	Farm dam at approximate CH 3380 located adjacent to the project boundary on the southern side of the alignment.
BR01							Flood immunity to Luddenham Road will be impacted due to the increased flows in the 100 year ARI event.	Survey of the existing property access culverts and the culvert beneath Luddenham Road indicate that the culverts are 2 x 525 RCP and 3x 900 RCP respectively. We have assessed that these culverts are undersized to provide the 100 year ARI flood immunity to the local road.	1) Upgrade the existing property access culvert and the culvert beneath Luddenham Road to 100 year ARI standard.	Project boundary
4600										Project boundary
4900							1) Increased flow will impact adversely on the performance of the spillway to the dam. 2) The dam footprint is partly affected by the motorway road/drainage works.	1) Survey the size of the existing spillway of the farm dam. 2) Need negotiation with the landowners regarding their intention-keep the dam or fill.	1) Spillway of the existing dam will require upgrade to convey the increased flow. 2) The dam spillway may require scour protection. 3) The landowner needs to be compensated for the partial filling of the dam.	Project boundary
5050										Project boundary

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
d/s 4600								2.78	2.89	0.11	4%	7.32	7.62	0.30	4%	13.70	13.90	0.20	1%	The increase in flow rate will be1% in the 100 year ARI storm event at the outlet of the minor drainage line to the tributary of Cosgrove Creek located at about 650m from the project boundary. There is a farm dam about 300m north from the project boundary	No	650m from the project boundary (from the project boundary to tributary of Cosgrove Creek)
5150	21.2	23.8	2.6	12%	0.1%	15%	15%	0.59	0.95	0.36	61%	1.57	1.78	0.21	13%	2.82	3.15	0.33	12%	Drainage lines 5150 and 5160 both discharge into a series of three (3) farm dams within the private property on the western side of the airport access road.	Yes	Between the project boundary and Badgerys Creek (about 550m from project boundary)
5160	26.2	25.7	-0.5	-2%	0.1%	12%	12%	0.77	0.84	0.07	9%	2.01	1.98	-0.03	-1%	3.64	3.68	0.04	1%			
d/s 5150								2.01	2.07	0.06	3%	5.21	5.39	0.18	3%	9.58	9.95	0.37	4%	The increase in flow rate will be 4% in the 100 year ARI event at the Badgerys Creek which is located about 550m from the project boundary.	No	

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
d/s 4600	1.270	1.273	0.00	1.8	1.81	0.01	1) The flow to the tributary of Cosgrove Creek will increase by up to 1% in the 100 year ARI event due the minor drainage as part of the motorway works. 2) The existing farm dam located about 300m from the project boundary, will be subjected to increased flow. This will have adverse impact on the performance of the spillway and its scour protection.	1) The mainstream flooding has been assessed as part of the Cosgrove Creek flood modelling. Refer to the flood report for commentary in this issue. 2) The existing dam, the spillway and its scour protection should be surveyed for assessing the capacity of the dam and its spillway.	1) Refer to flood report for commentary on the mitigation measure required for the mainstream flooding impact, if any. 2) Upgrade the dam spillway and scour protection. Negotiation and compensation to the land owner may be required.	At about 650m from the project boundary
5150	0.300	0.320	0.02	0.352	0.37	0.02	1) Afflux of 20mm at the project boundary. 2) Overall there will be increased flow to the farm dams. This is likely to impact adversely on the performance of the dams and their spillways.	Survey and assess the size of the existing farm dam spillways for all three dams.	1) EIS to recommend 20mm afflux acceptable through downstream drainage line as this afflux value is considered to be negligible given there are no houses or structures that could be impacted. 2)Upgrade the farm dam spillways including scour protection for the three farm dams within the private property.	Project boundary
5160										Project boundary
d/s 5150							Flow to Badgerys Creek increases by up to 4% in the 100 year storm event due to the motorway minor drainage works.	Flood modelling of the Badgerys Creek has assessed the impacts of the motorway works on the mainstream flooding.	Refer to the flooding report for commentary on the mainstream flood impacts.	At the outfall to Badgerys Creek about 550m from the project boundary

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
5300	19.4	17.47	-1.93	-10%	0.0%	0%	0%	1.50	1.36	1.60	-16%									Farm dam at approximate CH 5300 located at about 400m from the project boundary on the northern side of the alignment.	Yes	NA
5870	15.9	15.5	-0.4	-3%	0.1%	10%	10%	0.62	0.64	0.02	3%	1.38	1.34	-0.04	-3%	3.28	3.22	-0.06	-2%	Farm dam is located immediate downstream of project. The increase in flow rate is within 10% criteria which is unlike to cause significant hydrological impact and is considered acceptable. Mitigation measure is not required.There will not be any reduction in the dam yield as the 2 year ARI	No	NA
6820	46.1	44.9	-1.2	-3%	0.1%	0%	0%	1.14	1.11	-0.03	-3%	2.99	2.93	-0.06	-2%	5.62	5.48	-0.14	-2%	There will be reduction in the peak flow rate the project boundary. There are no farm dams and therefore reduction in peak flow rates will not cause adverse impact to this minor drainage lines and no mitigation measure is required.	No	NA
8700	4.4	2.9	-1.5	-34%	0.1%	7%	7%	0.16	0.11	-0.04	-27%	0.37	0.25	-0.12	-32%	0.81	0.58	-0.23	-28%	Culvert is located outside M12 project boundary	No	NA
8930	7.3	7.5	0.2	3%	0.1%	9%	9%	0.30	0.32	0.02	7%	0.65	0.67	0.01	2%	1.60	1.65	0.05	3%	Culvert is located outside the M12 project bound	No	NA
9140	2	1.2	-0.8	-40%	0.1%	14%	14%	0.20	0.10	-0.10	-50%	0.40	0.30	-0.10	-25%	0.70	0.40	-0.30	-43%	Culvert is located outside the M12 project bound	No	NA
9701	18.3	37.4	19.1	104%	0.1%	15%	15%	0.58	1.49	0.91	156%	1.44	2.88	1.44	100%	2.84	5.39	2.55	90%	Outfall of drainage line 9701 is located at Kemps Creek which is about 60m downstream of project boundary. The flow increase will be 90% in the 100 year ARI storm event along this minor drainage line until joining Kemps Creek 60m downstream of the project.	Yes	60m from project boundary
10510	21.7	21.24	-0.5	-2%	0.1%	5%	5%	0.71	0.70	-0.02	-2%	1.73	1.70	-0.03	-2%	3.52	3.44	-0.08	-2%	There will be flow reduction at this drainage line. No adverse imapct.	No	NA

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
5300	1705 cu. m (2 year ARI runoff volume)	1535 cu m (2 year ARI runoff volume)	-170 cu.m (2 year ARI reduction in runoff volume)				Yield of the dam reduced by 10%.		Compensate the land owner as the reduction in the yield is 10%.	Farm dam at approximate CH 5300 located at about 400m from the project boundary on the northern side of the alignment.
5870										Project boundary
d/s 5870										
6820										Project boundary
8700										At the culvert outlet
8930										At the culvert outlet
9140										At the culvert outlet
9701	0.589	0.750	0.16	0.90	1.00	0.10	1) Afflux of 160mm at the downstream project boundary. 2) Increased flow to Kemps Creek from this drainage line which could impact adversely on the mainstream flooding.	Flood modelling of Kemps Creek considered mainstream flooding . No further assessment as part of minor drainage line is required. Refer to the flood report for commentary on the impacts of the motorway works on the mainstream flooding.	1) RMS to acquire the land containing the area downstream of the culvert outlet to the Kemps Creek as a drainage easement.	At the outlet of culvert under access track just d/s of project boundary
10510										Project boundary

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
12030	6.7	7.9	1.2	18%	0.1%	20%	20%	0.23	0.42	0.19	85%	0.54	0.64	0.09	17%	1.14	1.46	0.32	28%	Drainage lines 12030 and 12300 join into an existing watercourse immediate downstream of the project boundary, run alongside the existing quarry site access road and then discharge into Kemps Creek about 800m from the project boundary.	Yes	From the project boundary to Kemps Creek about 800m
12300	19.5	24	4.5	23%	0.1%	16%	16%	0.68	0.99	0.32	47%	1.60	1.94	0.34	21%	3.43	4.07	0.64	19%		Yes	
ds 12030/12300								1.29	1.46	0.17	13%	3.32	3.78	0.46	14%	6.33	7.26	0.93	15%		Yes	
13080	1.5	0.97	-0.5	-35%	0.1%	1%	1%	0.08	0.05	-0.03	-35%	0.18	0.13	-0.06	-32%	0.64	0.44	-0.20	-31%	Confluence of drainage line 13080 and 13180 is about 60m downstream of the project boundary.	No	600m d/s of project boundary at the inlet of the property access culvert to Sydney International Shooting Centre
13180	5.8	8.3	2.5	43%	0.1%	27%	26%	0.27	0.58	0.31	113%	0.57	0.87	0.30	52%	1.47	2.29	0.82	56%		Yes	
d/s 13080/13180								0.50	0.59	0.09	18%	1.06	1.28	0.22	21%	2.77	3.38	0.61	22%		Yes	
d/s 13080/13180								0.88	0.97	0.09	11%	1.90	2.06	0.16	8%	4.47	4.97	0.50	11%		Yes	
13500	2.5	0.63	-1.9	-75%	0.1%	13%	13%	0.30	0.10	-0.20	-67%	0.60	0.20	-0.40	-67%	1.00	0.30	-0.70	-70%	Peak flow rate decrease at the project boundary for all storms mainly due to reduction in the catchment areas. There will be no adverse impact downstream form hydrological perspective. There is also no farm dam in the immediate vicinity of the drainage line.	No	NA

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
12030	0.254	0.271	0.02	0.57	0.60	0.03	1)Afflux of 20mm at the downstream project boundary. 2) There will be increase flow to Kemps Creek from the motorway works.	No local infrastructure, culverts or house exist of this minor drainage line. No further is assessment required for this line. Flood assessment of Kemps Creek has considered impact of the works on mainstream flooding. Refer to the flood report for commentary on flood impacts at this location.	1) EIS to recommend 40mm afflux through downstream drainage line. 2) RMS could acquire a drainage easement through the downstream property to Kemps Creek to formalise the existing drainage and properly discharge to Kemps Creek.	Project Boundary
12300	0.553	0.583	0.03	0.57	0.60	0.03	1)Afflux of 30mm at the downstream project boundary adjacent to quarry access road. 2) There will be increase flow to Kemps Creek from the motorway works.			Project Boundary
ds 12030/12300	0.592	0.628	0.04	1.53	1.59	0.06	1) Afflux of 40mm at the outfall to Kemps Creek. 2) Increased flow to Kemps Creek from this drainage line which could impact adversely on the mainstream flooding.	Flood modelling of Kemps Creek considered mainstream flooding . No further assessment as part of minor drainage line is required. Refer to the flood report for commentary on the impacts of the motorway works on the mainstream flooding.		At the outfall in Kemps Creek about 800m from the project boundary
13080										
13180	0.309	0.361	0.05	0.95	1.11	0.16	Afflux of 50mm at the downstream project boundary.		1) EIS to recommend 50mm afflux through downstream drainage line.	Project Boundary
d/s 13080/13180	0.317	0.338	0.02	1.16	1.23	0.07	Afflux of 20mm at 250m downstream of the project boundary.	Survey and investigate the existing dams and assess spillways sizes and the existing scour protection.	1) Upgrade of spillways of the two dams (one located 250m from the project boundary and the other located 360m from the project boundary) including scour protections. 2) Compensate the land owner for the farm dams and spillway upgrade.	250m d/s of project boundary at exisitng farm dam
d/s 13080/13180							Increase in the flows to the property access culvert. The existing culvert should be surveyed to assess the capacity and the potential impacts.	The existing culvert should be surveyed to assess the capacity and the potential impacts.	1) Upgrade the property access culvert on the access road to Sydney International Shooting Centre to provide for the existing flood immunity.	600m d/s of project boundary at the inlet of the property access culvert to Sydney International Shooting Centre
13500										Project Boundary

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
13790	3.65	3.17	-0.5	-13%	0.1%	16%	16%	0.26	0.29	0.03	11%	0.60	0.59	-0.01	-2%	1.01	0.99	-0.02	-2%	Confluence of drainage line 13790 and 13910 is about 70m downstream of the project boundary at Elizabeth Drive.		
13910	2.68	2.8	0.1	4%	0.1%	23%	22%	0.25	0.30	0.05	20%	0.55	0.60	0.05	9%	0.88	1.00	0.13	14%		Yes	
ds 13790/13910								0.84	1.11	0.27	32%	1.85	2.01	0.16	9%	2.97	3.16	0.19	6%		Yes	From the project boundary to Elizabeth Drive
14040	9.1	9.3	0.2	2%	0.1%	9%	9%	0.42	0.44	0.02	5%	0.88	0.91	0.03	4%	2.25	2.36	0.11	5%	Elizabeth Drive is approximately 130m downstream of the project	No	
ds 14040								0.54	0.55	0.01	2%	1.13	1.16	0.03	3%	2.95	3.08	0.13	4%		Yes	From the project boundary to Elizabeth Drive about 130m d/s of project boundary.

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
13790										
13910	0.190	0.200	0.01	0.773	0.799	0.03	Afflux of 10mm at the downstream project boundary.		1) EIS to recommend 10mm afflux through downstream drainage line.	Project boundary
ds 13790/13910							1)Potential for impact on the capacity of the existing culvert beneath Elizabeth Drive causing flooding. 2) Flood immunity to Elizabeth Dr will be reduced	The existing culvert has been assessed for the increased flow from the motorway works. It has been found that the culvert is undersized for the existing and the post developed flows and does not cater for the 100 year ARI flood immunity to Elizabeth Drive. By addition of extra 0.20 cumec due to the M12 works makes the culvert overflow higher and will increase the overflow depth over Elizabeth Drive.	2) Provision of detention basin at the upstream of culvert at 13910 so that the post developed peak flow rates are not more than the existing peak flow rates in all storm events up to 100 yr ARI. 3) Provision of detention basin at the downstream of the project boundary so that the post developed peak flow rates are not more than the existing peak flow rates in all storm events up to 100 yr ARI. 4) Reduce the size of the proposed culvert beneath M12 and increase the headwater to reduce the flow to Elizabeth Drive.	At Elizabeth Drive about 70m d/s of project boundary.
14040										Project boundary
ds 14040							Reduction in flood immunity to the existing culvert beneath Elizabeth Drive.	The existing culvert (600 RCP) has been assessed for the increased flow from the motorway works. The existing culvert does not have capacity to cater for the existing 100 year ARI flow and the additional flow from the motorway worsens the flooding situtaion.	1) Upgrade the existing culvert beneath Elizabeth Drive. 2) Provide a reduced size culvert in the M12 motorway to reduce the outflow to the Elizabeth Drive culvert making sure that post developed peak flows are less than the pre developed peak flows in the 100 year ARI. 3) Alternatively, provide a detention basin in the area between the M12 and Elizabeth Drive and size the basin so that the flow to the Elizabeth Drive culvert is reduced to a level that the culvert would provide 100 year ARI flood immunity to Elizabeth Drive.	At Elizabeth Drive about 130m d/s of project boundary.

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
14190	8.5	9.4	0.9	11%	0.1%	17%	17%	0.39	0.45	0.06	14%	0.83	0.95	0.12	14%	2.13	2.48	0.35	16%	Elizabeth Drive is approximately 130m downstream of the project. Drainage line joins an unnamed tributary of Ropes Creek immediately downstream of Elizabeth Drive	Yes	From the project boundary to Elizabeth Drive
ds 14190								0.58	0.59	0.02	3%	1.22	1.26	0.04	3%	3.10	3.25	0.15	5%	The peak flow rates decrease to acceptable limit of less than 10% at the Elizabeth Drive.	No	
13570	10.3	9.9	-0.4	-4%	0.1%	4%	4%	0.46	0.45	-0.01	-2%	0.96	0.93	-0.03	-3%	2.41	2.35	-0.06	-2%	Drainage lines 13570, 13700 and 13890 all discharge into a farm dam about 120m downstream of the project boundary.	Yes	ect boundary to Elizal
13700	4.5	4.13	-0.4	-8%	0.1%	7%	7%	0.23	0.21	-0.02	-8%	0.51	0.47	-0.04	-8%	1.45	1.35	-0.10	-7%		Yes	From project boundary to Elizabeth Drive
13890	5.5	7.7	2.2	40%	0.1%	35%	35%	0.27	0.71	0.43	160%	0.61	1.06	0.45	74%	1.70	2.75	1.05	62%		Yes	From project boundary to Elizabeth Drive

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
14190	0.442	0.460	0.02	1.18	1.23	0.05	Afflux of 20mm at the downstream project boundary.	The existing culvert should be assessed for the increased flow from the motorway works.	1) EIS to recommend 20mm afflux through downstream drainage line. 2) Provide a reduced size culvert in the M12 motorway to reduce the outflow to the Elizabeth Drive culvert making sure that post developed peak flows are less than the pre developed peak flows in the 100 year ARI. 3) Alternatively, provide a detention basin in the area between the M12 and Elizabeth Drive and size the basin so that the flow to the Elizabeth Drive culvert is reduced to a level that the culvert would provide 100 year ARI flood immunity to Elizabeth Drive.	Project boundary
ds 14190							Potential for impact on the capacity of the existing culvert beneath Elizabeth Drive causing flooding.	The existing culvert (900 RCP) has been assessed for the increased flow from the motorway works. It has been found that the existing culvert does not provide 100 year ARI flood immunity to Elizabeth Drive and the increase in the flow due to the motorway works by 5% will worsen the flooding situation.		At Elizabeth Drive, 130m from project boundary
13570							Drainage lines 13570 and 13700 discharge into an existing 2x 450 RCP beneath Elizabeth Drive. Flow rates have not increase, hence, upgrade of the existing culvert would not be required. However, it should be noted that the existing culvert is undersized and does not cater for the 100 year ARI peak flow. This will create flooding within the M12 project boundary.		Upgrade the existing culvert beneath Elizabeth Drive for 100 year ARI peak flow. Alternatively, provide a detention basin in the area between the M12 and Elizabeth Drive and size the basin so that the flow to the Elizabeth Drive culvert is reduced to a level that the culvert would provide 100 year ARI flood immunity to Elizabeth Drive.	Project Boundary
13700										Project boundary
13890	0.146	0.198	0.05	0.8	0.987	0.19	Potential for impact on the capacity of the existing culvert beneath Elizabeth Drive causing flooding.	Drainage line 13890 discharges into 2 x600 RCP culvert beneath Elizabeth Drive. The existing culvert has been assessed for the hydraulic capacity and it has been found that the existing culvert does not have capacity for the existing flows and the flow has increased by 62% due to the M12 works.This creates extensive flooding in the area.	1) Upgrade the existing culvert beneath Elizabeth Drive by adding another culvert adjacent to the existing. 2)Provide a detention basin in the area between the M12 and Elizabeth Drive and size the basin so that the flow to the Elizabeth Drive culvert is reduced to a level that the culvert would provide 100 year ARI flood immunity to Elizabeth Drive.	Project boundary

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
ds 13570/13700/13890	28.42	29.37	0.9	3%	0.1%			1.27	1.34	0.07	6%	2.73	2.95	0.22	8%	7.17	7.84	0.67	9%		No	At Farm dam (corner of Elizabeth Dr/Cecil Rd)
ds 13570/13700/13890								2.41	3.00	0.59	24%	5.50	6.04	0.54	10%	9.42	10.10	0.68	7%	Peak flow rate to the farm dam increased by 7% in 100 year ARI. This drainage line joins the drainage line 14220 and continues in northerly direction to connect to the tributary of Ropes Creek which has been further assessed as part of 15450/14220 drainage line assessement.	No	At Farm dam in a private property about 350m north of project boundary
14000	2.8	1.2	-1.6	-57%	0.1%	6%	6%	0.30	0.10	-0.20	-67%	0.60	0.30	-0.30	-50%	1.00	0.40	-0.60	-60%	Flows are reduced, no mitigation measure required.	No	NA
14220	24.8	23.8	-1	-4%	0.1%	13%	13%	1.20	1.50	0.30	25%	2.70	2.90	0.20	7%	5.10	4.90	-0.20	-4%	Confluence of the drainage line 14220 and the unnamed tributary of Ropes Creek is about 200m downstream of the project boundary.		
15450	39.2	40.6	1.4	4%	7.9%	16%	8%	1.70	2.60	0.90	53%	4.10	5.00	0.90	22%	7.50	8.30	0.80	11%	Drainage line discharges into the tributary of Ropes Creek.	Yes	
ds 15450/14220								6.34	6.95	0.61	10%	14.30	14.60	0.30	2%	25.30	25.80	0.50	2%		No	
14640	0.32	0.24	-0.1	-25%	0.1%	1%	1%	0.05	0.04	-0.01	-20%	0.10	0.10	0.00	0%	0.10	0.10	0.00	0%			

Drainage Line ID	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Exisitng	Proposed	Change	Existing	Proposed	Change				
ds 13570/13700/13890							Increased flow to the dam results in dam spillway to be upsized and extra scour protection is provided to the spillway. Increased flow to the dam will increase outflow from the dam resulting in adverse impact to the performance of the existing culvert beneath Cecil Road.	The existing culvert to be surveyed and assessed for hydraulic capacity.	1) Upgrade spillway of the dam including scour protection. 2) Upgrade of the existing culvert beneath Cecil Road.	At Farm dam (corner of Elizabeth Dr/Cecil Rd)
ds 13570/13700/13890							Increased flow to the dam results in dam spillway to be upsized and extra scour protection is provided to the spillway.	The existing dam to be surveyed and inspected at detail design.	1) Upgrade spillway of the dam including scour protection.	At Farm dam in a private property about 350m north of project boundary
14000										Project Boundary
14220							1) The increase in the 2 to 10 year ARI flow is considered significant and may impact adversely on the existing culverts beneath Wallgrove Road/Elizabeth Drive intersection. This may cause flooding at the intersection for these storm events.	The existing culvert to be surveyed and assessed for hydraulic capacity. Note the existing culverts typically are undersized and do not cater for the 100 year ARI standard for road drainage culverts.	1) Upgrade the existing culverts if the existing culverts are found to have insufficient capacity.	Project boundary
15450	0.337	0.347	0.01	1.18	1.22	0.04	1) Afflux 10mm on the existing watercourse in the private property at the project boundary.		1)EIS to allow 10mm afflux.	Project boundary
ds 15450/14220								Flood modelling must be carried out at detailed design to model and confirm the flooding impact in the tributary of Ropes Creek due to the proposed motorway road and drainage works.		In the tributary of Ropes Creek at the confluence of drainage line 14220 and 15450 about 500m from the project boundary off line 14220.
14640										

Drainage Line ID	Catchment Area (ha)				%Imp			Peak Discharges (m^3/s) - 2 Yr				Peak Discharges (m^3/s) - 10 Yr				Peak Discharges (m^3/s) - 100 Yr				Comment	Impact Modelling Required?	Extent of Impact
	Existing	Post	Difference	%Diff	Existing	Post	Difference	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff	Existing	Post	Diff	%Diff			
14810	4.5	5.6	1.1	24%	0.1%	23%	23%	0.40	0.70	0.30	75%	0.90	1.30	0.40	44%	1.50	2.00	0.50	33%	Drainage line 14810 discharges into a drainage pit on the reserve about 90m downstream of the project boundary. The drainage then flows through an existing pit and pipe system in the existing housing development.	Yes	Project boundary to the existing development
ds 14810								2.26	2.41	0.15	7%	4.00	4.25	0.25	6%	6.22	6.58	0.36	6%	The model has been extended to establish the location where the impact of the M2 works in this drainage line becomes insignificant in accordance with the 10% limit.	No	500m from the project boundary to Lancaster Avenue
15350	28.1	29	0.9	3%	14.6%	23%	9%	1.42	1.75	0.33	23%	3.74	3.02	-0.72	-19%	11.70	7.99	-3.71	-32%	Confluence of drainage line 15350 and 15520 is approximately 250m downstream of the project	No	
15520	27.7	27.5	-0.2	-1%	5.1%	8%	3%	1.36	1.25	-0.11	-8%	2.96	2.59	-0.37	-13%	8.01	6.58	-1.43	-18%			750m downstream of the project at Feodore Drive/ Cecil Street intersection
d/s 15350/15520								4.66	4.98	0.32	7%	10.60	9.89	-0.71	-7%	26.50	21.40	-5.10	-19%	Theere will be decrease in the peak flow rate in the 100 year ARI by about -19% at about 750m downstream of the project at Feodore Drive/ Cecil Street intersection. However, the 2 year ARI peak flow rate will increase by 7%.		

Notes:
1. The peak flow rates are estimated by using DRAINS software using ILSAX, RAFTS or both hydrological models as appropriate.
2. Manning's n of 0.05 has been assumed for the existing and the proposed case (brushy flow paths) at the 'Point of Interest'.
3. Dams that are located fully or partly within the road corridor are not assessed. It is assumed that these dams will be filled as part of the project works.
4. Dams that do not receive flow from the motorway drainage and the catchment areas have not changed from the pre developed to the post developed case have not been included in the assessment for impact to 'yield'.

Drainage Line ID	Catchment Area	Normal Depth m (100 yr)			Normal Velocity m/s (100 yr)			Potential Impacts	Further Investigation	Mitigation Measures	Point of Interest
	Existing	Exisitng	Proposed	Change	Existing	Proposed	Change				
14810	4.5	0.344	0.383	0.04	1.75	1.87	0.12	1) Afflux 40mm at project boundary. 2) velocity of flow in d/s channel increases requiring scour protection. 3) The 10 year ARI flow increases by 44%, this would impact adversely on the downstream pipe drainage system through the existing development. 4) Overland flow through the Jaquetta Close in the existing housing development will increase which causes road overland flooding.		1)EIS to allow 40mm afflux given that the affected land is a reserve and there are no houses or structures. 2) Culvert to be re-sized with reduced diameter providing high headwater at the inlet and ensuring that peak flow rate in 10 year ARI and above do not exceed the existing peak flows. This is to ensure that the downstream pipe drainage through the existing development is not impacted adversely by the proposed motorway works. 3) Provide a detention basin near the l the existing pit on the reserve just upstream of Jaquetta Close. Land acquisition is required.	Project boundary
ds 14810											About 500m downstream from Project boundary
15350	28.1										Project boundary
15520	27.7										
d/s 15350/15520								1) 2 year ARI peak flow rates increases by 7% which may increase depth of overland flow through the drainage reserve in the existing housing development.	Survey and investigate capacity of the existing pit and pipe system along the reserve within the housing development. The flow increase in the 2 year ARI due to M12 works should be catered for by the existing pit and pipe system through the development (assuming the existing drainage has been designed for 10 year ARI). However, this needs to be confirmed.	It is highly likely no mitigation measure will be required as the 10 and 100 year ARI peak flows have reduced. The increase in 2 year ARI peak flow rates is considered not significant as this would not impact on the existing pit and pipe system.	At Culvert 700m from the project boundary

Notes:
1. The peak flow rates are estimated by using DRAINS software using ILSAX, RAFTS or both hydrological models as appropriate.
2. Manning's n of 0.05 has been assumed for the existing and the proposed case (brushy flow paths) at the 'Point of Interest'.
3. Dams that are located fully or partly within the road corridor are not assessed. It is assumed that these dams will be filled as part of the project works.
4. Dams that do not receive flow from the motorway drainage and the catchment areas have not changed from the pre developed to the post developed case have not been included in the assessment for impact to 'yield'.

rms.nsw.gov.au/

13 22 13

Customer feedback
Roads and Maritime
Locked Bag 928,
North Sydney NSW 2059

October 2019
RMS 19.1374
ISBN: 978-1-925891-89-8