TECHNICAL PAPER

11

Hydrology, flooding and water quality

ALBURY TO ILLABO ENVIRONMENTAL IMPACT STATEMENT

ARTC INLAND RAIL

JULY 2022

ALBURY TO ILLABO (A2I) PROJECT

2-0008-210-EAP-00-RP-0010

TECHNICAL PAPER 11 – HYDROLOGY, FLOODING AND WATER QUALITY

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GLOSSARY

A2I	Albury to Illabo section of Inland Rail
Active level crossing	At grade road crossing of the rail corridor which uses flashing lights and boom barriers for motorists, and automated gates for pedestrians. These devices are activated prior to and during the passage of a train through a level crossing.
AEP	Annual Exceedance Probability. The probability that a design event (rainfall or flood) has of occurring in any one-year period.
Afflux	With reference to flooding, afflux refers to the predicted change, usually in flood levels, between two scenarios. It is frequently used as a measure of the change in flood levels, between an existing scenario and a proposal scenario.
AIDR	Australian Institute for Disaster Resilience
ANZECC	Australian and New Zealand Environment Conservation Council
ANZG	Australia New Zealand Guidelines for Fresh and Marine Water Quality
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
BTEX	Benzene, toluene, ethylbenzene, and xylene
Catchment	The area drained by a stream or body of water or the area of land from which water is collected.
CEMP	Construction Environment Management Plan A site-specific plan developed for the construction phase of a project, to ensure that all contractors and sub-contractors comply with the environmental conditions of approval for the project and manage environmental risks properly.
Construction compound	An area used as the base for construction activities, usually for the storage of plant, equipment and materials and/or construction site offices and worker facilities.
Construction footprint	The area that would be used for the construction of the proposal.
CSSI	Critical State Significant Infrastructure
Culvert	A structure that allows water to flow under a road, railway, track, or similar obstruction.
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts
DO	Dissolved oxygen
Down line	Track within a dual-track section of corridor on which trains travel away Sydney Central station
DPE	NSW Department of Planning and Environment
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
EC	Electrical conductivity

Enhancement site	Discrete sites within the A2I section that are proposed for infrastructure enhancement. Enhancement works at each of these discrete work sites may include raising, widening or replacing bridges, raising or replacing signal gantries, and lowering sections of track.
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
EY	Exceedances per year. Used to define the frequency of occurrence of more frequent rainfall or flood events. For example, a design event (rainfall or flood) that has a chance of occurring once during every six-month period is expressed as having 2 Exceedances per Year (2EY).
Flood Immunity	When a flood level of a specified AEP flood event will not exceed the referenced level of the infrastructure. Flood immunity is generally assessed at the top of formation where the top of formation level can be determined from information on the depth of the track, ballast and capping layers. Where this information is not available, the flood immunity is assessed at the top of the rail level (referred to as top of rail).
Flood prone land	Land susceptible to flooding by the probable maximum flood. Note that the flood prone land is also known as flood liable land.
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. It is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (i.e. flood prone land).
Gantry	An overhead metal structure with a frame supporting equipment such as a signals, lighting or cameras.
GDE	Groundwater dependent ecosystems (GDEs) are defined as ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services'.
GIS	Geographic information systems
Groundwater	Water found in the saturated zone below the water table or piezometric surface.
Hydrology	Term given to the study of the rainfall and runoff process, including surface and groundwater interaction; with particular focus on the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
IFD	Intensity–Frequency–Duration
Impact	Influence or effect exerted by a proposal or other activity on the natural, built and community environment.

Inland Rail program	The Inland Rail program comprises the design and construction of a new Inland Rail connection between Melbourne and Brisbane, via Wagga, Parkes, Moree, and Toowoomba. The route for Inland Rail is about 1,700 km in length. Inland Rail will involve a combination of upgrades of existing rail track and the provision of new track.
km	kilometres
Loop line	Track which briefly leaves the main line and re-join to allow for train passing or access to minor locations.
mAHD	Elevation in metres with respect to the Australian Height Datum.
Main line	Primary track on which trains travel within a sing track section of corridor
mm	Millimetre
N2NS	Narrabri to North Star
NSW	New South Wales
OCPs	Organochlorine pesticide
Operational footprint	Area occupied by permanent infrastructure and required for the operation of the proposal.
OPPs	Organophosphorus pesticides
Overbridge	A bridge over a railway or road. For the proposal, overbridges refer to those structures which allow a road to pass over the railway.
PAH	Polycyclic aromatic hydrocarbons
Passive level crossing	At grade road crossing of the rail corridor which uses stop or give way signs for motorists, and 'look for trains' signs for pedestrians.
Peak discharge	The maximum discharge occurring during a flood event.
Peak flood level	The maximum water level occurring during a flood event.
Pedestrian bridge	A bridge designed solely for pedestrians to cross a watercourse, rail corridor or road.
PFAS	Per- and poly-fluoroalkyl substances
PMF	Probable maximum flood. The flood that occurs as a result of the probable maximum precipitation on a study catchment. The probable maximum flood is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land (i.e. the floodplain).
Pollutant	Any measured concentration of solid or liquid matter that is not naturally present in the environment.
Precinct	Groupings of enhancement sites in line with the LGAs including Albury, Greater Hume – Lockhart, Wagga Wagga and Junee.
Rail corridor	The corridor within which the rail tracks and associated infrastructure are located
Runoff	The amount of rainfall that ends up as streamflow, also known as rainfall excess.

Shared user bridge	Descriptor of infrastructure or path bridge designed for to accommodate pedestrians and cyclists safely to cross a watercourse, rail corridor or road.
SSI	State Significant Infrastructure
Study Area	The wider area, including and surrounding the proposal site, with the potential to be directly or indirectly affected by the proposal. The extent of the study area varies according to the requirements of each assessment and the potential for impacts.
SWMP	Soil and Water Management Plan
TDS	Total dissolved solids
The Blue Book	The *Managing Urban Stormwater – Soils and Construction* (Landcom, 2004) series of handbooks, also known as the Blue Book, are an element of the NSW Government's urban stormwater program specifically applicable to the construction phase of developments. These provide guidance for managing soils in a manner that protects the health, ecology and amenity of urban streams, rivers estuaries and beaches through better management of stormwater quality.
The proponent	Australian Rail Track Corporation (ARTC)
The proposal	Proposed enhancement works to structures and sections of track along 185 kilometres of the existing operational standard gauge railway between Albury and Illabo for the purpose of meeting Inland Rail specifications.
The proposal site	The areas that enhancement works are required to operate the Albury to Illabo section of Inland Rail. It includes the location of construction worksites, operational rail infrastructure, new bridge structures (road and shared user) and other ancillary work. It is otherwise referred to as the construction footprint.
TN	Total Nitrogen
TP	Total Phosphorous
Track	The structure consisting of the rails, fasteners, sleepers and ballast, which conveys trains.
TRH	Total recoverable hydrocarbons
TSS	Total Suspended Solids
TUFLOW	Water Flow modelling software (www.tuflow.com)
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent).
WM Act	*Water Management Act 2000* (NSW)
XP-RAFTS	XP Runoff Analysis and Flow Training Simulation Software. A comprehensive software program to simulate runoff hydrographs at defined points throughout a watershed based on a set of catchment characteristics and specific rainfall events.

EXECUTIVE SUMMARY

The Australian Government has committed to delivering a significant piece of national transport infrastructure by constructing a high performance and direct interstate freight rail corridor between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland. Inland Rail is a major national program that would enhance Australia's existing national rail network and serve the interstate freight market.

Australian Rail Track Corporation Ltd (ARTC) ('the proponent') is seeking approval to construct and operate the Albury to Illabo section of Inland Rail ('the proposal').

This report has been prepared as part of the environmental impact statement (EIS) to assess potential impacts of the proposal to hydrology, flooding and water quality of the proposal. The report addresses the relevant Secretary's Environmental Assessment Requirements (SEARs) issued by the Secretary of the (former) NSW Department of Planning, Industry and Environment (now the Department of Planning and Environment (DPE)) on 14 October 2020.

The proposal involves enhancement works to structures and sections of track along 185 kilometres of the existing operational standard-gauge railway between Albury and Illabo. Enhancement works are required to provide the increased vertical and horizontal clearances required for double-stacked freight trains. The enhancement sites have been broken down into four precincts, which align with the local government areas (LGA) of Albury, Greater Hume – Lockhart, Wagga Wagga and Junee.

FLOODING

Available flood model data, which largely consisted of flood studies prepared for the LGAs for the proposal site, has been used to define flood conditions at the proposal and assess the possible flood impacts caused by the enhancement works. Where needed, drainage models have been developed to describe local catchment drainage conditions and runoff.

Quantitative Design Limits (QDL) for the flood impact assessment have been adopted from the criteria set by the Conditions of Approval for the Narrabri to North Star (N2NS) Phase 1 project and as revised in the Draft Conditions of Approval for the North Star to Border (NS2B) project (May 2022). The criteria were considered suitable on the basis of similarity of the proposal (enhancement of the existing rail line), similarity of land uses around the study area and similar flood behaviour. QDLs apply to the area outside the rail corridor and are identified for the following parameters:

- afflux (i.e., increase in flood level)
- scour and erosion (increase in flood velocity)
- flood hazard (increase in velocity depth (vd) product)
- flood duration (increase in duration of inundation).

Flood impacts in the construction phase are limited for the duration of the construction works, and the enhancement sites represent small areas in the wider local surface water catchments. As such, the impacts on drainage, flooding and water quality would be temporary, localised and minor.

As per the SEARS issued for the proposal, this assessment has considered the impacts of the proposal during operation for a full range of flood events up to the probable maximum flood. The upper limit of the QDLs is the 1% AEP event and has used as the indicator for flood performance. The existing flooding and drainage conditions for each precinct, and impacts at the proposal site, in the operation phase are summarised in the table below. Flood impacts are expected to be compliant with the QDL criteria, except at one location in Wagga Wagga where an increase in afflux was predicted. This would be re-modelled during detailed design with additional drainage and topography data which is expected to result in a reduction in the predicted afflux.. There are no specific mitigation measures required for the operation phase beyond standard practice scour and erosion management measures incorporated into the design of any drainage system modifications.

Table ES.1 Summary of flooding impacts

ENHANCEMENT SITE	KEY FEATURES	FLOOD RISK – EXISTING CONDITIONS	FLOOD IMPACTS (OPERATION PHASE)	QDL COMPLIANCE
Albury precinct				
Murray River bridge	Rail bridge alterations	Proposal site lies within the Murray River floodplain.	No flood impacts are expected as proposal enhancement works are limited to the bridge truss span (required to provide clearances for the Inland Rail rollingstock). There is no change to the existing drainage and flood conditions.	Yes
Albury Yard pedestrian bridge	Pedestrian bridge replacement	Proposal site is not affected by overland flooding up to and including the 1% AEP.	The site is not subject to flooding up to and including the 1% AEP flood event; therefore, no impacts to the existing flood and drainage conditions are expected as a result of the proposed works.	Yes
Albury Yard clearances	Track realignment	Proposal site is not affected by overland flooding up to and including the 1% AEP.	The site is not subject to flooding up to and including the 1% AEP flood event; therefore, no impacts to the existing flood and drainage conditions are expected as a result of the proposed works.	Yes
Riverina Highway bridge	Track lowering and realignment	The proposal site is affected by overland flooding.	The proposed drainage works within the rail corridor would convey surface water runoff and the overland flow from the upstream catchment mimicking the existing drainage and flood conditions., Drainage system modelling determined that the proposed works do not generate adverse flood impacts.	Yes
Billy Hughes bridge	Track lowering and realignment	Proposal site is not affected by flooding from the nearby watercourses (i.e. Eight Mile Creek and Billy Hughes Creek). An assessment of the rail drainage conditions has confirmed a 1% AEP rail flood immunity.	The drainage model results show that proposal is compliant with the QDLs.	Yes

ENHANCEMENT SITE	KEY FEATURES	FLOOD RISK – EXISTING CONDITIONS	FLOOD IMPACTS (OPERATION PHASE)	QDL COMPLIANCE
Table Top Yard Clearances	Gantry removal	The proposal site is not located within flood-prone land.	The proposed structural works have no impact on the existing flood and drainage conditions. There are no changes to the track alignment.	Yes
Greater Hume – Lockhart precinct				
Culcairn Yard clearances	Track realignment	The proposal site is not located within flood-prone land.	There would be no change to the existing flood and drainage condition at the site as a result of the proposal.	Yes
Culcairn Yard pedestrian bridge	Pedestrian bridge removal	The proposal site is not located within flood-prone land.	There would be no change to the existing flood and drainage condition at the site as a result of the proposal.	Yes
Henty Yard clearances	Track realignment Level crossing modifications	The proposal site is not located within flood-prone land up to and including the 1% AEP flood event.	Henty Yard clearances is not affected by regional flooding; therefore, proposed works are not expected to change the existing regional flood conditions. The proposed drainage works are limited to the management of the platform surface water run-off, as the proposed drainage works mimic the existing drainage conditions.	Yes
Yerong Creek Yard clearances	Track realignment	The works are located between two local sub-catchments and runoff is directed away from the site.	The works do not affect overland flows or defined watercourses would not generate any flood impacts at the site nor downstream of the site.	Yes
The Rock Yard clearances	Gantry modification	Council flood maps show that the rail corridor is not overtopped by flood water up to and including the 0.5% AEP flood event.	There would be no change to the existing flood and drainage conditions at the site as a result of the proposed enhancement works.	Yes

ENHANCEMENT SITE	KEY FEATURES	FLOOD RISK – EXISTING CONDITIONS	FLOOD IMPACTS (OPERATION PHASE)	QDL COMPLIANCE
Wagga Wagga precinct				
Uranquinty Yard clearances	Track realignment Rail bridge alterations Level crossing modifications	The proposal site is affected by overland flooding.	The flood modelling results show that the proposal has minimal impacts on flooding which satisfy the QDLs.	Yes
Pearson Street bridge	Track lowering and realignment	The western part of the proposal site is affected by overland flooding in the 1% AEP flood event.	The flood modelling results show that the proposal has minimal impacts on flooding which satisfy the QDLs.	Yes
Wagga Wagga Yard clearances	Track realignment	Proposal site is affected by overland flooding.	Initial flood model results indicated a small amount of afflux in the industrial area located 400m to the east of the Wagga Wagga Yard clearances enhancement site. Drainage via an existing culvert was not included in the council flood model and the predicted afflux in this area is expected to be attenuated by the existing drainage culverts. At the detailed design stage the flood model will be updated to include the culvert and local topography in the model to confirm the true afflux result in this area. The inclusion of the culvert is expected to reduce the afflux in this area.	Minor non-compliance. However further investigation will be undertaken during detailed design to investigate the minor afflux to the east of the site. The model results showed that the proposed enhancement works do not alter the hydraulic function of the floodplain.
Cassidy Parade pedestrian bridge	Pedestrian bridge replacement	The site is located at the edge of the flood extent.	There are no changes to the flood conditions.	Yes
Wagga Wagga Station pedestrian bridge	Pedestrian bridge replacement	The site is affected by overland flooding	The replacement of the pedestrian bridge would not alternate the existing flood conditions as the bridge structure covers the same footprint of the existing bridge.	Yes
Edmondson Street bridge	Road bridge replacement	The site is not affected by flooding.	The drainage assessment demonstrated no adverse impacts.	Yes

ENHANCEMENT SITE	KEY FEATURES	FLOOD RISK – EXISTING CONDITIONS	FLOOD IMPACTS (OPERATION PHASE)	QDL COMPLIANCE
Bomen Yard clearances	Track realignment Level crossing modifications	Proposal site is affected by overland flooding at Bomen Road level crossing.	The proposed drainage system mimics the existing drainage conditions; therefore, proposed drainage is not expected to generate afflux. At the Bomen Road level crossing, the proposed vertical alignment is expected to satisfy the QDLs due to the minor change in the vertical alignment.	Yes
Junee precinct				
Harefield Yard clearances	Track realignment Rail bridge alterations	Current data available does not show Harefield Yard clearances site affected by flooding.	There would be no change to the existing flood and drainage conditions at the site as a result of the proposal; local catchment drains are unchanged.	Yes
Kemp Street bridge	Road bridge replacement	The bridge and the adjacent connecting roads are not impacted by the flooding. Flood water flows beneath the bridge, along the rail corridor, from east to west.	The proposed works at Kemp Street bridge do not affect the current overland flood mechanisms—overland flow would continue to be conveyed under the bridge; therefore, no changes to afflux, flow velocity and flood hazard are expected. Change to the drainage catchments are minor in comparison to the catchment receiving network; therefore, proposed changes to the local drainage system satisfy the QDLs.	Yes
Junee Station pedestrian bridge	Pedestrian bridge removal	Proposal site is not affected by flooding.	There would be no change to the existing flood and drainage conditions at the site as a result of the proposal.	Yes
Junee Yard clearances	Track realignment	Proposal site is not affected by flooding.	There would be no change to the existing flood and drainage conditions at the site as a result of the proposal.	Yes

ENHANCEMENT SITE	KEY FEATURES	FLOOD RISK – EXISTING CONDITIONS	FLOOD IMPACTS (OPERATION PHASE)	QDL COMPLIANCE
Olympic Highway underbridge	Track realignment Rail bridge alterations	The site is not located in an area affected by river flooding; only local overland flooding occurs in the proximity of the site area. The review of the flood data available shows that the site is not affected by overland flooding up to and including the 1% AEP flood event.	The proposed enhancement works have no impact on the existing flood and drainage conditions at the site and surrounding areas.	Yes
Junee to Illabo clearances	Track realignment Level crossing modifications, including the upgrade of two level crossings.	The proposal site area is not within a regional flood-prone area. Only local overland flow mechanisms are relevant for the enhancement site.	Flood levels have been assessed for the proposed culvert replacements to define changes in water levels. Drainage model results show no adverse flood impacts upstream of the proposed culvert replacements.	Yes

HYDROLOGY

The proposal would not divert or alter flow regimes in downstream receivers as the works have been designed to mimic the existing drainage and surface water flow conditions at the sites. Minor increases in downstream flows would occur at some sites but these would connect to existing stormwater systems that drain catchments significantly larger than the rail corridor sub-catchments; therefore, any minor flow increases would be negligible when combined with the total catchments flows downstream of the sites. Temporary diversions of surface flows during construction would aim to maintain existing drainage patterns and stormwater discharge points to avoid impacts on downstream flows.

As there are no significant changes to hydrologic regimes downstream of the sites in the operational phase, there are no impacts on the water balance or water availability within the downstream catchments.

The operational phase would not involve wastewater discharges from the sites. During construction, wastewater from construction-worker facilities would be locally managed at the sites and disposed of offsite, with no additional wastewater discharges to the downstream environment.

WATER QUALITY

The construction of the proposal would involve a variety of construction activities at each of the proposal sites that have the potential to impact the water quality of the surrounding environment if not appropriately managed.

Potential impacts from erosion and sediment impacts would be accounted for in the overall proposal Construction Environmental Management Plan (CEMP) and associated Soil and Water Management Plan (SWMP). Site-specific erosion and sediment control plans would be required at each proposal site to manage and minimise the risks of impacts to water quality. Implementation of appropriate soil and water construction management measures would minimise impacts to water quality impacts from erosion and sedimentation during construction of the proposal. Additionally, impacts would be limited to the duration of construction and would be a short term.

Concrete pumps and agitators would be used at a number of sites for construction of site infrastructure. Spills of concrete slurry and wastewater from concrete batching plants and subsequent change to pH of receiving environment and subsequent impact to aquatic and riparian ecosystems. Any mobile and fixed concrete batching plants would be established with appropriate erosion and sediment controls, consistent with current best practice, which would minimise the risk of impacts as a result of concrete washout.

1 INTRODUCTION

1.1 OVERVIEW

The Australian Government has committed to delivering a significant piece of national transport infrastructure by constructing a high performance and direct interstate freight rail corridor between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland. Inland Rail is a major national program that would enhance Australia's existing national rail network and serve the interstate freight market.

The Inland Rail route, which is about 1,700 kilometres long, would involve:

- using the existing interstate rail line through Victoria and southern NSW
- upgrading about 400 kilometres of existing track, mainly in western NSW
- providing about 600 kilometres of new track in northern NSW and south-east Queensland.

Inland Rail has been divided into 13 projects, 7 of which are located in NSW. Each of these projects can be delivered and operated independently with tie-in points on the existing railway.

Australian Rail Track Corporation Ltd (ARTC) ('the proponent') is seeking approval to construct and operate the Albury to Illabo section of Inland Rail ('the proposal').

The proposal is Critical State Significant Infrastructure (CSSI) and is subject to approval by the NSW Minister for Planning under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). This report has been prepared as part of the EIS for the proposal. The EIS has been prepared to support the application for approval of the proposal, and address the environmental assessment requirements of the Secretary of the NSW Department of Planning, Industry and Environment (the SEARs), dated 14 October 2020.

1.2 THE PROPOSAL

The proposal involves enhancement works to structures and sections of track along 185 kilometres of the existing operational standard-gauge railway between Albury and Illabo. Enhancement works are required to provide the increased vertical and horizontal clearances required for double-stacked freight trains.

1.2.1 LOCATION

The proposal is generally within the existing active rail corridor between the town of Albury on the Victorian–NSW border and around 3 kilometres to the north-east of Illabo. The alignment passes through two major regional towns (Albury and Wagga Wagga, NSW) and several smaller regional towns. Works are proposed at 24 locations along the 'Main South Line' corridor, described as 'enhancement sites'.

The enhancement sites have been broken down into four precincts, which align with the LGAs of Albury, Greater Hume – Lockhart, Wagga Wagga and Junee, as identified in Table 1.1 and Figure 1.1.

Table 1.1 Enhancement sites

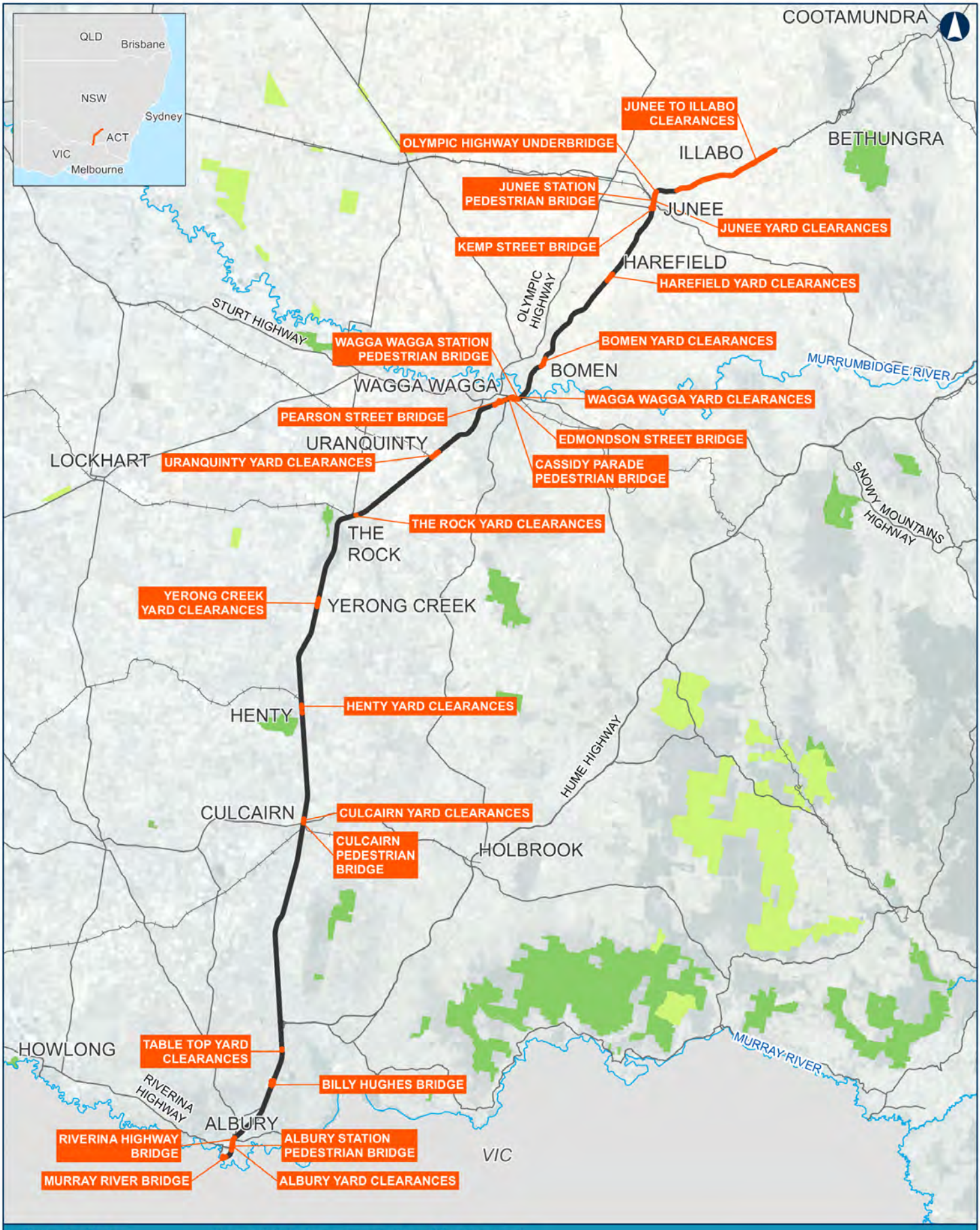
PRECINCT	ENHANCEMENT SITES
Albury	Murray River bridge
	Albury Station pedestrian bridge
	Albury Yard clearances
	Riverina Highway bridge
	Billy Hughes bridge
	Table Top Yard clearances
Greater Hume – Lockhart	Culcairn pedestrian bridge
	Culcairn Yard clearances
	Henty Yard clearances
	Yerong Creek Yard clearances
	The Rock Yard clearances
Wagga Wagga	Uranquinty Yard clearances
	Pearson Street bridge
	Cassidy Parade pedestrian bridge
	Edmondson Street bridge
	Wagga Wagga Station pedestrian bridge
	Wagga Wagga Yard clearances
	Bomen Yard clearances
Junee	Harefield Yard clearances
	Kemp Street bridge
	Junee Station pedestrian bridge
	Junee Yard clearances
	Olympic Highway underbridge
	Junee to Illabo clearances

1.2.2 KEY FEATURES

The key features of the proposal include:

- adjustments to approximately 44 kilometres of track across 14 enhancement sites to accommodate the vertical and horizontal clearances according to Inland Rail clearance specifications, comprising:
  - realignment of track within the rail corridor
  - lowering of track up to 1.6 metres at three enhancement sites
- changes to bridges and culverts at enhancement sites to accommodate vertical clearances and track realignment as follows:
  - replacement of two road bridges and adjustments to adjoining intersections
  - replacement of three pedestrian bridges
  - removal of two redundant pedestrian bridges
  - modifications to four rail bridges
- ancillary works, including adjustments to nine level crossings, modifications to drainage and road infrastructure, signalling infrastructure, fencing, signage, and services and utilities.

No additional works would be required outside the enhancement sites identified in Figure 1.1 as they meet the clearance requirement for the Inland Rail program.



Albury to Illabo

Figure 1.1 Enhancement sites of the proposal

0 10 20 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 4/11/2021 Paper: A3
Author: WSP Scale: 1:500,000
Data Sources: ARTC, NSWSS

- Proposal site
- Track alignment
- Existing railway
- Main road
- River
- National Park
- State Forest

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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1.2.3 TIMING

Subject to approval, further design and procurement, construction of the proposal is planned to start in early 2024 and is expected to take about 16 months. The proposal would be fully operational in 2025 with enhancement sites progressively commissioned on completion of construction. Inland Rail as a whole would be operational once all 13 sections are complete, which is estimated to be in 2027.

1.2.4 CONSTRUCTION

An indicative construction methodology has been developed based on the current design to be used as a basis for the environmental assessment process. Overall, the construction strategy is based on an approach of dividing the proposal into four construction packages, which align with the precincts: Albury, Greater Hume – Lockhart, Wagga Wagga and Junee.

Construction of the proposal would require:

- construction compounds, laydown areas and other areas needed to facilitate construction works
- temporary changes to the road network, including road closures to undertake works on road bridges and level crossings
- other ancillary works.

Construction within each precinct would generally involve the site establishment and enabling works, main construction works as relevant to the enhancement site and finishing works as outlined in Table 1.2.

Further information on the construction of the proposal is provided in Chapter 8 of the EIS.

Table 1.2 Indicative construction activities

CONSTRUCTION STAGES	INDICATIVE ACTIVITIES
Site establishment and enabling works	— Establishment of key construction infrastructure, work areas, access points and other construction facilities — Installation of environmental controls, fencing and site services — Preliminary activities including clearing/trimming of vegetation
Main construction works	— Track works — Rail bridge works — Road bridge replacement — Pedestrian bridge works — Associated infrastructure works on level crossings, culverts and signalling
Finishing works	— Testing and commissioning of the new and modified infrastructure — Demobilisation and removal of construction compounds and other construction infrastructure — Restoration of disturbed areas, as required, including revegetation and landscaping

1.2.5 OPERATION

The proposal would form part of the rail network managed and maintained by ARTC. Train services would be provided by a variety of operators.

The proposal would enable the use of double-stacked trains along its entire length. Inland Rail would operate 24 hours per day and would initially accommodate double-stacked freight trains up to 6.5 metres high and up to 1,800 metres in length. The possible future use of the railway between Albury and Illabo by freight trains up to 3,600 metres long would be subject to separate assessment. Freight train speeds would range from 60 to 115 kilometres per hour, which is consistent with current train speeds.

The average number of freight train movements between Albury and Illabo would increase from a current average of up to 12 per day in 2021 to 16 per day in 2025, further increasing to about 21 per day in 2040.

ARTC would continue to maintain the Main South Line. This would typically involve minor maintenance works, such as bridge and culvert inspections, rail grinding and track tamping, through to major maintenance, such as reconditioning of track and topping up of ballast, as required. Maintenance works and schedule are not proposed to change as a result of the proposal.

Further information on the operation of the proposal is in Chapter 7 of the EIS.

1.3 SCOPE AND PURPOSE OF THIS REPORT

This report has been prepared by WSP Australia as part of the EIS for the proposal, to assess potential impacts to hydrology, flooding, and water quality.

This surface water assessment addresses the relevant SEARs issued for the proposal on 14 October 2020. The SEARs relevant to the assessment of hydrology, flooding and water quality are presented in Table 1.3.

Table 1.3 Secretary's Environmental Assessment Requirements relevant to hydrology, flooding and water quality

KEY ISSUE	ASSESSMENT REQUIREMENT	REPORT REFERENCE
8. Flooding The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	**1** Changes to flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood including consideration of the impacts of climate change and differing storm durations) including:	
	a any detrimental increases in the potential flood affectation of other properties, assets and infrastructure	Section 5.1 and 5.2
	b consistency (or inconsistency) with applicable Council floodplain risk management plans	Section 3.3.8, Chapter 4 and Section 5.1.2, Chapter 6
	c compatibility with the flood hazard of the land	Section 5.1 and 5.2
	d compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	Section 5.1 and 5.2
	e downstream velocity and scour potential	Section 5.1 and 5.2
	f impacts the development may have upon existing community emergency management arrangements for flooding; These matters must be discussed with the State Emergency Services and Council	Section 3.3.9, 5.1 and 5.2

KEY ISSUE	ASSESSMENT REQUIREMENT	REPORT REFERENCE
	g any impacts the development may have on the social and economic costs to the community as consequence of flooding.	Technical Paper 4 – Social and Technical Paper 5 – Economic
	2 Flood management objectives and outcomes must be clearly identified and substantiated to address the characteristics of the environment and relevant legislative, management and guidance requirements.	Chapter 3 and Chapter 5
9. Water – Hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved). Sustainable use of water resources.	1 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 BAM.	Technical Paper 8 – Biodiversity development assessment report and Technical Paper 9 –Aquatic Biodiversity Section 4.2, 4.2.3
	2 Prepare a conceptual water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration, sources, security and licensing requirements.	Section 3.4.2 The water balance for groundwater is considered in Technical Paper 12 – Groundwater
	3 Surface and groundwater hydrology impacts 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, and floodplains that affect the health of the fluvial, riparian, estuarine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge	Section 4.2, 4.4, 4.5 and Section 5.2
	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	Technical Paper 12 – Groundwater Section 5.2, 5.3
	c changes to environmental water availability and flows, both regulated/licenced and unregulated/rules-based sources	Technical Paper 12 – Groundwater Section 5.2.2.3
	d direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses	Section 5.2.2.5

KEY ISSUE	ASSESSMENT REQUIREMENT	REPORT REFERENCE
	e minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flows rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems	Section 5.2
	f water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation and an assessment of current market depth where water entitlement is required to be purchased	Section 5.2.2.3 Technical Paper 12 – Groundwater
	g identify any requirements for baseline monitoring of hydrological attributes.	Section 5.3
10. Water – Quality 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).	**4** Water quality impacts, including:	
	a identifying the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the Project, including the indicators and associates trigger values or criteria for the identified environmental values	Section 2.2, 2.1, 4.8
	b identifying and estimating the quality and quantity of 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 pollutants that pose a risk of non-trivial harm to human health and the environment	Section 5.3 Technical paper 13 – Contamination
	c identifying the rainfall event that the water quality protection measures will be designed to cope with	Sections 5.3.1.1 and 7.3
	d the significance of any identified impacts including consideration of the relevant ambient water quality outcomes	Section 5.3 Technical paper 12 – Groundwater
	e demonstrating how construction and operation of the Project will, to the extent that the Project can influence, ensure that: **i** where the NSW WQO for receiving waters are currently being met they will continue to be protected **ii** where the NSQ WQOs are not being met, activities will work toward their achievement over time	Section 5.3.1, 5.3.2
	f justifying, if required, why the WQOs cannot be maintained or achieved over time	Section 5.3

KEY ISSUE	ASSESSMENT REQUIREMENT	REPORT REFERENCE
	g demonstrating that all practical measures to avoid or minimise water pollution and protection human health and the environment from harm are investigated and implemented	Chapter 6 Technical paper 12– Groundwater and Technical paper 13– Contamination
	h identifying sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid to or minimise impacts on these environments	Technical Paper 13 – Groundwater Section 4.2, 5.2 and Chapter 6
	i identifying proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Chapter 6

1.4 STRUCTURE OF THE REPORT

The structure of the report is as follows:

- **Chapter 1 – Introduction –** provides a broad introduction to the proposal and identifies the key features for assessment
- **Chapter 2 – Legislation and policy context** – includes background information for assessed legislation, policy and guidelines
- **Chapter 3 – Methodology** – provides information on the processes for assessment
- **Chapter 4 – Existing environment** – describes the existing environment within the proposal study area
- **Chapter 5 – Impact assessment** for flooding, hydrology and water quality
- **Chapter 6 – Cumulative impact assessment**
- **Chapter 7 – Mitigation and management measures** – provides the recommended mitigation and management measures to address the findings on impact assessment
- **Chapter 8 – Conclusion**
- **Chapter 9 – References**.

2 LEGISLATION AND POLICY CONTEXT

2.1 COMMONWEALTH LEGISLATION AND POLICY

2.1.1 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), proposed 'actions' that have the potential to significantly impact on matters of national environmental significance (MNES), the environment of Commonwealth land, or that are being carried out by an Australian Government agency, must be referred to the Australian Minister for the Environment for assessment.

Preliminary environmental investigations identified threatened species under the EPBC Act that have the potential to be impacted by the proposal. As a result of the potential for impacts on protected matters, the proposal was referred to the (then) Australian Minister for the Environment in June 2020 (EPBC Referral No 2020/8670). On 29 June 2020, the Australian Government Department of Agriculture, Water and the Environment notified that the proposal is a not controlled action and, therefore, approval under the EPBC Act is not required.

No potential impacts to MNES from the proposal relevant to hydrology, flooding and water quality were identified by this assessment.

2.1.2 NATIONAL WATER QUALITY MANAGEMENT STRATEGY (ANZECC / ARMCANZ 2018)

The National Water Quality Management Strategy (ANZECC/ARMCANZ 2018) has been developed by the Australian government in cooperation with state and territory governments. The strategy establishes objectives to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.

The National Water Quality Management Strategy includes guidelines for protection of water resources across Australia. These guidelines have been used to determine the existing condition of rivers and water quality objectives for the proposal.

2.1.3 AUSTRALIAN AND NEW ZEALAND GUIDELINES FOR FRESH AND MARINE WATER QUALITY (ANZG 2018/ ANZECC 2000)

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

The ANZG 2018 guidelines provide a process for assessing existing water quality conditions, and developing water quality objectives to sustain current or likely future environmental values for natural and semi-natural water resources.

The process involves the following steps:

- identify the environmental values that are to be protected in a water body. Environmental values are values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health, and which require protection from the effects of pollution, waste discharges and deposits
- identify water quality objectives that must be met to maintain the environmental values. Water quality objectives are the specific values or criteria agreed between stakeholders, or set by local jurisdictions, that become the indicators of management performance; and
- develop trigger values – these are concentrations for water quality indicators that, if exceeded, would indicate a potential environmental problem, and so 'trigger' a management response, e.g. further investigation and subsequent refinement of the guidelines according to local conditions.

Default guideline values (trigger values) for water quality indicators are provided for different environmental values, as generic starting points for assessing water quality where site-specific information is not available. These are regarded as guideline trigger values that can be modified into regional, local or site-specific guidelines. The ANZG 2018 guidelines provide decision frameworks that help users tailor water quality guidelines to local environmental conditions.

2.1.4 WATER ACT 2007

The *Water Act 2007* (the Water Act) enables the Commonwealth, in conjunction with the relevant states, to manage the water resources of the Murray Darling Basin in the national interest. It also provides for the powers and functions of the Murray Darling Basin Authority (MDBA). Part 2, Division 1 of the Water Act provides for the preparation of a Basin Plan to provide for the integrated management of the Basin water resources in a way that promotes the objectives of the Water Act.

2.1.5 MURRAY-DARLING BASIN PLAN 2012

The Murry Darling Basin Plan (the Basin Plan 2012) was developed in 2012 to manage water in the Basin as a connected system. The aim of the Basin Plan is to bring the Basin back to a healthier and more sustainable level while supporting farming and other industries.

Schedule 11 of the Basin Plan 2012 outlines water quality zones and provides water quality targets that are used to assess water quality at inland monitoring stations. These water quality targets were developed following the methods outlined in the ANZECC Guidelines (2000). Water quality data for rivers and streams, in 'reference' to conditions from each of the water quality zones, were used to develop the target values for each zone (Tiller and Newall 2010). Where there were no reference sites, the appropriate default trigger value from the ANZECC Guidelines (2000) for slightly to moderately disturbed systems were used. These replace the previous default trigger values for slightly disturbed ecosystems listed in the National Water Quality Management Strategy, and are reproduced in the water resource plans for each sub catchment of the Murray Darling Basin along with water quality objectives for each catchment.

2.1.5.1 WATER RESOURCE PLANS AND WATER QUALITY MANAGEMENT PLANS

The Basin Plan 2012 requires the preparation of water resource plans (WRP). The water resource plans set rules on how much water can be taken from the Basin, ensuring that the sustainable diversion limit is not exceeded over time. The MDBA is responsible for monitoring and enforcing compliance with water resource plans. The proposal will be governed by the NSW Murrumbidgee surface water resource plan and the NSW Murray and Lower Darling surface WRP.

The WRPs provides water quality management plans (WQMP) to support water quality management within the catchments. These management plans provide a framework to protect, improve and restore water quality. The WRPs and WQMPs divide the catchments into a number of water quality zones. The proposal is in zones (central Murray zone) cMum, B6, A3 and B3. As per the ANZG 2018, the WQMPs identify relevant water quality objectives from the Basin Plan 2012 for both catchments, as shown in Table 2.1.

Table 2.1 Water quality objectives for the Murray and Murrumbidgee catchments under the Basin Plan 2012

OBJECTIVE	DESCRIPTION	BASIN PLAN REFERENCE
Maintain water quality to protect First Nations people's water dependent values and uses	The objective is to ensure water quality is sufficient to maintain the spiritual, social, customary and economic values and uses of water by First Nations people.	10.52
Maintain water quality to protect and restore water dependent ecosystems	The objective is to ensure water quality is sufficient to: — protect and restore ecosystems and ecosystem functions — ensure ecosystems are resilient to climate change — maintain the ecological character of Ramsar wetlands.	9.04
Maintain the quality of raw surface water for treatment for human consumption	The objective is to minimise the risk that the quality of raw water taken for human consumption results in: — adverse human health effects — the odour of drinking water being offensive to consumers. The objective also aims to maintain the palatability of rating of drinking water at the level of good, as set out in the Australian Drinking Water Guidelines.	9.05
Maintain the quality of surface water for irrigation use	The objective is to ensure the quality of surface water, when used in accordance with the best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation. This objective applies at sites where water is extracted by an irrigation infrastructure operator for the purpose of irrigation.	9.06
Maintain the quality of surface water for recreational use	The objective ensures a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact during recreational use of NSW Murray and Lower Darling water resources.	9.07
Maintain good levels of water quality	The objective is to maintain the value of a water quality characteristic if it is at a level that is better than the target value.	9.08

The WRPs includes associated targets for the zone, as shown in Table 2.2. Electrical conductivity targets are not described for each water quality zone of the Murray-Darling Basin Plan. Instead, the Plan adopts End-of-Valley salinity targets, as described in Schedule B Appendix 1 of the Commonwealth *Water Act 2007* and shown in Table 2.3.

Table 2.2 Water quality targets under the Basin Plan 2012 for the proposal

INDICATOR	WATER QUALITY ZONE			
	Upper Middle Murray (cMum)	Upland (B6)	Murrumbidgee (B3)	Murrumbidgee (A3)
Turbidity (NTU)	15	5	20	35
Total Phosphorus (µg/L)	340	30	35	50
Total Nitrogen (µg/L)	500	350	600	600
Dissolved oxygen (mg/L; or saturation (%)	90–110% or >7.7 mg/L	85–110% or >8.5 mg/L	90–110% or >8 mg/L	60–110% or >7 mg/L
pH	6.5–7.5	6.4–7.7	7.0–8.0	6.5–8.0

INDICATOR	WATER QUALITY ZONE			
	Upper Middle Murray (cMum)	Upland (B6)	Murrumbidgee (B3)	Murrumbidgee (A3)
Salinity	End-of-Valley targets for salinity			
Temperature (Monthly median within the range)	Between the 20% and 80% of natural monthly water temperature			
Pesticides, heavy metals and other toxic contaminants	The protection of 95% of species (values in table 3.4.1 of the ANZECC Guidelines for) (Must not be exceeded))			

Table 2.3 End of valley salinity targets

WATER QUALITY ZONE	ECOSYSTEM TYPE	END OF VALLEY TARGETS (AS ABSOLUTE VALUES)		
		Salinity (EC µS/cm)		Salt load (t/yr)
		Median (50%ile)	Peak (80%ile)	Mean
Murray (cMum only)	Streams, rivers, lakes, wetlands	–	412	576,400
Murrumbidgee		162	258	169,600

2.2 STATE LEGISLATION AND POLICY

2.2.1 *ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979*

The EP&A Act and Environmental Planning and Assessment Regulation 2021 (EP&A Regulation) establish a framework for the assessment and approval of developments in NSW.

The proposal has been declared as CSSI and is subject to approval by the Minister for Planning under Division 5.2, Part 5 of the EP&A Act. An EIS has been prepared for the proposal to assess the impacts of the proposal in accordance with the SEARs. This technical paper supports the EIS.

Under section 5.23(1) of the EP&A Act, approved CSSI does not require a water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the *Water Management Act 2000* (WM Act) (discussed further below).

2.2.2 *WATER ACT 1912 AND WATER MANAGEMENT ACT 2000*

Water resources are administered under the *Water Act 1912* and the WM Act by the NSW DPE. The *Water Act 1912* is being progressively phased out and replaced with the WM Act with the implementation of water sharing plans. The object of the WM Act is the sustainable and integrated management of the state's water sources for the benefit of present and future generations. The WM Act governs the issue of water access licences (WALs) and approvals for those water sources (rivers, lakes, estuaries and groundwater) in NSW where water sharing plans have commenced. Water sharing plans establish rules for sharing water between water users and the environment, and areas rules for water trading. The *Water Act 1912* governs the issue of water licences for water sources where water sharing plans have not been enacted.

Part 3 of the WM Act establishes three types of approvals that a proponent may be required to obtain. These are:

- water use approvals
- water management work approvals (water supply work approvals, drainage work approvals and flood work approvals)
- activity approvals (controlled activity approvals and aquifer interference approvals).

However, under section 5.23(1) of the EP&A Act, approved CSSI does not require a water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the WM Act. The design and construction of the proposal would consider the NSW Office of Water's guidelines for controlled activities on waterfront land to enable the mitigation of potential impacts to water quality.

Water access licenses are required for dewatering and any other taking of water from a water source.

In addition, the provisions relating to aquifer interference approvals have not yet been activated in NSW, so there is currently no requirement to obtain an aquifer interference approval. Refer to Technical Paper 12 – Groundwater for further discussion of groundwater.

2.2.2.1 WATER SHARING PLANS

Water sharing plans establish rules for sharing water between water users and the environment, and rules for water trading. There are water sharing plans for regulated and unregulated river catchments and groundwater sources in water management areas. Water sharing plans describe the annual surface and groundwater recharge volumes for each identified water source and the volumes of water that are available for sharing. Available water volumes are based on calculated long-term average annual extraction limit (LTAAEL). Provisions are made for environmental water allocation, basic landholder rights, domestic and stock rights and native title rights.

The proposal is overlying several water sharing plans which essentially are 'stacked' on top of each other and include:

- Lower Murray–Darling Unregulated River Water Source 2011
- Murray Unregulated River Water Sources 2011
- NSW Murray and Lower Darling Regulated Rivers Water Sources 2016
- Murrumbidgee Regulated River Water Source 2016
- Murrumbidgee Unregulated River Water Sources 2012.

2.2.3 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) establishes, among other things, pollution management, pollution incident reporting and the procedures for issuing licences for environmental protection on aspects such as waste, air, water, and noise discharge control.

Schedule 1 of the POEO Act specifies the following rail track-related activities as activities that need an EPL: Railway activities—railway infrastructure construction (clause 33) and Railway activities—railway infrastructure operations (clause 33A).

ARTC currently holds a licence to carry out railway systems activities (licence number EPL3142) within the Albury to Illabo rail corridor. This EPL would be amended to include the operation of the proposal. A separate EPL would be obtained by the construction contractor for the construction of the proposal. Licensing requirements for the proposal would be considered in consultation with the EPA.

Rollingstock operators on ARTC's network in NSW are regulated by the NSW EPA and may require a separate EPL.

2.2.4 NSW WATER QUALITY OBJECTIVES

Consistent with the ANZG 2018 framework the NSW Government has endorsed environmental values for surface waterbodies and identified water quality objectives for each catchment in NSW. These are presented in the NSW Water Quality and River Flow Objectives ('NSW WQO') (Office of Environment and Heritage, 2006).

The water quality objectives are the specific water quality targets agreed between stakeholders, or set by local jurisdictions, that become the indicators of management performance. These limits or descriptive statements are selected to support and maintain the environmental values of the catchment. They are consistent with the agreed national framework for assessing water quality set out in the ANZG 2018. Essentially, the NSW WQO provide the environmental values, water quality objectives and indicators for NSW water and refers to the ANZG 2018 for default guideline trigger values technical guidance in applying these values.

The guideline trigger values are concentrations that, if exceeded, would indicate a potential environmental problem, and so 'trigger' a management response, e.g. further investigation and subsequent refinement of the guidelines according to local conditions. Assessing whether the exceedance means a risk of impact to the water quality objective requires site-specific investigation, using decision trees provided in the ANZG 2018. If the trigger values are not exceeded, a very low risk of environmental damage can be assumed.

The catchments affected by the proposal are the Murrumbidgee River and Murray River catchments. The NSW WQO categorise and map the rivers and streams within NSW catchments as shown in Figure 2.1 and Figure 2.2. All streams within or near the proposal sites are categorised as 'Uncontrolled Streams', that is streams, wetlands and natural lakes that have largely natural flow patterns and are not major rivers, within estuaries, or urban areas.

All criteria and water quality indicators associated with the environmental values for the proposal are shown in Appendix A. It is noted that the NSW WQO were completed prior to the ANZG 2018 update and, as such, still reference the ANZECC 2000 guidelines.

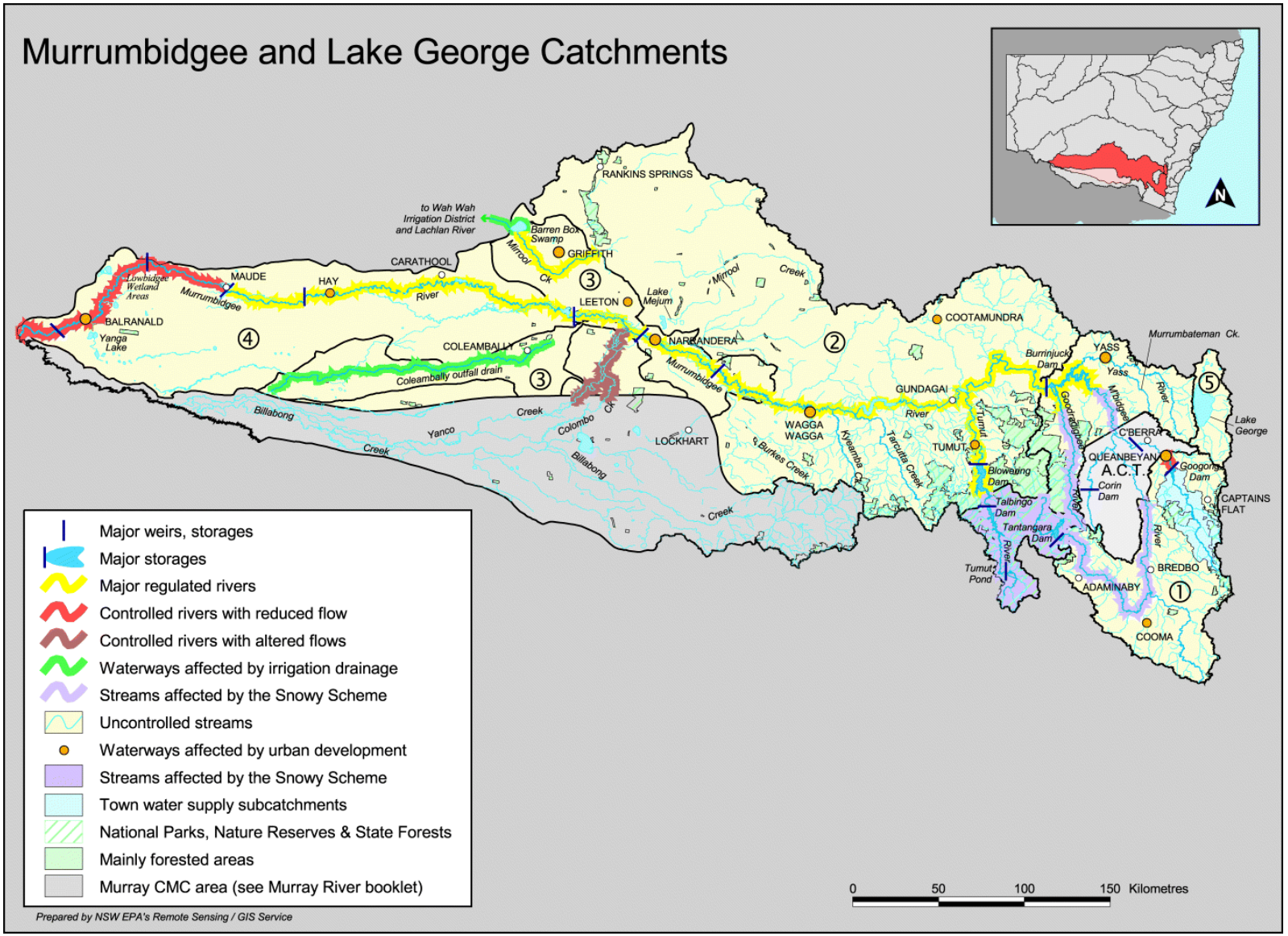


Figure 2.1 Waterway classification under the NSW WQO for the Murrumbidgee catchment

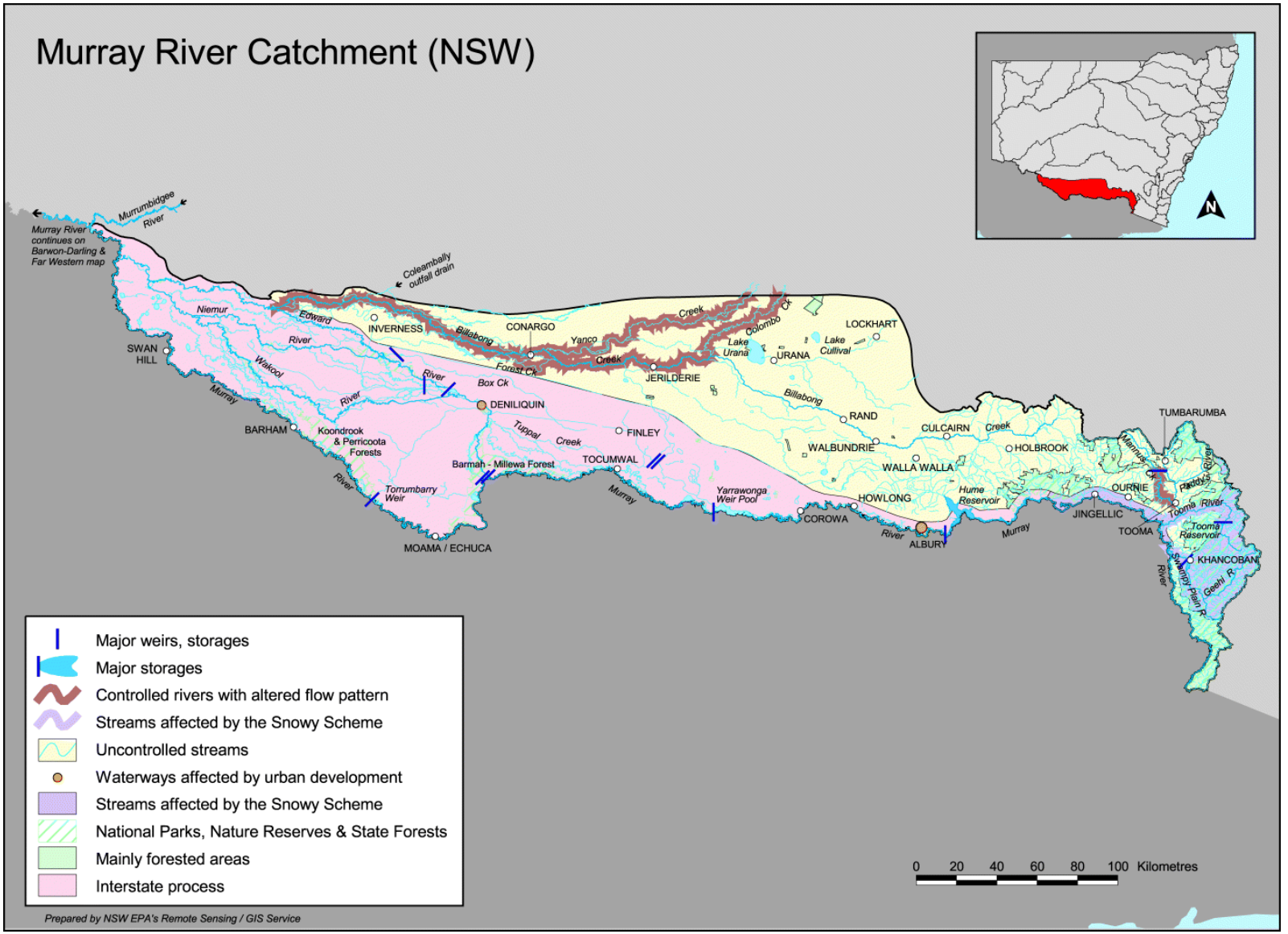


Figure 2.2 Waterway classification under the NSW WQO for the Murray River catchment

2.3 LOCAL PLANNING POLICY

Table 2.4 shows the local flood management documents relevant to the proposal.

Table 2.4 Floodplain risk management study and plan

COUNCIL	FLOOD MANAGEMENT AND RISK DOCUMENT	RELEVANT SITE
Albury City Council		
Albury Floodplain Risk Management Study and Plan (WMA, 2016)	The Floodplain Risk Management Study and Plans for Albury determines the nature and extent of the floodplain and assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood-affected land at the sites in Albury.	Murray River bridge Albury Station Yard clearances Riverina Highway bridge Billy Hughes bridge
Greater Hume Shire Council		
Culcairn Floodplain Risk Management Study and Plan (WMA water 2017)	The Culcairn Floodplain Risk Management Study and Plan determines the nature and extent of the floodplain at Culcairn and assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood affected land at the Culcairn Yard clearances site.	Culcairn Yard clearances and pedestrian bridge
Henty Floodplain Risk Management Study and Plan (WMA water,2017)	The Henty Floodplain Risk Management Study and Plan determines the nature and extent of the floodplain at Henty and assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood-affected land at the Henty Yard clearances site.	Henty Yard Clearances
Lockhart Shire Council		
Floodplain Risk Management Study and Plans for Lockhart and The Rock (WMA water, 2014)	The Floodplain Risk Management Study and Plans for Lockhart and The Rock determines the nature and extent of the floodplain assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood-affected land at The Rock Yard clearances site.	The Rock Yard clearances

COUNCIL	FLOOD MANAGEMENT AND RISK DOCUMENT	RELEVANT SITE
Wagga Wagga City Council		
2018 Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan	The 2018 Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan determines the nature and extent of the floodplain assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood-affected land at the Wagga Wagga sites.	All sites at Wagga Wagga
Tarcutta, Ladysmith and Uranquinty Floodplain Risk Management Studies and Plans (2020)	This floodplain risk management study has been used to inform the understanding of the flood conditions.	Uranquinty Yard clearances
Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (MOFFS), 2021	This floodplain risk management study has been used to inform the understanding of the flood conditions of the enhancement sites at Wagga Wagga.	Pearson Street bridge Wagga Wagga Station and surrounds Bomen Yard clearances
Junee Shire Council		
The Lower Butlers Gully FRMS&P (2011)	The Lower Butlers Gully FRMS&P determines the nature and extent of the floodplain assesses management options for the floodplain. This study has been used to inform the understanding of the historic flooding condition and to identify the flood-affected land at Junee Yard Clearances site.	Junee Yard clearances Junee Station pedestrian bridge Olympic Highway underbridge Kemp Street bridge
Jeralgambeth Creek at Illabo FRMS&P (March, 2012)	The Jeralgambeth Creek at Illabo FRMS&P determines the nature and extent of the floodplain assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood-affected land at Junee to Illabo Clearances site.	Junee to Illabo clearances

2.4 GUIDELINES

Table 2.5 describes other guidelines that are relevant to flooding, hydrology and water quality assessment of the proposal. These guidelines have been used in the design process for the flooding and drainage assessment or may be referred to for the development of mitigation measures.

Table 2.5 Relevant guidelines for the flooding, hydrology and water quality assessment

AUTHORITY	GUIDELINE	DESCRIPTION
Commonwealth, Geoscience Australia	Australian Rainfall and Runoff 2019 (Ball et al. 2019)	Australian Rainfall and Runoff (ARR, 2019 prepared by Ball et al 2019) is a national guideline for the estimation of design flood characteristics in Australia. The aim of the guide is to provide the best available guidance and information on design flood estimation in a manner suitable for use by Australian practitioners to be able to estimate the design flood problem, flood processes and engineering hydrology. These guidelines have been used for the flooding and drainage assessments carried out for the proposal.
Commonwealth, Australian Institute for Disaster Resilience	Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, Handbook 7, 2017	This guide prepared by the Australian Institute for Disaster Resilience (AIDR) has been developed to provide guidance on the national principles supporting disaster reliance in Australian through the management and publication of this Handbook and others for other types of hazards. This Handbook is supported by six additional guidelines that cover specific aspects of flood risk management and a practice note to assist with land use planning. This Handbook has been considered when developing criteria for managing flood risk from the proposal and compliments the NSW Floodplain Development Manual (DIPNR 2005) by outlining current best practices for flood risk management. These guidelines have been used for the flooding and drainage assessments carried out for the proposal.
NSW, Department of Natural Resources	NSW Floodplain Development Manual, 2005	This is the NSW Government's manual relating to the management of flood liable land in accordance with Section 733 of the *Local Government Act 1993*. The manual supports the NSW Government's Flood Prone Land Policy in providing for the development of sustainable strategies for managing human occupation and use of the floodplain. The manual applies to floodplains across NSW, in both urban and rural areas. It is also used to manage major drainage issues in local overland flooding areas. These guidelines have been used for the flooding and drainage assessments carried out for the proposal.
NSW, Office of Environment and Heritage	Floodplain Risk Management Guide, Incorporating 2016 ARR in studies, 2019	This guide provides advice on incorporating changes with recent updates to Australian Rainfall and Runoff (ARR) to flood risk management in NSW. These guidelines have been used for the flooding and drainage assessments carried out for the proposal.

AUTHORITY	GUIDELINE	DESCRIPTION
NSW, Department of Primary Industries	Guidelines for controlled activities on waterfront land, 2012	Provides guidance on development and activities on waterfront land. These guidelines have been considered in the development of mitigation measures for any proposal activities that impact waterfront land.
NSW, Office of Environment and Heritage	Guidelines for developments adjoining land and water, 2013	Managed by the Department of Environment, Climate Change and Water it provides guidance on development and activities on waterfront land. These guidelines have been considered in the development of mitigation measures for any proposal activities that impact waterfront land.
Landcom, 2004	Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition (The Blue Book)	The Managing Urban Stormwater – Soils and Construction (Landcom, 2004) series of handbooks are an element of the NSW Government's urban stormwater program that provide best practice for management of stormwater during construction works for a wide variety of proposals. They provide guidelines, principles, and recommended minimum design standards for good management practice in erosion and sediment control during construction works. Of particular relevance to the proposal is Volume 1, 4th Edition (commonly known as The Blue Book). These guidelines have been considered in the development of mitigation measures for water quality impacts.
Department of Environment and Heritage, Australian Greenhouse Office	Climate Change Impacts & Risk Management: A Guide for Business and Government	A guide to integrating climate change impacts into risk management and other strategic planning activities in Australian public and private sector organisations.
NSW Government	Sustainable design Guidelines Version 4.0	The Sustainable Design Guidelines (the guidelines) seek to deliver sustainable development practices by embedding sustainability initiatives into the planning, design, construction, operations and maintenance of transport infrastructure projects.
NSW Department of Planning	PS 21-006 Circular. Considering flooding in land use planning: guidance and statutory requirements.	This circular replaces Planning Circular PS07-003 and provides information on how to consider flooding in land use planning. The circular provides advice on a package of changes concerning flood-related development controls on residential development on land above the 1-in-100 year flood and up to the PMF.
NSW Department of Environment & Climate Change	Practical consideration of climate change – flood risk management guidelines (DECC 2007)	Advises how to consider the climate changes adverse impacts on sea levels and rainfall intensities. The guideline provides practical consideration on how to quantify climate change effects in flood risk management projects.
Department of the Environment and heritage Australian Greenhouse Office	Climate change impacts and risk management: a guide for business and government	Guideline that integrates climate change impacts into risk management and other strategic planning activities in Australian public and private sector organisations. The purpose of this guide is to assist Australian businesses and organisations to adapt to climate change.
	AS/NZS 3100:2018 risk management – principles and guidelines	Document that provides guidelines on managing risks faced by organisations.

3 METHODOLOGY

This chapter outlines the methodology undertaken to assess potential surface water impacts (i.e. including drainage, flooding and water quality) and identify mitigation measures for the proposed enhancement sites.

The methodology included the following key tasks:

- establish the study area for the assessment
- data collection and review
- establishing existing flood behaviour and hydrology environment
- establishing existing water quality conditions
- flood impact assessment; and
- mitigation measures.

3.1 STUDY AREA

The proposal sites are located within the Murray River and Murrumbidgee River catchments and minor watercourses within these catchments.

The technical study area for the hydrology, drainage and flooding, and water quality impact assessment is the area that may be directly or indirectly affected by the enhancement sites including sensitive receiving environments downstream of the proposal sites. This was established through a review of topographic information and watercourse catchment boundaries.

The proposal study area is considered a buffer of approximately 200 metres around the site.

3.2 DESKTOP ASSESSMENT

The desktop assessment included the following tasks:

- background data collection and review, including review of relevant existing flooding information and historic records of flooding at and near the study area and a review of streamflow records in the vicinity of the proposal sites
- review of councils and relevant stakeholders legislation/planning policies and guidelines for floodplain management, water supply and water quality conditions
- obtain and review relevant hydrology and hydraulic models (where available) from relevant local councils or relevant stakeholders to inform the description of the existing flood conditions and mechanisms at the study area
- obtain and review State and Federal Government documents relating to the Murray-Darling Basin and its management.

A desktop review was carried out to establish the existing water quality conditions at the proposal sites, existing sensitive receivers, and the construction and operational activities for the proposal that may affect water quality in the study area. This included:

- reviewing relevant legislation and guidelines to establish water quality objectives for the study
- reviewing available data and reports to establish existing environmental conditions, sensitive receivers and the likely water quality of the waterways surrounding the proposal sites. This included publicly available catchment and environmental data and reports
- cross reference to the Hydrogeology, Contaminated Land and Ecology impact assessment reports being prepared concurrently for the proposal to establish the existing environment and presence of sensitive receivers
- reviewing the proposal design features (i.e. culverts, drainage channel and other structures) near waterways and identifying potential sources of pollutants that may be introduced into the water cycle.

3.3 FLOODING

To inform an understanding of the existing flood behaviour at the proposal site and impacts from the proposal, information gathered from the desktop review (discussed above) was used to determine the existing flooding conditions at the study area and risk to the enhancement sites. Primarily, available flood studies sourced from local councils and flood modelling completed for the proposal, have provided an understanding of historic events and how flood risk is managed across the study area.

Hydrologic and hydraulic models were developed where required to describe the local drainage and flood conditions and assess the potential impacts of the proposal. The hydrologic model assesses the changes in catchment runoff whereas the hydraulic model assesses the changes in flow conveyance and flood propagation. The approach to completing hydrologic and hydraulic modelling is discussed further in the following section.

3.3.1 APPROACH TO ASSESSMENT OF FLOODING

The assessment of flooding includes review of information collected during the desktop assessment, including existing flood studies, to determine the existing hydrology and flood conditions at each enhancement site, (i.e. flood extent, rail flood immunity, flood velocity, etc.).

A qualitative risk assessment was completed to determine where additional modelling was required to assess potential impacts from the proposal. The approach to the assessment of flooding is summarised in Table 3.1.

Table 3.1 Approach to assessment of flooding

APPROACH	DESCRIPTION
Review of existing flood studies and data	Where available, a review of existing flood models was undertaken to assess the existing hydrology and flood conditions within the study area and adjacent land (i.e. flood extent, flood immunity, flood velocity, etc.). Flood studies have been sourced from local government authorities to understand historic management issues for the study area. See section 3.3.2.
Qualitative assessment of risk for enhancement sites (hydraulic complexity)	A qualitative risk assessment was completed, including consideration of existing information relevant to flooding, to determine the relevant risk to flooding at each enhancement site, and requirement for additional flood modelling. The risk at each enhancement site was categorised as: — high hydraulic complexity (i.e. proposed enhancement works have the potential to impact on a major watercourse and/or floodplain) — moderate hydraulic complexity (i.e. proposed enhancement works have the potential to impact in local drainage channels or overland flow paths) — low hydraulic complexity (i.e. proposed enhancement works would not impact on watercourses, floodplains, drainage channels or overland flow paths).
Flood modelling	Where required flood or drainage modelling was undertaken to assess the potential impacts from the proposal. See section 3.3.3.2 and 3.3.3.3.

3.3.2 REVIEW OF EXISTING FLOOD MODELS

A review of available flood modelling was completed through studies prepared for local councils and other sources. Available flood modelling is summarised in the following sections.

3.3.2.1 LOCAL COUNCIL FLOOD STUDIES

Local council flood studies relevant to the proposal sourced for the assessment are outlined in Table 3.2 and Figure 3.1. Table Top Yard clearances, Yerong Creek Yard clearances and Harefield Yard clearances enhancement sites are not covered by a local council flood studies.

Table 3.2 Local council flood studies

PRECINCT	ENHANCEMENT SITES	FLOOD MANAGEMENT AND RISK DOCUMENT
Albury		
The Albury Floodplain Risk Management Study and Plan (WMA Water, January 2016)	Murray River bridge Billy Hughes bridge	The Albury Floodplain Risk Management Study defines the flood conditions and flood extent generated by the Murray Catchment and Eight Mile and Thurgoona Catchment.
The Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011)	Albury Yard clearances Albury Station pedestrian bridge Riverina Highway bridge	The Bungambrawatha Creek, Lavington, South Albury and West Albury flood study determines the flood behaviour in the catchments of Bungambrawatha Creek, Lavington, South Albury and West Albury.
Greater Hume – Lockhart		
Culcairn Floodplain Risk Management Study and Plan (WMA Water, 2017)	Culcairn pedestrian bridge Culcairn Yard clearances	The Culcairn Floodplain Risk Management Study and Plan determines the nature and extent of the floodplain at Culcairn and assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood affected land at the Culcairn Yard clearances site.
Henty Floodplain Risk Management Study and Plan (WMA Water, 2017)	Henty Yard clearances	The Henty Floodplain Risk Management Study and Plan determines the nature and extent of the floodplain at Henty and assesses management options for the floodplain. This has been used to inform the understanding of the flooding condition and to identify the flood-affected land at the Henty Yard clearances site.
Floodplain Risk Management Study and Plans for Lockhart and The Rock (WMA Water, 2014)	The Rock Yard clearances	The Floodplain Risk Management Study and Plans for Lockhart and The Rock determines the nature and extent of the floodplain assesses management options for the floodplain. This has been used to inform the understanding of the historic flooding condition and to identify the flood-affected land at The Rock Yard clearances site.

PRECINCT	ENHANCEMENT SITES	FLOOD MANAGEMENT AND RISK DOCUMENT
Wagga Wagga		
Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan (2018) The Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (MOFFS), 2021	Pearson Street bridge Cassidy Parade pedestrian bridge Edmondson Street bridge Wagga Wagga Station pedestrian bridge Wagga Wagga Yard clearances Bomen Yard Clearances	The studies determine the nature and extent of the floodplain and assess management options for the floodplain. These studies have been used to inform the understanding of the historic flooding condition and to identify the flood affected land at the Wagga Wagga sites.
The Tarcutta, Ladysmith and Uranquinty Flood Floodplain Risk Management Studies and Plans (GRC Hydro, December 2020)	Uranquinty Yard clearances	The Tarcutta, Ladysmith and Uranquinty Flood Floodplain Risk Management Studies determines the flood conditions at the proposal sites and surrounding areas.
Junee		
The Lower Butlers Gully Flood Study (Lyall & Associates, 2009) The Lower Butlers Gully Risk Management Study and Plan (Lyall & Associates, 2011)	Kemp Street bridge Olympic Highway underbridge Junee Station pedestrian bridge	The Lower Butlers Gully Flood Study defines the overland flood condition in Lower Butlers Gully.
The Jeralgambeth Creek at Illabo FRMS&P (Lyall & Associates, 2012)	Junee to Illabo Clearances	The Jeralgambeth Creek at Illabo flood study determines the flood conditions at Illabo.

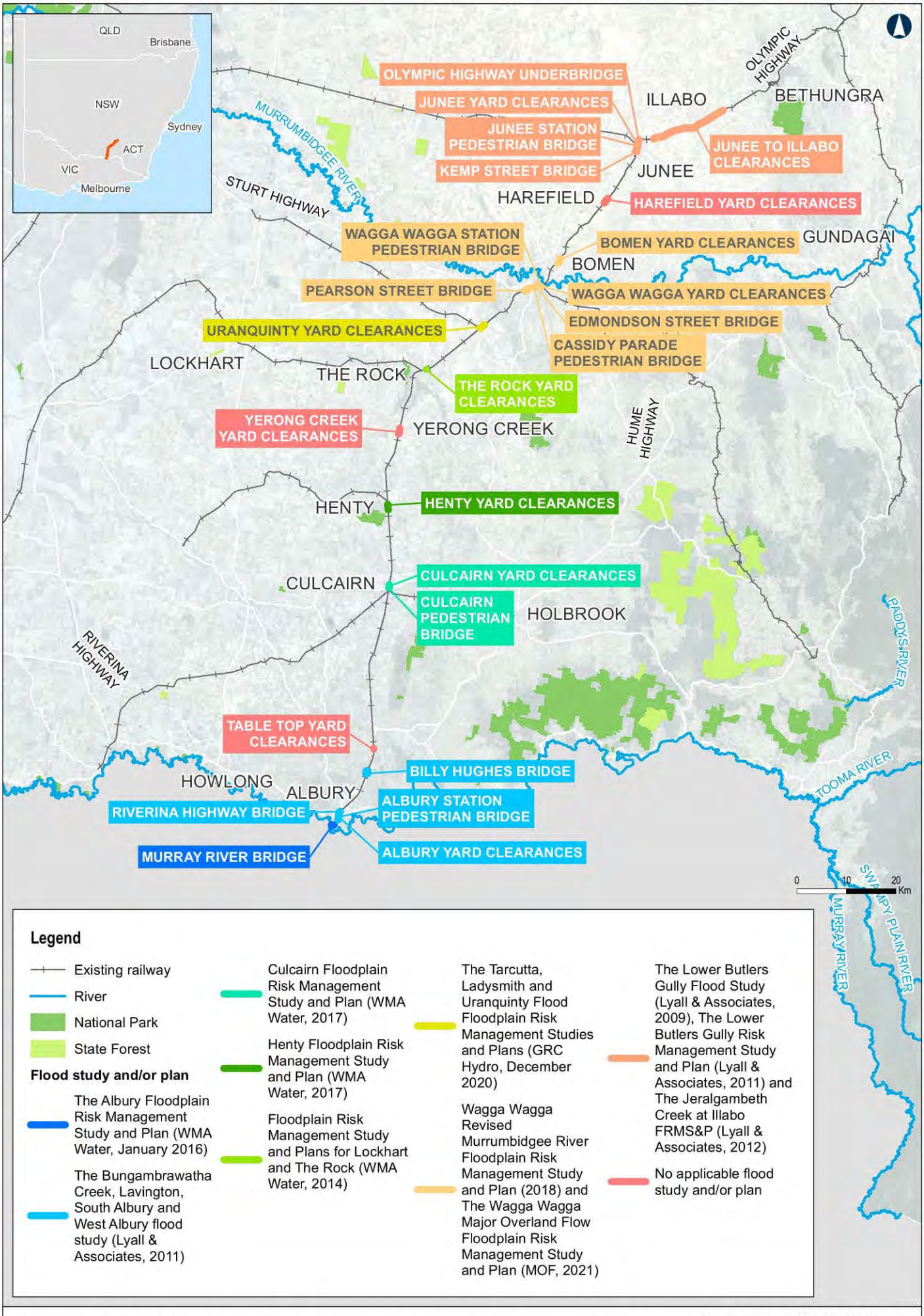


Figure 3-1 Applicable flood study and/or plans to the proposal

Data Sources: ARTC, NSWSS

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:1,000,000
Paper size: A3
Date: 1/07/2022

210_EAP_F0301_ApplicableFloodStudy_r1v1.mxd

3.3.3 HYDROLOGICAL AND HYDRAULIC MODELLING

3.3.3.1 APPROACH TO MODELLING

As discussed above, each enhancement site has a different design, and level of hydrology and hydraulic complexity. In response to this variation, the assessment categorised each of the enhancement sites into three levels of hydraulic complexity and an assessment approach was assigned for each category. The hydrologic and hydraulic modelling assessment categories and approach is summarised in Table 3.3.

Table 3.3 Hydrologic and hydraulic modelling assessment categories and approach

ASSESSMENT CATEGORY	ASSESSMENT APPROACH
High complexity – the proposal was considered to have the potential to impact on a major watercourse and/or floodplain):	A hydrological and hydraulic model (typically a combined one and two-dimensional hydraulic model) was developed to define the flood behaviour and drainage conditions at the site and adjacent land. Where existing models are available from local flood studies, these models would be reviewed and adopted if considered fit for purpose or modified as required to achieve the assessment requirements. Where new models were required to be developed, hydrological models have been developed using the RAFTS software program and hydraulic model analysis has been undertaken using the TUFLOW software program.
Moderate complexity – the proposal was considered to have the potential to impact local drainage channels or overland flow paths	A hydrological model and a one-dimensional hydraulic model (i.e. drainage model) to define the drainage and flood conditions of the site and surrounding areas. Where existing models are available from local drainage studies, these models would be reviewed and adopted if fit for purpose or modified as required to achieve the assessment requirements. Where new models need to be developed, hydrological models have been developed using the RAFTS software program and hydraulic model analysis has been undertaken using the DRAINS software program.
Low complexity – the proposal will not impact on watercourses, floodplains, drainage channels or overland flow paths	Either a qualitative assessment was undertaken to demonstrate that the works have no, or negligible, impacts on drainage and flooding patterns, or a hydrological model has been developed to determine the baseline and proposed scenario runoff regimes and to demonstrate that the works have no or negligible impacts on the runoff regime. Where models need to be developed, hydrological models have been developed using either RAFTS, DRAINS or 12d software programs.

3.3.3.2 HYDROLOGICAL MODELLING METHODOLOGY

The hydrological modelling approach for each assessment category is outlined in Table 3.4.

Table 3.4 Assessment category and hydrological modelling approach

ASSESSMENT CATEGORY	ASSESSMENT APPROACH
High complexity Moderate complexity	— Define relevant catchments and catchment characteristics that contribute runoff to the site and surrounding areas. — Review existing data and determine if a hydrologic model already exists for the site location. — If no existing assessment has been done, build a hydrological model of the site using the RAFTS software. Otherwise use the existing model to generate required hydrological data. — Calibrate the model to local rainfall and streamflow gauge data, where available. If no calibration data is available, check the model against the Regional Flood Frequency Estimation (RFFE) method for selected design storm events (typically, selected design storm events range from 10% to 1% AEP – depending on the flood conditions at the enhancement site). — Compare RFFE peak flows to modelled peak flows; if reasonable agreement is obtained then consider hydrological model established for design flow estimation. — Generate required data for desired events and durations. Different rainfall events have been considered to confirm the existing site flood immunity.
Low complexity	— Define relevant catchments and catchment characteristics that contribute runoff to the site and surrounding areas. — Build a model of the catchments using the RAFTS, DRAINS or 12d software package. — Use the model to generate baseline and proposed scenario catchment runoff rates for desired events and durations.

3.3.3.3 HYDRAULIC MODELLING METHODOLOGY

The hydraulic modelling approach for each assessment category is outlined in Table 3.5.

Table 3.5 Assessment category and hydraulic modelling approach

ASSESSMENT CATEGORY	ASSESSMENT APPROACH

High complexity	— Review existing data and determine if a council hydraulic model*already exists for the location.
	— If no existing assessment has been done, build and undertake hydraulic modelling of the site using TUFLOW software. Otherwise use the existing model to complete assessment. No change to the existing model cell size resolution was included in the assessment.
	— Use the TUFLOW model to define the existing (i.e. baseline scenario) flood and drainage conditions for the relevant storm events considered in the hydrology assessment. The existing flood conditions would include the following:
	  — maximum flood extent
	  — maximum flood levels and water depths at the site and surrounding areas
	  — maximum flood velocities at the site and surrounding areas
	  — flood hazard at the site and surrounding areas.
	— Assess the existing flood immunity.

ASSESSMENT CATEGORY	ASSESSMENT APPROACH
	— Prepare maps to describe the baseline scenario flood and drainage conditions. — Update the TUFLOW model to reflect the post enhancement work design configuration (i.e. proposed scenario). — Use the TUFLOW model to define the proposed scenario flood and drainage conditions (i.e. maximum flood extent, flood levels, flood velocities, flood hazard and rail flood immunity). — Compare the baseline and proposed scenario model results (i.e. flow paths, peak flow, flood levels, flood velocities and flood hazard) and assess the flood and drainage impacts. Flood assessment criteria are included in Table 3.7. — Produce flood impact maps to describe changes in flood conditions. *Council flood model parameters (i.e., cell size, blockage, manning's) were maintained to be consistent with the published flood maps.
Moderate complexity	— Review existing data and determine if a hydraulic model already exists for the location. — If no existing assessment has been done, build and undertake hydraulic modelling of the site using DRAINS software (with previously generated RAFTS hydrology). Otherwise use the existing model to complete assessment. — Use the DRAINS model to assess baseline scenario flood and drainage conditions (i.e. maximum flood extent, flood levels, flood velocities, flood hazard and rail flood immunity). — Update the DRAINS model to reflect the proposed scenario design configuration. — Use the DRAINS model to assess baseline scenario flood and drainage conditions (i.e. maximum flood extent, flood levels, flood velocities, flood hazard and rail flood immunity). — Compare the baseline and proposed scenario model results (i.e. flow paths, peak flow, flood levels, flood velocities and flood hazard) and assess the flood and drainage impacts. Flood assessment criteria are included in Table 3.7 below. — Produce flood impact maps to describe changes in flood conditions.
Low complexity	— Where the hydrological modelling described in section 3.3.3.2 can be used to demonstrate no change to catchment runoff rates, no hydraulic modelling has been undertaken. — Where some changes in runoff rates are identified, use the 12d drainage model to determine changes in offsite discharge characteristics as a result of the enhancement works. — Compare the baseline and proposed scenario model results and assess the flood and drainage impacts. Flood assessment criteria are included in Table 3.7 below.

For the sites where flood modelling was undertaken (i.e., Uranquinty Yard Clearances, Pearson Street bridge and Wagga Wagga Yard clearances) afflux maps were prepared to assess possible flood impacts. Where the afflux maps show no change in flood levels, there would be consequently no change to the hydraulic function of the floodplain and flow propagation. Therefore, changes in other parameters (i.e., flow velocities, flood hazard and time of inundation) would not occur and have not been mapped. Flow velocity change was checked in the model results and reported for these sites in key locations (upstream or downstream) to demonstrate negligible (i.e., compliant with the QDLs) change in flow velocity. No change in flood depth and flow velocity implies no change in flood hazard as the flood hazard is the product of flood depth and flow velocity.

For the other sites where a drainage assessment was undertaken the change in flood level (afflux) and flow were assessed to demonstrate no change in the drainage conditions.

3.3.3.4 SUMMARY OF ASSESSMENT CATEGORIES AT ENHANCEMENT SITES

The proposal is considered to have low risk to impact the flood conditions and hydraulic function of the floodplain. There is no flow diversion as the works have been designed to mimic the existing drainage and surface water flow conditions at the sites.

The hydraulic complexity determined for the enhancement sites and resulting assessment type are outlined in Table 3.6. The sites subject to flood modelling were discussed and agreed following engagement with DPE (BCD division).

Table 3.6 Summary of hydrological and hydraulic assessment categories at enhancement sites (operational phase)

ENHANCEMENT SITES	KEY FEATURES	ASSESSMENT CATEGORY	ASSESSMENT TYPE
Albury precinct			
Murray River bridge	Rail bridge alterations	Low complexity The proposed work at this enhancement site does not interact with the flood conditions. Proposed works are above the PMF flood level. Thus, the site of low complexity.	Qualitative
Albury Station pedestrian bridge	Pedestrian bridge replacement (of section over the rail corridor) and adjustments to the ramps on the eastern section of the bridge near Kenilworth Street.	Low complexity The proposed enhancement works are not affected by flooding up to and including the 1 per cent flood event. The site is of low complexity.	Qualitative
Albury Yard clearances	Track realignment	Low complexity The proposed enhancement works are not affected by flooding up to and including the 1 per cent flood event. The site is of low complexity.	Qualitative
Riverina Highway bridge	Track lowering and realignment	Moderate complexity The proposed enhancement work involves new drainage design that might cause impacts to the local drainage conditions. The site is not affected by local flooding. The site is of moderate complexity. A drainage model was developed to assess possible impacts in flow regime.	Quantitative
Billy Hughes bridge	Track lowering and realignment	Moderate complexity The proposed track lowering might affect the local catchment runoff and impact the local drainage channels or overland flow paths. The site is of moderate complexity. A drainage model was developed to assess possible impacts in flow regime.	Quantitative
Table Top Yard clearances	Gantry removal	Low complexity The site is of low complexity due to the type of work proposed.	Qualitative

ENHANCEMENT SITES	KEY FEATURES	ASSESSMENT CATEGORY	ASSESSMENT TYPE
Greater Hume—Lockhart precinct			
Culcairn pedestrian bridge	Pedestrian bridge removal	Low complexity The proposed enhancement works are not affected by flooding up to and including the 1 per cent flood event. The site is of low complexity.	Qualitative
Culcairn Yard clearances	Track realignment	Low complexity The proposed enhancement works are not affected by flooding up to and including the 1 per cent flood event. The site is of low complexity.	Qualitative
Henty Yard clearances	Track realignment Level crossing modifications	Moderate complexity: The proposed enhancement works is not affected by flooding. New drainage works might affect local drainage or flow paths. The site is of moderate complexity. A drainage model was developed to assess change in the drainage conditions.	Qualitative
Yerong Creek Yard clearances	Track realignment	Low complexity The site is not documented as affected by river or overland flooding. Thus, the site is of low complexity.	Qualitative
The Rock Yard clearances	Gantry modification	Low complexity The proposed works have no interaction with the flood or drainage conditions. Thus, the complexity of the site is low. No assessment is required for this site.	Qualitative
Wagga Wagga precinct			
Uranquinty Yard clearances	Track realignment Rail bridge alterations Level crossing modifications	High complexity The changes in the vertical alignment might affect the overland flood conditions. The site is of high complexity. Flood modelling was undertaken for this site.	Quantitative (Flood modelling was undertaken for this site)
Pearson Street bridge	Track lowering and realignment	Moderate complexity The proposed works might affect the overland flood conditions. The site is of moderate complexity. Flood modelling was undertaken for this site.	Quantitative (Flood modelling was undertaken for this site)
Cassidy Parade pedestrian bridge	Pedestrian bridge replacement	Low complexity The site is located at the edge of the flood extent. Proposed works do not affect the existing drainage and have minor interaction with the flood conditions. The site is of low complexity.	Qualitative

ENHANCEMENT SITES	KEY FEATURES	ASSESSMENT CATEGORY	ASSESSMENT TYPE
Edmondson Street bridge	Road bridge replacement	Low complexity The proposed works might affect the drainage discharge. The site is of low complexity. A drainage assessment was completed for this site.	Quantitative
Wagga Wagga Station pedestrian bridge	Pedestrian bridge replacement	Low complexity Proposed works do not affect the existing drainage and have minor interaction with the flood conditions. The site is of low complexity.	Qualitative
Wagga Wagga Yard clearances (including Docker Street gantry)	Track realignment	Moderate complexity The changes in the vertical alignment might affect the local overland flood conditions. The site is of moderate complexity. Flood modelling was undertaken for this site.	Quantitative (Flood modelling was undertaken for this site)
Bomen Yard clearances	Track realignment Level crossing modifications	Low complexity The site is not affected by regional flooding. Minor changes in the vertical alignment (up to 50mm) are not expected to affect any flood conditions. The proposed drainage would mimic the existing conditions. Thus, the site is of low complexity.	Qualitative
Junee precinct			
Harefield Yard clearances	Track realignment Rail bridge alterations	Low complexity The site is not documented as affected by flooding. As the proposed drainage would mimic the existing conditions the site is of low complexity.	Qualitative
Kemp Street bridge	Road bridge replacement	Moderate complexity The replacement of the existing bridge might affect the local drainage conditions. Thus, the site is of moderate complexity. Drainage modelling was undertaken to assess possible change in the local flow paths and drainage system was completed.	Qualitative
Junee Station pedestrian bridge	Pedestrian bridge removal	Low complexity The proposed work would not have any permanent structure that can affect the flood or drainage conditions. Thus the site is of low complexity.	Qualitative
Junee Yard clearances	Track realignment	Low complexity There is no change in vertical alignment that might affect the overland flood conditions. Thus, the site is of low complexity.	Qualitative

ENHANCEMENT SITES	KEY FEATURES	ASSESSMENT CATEGORY	ASSESSMENT TYPE
Olympic Highway underbridge	Track realignment Rail bridge alterations	Low complexity The site is not affected by regional or overland flooding. Thus, the site is of low complexity.	Qualitative
Junee to Illabo clearances	Track realignment Culvert replacement	Moderate complexity The site is not affected by regional flooding. Proposed works might affect local drainage and flow conditions. Thus, the site is of moderate complexity. A drainage model was developed to assess possible impacts.	Qualitative

3.3.4 HYDROLOGY MODELLING – COMPARISON OF ARR2019 AND ARR1987

For some proposal sites, the flood studies sourced from local government authorities were prepared under previous versions of the ARR and have not been updated. NSW Government (OEH, 2019) outlines that studies that were developed to be consistent with previous versions of ARR, outlined in the Flood Development Manual (NSW Government, 2005), remain the best available information to manage flood risk in a location until more detailed investigations that fully consider ARR2016 are completed and considered. For the studies that have been developed with reference to ARR1987, the NSW Government advice is to consider testing the sensitivity to change. As such, this has been the adopted approach for this assessment.

The sensitivity analysis on the different hydrology approach discussed in the Floodplain Risk Management Guidelines shows that, on average, the previous version of the ARR (i.e. ARR1987) has conservative Intensity–Frequency–Duration (IFDs) for the proposal sites for short storm durations (up to 1 hour) and similar or minor difference (i.e. +/- 5 per cent) to the latest ARR IFDs for storm duration up to 6 hours. For longer storm durations (i.e. up to 2 days) the differences with the latest ARR IFDs are mostly minor (i.e. up to 5 per cent) except for the areas at Junee where the differences are up to 10 per cent. However, for the sites at Junee only short storm durations are relevant to define the peak flood levels.

Therefore, the flood studies sourced from local government authorities are considered appropriate for the purpose of this assessment, and the reliance on studies that used ARR1987 is a conservative approach and does not affect the outcome of this assessment.

3.3.5 CLIMATE CHANGE SENSITIVITY ANALYSIS

A climate change scenario was simulated in the hydrological models, which involved assessment of a 20 per cent increase in rainfall intensity, based on the ARR2019 recommendation to adopt the CSIRO Representative Concentration Pathway (RCP) of 8.5 and an expected design life of 100 years. ARR2019 outlines a procedure to determine an appropriate increase. The 20 per cent increase is based on the year 2090 and RCP 8.5 values.

The 1 per cent AEP rainfall data was then factored up by 20 per cent to assess the sensitivity of flood and drainage behaviour resulting from the projected increase in rainfall intensity. The climate change scenario was run for the 1 per cent AEP event to determine the potential impacts on rail formation flood immunity and impacts on adjacent land.

3.3.6 FLOOD IMPACT ASSESSMENT AND MANAGEMENT OBJECTIVES

The SEARs (at Key Issue 8, Item 2) require the preparation of "Flood Management Objectives". For consistency with other Inland Rail projects—these objectives have been termed "Quantitative Design Limits" (QDL).

The impact assessment has been based on comparing the flooding conditions with and without the proposal, using flood/drainage model outputs, use of GIS data mapping and assessments of flows through hydraulic structures (i.e. culverts and bridges). The design has undergone several iterations to ensure proposed flooding and drainage structures, and mitigation measures, address the QDLs developed for the Inland Rail program and maintain appropriate flood immunity for the railway. Revisions to the vertical alignment of the track have been undertaken to achieve the required clearances and associated grades.

The QDLs have been established from those set by the Conditions of Approval for the Narrabri to North Star (N2NS) Phase 1 project (August 2020) and subsequently the Draft Conditions of Approval for the North Star to Border (NS2B) project (as at May 2022), which form the basis of consolidated QDLs for the Inland Rail program. These criteria were considered suitable on the basis of similarity of the proposal (enhancement of the existing rail line), similarity of land uses around the study area and similar flood behaviour.

These QDLs are intended to address variable flooding conditions and risks across a range of catchment types and sizes and provide a common basis across the Inland Rail program.

Assessment of the reference design and proposal characteristics has been undertaken against the proposed QDLs. Compliance of the proposal against the conditioned QDLs would be demonstrated at the detailed design stage in a Flood Design Verification Report that documents the compliance outcomes for the final detailed design.

The proposed QDLs for the proposal are provided in Table 3.7. The QDLs are broken down into the following key flood parameters and criteria or limits, and are only applicable beyond the SSI corridor for the proposal corridor unless otherwise noted. The QDLs do not apply to model noise (refer to Note (1) to Table 3.7).

Table 3.7 Quantitative Design Limits

PARAMETER	CRITERIA / LIMITS	PROPOSED QDL FOR THE PROPOSAL
Afflux i.e. increase in flood level resulting from implementation of CSSI.	Habitable floors[2]	10mm increase[3]
	Non-habitable floors[2]	20mm increase
	Surrounds of residential building, other urban, open space and recreational land and infrastructure (excluding sensitive infrastructure)	100mm increase
	Agricultural	200mm increase
	Forest and unimproved grazing land	300mm increase
	Classified roads managed by TfNSW[6]	50mm on areas flooded under existing conditions. Otherwise, no increase[5]
	Highways and sealed roads >80km/hr[4]	No afflux where aquaplaning risk exists and remains unmitigated. Otherwise 50mm increase
	Unsealed roads and sealed roads <80km/hr[6]	100mm increase

PARAMETER	CRITERIA / LIMITS	PROPOSED QDL FOR THE PROPOSAL
Scour/Erosion Potential i.e. increase in flood velocity resulting from implementation of CSSI.[6]	Ground surfaces that have been sealed or otherwise protected against erosion. This includes roads and most urban, commercial, industrial, recreational and forested land	20% increase in velocity where existing velocity already exceeds 1m/s[7]
	Classified roads managed by TfNSW[6]	10% increase in velocity where existing velocity already exceeds 1m/s
	Other areas, including watercourses, agricultural land, unimproved grazing land and other unsealed or unprotected areas	An erosion threshold velocity (ETV) is to be adopted through a site specific assessment(s) conducted by an experienced geotechnical or scour/erosion specialist.[8] An ETV of 0.5m/s is to be adopted in the absence of a site specific assessment(s). Where existing velocity exceeds ETV, velocity is limited to a 0.025m/s increase.[9] Where existing velocity is less than ETV, velocity is limited to the lesser of: — ETV — 20% increase[10] or 0.5m/s, whichever is greater.
Flood Hazard i.e. increase in velocity depth product (vd) and/or flood hazard category resulting from implementation of CSSI. (Does not apply where vd<0.1m^2/s).	Urban, commercial, industrial, highways[6] and sealed roadways[6]	10% increase in vd
	Classified roads managed by TfNSW[6]	10% increase in vd where this does not result in an increase in hazard category. Otherwise, no increase.[6]
	Elsewhere	20% increase in vd
Flood Duration i.e. increase in duration of inundation resulting from implementation of CSSI. (Does not apply to inundated areas less than 100m^2).	Habitable floors[2]	Where existing above floor flooding is: — less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour — greater than 1 hour in duration, up to 5% increased inundation duration. Where existing below floor flooding is: — less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour — greater than 1 hour in duration, up to 10% increased inundation duration.
	Classified roads managed by TfNSW[6]	No increase in duration of flood inundation to sections of road not already inundated.[11] Otherwise 10% increase in inundation duration.
	Highways and sealed roads >80km/hr[6]	10% increase in inundation duration.

PARAMETER	CRITERIA / LIMITS	PROPOSED QDL FOR THE PROPOSAL
	Elsewhere	Where existing inundation is less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour. Where existing inundation is greater than 1 hour in flood duration, up to 10% increase in duration of inundation. No duration limits apply to newly flooded land no greater than 1000m^2 in area.

Notes:

(1) Model noise is an artefact of the modelling process and does not provide any useful information and is not the same as model tolerance. Modelling noise is to be ignored when assessing compliance with the QDL. All modelling noise exclusions are to be reviewed by the independent reviewer.

(2) Habitable floors/rooms are defined consistent with the use of this term in the NSW Floodplain Development Manual. In a residential situation this comprises a living or working area such as a lounge room, dining room, rumpus room, kitchen, bedroom, workroom. In an industrial, commercial or other building, this comprises an area used for an office or to store valuable possessions, goods or equipment susceptible to flood damage in the event of a flood.

(3) 10mm has been set to provide a margin for modelling uncertainties/tolerances. The intent of this requirement is that existing flood levels above floor level do not increase.

(4) Including where located within CSSI rail corridor.

(5) Any afflux on newly inundated sections of road must be negotiated with the roads authority.

(6) Any variation must be negotiated with the roads authority.

(7) Local variations in velocity can exceed a 20% change provided that when assessed over a 30m wide flowpath, the velocity change on average does not exceed 20%.

(8) Shear stress assessments may be used as an alternative method from which to describe the erosion threshold in a specific environment (i.e. soil type, depth, velocity). An erosion threshold sheer stress (ETSS) can be used as an alternative to the ETV to ensure the erosion threshold is not exceeded beyond the limits of this velocity QDL. (If the ETSS is used, compliance with the limiting increases in velocities specified within this QDL are also required).

(9) Where velocity exceeds this QDL, an Operational Erosion Mitigation and Monitoring Program must be prepared and implemented.

(10) Local variations in velocity can exceed a 20% change provided that when assessed over a 30m wide flowpath, the velocity change on average does not exceed 20%.

(11) Any flooding duration on newly inundated sections of road must be negotiated with the roads authority.

3.3.7 SCOUR AND EROSION IMPACTS

The proposal would involve works over and adjacent to rivers, creeks, drainage lines and overland flow paths, and modifications to existing drainage infrastructure.

The drainage and flooding impact assessments determine where the works may cause changes to the existing velocity regimes and, where changes are predicted, the risk of downstream scour and erosion is managed through design of appropriate mitigation measures, as follows:

- New or modified drainage infrastructure: Flood or drainage model predictions or calculations of flood levels and velocities in new or modified drainage infrastructure, such as cross and longitudinal drainage culverts, pipes and channels, are used to design scour protection measures within these drainage systems, and at their outlets and points of discharge to the receiving systems downstream. The design is based on the procedure recommended in the Austroads Guide to Road Design, Part 5: Drainage – General and Hydrology Considerations (Austroads 2013), which identifies requirements for rip rap aprons, extended aprons and energy dissipaters depending on velocities, Froude Numbers and in-situ soil type.

- New or modified waterway bridges: Flood model predictions of flood levels and velocities at bridges are used to estimate scour depths at bridge abutments and piers to inform the geotechnical and structural design calculations and to design appropriate scour protection measures around the bridges. The design is based on the Austroads Guide to Bridge Technology, Part 8: Hydraulic Design of Waterway Structures (Austroads 2018). As per industry standards, scour protection at abutments are designed for the one per cent AEP flood event while no scour protection is provided at piers as the geotechnical and structural design allows for the predicted scour depths at the piers.
- The above measures would be extended beyond the rail corridor where necessary to manage any elevated velocities and scour potential in receiving channels and overland flow paths downstream of the works. Such extensions of scour protection measures would be agreed with the adjacent landowners.

3.3.8 CONSISTENCY WITH COUNCIL FLOODPLAIN RISK MANAGEMENT PLANS

Where changes in flood behaviour and non-compliances with the QDL are predicted, they were compared with local council floodplain risk management plans and policies to determine if they are consistent with allowable levels of change in flood behaviour for brownfield development in flood-prone lands.

3.3.9 IMPACTS ON FLOOD EMERGENCY MANAGEMENT PLANS

Changes to flood behaviour could result in increased flood risk to residential areas and key access and evacuation routes during flood events. The State Emergency Service (SES) and local councils maintain flood emergency management plans that identify key flood risk areas and flood warning and evacuation plans for such areas. The available plans have been reviewed and the impact of the proposal qualitatively assessed. Where changes in flood behaviour are identified that would increase risk to flood prone residences and accesses, consultation would be undertaken with SES and local council to determine the acceptability of the increased risk and the form of any risk mitigation measures that may be required (refer to section 5.1.2.6).

3.3.10 SOCIAL AND ECONOMIC COSTS OF FLOOD IMPACTS

Changes in flood behaviour may increase flood risk and flood affectation on key social and economic assets such as residences; commercial, industrial and agricultural properties; highways and local roads; and recreational facilities. Where significant changes and QDL non-compliances are identified for such assets, an assessment of the associated social and economic costs of the potential impacts have been considered in Technical Paper 4 – Social and Technical Paper 5 – Economic.

3.4 HYDROLOGY

3.4.1 HYDROLOGICAL REGIMES

The potential impacts have been qualitatively and quantitatively estimated to understand be changes in downstream flow rates, volumes and durations, and suitable mitigation measures proposed.

The description of the hydrologic regime is based on photographs available of the waterways and stream data, where available, and informs the understanding of flow behaviour at each site, such that it provides and understanding of the watercourses with permanent flow and those that only flow flowing rainfall events.

3.4.2 WATER BALANCE

The proposal site would involve minor works at each site and, as such, a qualitative assessment of changes to the hydrological regimes has been completed with consideration of groundwater and water requirements for construction.

There is negligible change to catchment and drainage sub catchment, and hydrology regimes downstream of the proposal sites, and there are no impacts on the water availability to the downstream catchment during operation. As such, a simple water balance has been provided.

3.4.3 WATER AVAILABILITY AND WATER TAKE

The available water has been defined through a review of the relevant water sharing plans, the Murray-Darling Basin Plan and a summary of surface water licences near the proposal sites.

3.4.4 STORMWATER AND WASTEWATER DISCHARGES

The identification of stormwater and wastewater discharges has been based on the proposed design for each site and proposed changes to the management of stormwater at each site A qualitative assessment has been undertaken due to the minor works proposed for each site and this was deemed adequate to inform the assessment and develop mitigation measures. No accommodation camps or additional wastewater discharge points are proposed so assessment of wastewater discharges was deemed not applicable.

The flooding assessment would identify the baseline and proposed scenario stormwater discharge infrastructure and in the vicinity of the sites and would use drainage and flood modelling where necessary to quantify changes to the stormwater discharge regimes. This assessment has included any new permanent stormwater discharges or connections required by the works.

3.4.5 EROSION, SEDIMENTATION AND WATERCOURSE STABILITY

Changes in the stormwater discharge regime and other catchment flow changes resulting from the proposal have the potential to change flow rates and velocities in the downstream receiving watercourses. Such changes could introduce erosion and sedimentation risks with associated impacts on watercourse stability. With the works largely occurring within the existing rail corridor the assessment has been qualitative with a focus on defining appropriate at site mitigation. Any new or modified drainage systems within the rail corridor and any modifications to rail bridges over watercourses would be subject to scour assessment and protection (see section 3.3.7). The works may also change velocity regimes beyond the rail corridor and in these cases these changes were compared to the QDL.

Construction would require vegetation clearing, ground disturbance, excavation and stockpiling of excavated material. Such activities may impact downstream watercourses and water quality due to temporary obstructions or changes to flow directions, and offsite discharge of high sediment loads in construction site runoff. The potential for such impacts were assessed and best-practice mitigation measures were identified. These measures would typically involve local sediment controls such as silt fences and bunds or sedimentation basins designed in accordance with The Blue Book (Landcom, 2004) where disturbed areas are more extensive.

3.5 WATER QUALITY ASSESSMENT

The following methodology has been used to understand the existing water quality environment in the study area, assess potential construction and operation phase impacts, and develop mitigation measures.

3.5.1 WATER QUALITY MONITORING

A desktop review of available monitoring data has been undertaken for this assessment; the outcome of the desktop review is documented in section 4.8. It is noted that many of the watercourses intersected by the proposal are ephemeral and opportunities for the collection of representative water samples directly is limited. Publicly available water monitoring data was available for major watercourses, including the Murray River and Murrumbidgee River, which represent the point of discharge downstream for other minor watercourses relevant to the proposal.

A desktop review of available monitoring data has been collected and reviewed for this assessment; the outcome of the desktop review is documented in Chapter 4.

As there are no expected flow changes and no changes to nor additional stormwater discharges from the rail corridor that would impact downstream water quality and or sensitive downstream surface water uses, water quality monitoring would not be required for the proposal.

3.5.2 SENSITIVE RECEIVING ENVIRONMENTS

Sensitive receiving environments were identified using aquatic habitat as an indicator, which was assessed against the NSW Department of Primary Industries (DPI) Policy and Guidelines for Fish Habitat Conservation and Management (DPI, 2013) and Fish Passage Requirements for Waterway Crossings (Fairfull and Witheridge 2003). Sensitive receiving environments are identified based on the following considerations:

- key fish habitat (DPI 2013)
- records of threatened species listed under the Fisheries Management Act 1994 and Environment Protection and Biodiversity Conservation Act 1999
- groundwater and surface water dependent vegetation and fauna communities listed under the Biodiversity Conservation Act 2016 and Environment Protection and Biodiversity Conservation Act 1999
- Ramsar Wetlands
- whether the catchment falls within a drinking water catchment
- areas that contribute to aquaculture and commercial fishing
- activities and decisions made upstream affect water quality downstream, particularly the cumulative impacts of nutrients and sediment.

3.5.3 IMPACT ASSESSMENT

As no site-specific water quality data was available and most sites were not located near significant sensitive receivers, and/or no permanent works are proposed in waterways, a qualitative assessment has been carried out for all sites. The qualitative assessment of the potential water quality impacts considers:

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

The potential impacts of the proposal are assessed qualitatively, with reference to standard water quality trigger values (ANZG 2018) in lieu of site-specific water quality data.

The construction impact assessment aims to identify potential water quality impacts based on current understanding of the construction approach and construction methods. The operational impact assessment identifies potential impacts to water quality during operation of the proposal.

Based on these assessments, this report provides recommendations for mitigation measures during construction and operation to minimise and manage potential impacts to waterways.

4 EXISTING ENVIRONMENT

4.1 REGIONAL CATCHMENTS

The proposal is located in the Murray and Murrumbidgee catchments of the Murray-Darling Basin. Figure 4.1 shows these catchments in relation to all NSW Murray-Darling Basin catchments. The catchments are discussed further in the following section.

Figure 4.1 Major catchments in NSW (Office of Environment and Heritage, 2006)

4.1.1 MURRAY CATCHMENT

Enhancement sites between (and including) the Murray River bridge at Albury through to Culcairn Yard clearances are located in the Murray catchment, specifically the mid-Murray catchment, which reaches from the Hume Dam to the confluence of the Murray and Darling Rivers at Wentworth in western NSW. The Murray River is the major watercourse in this catchment; however, the Kiewa, Ovens, Goulburn, Campaspe, Loddon and Murrumbidgee rivers all flow into the Murray River.

The landscape of the mid Murray catchment includes extensive floodplains and wetlands, including nationally and internationally significant sites such as the Barmah–Millewa Forest and the Gunbower–Koondrook–Perricoota Forest. There are many large urban centres established on the banks of the Murray River, and many significant dryland and irrigated agricultural industries located within the region. Tourism based around the river environment and water activities are also economically important to the region.

The Murray River water is highly regulated. Weirs and dams are located along the river to regulate flow and service irrigation areas. The major dam located near the proposal is the Hume dam, which is located 10km east of Albury and impounds the Hume reservoir. The Hume reservoir is the main operating storage of the Murray River system. Releases from the reservoir supply water along the Murray for irrigation, stock, and domestic and urban consumption, as well as for environmental purposes.

4.1.2 MURRUMBIDGEE CATCHMENT

Enhancement sites from Henty Yard clearances to Junee to Illabo clearances are located in the Murrumbidgee catchment. The Murrumbidgee catchment is in southern New South Wales and covers 84,000 square kilometres (NSW DPI, 2020), approximately eight per cent of the Murray-Darling Basin. The Murrumbidgee River is the catchment's major watercourse and runs west 1,600km from the Kosciuszko National Park to the Murray River near Balranald. Most of the inflow of the catchment occurs in the Great Dividing Range.

4.2 LOCAL WATERCOURSES AND HYDROLOGIC REGIMES

4.2.1 OVERVIEW

The proposal site interacts with a range of watercourses, including rivers, creeks, piped and open channel urban drainage systems and overland flow paths, as well as other waterbodies such as farm dams and ponds.

Table 4.1 describes the watercourses and other waterbodies crossed by or located near the enhancement sites. Figure 4.2 shows the watercourses intersected or located near the enhancement sites. Table 4.1 also provides a description of the general drainage patterns at the enhancement sites.

Table 4.1 Watercourses and other waterbodies relevant to the enhancement sites

CATCHMENT	ENHANCEMENT SITE	WATERCOURSES	OTHER WATERBODIES
Albury precinct			
Murray	Murray River bridge	Murray River and Oddies Creek intersect the enhancement site.	None
Murray	Albury Yard clearances, Albury Station pedestrian bridge, and Riverina Highway bridge	A concrete lined channel runs from north to south through the site. This channel links to ponds that discharge to the Murray River. Browns Lagoon is located 450m to the south west of the enhancement site.	Two ponds (collecting surface water runoff)
Murray	Billy Hughes bridge	An unnamed tributary of Eight Mile Creek intersects the enhancement site. This drains to Eight Mile Creek to the east. Eight Mile Creek then flows South and discharges to the Murray River.	None
Murray	Table Top Yard clearances	No watercourses intersect the enhancement site.	Two farm dams Lake Hume is located 3km to the east of the site

CATCHMENT	ENHANCEMENT SITE	WATERCOURSES	OTHER WATERBODIES
Greater Hume – Lockhart precinct			
Murray	Culcairn Yard clearances and pedestrian bridge	No watercourses intersect the enhancement site. Billabong Creek is located 350m to the south and an unnamed tributary is located 80m to the north. The site is part of the Middle Billabong sub catchment of the Murray catchment.	None
Murrumbidgee	Henty Yard clearances	No watercourses intersect the enhancement site. Buckargingah Creek is located 30m to the north of the enhancement site. The enhancement site is part of the Burkes/Bullenbung sub catchment of the Murrumbidgee catchment.	None
Murrumbidgee	Yerong Creek Yard clearances	Sandy Creek intersects the enhancement site and Yerong Creek is located 400m to the north. Yerong Creek flows to the west and is part of the Burkes/Bullenbung sub catchment of the Murrumbidgee catchment.	Several farm dams around the site
Murrumbidgee	The Rock Yard clearances	No watercourses intersect the enhancement site. Burkes Creek is located 380m north of the enhancement site. Burkes Creek flows to the west and eventually joins Bullenbung Creek.	Three farm dams north of the site
Wagga Wagga precinct			
Murrumbidgee	Uranquinty Yard clearances	Sandy Creek intersects the enhancement site. Sandy Creek flows towards north and joins the Murrumbidgee River.	Three farm dams to the north
Murrumbidgee	Pearson Street bridge	An unnamed tributary of Flowerdale Lagoon intersects the enhancement site. Flowerdale Lagoon is located about 1.5km north of the enhancement site and discharges to the Murrumbidgee River.	None
Murrumbidgee	Cassidy Parade pedestrian bridge, Edmondson Street bridge, Wagga Wagga Station pedestrian bridge and Wagga Wagga Yard clearances	No watercourses intersect the enhancement site. The Murrumbidgee River is located approximately 800m to the north.	None
Murrumbidgee	Bomen Yard clearances	No watercourses intersect the enhancement site. The Murrumbidgee River is located about 3.5km to the south of the site. Bomen Lagoon is located about 2km south of the site.	Several small farm dams around the site.

CATCHMENT	ENHANCEMENT SITE	WATERCOURSES	OTHER WATERBODIES
Junee precinct			
Murrumbidgee	Harefield Yard clearances	Reedy Creek intersects the enhancement site at two locations. The enhancement site is part of the Houaghans sub catchment of the Murrumbidgee catchment.	Four small farm dams surrounding the site
Murrumbidgee	Kemp Street bridge	Butlers Gully, a tributary to Houaghans Creek intersects the enhancement site and flows to the north.	None
Murrumbidgee	Olympic Highway underbridge	A tributary to Houaghans Creek intersects the enhancement site and flows to the north.	None
Murrumbidgee	Junee Station pedestrian bridge	No watercourses intersect the enhancement site. The enhancement site is part of the Houaghans sub catchment of the Murrumbidgee catchment.	None
Murrumbidgee	Junee Yard clearances	No watercourses intersect the enhancement site. The enhancement site is part of the Houaghans sub catchment of the Murrumbidgee catchment.	None
Murrumbidgee	Junee to Illabo clearances	Jeralgambeth Creek and some other unnamed tributaries flow through the site. The enhancement site is part of the Billabong Creek sub catchment of the Murrumbidgee catchment.	Several farm dams surrounding the site, the largest of which is adjacent to Illabo station, Illabo dam.

4.2.2 STREAMFLOW RECORDS

Identification of stream flow records informs the flow regime for a watercourse, which can then inform design and construction for the proposal. The MDBA operates a network of remote hydrometric monitoring stations along the Murray River and its tributaries. The network records and distributes data via telemetry, including river and storage levels, calculated flow rates, rainfall, and various water-quality attributes. The data is near-real-time and is updated on an hourly to six hourly intervals. Other types of data, including river flow and storage volume, are calculated using these primary measurements.

Table 4.2 lists gauges relevant to the proposal where there is flow data available. No gauged streams were located near the enhancement sites within the Junee precinct.

Table 4.2 Streamflow gauges within the study area

GAUGE ID	CATCHMENT	GAUGE NAME	LOCATION IN RELATION TO PROPOSAL SITE	LATITUDE	LONGITUDE
Albury precinct					
409001	Murray	Murray River at Albury (Union Bridge)	1.3km downstream of the Murray River bridge enhancement site.	-36.0916	146.9071
409017	Murray	Murray River at Doctors Point	7km upstream of Murray River bridge enhancement site.	-36.1126	146.9399
Greater Hume Lockhart					
410183	Murray	Billabong Creek at Parkside	15km downstream of Culcairn Yard clearances and Culcairn enhancement sites.	-35.6972	146.8855
410186	Murrumbidgee	Billabong Creek Downstream Ten Mile & Mountain Creeks	15km upstream of Culcairn Yard clearances enhancement site.	-35.6855	147.185
Wagga Wagga					
410001	Murrumbidgee	Murrumbidgee River at Wagga Wagga	2km north of Edmondson Street bridge	-35.1008	147.3676

4.2.3 HYDROLOGIC REGIMES

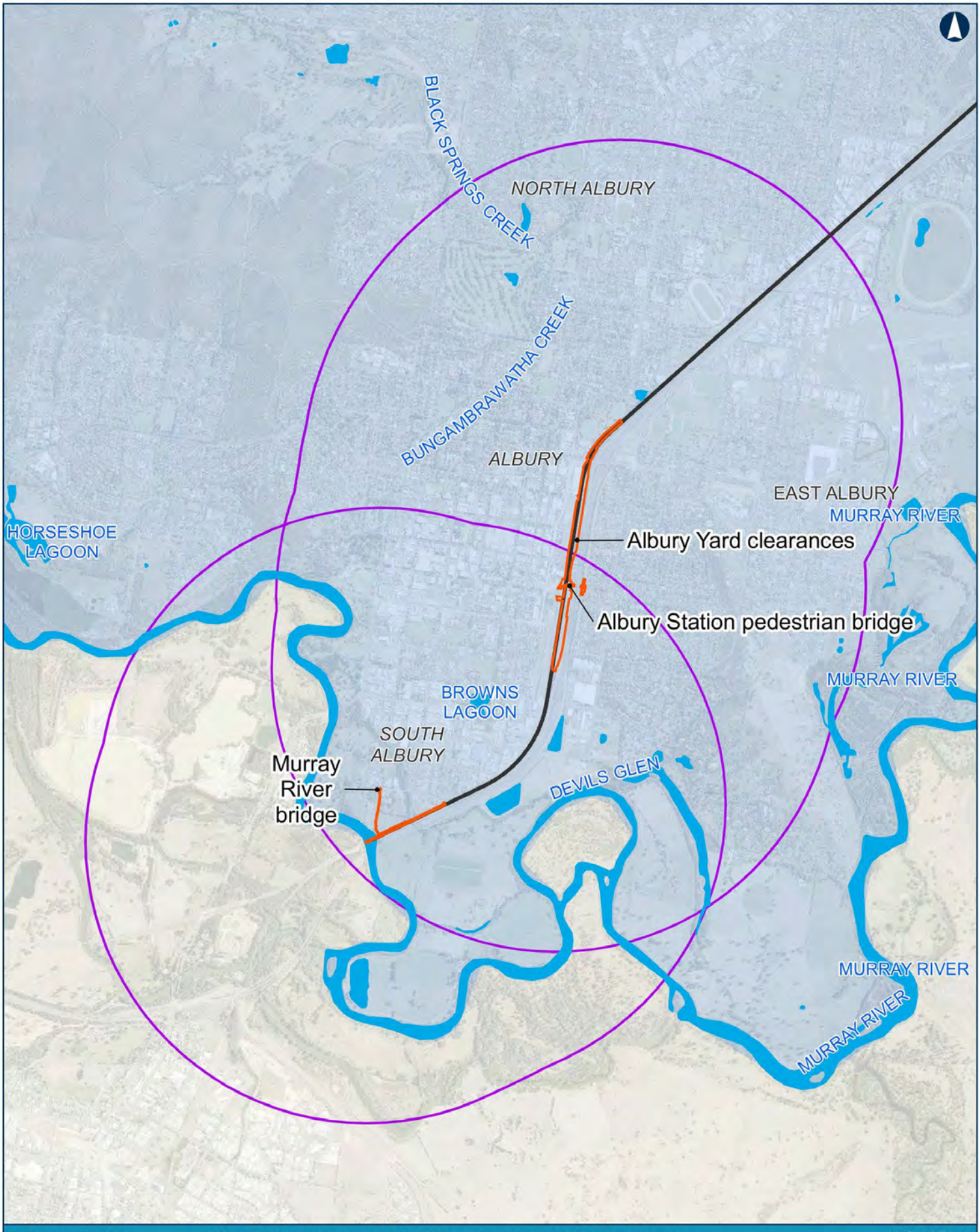
Table 4.3 summarises the stream order of the watercourses within the study area and provides a description of the hydrologic regime.

The Strahler stream order classification is a "top down" system in which streams of the first order are the outermost tributaries that don't have permanent water and often only flow following rainfall events.

The named watercourses within the study area are between 3rd order and 9th order. Major watercourses within the study area include the Murray River, Murrumbidgee River and Billabong Creek. Medium watercourses are Eight Mile Creek, Sandy Creek, Yerong Creek, Burkes Creek, Reedy Creek and Bucks Creek. All unnamed tributaries that are crossed by the proposal are 1st order streams.

Table 4.3 Stream order and hydrologic regime of named waterways in the study area

WATERCOURSE	STRAHLER STREAM ORDER	ENHANCEMENT SITE	HYDROLOGIC REGIME
Murray River	9th	Murray River bridge	Major perennial river
Oddies Creek	1st	Murray River bridge	Ephemeral watercourse
Eight Mile Creek	4th	Billy Hughes bridge	Ephemeral. No water was found during the site inspection but some residual pools were found
Billabong Creek	7th	Culcairn Yard clearances	Partly perennial creek (located 350m south of the proposal site)
Buckaringah Creek	4th	Henty Yard clearances	Mostly perennial river (located near the north edge of the proposal site)
Sandy Creek	6th	Uranquinty Yard clearances	Ephemeral
Yerong Creek	6th	Yerong Creek Yard clearances	Ephemeral
Burkes Creek	6th	The Rock Yard clearances	Ephemeral
Murrumbidgee River	9th	Cassidy Parade pedestrian bridge, Edmondson Street bridge, Wagga Wagga Station pedestrian bridge and Wagga Wagga Yard clearances Bomen Yard clearances	Perennial river
Reedy Creek	4th	Harefield Yard clearances	Ephemeral
Bucks Creek	4th	Harefield Yard clearances	Ephemeral
Butlers Gully	3rd	Kemp Street bridge	Ephemeral
Jeralgambeth Creek	3rd	Junee to Illabo clearances	Ephemeral



Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 1 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:25,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murray River Basin

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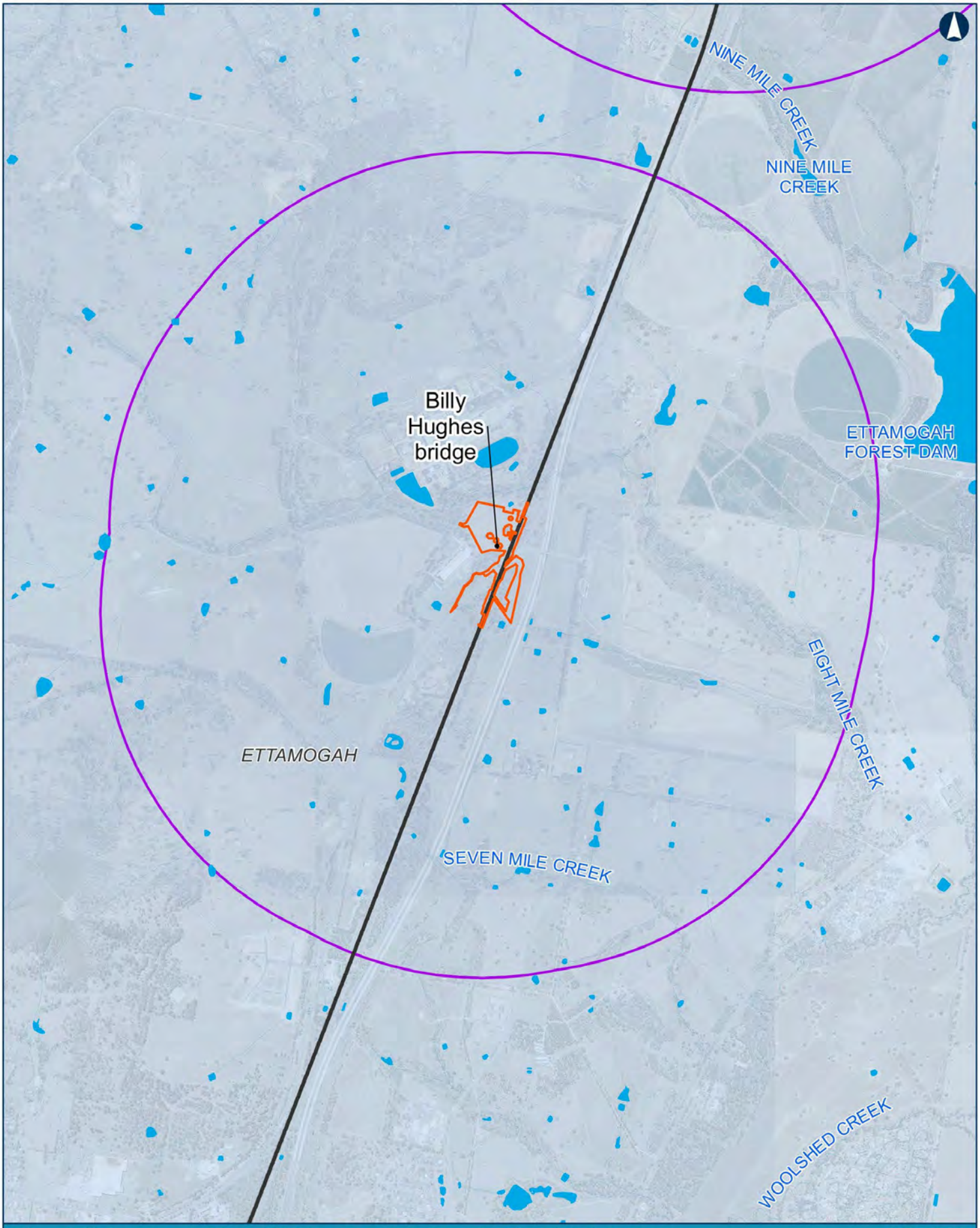

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 2 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:20,000
Data Sources: ARTC, NSWSS

- Proposal site
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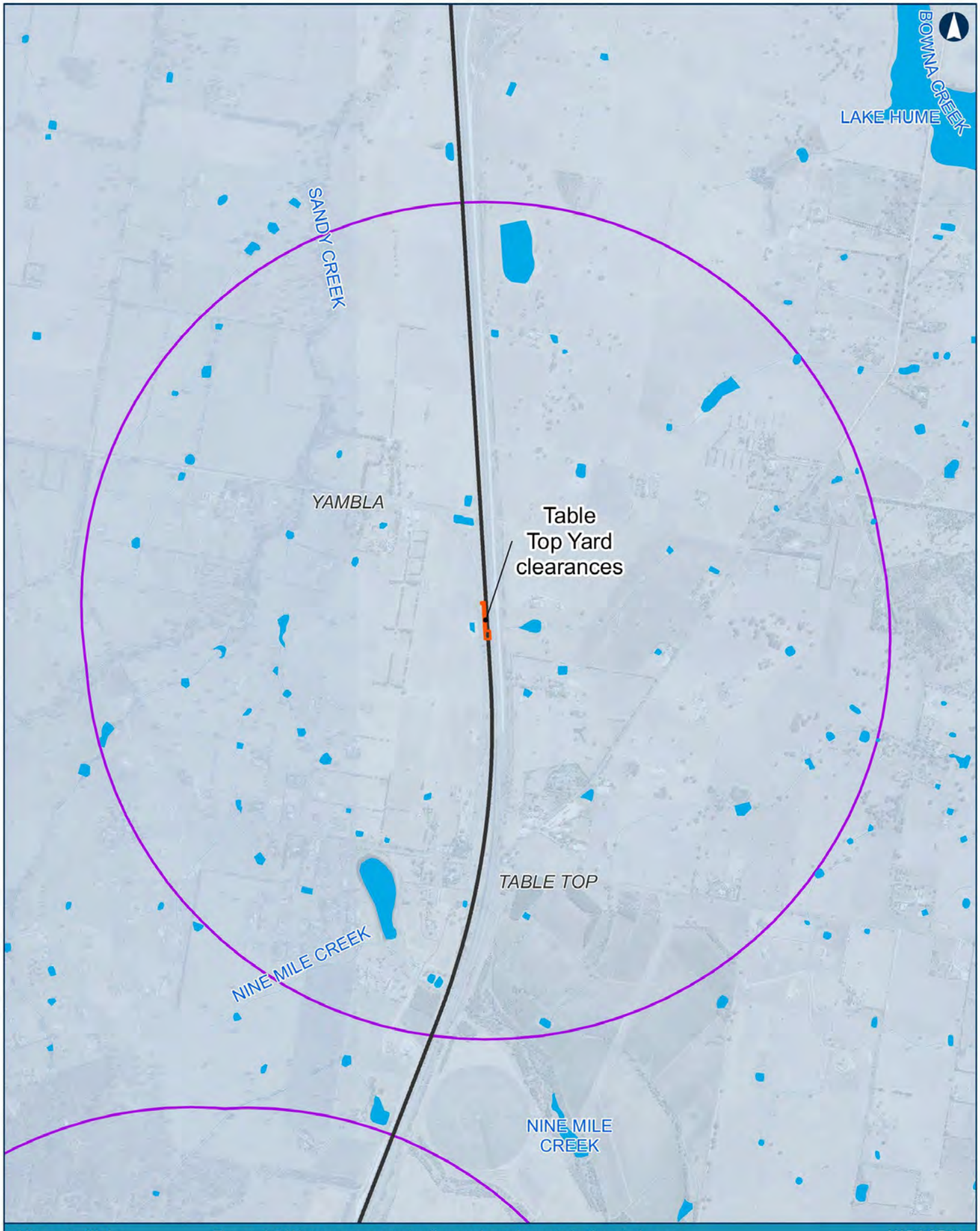

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 3 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:17,500
Data Sources: ARTC, NSWSS

- Proposal site
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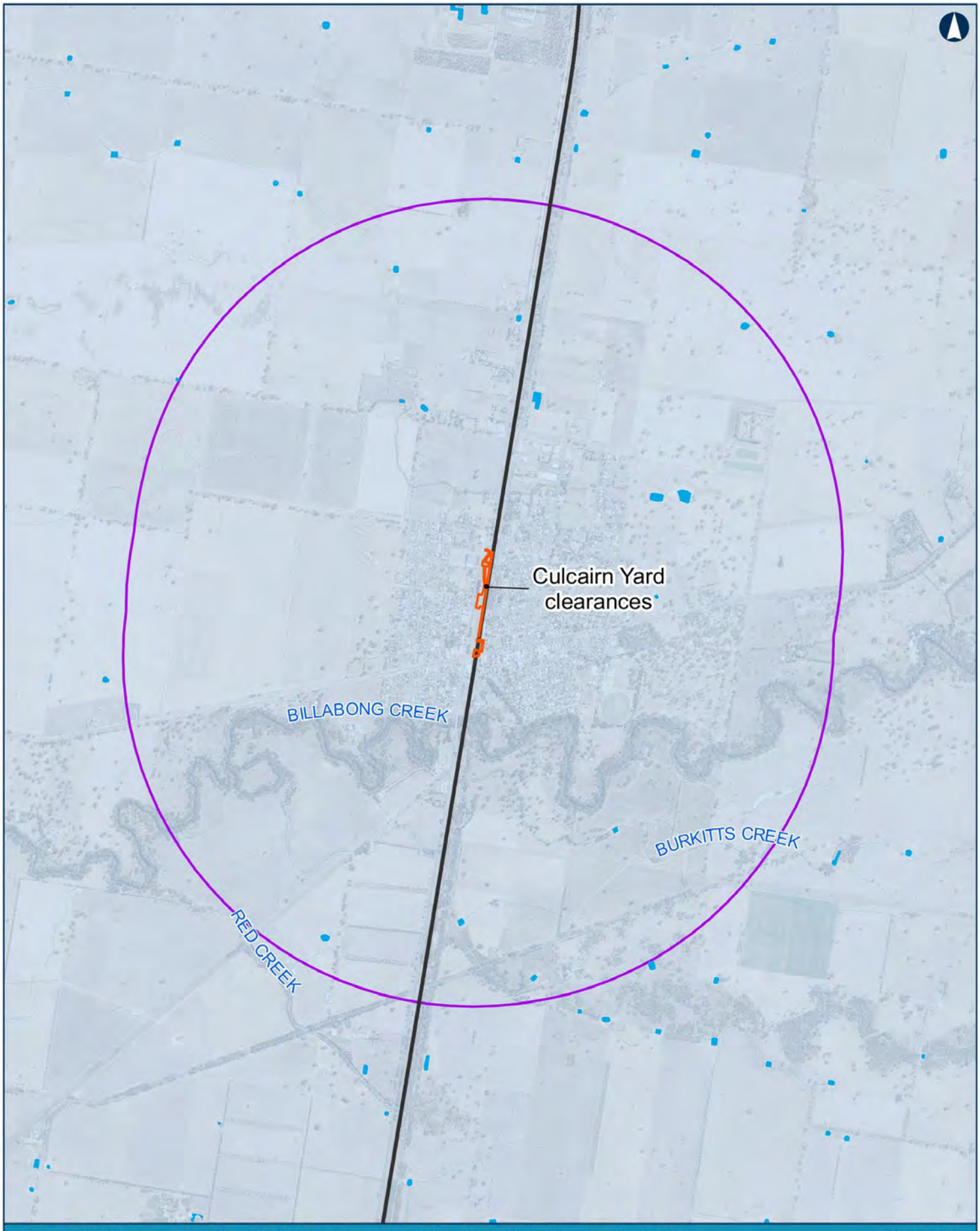

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 4 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
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- Proposal site
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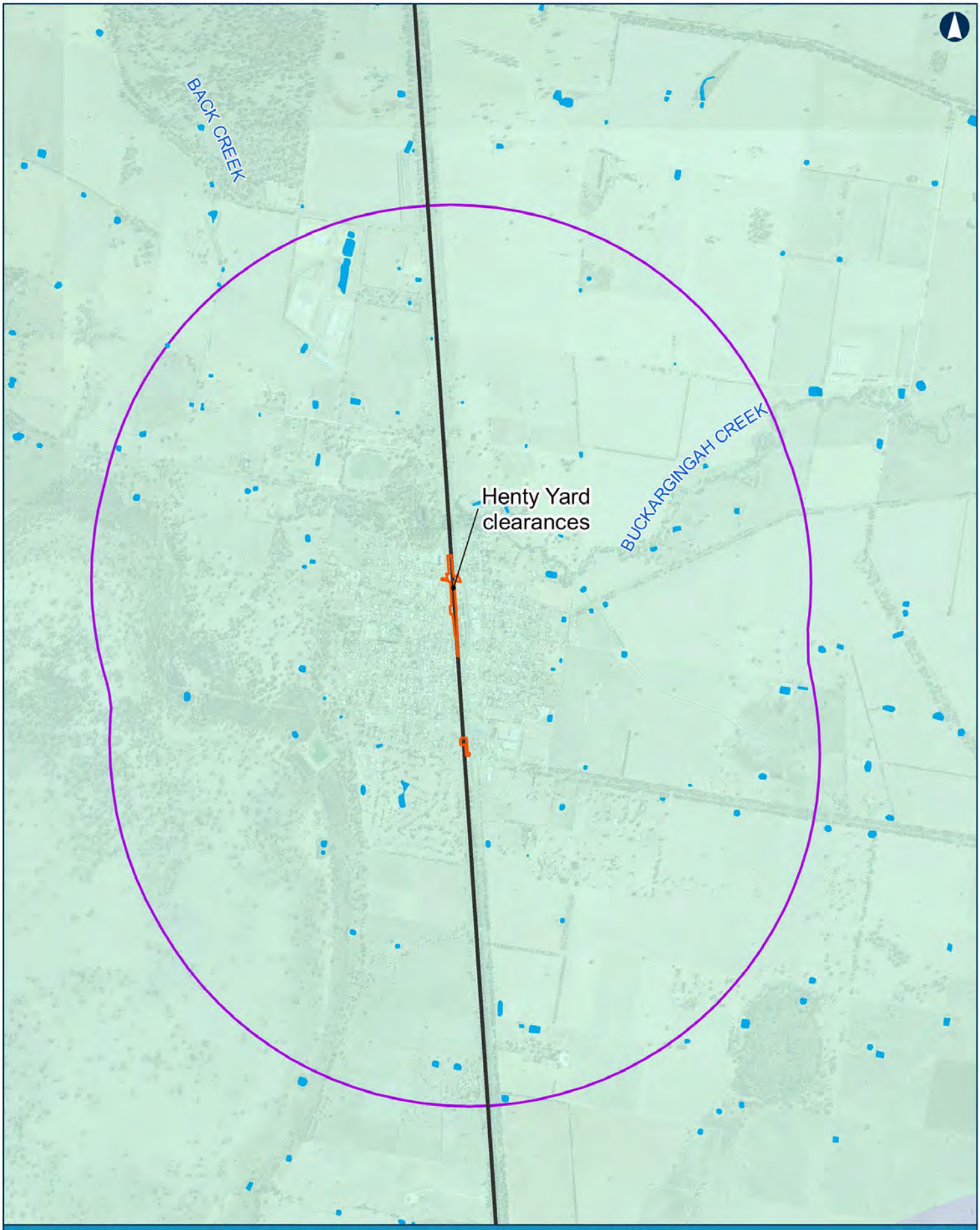

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 5 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:20,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murray River Basin
- Murrumbidgee River Basin

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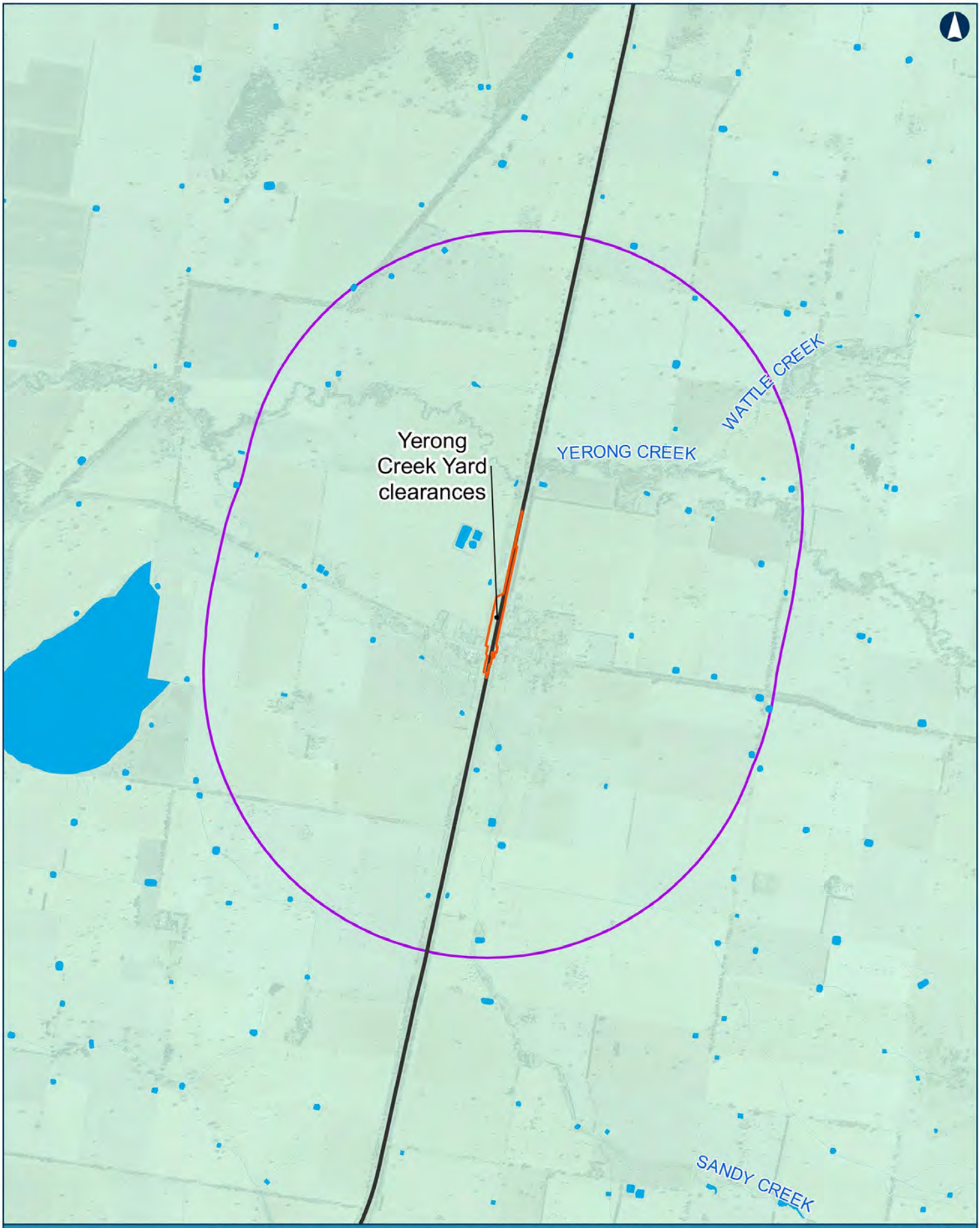

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 6 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:25,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murrumbidgee River Basin

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Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 7 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:20,000
Data Sources: ARTC, NSWSS

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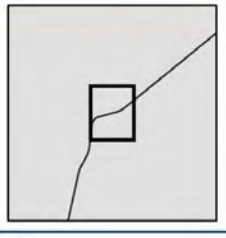

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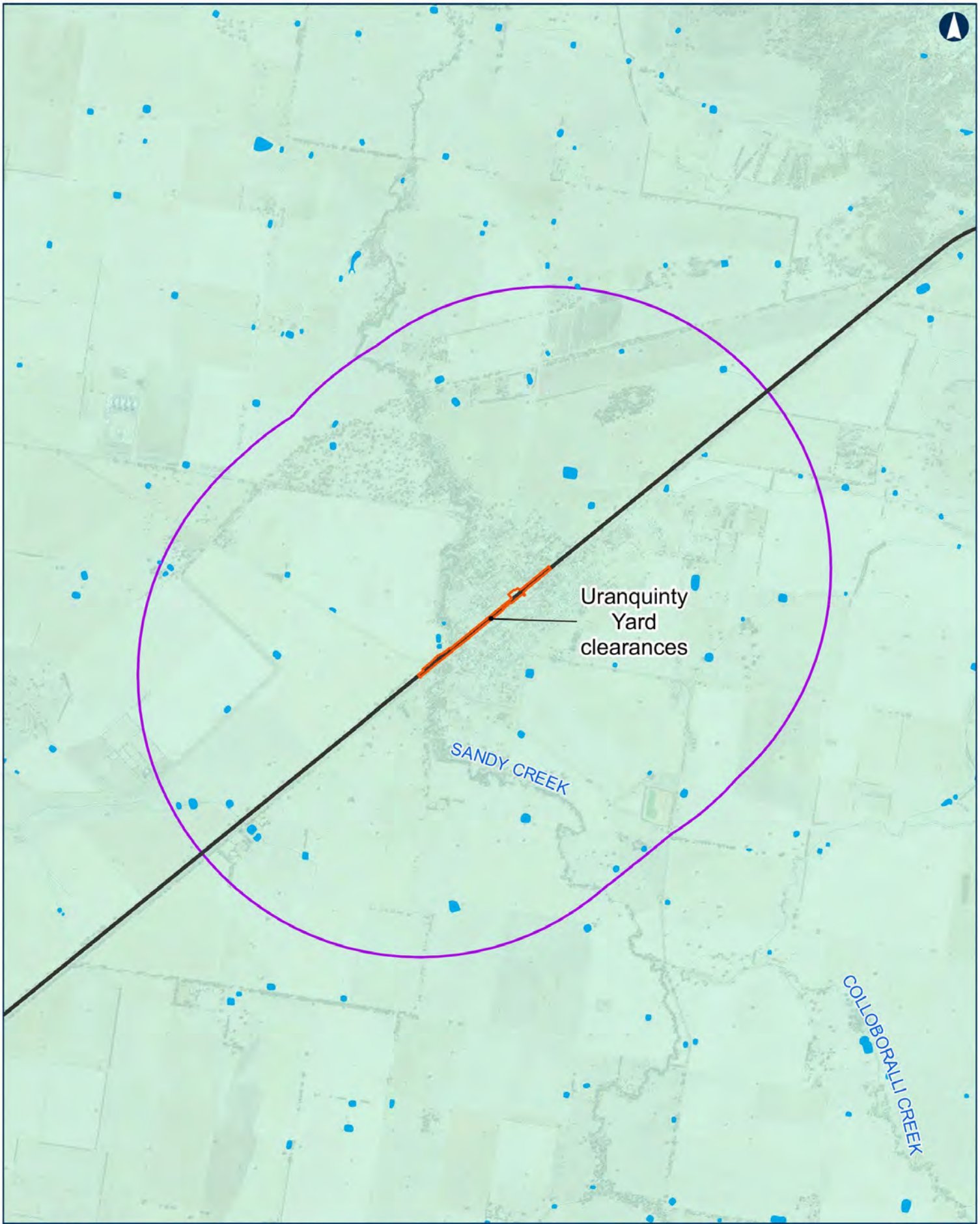

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 8 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:25,000
Data Sources: ARTC, NSWSS

- Proposal site
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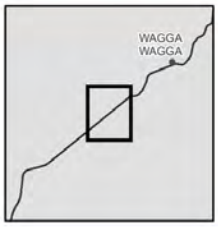

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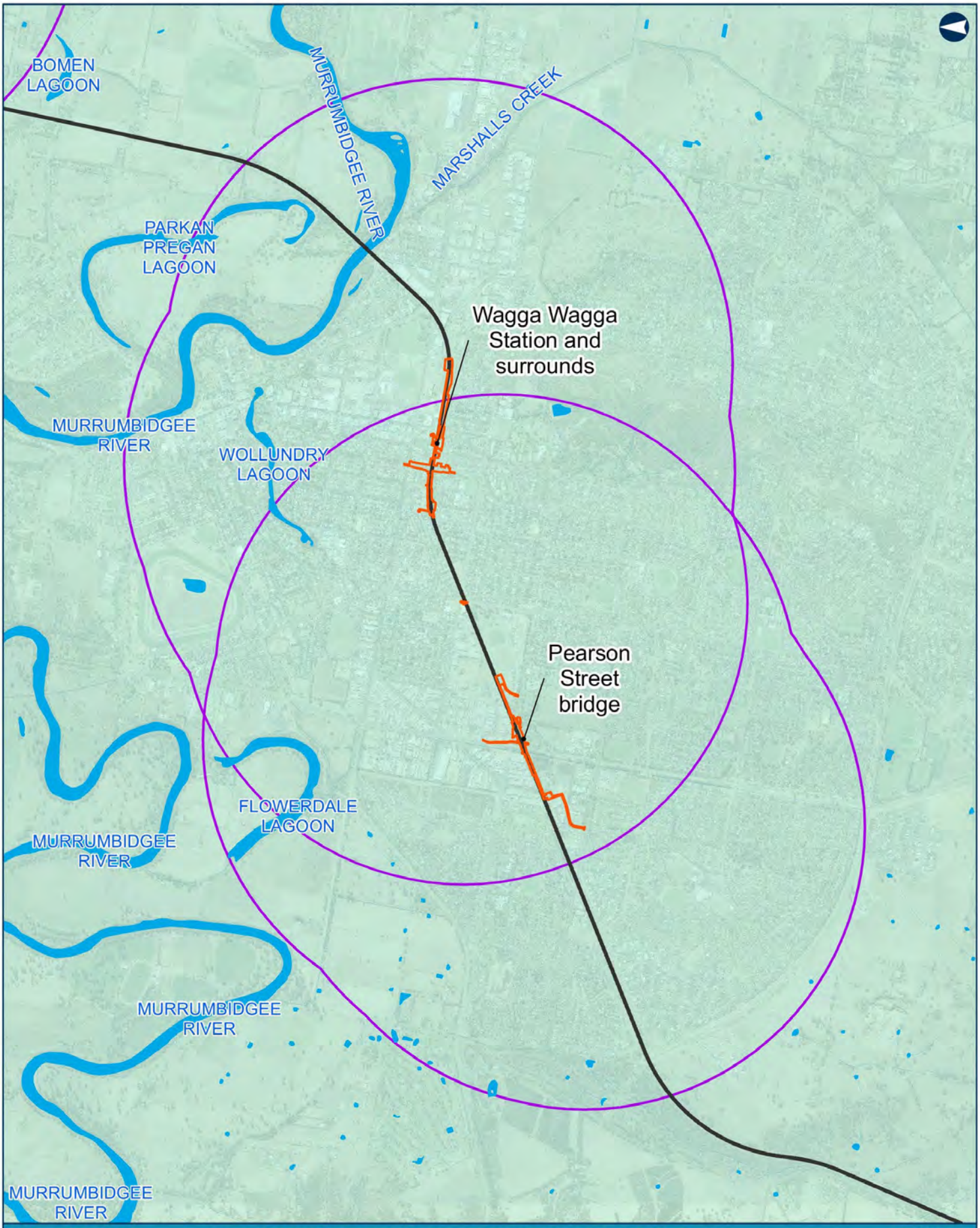

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 9 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:25,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murrumbidgee River Basin

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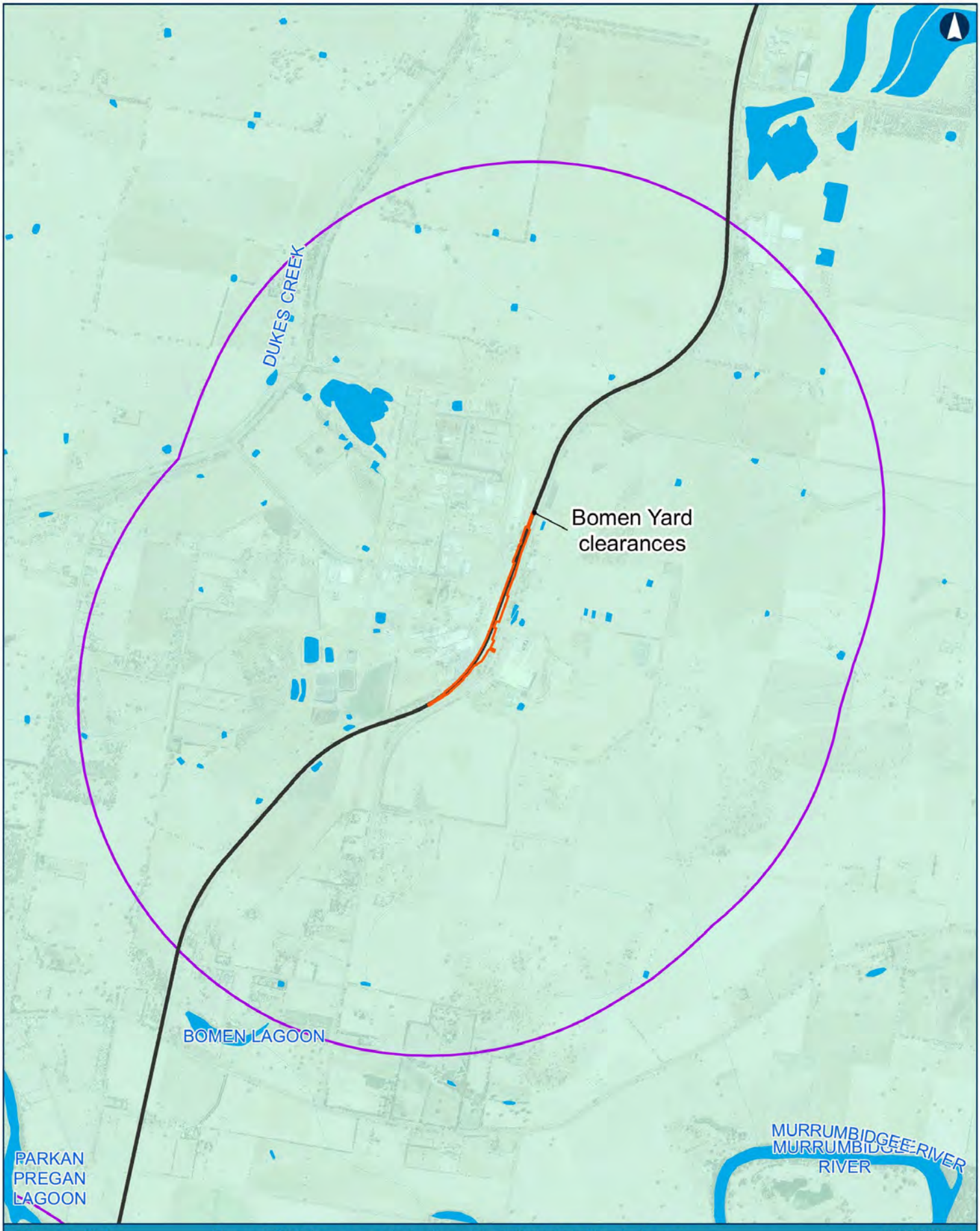

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 10 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:20,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murrumbidgee River Basin

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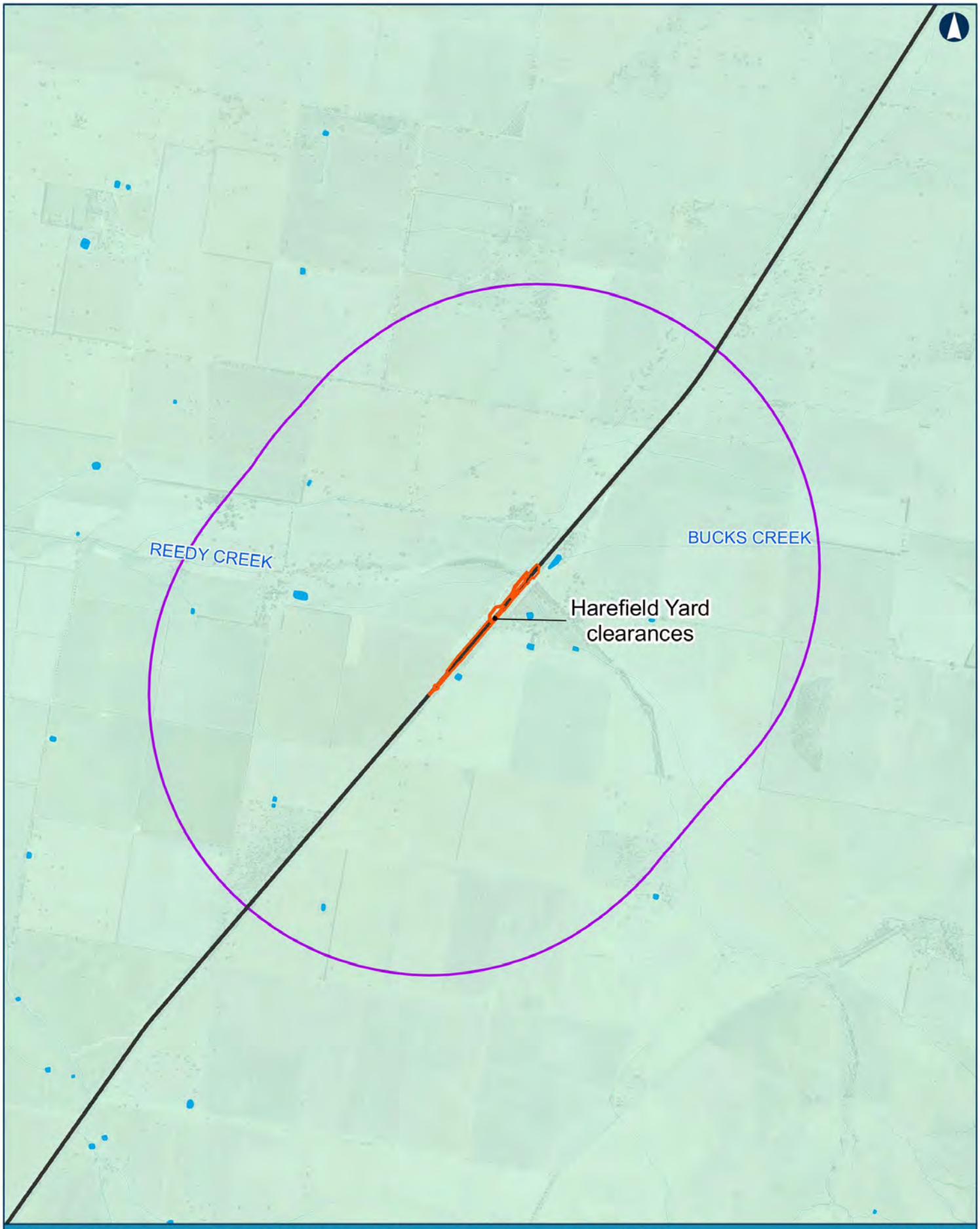


Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 11 OF 14

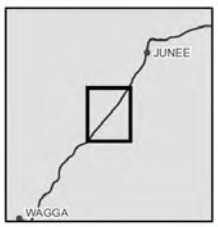
0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021
Author: WSP
Paper: A3
Scale: 1:25,000

Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murrumbidgee River Basin



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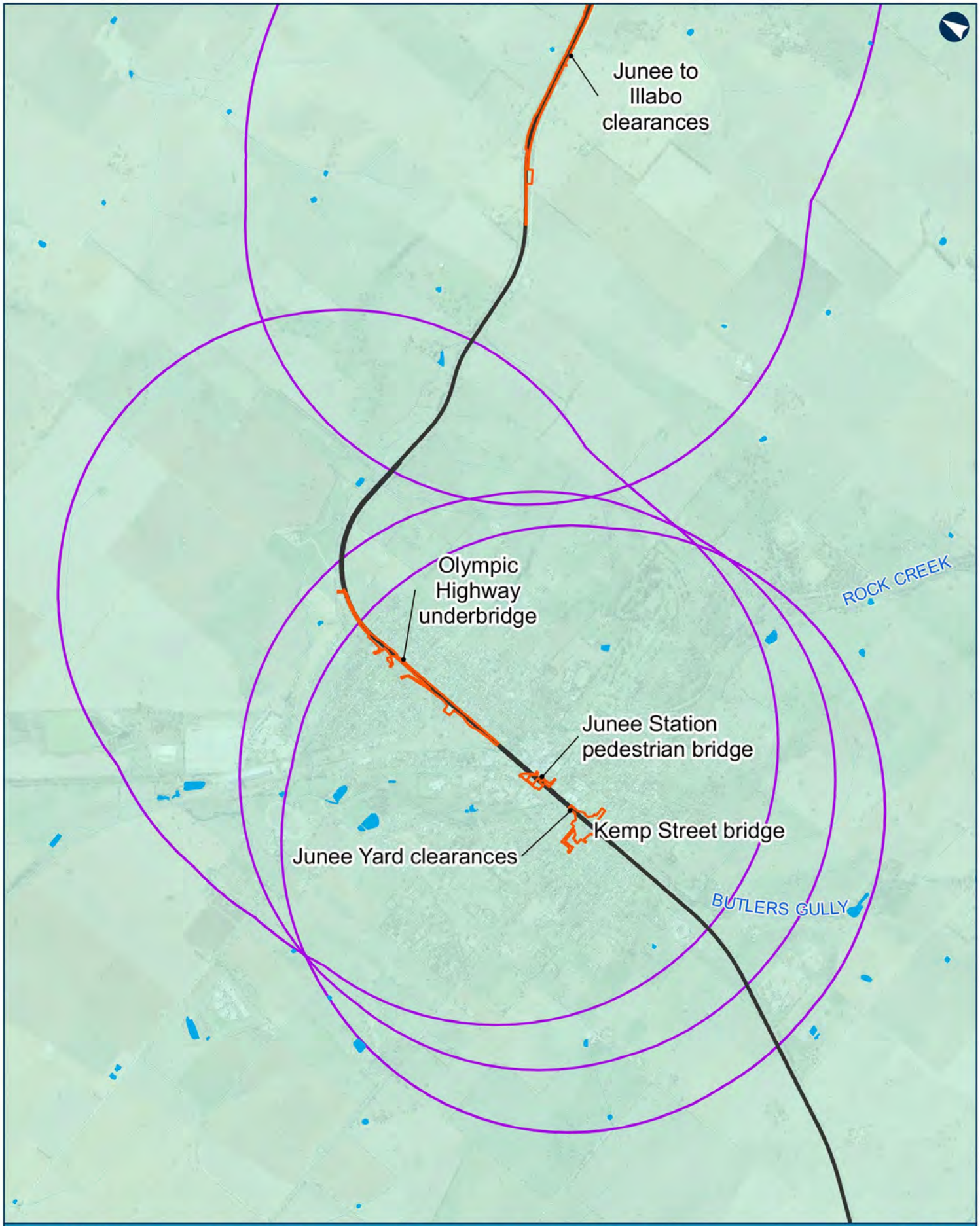


Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

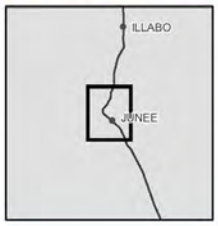
MAP 12 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021 Paper: A3
Author: WSP Scale: 1:25,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murrumbidgee River Basin



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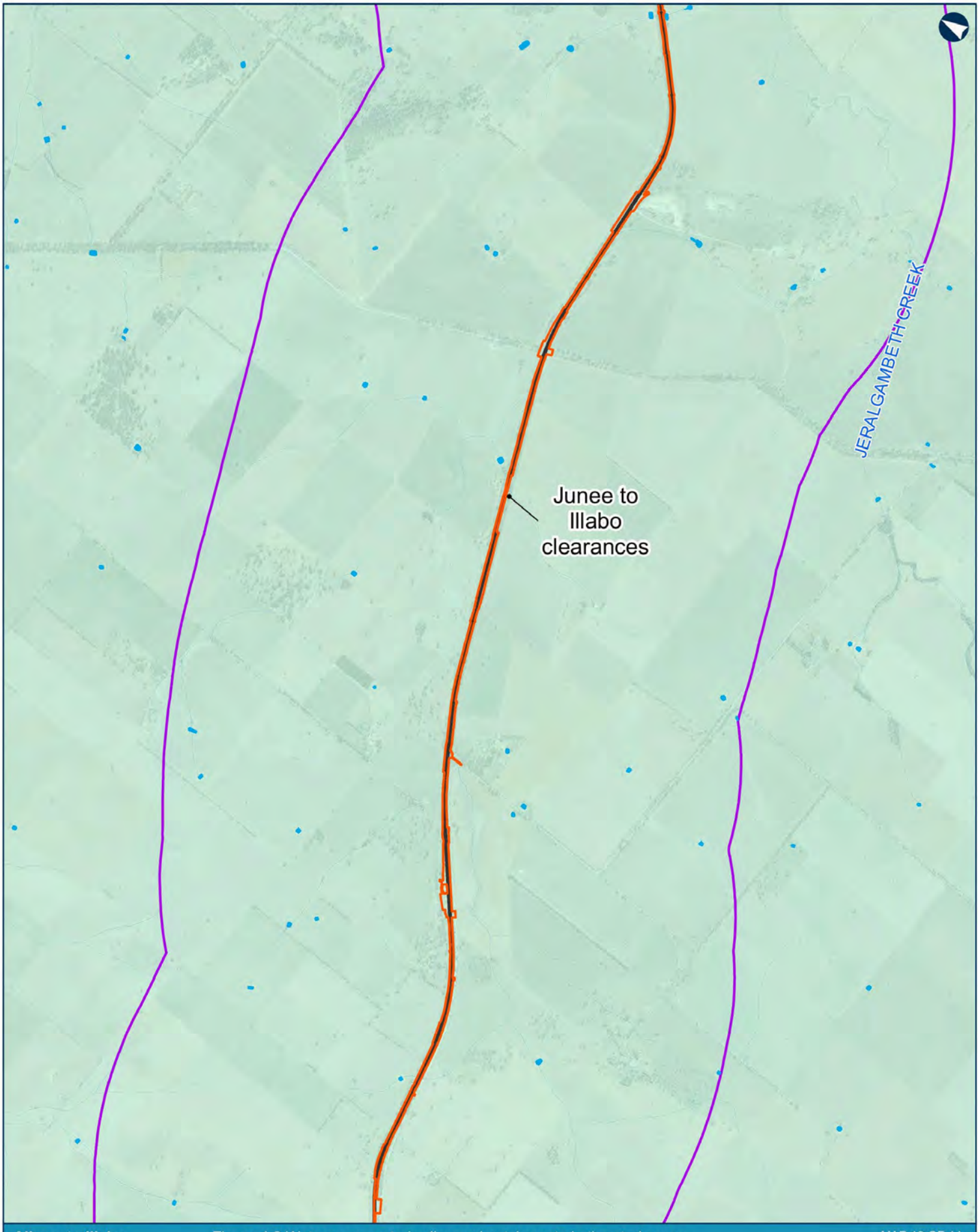


Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 13 OF 14

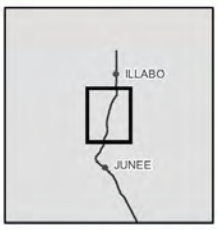
0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021
Author: WSP
Data Sources: ARTC, NSWSS

Paper: A3
Scale: 1:25,000

- Proposal site
- Existing railway
- Waterbodies
- Waterways
- Surface water study area
- Murrumbidgee River Basin



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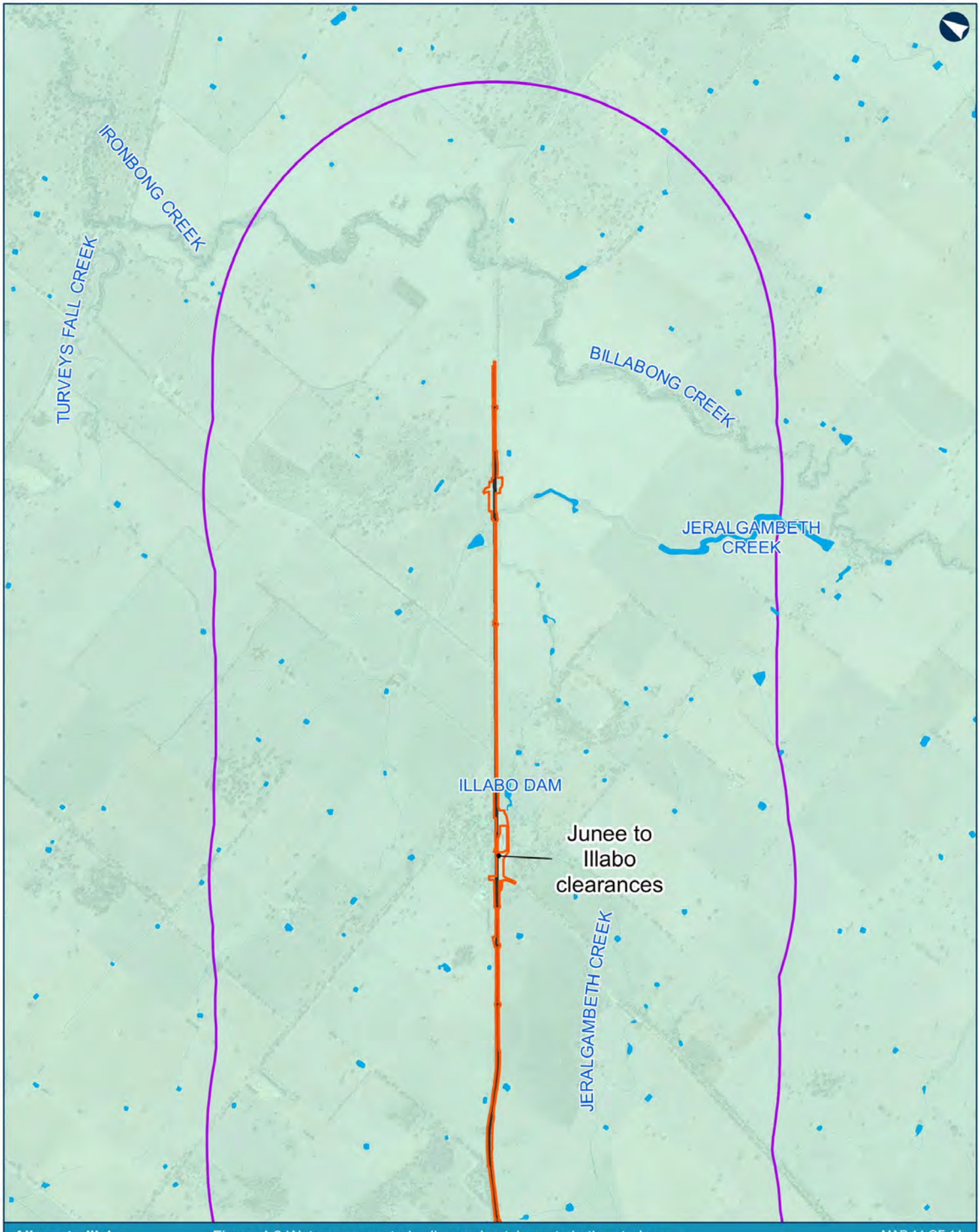

Albury to Illabo

Figure 4.2 Waterways, waterbodies and catchments in the study area

MAP 14 OF 14

0 0.25 0.5 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 10/12/2021
Author: WSP
Paper: A3
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Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Waterbodies
- Waterways
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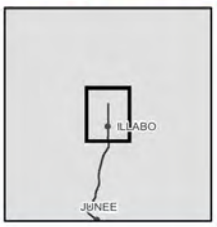

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4.3 TOPOGRAPHY

The topographic conditions vary across the proposal sites and, therefore, they have been described separately for each precinct.

Table 4.4 Topographic conditions

PRECINCT	TOPOGRAPHY
Albury	The elevation of the enhancement sites in the Albury precinct range from about 230 to 150mAHD at the Murray River bridge enhancement site. The land slopes generally to the south towards the Murray River.
Greater Hume – Lockhart	The enhancement sites in this precinct are located at about 210 to 220mAHD. The topography generally slopes to the north west to the Murrumbidgee River; however, there are localised high points along the Olympic Highway, which drain to various tributaries to the Murrumbidgee River.
Wagga Wagga	The enhancement sites at Wagga Wagga are located at an elevation of about 190 to 200mAHD. The topography generally slopes to the north to the Murrumbidgee River; however, there are localised high points along the Olympic Highway, which drain to various tributaries to the Murrumbidgee River. The Bomen Yard clearance enhancement site is located at about 230mAHD elevation and generally slopes south to the Murrumbidgee River.
Junee	The topography generally slopes from the Harefield Yard clearances enhancement site, at an elevation of about 250mAHD towards Junee with the Kemp Street bridge, Junee Yard clearances and Olympic Highway underbridge at elevations of about 300 to 320mAHD. For the Junee to Illabo clearances, the elevation varies from 250 in the east to 360mAHD in the west.

4.4 SOILS

Understanding the soils in the vicinity of the proposal sites helps inform the rainfall runoff characteristics and erosion potential; however, it is noted that the proposal would be occurring within the existing rail corridor and therefore site-specific soil conditions may not be reflective of regional conditions due to the land within the rail corridor already being disturbed. The soil information also includes consideration of the potential for acid sulfate soils to occur near the proposal sites.

4.4.1 ALBURY PRECINCT

The NSW government's eSPADE website indicates the sites within the Albury area are expected to overlie Wait-A While Stagnant Alluvial landscape or Ettamogah landscape. A summary of these soil landscapes is provided in Table 4.5.

The Australian Soil Resource Information System (ASRIS) database shows that the Murray River bridge site has high probability of occurrence of inland acids sulfate soils within Murray River sediment; however, the soils either side of the site have a low probability. All other sites in the Albury package have low risk of presence of acid sulfate soils.

Table 4.5 Soil landscapes relevant to the Albury precinct

SOIL LANDSCAPE	DESCRIPTION	RISKS
Riverina Highway bridge, Murray River bridge, Albury Yard clearances		
Wait-A-While	— sparse narrow linear drainage lines — topsoils that are prone to structural decline and loss by wind erosion — low lying areas with poor drainage — localised salinity.	Localised non-cohesive soils, localised wind erosion hazard, localised seasonal waterlogging and flood hazard.
Table Top Yard clearances, Billy Hughes bridge		
Ettamogah	— slopes are gentle and waxing — drainage lines are widely spaced and poorly defined.	High gully erosion risk, localised sodicity, localised poor drainage, seasonal waterlogging and moderate sheet erosion risk.

4.4.2 GREATER HUME – LOCKHART PRECINCT

Expected soil landscapes at the proposal site are described in Table 4.6.

Table 4.6 Soil landscapes relevant to the Greater Hume – Lockhart precinct

SOIL LANDSCAPE	DESCRIPTION	RISKS
Henty Yard clearances		
Henty Aeolian	— extensively to gently inclined westerly sloping plain with significant fine sand aeolian deposits — extensive to broad westerly sloping plain with numerous deflation basins and terraces, and sparse narrow drainage lines — soils are typically brown and yellow sodosols on the higher, older terraces with brown dermosols and yellow chromosols occurring on lower, younger terraces — static rudosols (alluvial soils) occur in recent channels.	Moderate wind erosion hazard, localized acidity, localised waterlogging and poor drainage, localised sodicity, and moderate gully erosion hazard.
Culcairn Yard clearances		
Culcairn Soil	— extensive level alluvial plains of Billabong Creek — extensive to broad plains with sparse narrow drainage lines. — red and brown chromosols and kurosols, yellow and grey sodosols occur on the higher, older terraces with grey and brown dermosols occurring on the lower, younger terraces — static rudosols (alluvial soils) occur in recent channels.	Localised high gully erosion hazard, localised acidity, localised waterlogging and poor drainage, localised sodicity.

SOIL LANDSCAPE	DESCRIPTION	RISKS
The Rock Yard clearances		
Transferral landscape	— very gently inclined sloping plain adjacent to hills of Devonian sandstones — extensive and unidirectional inclined plain and narrow drainage lines — moderately deep brown sodosols.	High erosion hazard, localised foundation hazard, strong acidity.
Yerong Creek Yard clearances		
Mangoplan alluvial soil	— extensive level plains of Burkes Creek alluvial sediments — extensive plains with incised narrow drainage lines — moderately deep red sodosols.	Localised stream bank erosion, acidity.

4.4.3 WAGGA WAGGA

Expected soil landscapes at the proposal site is described in Table 4.7.

Table 4.7 Soil landscapes relevant to the Wagga Wagga precinct

SOIL LANDSCAPE	DESCRIPTION	RISKS
Uranquinty Yard clearances		
O'Briens Creek landscape	— gently undulating plains of alluvial sediments — extensive sloping plains adjacent to hillslopes, river channels and narrow drainage lines.	Localized stream bank erosion, waterlogging, strong acidity.
Wagga Wagga station and surrounds		
Becks Lane transferal and Pulletop erosional	Becks Lane Transferral: — gently inclined foot slopes adjacent to hills of Ordovician metasedimentary rocks — long waning slopes and mostly parallel, shallow drainage lines. Pulletop Erosional: — undulating rises of Ordovician metasedimentary rocks — broad crests and ridges, long, waning slopes and moderately broad drainage depressions.	Becks Lane Transferral: high erosion hazards, localized foundation hazards, acidity and locally hard setting soil. Pulletop Erosional: erosion hazard, localized foundation hazard, localized salinity, strongly acid and locally shallow stony soil.
Bomen Yard clearances		
East Bomen Aeolian landscape	— undulating rises of Silurian antabadgery Grandiorite — broad crests and ridges, long waning slopes and shallow drainage depressions.	Moderate erosion hazards, moderately acid and locally shallow soil.

4.4.4 JUNEE

Expected soil landscapes at the proposal site is described in Table 4.8.

Table 4.8 Soil landscapes relevant to the Junee precinct

SOIL LANDSCAPE	DESCRIPTION	RISKS
Currajong	— gently to undulating footslopes and colluvial plains — extensively cleared Eucalypt woodlands — deep, well-drained red kandosoils and red and brown chromosols on upper, mid and lower slopes — moderately deep to deep brown and red dermosols occur on mid to lower slopes — imperfect to moderately well-drained red, brown and yellow chromosols occur on lower slopes with occasional imperfectly drained brown sodosols and red dermosols on some lower slopes, in drainages depressions and along creek flats.	Limitations include localised salinity hazard, localised high run-off, sodicity, dispersibility, localised subsoil dispersibility, high erodibility, localised subsoil hardsetting surface, high organic matter (topsoil), topsoil acidity and high potential localised aluminium toxicity.

4.5 CONTAMINATION

A summary of potential sources of contamination and associated potential contaminants of concern identified within the proposal site is provided in Table 4.9. A full description of where these materials may be present is provided in Technical Paper 13 – Contamination. Potential source of pollutants are also discussed in section 4.8 and section 5.3 of this technical paper.

Table 4.9 Summary of potential contamination sources/ contaminants of concern

ACTIVITY ALONG PROPOSAL SITE	CONTAMINANT SOURCE	POTENTIAL CONTAMINANTS OF CONCERN
Roadway and general use	Dumped material and stockpiles adjacent to the proposal site, particularly at road crossings	Heavy metals, asbestos, Polycyclic aromatic hydrocarbons (PAHs)
	Rural fire sheds and fire suppressants	PAHs, total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene and xylene (BTEX), and Per- and polyfluoroalkyl substances (PFAS)
	Fuel storage adjacent to the proposal site	TRH, BTEX, PAHS and lead
Agricultural land adjacent to the proposal site	Use of agricultural chemicals on farm land	Heavy metals, organochlorine pesticide (OCPs) and organophosphorus pesticides (OPPs)
	Machinery storage and maintenance, refuelling and spray rig filling, agricultural sheds and silos	Point sources of heavy metals, TRH, BTEX, solvents, OCPs and OPPs, and asbestos fragments
Existing railway line	Fill used in construction of the original rail line, possible historical waste disposal along the alignment and weed suppression activities (sections of the alignment between chainage 0 and 3500, and 38500 and 42500)	Diffuse presence or isolated hotspots of heavy metals, TRH, BTEX, PAHs, asbestos along the existing rail easement, lead containing dust and/or paint

ACTIVITY ALONG PROPOSAL SITE	CONTAMINANT SOURCE	POTENTIAL CONTAMINANTS OF CONCERN
	Old tanker carriage at Albury Station precinct	Heavy metals, TRH, BTEX, PAHs
	Rail line ballast	Heavy metals, TRH, BTEX, PAHs, asbestos, lead containing dust and/or paint
	Possible maintenance activities in sidings and near silos	Heavy metals, TRH, BTEX, PAHs, asbestos, lead containing dust and/or paint
	Unknown chemical storage adjacent to the track	Heavy metals, TRH, BTEX, PAHs, Phenols, pesticides, herbicides
	Building containing hazardous materials	Asbestos and lead dust and/or paint

4.6 FLOODING

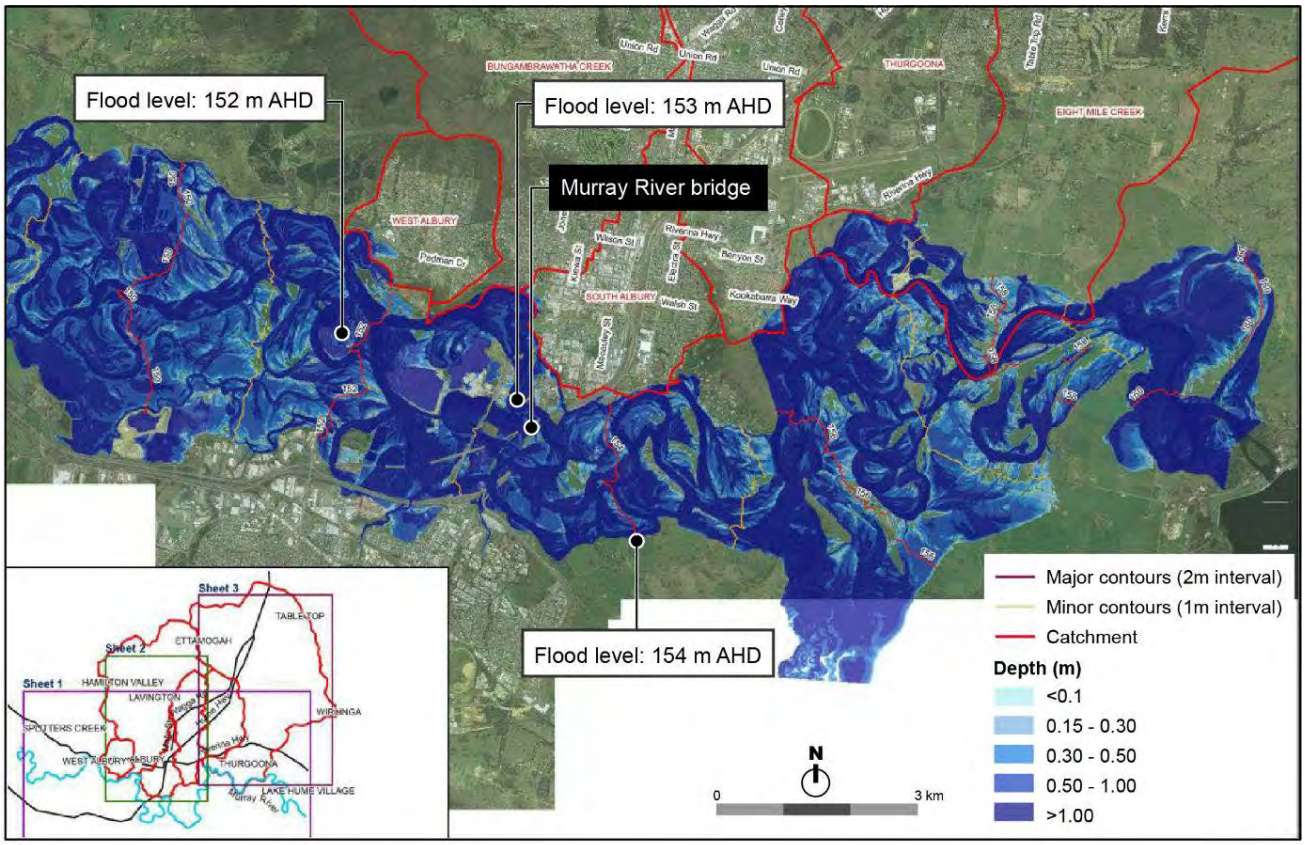
4.6.1 ALBURY PRECINCT

4.6.1.1 MURRAY RIVER BRIDGE

The Murray River bridge enhancement site is subject to regional flooding due to its proximity to the Murray River. As such, a Floodplain Risk Management Study and Plan (WMAWater, 2016) has been used to inform the flood conditions at Murray River bridge proposal site and surrounding areas. The Albury Floodplain Risk Management Study and Plan (WMA Water, January 2016) has been prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005), and included 5 per cent, 2 per cent, 1 per cent AEPs and PMF flood events.

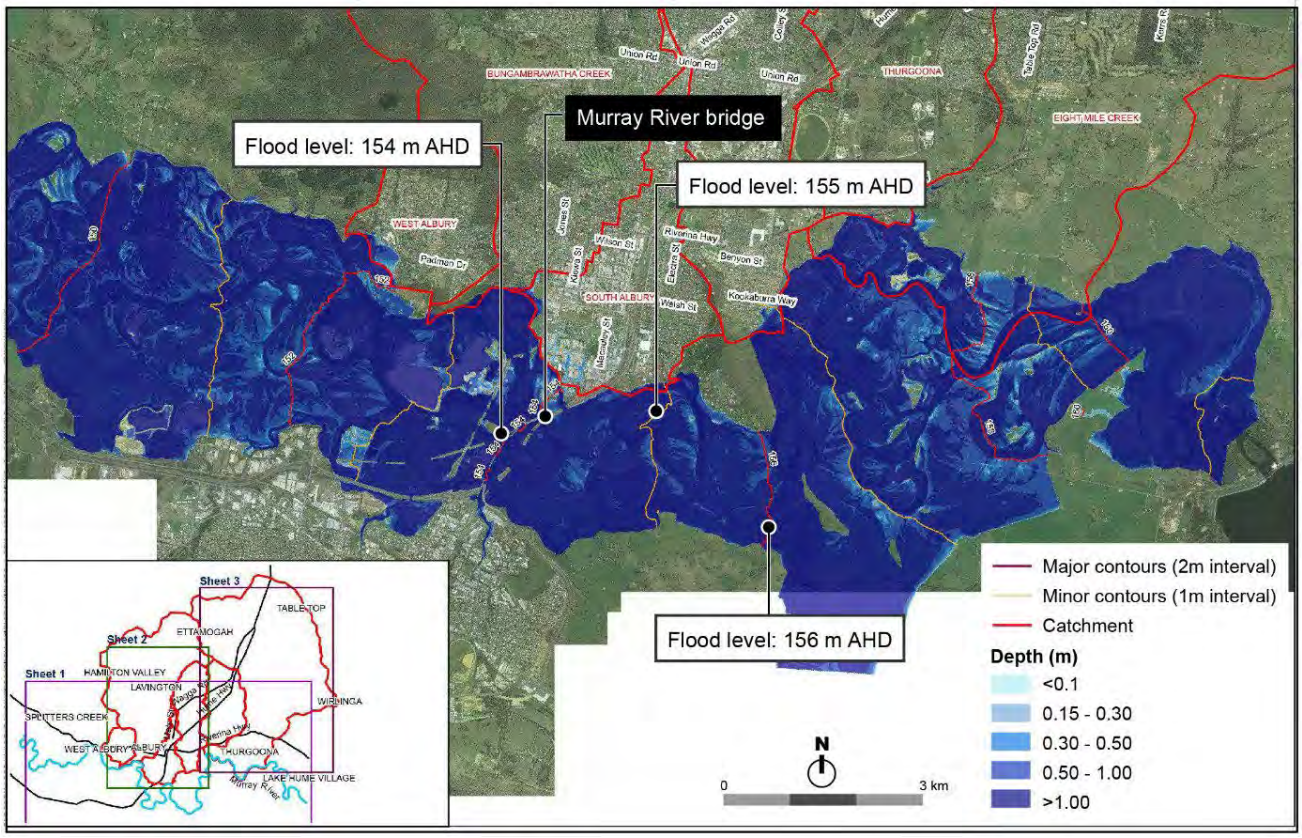
Flooding at the Murray River bridge enhancement is mitigated to an extent by the Hume Dam, which is located about 25km upstream. The primary purpose of Hume Dam is water supply; however, it also serves additional purposes for flood mitigation. The largest flood recorded downstream of Hume Dam since the dam was built in 1936 was in October 1975 when the river height reached 5.6m at the Albury gauge. This flood was only 20 centimetres (cm) below the highest recorded flood level of 5.89m from before the dam's completion, in 1870. The likelihood of downstream flooding is higher when Hume Dam is full or near full (*Source:* WMAWater*, 2016*).

Figure 4.3, Figure 4.4 and Figure 4.5 show the flood extent for the 5 per cent, 1 per cent AEP and PMF flood events, respectively. The top of rail is above the 1 per cent flood level.



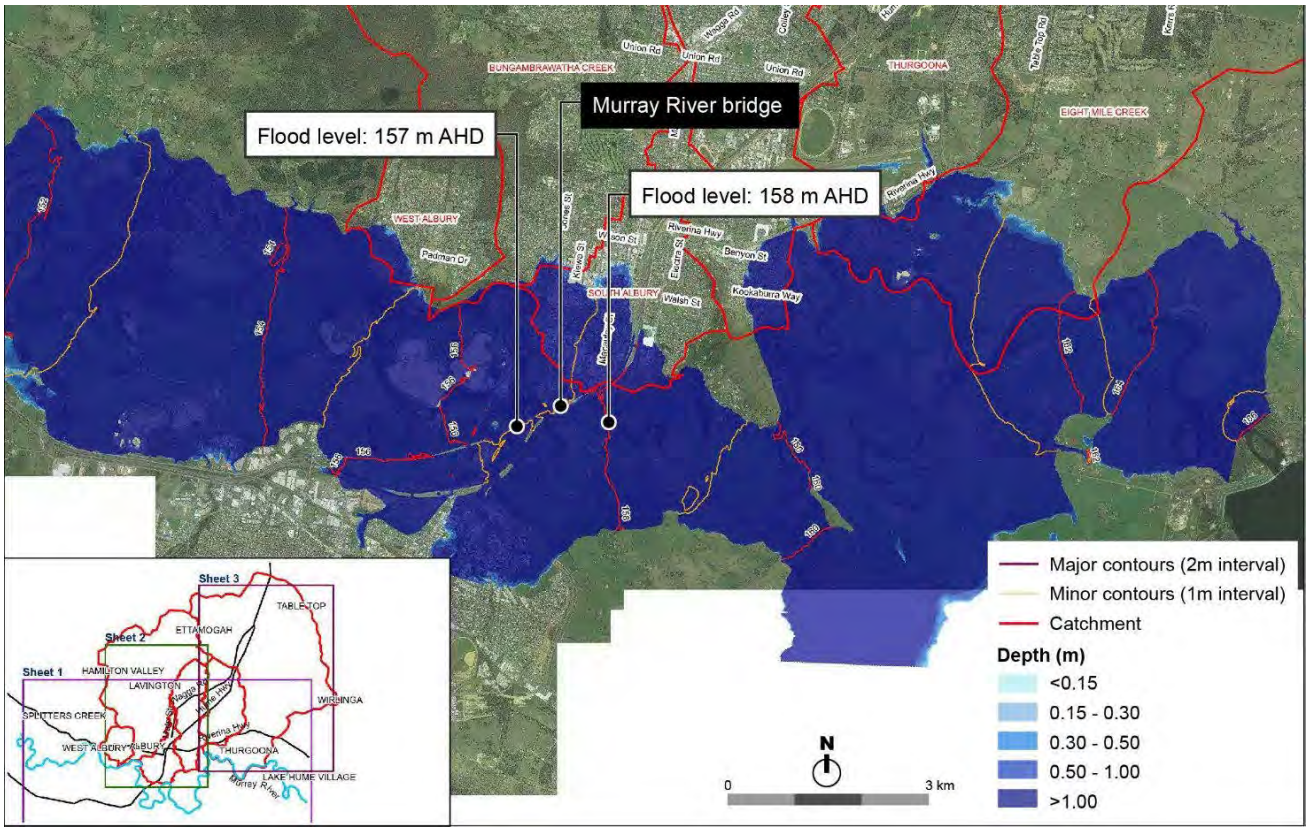
Source: Albury Floodplain Risk Management Study and Plan (WMA Water, 2016), Albury City Council

Figure 4.3 5 per cent AEP flooding extent – Murray River



Source: Albury Floodplain Risk Management Study and Plan (WMA Water, 2016), Albury City Council

Figure 4.4 1 per cent AEP flooding extent – Murray River



Source: Albury Floodplain Risk Management Study and Plan (WMA Water, 2016), Albury City Council

Figure 4.5 PMF flooding extent – Murray River

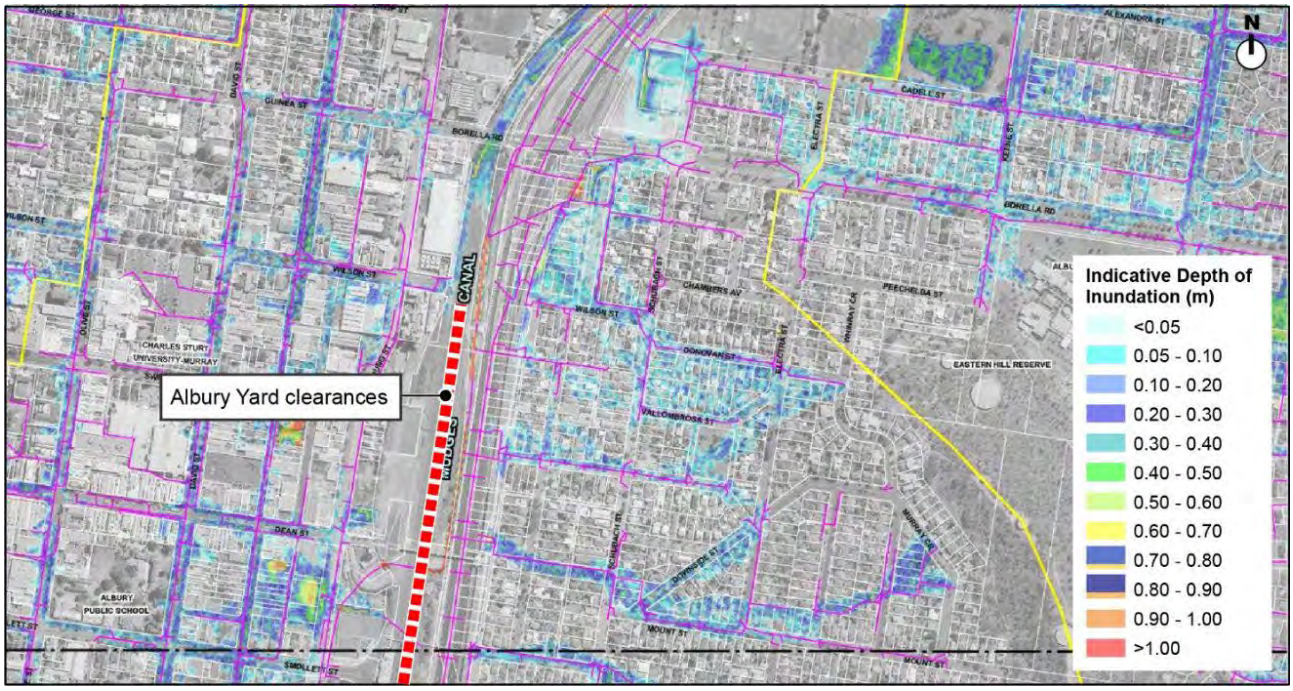
4.6.1.2 ALBURY YARD CLEARANCES AND ALBURY STATION PEDESTRIAN BRIDGE ENHANCEMENT SITES

The Albury Yard clearances and Albury Station pedestrian bridge enhancement sites are located within the South Albury catchment, which is a local urban catchment through South Albury but discharges into the Murray River to the south of the enhancement sites.

The enhancement sites are not subject to regional flooding from the Murray River. Local flood behaviour has been described by the Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011) which has been adopted by Albury City Council. The study was prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005) and included 5 per cent, 2 per cent, 1 per cent AEPs and PMF flood events.

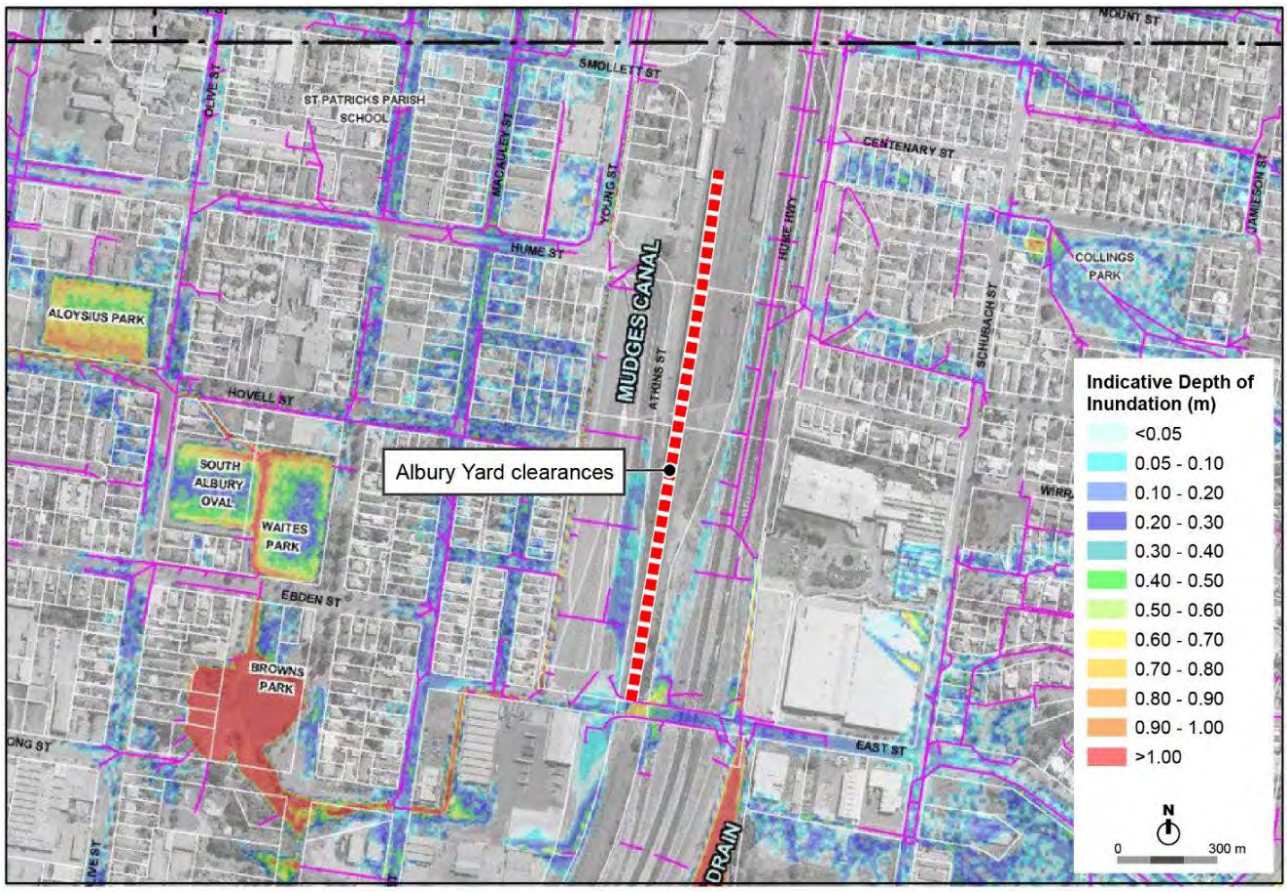
The flood study indicates that:

- flooding does not overtop the existing rail line up to and including the 1 per cent AEP flood event
- the enhancement sites are not affected by flooding up to and including the 1 per cent AEP flood event but are affected by flooding for a PMF flood event (refer to Figure 4.6, Figure 4.7 and Figure 4.8)
- in a PMF flood event, water depths are expected to be significant (i.e. greater than one metre within the enhancement sites).



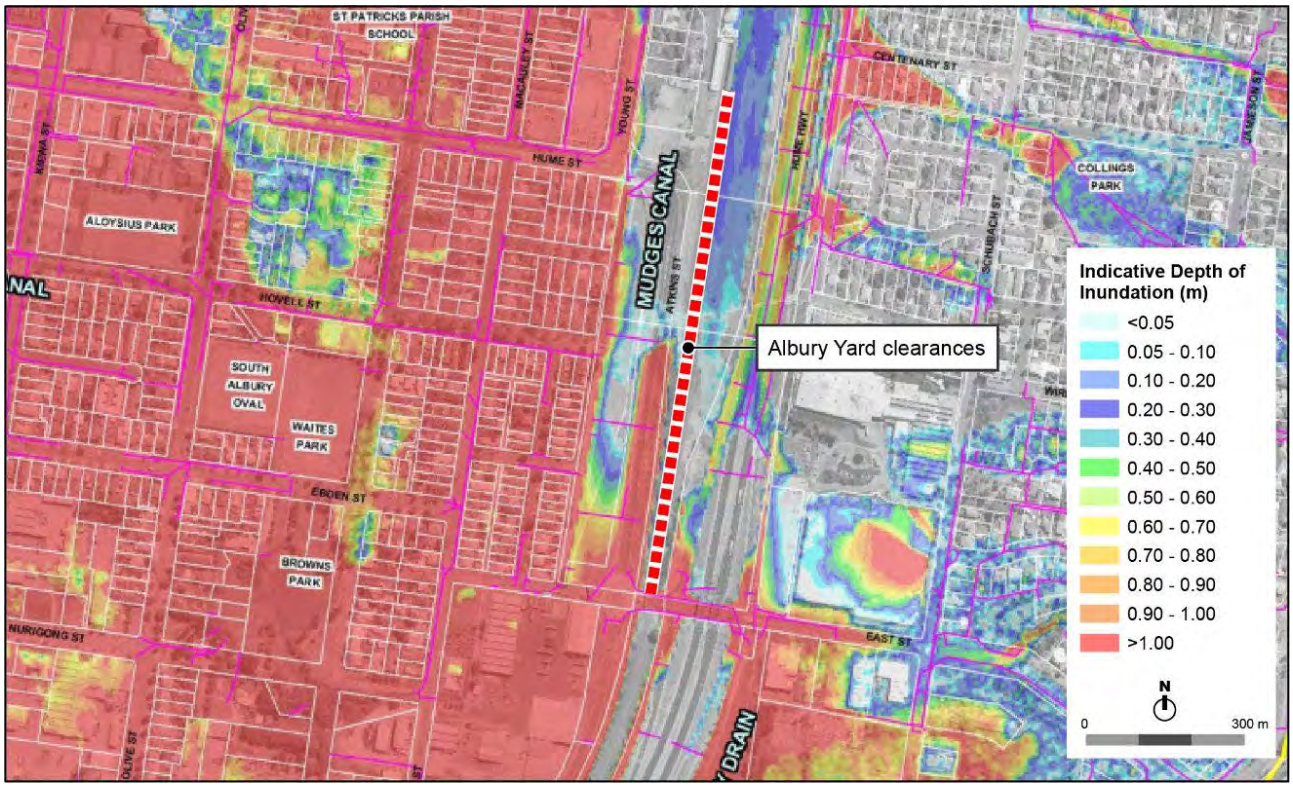
Source: Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011), Albury City Council)

Figure 4.6 20 per cent AEP flooding at Albury Yard clearances and Albury Station pedestrian bridge enhancement sites



Source: Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011), Albury City Council)

Figure 4.7 1 per cent AEP flooding at Albury Yard clearances and Albury Yard clearances and Albury Station pedestrian bridge enhancement sites



Source: Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011), Albury City Council)

Figure 4.8 PMF flooding at Albury Yard clearances and Albury Station pedestrian bridge enhancement sites

4.6.1.3 RIVERINA HIGHWAY BRIDGE

The Riverina Highway bridge enhancement site is located within an urban area of Albury and away from the Murray River, and is not subject to regional flooding, with drainage controlled by local urban drainage. The Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011) was used to inform the assessment of flooding for this enhancement site.

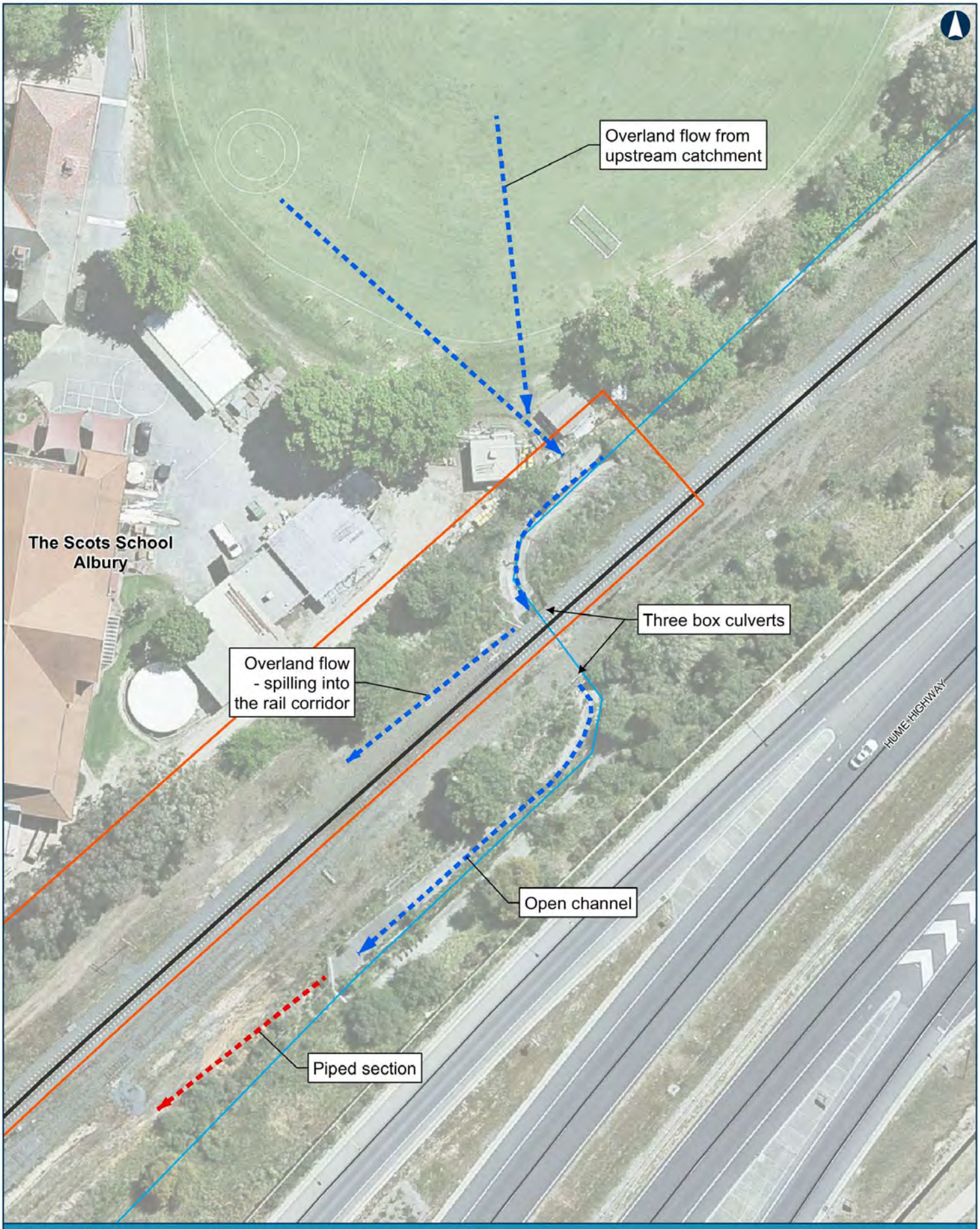
The enhancement site is affected by overland flooding. Surface water runoff is conveyed from the catchment at the north of The Scots School Albury in a south-east direction towards the rail corridor. At the interface of this property with the rail corridor, surface water flows through three box culverts, located at proposal chainage 644.770m, beneath the rail corridor into an open channel on the eastern side of the rail, before entering a piped section that discharges into Mudges Canal. Mudges Canal continues about 1.5km to the south before discharging into the Murray River.

Flood modelling indicates the three box culverts do not have sufficient capacity to convey the upstream runoff. As a consequence, water spills into the rail corridor during the 20 per cent AEP and greater events (refer to Figure 4.9).

The portion of overland flow that spills into the rail corridor proceeds in a south-west direction, following the terrain slope. Figure 4.10 shows the flow direction within the enhancement site.

Figure 4.11, Figure 4.12, Figure 4.13 and Figure 4.14 illustrate the overland flow flood extents at the enhancement site for the 20 per cent, 5 per cent,1 per cent AEP and PMF flood events.

Flood modelling does not include a representation of the rail corridor drainage system. As such, the storage and attenuating function of the local shallow storage/surface flows may be over represented.



Albury to Illabo

Figure 4.9 Surface water flow paths at The Scots School Albury

0 10 20 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 15/09/2021 Paper: A3
Author: WSP Scale: 1:500
Data Sources: ARTC, NSWSS

Proposal site
Existing railway
Main road
Watercourse

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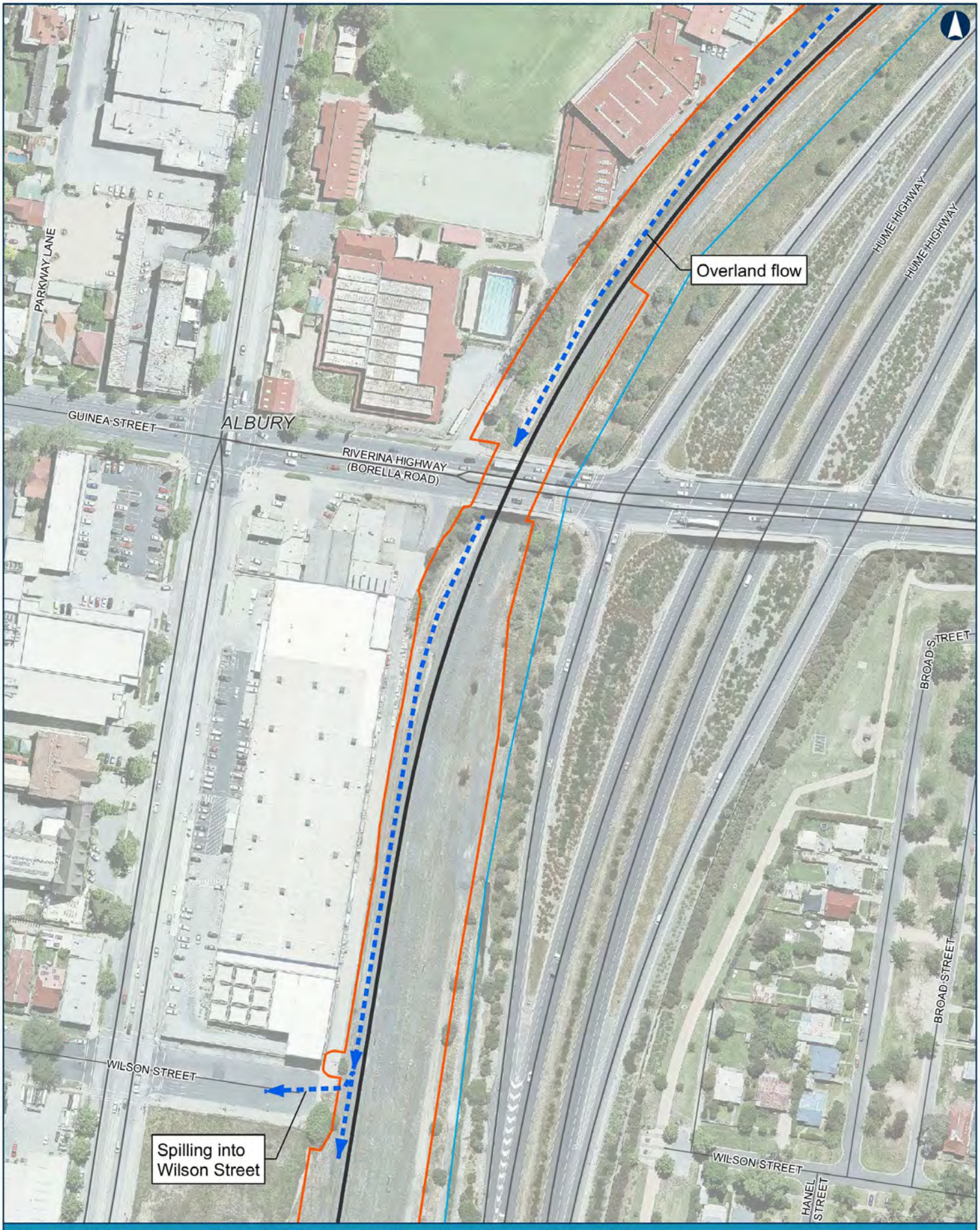

Albury to Illabo Figure 4.10 Surface water flow paths at Riverina Highway Bridge

0 25 50 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 22/07/2022 Paper: A3
Author: WSP Scale: 1:1,500
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse

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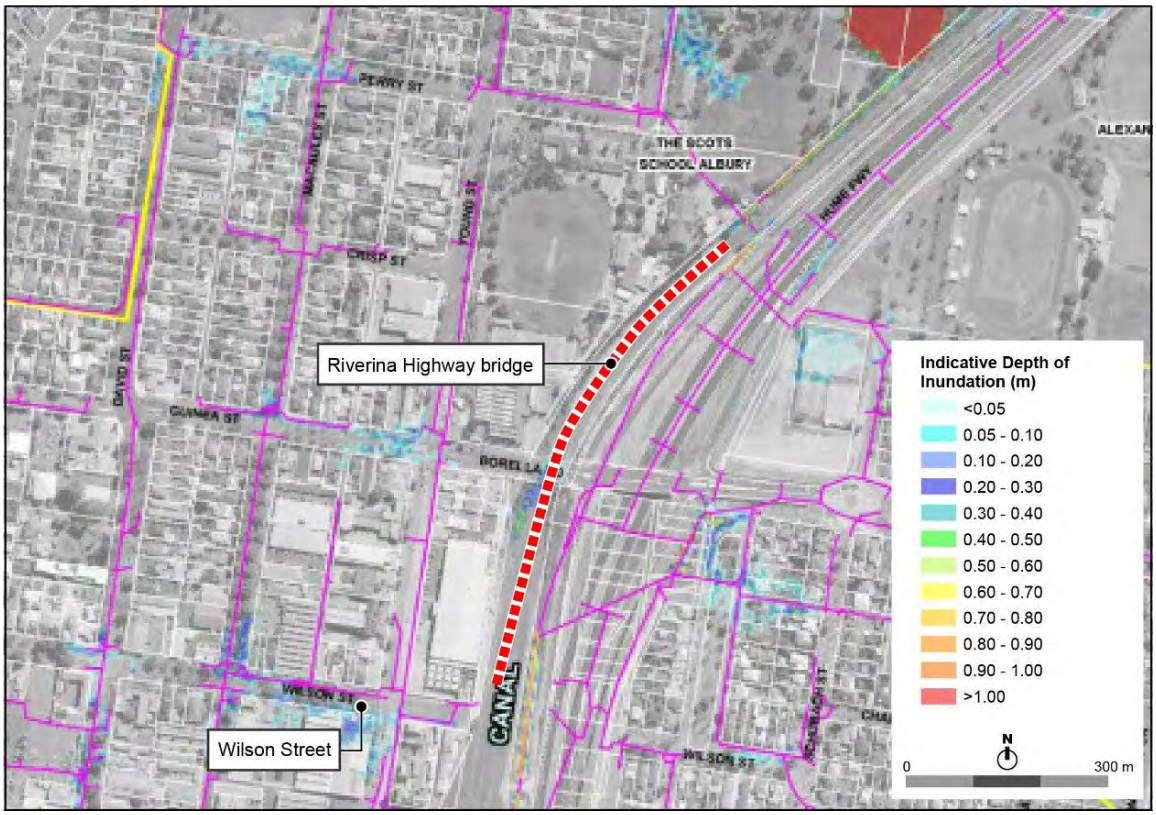
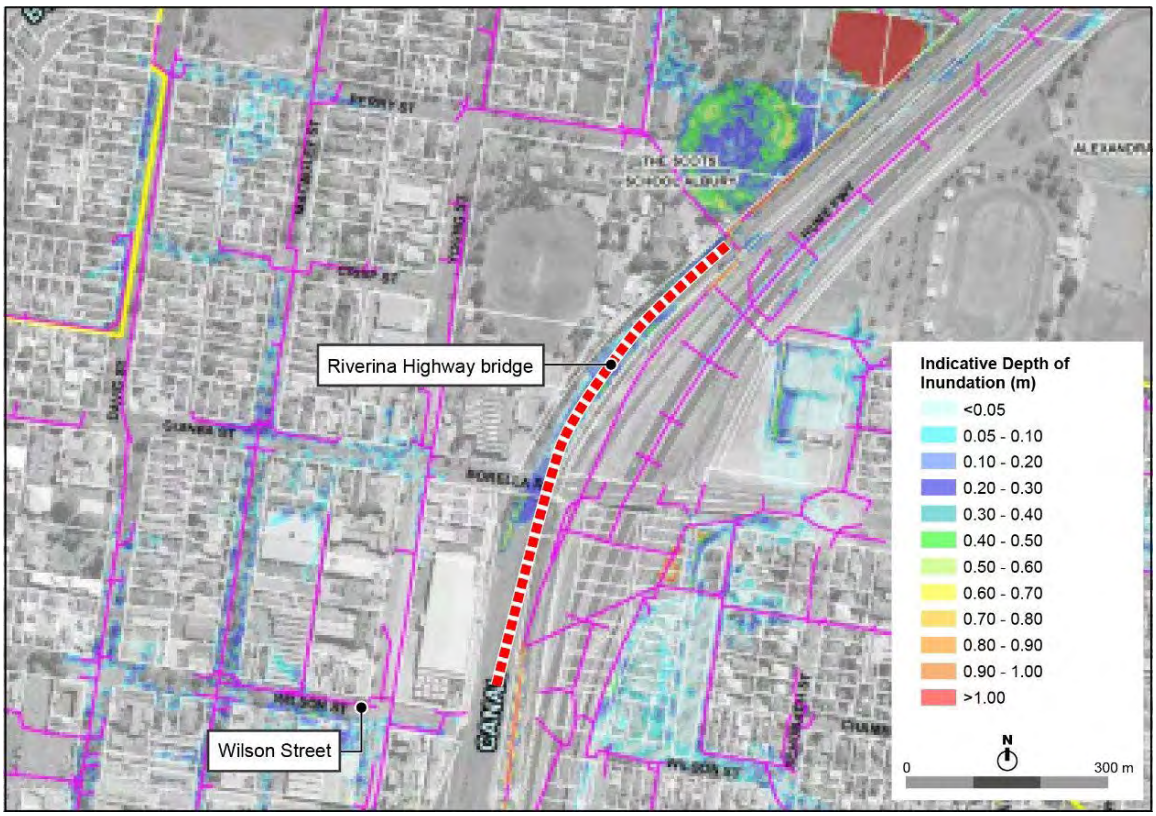


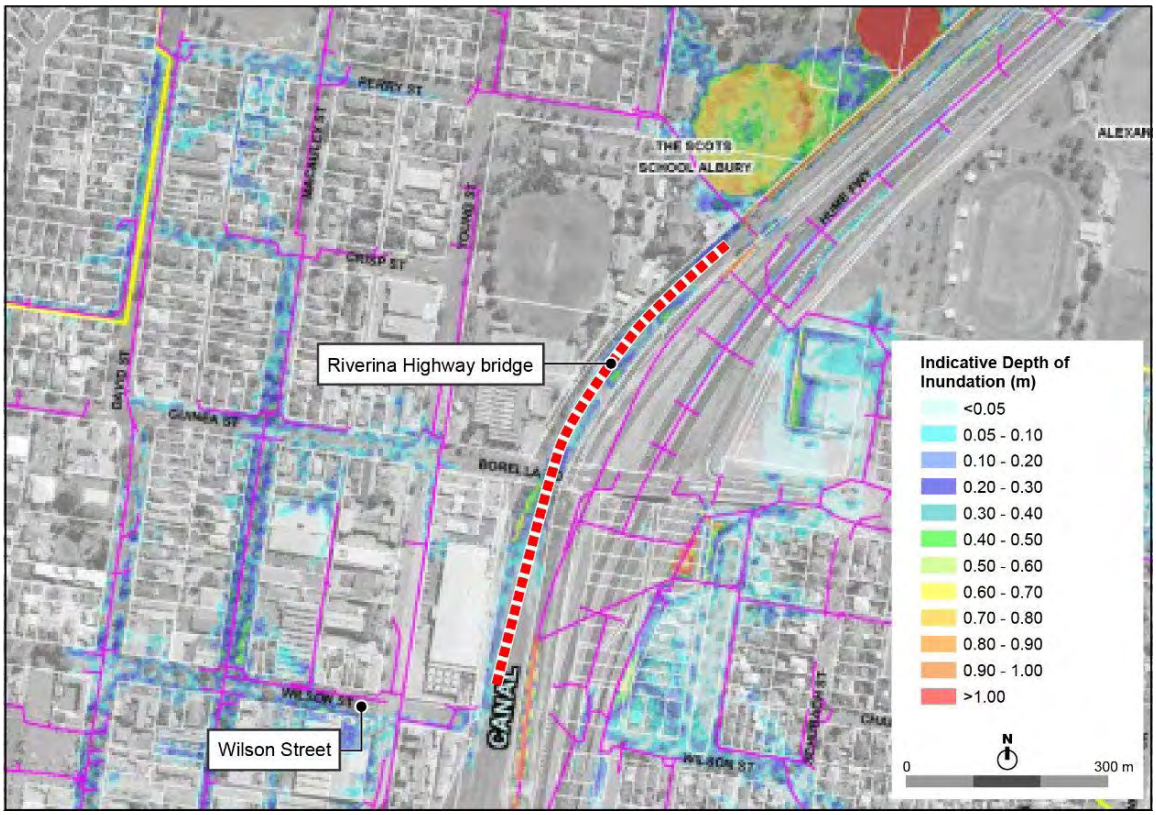
Source: The Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011), Albury City Council)

Figure 4.11 20 per cent AEP flood depth map at Riverina Highway bridge enhancement site



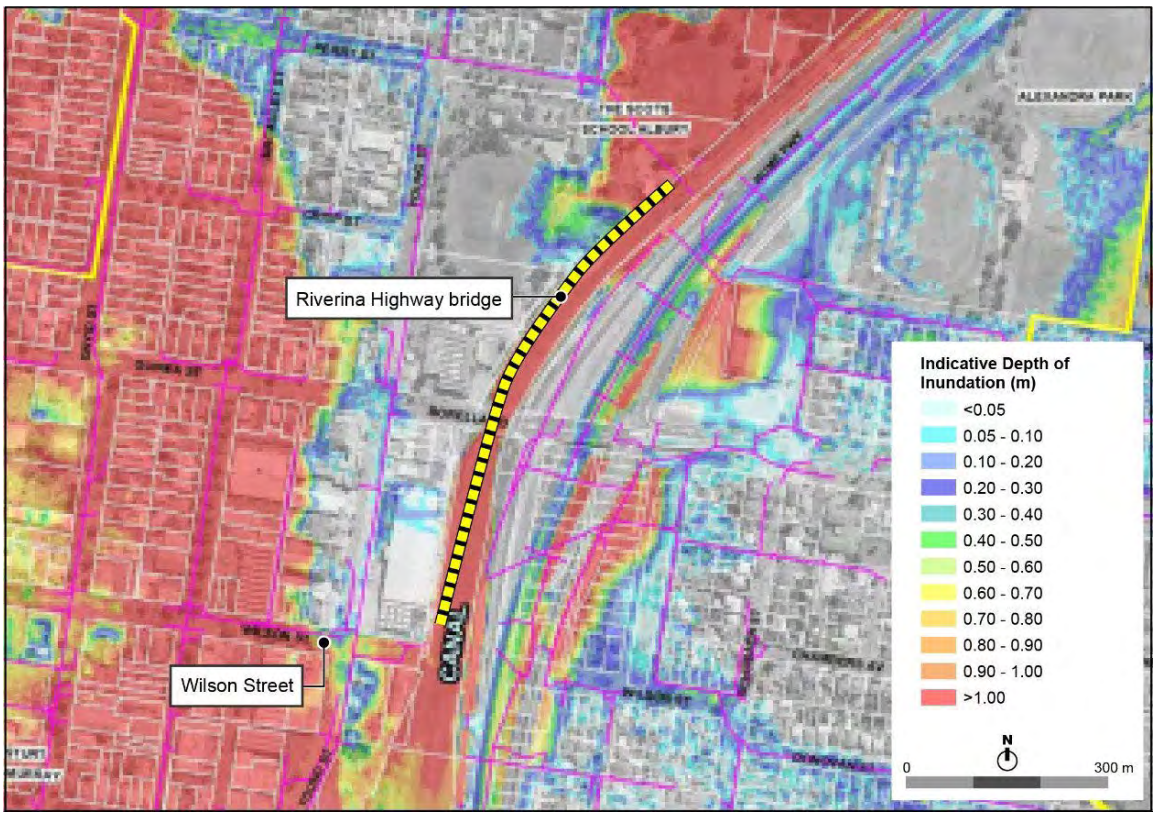
Source: The Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011), Albury City Council)

Figure 4.12 5 per cent AEP flood depth map at Riverina Highway bridge enhancement site



Source: The Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011), Albury City Council)

Figure 4.13 1 per cent AEP flood depth map at Riverina Highway bridge enhancement site



Source: The Bungambrawatha Creek, Lavington, South Albury and West Albury flood study (Lyall & Associates, 2011), Albury City Council)

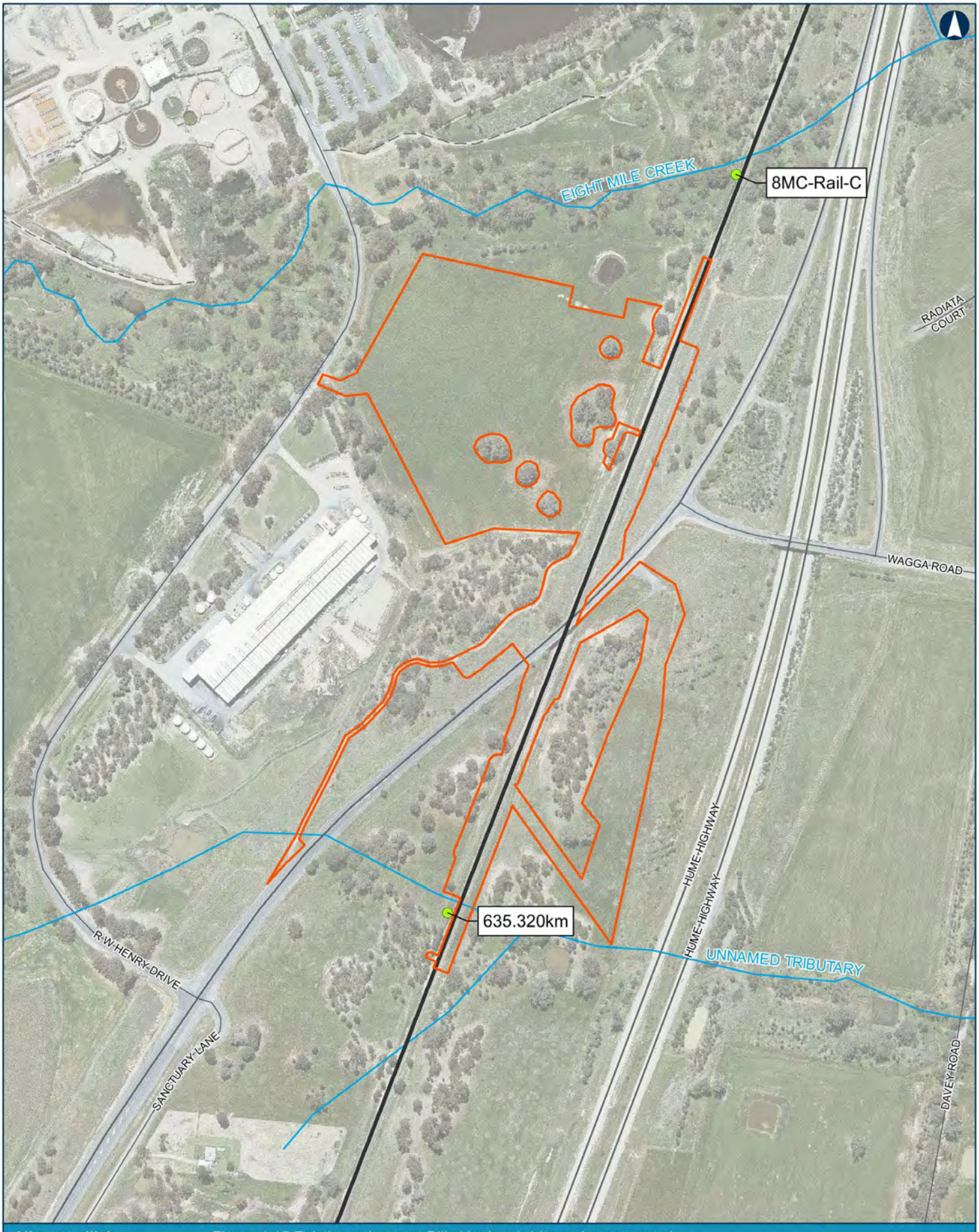
Figure 4.14 PMF flood depth map at Riverina Highway bridge enhancement site

4.6.1.4 BILLY HUGHES BRIDGE

The Billy Hughes bridge enhancement site is located south of Eight Mile Creek. According to Albury City Council, historic flood records show two significant flooding events occurred at the Eight Mile Creek catchment in 1974 and 1983. The 1983 event was estimated at a two-year average recurrence interval. Despite being a smaller event, damage was caused at the Riverina Highway at the old timber road bridge and floodwaters in the downstream reaches were observed to discharge from the main channel across the floodplain to the Murray River. The 1974 flood event was estimated to have an average recurrence interval of 50 to 70 years; however, there are no flood markers or photographs available from this event.

There are two rail culverts located near the enhancement site at the north and south side of the site. These have been identified as culvert 8MC-Rail-C and culvert at chainage 635,320m as shown in Figure 4.15.

The Albury Floodplain Risk Management Study and Plan (WMAWater, 2016) has been used to inform the flood conditions at the Billy Hughes bridge enhancement site and surrounding areas. The flood study shows that up to and including the 1 per cent AEP flood event, the enhancement site is not affected by flooding from Eight Mile Creek or the unnamed tributary located at the south of the site; the site is affected by flooding from Eight Mile Creek in the PMF flood event. The maximum 1 per cent AEP and PMF flood extent are shown in Figure 4.16 and Figure 4.17.



Albury to Illabo

Figure 4.15 Existing culverts at Billy Hughes bridge enhancement site

0 50 100 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 16/09/2021 Paper: A3
Author: WSP Scale: 1:3,500
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Main road
- Local road
- Track
- Watercourse
- Culvert

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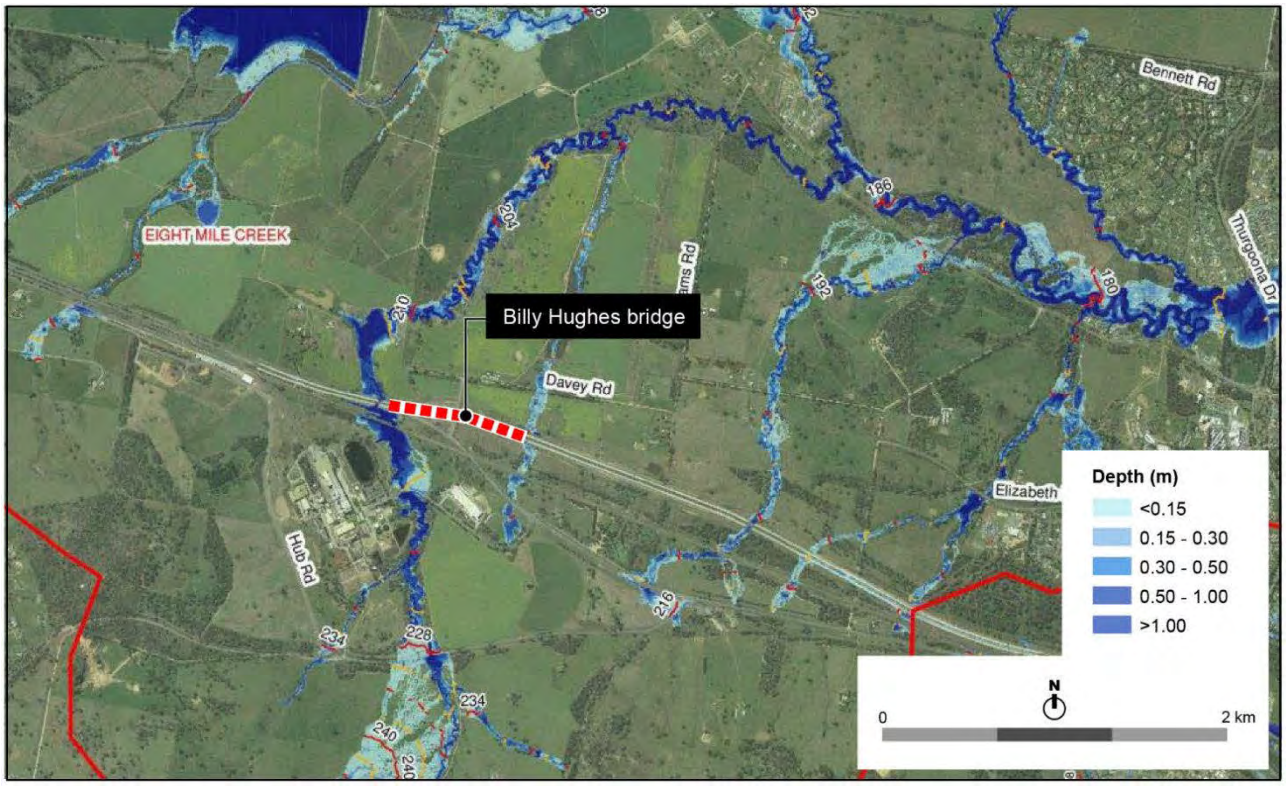
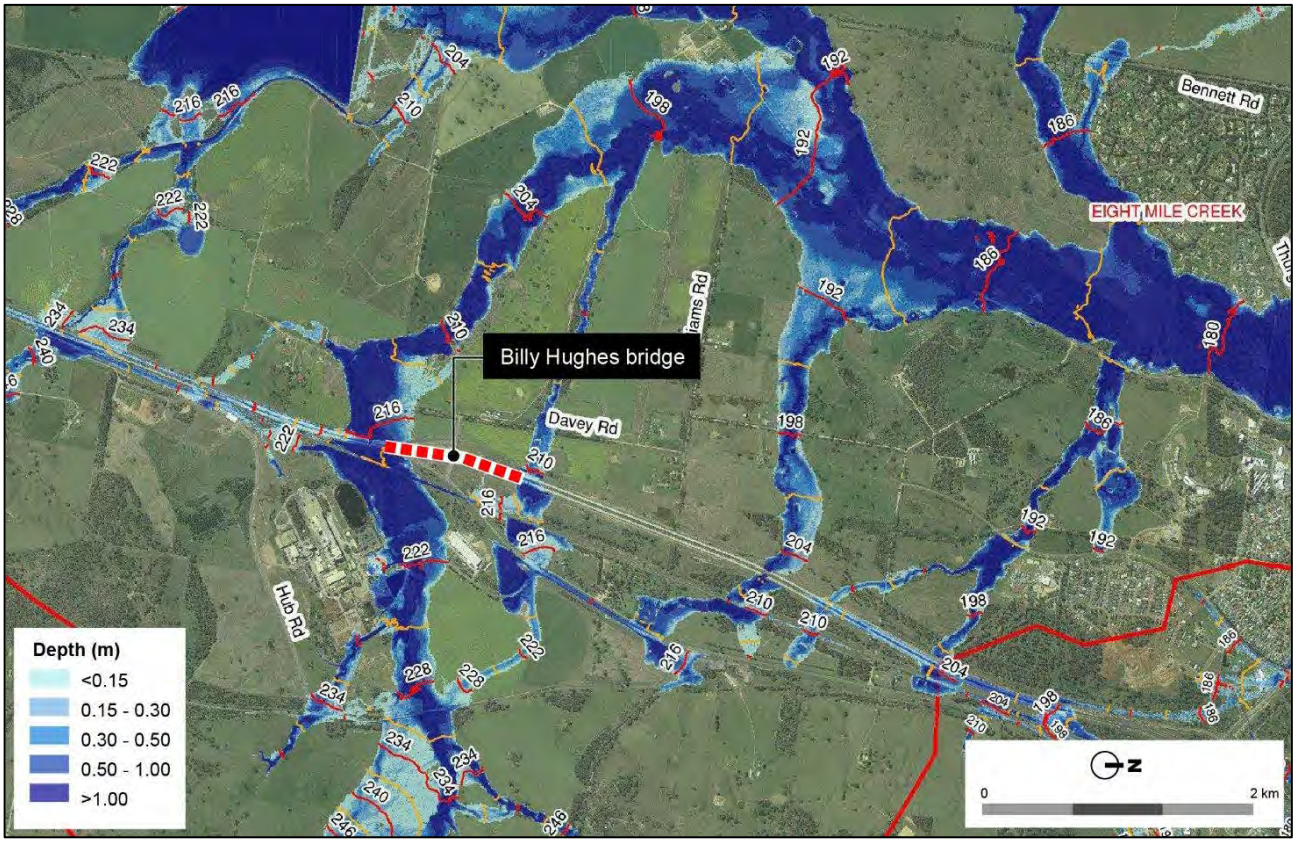


Source: The Albury Floodplain Risk Management Study and Plan (WMAWater, 2016), Albury City Council)

Figure 4.16 Flooding extent in the 1 per cent AEP at Billy Hughes bridge enhancement site near Eight Mile Creek and its tributary



Source: The Albury Floodplain Risk Management Study and Plan (WMAWater, 2016), Albury City Council)

Figure 4.17 Flooding extent in the PMF flood event at Billy Hughes bridge enhancement site near Eight Mile Creek and its tributary

An assessment of the existing rail drainage conditions for the 1 per cent AEP flood event has been carried out using the software package DRAINS. The results of the drainage assessment for the 1 per cent AEP flood event for both culverts are reported in Table 4.10.

As the 1 per cent AEP flood level is below the rail level at both culvert locations (refer to Figure 4.16), the hydraulic assessment undertaken confirms that the rail corridor within Billy Hughes bridge enhancement site has a 1 per cent AEP flood immunity.

Table 4.10 Existing 1 per cent AEP flood afflux, levels and immunity at Billy Hughes bridge

CULVERT	1% AEP FLOW (m^3/s)	1% AEP FLOOD LEVEL (m AHD)	RAIL LEVEL (m AHD)	RAIL IMMUNITY (% AEP)
8MC-Rail-C	46.5	217.11	218.29	1%
635.320km	7.23	214.74	217.22	1%

4.6.1.5 TABLE TOP YARD CLEARANCES

The enhancement site is not located within flood-prone land. Sandy Creek, located approximately 1.5 kilometres west of the site, is the nearest watercourse. Flooding from Sandy Creek is not expected to affect the proposal site as topography slopes in a north-west direction; therefore, there is no flood risk at this site.

4.6.2 GREATER HUME – LOCKHART

4.6.2.1 CULCAIRN YARD CLEARANCES

The Culcairn Floodplain Risk Management Study & Plan report (Greater Hume Shire Council – WMA Water, April 2017) has been used to inform the flood conditions at the Culcairn pedestrian bridge and Culcairn Yard clearances enhancement sites. The study has been prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005) and included 20 per cent, 5 per cent and 1 per cent AEP flood events.

Culcairn is located predominately on the northern side of Billabong Creek. Flooding in the region is caused by local overland flow, flooding at Billabong Creek and flooding in an anabranch that exits Billabong Creek on the northern side of town about 2km upstream of the Olympic Highway at Culcairn. The anabranch runs parallel to Billabong Creek and runs through the town passing under Balfour Street near the corner of Federal Street and then continues in a north-westerly direction through the town before crossing the Olympic Highway north of Hopetoun Street.

Floods have been recorded for over 120 years with the largest event likely to have been in 1931 and the second largest in October 2010. Flood mechanisms at Culcairn during the October 2010 event were complex, involving overland flow inundation from local rainfall on 15 October and flooding from Billabong Creek, which peaked at 10.2m on the Billabong Creek gauge on the afternoon of 16 October. It is reported that an effect of the Billabong Creek flood was causing water to flood back up the Gordon Street stormwater system to inundate areas not directly adjacent to the creek.

The railway culvert crossing near Victoria Street, which carries overland flow beneath the railway near Victoria Street to the western side of Culcairn (refer to Figure 4.18), was identified as a piece of ‘Key Infrastructure in the Floodplain’ in the Culcairn Floodplain Risk Management Study and Plan (WMA Water, 2017). Key infrastructure in the floodplain are those that impact on flood levels, such as through upstream backwatering (and retention of floodwater).

The formation within the enhancement site is not overtopped up to and including the 1 per cent AEP flood event. Flood modelling shows that the eastern side of the enhancement site, adjacent to the rail corridor, is impacted by flood levels with water depths up to 2m in the 1 per cent AEP flood event.

The rail is overtopped in the PMF flood event. The flood-prone area and flooding levels along Billabong Creek and its tributary are shown in Figure 4.18 and Figure 4.19.

Albury to Illabo

Figure 4.18 1% AEP flooding levels at the Culcairn Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:4,500
Data Sources: ARTC, NSWSS, Greater Hume Shire Council

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse
- Culvert

Flood depth (m)

- 0 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- > 2

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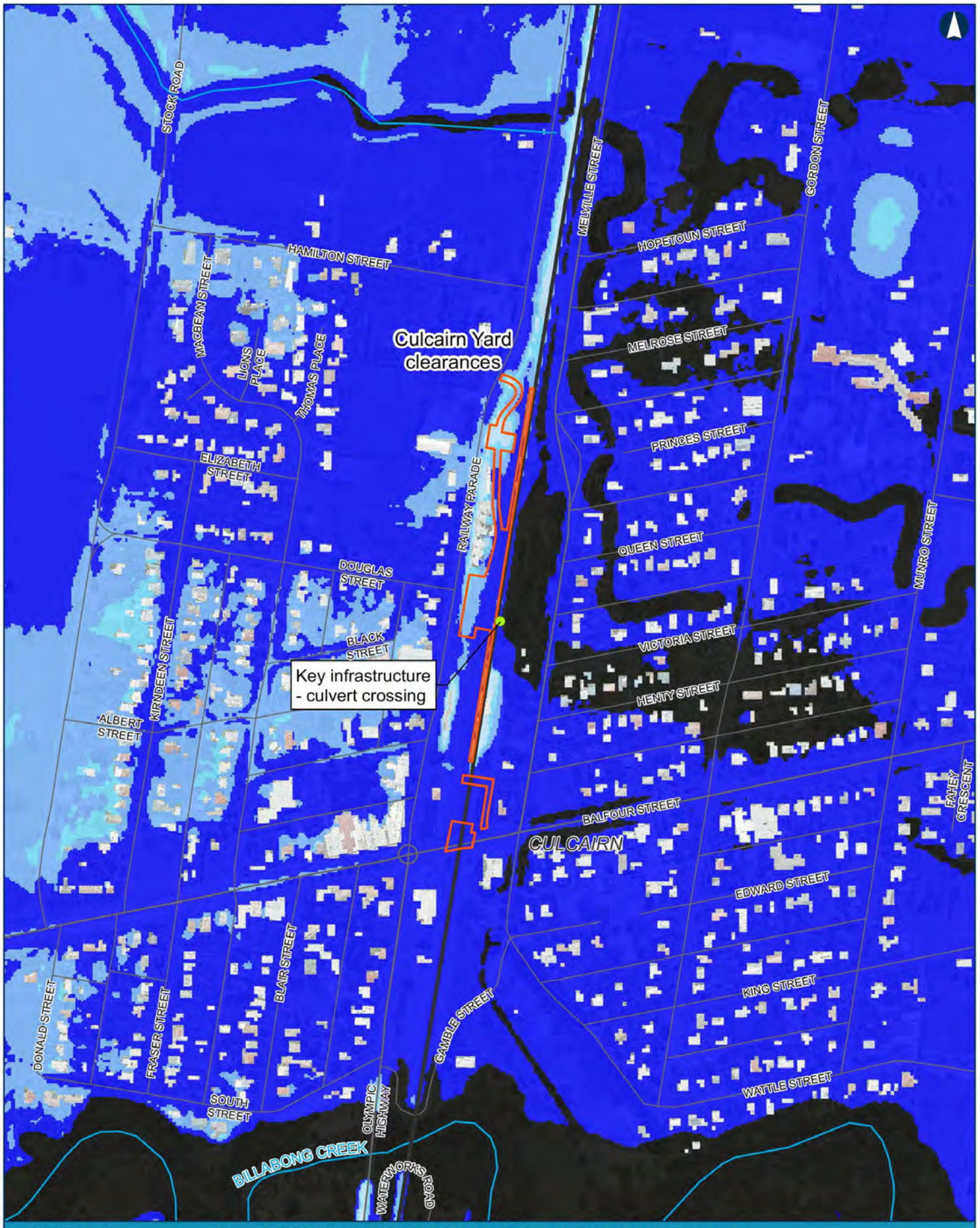

Albury to Illabo

Figure 4.19 PMF flood depth at the Culcairn Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:4,500
Data Sources: ARTC, NSWSS, Greater Hume Shire Council

Proposal site
Existing railway
Main road
Local road
Watercourse
Culvert

Flood depth (m)
0 - 0.5
0.5 - 0.75
0.75 - 1
1 - 2
> 2

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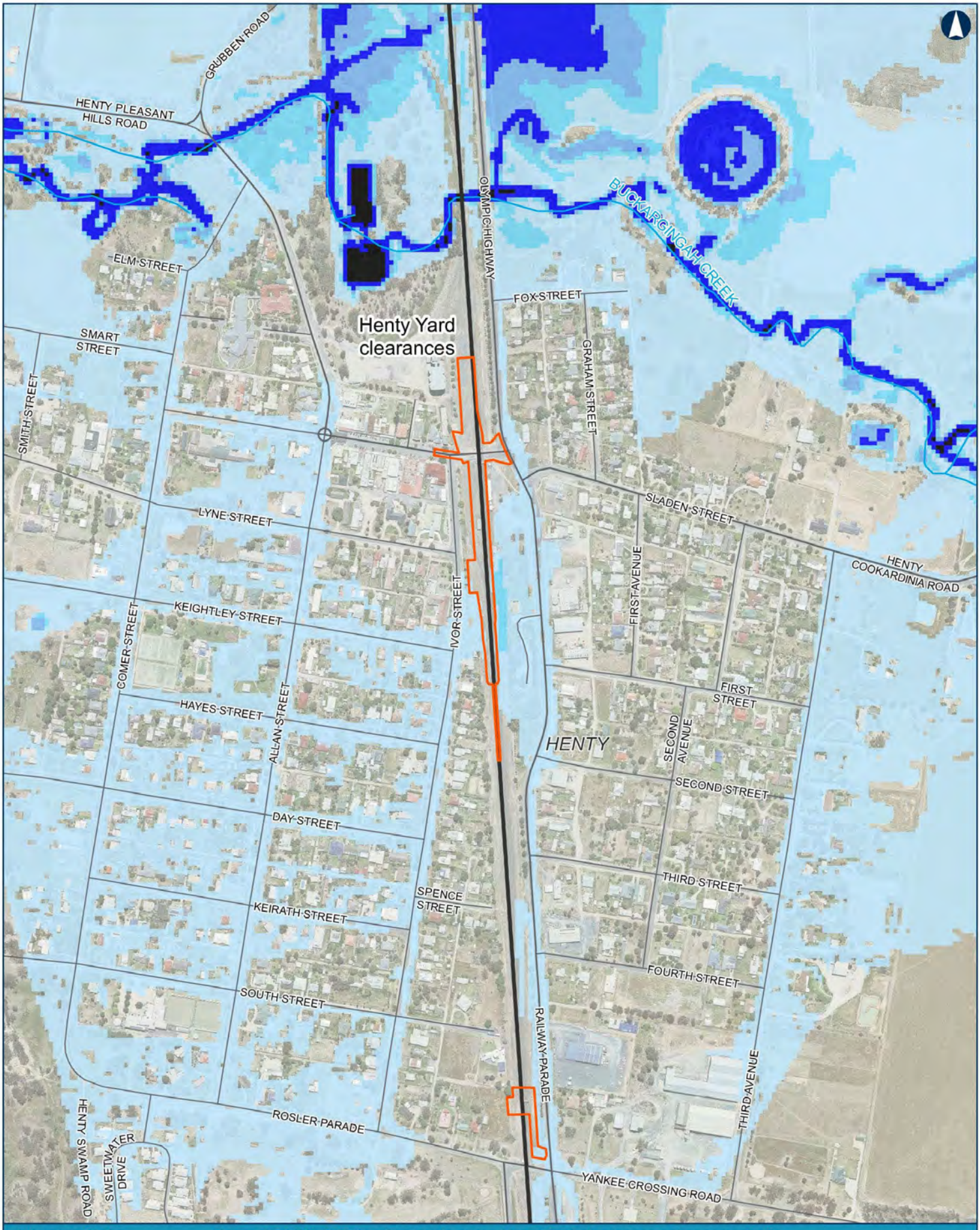
4.6.2.2 HENTY YARD CLEARANCES

The Henty Yard clearances enhancement site is located within the catchment of Buckargingah Creek but is located away from the main floodplain and local overland flows. The northern fringe of the Henty Yard clearances enhancement site is crossed by Buckargingah Creek which originates 15km to the east. It is an ephemeral watercourse that discharges to Doodle Comer Swamp to the south-west. In the late 19th century, Buckargingah Creek was diverted for safety reasons to its current course. As a result of this diversion, remnant levee banks exert some influence over flood mechanisms at Henty-Rand railway, the Main South Line, Bartsch Avenue and Grubben Road.

The Henty Floodplain Risk Management Study & Plan (WMA Water, 2017) has been used to inform the flood conditions at the enhancement site and surrounding areas. This indicates that the Henty Yard clearances enhancement site is not affected by flooding from Buckargingah Creek up to the PMF flood event (refer to Figure 4.20 and Figure 4.21).

Local surface water drainage from the enhancement site flows in a northerly direction towards Buckargingah Creek via cess drains at the base of the rail formation. An existing culvert under the Sladen Street level crossing connects the cess drain within the rail corridor and allows for the passage of stormwater under the existing level crossing.

The study has been prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005), and included 20 per cent, 5 per cent and 1 per cent AEPs and PMF flood events.



Albury to Illabo

Figure 4.20 1% AEP flooding levels at the Henty Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP

Paper: A3
Scale: 1:5,000

Data Sources: ARTC, NSWSS, Greater Hume Shire Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)

0 - 0.5
0.5 - 0.75
0.75 - 1
1.000000001 - 2
2.000000001 - 10

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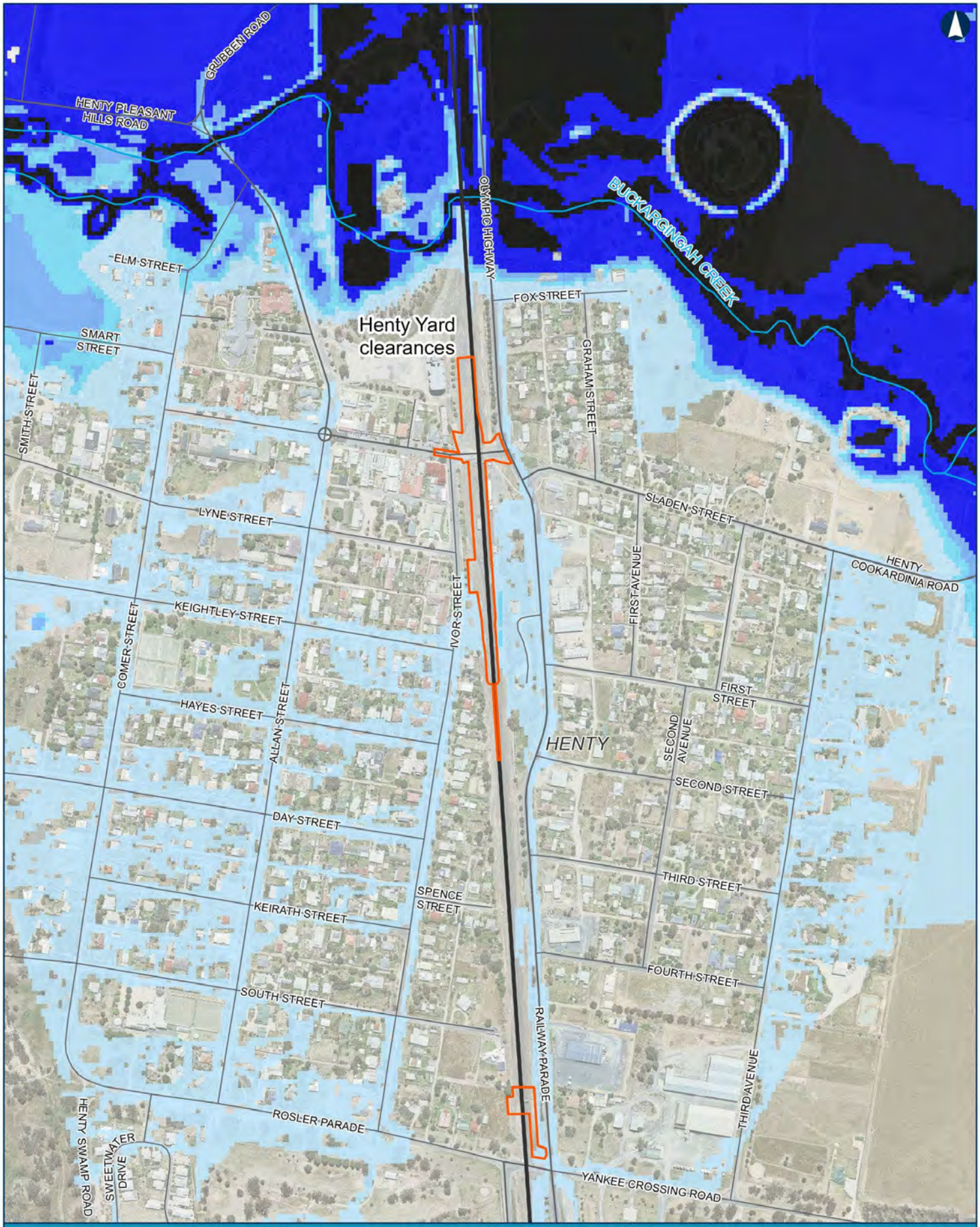

Albury to Illabo

Figure 4.21 PMF flood depth at the Henty Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP
Paper: A3
Scale: 1:5,000

Data Sources: ARTC, NSWSS, Greater Hume Shire Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)

0 - 0.5
0.5 - 0.75
0.75 - 1
1 - 2
> 2

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4.6.2.3 YERONG CREEK YARD CLEARANCES

This enhancement site lies between Yerong Creek to the north and Sandy Creek to the south. The town of Yerong Creek also lies between the two watercourses and therefore the higher ground and away from the floodplains of both creeks. No existing flood models were available for these watercourses.

Flood behaviour at the enhancement site was considered to be of low complexity and the site is subject to local runoff as a result of rainfall across the site only.

A site inspection was completed and it determined that Sandy Creek is an ephemeral creek with no defined bank or channels (refer to Figure 4.22). At this location, the topography is flat and the surface water runoff from the catchment upstream the enhancement site (i.e. approximately 10 hectares (ha)) is expected to flow as sheet flow in a west direction towards the Olympic highway, which is at higher ground and intercepts the flow. From upstream of the Olympic Highway, the flow is conveyed through a series of culverts located beneath the road and railway downstream where it progresses in a north-west direction according to the slope of the topography.

Yerong Creek is located approximately 200 metres north of the enhancement site. The creek conveys the surface water runoff from east to west. From the creek top of the embankment, the ground topography slopes in a north-west direction; as such, any flooding from Yerong Creek is expected to propagate north-west according to the terrain topography, and not towards the site, which is at higher ground.

Figure 4.22 Yerong Creek Yard clearances enhancement site – site visit photos

4.6.2.4 THE ROCK YARD CLEARANCES

The Rock Flood Study (WMAWater, 2014) has been used to inform the flood conditions at The Rock Yard clearances enhancement site and surrounding areas. The study has been prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005), and included 5 per cent, 2 per cent, 1 per cent and 0.5 per cent AEPs and PMF flood events.

Flooding at The Rock generally occurs via two mechanisms. The first is flooding via overland flows from Flowerpot Hill, which is located to the south of the enhancement site. This occurs after high-intensity rainfall, which discharges as sheet flow through properties located south of the Olympic Highway/Railway Street. There are a series of table drains on Yerong Street and Urana Street that drain the runoff originating at Flowerpot Hill towards Burkes Creek. The second is flooding from Burkes Creek, which occurs when floodwaters overtop the banks of the creek. This largely affects the parts of town located to the north and east of Urana Street.

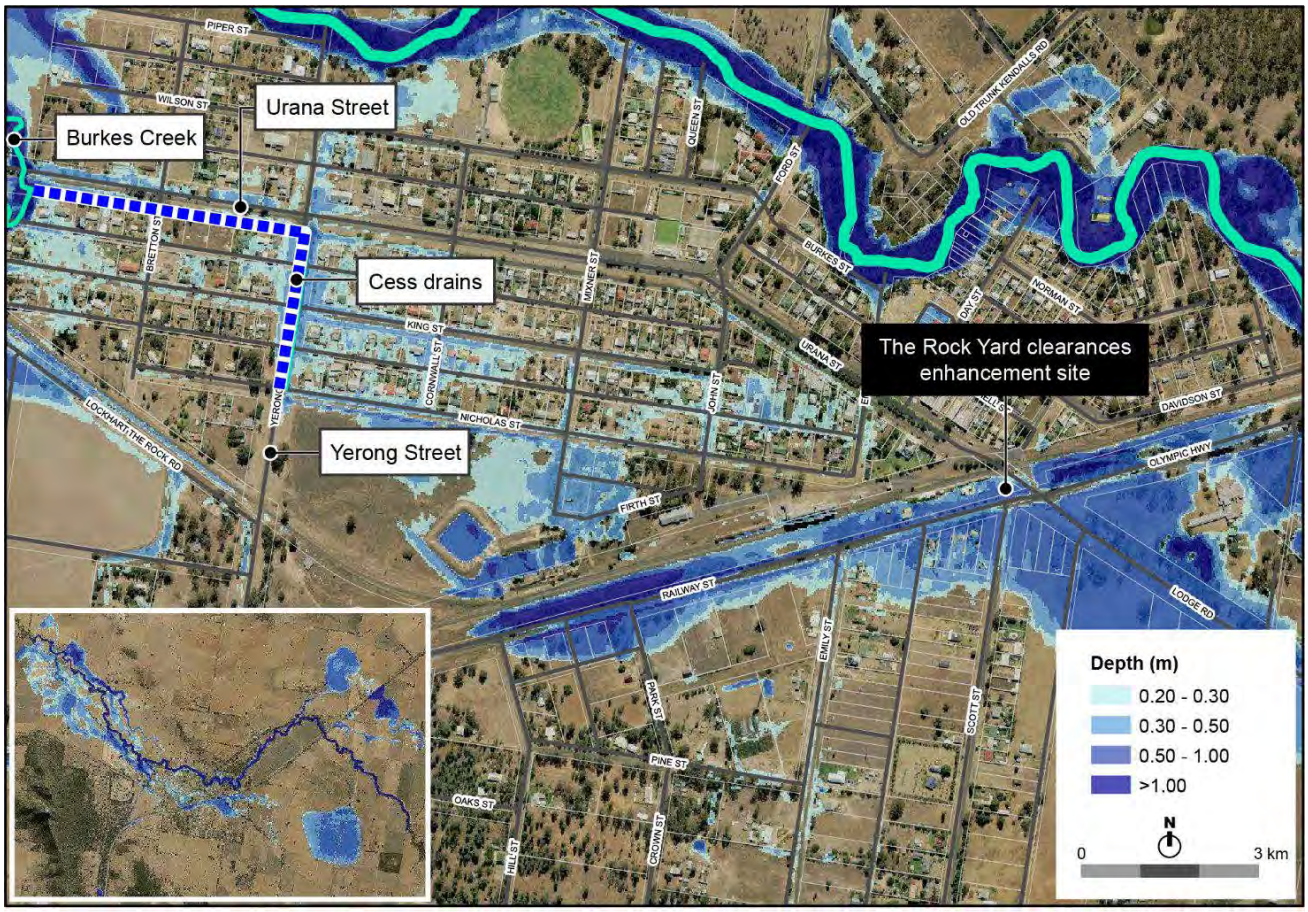
Burkes Creek is an ungauged stream, so no continuous, quantitative record of historic flood heights is available. The period from 2010 to 2012 is the wettest on record throughout NSW, with The Rock experiencing record or near-record floods. The largest of these events occurred in October 2010 and March 2012. The flood of October 2010 caused significant damage to The Rock community. The Rock was again severely impacted by the March 2012 event.

Prior to October 2010 anecdotal reports estimated that the June 1931 flood event was the highest flood on record, with an estimated peak of 213.2mAHD at Old Collingullie Road bridge (110m upstream of current bridge). This event caused significant flooding and damage throughout the region. Floods in other years at The Rock are known to have occurred in January 2000, December 1992, April 1989, December 1988, January 1974, March 1955, February 1939, January 1934, June 1931, February 1928 and 1927, 1912 and 1891.

Flood modelling shows that the rail corridor is not overtopped by floodwater up to and including the 1 per cent AEP flood event.

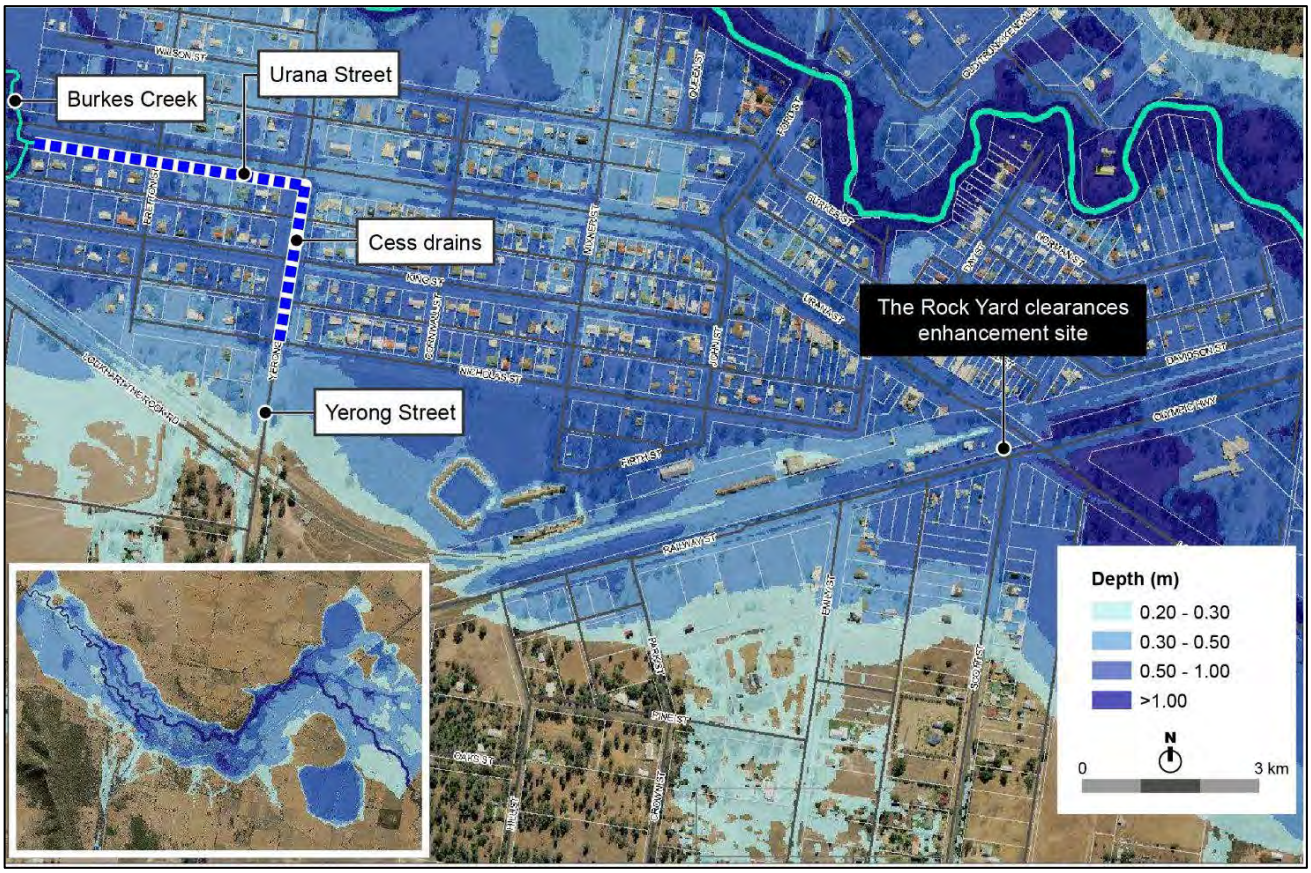
Figure 4.23 shows the 1 per cent AEP flood extent at the enhancement site. Overland flooding occurs at the south of the enhancement site where overland flow is conveyed from south east towards the terrain depression between the rail corridor and Railway Street.

Figure 4.24 shows the PMF flood extent at the enhancement site. The enhancement site is affected by flooding in the PMF flood event.



Source: The Rock Flood Study (WMAWater, 2014), Lockhart Shire Council)

Figure 4.23 1 per cent AEP flooding extent at The Rock Yard clearances enhancement site



Source: The Rock Flood Study (WMAWater, 2014), Lockhart Shire Council)

Figure 4.24 PMF flooding extent at The Rock Yard clearances enhancement site

4.6.3 WAGGA WAGGA

4.6.3.1 URANQUINTY YARD CLEARANCES

The Tarcutta, Ladysmith and Uranquinty Flood Floodplain Risk Management Studies and Plans (GRC Hydro, December 2020) has been used to inform the flood conditions at the site and surrounding areas, and has been adopted by Wagga Wagga Council. The study has been prepared in accordance with ARR2019 and the NSW Floodplain Development Manual (NSW 2005) and included 20 per cent, 5 per cent, 1 per cent AEPs and PMF flood events.

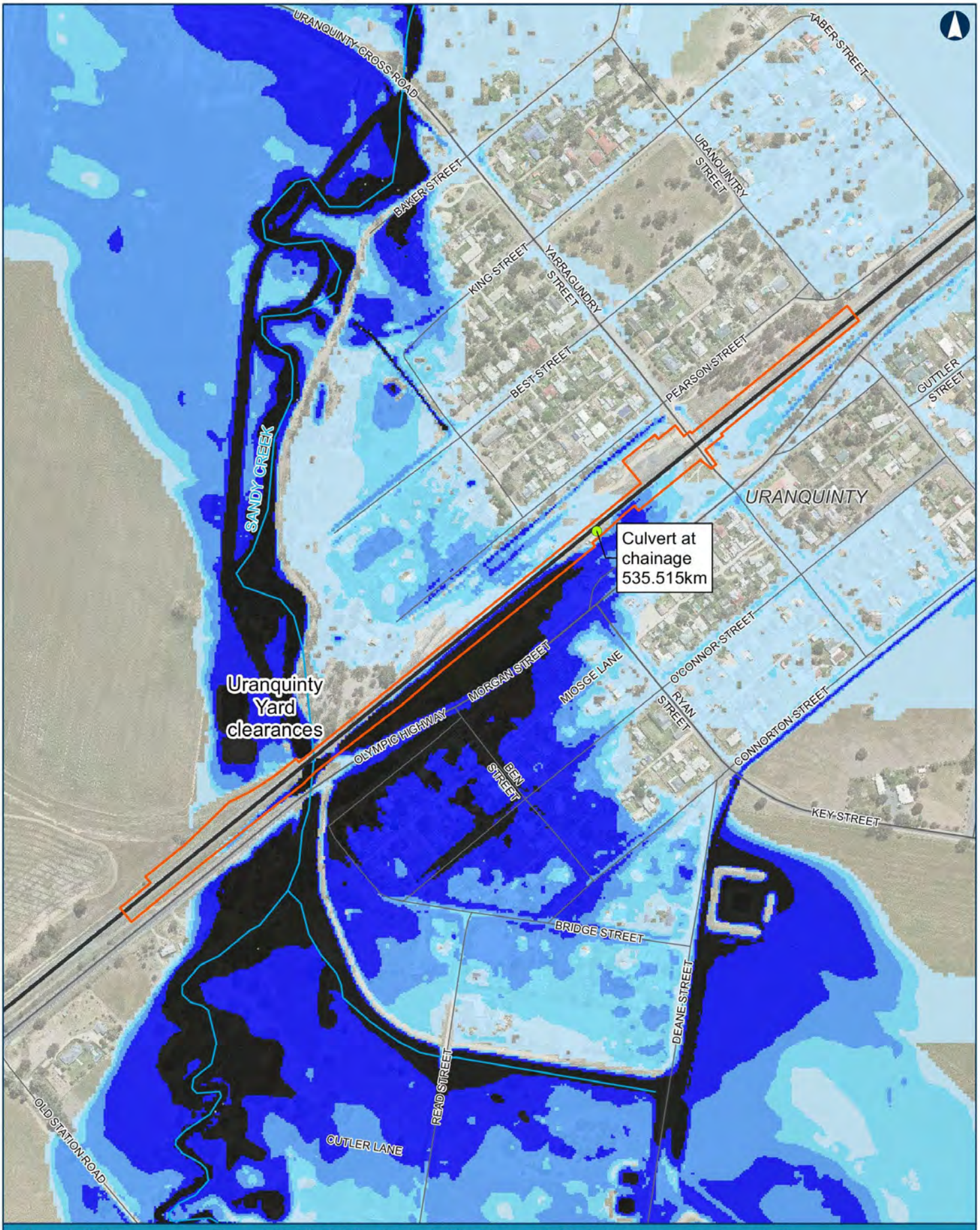
The Uranquinty Yard clearances enhancement site is within the Sandy Creek floodplain. Sandy Creek is the only watercourse that represents a possible source of flooding for the enhancement site. Sandy Creek conveys the overland flow from the upstream catchment in a north-west direction towards the Murrumbidgee River.

Figure 4.25 and Figure 4.26 shows the flood extent at the site and surrounding areas for the 1 per cent AEP and PMF flood events. The enhancement site is not subject to regional flooding from the Murrumbidgee River.

Flood modelling shows that:

- the areas upstream and downstream of the enhancement site are affected by flooding
- the rail embankment is overtopped to the east of the Sandy Creek Underbridge in the PMF, 1 per cent and 2 per cent AEP flood events (refer to Figure 4.25, Figure 4.26 and Figure 4.29). There is no overtopping of the rail corridor at the site in the 5 per cent AEP flood event
- the existing Sandy Creek underbridge (refer to Figure 4.27 and Figure 4.28) does not experience overtopping and the flood flows are conveyed below the rail bridge.

The culvert at chainage 535,515km conveys the overland flow from east to west across the rail corridor (refer to Figure 4.27 and Figure 4.28).



Albury to Illabo

Figure 4.25 1% AEP flood extent at the Uranquinty Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:4,500

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse
Culvert

Flood depth (m)

0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1
> 1

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Albury to Illabo

Figure 4.26 PMF flood depth at the Uranquinty Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP
Paper: A3
Scale: 1:4,500

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse
- Culvert

Flood depth (m)

- 0 - 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1

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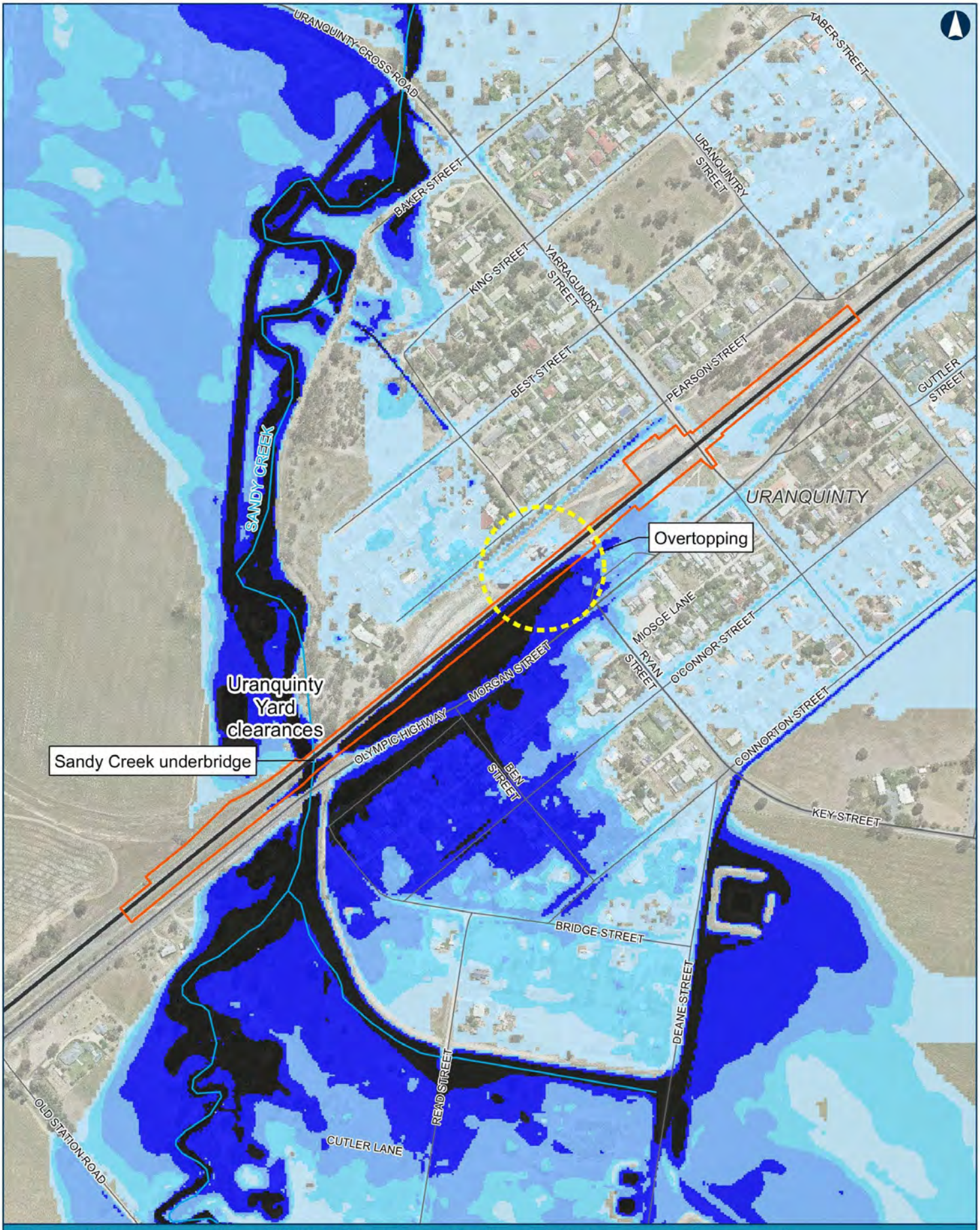
Figure 4.27 Uranquinty Yard clearances – existing culvert at 535,515m

Figure 4.28 Uranquinty Yard clearances – existing culvert at 535,515m



Albury to Illabo

Figure 4.29 2% AEP flood extent at the Uranquinty Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP

Paper: A3
Scale: 1:4,500

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)

0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1
> 1

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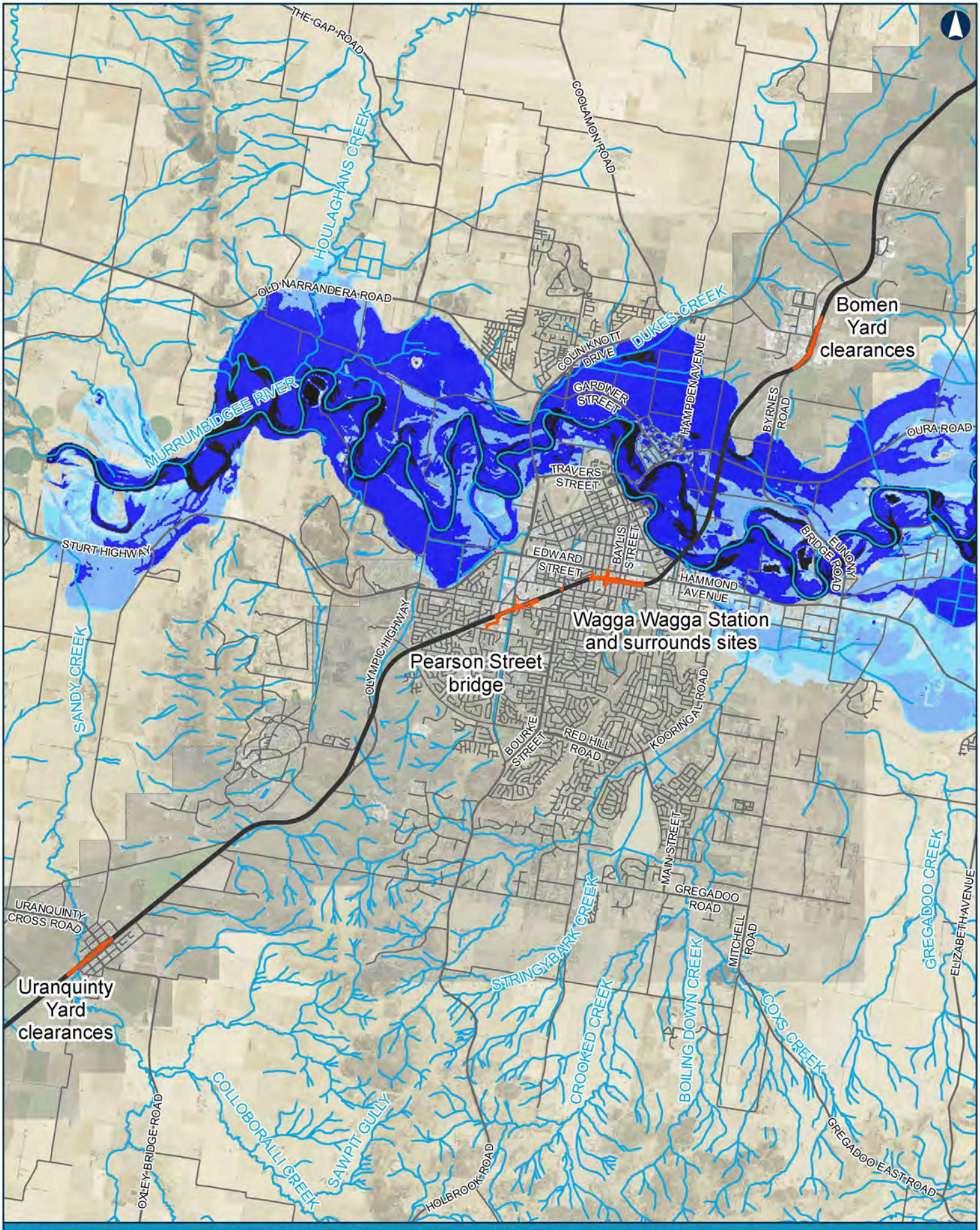
4.6.3.2 PEARSON STREET BRIDGE

RIVER FLOODING

Wagga Wagga City Council provided the hydraulic model data for Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan (WMA Water, 2018). The study includes flood events up to the PMF.

The enhancement site is located about 2km south of Murrumbidgee River. Flood modelling shows that the enhancement site is not affected by flooding from Murrumbidgee River up to and including the PMF flood event. Figure 4.30 and Figure 4.31 show the maximum 1 per cent AEP and PMF flood extent.



Albury to Illabo

Figure 4.30 Regional flooding in the 1% AEP at Murrumbidgee River

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:75,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)
0 - 0.5
0.5 - 1
1 - 2
2 - 5
> 5

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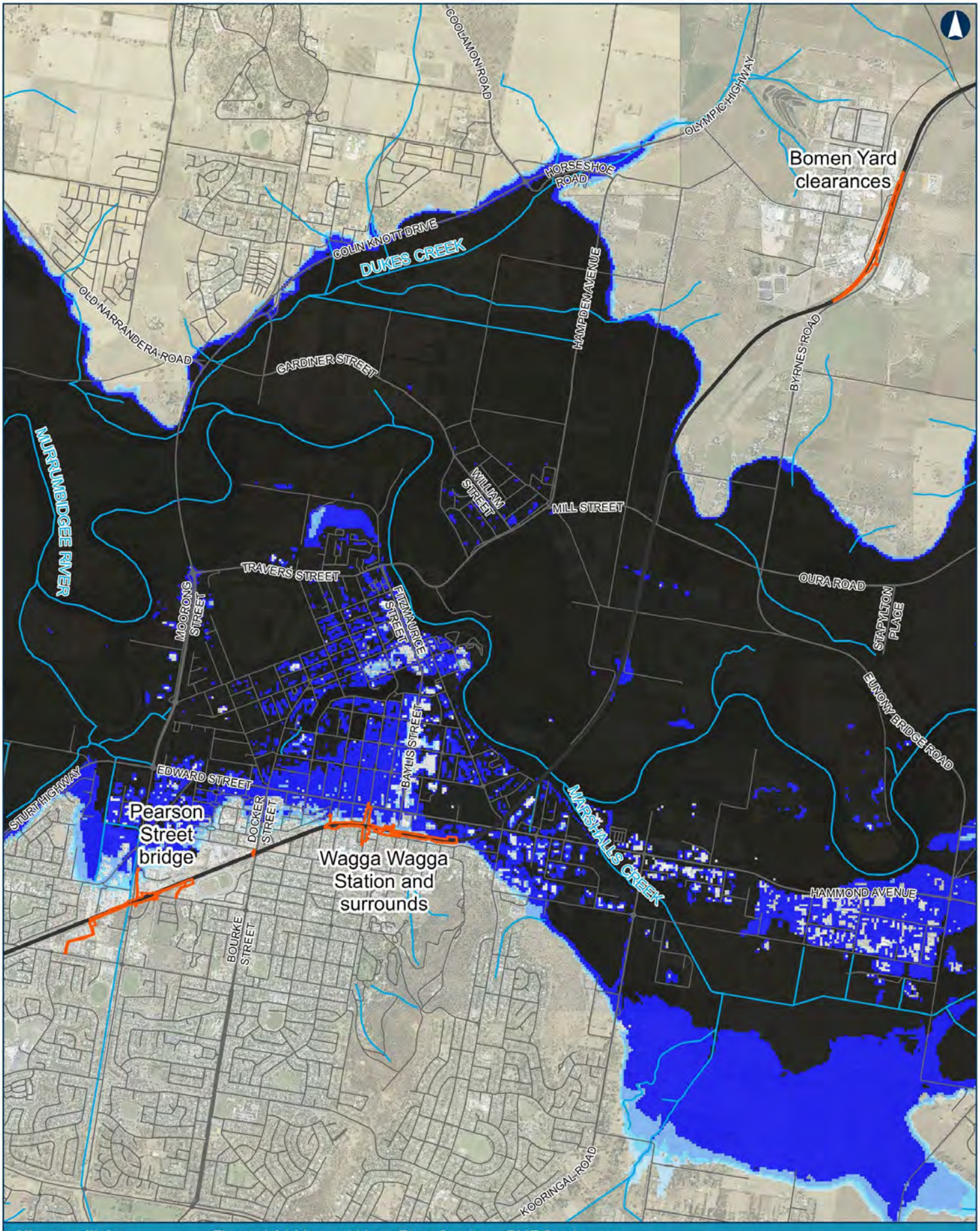

Albury to Illabo

Figure 4.31 Murrumbidgee River flooding - PMF flood event

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP

Paper: A3
Scale: 1:30,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)

0 - 0.5
0.5 - 1
1 - 2
2 - 5
> 5

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CREEK FLOODING

The Glenfield Drain passes under the rail corridor within the enhancement site via a concrete box culvert at chainage 523,560m (refer to Figure 4.32). This drain flows parallel to Pearson Street in a northern direction towards the Murrumbidgee River, located about 2km north of the enhancement site.

Figure 4.32 Existing box culvert at the Pearson Street bridge enhancement site (at chainage 523,560m)

A culvert at chainage 523,515m (a 450 millimetre [mm] circular culvert) collects local runoff from the adjacent Wagga Wagga Showground and a portion of the rail corridor, and drains in a north-west direction towards the council stormwater drainage network (refer to Figure 4.33). An overland flows path exists south of the rail corridor and runs in west direction towards a council stormwater detention basin.

Figure 4.33 Pearson Street bridge enhancement site – photograph of existing culvert at 523,515m

Cut-off channels to the west of the Pearson Street bridge capture surface water flow from the batter and directs it into the Glenfield Drain. There is no other formal stormwater drainage infrastructure located within the enhancement site.

Wagga Wagga City Council provided the flood model data prepared for the Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan in 2021. The flood model describes the flow conditions at the Glenfield Drain and surrounding areas.

The flood model results shows that the enhancement site is not affected by overland flooding up to and including the 1 per cent AEP flood event as described in Figure 4.34. In the PMF flood event the site is affected by flooding; flood depths are up to 700mm as shown in Figure 4.35.

Flood maps show that the enhancement site has a 1 per cent AEP flood immunity.

Albury to Illabo

Figure 4.34 1% AEP flood extent at Pearson Street bridge enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP

Paper: A3
Scale: 1:5,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Local road
Watercourse

Flood depth (m)

0 - 0.5
0.5 - 1
1 - 2
2 - 5
> 5

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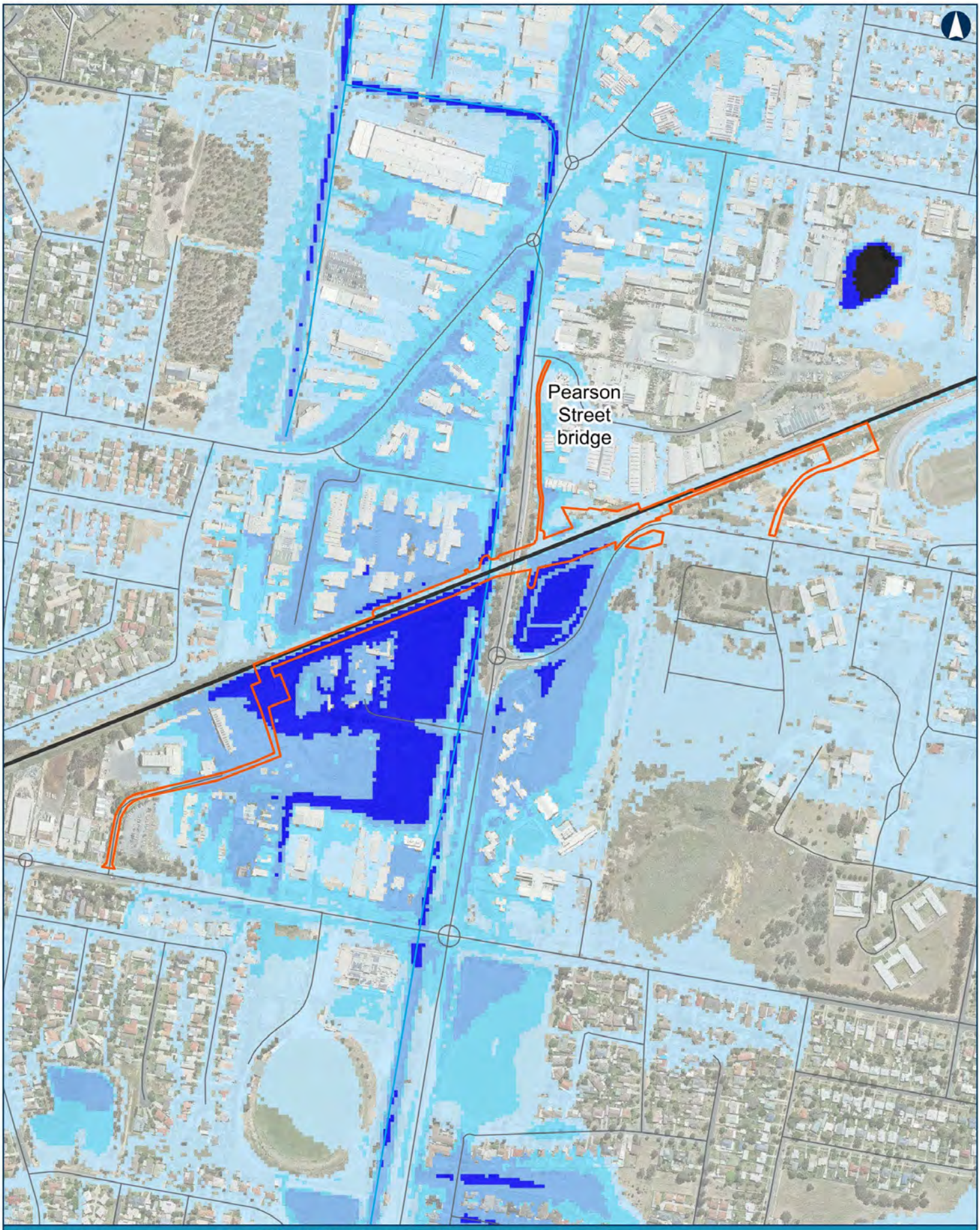

Albury to Illabo

Figure 4.35 PMF flood extent at Pearson Street bridge enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP

Paper: A3
Scale: 1:5,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Local road
Watercourse

Flood depth (m)

0 - 0.5
0.5 - 1
1 - 2
2 - 5
> 5

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4.6.3.3 WAGGA WAGGA STATION AND SURROUNDS

RIVER FLOODING

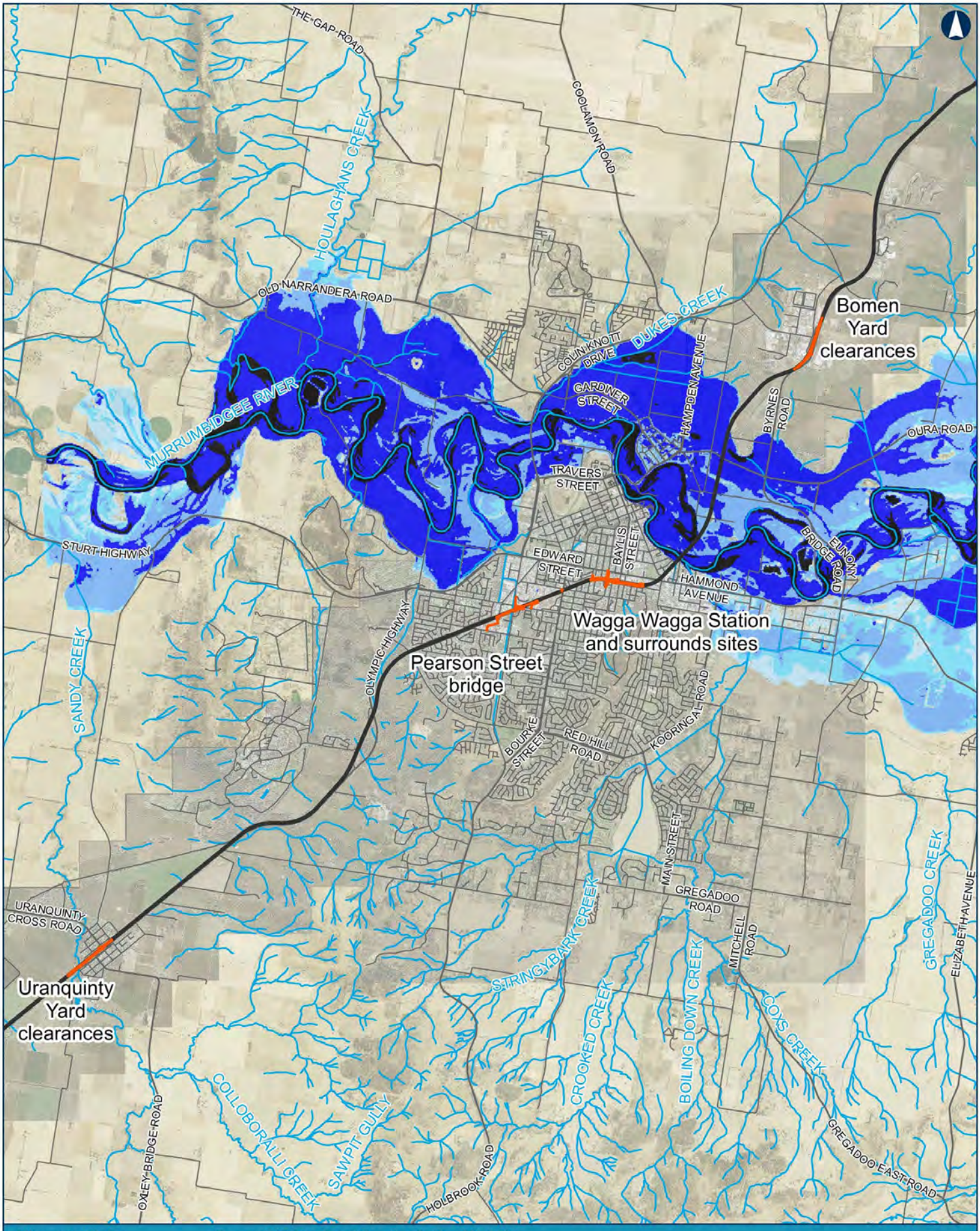
Wagga Wagga City Council has provided hydraulic model data for Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan (WMA Water, 2018) and overland flooding for the Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (MOFFS) (WMAWater , 2021). The study has been prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005) and included 5 per cent, 2 per cent, 1 per cent AEPs and PMF flood events.

The enhancement sites are located approximately 1.7km west of Murrumbidgee River. Flood modelling shows that the enhancement sites are not affected by flooding from Murrumbidgee River up to and including the PMF flood event. Figure 4.36 and Figure 4.37 show the 1 per cent AEP and PMF.

OVERLAND FLOODING

The overland flood data from the Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (WMA Water, 2021) shows that the rail corridor within the enhancement sites is affected by overland flooding for the 1 per cent AEP flood event (refer to Figure 4.38 and Figure 4.39) and in the 5 per cent AEP (refer to Figure 4.40). Maximum flood depths (i.e. up to approximately 400 to 500mm) occur at the enhancement sites in the 1 per cent AEP flood event. Figure 4.41 shows the flood extent in the PMF flood event.

The flood assessment shows that surface water run-off flows from south towards north-east according to the terrain slope, overtopping the rail formation at the east of Edmondson Street bridge in the 1 per cent AEP flood event. Railway Street that runs parallel to the rail corridor is approximately 2m higher than the rail formation. Surface water ponds in the area between Railway Street and the rail corridor before flowing towards north-east. In this area, peak water depths are up to approximately 600mm in the 1 per cent AEP flood event.



Albury to Illabo Figure 4.36 Regional flooding in the 1% AEP

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:75,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)
0 - 0.5
0.5 - 1
1 - 2
2 - 5
> 5

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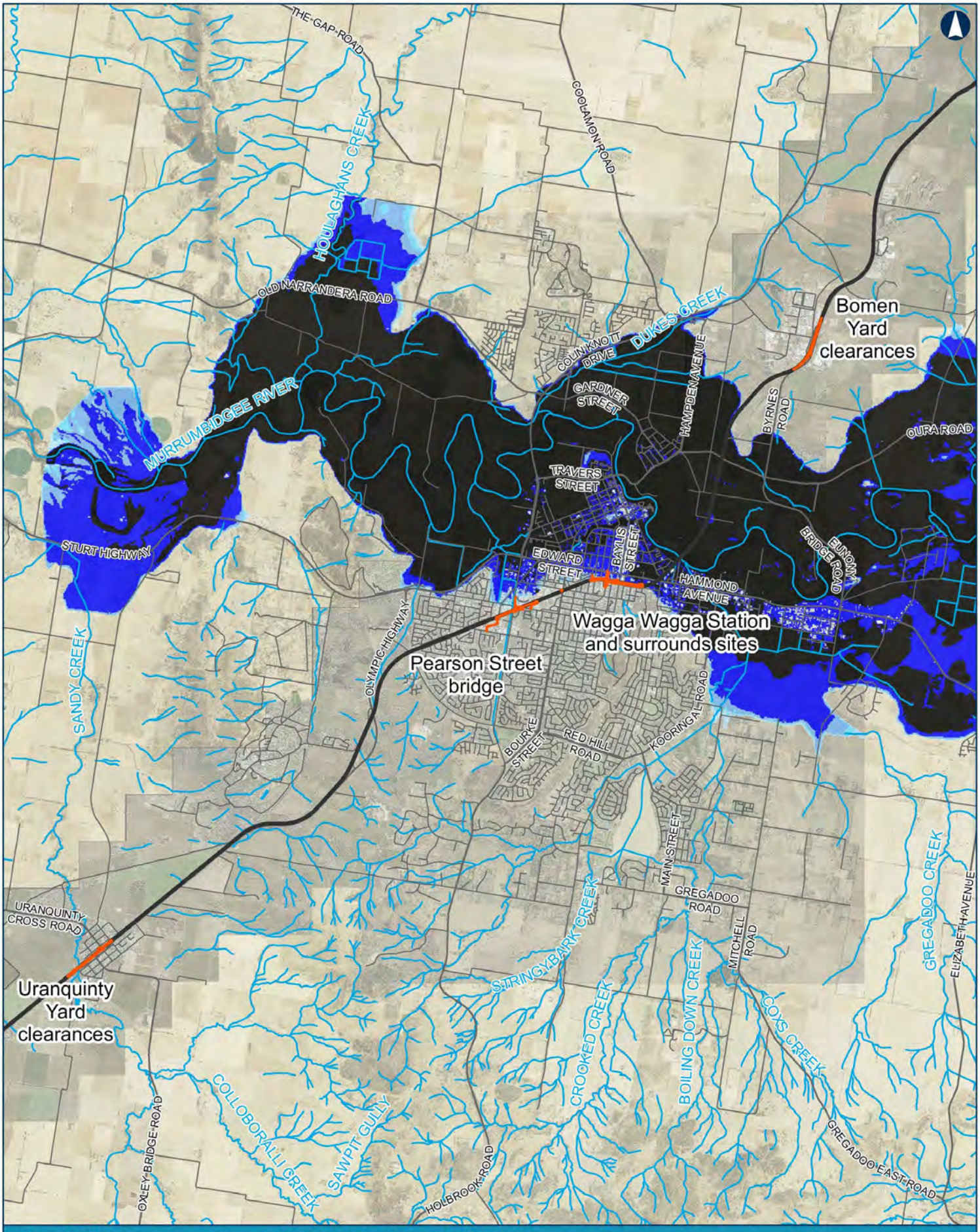

Albury to Illabo Figure 4.37 Regional flooding in the PMF flood event

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:75,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)
0 - 0.5
0.5 - 1
1 - 2
2 - 5
> 5

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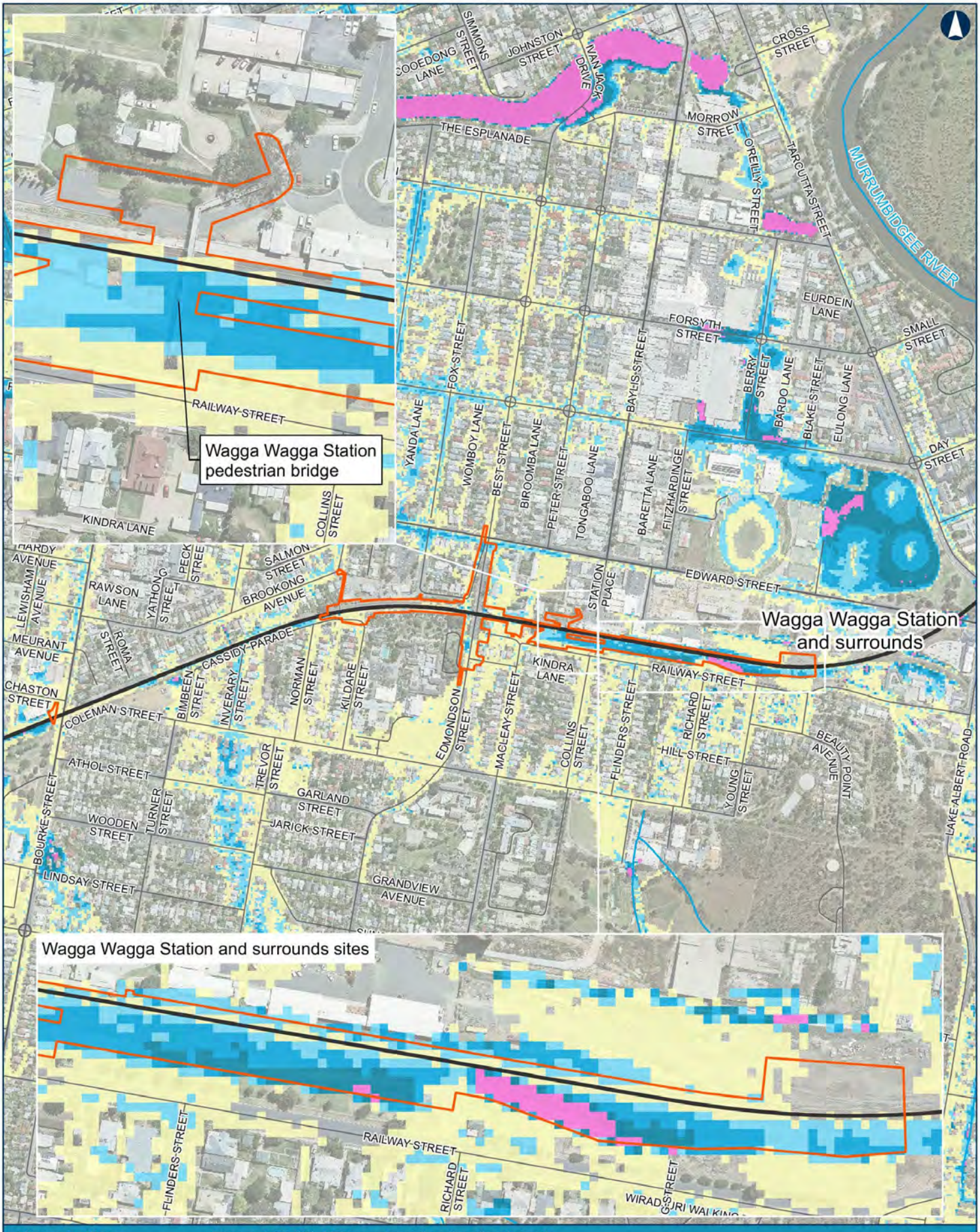

Albury to Illabo Figure 4.38 1% AEP overland flooding flood depth

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:8,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)
0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 0.75
> 0.75

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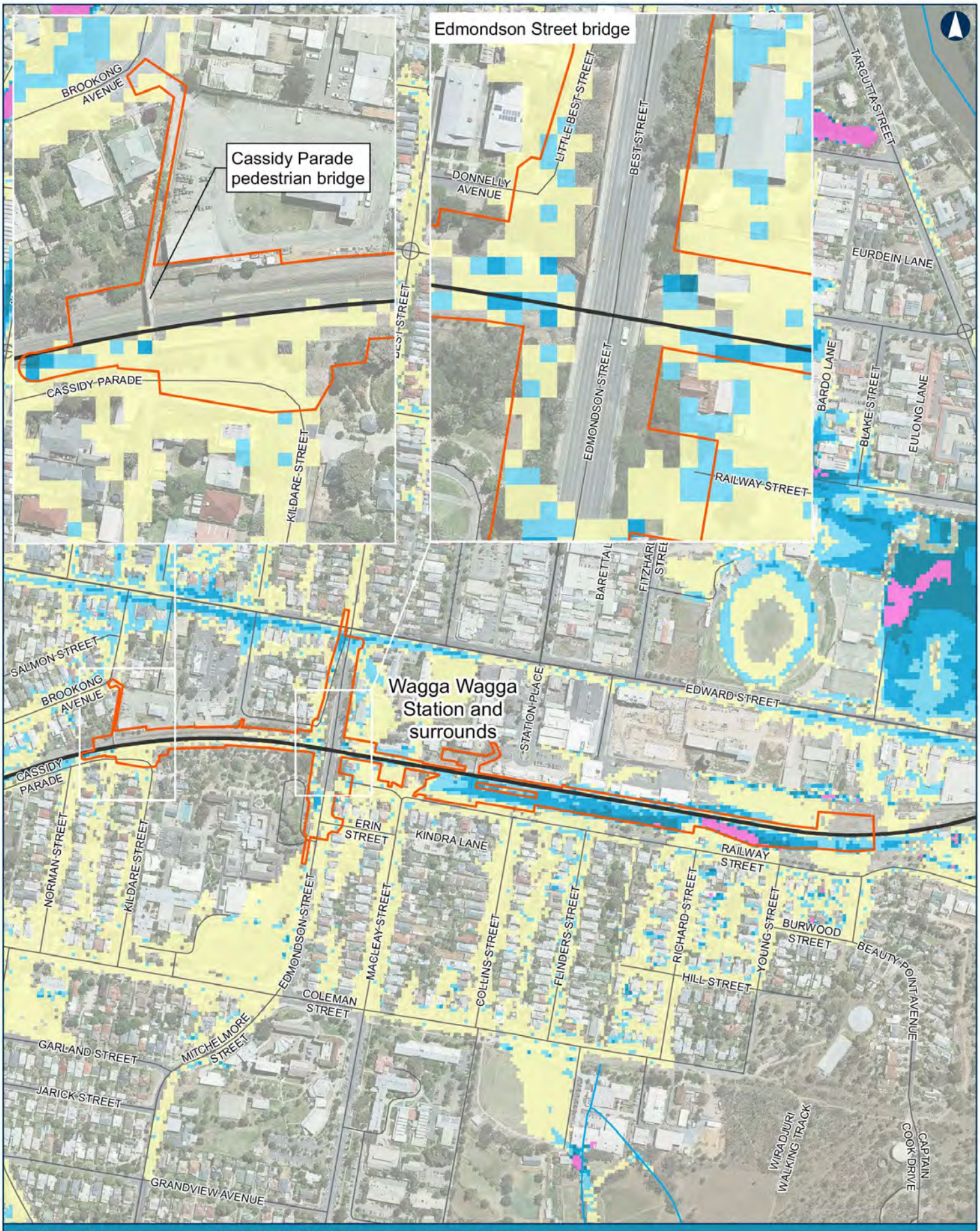

Albury to Illabo Figure 4.39 1% AEP overland flooding flood depth

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:5,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)
0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 0.75
> 0.75

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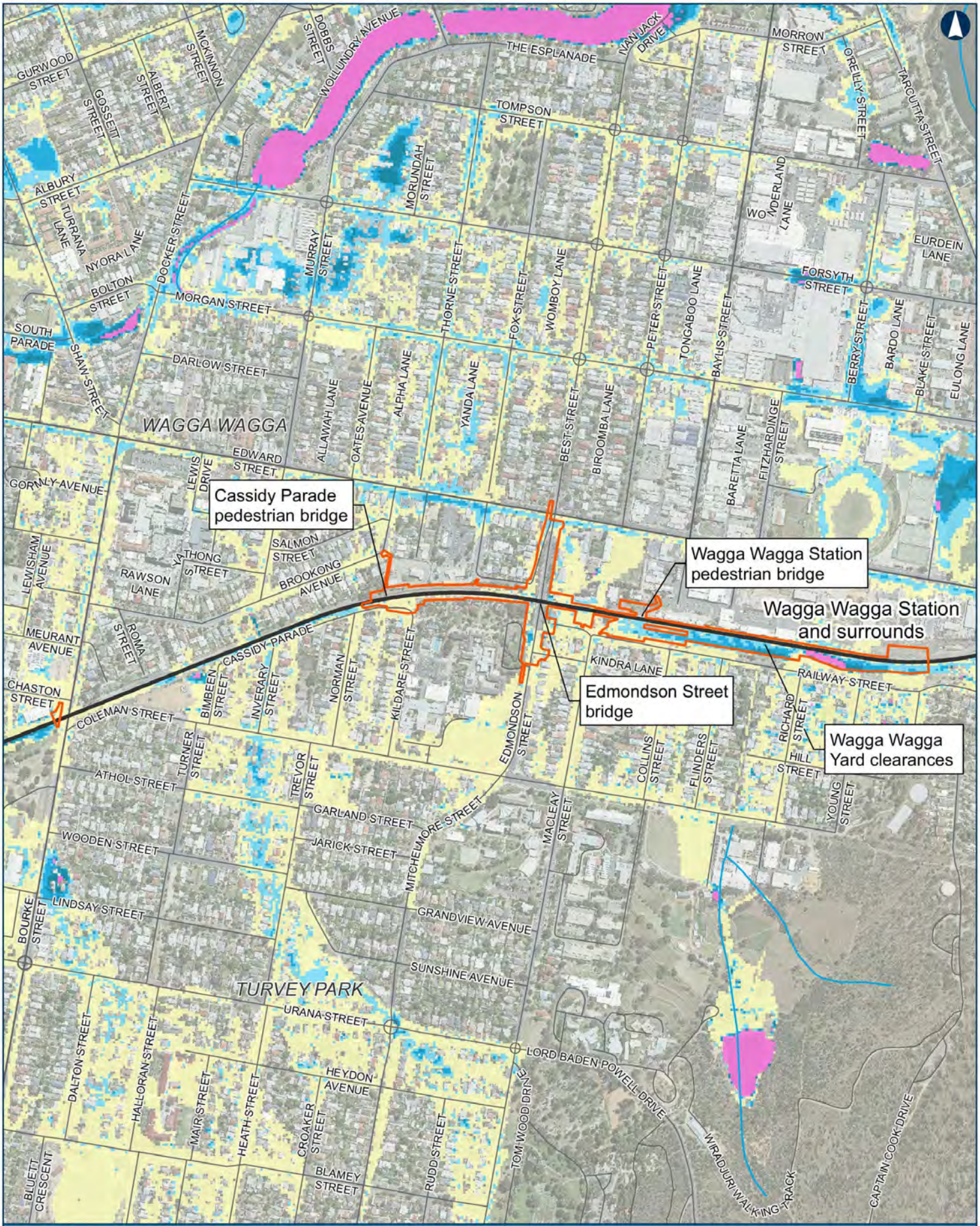

Albury to Illabo Figure 4.40 5% AEP overland flooding flood depth

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:7,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)
0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 0.75
> 0.75

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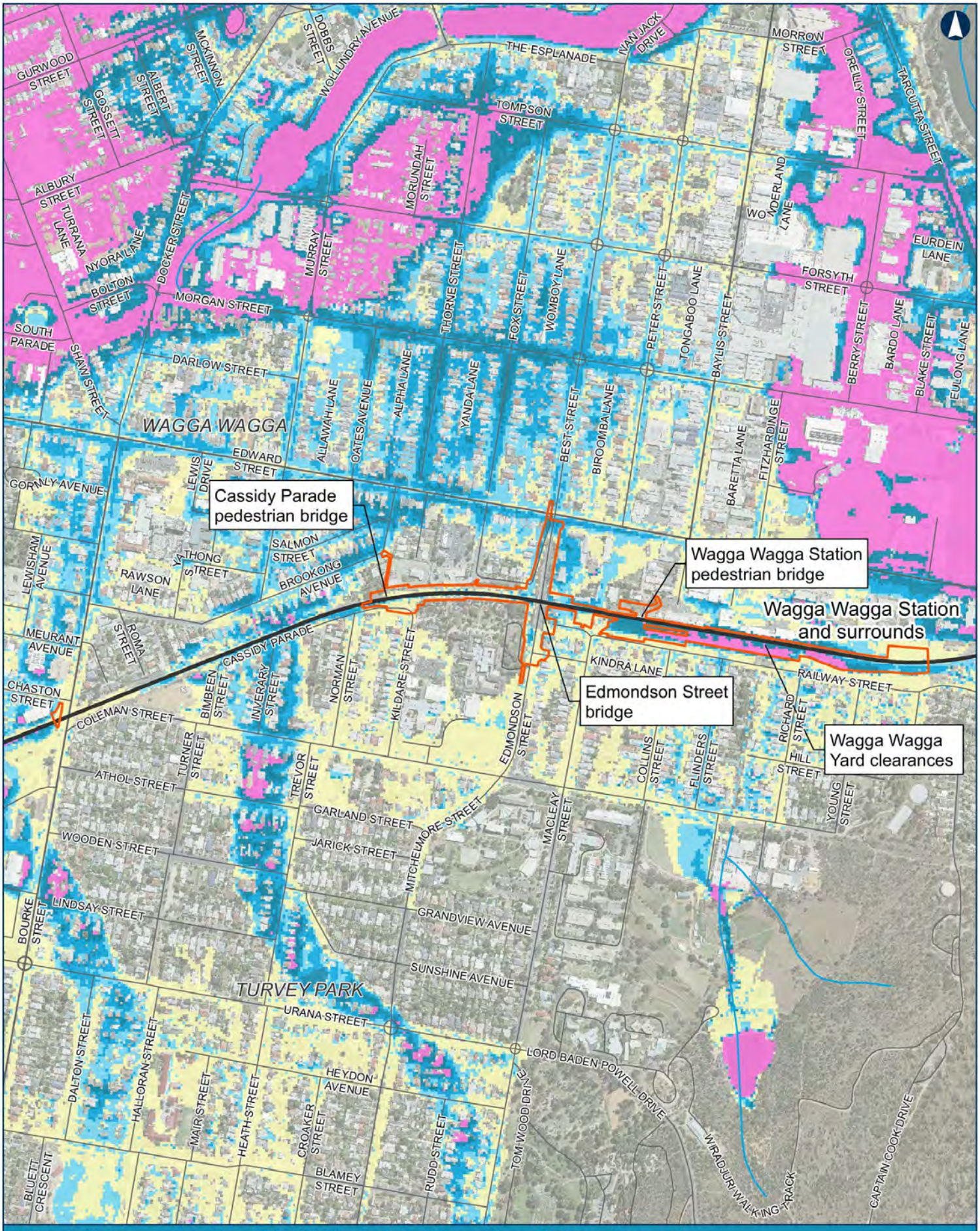

Albury to Illabo

Figure 4.41 PMF flood extent at Wagga Wagga Station and surrounds

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:7,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)
0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 0.75
> 0.75

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EXISTING DRAINAGE CONDITIONS

There is no formal drainage located within the Wagga Wagga Yard clearances or Wagga Wagga Station pedestrian bridge enhancement sites. Surface water runoff flows according to the terrain slope. There are cess drains and catch drains at Cassidy Parade pedestrian bridge.

Figure 4.42 below shows the existing drainage network at Edmondson Street bridge. At the Edmondson Street bridge, surface water runoff discharges into the council stormwater drainage system. The historic drainage records provided by Wagga Wagga City Council indicates that the key drainage systems were in existence and/or constructed in 1961. A detailed survey of the existing Wagga Wagga City Council stormwater network was not available for this assessment. The current condition of the network is unknown. Network locations and levels have been estimated using the historical data and Wagga Wagga City Council Council's GIS records.

Figure 4.42 Estimated Wagga Wagga Council drainage based on historical records at Edmondson Street bridge

A detailed hydraulic assessment of the Wagga Wagga City Council stormwater drainage network has not been undertaken. It is anticipated that the local drainage system has sufficient capacity for storm events up to 5 per cent AEP flood event. This assumption is consistent with anecdotal information obtained from discussions with Wagga Wagga City Council's drainage engineer where it was noted that the area around Edmondson Street and Best Street have not experienced any notable historic flooding or drainage issues.

4.6.3.4 BOMEN YARD CLEARANCES

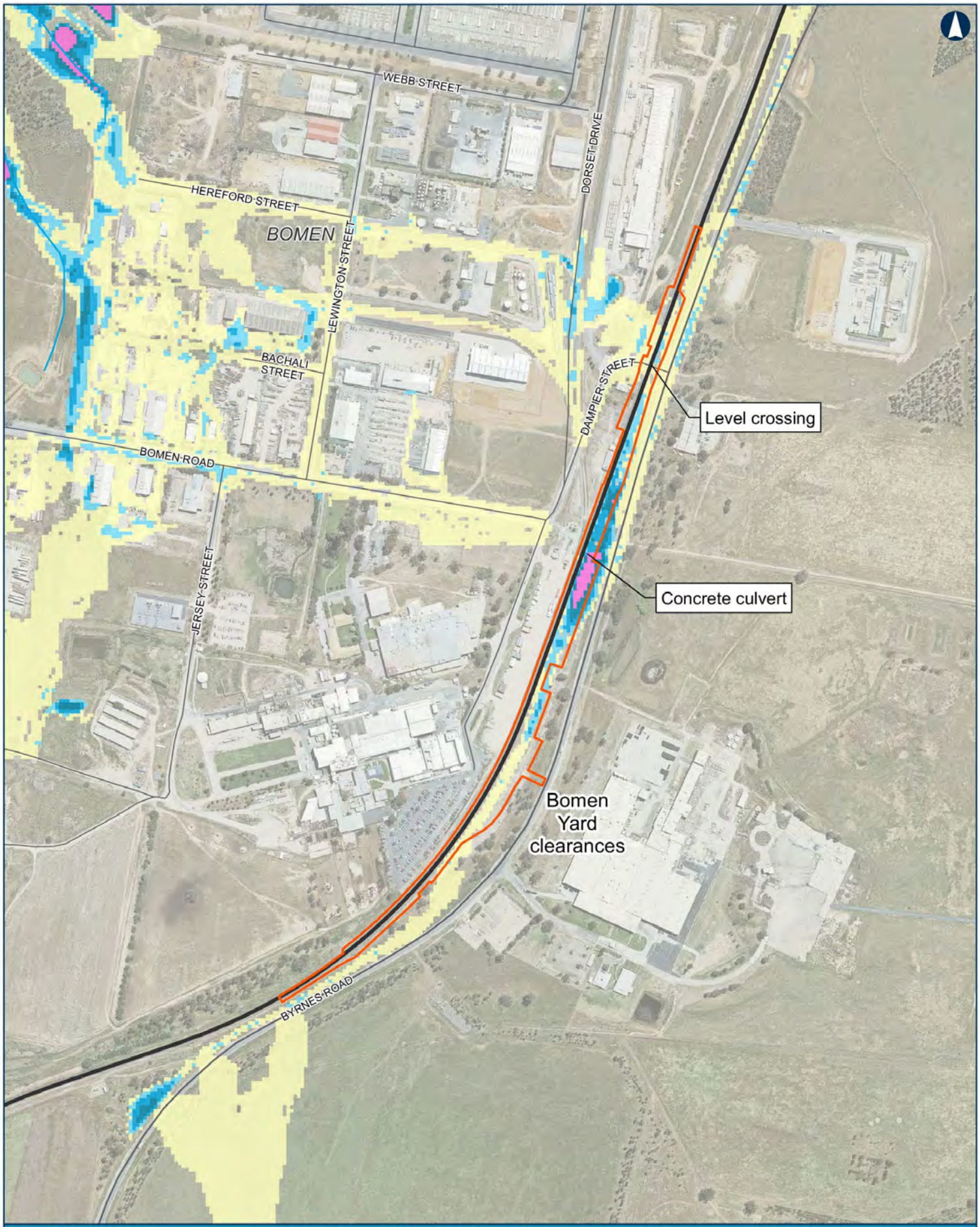
Flood maps from the Draft Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (WMA Water, 2021) show that the Bomen Yard clearances are affected by overland flooding (refer to Figure 4.43). The study has been prepared in accordance with ARR2019 and the NSW Floodplain Development Manual (NSW 2005) and included 20 per cent, 5 per cent and 1 per cent AEPs flood events.

Flooding occurs at Bomen Road level crossing where overland flow surcharges the rail formation. At this location the maximum flood depths are up to 150mm in the 1 per cent AEP flood event, up to 90mm in the 5 per cent AEP flood event and up to 80mm in the 20 per cent AEP flood event.

There is an existing concrete culvert at chainage 513,820m. There is no other formal drainage infrastructure located within the enhancement site except for longitudinal drainage channels parallel to the rail formation.

With the exception of the portion of the rail corridor in the vicinity of the closed Bomen Road level crossing, the rail corridor is not flooded up to the 1 per cent AEP flood event.

The rail is overtopped in the PMF flood event in two locations as shown in Figure 4.44.



Albury to Illabo

Figure 4.43 1% AEP local flood extent at the Bomen Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:5,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Flood depth (m)

0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 0.75
> 0.75

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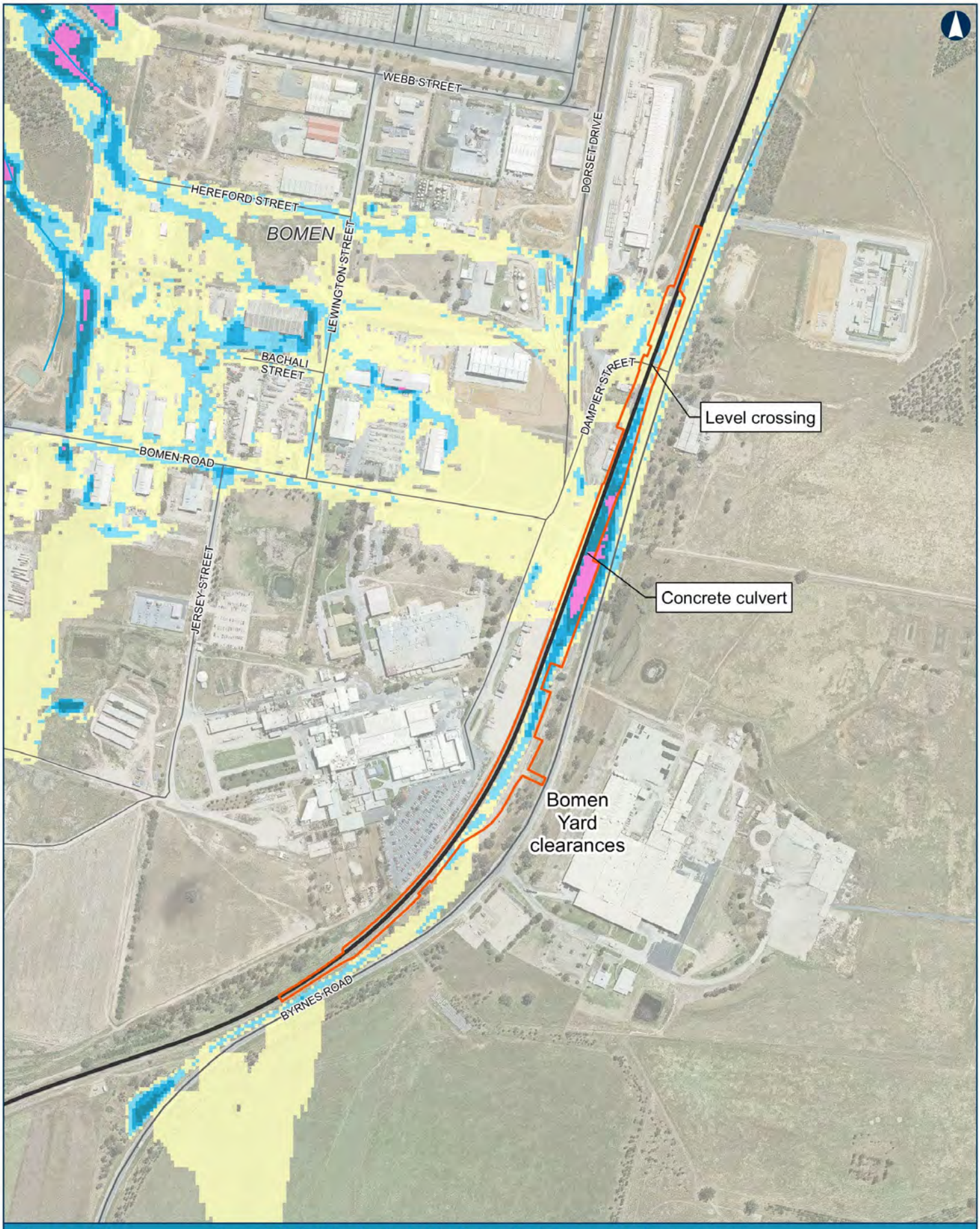

Albury to Illabo Figure 4.44 PMF flood extent at the Bomen Yard clearances enhancement site

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:5,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse

Flood depth (m)

- 0 - 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- > 0.75

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4.6.4 JUNEE

4.6.4.1 HAREFIELD YARD CLEARANCES

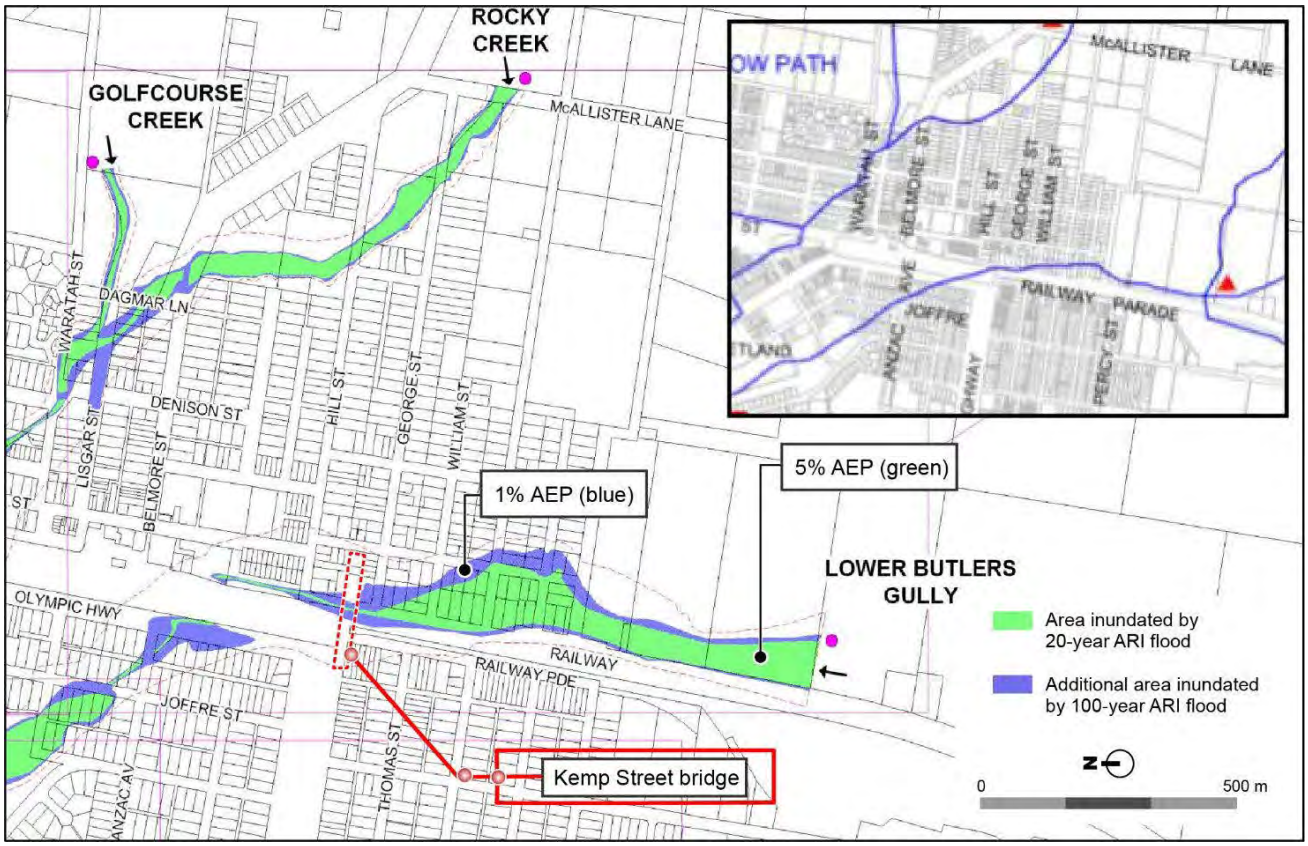
Current information does not show Harefield Yard clearances site affected by regional flooding.

Reedy Creek is an ephemeral watercourse that intersects the enhancement. The Reedy Creek catchment upstream of the proposal is approximately 3ha. No flood information was available for the Reedy Creek.

4.6.4.2 KEMP STREET BRIDGE

The Lower Butlers Gully Flood Study (Lyall & Associates, 2009) has been used to inform the flood conditions at Kemp Street bridge site and surrounding areas. The flood study indicates overland flooding within the rail corridor at the enhancement site in the 1 per cent and 5 per cent AEP flood events (refer to Figure 4.45). The study has been prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005) and included 20 per cent, 5 per cent and 1 per cent AEPs flood events.

The bridge and the adjacent connecting roads are not impacted by the flooding. Flood water flows beneath the bridge along the rail corridor from east to west.



Source: The Lower Butlers Gully Flood Study (Lyall & Associates, 2009), Junee Shire Council)

Figure 4.45 1% AEP flood extent at Kemp Street bridge

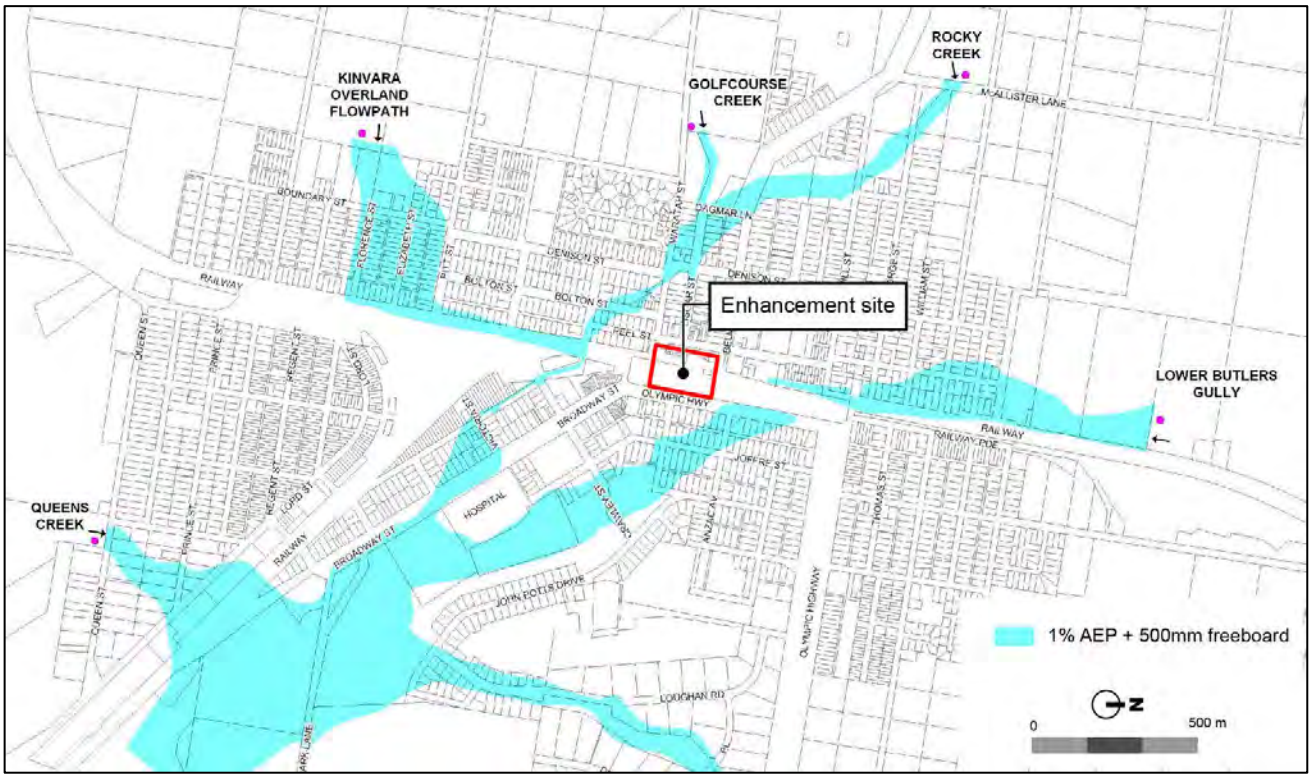
No detailed survey of the existing drainage system was made available. Junee Shire Council's GIS records of the drainage network at Kemp Street bridge are shown in Figure 4.46.

Figure 4.46 Junee Shire Council stormwater drainage network – Kemp Street bridge enhancement site

4.6.4.3 JUNEE STATION PEDESTRIAN BRIDGE

The enhancement site is located approximately 350m south of Rock Creek and 250m north of the Lower Butlers Gully. The Lower Butlers Gully flood study (Lyall & Associates, 2009) has been used to inform the flood and drainage conditions at the site and surrounding areas.

Flood modelling indicates that the enhancement site is not within a flood prone area. Figure 4.47 shows the 1 per cent AEP with a 500mm freeboard flood extent for the areas in the proximity to the enhancement site. Stormwater at the site would therefore be managed via the local drainage network and no known deficiencies in this system have been identified for existing conditions.



Source: The Lower Butlers Gully flood study (Lyall & Associates, 2009)

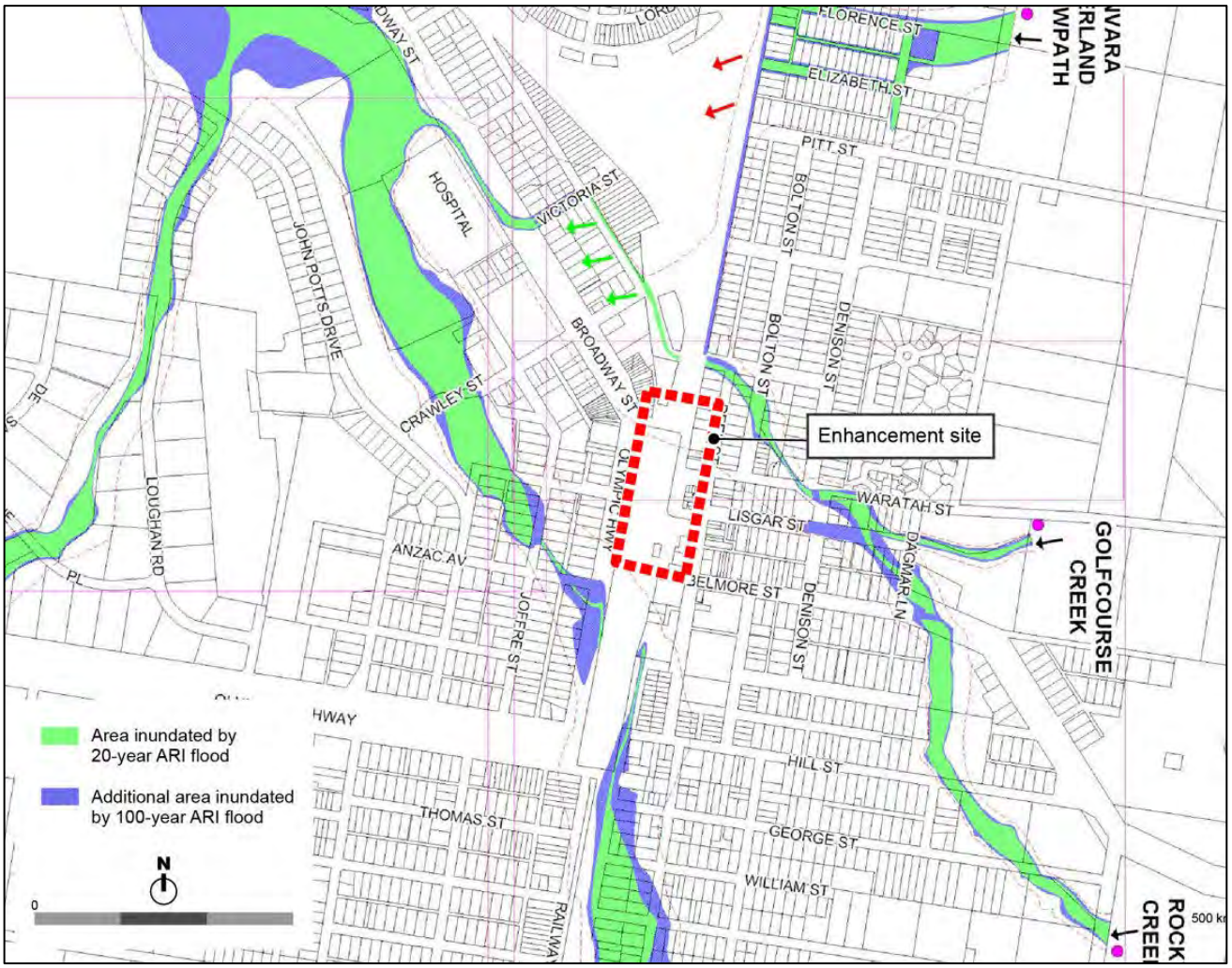
Figure 4.47 1 per cent AEP + 500mm freeboard flood extent near Junee Station pedestrian bridge

4.6.4.4 JUNEE YARD CLEARANCES

Junee Yard clearances enhancement site is crossed by the Lower Butlers Gully, which flows through five box culverts under the rail corridor (refer to Figure 4.48). Lower Butlers Gully proceeds to the north where it joins Rock Creek near Broadway Street.

The Lower Butlers Gully flood study (Lyall & Associates, 2009) shows that there is flood affected land associated with the Lower Butlers Gully surrounding the Junee Yard clearances site (Figure 4.49); however, the enhancement site is not located within flood prone land.

Figure 4.48 Junee Yard clearances – rail box culverts



Source: The Lower Butlers Gully flood study (Lyall & Associates, 2009)

Figure 4.49 Junee Yard clearances – 1% and 5% AEP flood extent

4.6.4.5 OLYMPIC HIGHWAY UNDERBRIDGE

The Olympic Highway underbridge enhancement site is located about 1.2km north of Rock Creek and 1.9km north of Lower Butlers Gully and is not subject to flooding from these two watercourses. At the east of the rail corridor surface water runoff is conveyed along Main Street towards Florence and Elisabeth Street where it joins an overland flow path that connects to Rock Creek on the western side of the rail corridor. The overland flows traverse under the existing rail embankment via three box culverts as show in Figure 4.50.

On the western side of the rail corridor there is an existing stormwater drain that flows from north to south towards Rock Creek. At the Olympic Highway underbridge road drainage at the low point under the bridge joins to this channel to convey stormwater runoff towards Rock Creek and away from the enhancement site.

The Lower Butlers Gully Flood Study (Lyall & Associates, 2009) undertaken for Junee Shire Council has been used to inform the flood conditions at the site and surrounding areas. The flood study indicates there is overland flooding adjacent to the rail corridor along Main Street. Overland flooding occurs in the 1 per cent and 5 per cent AEP flood events as shown in Figure 4.51. The study has been prepared in accordance with ARR87 and the NSW Floodplain Development Manual (NSW 2005) and included 20 per cent, 5 per cent and 1 per cent AEP flood events.

The enhancement site is not located within an area affected by river flooding and a review of the flood data available shows that the site is not affected by overland flooding up to and including the 1 per cent AEP flood event.

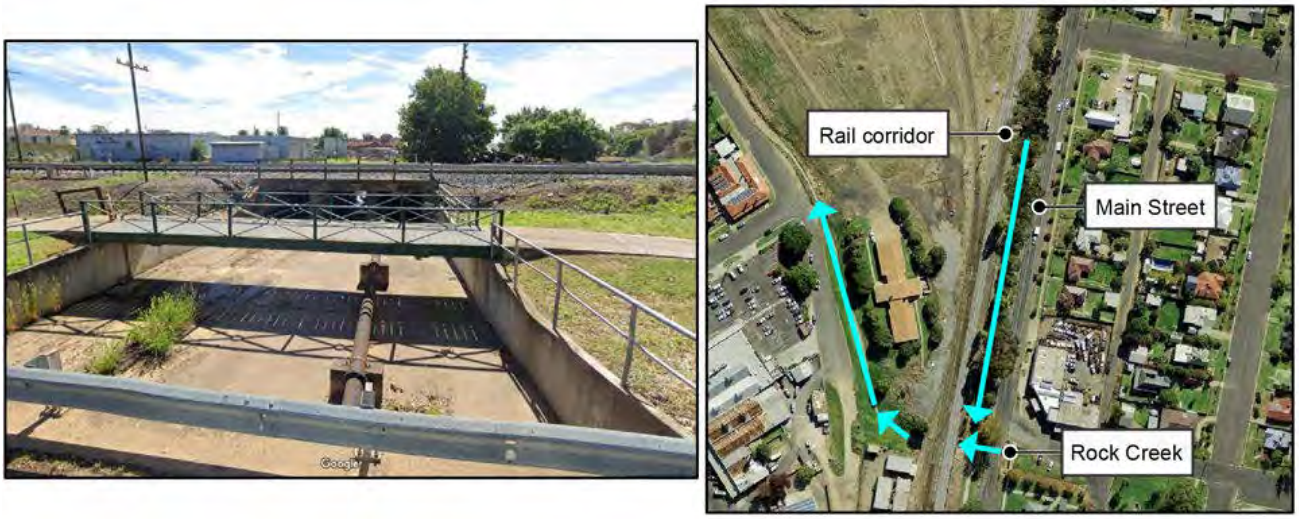
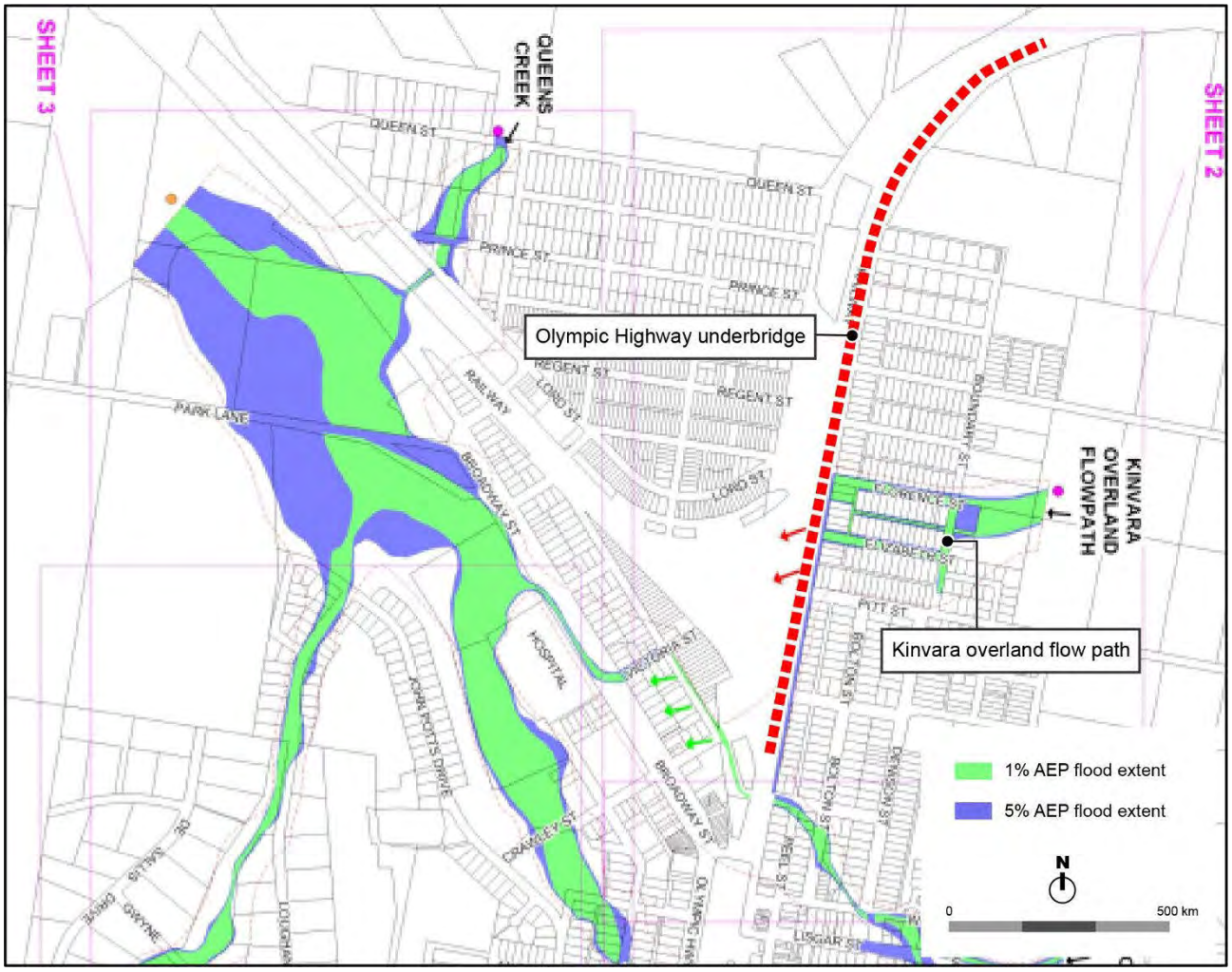


Figure 4.50 Rock Creek and overland flow direction at Olympic Highway underbridge



Source: The Lower Butlers Gully flood study (Lyall & Associates, 2009)

Figure 4.51 1 per cent AEP and 5 per cent AEP flood extent for the Olympic Highway underbridge enhancement site

4.6.4.6 JUNEE TO ILLABO CLEARANCES

The Junee to Illabo clearances enhancement site has a total length of about 10km. The enhancement site is located within the Murrumbidgee catchment but is not subject to regional flooding.

Minor and local waterways intersect the enhancement works. Thirteen minor watercourse crossings have been identified for this section of the proposal. All locations are subject to local overland flows with the existing rail corridor. The adjacent Olympic Highway is the dominant hydraulic control, such that surface flows are directed to these culverts and bridges via surface drains and then the culvert or bridge controls the conveyance of flow at each location.

The enhancement site is not within a flood-prone area. Only local overland flow mechanisms are relevant for the enhancement site.

Thirteen hydraulic structures (i.e. culverts and bridges) are along the existing rail alignment within the Junee to Illabo clearances enhancement site. A hydrological assessment using the software package DRAINS in accordance with ARR2019 guidelines was undertaken. The hydrological assessment was carried out for the hydraulic structures that are subject to change.

No hydraulic assessment has been undertaken for the hydraulic structures that are maintained in the current status.

Table 4.11 shows the results for the hydraulic structures within the proposal subject to change. These results indicate that overland flows do not overtop the rail up to and including the 1 per cent AEP event.

Table 4.11 Hydraulic structures (i.e. culverts and bridges) and estimated peak flood levels

ASSET ID	ASSET TYPE	ASSET CHAINAGE (m)	UPSTREAM AND DOWNSTREAM TRACK LEVEL (mAHD)	1% AEP FLOOD LEVEL (mAHD)	2% AEP FLOOD LEVEL (mAHD)	TOP OF RAIL IMMUNITY (%AEP)
S00100440 469.370SC	Culvert	469,370	271.58 271.78	270.95	270.89	1
S00100440 469.792SC	Culvert	469,792	277.01 277.17	276.00	275.95	1
S00100440 472.406SC	Culvert	472,406	296.13 296.39	295.53	295.51	1
S00100440 476.988UB	Bridge	476,988	313.41 313.50	312.48	312.30	1

Note: ^ Headwater levels are from the 1d model and represent peak head at peak flow.

4.7 LAND USES

Land uses within the proposal site are predominantly associated with railway uses in most instances. Land uses beyond the proposal site varies across the enhancement sites, and includes rural, residential (low to medium density), commercial and industrial uses with some parklands and open spaces. Highways are also located in the immediate vicinity of most of the enhancement sites. Land zoning at each enhancement site is summarised in Table 4.12. This information informs the assessment because it assists with identifying sensitive land uses and receivers beyond the project boundary. Refer to section 4.11 for more information.

Table 4.12 Land zoning at each enhancement site and surrounds

ENHANCEMENT SITE	LAND ZONING OF THE ENHANCEMENT SITE AND SURROUNDS
Albury Precinct	
Murray River bridge	Special Uses (Infrastructure) (SP2), Recreational Waterway (W2), Rural Landscape (RU2), Medium Density (R2), General Industrial (IN1)
Albury Yard clearances and Riverina Highway bridge	Special Uses (Infrastructure) (SP2), General Residential (R1), Mixed Use (B4), General Industrial (IN1), Public Recreation (RE1)
Billy Hughes bridge	Special Uses (Infrastructure) (SP2), General Industrial (IN1), Environmental Management (E3), B7 (Business Park), Primary Production – small lots (RU5)
Table Top Yard clearances	Special Uses (Infrastructure) (SP2), Primary Production – small lots (RU5)
Greater Hume – Lockhart Precinct	
Culcairn Yard clearances	Special Uses (Infrastructure) (SP2), Village (RU5)
Henty Yard clearances	Special Uses (Infrastructure) (SP2), Village (RU5)
Yerong Creek Yard clearances	Special Uses (Infrastructure) (SP2), Village (RU5)
The Rock Yard clearances	Special Uses (Infrastructure) (SP2), Village (RU5)
Wagga Wagga Precinct	
Uranquinty Yard clearances	Special Uses (Infrastructure) (SP2), Village (RU5), Primary Production (RU1)
Pearson Street bridge	Special Uses (Infrastructure) (SP2), Special Uses (SP1) (Special activities), General Residential (R1), Medium Density (R3), Light Industrial (IN2), Business Development (B5), Private Recreation (RE2)
Cassidy Parade pedestrian bridge	Special Uses (Infrastructure) (SP2), General Residential (R1), Medium Density (R3)
Edmondson Street bridge	Special Uses (Infrastructure) (SP2), General Residential (R1)
Wagga Wagga Station pedestrian bridge	Special Uses (Infrastructure) (SP2), General Residential (R1), Medium Density Residential (R3), General Industrial (IN1), Commercial Core (B3)
Wagga Wagga Yard clearances	Special Uses (Infrastructure) (SP2), General Residential (R1), Medium Density Residential (R3), General Industrial (IN1), Commercial Core (B3), Public Recreation (RE1)
Bomen Yard clearances	Special Uses (Infrastructure) (SP2), General Industrial (IN1)
Junee Precinct	
Harefield Yard clearances	Special Uses (Infrastructure) (SP2), Primary Production (RU1)
Kemp Street bridge	Special Uses (Infrastructure) (SP2), Village (RU5), Public Recreation (RE1)
Junee Station pedestrian bridge	Special Uses (Infrastructure) (SP2), Village (RU5)
Junee Yard clearances	Special Uses (Infrastructure) (SP2), Village (RU5)
Olympic Highway underbridge	Special Uses (Infrastructure) (SP2), Village (RU5), Primary Production (RU1), Large Lot Residential (R5)
Junee to Illabo clearances	Special Uses (Infrastructure) (SP2), Primary Production (RU1), Village (RU5), Public Recreation (RE1)

4.8 WATER QUALITY

A desktop review was carried out to establish the existing water quality condition in the area. As site-specific water quality data was not available, existing water quality data from the broader catchment areas was reviewed to assess the general water quality of the downstream catchments that ultimately receive runoff from the proposal site. The following reports and data were reviewed:

- NSW State of the Environment, 2018 (NSW EPA, 2018)
- NSW Murray And Lower Darling Water Quality Management Plan (NSW DPI, 2019a)
- Murrumbidgee Water Quality Management Plan (NSW DPI, 2019b)
- Real-time Data network (WaterNSW, 2021).

These reports generally use pH, dissolved oxygen (DO), total suspended solids (TSS), total nitrogen (TN), total phosphorus (TP) and salinity as key indicators of water quality.

A summary of water quality information from the sources above is discussed in the following sections.

4.8.1 NSW STATE OF THE ENVIRONMENT, 2018

The NSW State of the Environment, 2018 (NSW EPA, 2018) is a report prepared every three years and reports on the status of key environmental issues facing NSW including river health and water quality. The 2018 State of the Environment reported water quality data against the water quality criteria set out in the Murray Darling Basin Plan 2012. This report showed monitoring sites located nearest the proposal on both the Murray River and the Murrumbidgee River; the exceedance of the water quality criteria for TN and TP was less than 25 per cent for the samples taken. Figure 4.52 shows the monitoring sites across NSW and the exceedance rate at each of the sites for TN and TP.

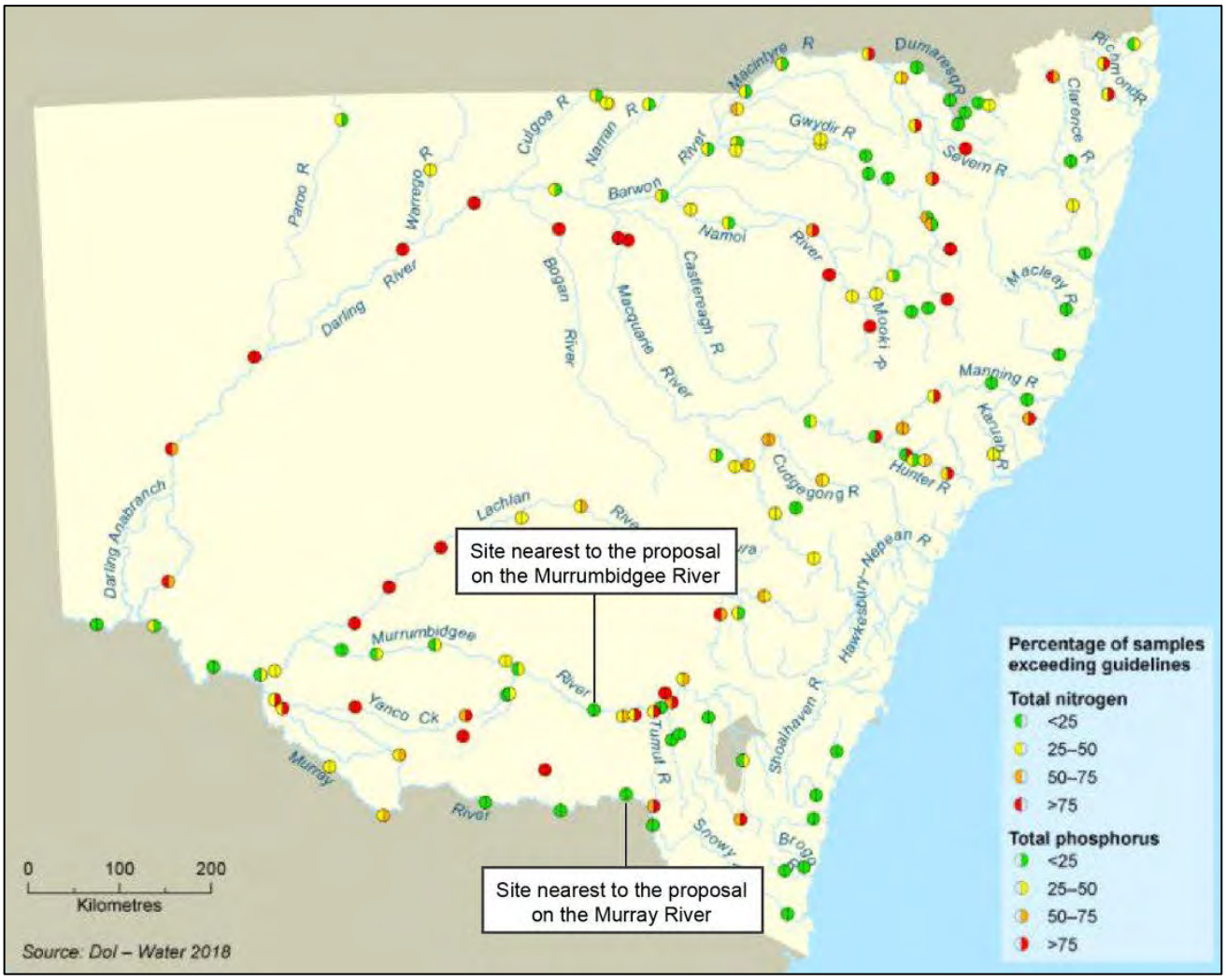


Figure 4.52 Compliance of water quality samples for TP and TN in NSW, State of the Environment 2018

4.8.2 NSW MURRAY AND LOWER DARLING WATER QUALITY MANAGEMENT PLAN, 2019

The NSW Murray and Lower Darling Water Quality Management Plan (NSW DPI, 2019a) noted that the condition of the catchment varies from 'poor' to 'excellent'. The Murray River at Union Bridge monitoring site (site 409001) is located about 900m downstream of the Murray River bridge enhancement site at Wodonga Place. The water quality index (WaQI) at this site was rated as 'Good' as shown in Figure 4.53.

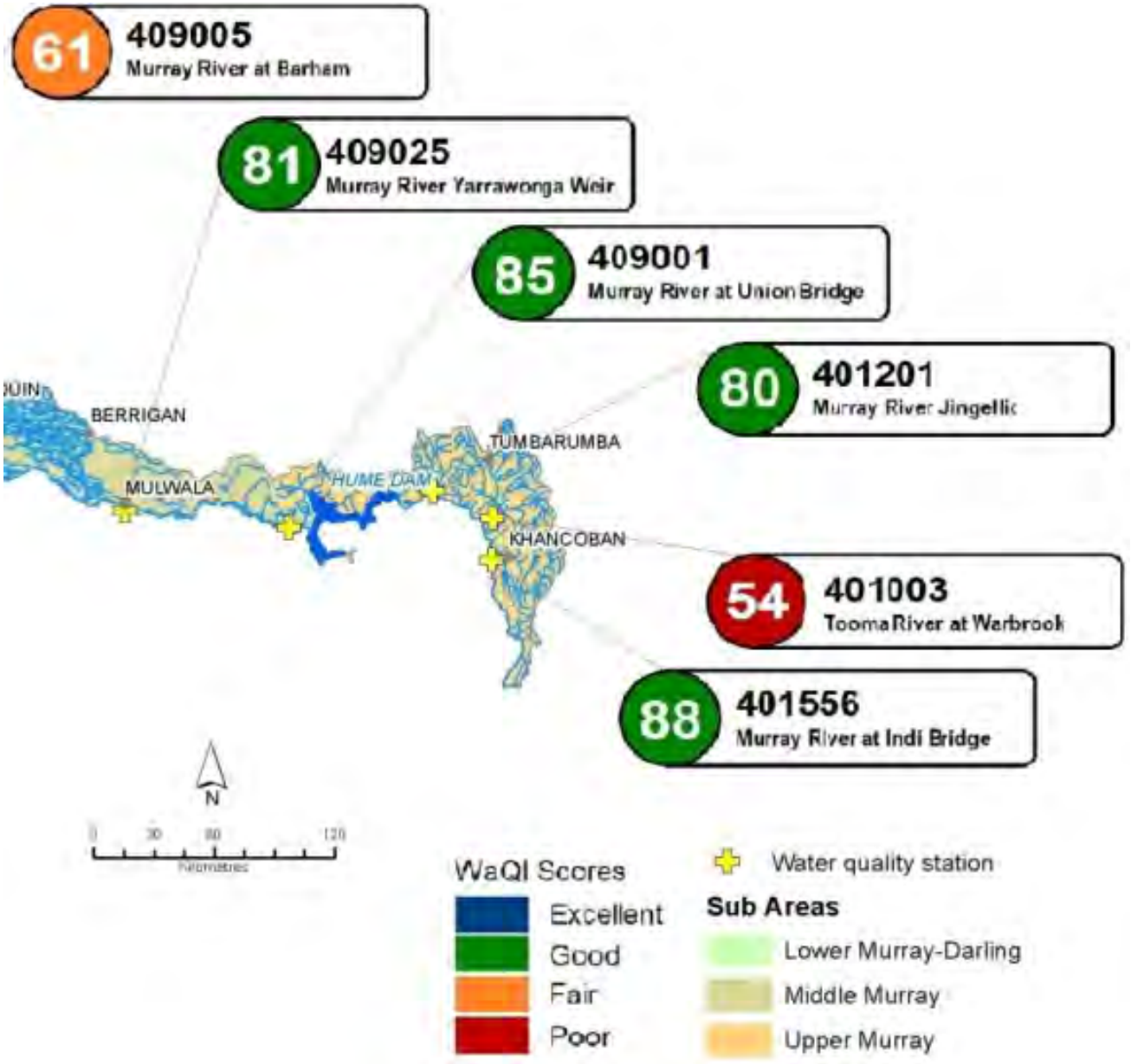


Figure 4.53 Water quality indicator for the Murray River Union Bridge monitoring site (site 409001)

4.8.3 MURRUMBIDGEE WATER QUALITY MANAGEMENT PLAN, 2019

The Murrumbidgee Water Quality Management Plan (NSW DPI, 2019b) noted that the condition of the Murrumbidgee varies from 'poor' to 'excellent'. Water quality was assessed using an integrated indicator of TN, TP, pH, turbidity and DO.

The report noted that water quality attributes in the Murrumbidgee are related to flow condition. High flow from rainfall and runoff resulted in higher turbidity, nutrients and possibly pesticides and pathogens, but lower electrical conductivity (in stream salinity). There is also a general trend towards increasing turbidity concentration with distance down the catchment. This shows the cumulative impacts of land use, soil disturbance and human activity on water quality. In the lower Murrumbidgee the report notes electrical conductivity is generally considered excellent and rarely exceeds targets even during low flows.

The site closest to the proposal is the Murrumbidgee River downstream of Wagga Wagga site (i.e. site 41010395) which rated 'good' as shown in Figure 4.54. The nearest site upstream of the proposal study area is the Tarcutta Creek Old Borambola site (site 410047), which rated 'Fair'. The water quality at these sites was very good in terms of pH levels and generally fair with regard to total nitrogen. At both sites pH and DO measurements were excellent. At the Murrumbidgee River downstream of Wagga Wagga all other parameters were good. At the Tarcutta Creek Old Borambola site the scores for turbidity and TP were fair and good for TN.

The report also commented that in unregulated rivers greater focus should be given to land, soil and vegetation management to prevent sediment and nutrients from entering waterways as sediment is a major transport mechanism for many pollutants.

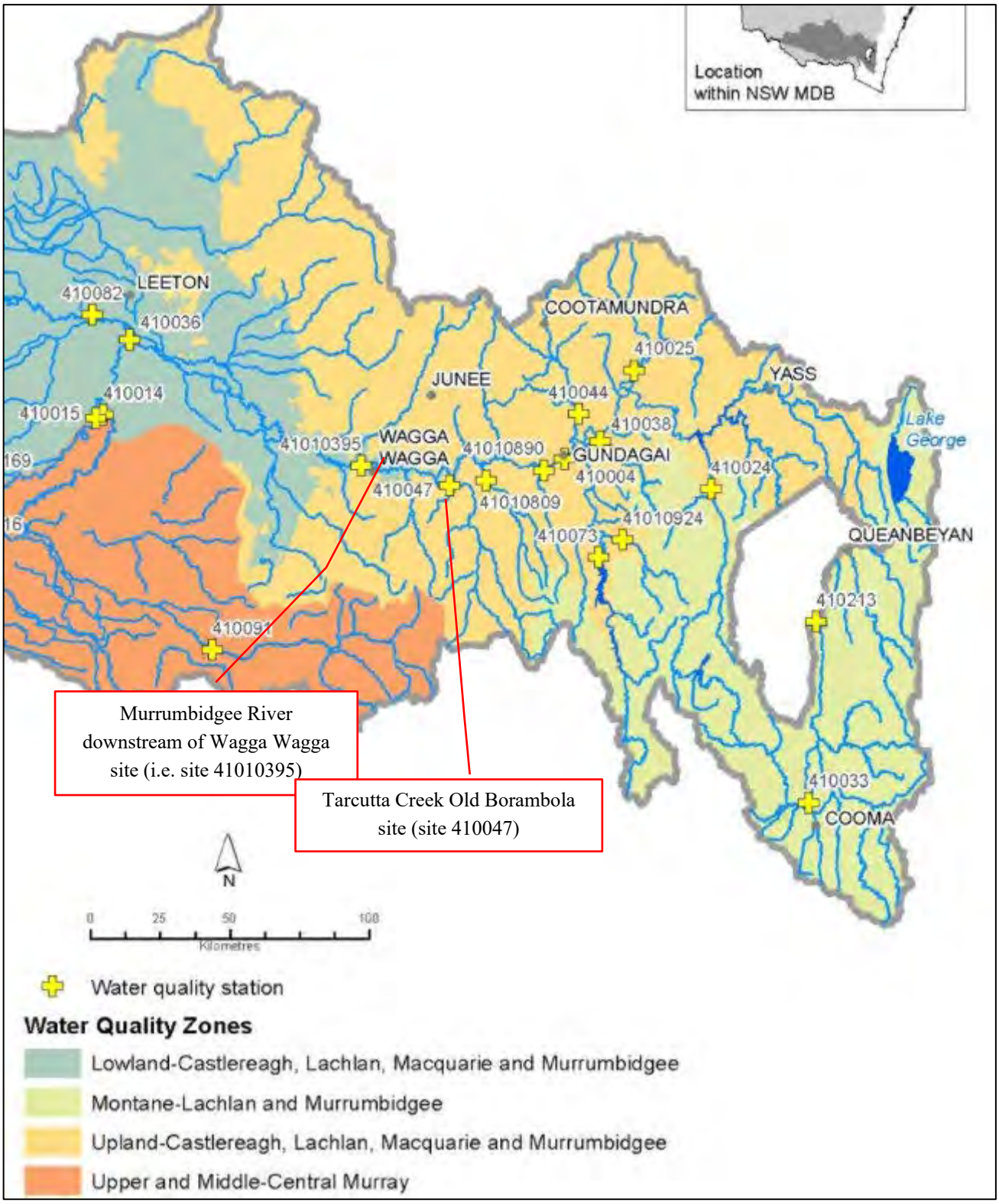


Figure 4.54 Water quality indicators in the Murrumbidgee River catchment from the Murrumbidgee WRP Water Quality Management Plan, 2019

4.8.4 REAL TIME WATER QUALITY DATA FOR THE MURRAY RIVER

The Real-time Data website maintained by WaterNSW provides access to data from monitoring stations on rivers, streams, dams and bores in NSW. Data was extracted for four sites upstream and downstream of the Murray River bridge enhancement site on the Murray River as shown in Table 4.13. Monitoring stations 409001 at Albury (Union Bridge) and 409037 at Howlong are located downstream and sites 409016 downstream of the Hume Dam (Heywoods) and 409017 at Doctors Point are located upstream of the Murray River bridge at Albury.

Table 4.13 shows the minimum, mean and maximum values for pH, DO, EC and turbidity for the available monitoring periods these monitoring sites. Electrical conductivity is the only value that was monitored consistently at all sites. These values were taken on a monthly basis beginning in late 2001 up until 2021. pH and DO values were recorded at site 409001 at Albury Union Bridge and 409016 Downstream of the Hume Dam. The pH and DO values at Albury Union Bridge were recorded between August 2013 and September 2014. pH, DO and turbidity were monitored daily at site 409016 downstream of the Hume Dam from late March 2021 to early June 2021.

Table 4.13 Water quality monitoring data on the Murray River near Albury[1]

		ALBURY (UNION BRIDGE) SITE: 409001	DOWNSTREAM HUME DAM (HEYWOODS) SITE: 409016	DOCTORS POINT SITE: 409017	HOWLONG SITE: 409037
Site ID		409001	409016	409017	
Location		-36.09163611, 146.9071167	-36.09927778, 147.0239833	-36.11256944, 146.9399083	-35.9764, 146.6196
pH Target: 6.5–7.5	Min	7.0	6.8	–	–
	Mean	7.3	6.9	–	–
	Max	7.7	7.1	–	–
EC Target peak (80percentile): 412 µS/cm	Min	21.0	34.1	18.0	31.5
	Mean	55.3	49.5	51.8	64.5
	Max	170.8	78.5	119.6	318.2
DO Target: >7.7 mg/L	Min	6.6	6.5	–	–
	Mean	9.2	8.3	–	–
	Max	11.4	10.4	–	–
Turbidity Target: 15 NTU	Min	–	2.6	–	–
	Mean	–	5.1	–	–
	Max	–	9.3	–	–

Grey denotes the water quality values that exceed target values given under the Murray Darling Basin Plan (refer to section 2.1.5)

The monitoring data shows that the mean EC values at all sites were below the target values given under the Murray Darling Basin Plan (refer to section 2.12.1.5). The mean pH values taken at each site were within the target range under the Murray Darling Basin Plan. While the minimum values for DO were below the targets, the mean DO values at the relevant monitoring sites were both greater than the target DO values for the catchments and therefore satisfied the catchment target. Turbidity data was only available at the Hume Dam (Heywoods) site. The turbidity value for this site was below the target values.

Data was extracted from the Surface Water Monitoring Portal maintained by the Victorian Department of Environment, Land, Water & Planning (2021). Monitoring data at site 402205 Kiewa River at Bandiana (-36.1377051, 146.9541519) near the Murray River was available for a variety of physical and chemical parameters including nutrients and metals for a variety of time frames. This site is located on a tributary to the Murray River about 6km south-east of the Murray River bridge enhancement site and about 12km upstream of the site. A summary of this data is shown in Table 4.14. The monitoring data shows that the mean nutrient values for all parameters achieved the target values given under the Murray Darling Basin Plan (refer to section 2.1).

Table 4.14 Water quality monitoring data on the Kiewa River near the Murray River[1]

PARAMETER	WATER QUALITY TARGET VALUE	MONITORING PERIOD	FREQUENCY	MIN	MEAN	MAX
pH	6.5 – 7.5	01/1990 – 05/2021	Monthly	3.70	6.74	8.60
DO	90–110% or >7.7mg/L	01/1990 – 05/2021	Monthly	5.10	9.16	13.00
Turbidity	15 NTU	01/1990 – 05/2021	Monthly	1.2	10.0	190
Total Nitrogen	500µg/L	10/2018 – 05/2021	Monthly	160	260	380
Total Phosphorus	340µg/L	08/1990 – 05/2021	Monthly	10	40	82

Grey denotes the water quality values that exceed target values given under the Murray Darling Basin Plan (refer to section 2.1.5)

4.8.5 WATER QUALITY DATA ON THE MURRUMBIDGEE RIVER

Data from four sites near Wagga Wagga on the Murrumbidgee River, Tarcutta and Billabong Creek were also extracted from the Real-time Data website (WaterNSW, 2021) as shown in Table 4.15. Monitoring stations 410001 at Wagga Wagga on the Murrumbidgee, 410017 at Old Borambola on Tarcutta Creek and 410048 at Ladysmith at Kyeamba Creek are located upstream of the proposal at Wagga Wagga. Site 410186 at Billabong Creek downstream of Ten Mile & Mountain Creeks is located upstream of the proposal at Culcairn.

Table 4.15 shows the minimum, mean and maximum values for EC and turbidity for the available monitoring periods at these monitoring sites. Electrical conductivity is the only value that was monitored consistently at all sites. These values were taken on a monthly basis beginning in May 1993 (site 410001), December 2000 (site 410048) and February 2002 (site 410047) up until 2021. It is noted that data sets were not complete for the time periods monitored. Turbidity was monitored intermittently at site 410001 at Wagga Wagga on the Murrumbidgee between June 1993 and February 2012. 12 samples of turbidity were available from site 410048 at Ladysmith at Kyeamba Creek between December 2004 and June 2010.

The monitoring data shows that the mean EC values on the Murrumbidgee and at Tarcutta Creek were below or close to the target values given under the Murray Darling Basin Plan (refer to section 2.1.5). The mean EC values at Kyeamba Creek and Billabong Creek were both two to three times the target EC values. Turbidity data was only available at the Murrumbidgee River site and Kyeamba Creek site. The mean turbidity values for these sites were above the target values but represent smaller average exceedances than exceedances recorded in EC values.

Table 4.15 Water quality monitoring data on the Murrumbidgee River near Wagga Wagga[1]

		MURRUMBIDGEE RIVER AT WAGGA WAGGA SITE: 410001	TARCUTTA CREEK AT OLD BORAMBOLA SITE: 410047	KYEAMBA CREEK AT LADYSMITH SITE: 410048	BILLABONG CREEK DOWNSTREAM TEN MILE & MOUNTAIN CREEKS SITE: 410186
Location		-35.10080647, 147.36759317	-35.1623, 147.6555	-35.19559444, 147.510544	-35.6855, 147.185
EC Target peak (80%ile): 258µS/cm	Min	30.0	35.9	20.8	2
	Mean	142.0	266.8	733.7	856.0
	Max	309.4	727.4	2109.2	2185.1
Turbidity Target: 35-50 NTU	Min	3.7	–	-1	–
	Mean	71.6	–	54.6	–
	Max	316.6	–	131.4	–

Grey denotes the water quality values that exceed target values given under the Murray Darling Basin Plan (refer to section 2.1.5)

4.8.6 SUMMARY OF WATER QUALITY DATA IN THE AREA

The existing water quality is varied across the study area. Water quality targets for turbidity and EC were generally achieved, particularly on larger waterways such as the Murrumbidgee and Murray rivers. Monitoring data from the Kiewa River site showed that the water quality targets were also achieved for nutrient values.

There is limited water quality data available for watercourses intersected by the proposal. Given the high proportion of land developed for urban and agricultural purposes within the study area, it is likely that runoff from these areas contributes to degradation of water quality, and some watercourses near the proposal would not achieve the water quality criteria as laid out in the ANZG 2018 and Murray Darling Basin Plan 2012, particularly for nutrients. The sources of the high nutrient levels are likely to be diffuse and related to current and historical agricultural activities within the study area.

4.9 SURFACE WATER SUPPLY

For the land surrounding most of the proposal site, surface water supply predominantly comes from rainfall collected via rainwater tanks, farm dams and from the reticulated water network. Goldenfields Water operate the reticulated network for Junee Shire and Temora local Government areas. The sources of water include bores and reservoirs and the network covers 11,000 properties. (Goldenfields, accessed 9/2/2021 1:57 PM). Riverina Water operate the reticulated water supply network for Wagga Wagga, Lockhart and Greater Hume Shire Councils from groundwater bores and the Murrumbidgee River. Albury City Council are responsible for supplying potable water for the Albury LGA, which is sourced from the Murray River and treated for distribution.

Water supply to all the enhancement sites is therefore covered by reticulated networks.

The Murray River bridge enhancement site is located on a major regulated river which provides water supply to numerous towns, settlements and agricultural activities. With the exception of the Murray River, the proposal site is located within the catchments of ephemeral or perennial watercourses in urban or rural residential areas with no licensed surface water extractions from the watercourses or environmental flow requirements in the vicinity of the proposal site.

4.10 ENVIRONMENTAL VALUES

The NSW Water Quality and River Flow Objectives (NSW Department of Environment, Climate Change and Water, 2006) provide a number of environmental values for the Murray and Murrumbidgee catchments. 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 (ANZECC/ARMCANZ, 2000). The applicable water quality objectives and relevant trigger values are provided in more detail in Appendix A.

The Basin Plan also sets out water quality objectives for the Murray and Murrumbidgee catchments, as discussed in section 2.1.

Table 4.16 Environmental values (NSW Department of Environment, Climate Change and Water, 2006)

ENVIRONMENTAL VALUE	MURRAY, MURRUMBIDGEE RIVER AND LAKE GEORGE CATCHMENTS			
	Murray River[1]	Waterways affected by urban development[2]	Uncontrolled streams	Major regulated rivers (Murrumbidgee)
Aquatic ecosystems	X	X	X	X
Visual amenity		X	X	X
Primary contact recreation	X	X	X	X
Secondary contact recreation	X	X	X	X
Livestock water supply			X	X
Irrigation water supply	X		X	X
Homestead water supply			X	X
Drinking Water – disinfection only			X	X
Drinking water – clarification and disinfection			X	X
Drinking water – groundwater			X	
Aquatic foods (cooked)			X	

(1) These are draft provisional water quality objectives set by the Murray Darling Basin Ministerial Council in August 2002 for the section of the Murray River between the Hume Dam and Yarraonga Weir.

(2) Applies to Albury and Wagga Wagga

4.11 SENSITIVE RECEIVING ENVIRONMENTS

A sensitive receiving environment has a high conservation or community value, or supports ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality. In turn, understanding the location and value of these sites informs mitigation and management measures for the proposal.

The watercourses listed in Table 4.17 have been identified as sensitive receiving environments. Watercourses identified as key fish habitat has been informed by mapping by DPI and by field survey completed to inform Technical Paper 9 – Aquatic biodiversity.

As identified in Technical Paper 8 – Biodiversity development assessment report and Technical Paper 9 – Aquatic biodiversity, there are no nationally important wetlands were identified within 10km of the proposal site. No Ramsar wetlands or Wetlands of International Importance are located within 100km of the proposal site.

The study area lies within the Lowland Murray River aquatic ecological community. This ecological community is listed as an endangered ecological community in NSW under the FM act. This applies to all native fish and aquatic invertebrates within all natural creeks, rivers and associated waterbodies within the study area.

The Doodle Comer Swamp is located downstream of Buckaringah Creek, within 250m of the Henty Yard clearances enhancement site. This wetland is listed in the Directory of Important Wetlands (Department of Agriculture, Water and the Environment). The wetland is a shallow basin that receives seasonal inflow from winter rains.

Table 4.17 Sensitive receiving environments

SITE	ENHANCEMENT SITE	REASONS FOR CLASSIFICATION
Albury precinct		
Murray River	Within Murray River bridge	Key Fish Habitat Potential for threatened species
Oddies Creek	Within Murray River bridge	Key fish habitat
Greater Hume – Lockhart precinct		
Buckargingah Creek, Henty	In proximity to Henty Yard clearances	Key Fish Habitat Potential for threatened species Doodle Comer Swamp within 250 metres
Yerong Creek	In proximity to Yerong Creek Yard clearances	Key Fish Habitat
Sandy Creek (Yerong Creek)	In proximity to Yerong Creek Yard clearances	Key Fish Habitat
Wagga Wagga precinct		
Sandy Creek	Within Uranquinty Yard clearances	Key Fish Habitat Potential for threatened species
Junee		
Jeralgambeth Creek	Within Junee to Illabo clearances	Key Fish Habitat

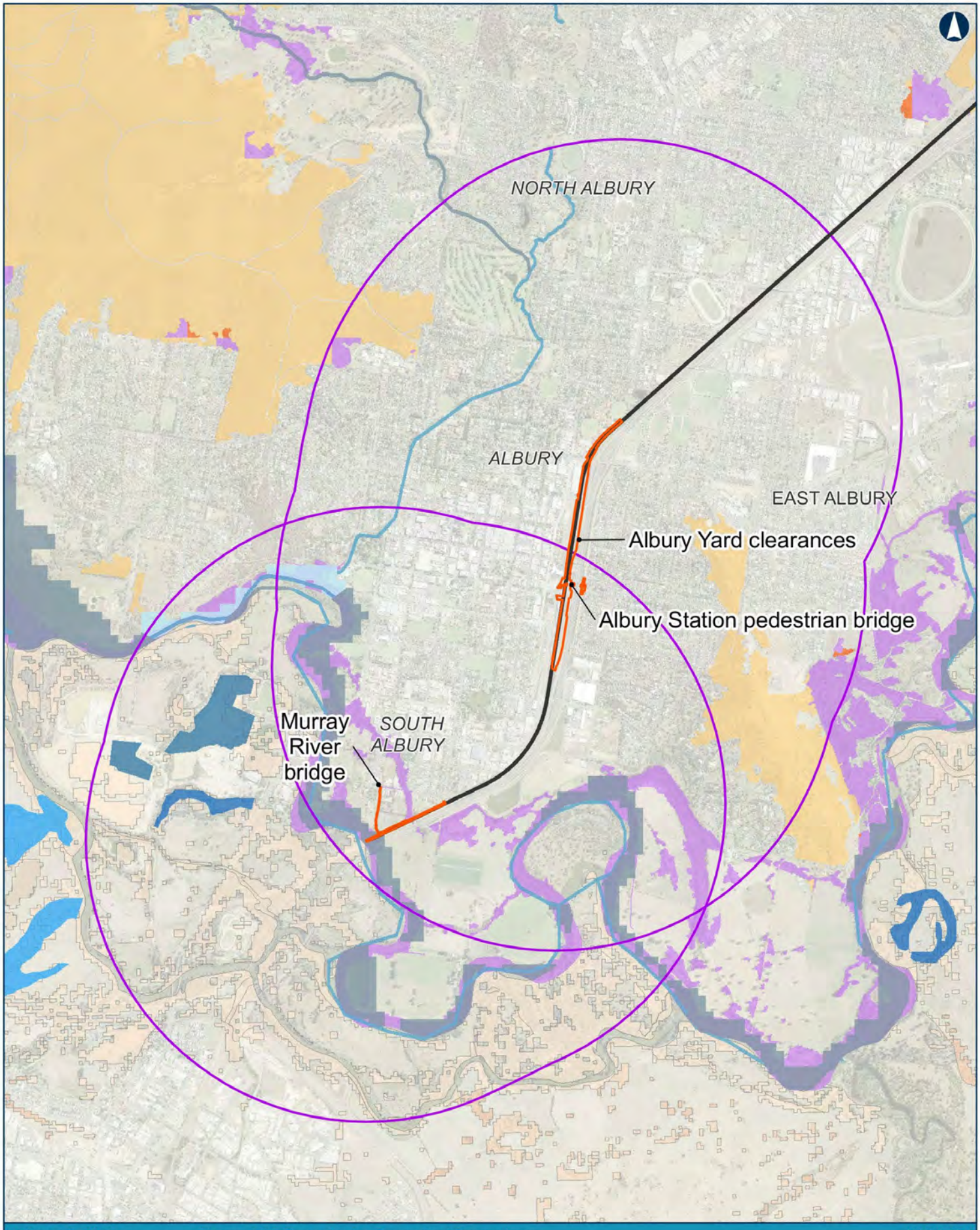
4.12 GROUNDWATER DEPENDENT ECOSYSTEMS

Groundwater dependent ecosystems (GDEs) rely on a supply of groundwater to support the species composition, structure and function of the ecosystem. GDEs are classified as aquatic (dependent on the surface expression of groundwater) or terrestrial (dependent on the subsurface presence of groundwater).

A review of the Groundwater Dependent Ecosystem Atlas (Bureau of Meteorology, 2021) identified the following potential GDEs within the proposal site:

- Murray River (Murray River bridge enhancement site) – moderate aquatic GDE potential
- Sandy Creek (Uranquinty Yard clearances enhancement site) – high aquatic GDE potential
- Jeralgambeth Creek (Junee to Illabo clearances enhancement site) – high aquatic GDE potential.

A number of GDEs are located within the broader study area for the groundwater impact assessment, and are shown in Figure 4.55 below. Further detail is available in Technical Paper 12 – Groundwater.



Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 1 OF 8

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3

Author: WSP Scale: 1:25,000

Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Surface water study area

Murray Aquatic GDE

- High potential terrestrial GDE
- High potential GDE - from national assessment
- Moderate potential terrestrial GDE
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment
- Unclassified potential GDE - from regional studies

Murray GDE

- High potential terrestrial GDE
- High potential GDE - from national assessment
- Moderate potential terrestrial GDE
- Moderate potential GDE - from national assessment
- Low potential terrestrial GDE
- Low potential GDE - from national assessment

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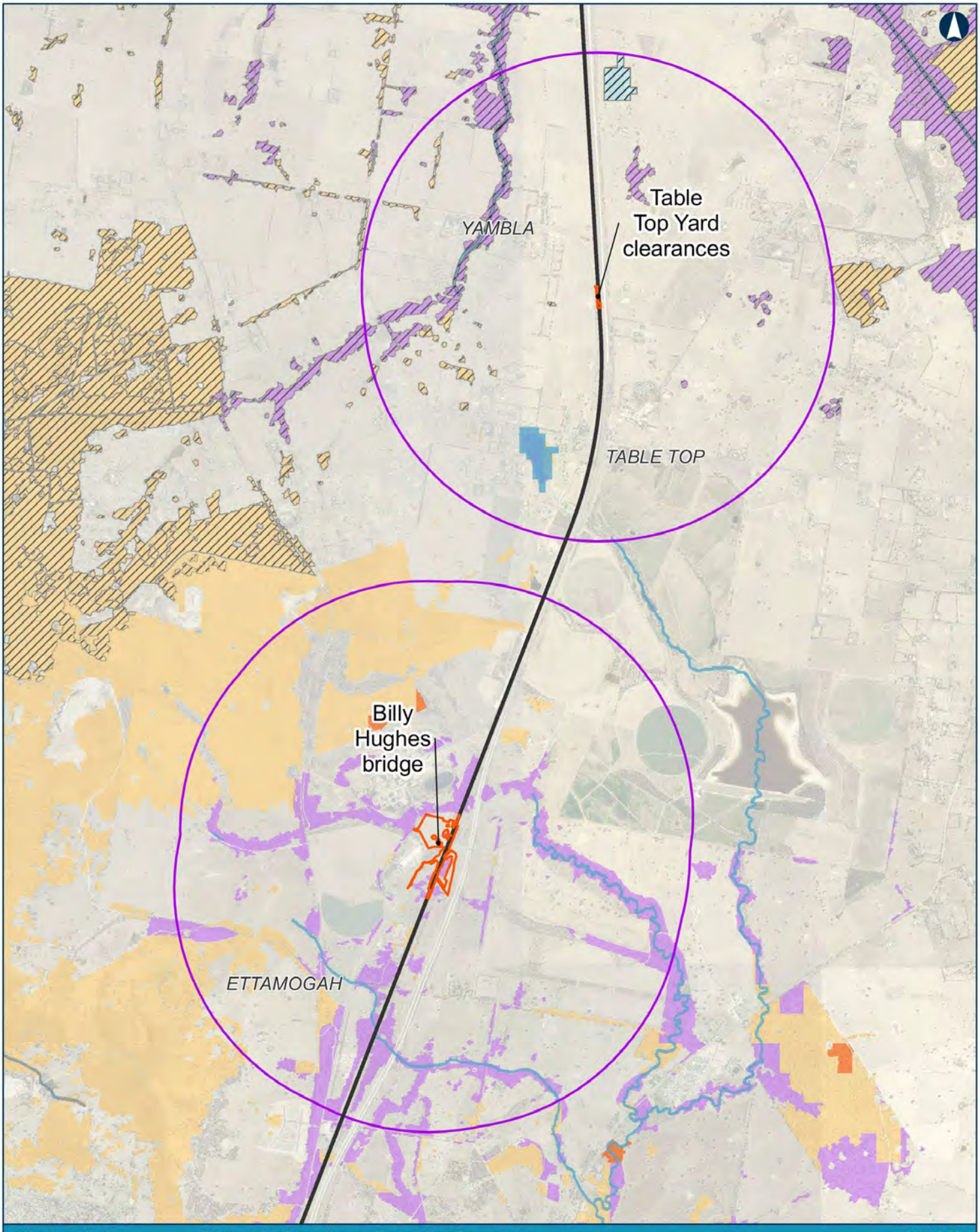

Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 2 OF 8

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP
Paper: A3
Scale: 1:30,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Surface water study area

Murray Aquatic GDE
- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment

Upper Murray Aquatic GDE
- High potential GDE - from national assessment
- Low potential GDE - from national assessment

Murray GDE
- High potential terrestrial GDE
- Moderate potential terrestrial GDE
- Low potential terrestrial GDE

Upper Murray GDE
- High potential terrestrial GDE
- Low potential terrestrial GDE

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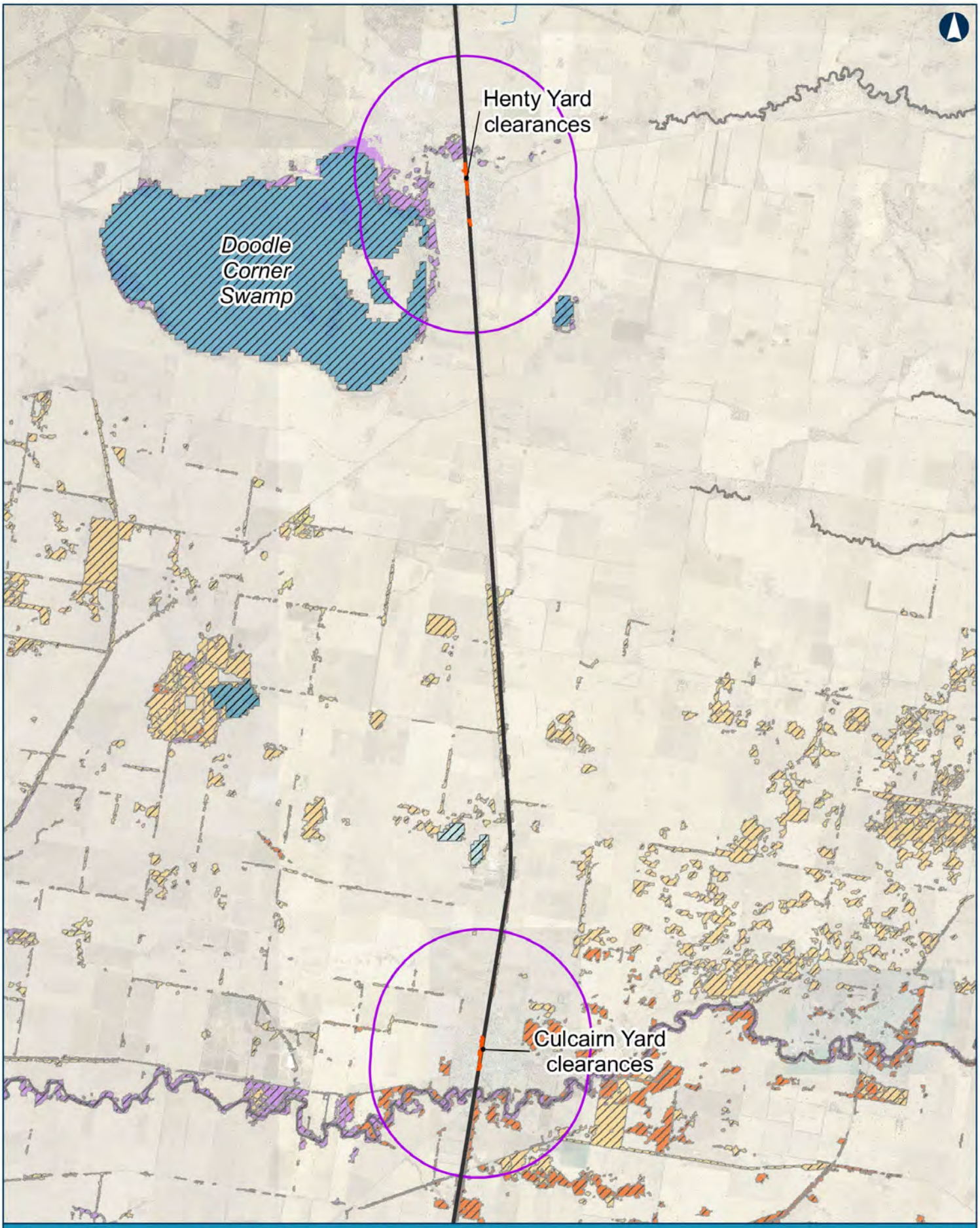

Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 3 OF 8

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:65,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Surface water study area

Murrumbidgee Aquatic GDE
- High potential GDE - from national assessment

Billabong-Yanco Aquatic GDE
- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment

Murrumbidgee GDE
- High potential terrestrial GDE

Billabong-Yanco GDE
- High potential terrestrial GDE
- Moderate potential terrestrial GDE
- Low potential terrestrial GDE

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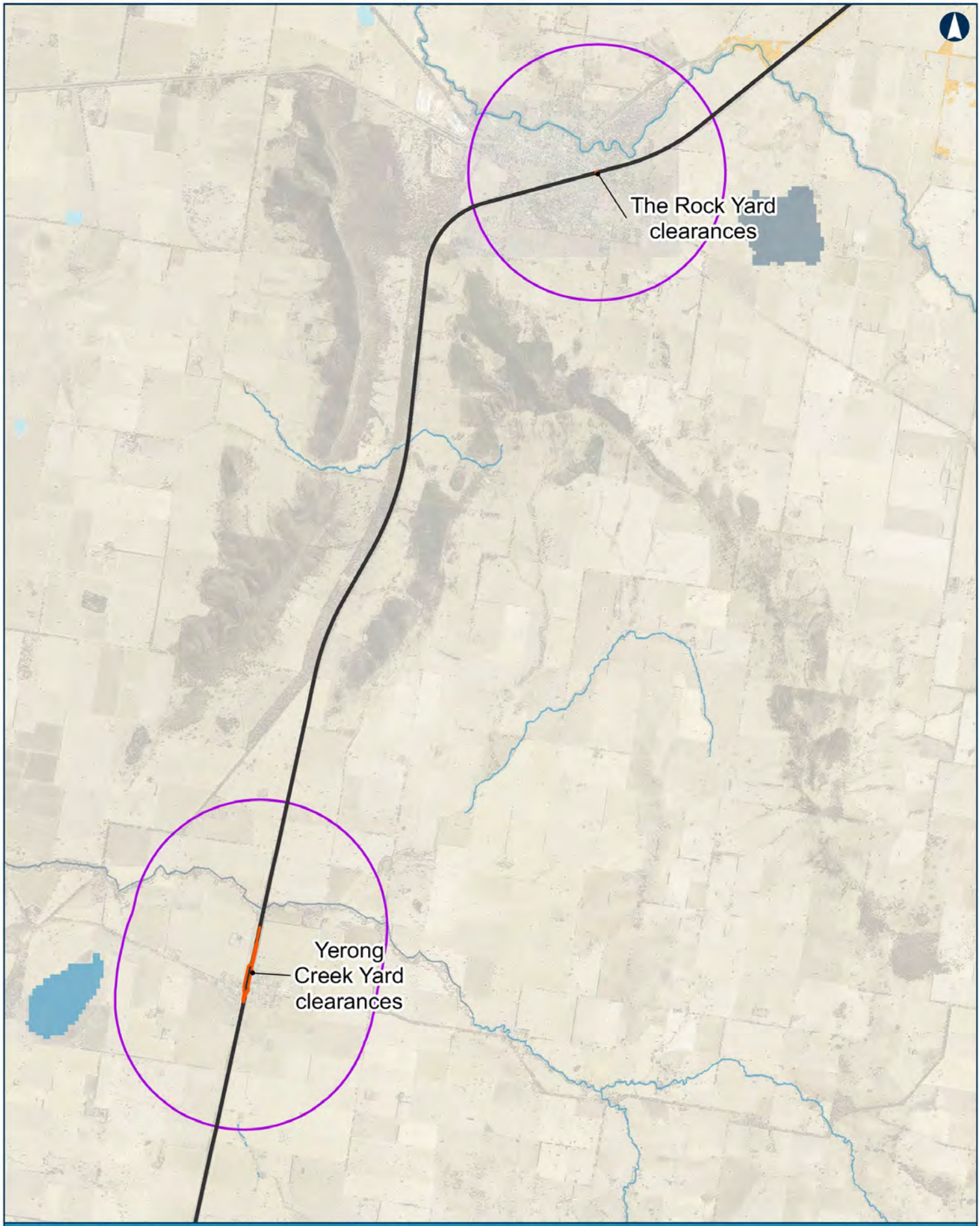

Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 4 OF 8

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:55,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Surface water study area

Murrumbidgee Aquatic GDE

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment

Murrumbidgee GDE

- Low potential terrestrial GDE

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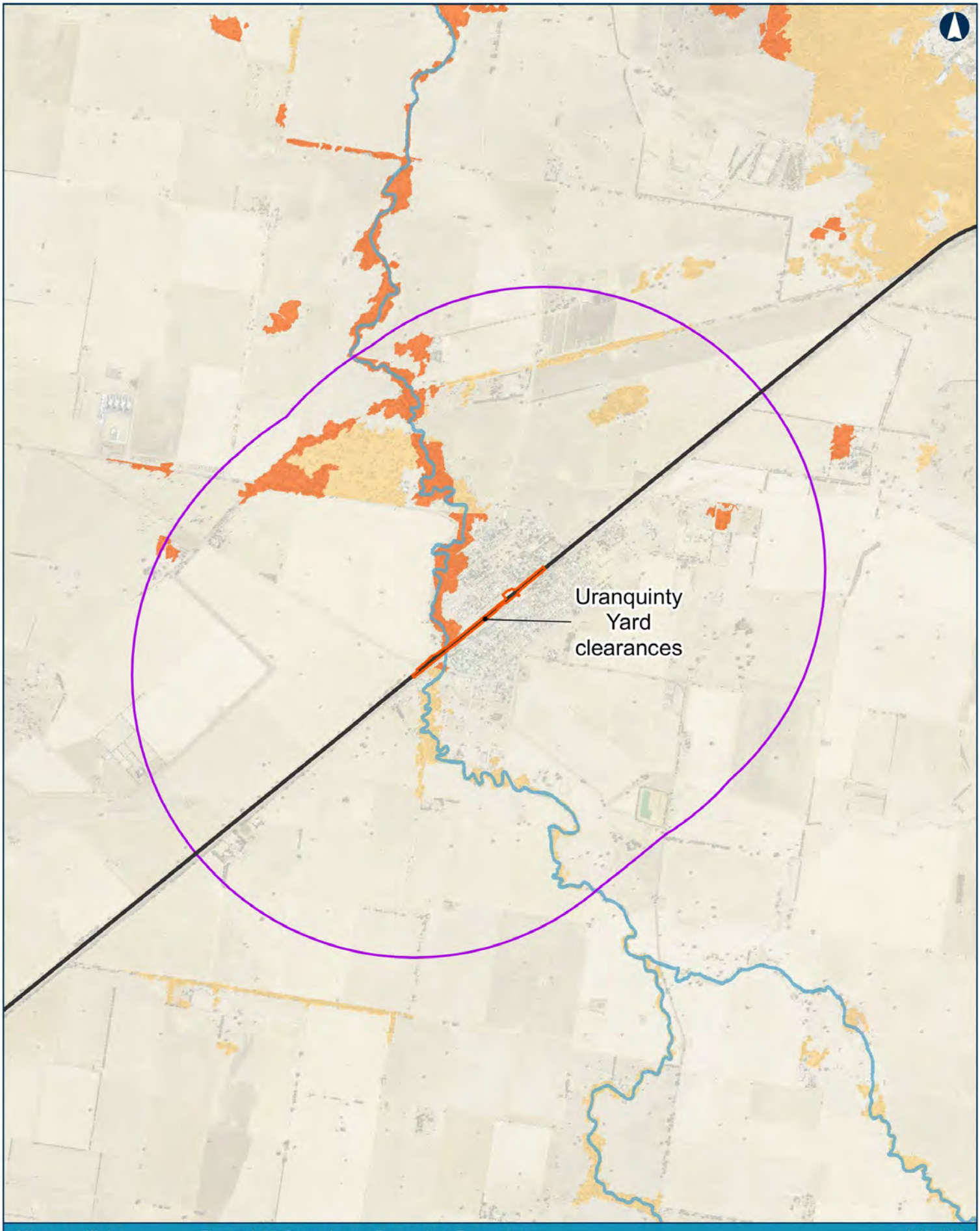


Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 5 OF 8

0 0.5 1 km

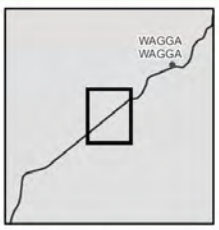
Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:25,000
Data Sources: ARTC, NSWSS

Proposal site
Existing railway
Surface water study area

Murrumbidgee Aquatic GDE
High potential GDE - from national assessment

Murrumbidgee GDE
Moderate potential terrestrial GDE
Low potential terrestrial GDE



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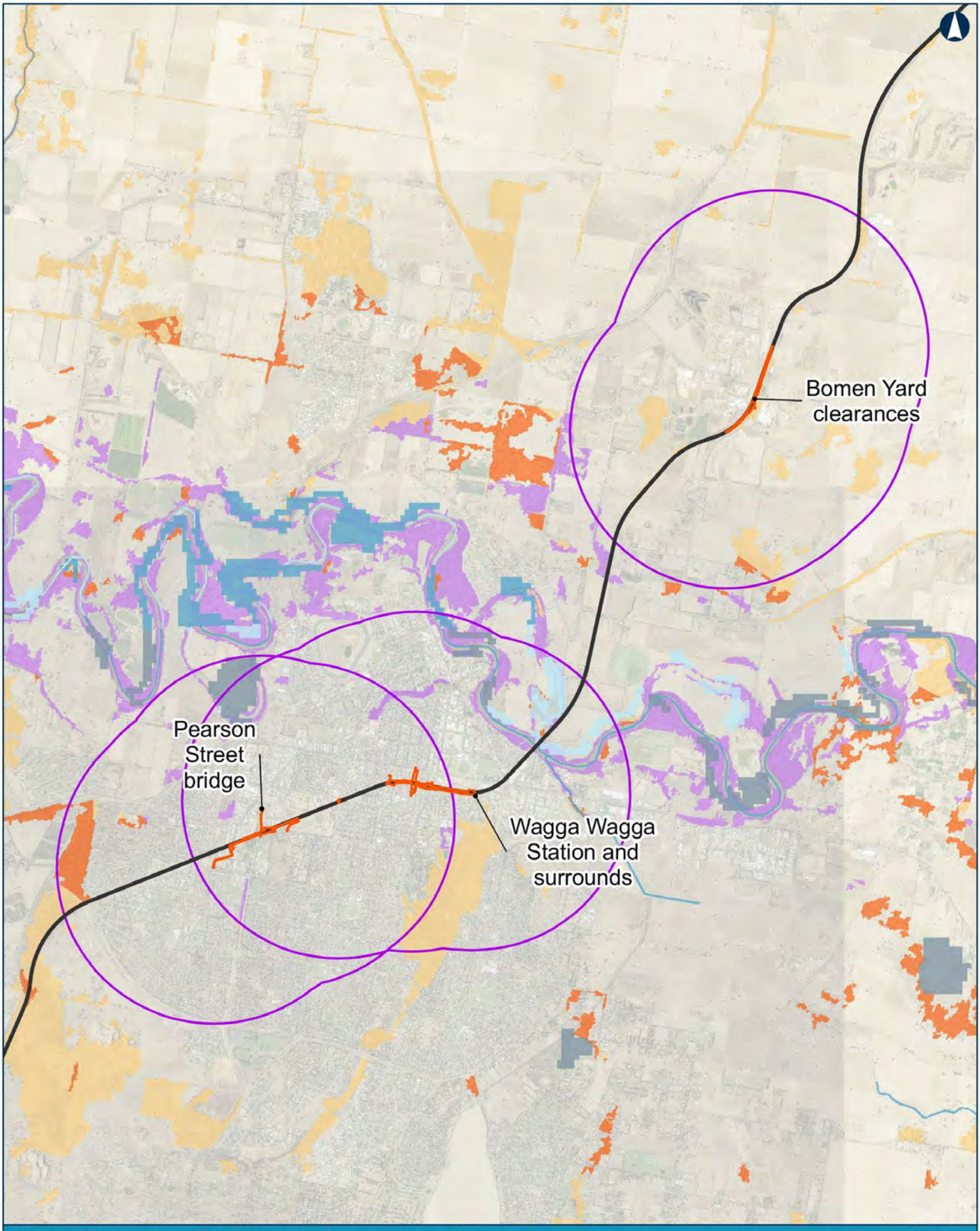

Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 6 OF 8

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022
Author: WSP
Data Sources: ARTC, NSWSS

Paper: A3
Scale: 1:45,000

- Proposal site
- Existing railway
- Surface water study area

Murrumbidgee Aquatic GDE

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment

Murrumbidgee GDE

- High potential terrestrial GDE
- Moderate potential terrestrial GDE
- Low potential terrestrial GDE

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Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 7 OF 8

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3
Author: WSP Scale: 1:25,000
Data Sources: ARTC, NSWSS

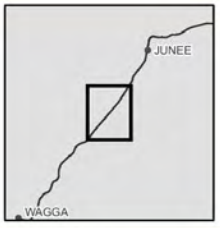
- Proposal site
- Existing railway
- Surface water study area

Murrumbidgee Aquatic GDE

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment

Murrumbidgee GDE

- Moderate potential terrestrial GDE
- Low potential terrestrial GDE



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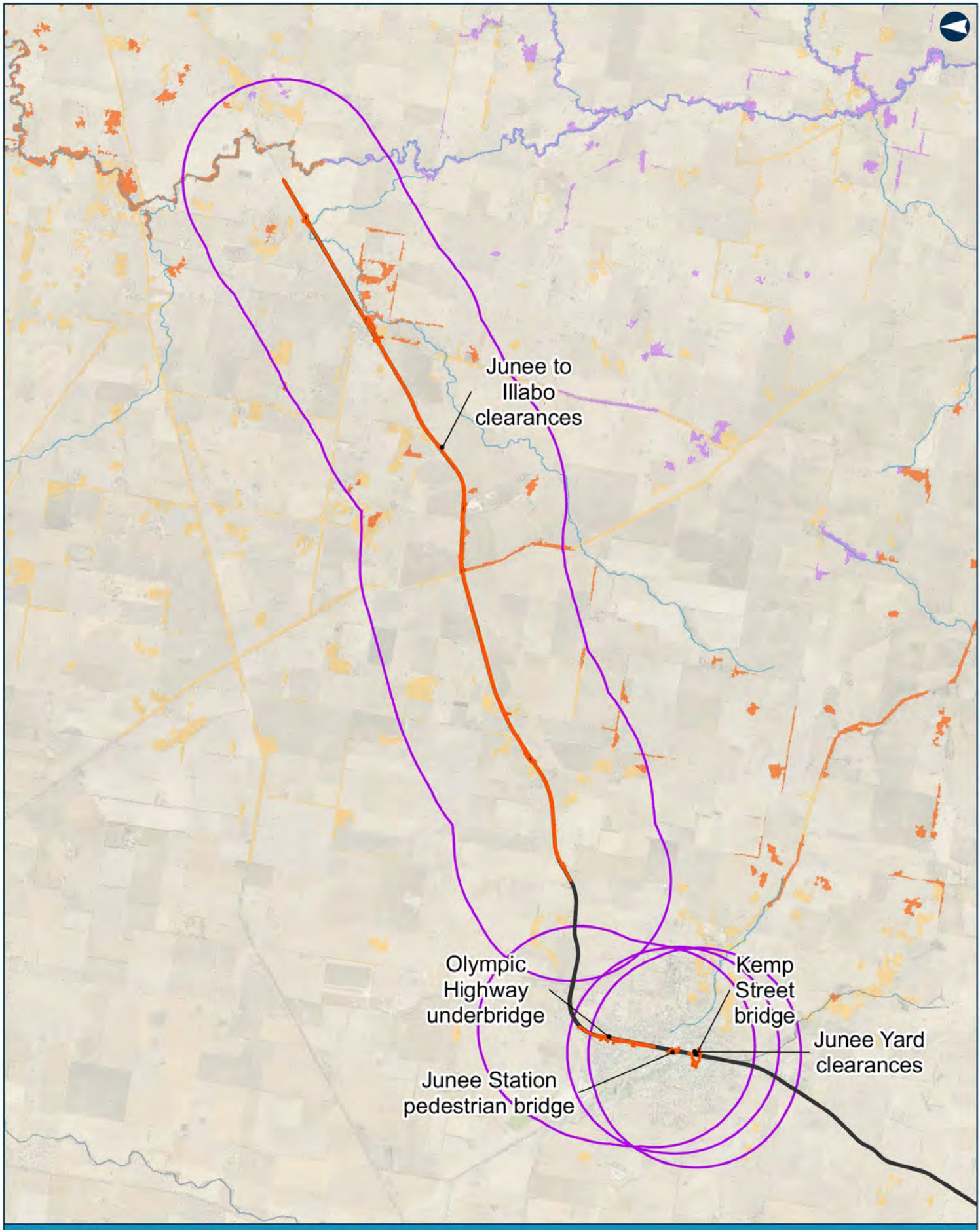

Albury to Illabo

Figure 4.55 Groundwater Dependent Ecosystems

MAP 8 OF 8

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/05/2022 Paper: A3

Author: WSP Scale: 1:70,000

Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Surface water study area

Murrumbidgee Aquatic GDE

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment

Murrumbidgee GDE

- High potential terrestrial GDE
- Moderate potential terrestrial GDE
- Low potential terrestrial GDE

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5 IMPACT ASSESSMENT

5.1 FLOODING

5.1.1 CONSTRUCTION

Construction activities associated with the proposal may temporarily impact flooding behaviour during construction due to features obstructing and redirecting flood flows, resulting in increases in flood depths and flow velocities. Key activities, where they occur in flood-prone areas, that may have an impact on flooding include:

- earthworks for modified or new rail formations
- earthworks and concrete works for installation of new/modified drainage structures
- laydown and staging areas
- stockpile locations; and
- earthworks and structures for construction compounds, site offices and access tracks.

For any of these construction activities located in a flood prone land, potential impacts due to flooding include:

- temporary blockage of flow paths due to stockpiling, location of construction works or equipment and fencing, which may cause changes to flood level, duration or velocities upstream and downstream of the construction impacted areas
- inundation and damage to construction sites, machinery, plant and equipment
- increased flow rates in receiving drainage lines, downstream of the construction footprint due to vegetation clearing and increased hardstand areas; and
- changes to flow paths downstream of the construction footprint due construction of culverts, civil works required for rail embankments, permanent and temporary roads, which may cause damage due to changes in scour and bank erosion.

Required earthworks, stockpiles and site infrastructure may cause the temporary redistribution of overland flows as it could redistribute and redirect stormwaters, and subsequently impact other land and infrastructure. The construction planning during detailed design would consider how these temporary changes would be managed to prevent impacts occurring.

The likelihood and magnitude of risks would vary depending on the stage of construction and timing of high rainfall events in relation to the stage of constructions activities. Given construction of the proposal would be short term and the proposal site represents a small area in the total catchment, the impacts on drainage and flooding are likely to be temporary, localised and minor.

For enhancement sites located outside flood-prone land, the risk of impacts is still present from drainage lines and overland flow. Flood mitigation measures at these sites are provided in Chapter 7 and effective implementation of these measures would minimise or avoid temporary impacts.

Table 5.1 summarises the flooding affectation of each site and any specific flood impact considerations relevant to construction of the proposal.

Table 5.1 Potential impacts from flooding during construction

SITE NAME	PROPOSAL SITE LOCATED IN FLOOD PRONE LAND	APPROX. DURATION OF CONSTRUCTION WORK	POTENTIAL CONSTRUCTION IMPACT
Murray River bridge	Yes	12 months	The site is impacted by regional flooding along the Murray River as shown in section 4.6.1.1. As such, flooding might affect the enhancement site. However, it is anticipated that construction works would be carried out from the bridge deck and there would be no requirement for temporary works in the river or floodplain. Furthermore, construction activities would be short term. Thus, impacts to construction activities are expected to be minor.
Albury Yard clearances and Albury Station pedestrian bridge	No	7 months	The enhancement site is not affected by flooding up to and including the 1% AEP flood event (refer to section 4.6.1.2). As such no impacts are anticipated for construction activities. The construction layout would consider local overland flow paths to manage potential impacts from local flooding.
Riverina Highway bridge	Yes	16 months	The enhancement site is affected by overland flooding (refer to section 4.6.1.3). Site infrastructure may cause the temporary redistribution of overland flows as it could redistribute and redirect stormwaters. Construction mitigation would be required to manage potential impacts from flooding at the low point under the Riverina Highway bridge. The construction layout would consider local overland drainage paths.
Billy Hughes bridge	No	16 months	The enhancement is not affected by regional flooding (refer to section 4.6.1.4). Site infrastructure may cause the temporary redistribution of overland flows as it could redistribute and redirect stormwaters. The construction layout would consider local overland drainage paths.
Table Top Yard clearances	No	less than a month	The enhancement is not affected by flooding (refer to section 4.6.1.5). The construction layout would consider local overland drainage paths.
Culcairn Yard clearances	No	3 months	Flood affected land is present on the western side of the rail corridor; however, the enhancement site is not affected by flooding (refer to section 4.6.2.1). Construction mitigation would manage potential impacts from overland drainage paths.

SITE NAME	PROPOSAL SITE LOCATED IN FLOOD PRONE LAND	APPROX. DURATION OF CONSTRUCTION WORK	POTENTIAL CONSTRUCTION IMPACT
Henty Yard clearances	Yes	3 months	The enhancement site is not affected by flooding up to the 1 per cent flood event (refer to section 4.6.2.2). Site infrastructure may cause the temporary redistribution of overland flows. Construction mitigation would manage potential impacts from overland drainage paths.
Yerong Creek Yard clearances	No	3 months	The enhancement site is not affected by regional flooding (refer to section 4.6.2.3). Site infrastructure may cause the temporary redistribution of overland flows. The construction layout would consider local overland drainage paths.
The Rock Yard clearances	Yes	1 month	The enhancement site is affected by overland flooding (refer to section 4.6.2.4). Site infrastructure may cause the temporary redistribution of overland flows. The construction layout would consider local overland drainage paths. Construction mitigation would be required to manage potential impacts from overland drainage paths
Uranquinty Yard clearances	Yes	2 months	The enhancement site is affected by overland flooding (refer to section 4.6.3.1). Construction stockpiles, materials and temporary creek crossing located in this area may be impacted by flooding and have affects to the flow distribution of flood waters. The construction layout would consider local overland drainage paths.
Pearson Street bridge	Yes	16 months	The enhancement site is not affected by regional flooding (refer to section 4.6.3.2). Overland flooding affects the enhancement site. Construction stockpiles, materials and laydown located in this area may be impacted by flooding and affects to the flow distribution of flood waters. The construction layout would require consideration of local flooding behaviour, including temporary crossing of the Glenfield Drain. Construction mitigation would be required to manage potential impacts from flooding.

SITE NAME	PROPOSAL SITE LOCATED IN FLOOD PRONE LAND	APPROX. DURATION OF CONSTRUCTION WORK	POTENTIAL CONSTRUCTION IMPACT
Cassidy Parade pedestrian bridge, Edmondson Street bridge, Wagga Wagga Station pedestrian bridge and Wagga Wagga Yard clearances	Yes	Up to 17 months	The enhancement site is not affected by regional flooding (refer to section 4.6.3.3). The enhancement is affected by overland flooding. Construction stockpiles, materials and laydown located in this area may be impacted by flooding and affects to the flow distribution of flood waters. The construction layout would require consideration of local flooding and drainage.
Bomen Yard clearances	Yes	2 months	The enhancement site is not affected by regional flooding (refer to section 4.6.3.4). The enhancement site is affected by overland flooding. Construction stockpiles, materials and laydown located in this area may be impacted by flooding and affect the flow distribution of flood waters.
Harefield Yard clearances	No	2 months	The enhancement site is not affected by regional flooding (refer to section 4.6.4.1).
Kemp Street bridge	Yes	10 months	The enhancement site is not affected by regional flooding (refer to section 4.6.4.2). The enhancement site is affected by overland flooding. Construction stockpiles, materials and laydown located in this area may be impacted by flooding and affect the flow distribution of flood waters.
Junee Station pedestrian bridge	No	1 month	The enhancement site is not affected by regional flooding (refer to section 4.6.4.3).
Junee Yard clearances	No	2 months	The enhancement site is not affected by regional flooding (refer to section 4.6.4.4).
Olympic Highway underbridge	No	3 months	The enhancement site is not affected by regional flooding (refer to section 4.6.4.3).
Junee to Illabo clearances	Yes	10 months	The enhancement site is not affected by regional flooding (refer to section 4.6.4.6). The enhancement site is affected by overland flooding. Construction stockpiles, materials and laydown located in this area may be impacted by flooding and affect the flow distribution of flood waters.

5.1.2 OPERATION

The operational impacts are described in the next sections. The description of the impact includes a short description of the proposal works for each enhancement site to provide context for the assessment. A further description of the proposed works is included in section 1.2.2.

5.1.2.1 ALBURY

MURRAY RIVER BRIDGE

The proposal involves the modification to the bridge superstructure, which is the part of the bridge above the bridge deck, to provide sufficient clearances for the double-stacked container freight trains. Works are not required to the bridge abutments, piers and approach rail embankments, and there are no changes proposed to the vertical or horizontal track alignment.

As the proposal would not result in any new or modified structures that could alter the flooding regime at this site or change the drainage conditions at the proposal site, no further assessment is required.

ALBURY STATION YARD CLEARANCES AND ALBURY STATION PEDESTRIAN BRIDGE

At this location, the proposal involves:

- the replacement of the existing pedestrian bridge with a taller pedestrian bridge to accommodate the required vertical clearances. There are no changes to the existing drainage system associated with this work
- changes to the horizontal alignment (up to 630mm) and vertical alignment (up to 50mm) of a section of track to achieve the required clearances. Due to the flat topography in the yard, free drainage of the new capping layer is not possible. The drainage design mimics the existing drainage conditions.

IMPACT ASSESSMENT

The proposal site is not subject to flooding up to and including the 1 per cent AEP flood event but is subject to inundation from local overland flooding for the PMF event. The proposed bridge would not have any impact to local flood behaviour at the site as it above the PMF flood level; the bridge piers located at the edge of the flood extent would have minor interaction with the PMF flood extent and would not affect the flow conveyance .. The horizontal and vertical shifts in the alignment are estimated to have no impacts to flood behaviour beyond the rail corridor. The works would include realignment of the local drainage to account for the formation shift and as such would manage local overland flows similarly to existing conditions.

As such, no impacts to the flood regime are expected as a result of the proposal. The 50mm raising of the vertical alignment would not change the existing flood immunity for the rail nor would it change flow paths and flow conveyance.

There are no changes to drainage catchment areas or discharge locations and the proposed realigned drainage would connect to existing networks beyond the proposal works. As such, there are no changes to the existing drainage conditions and flood conditions. As there is no change in flood level, flow velocities and flood hazard the QDLs would therefore be met for this enhancement site.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

Realigned drainage to suit the horizontal shift in the alignment would consider climate change projections for rainfall as part of the detailed design. It is estimated that there any projected increases in stormwater runoff would be catered for within the existing rail corridor and, as such, there would be no impact beyond the project boundary.

RIVERINA HIGHWAY BRIDGE

At this location, the proposal involves the lowering of a section of track where it passes under the Riverina Highway bridge to achieve the required clearances for double-stacked container freight trains. This would require adjustments to drainage within the rail corridor.

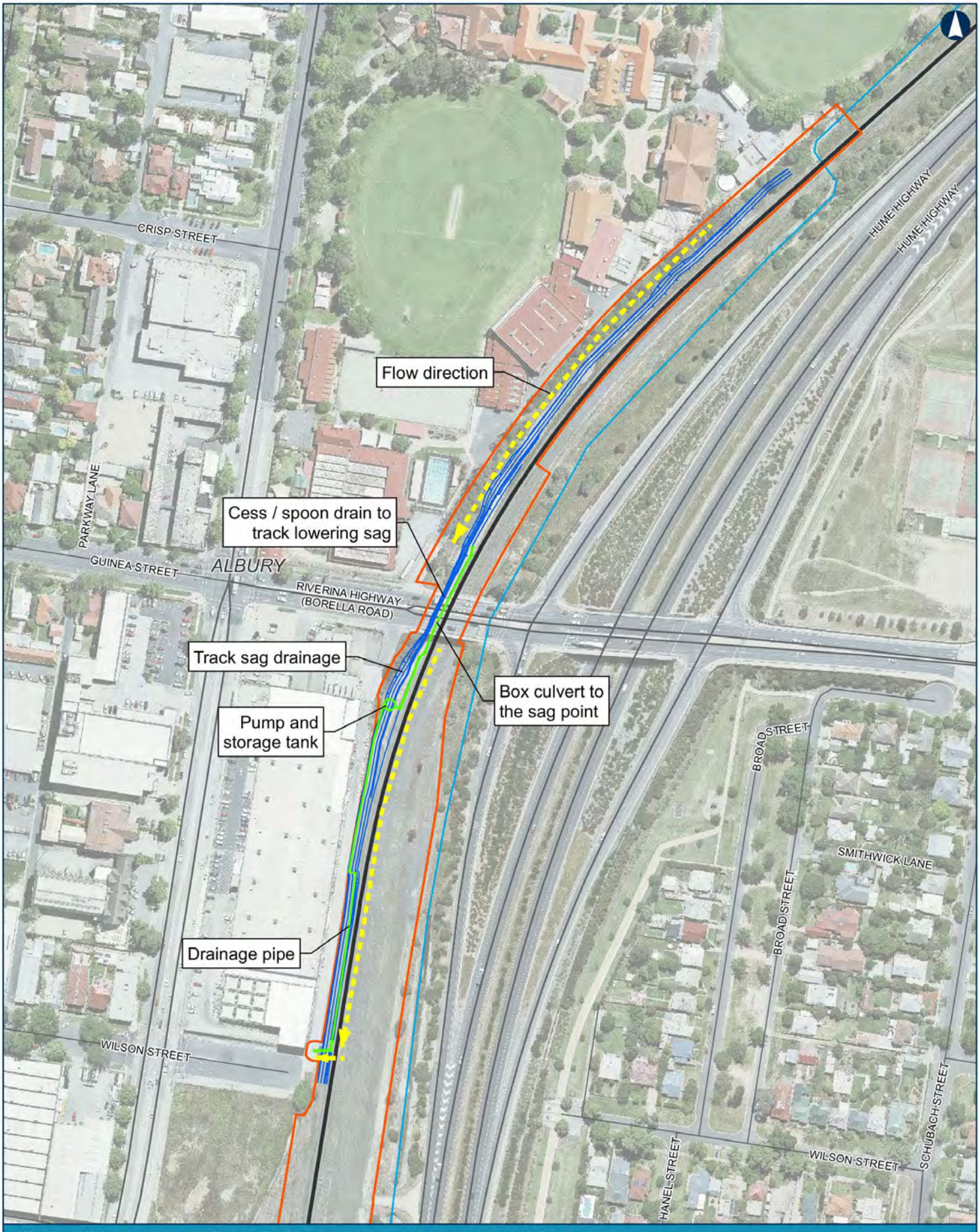
Figure 5.1 shows a schematisation of the proposed drainage works at the site.

For track drainage, the lowered track would be managed using cess drains to convey surface water runoff from the lowered track to the south of the existing overbridge. To account for this the flows would be captured in ballast cage pits and then transferred to the combined pumping station and buffer storage tank within rail corridor. Platform runoff from the north of the bridge would be conveyed by cess and spoon drains into a 450mm longitudinal pipe that discharge into the buffer storage.

A concrete pump and buffer storage tank in the order of 150 cubic metres would be required to move and store the low point surface water, with a duty and standby pump arrangement. The pump, tank storage and rising main would be located on the south-western side of the track slot. A rising main would traverse the south western side of the rail corridor to discharge to a grated drainage pit located adjacent Wilson Street. Flow would then gravitate into the council stormwater drainage system in Wilson Street.

With respect to the overland flows originating from The Scots College, the proposal would not affect the overland flood mechanisms upstream of the rail corridor as works do not extend into the Scott's College rail overtopping location. The overland flows spilling into the rail corridor would be directed to a separate channel, away from the lowered track, and would discharge into the council stormwater drainage system

The proposal would also require a modification to the existing concrete channel wall within rail corridor at the box culvert located at chainage 644,770m. The modification consists of two ramps that would allow rail maintenance vehicles to traverse the channel; the channel levels would be unaltered.



Albury to Illabo

Figure 5.1 Riverina Highway bridge - proposed drainage

0 25 50 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 16/09/2021 Paper: A3
Author: WSP Scale: 1:2,000
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse
- Proposed drainage design
- Proposed drainage features

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IMPACT ASSESSMENT

The proposal would not result in any change to the existing overland flow mechanisms outside the rail corridor. Overland flooding would be managed through the rail corridor.

Modification to the concrete channel in the vicinity of the box culvert at chainage 644,770m would not impact top levels of the channel and the impact to upstream flooding is therefore considered negligible.

The proposed drainage work within the rail corridor would convey surface water runoff and the overland flow from the upstream catchment into the Albury City Council stormwater drainage network mimicking the existing drainage and flood conditions.

A hydraulic model has been developed to assess the rail flood immunity using the software package DRAINS. The model confirms the 1 per cent AEP flood level is at 159.57mAHD at the critical ballast cage pit (chainage 645,144m). This level is located 230mm below the underside of the adjacent proposed railway formation. The proposed drainage would provide a 1 per cent AEP flood immunity to the railway line.

The drainage model was used to compare the existing and post development drainage conditions. As indicated in Table 5.2 below the drainage model showed a reduction in peak flow downstream of the proposed work. The reduction in peak flow is caused by the storage tank included at the low point of the track lowering. The drainage model results are presented for the 1 per cent AEP flood event. Reduction in downstream flow would occur in more frequent flood events where flows are smaller.

Table 5.2 Existing and post development peak flow downstream the track lowering 1 per cent AEP

LOCATION	1% AEP – PEAK FLOW (m^3/s)		
	Existing	With proposal	Variation
Downstream flow	1.22	1.05	-0.17

As indicated in Table 5.2 there is a reduction in discharge downstream of the proposed enhancement site. The reduction in flow would generate a reduction in flood impacts. Thus, there is no adverse flood impacts caused by the proposed work at this location.

Further flood storage mitigation potential also exists in the eastern rail track and or via potential discharges to Mudges Canal. The final mitigation strategy should be confirmed in the detailed design stage.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A climate change sensitivity assessment has been undertaken (refer to Table 5.3). A rainfall/flow increase of 20 per cent has been adopted based on information from ARR2019 Data Hub and represents a likely upper limit for climate change. The rainfall increase of 20% corresponds to the year 2090 RCP 8.5 and represents a likely upper limit for climate change.

Table 5.3 Climate change sensitivity analysis – Riverina Highway bridge

LOCATION	1% AEP FLOOD LEVEL (mAHD)	1% AEP + 20% FLOOD LEVEL (mAHD)	RAIL LEVEL (mAHD)	UNDERSIDE OF CAPPING LAYER (mAHD)	20% CHANGE IN FLOOD LEVEL (mm)	RAIL IMMUNITY (%AEP)
645.143km (track sag)	159.53	159.53*	160.77	159.76	0	1%

* the level is a head water depth over the inlet pit and the two approach flows are 26 l/s (in the 1% AEP) and 32 l/s (in the 1% AEP +Climate Change). The flow increase is insufficient to trigger higher head water depth in the DRAINS model.

BILLY HUGHES BRIDGE

The proposed enhancement work at Billy Hughes bridge involves a track lowering to provide a minimum of 7.1m vertical clearance to the existing bridge. Vertical alignment would be lowered up to 1.39m over a length of 310m. The lowered track would be managed using cess drains adjacent to batters, spoon drains with subsoil and a longitudinal drainage adjacent the retaining structures (refer to Figure 5.2).

In the vicinity of the track low-point, flows would be captured in ballast cage pits and transferred into an outlet pipe. This pipe would discharge via gravity upstream of the existing transverse rail culvert at 635,320m. The drainage system has been designed to provide a 1 per cent AEP immunity to the lowered track section. Figure 5.2 summarises the proposed drainage.

IMPACT ASSESSMENT

As identified in section 4.6.1.4, the enhancement site is not flood affected in the 1 per cent AEP event from regional flooding. The proposal would, however, result in a small change in the rail drainage catchment of around 0.6 hectares. This would be directed to an existing culvert (located at chainage 635.320 kilometre). The change in the surface water runoff due to the change in the catchment area was assessed using the software package DRAINS and is presented in Table 5.4. This is discussed further in the following sections.

Table 5.4 Baseline and proposed 1 per cent AEP flood conditions at Billy Hughes bridge

LOCATION	1% AEP FLOW (m^3/s)		1%AEP FLOOD LEVEL (mAHD)		RAIL LEVEL (mAHD)		AFFLUX (mm)	RAIL IMMUNITY (% AEP)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed		Baseline	Proposed
8MC-Rail-C	46.5	46.5	217.11	217.11	218.29	218.49	0	1%	1%
635.320km	7.23	7.5	214.74	214.78	217.22	216.33	40	1%	1%

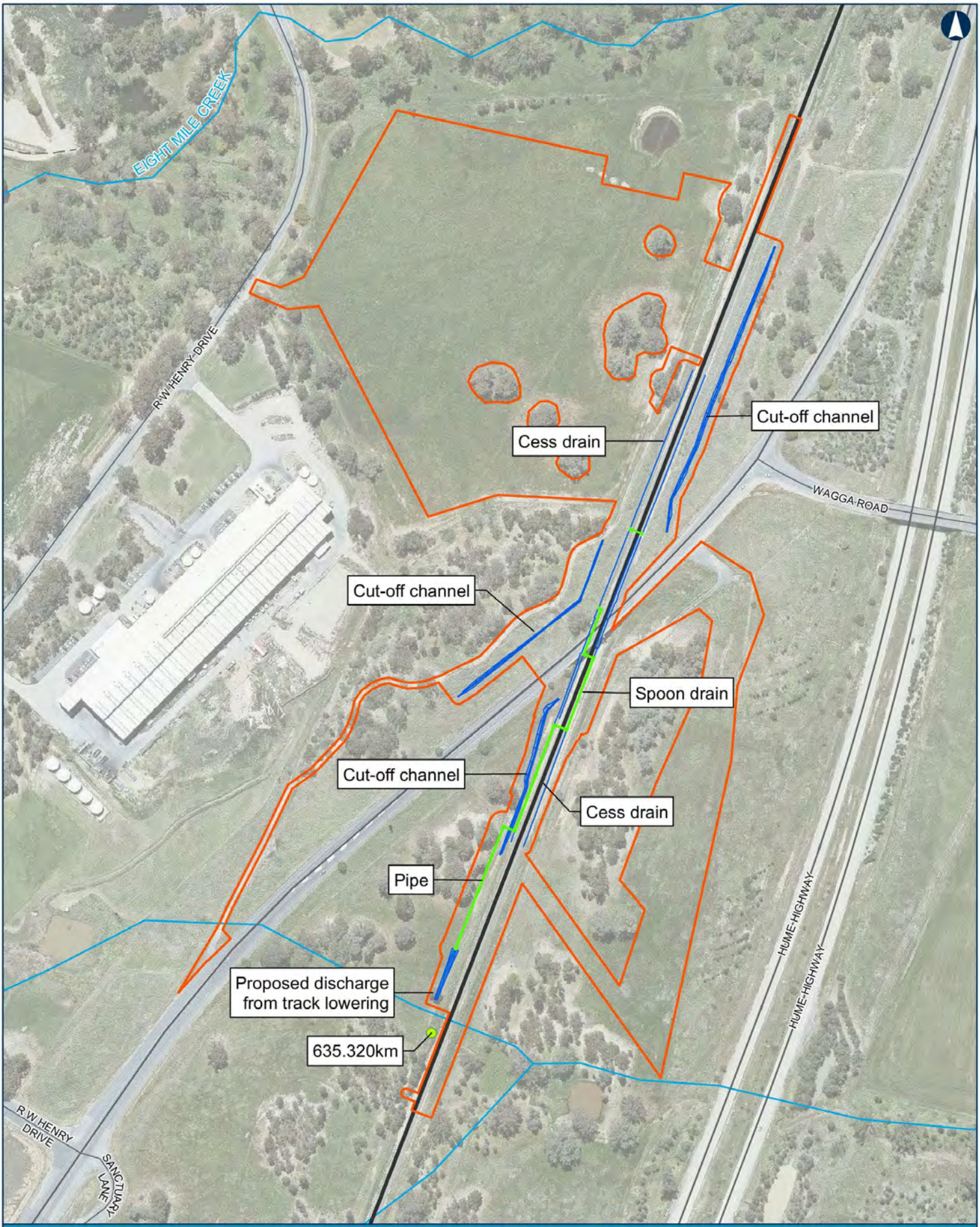
The drainage assessment results show that there is no change in flows to culvert located to the north of the lowered track slot and, therefore, there would be no changes to the flooding regime (including afflux) for areas to the north of Billy Hughes bridge.

The minor change in the flows to culvert 635,320m (around 3.7 per cent) would result in an afflux of 40mm contained within the Creek floodplain area. The increase in water level satisfies the QDLs.

As the change to the existing drainage conditions are minor, change in flow velocities are expected to satisfy the QDLs.

The estimated afflux of 40mm would result in an increased depth for the 1% AEP but no change to velocity is predicted, so the provisional hazard at the culvert would not change.

In the PMF flood event, the west and east sides of the enhancement site are affected by flooding. However, the proposed works do not affect the flow propagation towards downstream nor the hydraulic function of the floodplain. The minor change in drainage discharge and catchments would have only localised effects within the watercourses and would not be relevant for changes in flood conditions in floodplain.



Albury to Illabo Figure 5.2 Billy Hughes bridge - proposed drainage

0 50 100 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 16/09/2021 Paper: A3
Author: WSP Scale: 1:2,500
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Main road
- Local road
- Track
- Watercourse
- Culvert
- Proposed drainage design
- Proposed drainage features

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CLIMATE CHANGE SENSITIVITY ASSESSMENT

A rainfall increase of 20 per cent has been adopted based on information from ARR2019 Data Hub and represents a likely upper limit for climate change. The rainfall increase of 20 per cent corresponds to the year 2090 RCP 8.5 and represents a likely upper limit for climate change. The 1 per cent AEP sensitivity results are presented below in Table 5.5.

The results demonstrate that the track immunity at existing culvert, 635,320m would be retained at the 1 per cent AEP. The new drainage would continue to provide a 1 per cent AEP immunity to the lowered track. The track, however, is not overtopped and there is 0.96m freeboard to top of rail.

Table 5.5 Proposed design Sensitivity Analysis – Billy Hughes bridge

LOCATION	1% AEP FLOOD LEVEL (mAHD)	1% AEP + 20% FLOOD LEVEL (mAHD)	RAIL LEVEL (mAHD)	UNDERSIDE OF CAPPING LAYER (mAHD)	20% CLIMATE CHANGE INCREASE IN FLOOD LEVEL (m)	RAIL IMMUNITY (%AEP)
635.027km (track sag)	216.41	216.76	217.58	216.65	0.25	1%
635.320km	214.78	216.14	217.22	216.33	1.44	1%

TABLE TOP YARD CLEARANCES

The proposal at this enhancement site involves the removal of a signal gantry. This would not require any changes to track alignment or stormwater drainage. As such, there would be no changes to the flooding or drainage regimes at this enhancement site.

5.1.2.2 GREATER HUME – LOCKHART

CULCAIRN YARD CLEARANCES AND PEDESTRIAN BRIDGE

The proposal would involve changes to the horizontal alignment (up to 99mm) and vertical alignment (up to 75mm) of the rail track to achieve the required clearances. These proposed shifts in the horizontal and vertical alignment would not require changes to the existing drainage discharge conditions of the site. These proposed shifts would also not result in any change to the existing culvert under the rail near Victoria Street.

The existing pedestrian bridge would be removed.

IMPACT ASSESSMENT

As discussed in section 4.6.2.1, the rail corridor within the enhancement site is not affected by flooding up to and including the 1 per cent AEP flood event. As such, the changes in the horizontal and vertical alignment would not impact existing flood conditions and, as such, no afflux or changes to flow velocity or flood hazard is expected.

The proposal would provide a minor improvement to the existing rail flood immunity due to the proposed nominal lift (up to 75mm).

In the PMF flood event, the enhancement site and the surrounding areas are affected by flooding with flood depths greater than 1m. The minor change in vertical alignment (i.e., 75mm) would not affect the flood propagation upstream and downstream of the rail.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

As there are no changes to the drainage arrangements at this site, a climate change impact assessment was not undertaken.

HENTY YARD CLEARANCES

The proposal would involve changes to the horizontal alignment (up to 554mm) and vertical alignment (up to 50mm) of the rail track to achieve the required clearances. New cess drainage would be provided for the shifted rail formation, and would tie into the existing cess upstream and downstream of the enhancement site. In the vicinity of the Goods Shed, the surface water flow in the cess drain would be directed to a culvert of 0.3m x 1.2m (i.e. culvert reference DR LX-1 in Figure 5.3) before discharging back to a rail cess drain.

The downstream cess drain has been regraded, necessitating the replacement of the existing 225mm road culvert at the Sladen Street level crossing with a 300mm pipe (DR A-1).

Figure 5.3 shows a schematization of the proposed drainage work at Henty Yard clearances enhancement site.

IMPACT ASSESSMENT

The site is not affected by regional flooding and, as such, there would be no changes to the existing flood conditions.

A drainage model for the baseline and proposal within Henty Yard and the Sladen Street culvert was carried out (refer to Table 5.6) to assess the local platform surface water runoff. A change in water level would occur due to the cess channel regrade. The proposed design maintains the existing immunity. As the Henty Yard clearances enhancement site does not impact regional flooding, there would be no afflux or changes to the flow velocity and flood hazard.

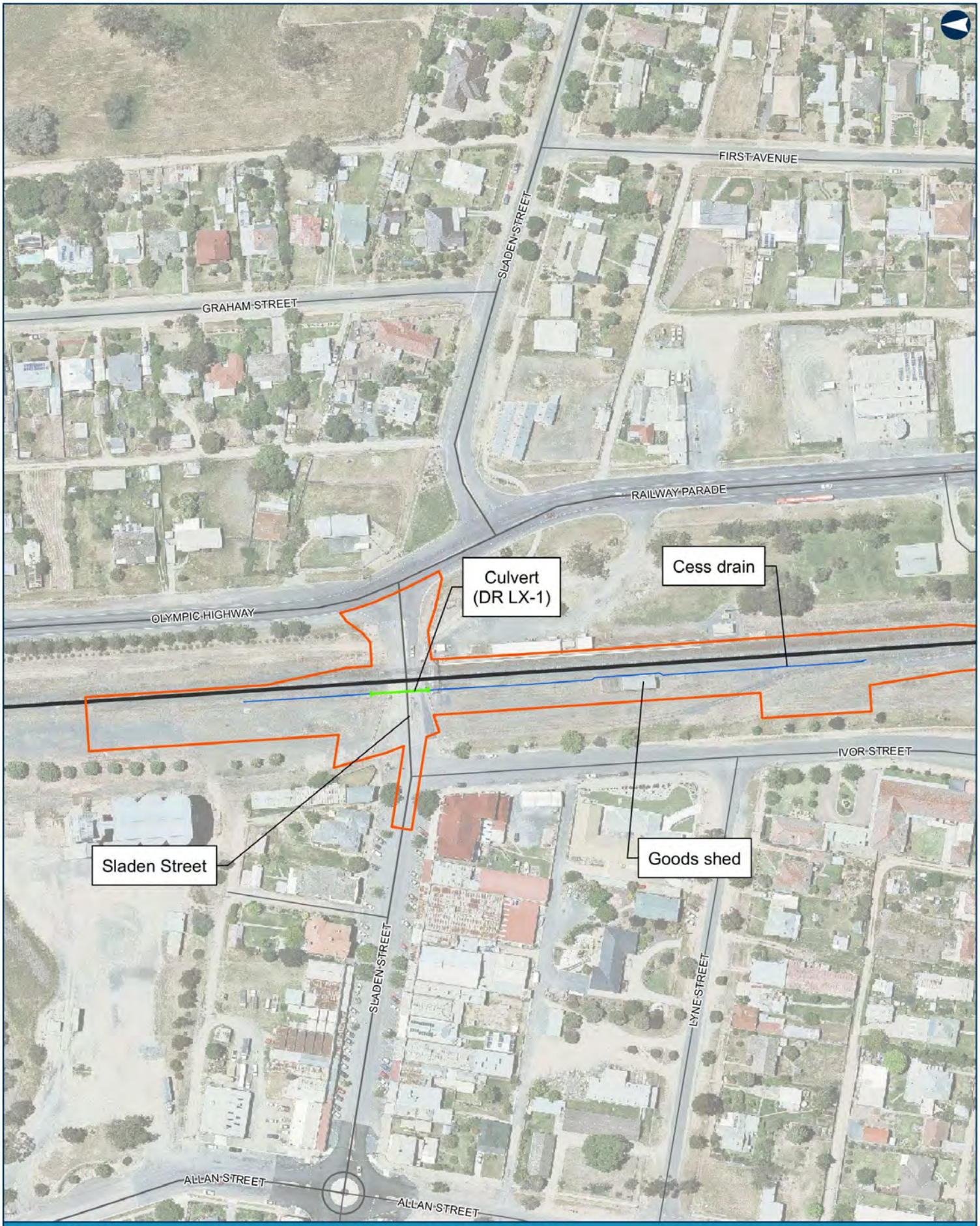
The proposed drainage works are limited to the management of the proposed site platform surface water run-off; furthermore, proposed drainage works mimic the existing drainage conditions. Thus, changes as a result of the proposed works are expected to have negligible flood impacts.

Table 5.6 1 per cent AEP flood change assessment at Henty Yard clearances

CHAINAGE	FLOW			WATER LEVEL			CHANGE IN WATER LEVEL (m)	PROPOSED UNDERSIDE OF TRACK CAPPING LEVEL (mAHD)
	Baseline flow (m^3/s)	Proposed flow (m^3/s)	Proposed flow climate change (m^3/s)	Baseline water level (mAHD)	Proposed water level (mAHD)	Proposed water level – climate change (mAHD)		
580.224 (Sladen Street)	0.076	0.074	0.92	237.84	237.42	237.52	-0.42	237.40

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A rainfall/flow increase of 20 per cent has been adopted based on information from ARR2019 Data Hub and represents a likely upper limit for climate change. The results confirm that the rail track and level crossing maintain a 1 per cent AEP immunity.



Albury to Illabo

Figure 5.3 Henty Yard clearances - proposed drainage

0 25 50 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 2/11/2021
Author: WSP
Paper: A3
Scale: 1:1,500
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Main road
- Local road
- Proposed drainage design
- Proposed drainage features

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YERONG CREEK YARD CLEARANCES

The proposal would involve changes to the horizontal alignment (up to 669mm) and vertical alignment (up to 50mm) of the rail track to achieve the required clearances.

The new track formation has been provided with free draining cess drains that tie back into existing track cess drains or road table drains. The proposed drainage works are of a minor nature only and would not results in any changes to stormwater capture or behaviour across the site. The existing cess drain catchment areas and flow regime are unchanged.

IMPACT ASSESSMENT

The proposed horizontal and vertical shifts in the alignment would be accompanied by horizontal shifts in the drainage around the formation for the length of the enhancement works only. This would result in local changes at the tie in points to existing cess drains but these changes would be within the proposal corridor and would not be perceptible due to the gradual horizontal shift. There would be no change to catchment areas contributing runoff to these cess drains, so there would be no change to flows and therefore no afflux estimated. Similarly, there would be no change in velocity and therefore no change to provisional hazard conditions within the enhancement site. The minimal vertical lifts are not expected to generate any impact to the overland flooding from Yerong and Sandy Creek. As anticipated in section 4.6.2.3, overland flooding from Yerong Creek is expected to propagate north west according to the terrain profile; therefore, flooding from Yerong Creek would not impact the proposal.

Possible flooding from Sandy Creek is expected to have no interaction with the vertical lift.

The vertical shift in the alignment would result in no change or a slight improvement to the existing flood immunity for the rail line.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

Drainage conditions would not change at the enhancement site but the realigned cess drains would consider the latest climate change projections as part of detailed design.

THE ROCK YARD CLEARANCES

The proposal at this enhancement site involves the modification of a signal gantry, which is an elevated structure and has no required stormwater drainage infrastructure upgrades. These works would not require any earthworks or alterations to the footings of the gantry. As such, there would be no changes to the existing overland flooding levels, or velocities or provisional hazards at this site. There are no drainage impacts at this enhancement site.

5.1.2.3 WAGGA WAGGA

URANQUINTY YARD CLEARANCES

The proposal involves changes to the horizontal alignment (up to 550mm) and vertical alignment (up to 50mm) of the rail track to achieve the required clearances and to ensure compliant ballast depths. At the Uranquinty Yard clearances site minor drainage channels have been provided to drain the new rail formation as follows:

- Southern Main Line rail cess drains tie into a retained existing culvert (located at chainage 535,515m)
- Main Line rail cess drain provided south of signal hut (at chainage 535,710m) and would drain northward
- a Main Line cess would also drain southward and discharges to the cess low point above. The cess low-point is graded out to free discharge to the adjacent road reserve
- south of the Sandy Creek Bridge, the cess discharges via a batter chute to the creek.

IMPACT ASSESSMENT

The proposal would not alter the drainage catchment within the proposal site. The adjustments to track drainage would mimic the existing discharge conditions.

Except for the transverse culvert crossing near Ryan Street (at chainage 535,515m), the site does not have a formal drainage system. As a result of the proposal, the new cess drains along the rail formation would facilitate the runoff conveyance towards the existing discharge locations.

In the proximity of Ryan Street, at chainage 535,790m, the change in vertical alignment may generate localised changes in flood conditions for the flood events in which the rail is overtopped (i.e., the 2 per cent AEP, 1 per cent AEP and PMF flood events).

As shown in Figure 5.4, where the water overtops the rail corridor, the proposed vertical lift is approximately 41mm on average for 35m of the rail corridor, 5.5mm on average for 60m of the rail corridor and 15.5mm on average for 40m of the rail corridor.

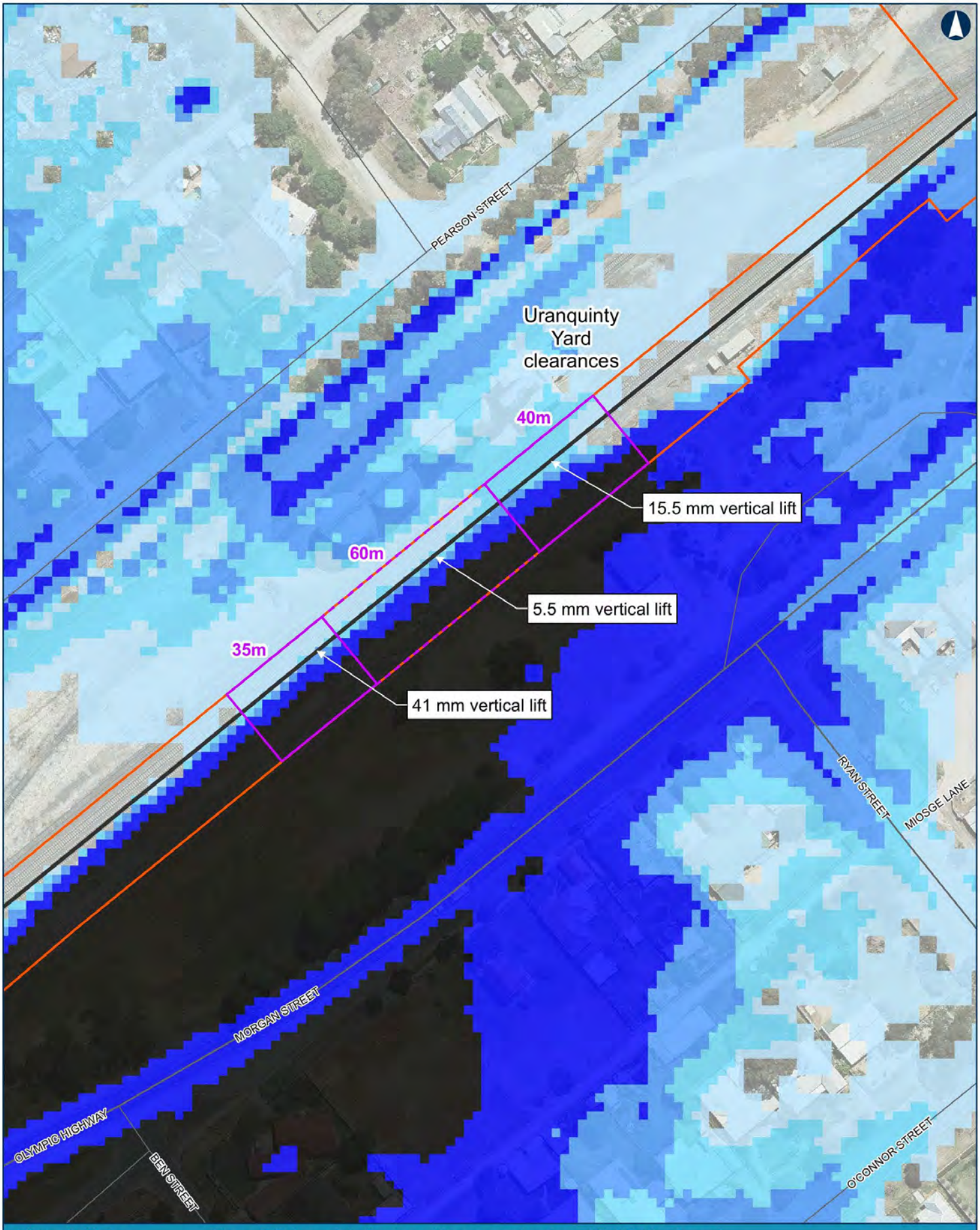
Although the vertical lift would raise the overtopping level at the rail, changes to the flood conditions are minor (i.e., less than 10mm), localised and contained within the area between the rail and the Olympic Highway.

The flood model results for the existing and post development conditions were compared to identify possible flood impacts in the 2 per cent AEP, 1 per cent AEP and PMF flood events. As shown in Figure 5.5, Figure 5.6 and Figure 5.7 there are negligible changes (i.e., less than 10mm) in flood levels for the 2 per cent AEP, 1 per cent AEP and PMF flood events. The flood model results demonstrated that the proposed works have none or negligible impacts in the flood propagation. There are none or negligible change (i.e., compliant with the QDLs) in flow velocities. Minor changes in flow velocities occur in a few isolated areas near the rail formation. As an example, a change in flow velocities is reported for point 1 where minor afflux (10mm) occurs (refer to Figure 5.6 for points location). Flow velocities change from 1.069m/s to 1.10m/s (change in 0.021m/s). The flood model results show no change in flood hazard.

As there are negligible (i.e., less than the QDLs) or no flood impacts, the proposal does not change the flood conditions and mechanisms upstream and downstream of the rail corridor. Flood impacts are therefore compliant with the QDLs.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A qualitative assessment of climate change indicates that change to the rainfall intensity would generate a minor reduction in the rail flood immunity.



Albury to Illabo

Figure 5.4 Uranquinty flood conditions – overtopping – 1% AEP flood event

0 20 40 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 2/11/2021 Paper: A3
Author: WSP Scale: 1:1,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road

Flood depth (m)
0 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1
> 1

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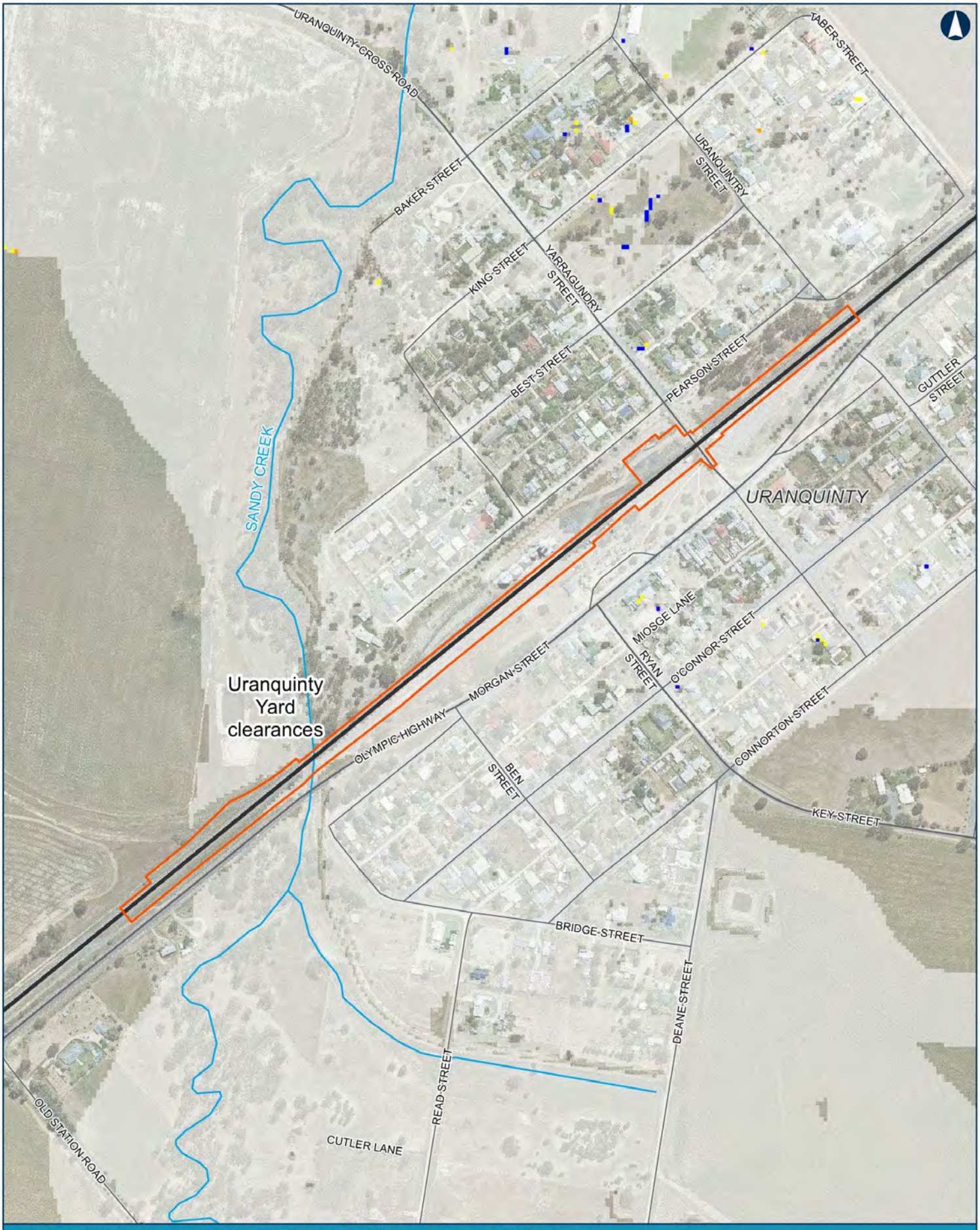

Albury to Illabo

Figure 5.5 Uranquinty Afflux - 2 per cent AEP flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 1/06/2022
Author: WSP
Paper: A3
Scale: 1:4,500

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Afflux (mm)

<= -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.05

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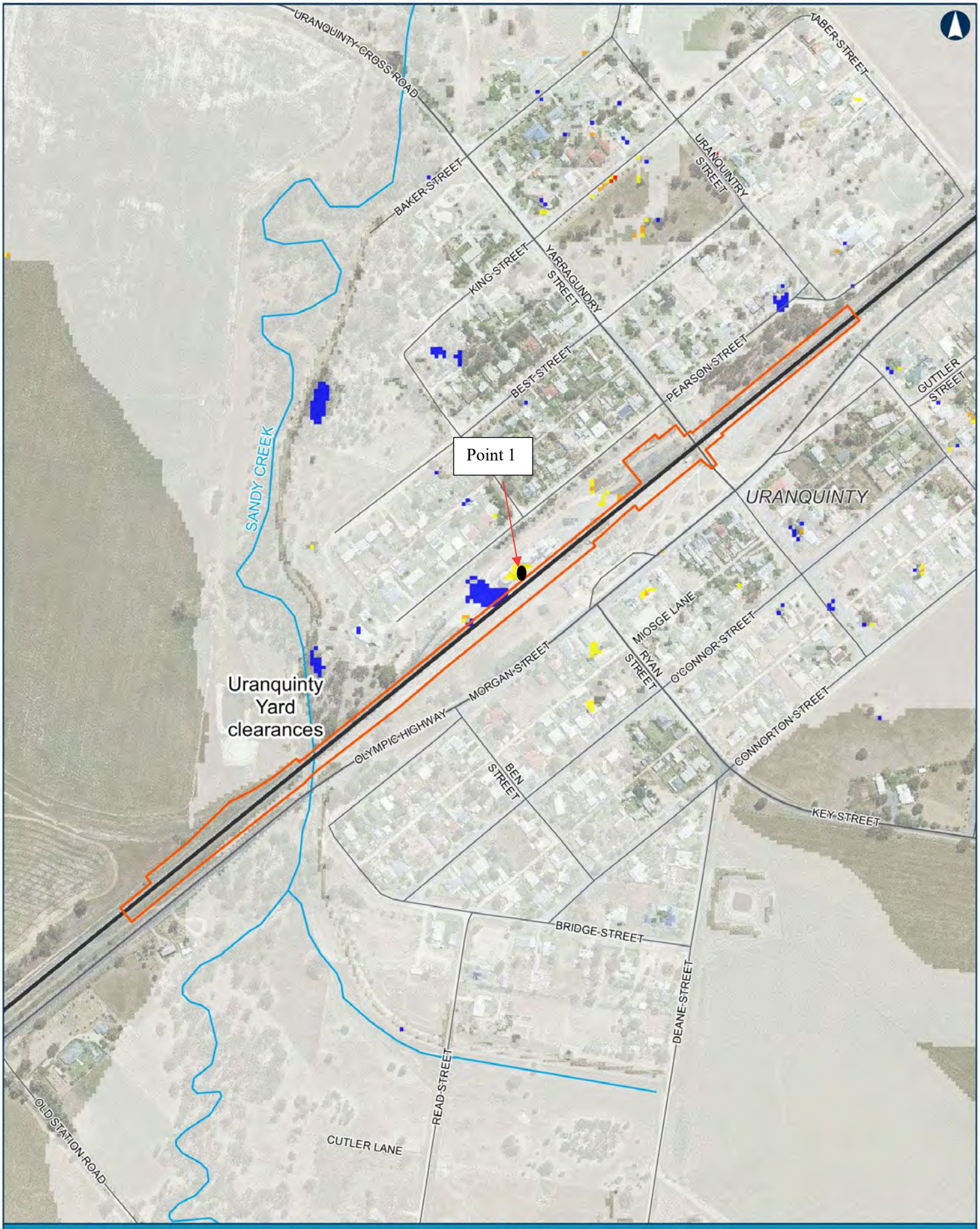

Albury to Illabo

Figure 5.6 Uranquinty Afflux - 1 per cent AEP flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 1/06/2022 Paper: A3
Author: WSP Scale: 1:4,500
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse

Afflux (mm)

- <= -0.01
- -0.01 - 0
- 0 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1

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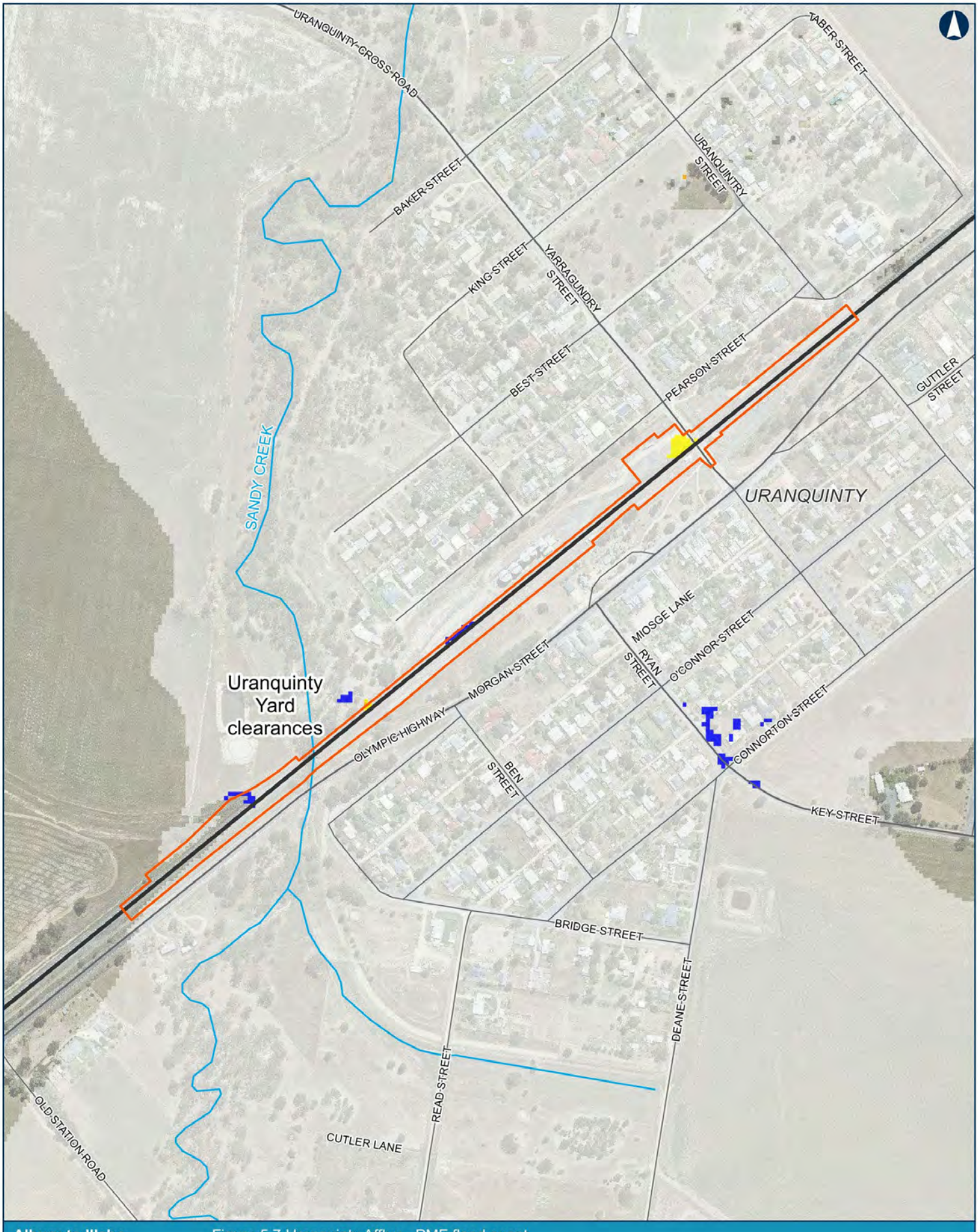

Albury to Illabo

Figure 5.7 Uranquinty Afflux - PMF flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 1/06/2022 Paper: A3
Author: WSP Scale: 1:4,500

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse

Afflux (mm)

- <= -0.01
- -0.01 - 0
- 0 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05

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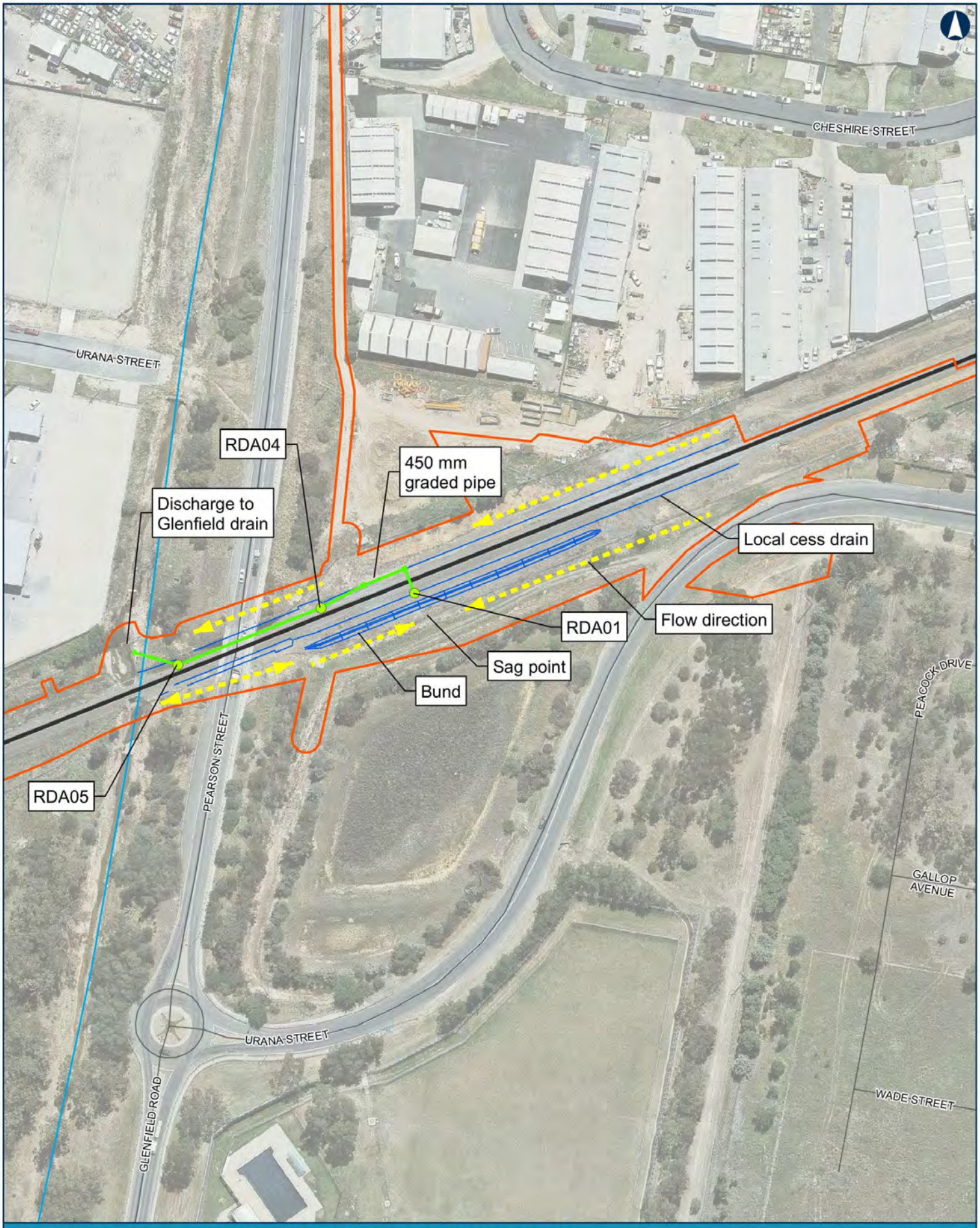
PEARSON STREET BRIDGE

The proposed enhancement work at Pearson Street bridge involves a track lowering to provide a minimum of 7.1 metres vertical clearance to the existing bridge. No change to the horizontal alignment is proposed.

At the south-western extent of the works, rail cess drains and ballast cage pits are proposed to collect and convey surface water runoff from the rail formation to the sag point, where water flow is transferred east via a reverse 450mm graded pipe that passes below Pearson Street bridge and discharges into the Glenfield Drain.

The areas to the north-east of Pearson Street bridge, including the existing cut-off drain, are managed by track cess drains and channels that discharge into the Glenfield Drain by batter chutes.

Figure 5.8 shows a schematic representation of the proposed drainage system at the site.



Albury to Illabo

Figure 5.8 Pearson Street bridge - proposed drainage

0 20 40 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 1/06/2022 Paper: A3
Author: WSP Scale: 1:1,250
Data Sources: ARTC, NSWSS

Proposal site
Existing railway
Local road
Watercourse
Culvert
Proposed drainage design
Proposed drainage features

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IMPACT ASSESSMENT

The enhancement site is not impacted by regional flooding; as such, there is no change to the flooding regime of the Murrumbidgee River.

As indicated in section 4.6.3.2 the enhancement site is not impacted by overland flooding up to and including the 1 per cent AEP flood event.

To prevent overtopping of the rail alignment, a 500mm flood bund would be provided at the top of the south-eastern cutting. The provision of the bund would provide a 1 per cent AEP flood immunity to the lowered track. The proposed bund is shown in Figure 5.9, and would be subject to further refinement during detailed design.

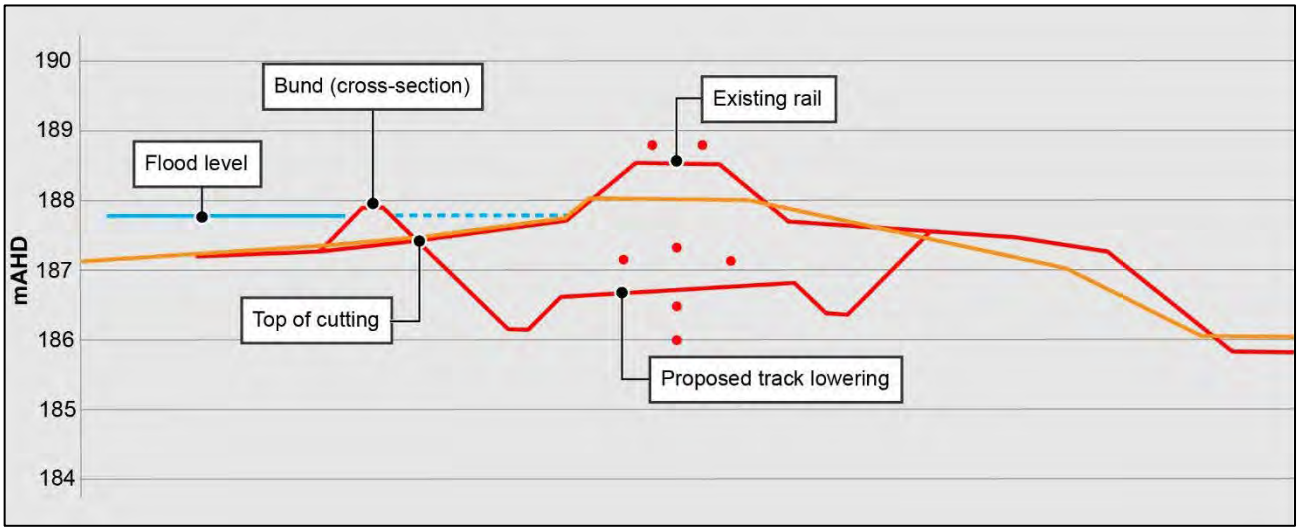

Figure 5.9 Proposed bund at Pearson Street bridge to prevent rail overtopping

The proposed bund would cause a loss in flood storage of approximately 115m^3, which is about 0.01 per cent of the immediate upstream flooded area; therefore, the loss in flood storage is negligible.

Given the drainage immunity at this site may be impacted by both the intensity of the storm event and the existing tailwater level in the Glenfield Drain, several flow scenarios have been tested.

Table 5.7 shows the local rainfall events, Glenfield Drain tailwater level event and the approximate combined event probability. The local rail catchment storm and Glenfield Drain flood event are unlikely to be concurrent due to the difference in catchment size. The Glenfield Drain catchment is approximately 6km^2 while the rail catchment is approximately 1ha.

Table 5.7 Drainage immunity scenarios assessed for Pearson Street bridge

SCENARIO	LOCAL CATCHMENT RAINFALL EVENT (RAIL CATCHMENT)	GLENFIELD DRAIN AEP FLOOD EVENT (TAILWATER mAHD)	APPROXIMATE COMBINED PROBABILITY OF SCENARIO
1	1% AEP	1% AEP (TWL = 186.10)	1 in 10 000
2	1% AEP	5% AEP (TWL = 185.75)	1 in 2000
3	5% AEP	1% AEP (TWL = 186.10)	1 in 2000
4	5% AEP	10% AEP (TWL = 185.65)	1 in 200

Drainage immunity is achieved where the Hydraulic Grade Level (HGL) is below the underside level of the capping layer of the rail track.

The results of the drainage immunity assessment for the scenarios described in Table 5.7 are shown in Table 5.8. Refer to Figure 5.8 for drainage location.

Table 5.8 Drainage immunity and hydraulic grade level levels at Pearson Street bridge

DRAINAGE LINE	UNDERSIDE CAPPING LEVEL (mAHD)	TRACK LEVEL (mAHD)	HGL IN SCENARIO 1	HGL IN SCENARIO 2	HGL IN SCENARIO 3	HGL IN SCENARIO 4
RD.A-01	186.30	187.10	186.38	186.17	186.27	185.94
RD.A-04	186.74	187.28	186.27	186.01	186.20	185.83
RD.A-05	187.66	188.20	186.16	185.84	186.14	185.71

The HGL in Scenario 1 marginally reaches the underside of capping; however, it does not overtop the rail. The track, therefore, is considered to have a 1 per cent AEP effective immunity.

The proposal produces minor changes to the local rail corridor drainage system within the site area. The modified rail drainage system formalises the runoff from the rail corridor into the Glenfield Drain, as shown in Figure 5.8. The peak runoff discharge for the 1 per cent AEP flood event from the proposed rail drainage system into the Glenfield Drain is 0.2m^3/s, which corresponds to 0.003 per cent of the peak flow in the Glenfield Drain (i.e. Glenfield Drain peak flow is approximately 62m^3/s). As such, discharges from the rail corridor would be negligible compared to the Glenfield Drain flow.

The flood model results for the existing and post development conditions were compared to identify possible flood impacts caused by the proposed enhancement work.

As indicated in Figure 5.10, Figure 5.11 and Figure 5.12, there are no changes in flood level in the 2 and 1 per cent AEP and PMF flood events.

The proposed works do not change the existing flood conditions. As there is no change to flood conditions or hydraulic function of the floodplain there are no or negligible changes in flow velocities. In the isolated areas where there is change in flow velocity, the change is below 0.010m/s. Point 1 (refer to Figure 5.11 for point location) was selected as example location to compare the change in flow velocity. Point 1 is near the proposed bund where possible change of flow velocity might occur. The magnitude of the change in flow velocity in Point 1 is 0.001m/s (i.e., from 0.105m/s to 0.106m/s). As there is no change in flood levels and flow velocities there is no change in flood hazard. Thus, flood impacts are compliant with the QDLs.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A climate change sensitivity analysis was carried out for the drainage immunity of the site. This sensitivity assessment used a rainfall increase of 20 per cent, which represents the likely upper limit of rainfall change in a RCP 8.5 scenario.

The climate change assessment demonstrated that the new drainage would continue to provide 1% AEP flood immunity to the track lowering. Results of the climate change sensitivity analysis are included in Table 5.9.

Table 5.9 Proposed drainage – Hydraulic summary with climate change (20% increase in rainfall capacity)

DRAINAGE LINE	UNDERSIDE CAPPING LEVEL (mAHD)	TRACK LEVEL (mAHD)	HGL IN SCENARIO 2 + CLIMATE CHANGE
RD.A-01	186.30	187.10	186.30
RD.A-04	186.74	187.28	186.09
RD.A-05	187.66	188.20	185.87

Albury to Illabo

Figure 5.10 Pearson Street bridge: Afflux - 2 per cent AEP flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/06/2022
Author: WSP

Paper: A3
Scale: 1:5,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Local road
Watercourse

Afflux (mm)

<= -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2

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Albury to Illabo

Figure 5.11 Pearson Street bridge: Afflux - 1 per cent AEP flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/06/2022
Author: WSP

Paper: A3
Scale: 1:5,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Local road
Watercourse

Afflux (mm)

<= -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2

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Albury to Illabo

Figure 5.12 Pearson Street bridge: Afflux - PMF flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 30/06/2022
Author: WSP

Paper: A3
Scale: 1:5,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Local road
Watercourse

Afflux (mm)

<= -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.05
0.05 - 0.01
0.01 - 0.2
> 0.2

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CASSIDY PARADE AND WAGGA WAGGA STATION PEDESTRIAN BRIDGE ENHANCEMENT SITES

The proposal would involve the replacement of two pedestrian bridges at Cassidy Parade and Wagga Wagga Station. Existing channels within the rail corridor have been realigned around the bridge pile caps and so there would be no changes to the existing drainage catchment; as such, these bridges would not alter flood regimes at these sites.

WAGGA WAGGA YARD CLEARANCES

The proposal involves changes to the alignment for around 900m to achieve the required clearances and to ensure compliant ballast depths, extending from around 150m west of Edmondson Street bridge to the east of Wagga Wagga Station. Changes to the horizontal alignment would be up to 608mm. The changes to the vertical alignment to the east of Edmondson Street bridge would be up to 50mm. For the remainder of the enhancement site, the maximum vertical alignment would up to 80mm.

The topography of the Wagga Wagga Yard clearances is very flat. The surrounding terrain rises to the north of the enhancement site.

The track drainage design incorporates shallow concrete lined cess drains to provide free drainage to the new formation. These cess drains discharge to the existing cross-drainage culvert, allowing free draining for the new formation with no existing drainage features or depressions.

The drainage solution would be reviewed at detailed design and supported by detailed survey to determine if a better opportunity exists to formalise the drainage of the corridor.

IMPACT ASSESSMENT

The enhancement site is not impacted by regional flooding; as such, there is no change to the flooding regime of the Murrumbidgee River.

The enhancement site is, however, impacted by overland flows that flow from the south in north-west direction across the rail formation according to the ground topography.

The flood model results for the existing and post development conditions were compared to identify possible flood impacts. Figure 5.13, Figure 5.14 and Figure 5.15 below shows the flood impacts in the 2 per cent, 1 per cent AEP and PMF flood events.

In the 2 per cent AEP flood event the model results show change in flood level up to 16mm in area of 116 m^2 located at the north of the rail corridor as indicated in Figure 5.13. There are no changes in flow velocities and no change in flood hazard.

In the 1 per cent AEP flood event the model results show afflux up to 20mm in the area between the track and Railway Street and afflux up to 30mm in the industrial area located 400m at the east of the enhancement site.

The 20mm afflux in the area between the track and Railway Street is less than the QDL criteria (i.e., 100mm increase).

The afflux at the industrial area (total area of afflux is approximately 0.4ha) at east of the enhancement site is on average 14mm; there is an isolated area (less than 84m^2) where afflux on average is 38mm and a depression area of 112m^2 where afflux is up to 79mm. Afflux is caused by more water conveyed into the area on the southern side of the rail due to a reduction in overtopping flow from south to north across the rail corridor. This area is a terrain depression with no outlet drainage included in the flood model. Thus, additional flow conveyed into the area as a result of the proposal causes a minor increase in flood level.

The review of the aerial images showed that there is a drainage culvert at the north of the industrial area which was not included properly in the council flood model. The culvert is expected to reduce the flood level at the industrial area by conveying the ponding flood water towards the north east through the rail corridor. Thus, the culvert would reduce the increased afflux that appear in the flood model results for the 1 per cent AEP flood event. At detailed design stage the flood model would be updated to include the drainage and culvert in the model to confirm the true afflux result in this area, which is likely to be minor.

The proposed works have no or negligible changes in the flow velocities; Where an increase in afflux potentially occurs as a result of the proposal, the change in flow velocities are low and in the order of 0.1 to 0.2m/s. Where increases in flow velocities could occur at this location, the change in flow velocities are compliant with the QDLs (e.g. peak flow velocity in Point 1 indicated in Figure 5.14 in the 1 per cent AEP flood event changes from 1.072m/s to 1.101m/s).

West of Edmondson Street, water flows towards the rail corridor from the north and does not overtop the rail; the change in the vertical alignment at this location would not affect the flow behaviour and flood water would continue to be stored within the rail corridor, as in the existing conditions.

The flood model results show no change in flood hazard categories.

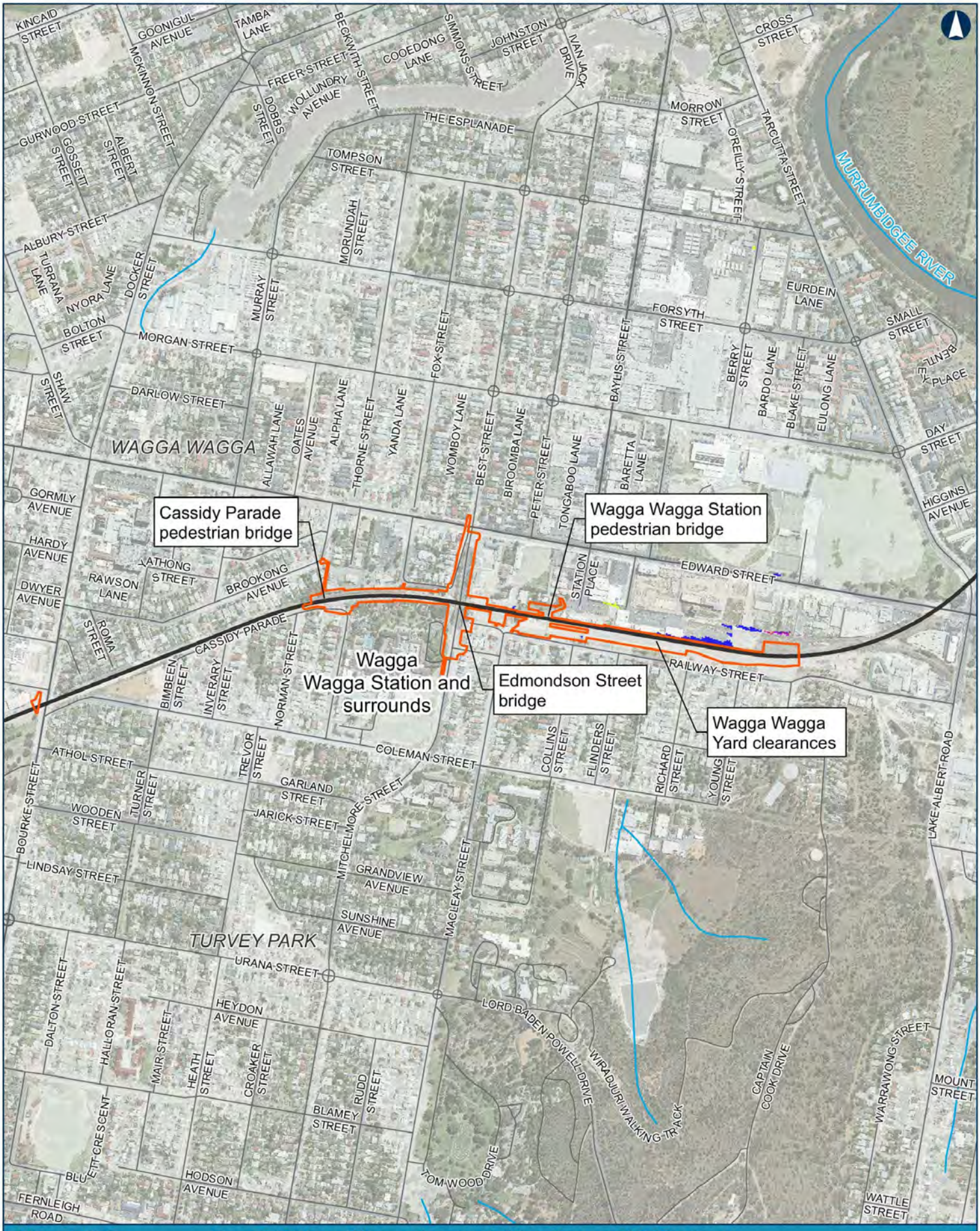
In the PMF event the changes in flood levels are minor and up to 30mm in the areas immediately north and south of the rail track. The model results show afflux in an isolated area (0.2ha) located 1.5km north – west from the enhancement site (refer Figure 5.15). This area is too far to be affected by the proposed works. As there are no changes in flood levels to the surrounding areas the isolated change in flood level is related to a local model instability. Model instability will be investigated at detail design stage.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

Increases in the rainfall intensity due to climate change may reduce flood immunity of the rail but this is considered to be a low risk given the flat topography.

EDMONSON STREET BRIDGE

The proposal involves the replacement of the Edmondson Street bridge to provide the required vertical clearances. New longitudinal drainage has been provided to manage runoff from the new bridge and associated interfaces. The new drainage would connect and discharge to five points in the existing council drainage network. The connection points for the new drainage are shown in Figure 5.16.



Albury to Illabo

Figure 5.13 Wagga Wagga and surrounds Afflux - 2 per cent AEP flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Proposal site
Existing railway
Main road
Local road
Watercourse

Afflux (mm)

<= -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2

Date: 2/06/2022
Author: WSP
Paper: A3
Scale: 1:8,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

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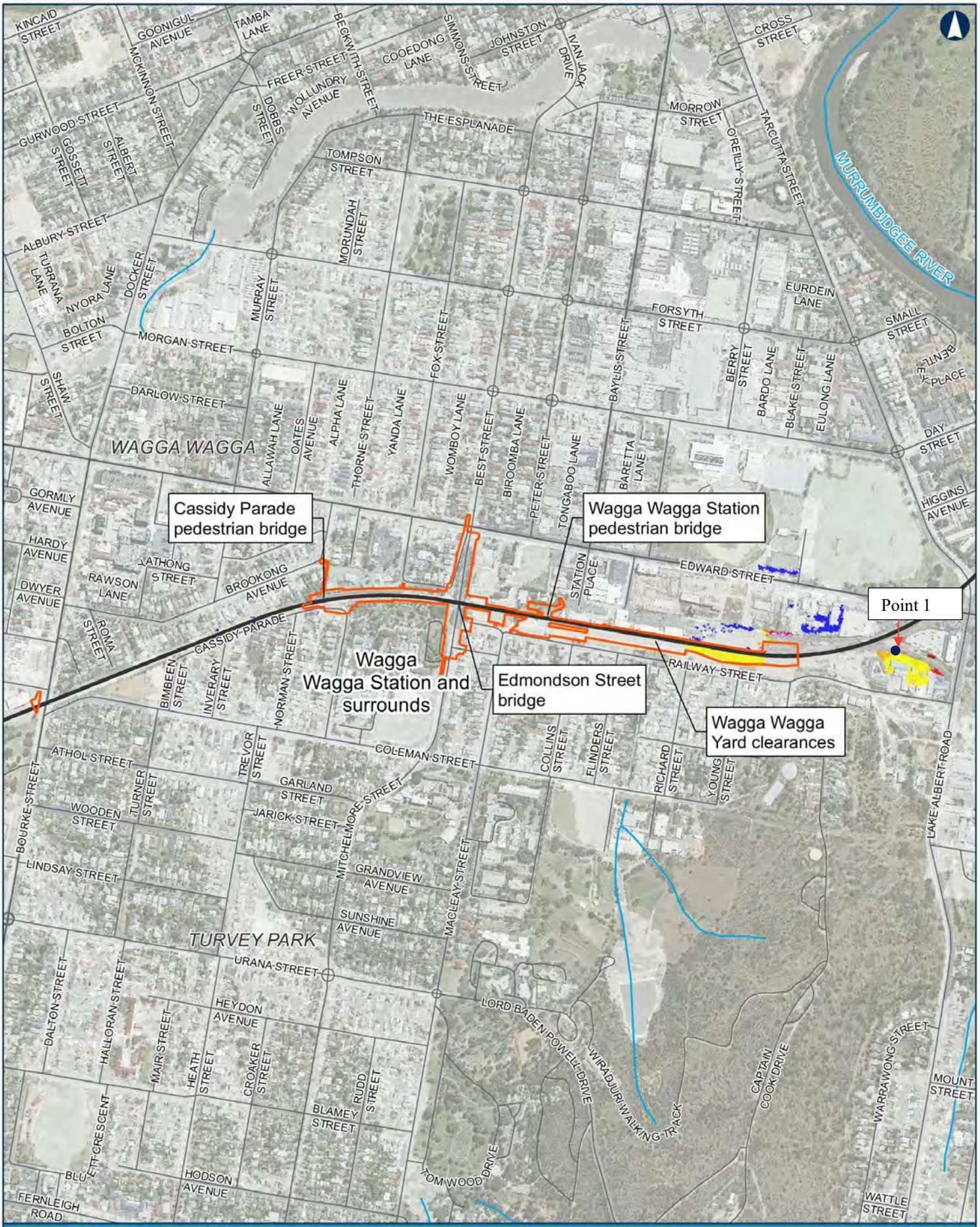

Albury to Illabo Figure 5.14 Wagga Wagga and surrounds Afflux - 1 per cent AEP flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 2/06/2022 Paper: A3
Author: WSP Scale: 1:8,000
Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Afflux (mm)

<= -0.01	0.02 - 0.05
-0.01 - 0	0.05 - 0.1
0 - 0.01	0.1 - 0.2
0.01 - 0.02	> 0.2

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Albury to Illabo

Figure 5.15 Wagga Wagga and surrounds Afflux - PMF flood event

0 100 200 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 2/06/2022
Author: WSP

Paper: A3
Scale: 1:8,000

Data Sources: ARTC, NSWSS, Wagga Wagga City Council

Proposal site
Existing railway
Main road
Local road
Watercourse

Afflux (mm)

<= -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.05
0.05 - 0.1
0.1 - 0.2

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Albury to Illabo

Figure 5.16 Edmondson Street bridge - proposed drainage

0 25 50 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 1/06/2022
Author: WSP

Paper: A3
Scale: 1:1,250

Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Main road
- Local road
- Proposed drainage connection point
- Proposed drainage design

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IMPACT ASSESSMENT

The enhancement site is not impacted by regional flooding from the Murrumbidgee River.

The drainage design for the replacement bridge would generally maintain the existing drainage catchment areas and connection points to the council stormwater drainage network. Table 5.10 summarises the baseline and proposed catchment areas to the key drainage connection points. Changes to catchment areas are minor only and would represent a negligible impact on the existing drainage system. Upgrades to the existing council stormwater drainage network is not considered necessary given these minor changes.

The drainage work at the bridge is not expected to generate flood impacts as the proposed drainage system mimics the existing drainage conditions. The change in the drainage catchments are minor as indicated in Table 5.10. Thus, flood impacts are expected to satisfy the QDLs.

Drainage work at the bridge would not impact on the flood immunity of the rail line.

Table 5.10 Drainage catchment change at Edmondson Street bridge

CONNECTION POINT	BASELINE CATCHMENT AREA (ha)	PROPOSED CATCHMENT AREA (ha)	% CHANGE
DR-A	0.362	0.362	0
DR-B	0.177	0.178	1.01
DR-E	0	0.044	–
DR-M	0.286	0.287	1.00
DR-N	0.204	0.212	1.04

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A climate change sensitivity was carried out for a rainfall increase of 20 per cent (selected to represent the likely upper limit of rainfall change) for the bridge drainage system.

The results demonstrate that the new drainage would provide a 10 per cent AEP immunity to the new bridge and approaches for minor events including climate change and for most areas for the 1 per cent AEP event.

Table 5.11 Drainage catchment with 20 per cent rainfall increase – Edmondson Street bridge enhancement site

CONNECTION POINT	10% AEP + 20% INCREASE IN RAINFALL	1% AEP + 20% INCREASE IN RAINFALL
DR-A	10% AEP immunity achieved	1% AEP immunity achieved. Nuisance flow immunity achieved (i.e. one lane in each direction is flood free).
DR-B	10% AEP immunity achieved	1% AEP immunity not achieved. Nuisance flow immunity achieved.
DR-E	10% AEP immunity achieved	N/A – not within road carriageway
DR-M	10% AEP immunity achieved	1% AEP immunity achieved. Nuisance flow immunity achieved.
DR-N	10% AEP immunity achieved	1% AEP immunity achieved. Nuisance flow immunity achieved.

BOMEN YARD CLEARANCES

The proposal involves changes to the vertical alignment of the rail track to achieve the required clearances. The proposed change to the vertical alignment is up to 50mm, with the exception of a short section of track (near chainage 514,510m). At this location, a lift of up to 78mm is required to provide compliant vertical grade.

Minor cess and tail-out channels have been provided to drain the new rail formation, which would involve a connection of the Main Line rail cess drains into the existing culvert at chainage 513,820m, except for:

- a section of Main Line rail cess drain that drains south and ties into the existing rail drainage cess
- a section of Main Line and Loop Line cess drains that drain to the north and discharge via an open channel to an existing culvert to the east.

IMPACT ASSESSMENT

The proposal site at this location is not impacted by regional flooding; as such, there is no change to the flooding regime of the Murrumbidgee River.

The proposed minor vertical lift at the level crossing is expected to raise the overtopping level. Water would continue to overtop the rail at the crossing and flow west, following the topography slope. No flood impacts are expected to the area at the east as it is at higher ground.

The proposed drainage system mimics the existing drainage conditions; thus, proposed drainage is not expected to generate afflux.

Drainage catchments are unchanged and proposed discharge locations mimic the existing conditions. The proposed drainage would have a negligible impact on offsite discharges.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

Any increase in the rainfall intensity due to climate change would reduce the rail flood immunity.

5.1.2.4 JUNEE

HAREFIELD YARD CLEARANCES

The proposal involves changes to the horizontal alignment (up to 457mm) and vertical alignment (up to 75mm, with an average lift of 43mm) to achieve the required clearances and to ensure compliant ballast depths.

The existing two-span steel and concrete structure at chainage 497,410m would be retained. The proposed track realignment works are contained within the existing structure, with no impacts to the existing waterway area and current hydraulic performance. No other drainage structures are impacted.

Localised and short sections of cess drains have been provided to free-drain the capping. These cess drains discharge to existing shallow drainage lines at various locations.

IMPACT ASSESSMENT

There would be no change to the existing drainage catchment at the site as a result of the proposal. Proposed drainage works would mimic the existing discharge conditions.

As the proposal site is not affected by regional flooding, no flood impacts are expected.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

As there are no expected changes to the existing flood and drainage conditions, no climate change impact assessment has been carried out for the site.

KEMP STREET BRIDGE

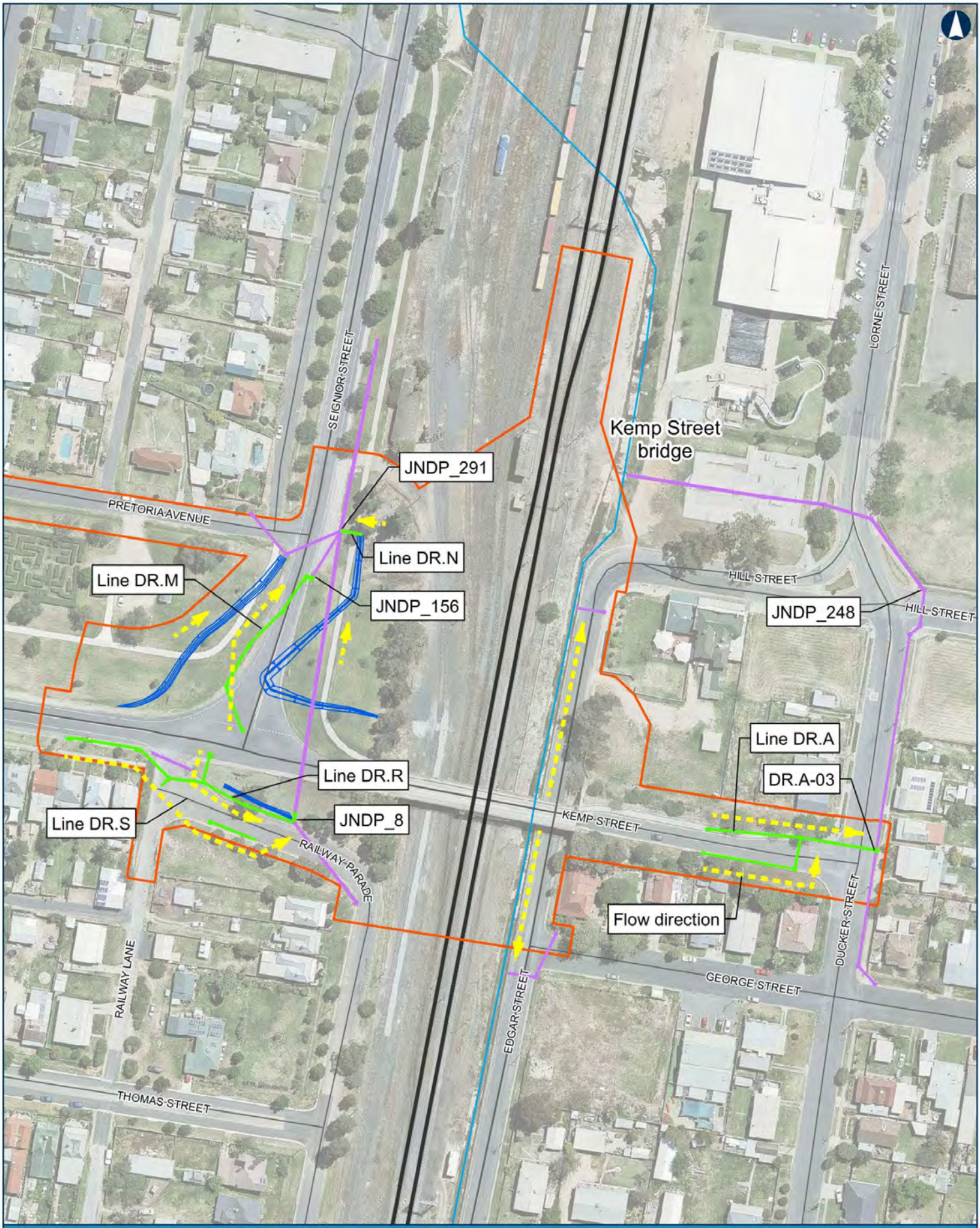
The proposal involves the replacement of the existing bridge to provide sufficient vertical clearances and adjustments to the connecting roads. The new bridge would not alter drainage arrangements within the rail corridor.

New longitudinal drainage would be provided to manage runoff from the new bridge and associated interfaces. Drainage consists primarily of pipes, some toe drains and spoon drains used to manage minor catchments adjacent to the retaining wall and road batters. The new drainage would connect and discharge to the existing council stormwater drainage network.

Figure 5.17 shows the proposed drainage network and Table 5.12 summarises the connections.

Table 5.12 Proposed drainage connection network – Kemp Street bridge

PIPE	CONNECTION POINT	COMMENT
DR.A	DR.A-03	New pipe over existing drainage line
DR.R	JNDP_8	New pipe connection to existing pit
DR.S	JNDP_8	Replace existing pipe
DR.M	JNDP_156	New pipe connection to existing pit
DR.N	JNDP_291	New pipe connection to existing pit



Albury to Illabo

Figure 5.17 Proposed drainage connection plan

0 20 40 m

Coordinate System: GDA 1994 MGA Zone 55

Date: 1/06/2022
Author: WSP
Paper: A3
Scale: 1:1,250
Data Sources: ARTC, NSWSS

- Proposal site
- Existing railway
- Main road
- Local road
- Watercourse
- Council network
- Proposed network
- Proposed drain channel

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IMPACT ASSESSMENT

Regional flood flows at this location are conveyed under the bridge in the 1 per cent AEP and 5 per cent AEP; the proposal would not alter this conveyance. As such, there would be no afflux, or changes to the flow velocity and flood hazard.

Rail flood immunity is not affected by the proposed drainage work at Kemp Street bridge.

The altered drainage network has been assessed for a 10 per cent and 1 per cent AEP event under two scenarios. Scenario 1 (minor event) considering the downstream water level in the receiving network at the pipe soffit and scenario 2 (major event) considering the downstream water level in the receiving network at the ground surface. The assessment demonstrated that new drainage would provide a 1 per cent AEP flood immunity to the new bridge and connecting roads.

The new bridge would be marginally wider (approximately 300mm) than the existing bridge and the proposed drainage would maintain the existing connection points. A detailed hydraulic assessment of the council stormwater drainage network capacity has not been undertaken due to the lack of available data. As such, an assessment of the catchment areas has been carried out to identify the potential changes in surface water runoff conditions.

Table 5.13 summarises the baseline and post development catchment areas to the key connection points. The assessment included in the table confirms that changes in catchment areas are minor and would represent a negligible impact on the existing drainage system capacity.

Connection point DR.A-03 has a local increase and subject to survey and discussion with Junee Shire Council the drainage line from DR.A-03 to JNDP_248 may need to be upgraded. At JNDP_248, the flood impact is expected to be negligible.

Table 5.13 Catchment area change assessment – Kemp Street bridge enhancement site

CONNECTION POINT	BASELINE CATCHMENT AREA (ha)	POST CATCHMENT AREA (ha)	% CHANGE	COMMENT
DR-A – 03	0.099	0.142	43.8	Increase from bridge widening. Despite the significant increase in the drainage catchment area of 43%, this constitutes a negligible increase (i.e. 0.7%) compared to the total area of the catchments discharging to DS connection pit JNDP_248.
JNDP_248	6.503	6.546	0.7	Connection point downstream of DR-A-03. The change in the drainage catchment area includes the change in connection point DR-A-03.
JNDP_8	3.412	3.416	0.1	Increase from bridge widening but insignificant to total catchment area south-east of bridge.
JNDP_156	0.074	0.08	7	Increase from bridge widening but insignificant to total catchment at DS connection point JNDP_291.
JNDP_291	2.008	2.015	0.3	Increase from bridge widening, insignificant to total catchment area south-east of bridge.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A climate change sensitivity assessment has been carried out. A rainfall increase of 20 per cent was assumed as representing the RCP 8.5 upper limit.

This demonstrated that the new drainage would provide a 1 per cent AEP flood immunity to the new bridge and approaching roads.

JUNEE STATION PEDESTRIAN BRIDGE

The proposal would remove the existing Junee Station pedestrian bridge and would not have any permanent structures in yard; as such, this site has not been carried forward for further assessment.

JUNEE YARD CLEARANCES

The proposal involves changes to the horizontal alignment (up to 440mm) of the loop line and would be built to the same vertical alignment as the existing track.

As anticipated in section 4.6.4.4 the proposal site is not affected by regional or overland flooding.

There are no changes to the drainage catchment of the site; therefore, no flood impacts are expected to occur as a result of the proposal.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A climate change assessment is not required as there is no change to the existing drainage conditions.

OLYMPIC HIGHWAY UNDERBRIDGE

The proposal involves changes to the horizontal alignment (up to 95mm) to achieve the required clearances, and adjustments to the existing underbridge. There are no changes to the existing Olympic Highway road culvert or existing rail culvert (located at chainage 484,185m).

As discussed in section 4.6.4.3, the proposal site is not affected by regional or overland flooding.

Proposed enhancement works do not change the existing drainage catchment nor drainage discharge conditions.

A climate change assessment is not required as there is no change to the existing drainage conditions for the site.

JUNEE TO ILLABO CLEARANCES

The proposal involves changes to the horizontal alignment and vertical alignment for around 15.4km of track, which would require some shoulder widening and adjustments to drainage. The proposal would involve changes to vertical alignment up to a nominal lift of 50mm.

New transverse rail culverts would replace the existing culverts, as indicated in Table 5.14.

Table 5.14 Culvert replacement for the Junee to Illabo enhancement site

EXISTING CULVERT ID	DESIGN CULVERT ID / CHAINAGE (m)	SIZE (mm)	COMMENT
S00100440469.370SC	469,370	0.6H x 1.2W RCBC	Like for like replacement
S00100440469.792SC	469,792	0.6H x 1.2W RCBC	Like for like replacement
S00100440472.406SC	472,406	0.6H x 0.6W RCBC	Like for like replacement
S00100440476.988UB	476,988	9.375W x 25H	Replace with equivalent standard RCBC

IMPACT ASSESSMENT

As discussed in section 4.6.4.6, this section lies within the Murrumbidgee catchment but is not subject to regional flooding.

The drainage assessment for culverts that would be replaced is provided in Table 5.15. The drainage modelling assessment shows that there are negligible changes in culvert flow discharge.

Table 5.15 Culvert replacement flow capacity at Junee to Illabo site

EXISTING CULVERT ID	CULVERT CHAINAGE	EXISTING		PROPOSED		DIFFERENCE IN CULVERT DISCHARGE (m^3/s)
		Culvert peak discharge (m^3/s)	Bypass flow (m^3/s)	Culvert peak discharge (m^3/s)	Bypass flow (m^3/s)	
S00100440469.370SC	469.367	1.51	1.42	1.51	1.42	0.00
S00100440469.792SC	469.790	0.96	0.	0.96	0.0	0.00
S00100440472.406SC	472.410	0.92	0 73	0.92	0 73	-0.00
S00100440476.988UB	476.988	44.984	0.00	44.978	0.00	-0.006

At culverts that would be replaced, flood levels have been assessed to understand changes in flood levels upstream and downstream of rail.

Table 5.16 compares the maximum flood levels upstream of the culverts, subject to replacement for the baseline and proposed enhancement work conditions. The assessment identified that no adverse afflux upstream of the proposed culvert replacements would occur as a result of the proposal.

As indicated in Table 5.16, there is no change to the existing rail flood immunity at the culverts subject to replacement.

All overland flow paths and overtopping points would be unaffected, and the drainage/flooding patterns are therefore unchanged. The proposed track immunity in the vicinity of the works is therefore unchanged from the baseline.

Table 5.16 Culvert replacement flood level – afflux for the Junee to Illabo enhancement site

EXISTING CULVERT ID	CHAINAGE (km)	TRACK LEVEL (mAHD)	BYPASS LEVEL (mAHD)	BASELINE	PROPOSED	AFFLUX 1%AEP
				1%AEP	1% AEP	
S00100440469.370SC	469.367	271.58	270.650	Up 270.95 Ds 270.49	Up 270.95 Ds 270.49	0
S00100440469.792SC	469.790	277.01	276.00	Up 275.95 Ds 275.64	Up 275.95 Ds 275.64	0
S00100440472.406SC	472.402	294.18	295.53	Up 295.51 Ds 294.71	Up 295.51 Ds 294.71	0
S00100440476.988UB	476.988	310.35	313.50	Up 312.48 Ds 311.38	Up 312.16 Ds 311.28	- 0.32

The model results confirm no adverse afflux upstream or downstream of the proposed culverts.

CLIMATE CHANGE SENSITIVITY ASSESSMENT

A 20 per cent sensitivity assessment has been undertaken. This selected sensitivity is based on to the year 2090 and RCP 8.5, as per the ARR2019 Data Hub, and is suitable as an upper limit for climate change. The assessment demonstrated that rail flood immunity would be reduced in a climate change scenario.

Table 5.17 Culvert replacement flood level – afflux at Junee to Illabo site

EXISTING CULVERT ID	CHAINAGE	TRACK LEVEL (mAHD)	1% AEP HWL (mAHD)	1% AEP + CC HWL (mAHD)	DH (m)
S00100440469.370SC	469.370	271.58	270.95	271.06	0.11
S00100440469.792SC	469.790	277.01	275.95	276.05	0.10
S00100440472.406SC	472.410	296.13	295.51	295.59	0.08
S00100440476.988UB	476.990	313.4	312.16	312.56	

5.1.2.5 HYDRAULIC STRUCTURE BLOCKAGE FACTORS

The flood models received from councils did not include blockage factors for drainage structures such as waterway bridges, culverts and pipe crossings of road and rail corridors. This was not altered in the flood modelling analyses undertaken for this assessment to ensure the analysis was consistent with council baseline models. If blockage is to be considered, the same blockage factors would be applied to both baseline and design conditions. The effect would be to raise flood levels in both cases, and the impacts of the works would therefore be very similar in both the blocked and unblocked scenarios. At the detailed design stage consultation will be undertaken with councils to determine if blockage should be applied to update the existing flood models to reflect the latest ARR2019 guidelines.

For the drainage design standard blockage factors were included in the design, including 20% blockage for on grade pits and 50% blockage for sag pits.

5.1.2.6 SUMMARY OF OPERATIONAL PHASE IMPACTS FOR ALL SITES

FLOOD HAZARD AND HYDRAULIC FUNCTION

As described in sections 5.1.2.1 to 5.1.2.4 the works have negligible effects on the existing flood conditions and mechanisms. There is no change to the existing flood hazards and hydraulic functions (i.e., conveying and storing water) of the floodplain as shown in Table 5.18.

Where the proposal results in changes to flood behaviour on classified roads managed by TfNSW, the impacts would satisfy the QDLs proposed for the proposal.

Table 5.18 Impact to Flood hazard and hydraulic function

SITE	PROPOSED WORK	FLOODING	FLOOD HAZARD AND HYDRAULIC FUNCTION IMPACT
Albury Sites			
Murray River bridge	Proposed works involve the bridge superstructures (i.e., above the bridge deck). There is no interaction with the flood mechanisms.	Proposed works are not affected by flooding	No change in flood hazard nor hydraulic functions.

SITE	PROPOSED WORK	FLOODING	FLOOD HAZARD AND HYDRAULIC FUNCTION IMPACT
Albury Station Yard clearances and Albury Station pedestrian bridge	Replacement of existing bridge and change to horizontal and vertical alignment.	The proposal site is not subject to flooding up to and including the 1 per cent AEP flood event as described in section 4.6.1.2. The site is affected by overland flooding in the PMF. In the PMF flood event, flood depths are up to 1m.	As the proposed works are not affected by flooding up to the 1 per cent AEP flood event there is no change in flood hazard or hydraulic function up to and including this event. In the PMF flood event the change in the vertical alignment (up to 50mm) has negligible effects on the flood hazard and hydraulic function as most of the urban area nearby is affected by overland flooding with flood depths greater than 1m.
Riverina Highway bridge	Track lowering.	The proposal site is affected by overland flooding.	The hydraulic analysis demonstrated no change in the flood conditions. Thus, there is no change to the flood hazard and hydraulic function.
Billy Hughes bridge	Track lowering.	The site is not flood affected up to the 1 per cent AEP flood event.	The hydraulic analysis demonstrated that the small change in the drainage catchment does not change the flood hazard or hydraulic function. Refer to section 5.1.2.1 for further details.
Table Top Yard	Removal of a signal gantry	Not relevant for the type of work.	Not relevant for the type of work.
Greater Hume Lockhart			
Culcairn Yard clearances and pedestrian bridge	Removal of the existing pedestrian bridge and changes to horizontal and vertical alignment.	Proposed works are not affected by overland flooding up to and including the 1 per cent AEP flood event (refer to section 4.6.2.1 for further details on flood conditions).	As the proposed works are not affected by overland flooding up to and including the 1 per cent AEP flood event there is no change to the flood hazard and hydraulic function. In the PMF flood event the site and the surrounding areas are affected by flooding with flood depth greater than 1m (refer to Figure 4.19). Thus the minor change in the vertical alignment (up to 75mm) has negligible effects on the PMF flood conditions and associated hazard and hydraulic function.

SITE	PROPOSED WORK	FLOODING	FLOOD HAZARD AND HYDRAULIC FUNCTION IMPACT
Henty Yard clearances	Changes to the horizontal and vertical alignment (up to 50mm) of the rail track to achieve the required clearances. New cess drainage would be provided for the shifted rail formation, and would tie into the existing cess upstream and downstream of the enhancement site	The site is not affected by flooding up to the PMF flood event.	As the site is not affected by flooding there are no changes to the flood hazard nor hydraulic function.
Yerong Creek Yard clearances.	The proposal would involve changes to the horizontal and vertical alignment (up to 50mm) of the rail track to achieve the required clearances.	The site is not documented to be affected by regional or overland flooding (refer to section 4.6.2.3 and section 5.1.2.2 for further details)	No change to flood hazard or hydraulic functions.
The Rock Yard clearances	Modification of a signal gantry	Not relevant for the type of work	Not relevant for the type of work
Wagga Wagga sites			
Uranquinty Yard clearances	Changes to the horizontal alignment (up to 550mm) and vertical alignment (up to 50mm) of the rail track to achieve the required clearances and to ensure compliant ballast depths	The site is affected by overland flooding.	Hydraulic modelling demonstrated no change in flood hazard nor hydraulic function as a result of the proposed works (refer to section 5.1.2.3 for further details).
Pearson Street Bridge	Track lowering to provide a minimum of 7.1 metres vertical clearance to the existing bridge.	The site is affected by overland flooding.	Hydraulic modelling demonstrated no change in flood hazard nor hydraulic function as a result of the proposed works (refer to section 5.1.2.3 for further details).
Wagga Wagga sites and surrounds	Changes to the horizontal alignment and vertical alignment (up to 80mm) of the rail track to achieve the required clearances and replacement of the Edmondson Street bridge to provide the required vertical clearances	The site is affected by overland flooding.	Hydraulic modelling demonstrated no change in flood hazard nor hydraulic function as a result of the proposed works (refer to section 5.1.2.3 for further details).

SITE	PROPOSED WORK	FLOODING	FLOOD HAZARD AND HYDRAULIC FUNCTION IMPACT
Bomen Yard clearances	Changes to the vertical alignment of the rail track to achieve the required clearances (up to 50mm)	The site is affected by overland flooding as described in section 4.6.3.3.	Proposed drainage work mimics the existing conditions (i.e., no change to drainage catchments). The minor change in the vertical alignment has negligible effects on the overland flood conditions as explained in section 5.1.2.3. Thus, there is no expected change in flood hazard or hydraulic functions.
Junee			
Harefield Yard clearances	The proposal involves changes to the horizontal alignment (up to 457mm) and vertical alignment (up to 75mm, with an average lift of 43mm) to achieve the required clearances.	The site is not impacted by flooding.	As the site is not affected by flooding there is no change to flood hazard or hydraulic function
Kemp Street bridge	Replacement of the existing bridge to provide sufficient vertical clearances	The site is not impacted by flooding (refer to section 5.1.2.4)	As the site is not affected by flooding there is no change to flood hazard or hydraulic function.
Junee Station pedestrian bridge	Removal of the existing Junee Station pedestrian bridge	Not relevant for the type of work.	Not relevant for the type of work.
Junee Yard clearances	Changes to the horizontal alignment (up to 440mm) of the loop line and would be built to the same vertical alignment as the existing track	The site is not impacted by flooding (refer to section 5.1.2.4)	As the site is not affected by flooding there is no change to flood hazard or hydraulic function.
Olympic Highway underbridge	Changes to the horizontal alignment (up to 95mm) to achieve the required clearances	The site is not impacted by flooding (refer to section 5.1.2.4)	As the site is not affected by flooding there is no change to flood hazard or hydraulic function.
Junee to Illabo clearances.	Changes to the horizontal alignment and vertical alignment for around 15.4km of track	The site is not impacted by regional flooding (refer to section 5.1.2.4).	The drainage assessment included in Section 5.1.2.4 demonstrated no change in flood hazard or hydraulic functions.

VELOCITY AND SCOUR

As described in sections 5.1.2.1 to 5.1.2.4, the works have no, or negligible, impact on flood velocities in the watercourses and receiving systems downstream of the sites, and would therefore not cause scour, erosion or sedimentation in the downstream systems.

Where drainage system modifications are required, appropriate scour protection measures have been provided at outlets and transitions to the receiving systems and have been designed in accordance with the methodology described in section 3.3.7. Table 5.19 lists the sites and infrastructure elements that have incorporated new scour protection measures.

The works do not require modifications of piers, abutments or other sub-structural elements of bridges that span waterways and, therefore, no impacts on scouring and erosion in waterways are anticipated.

Table 5.19 Scour protection measures

PACKAGE	SITE	SCOUR PROTECTION
Albury	Murray River bridge	No scour protection required
	Albury Yard clearances and Albury Station pedestrian bridge	No scour protection required
	Riverina Highway bridge	Scour protection has been provided (riprap D50= 150mm)
	Billy Hughes bridge	Scour protection has been provided (riprap D50= 150mm)
Greater Hume – Lockhart	Culcairn Yard clearances and Culcairn pedestrian bridge	No scour protection required
	Henty Yard clearances	No scour protection required
	Yerong Creek Yard clearances	No scour protection required
	The Rock Yard clearances	No scour protection required
Wagga Wagga	Uranquinty Yard clearances	No scour protection required
	Pearson Street bridge	Scour protection has been provided (riprap D50= 150mm)
	Wagga Wagga Yard clearances	No scour protection required
	Edmondson Street bridge	No scour protection required
	Bomen Yard clearances	No scour protection required
Junee	Harefield Yard clearance	No scour protection required
	Olympic Highway underbridge	No scour protection required
	Kemp Street bridge	No scour protection required
	Junee Yard clearances	No scour protection required
	Junee to Illabo clearances	Rip rap protection has been provided at all culvert inlet/outlets and turnouts from cess channels and catch drains. Riprap size D50=150mm has been adopted.

CONSISTENCY WITH COUNCIL FLOODPLAIN RISK MANAGEMENT PLANS

Relevant flood mitigation measures included in the councils FRMPs are listed in Table 5.20. Flood mitigation measures have been reviewed to assess possible interaction with the proposed enhancement works.

Table 5.20 Floodplain Risk Management Plans – Council proposed mitigation measures

PACKAGE	SITE	FLOOD RISK MANAGEMENT PLAN	PROPOSED MITIGATION PROPOSED RELEVANT TO THE PROPOSAL
Albury	Murray River bridge	Albury Floodplain Risk Management Study and Plan, WMA water 2016	South Albury levee upgrade (FM08)
	Albury Yard clearances and Albury Station pedestrian bridge	Albury Floodplain Risk Management Study and Plan, WMA water 2016	None
	Riverina Highway bridge	Albury Floodplain Risk Management Study and Plan, WMA water 2016	None
	Billy Hughes bridge	Albury Floodplain Risk Management Study and Plan, WMA water 2016	None
Greater Hume – Lockhart	Culcairn Yard clearances and pedestrian bridge	Culcairn Floodplain Risk Management Study and Plan, 2017	Clearing of Billabong Creek channel vegetation management Southern flow path, lowering Olympic Highway Mitigation Billabong Creek channel flooding Southern flow path flood mitigation
	Henty Yard clearances	Henty Floodplain Risk Management Study and Plan, WMAwater 2017	Increase Culvert conveyance 200m north of Buckargingah creek East Henty levee Henty combined levee system Straightening Buckargingah Creek Increased Buckargingah Creek bridge capacity
	Yerong Creek Yard clearances	The Rock Floodplain Risk Management Study and Plan, Lockhart Shire Council, 2014 Lockhart Floodplain Risk Management Study and Plan, Lockhart Shire Council, 2014	None

PACKAGE	SITE	FLOOD RISK MANAGEMENT PLAN	PROPOSED MITIGATION PROPOSED RELEVANT TO THE PROPOSAL
	The Rock Yard clearances	The Rock Floodplain Risk Management Study and Plan, Lockhart Shire Council, 2014	Semmens Lane levee Drainage on Emily Street and Semmens Lane Direct drainage pipe on Emily Street, Nicholas Street levee Downstream drainage upgrade Increase culvert capacity beneath Railway and Olympic Highway and replace private access bridge
Wagga Wagga	Uranquinty Yard clearances	Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan, 2021 Tarcutta, Ladusmith and Uranquinty Floodplain Risk Management Studies and Plans, 2020	Uranquinty levee system upgrade Deane and Connorton levee raised with channel improvement Levee system raised with bypass channel improvements Upgraded Culverts at Uranquinty Cross Road Concrete channel section in Sandy Creek Sandy Creek regular clearing of sedimentation
	Pearson Street bridge	Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan, 2021	Red Hill Road and Glenfield Road basin Adjin Street and Maher Street intersection civil works Anderson Oval basin and swale augmentation Rabaul Place trunk drainage line
	Wagga Wagga Yard clearances	Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan, 2021	Road raised downstream of the lake by 2m 3x1.8m trunk drain from railway underpass
	Edmondson Street bridge	Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan, 2021	3x1.8m trunk drain from railway underpass
	Bomen Yard clearances	Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan, 2021	None

PACKAGE	SITE	FLOOD RISK MANAGEMENT PLAN	PROPOSED MITIGATION PROPOSED RELEVANT TO THE PROPOSAL
Junee	Harefield Yard clearances	Jeralgambeth Creek at Illabo – Floodplain Risk Management Study and Plan	None
	Kemp Street bridge	Jeralgambeth Creek at Illabo – Floodplain Risk Management Study and Plan	None
	Junee Yard clearances Olympic Highway underbridge	Jeralgambeth Creek at Illabo – Floodplain Risk Management Study and Plan	None
	Junee to Illabo clearances	Jeralgambeth Creek at Illabo – Floodplain Risk Management Study and Plan	Levee along banks of creek Riparian corridor/Improved channel

The flood impact assessment described in sections 5.1.2 to 5.1.2.4 of this report confirmed that flood impacts caused by the proposed enhancement works satisfy the QDL set out in section 3.3.6.

The flood impact assessment described in sections 5.1.2 to 5.1.2.4 demonstrated that:

- the proposed enhancement works do not cause impacts to the regional flood conditions
- in the areas where the sites are affected by overland flooding, the proposed enhancement works have been designed to maintain the existing flow paths (and floodway). For these sites, only negligible flood impacts are expected; therefore, there are no changes to the overall flood behaviour; and
- where required (and possible) local drainage features (i.e. cross drainage extensions, cess drains, cut-off drains, etc.) have been implemented to manage runoff within and through the rail corridor. These features improve the existing drainage conditions.

As the proposal is not expected to cause changes to the flood behaviour, the flood mitigation measures proposed in the council floodplain risk management plans are not expected to be affected by the enhancement works. The low flood impacts of the proposal, and the proposed drainage improvements, are consistent with state and local government flood management policies and plans.

IMPACTS ON FLOOD EMERGENCY MANAGEMENT PLANS AND ENGAGEMENT

As demonstrated in the previous sections the proposal would not change flood behaviour or flood risk to sensitive assets such as residences, community facilities and roads that would be used for emergency evacuation or access. Existing council and SES flood emergency management plans would therefore not be affected and would not require updating to account for flood risk changes caused by the proposal. Therefore, specific consultation with council or SES is not considered necessary.

ARTC has maintained ongoing engagement with emergency management groups throughout the development of the EIS and reference design where possible, including presentations to:

- the Riverina Murray Regional Emergency Management Committee (REMC's) to provide a high-level project update, the potential issues/concerns in the Region regarding Inland Rail and design milestones and developments at key sites and interfaces in November 2020, March 2021 and July 2021. No flooding specific feedback was received
- the Junee LEMC (Local Emergency Management Committee) was briefed in April 2021 and April 2022. No flooding specific feedback was received
- the NSW SES has been included on the project mailing list and has been sent project updates as the project has progressed. No feedback has been provided.

ARTC would continue to carry out engagement with these emergency management groups through regular project updates and planned committee meetings. Targeted engagement with the NSW SES and NSW SES Community Action Teams would be pursued to advise of the key outcomes of the hydrology and flooding assessment and any feedback would be considered and documented in the response to submissions report.

Throughout the development of the reference design and EIS, ARTC has led engagement with each council at each design gate (30%, 70% and 100%). During this engagement, an overview of the findings of the EIS assessment at each design gate was presented to the council's, which included hydrology and flooding matters where appropriate. As documented in Appendix F: Engagement report of the EIS, flooding was raised as a key issue by government officials/ agencies and several key stakeholders raised particular concern about flooding impacts at track lowering sites. During operation, there would be negligible change to the flood hazard and hydraulic function of the floodplain where the vertical alignment of existing track has been altered. Where track lowering is proposed, the design would provide flood immunity up to the 1 per cent AEP flood event.

SOCIAL AND ECONOMIC COSTS OF FLOOD IMPACTS

The proposed enhancement works have been designed to maintain the existing overland flow paths and mimic the existing drainage conditions; as such, it is expected that there would be no flood-related social or economic impacts as a result of the proposed works.

5.2 HYDROLOGY

5.2.1 CONSTRUCTION

5.2.1.1 HYDROLOGICAL REGIME

During construction, some temporary localised flow diversions may be required to install new culverts and cess drains or to facilitate earthworks adjacent to existing drainage lines and overland flow paths. Such diversions would aim to preserve the existing points of stormwater discharge from the rail corridor and avoid changing discharge points or diverting flows from one sub-catchment into another, as identified in the mitigation measures in Chapter 7. Hydrologic regime impacts during the construction phase are therefore expected to be negligible.

5.2.1.2 EROSION, SEDIMENTATION AND WATERCOURSE STABILITY

As the downstream hydrologic regimes and stormwater discharges from the rail corridor would not be altered significantly during construction, there are no risks of increased erosion, sedimentation or destabilisation of watercourses downstream of the sites.

Any culverts or cess drains subject to modification would include scour protection measures at outlets and points of discharge to locally manage any potential scour impacts. Standard erosion and sediment control measures would be applied during construction, as detailed in Chapter 7, to minimise impacts in downstream receivers.

5.2.1.3 STORMWATER AND WASTEWATER DISCHARGES

During construction, the temporary works would preserve existing drainage discharge locations with minor localised diversions as required within the rail corridor to facilitate drainage infrastructure modifications. The construction works would maintain existing locations of stormwater discharges from the rail corridor.

Wastewater from construction worker facilities would be locally managed at the sites and disposed of offsite with no additional wastewater discharges to the downstream environment.

5.2.1.4 WATER AVAILABILITY AND WATER TAKE

It is estimated that about 56.9 megalitres (ML) of water would be required over the course of construction. Water would be required during construction to control dust, compact soil, undertake site concrete works, and for site amenities (toilets, sinks, showers, drinking). All material would be moisture conditioned prior to the importation from quarries to minimise water demand for dust suppression.

During construction, water would be sourced from:

- in the vicinity of Albury, Albury City Council and quarry sources. Alternative sources include seeking groundwater extraction licences and bores if other sources do not prove viable
- for works in the Greater Hume, Lockhart and Wagga Wagga local government areas, water would be sourced from the Riverina Water and quarry sources
- for Junee, water would be sourced from the Junee Council Recycled Water, Goldenfields Water, Riverina Water and quarry sources.

Alternative sources include seeking groundwater extraction licences and bores if other sources do not prove viable.

No new surface water extractions or harvesting of stormwater is proposed. The total amount of water required for the proposal is not anticipated to have an impact on the overall water supply for the region. Water availability for users downstream of the works sites would therefore be unaffected.

About 0.7ML of groundwater and 11.4ML of groundwater would be taken from the Upper Murray groundwater source and Lachlan Fold Belt MDB groundwater source respectively under a water access licence as a result of excavation works at the Riverina Highway Bridge and Kemp Street bridge enhancement sites respectively.

As assessed in Chapter 19: Groundwater of the EIS report, the potential groundwater take for the proposal would not impact the current water balance for this groundwater source. Opportunities to re-use this water take would be investigated during detailed design.

5.2.1.5 WATER BALANCE

Table 5.21 provides an indicative construction water balance for the proposal. Most of the water used for construction activities would either be used by the activity or product (e.g. go into ground for compaction, be used for dust suppression or concrete) or would evaporate. Potential surface water runoff from construction activities would be managed by standard erosion and sediment controls.

Any additional flow and infiltration would be negligible compared to regional rainfall levels based on the proposed water uses and the rainfall data.

Table 5.21 Indicative construction water balance

PRECINCT	WATER DEMAND (ML)
Demand	
Albury	9.7
Great Hume- Lockhart	3.4
Wagga Wagga	13.5
Junee	30.3
Total demand	56.9

PRECINCT	WATER DEMAND (ML)
Supply – Groundwater dewatering[1]	
Albury	0.7
Junee	11.4
Total supply	12.1
Difference	**44.8 ML**

1. Use of groundwater sourced during excavation works would be considered during detailed construction planning to determine suitability for use

5.2.2 OPERATION

5.2.2.1 HYDROLOGIC REGIMES

Changes to the hydrological regime of a watercourse or drainage network could occur due to new or modified drainage arrangements within the proposal site, resulting in:

- changes to the sub-catchment or land uses, which results in changes in downstream flows
- re-distribution and diversion of surface runoff through or from the proposal site.

In most cases, the proposal does not result in changes to the existing drainage arrangements and, as such, there would not be any impacts to the hydrological regime of the stormwater drainage network or receiving waterway. Where changes would occur to drainage catchments or overland flows, these changes are considered to be minor and would not have a significant impact on the hydrological regime.

Table 5.22 Operational impacts on downstream hydrological regimes

SITE NAME	SENSITIVE RECEIVING ENVIRONMENT	DISCUSSION
Murray River bridge	Murray River and Oddies Creek	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff distribution.
Albury Yard clearances	–	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff distribution.
Riverina Highway bridge	–	The proposal would alter the drainage arrangements within the corridor. This would result in a minor change to the flows discharged into the stormwater drainage network. As this would mimic the existing arrangement, there are no expected impacts.
Billy Hughes bridge	–	The proposal would alter drainage arrangements, which would result in a minor increase in catchment area (i.e. 0.6ha) but would not result in the redistribution or diversion of surface runoff through or from the site. The drainage assessment shows a 3.7% change in flows to the unnamed drainage line. As the drainage line is a tributary of Eight Mile Creek, the surface water would continue to flow to Eight Mile Creek and would not alter the overall hydrological regime of the waterway.
Table Top Yard clearances	–	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff distribution.

SITE NAME	SENSITIVE RECEIVING ENVIRONMENT	DISCUSSION
Culcairn Yard clearances	–	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff distribution.
Henty Yard clearances	Buckargingah Creek, Henty	New cess drainage would be required to manage runoff from the new rail formation. This would connect to mimic the existing flow conditions. There would be limited changes to the drainage catchment, which would manage the local platform surface water run-off; however, this would not result in the redistribution or diversion of surface runoff through or from the site. Given the minor changes, there would be no hydrological regime impact.
Yerong Creek Yard clearances	Yerong Creek and Sandy Creek	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff distribution.
The Rock Yard clearances	–	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff distribution.
Uranquinty Yard clearances	Sandy Creek	The modified drainage arrangements at this site would not change the catchment or alter drainage flow paths. As the receiver is located downstream of a large catchment, of which a portion of this is urbanised and the site catchment is a small portion of this wider urban catchment, changes in the hydrological regime at the site would have a negligible impact on the receiver.
Pearson Street bridge	–	The rail corridor currently discharges to Glenfield Drain; however, the proposal would formalise this discharge. This would result in very minor changes to the discharges to Glenfield Drain (e.g. less than 0.003% in the 1% AEP event) and would have a negligible change in the hydrological regime. There would be minor change in overland flow due to proposed bund. Given this would occupy less than 0.004% of the upstream flood area, there would be negligible change in the hydrological regime.
Cassidy Parade pedestrian bridge, Edmondson Street bridge, Wagga Wagga Station pedestrian bridge and Wagga Wagga Station Yard clearances	–	At these enhancement sites, there would be minor changes to the local drainage catchment associated with Edmondson Street bridge; however, the drainage would be maintained with no change in flood conditions. As such, there would be no change to the hydrological regime. At Wagga Wagga Station Yard Clearances there is a minor re-distribution of the flow that causes afflux to the industrial area at the east. This re-distribution in flow is considered minor and have negligible effects in the hydrological regime. Further detail flood modelling would be completed at detail design.
Bomen Yard clearances	–	Minor changes to the drainage infrastructure at this site would not alter drainage catchments or surface water runoff behaviour; as such, there would be no impacts to the hydrological regime.

SITE NAME	SENSITIVE RECEIVING ENVIRONMENT	DISCUSSION
Harefield Yard clearances	–	Cess drainage has been provided, which would discharge to existing shallow drainage lines at various locations. This would have no impact to the hydrological regime as it would not alter drainage catchments or redistribute surface water flows.
Kemp Street bridge	–	New road drainage would be provided in for the replacement bridge. This would connect and discharge to the existing council stormwater drainage network. There would be a minor change to the sub-catchment but this would not have an impact on the hydrological regime, noting that this represents 0.7% of the total catchment area.
Junee Yard clearances	–	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff.
Junee Station pedestrian bridge	–	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff.
Olympic Highway underbridge	–	No impact to hydrological regime as there would be no changes to drainage arrangements, catchments or surface runoff.
Junee to Illabo clearances	Jeralgambeth Creek	New or modified transverse rail culverts would replace existing culverts but the proposal would not alter catchments or redistribute surface water flows.

5.2.2.2 WATER BALANCE

As there are no significant changes to hydrological regimes downstream of the sites in the operational phase, there are no impacts on the water balance within the downstream catchments; therefore, no water balance modelling and analysis to determine impacts is necessary.

5.2.2.3 WATER AVAILABILITY AND WATER TAKE

The proposal would have negligible impacts on surface water hydrologic regimes and would not alter downstream surface water availability and water supply. The enhancement sites would not take surface water from the environment in the operational phase.

5.2.2.4 STORMWATER DISCHARGES

The enhancement works have been designed to closely mimic the existing stormwater drainage arrangements at the sites. Minor increases in downstream flows would occur at some sites but these would connect to existing stormwater systems that drain catchments significantly larger than the rail corridor sub-catchments. The operational phase would not involve wastewater discharges from the sites.

5.2.2.5 EROSION, SEDIMENTATION AND WATERCOURSE STABILITY

The downstream hydrologic regimes and stormwater discharges from the rail corridor would not be significantly altered by the proposal. Any culverts or cess drains subject to modification or replacement would include scour protection measures at outlets and points of discharge to locally manage any potential scour impacts.

5.3 WATER QUALITY

5.3.1 CONSTRUCTION

The construction of the proposal would involve a variety of construction activities at each of the proposal sites. These activities have the potential to impact the water quality of the surrounding environment if not appropriately managed. Construction of the proposal may cause the release of the following pollutants into waterways:

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

High-risk sites in the proposal are those located over or adjacent to watercourses, and which would involve any vegetation clearance and ground disturbance. These include the Murray River bridge site, over the Murray River; Billy Hughes bridge near Eight Mile Creek; Henty Yard clearances near Buckargingah Creek; Uranquinty Yard clearances over Sandy Creek; and the Junee to Illabo clearances over Jeralgambeth Creek.

The following sections describe potential impacts and the associated construction activities, the applicable sites and receiving waterways, and the potential water quality impacts that may result from these activities.

5.3.1.1 EROSION AND SEDIMENTATION

A number of construction activities would present a risk of increasing exposed soils and run-off volumes and, therefore, increasing pollutant, sediment load or organic matter entering receiving waterways. This, in turn, may lead to increased turbidity, lowered dissolved oxygen levels and increased nutrients in water ways, and reduction in channel habitat from sediment transport and deposition. Construction activities that present a risk of impacts from erosion and sedimentation are as follows:

- stripping topsoils for site preparation – this may destabilise soils and increase risk of erosion and soil transport to receiving waterways
- vegetation removal – removal of vegetation and root systems would destabilise soils and expose remaining soils to wind and rain, and therefore increase the risk of erosion
- construction of site access roads, crane pads, construction compounds and other site infrastructure – soil compaction for these construction areas may lead to increased volume of run-off and velocities, which may increase erosion potential in and around the construction site
- track realignment, including removal, treatment and fill of formation – disturbance of soils that may be transported to waterways and potential release of contamination
- excavations, including cut, fill and piling – these activities would cause direct disturbance of soils that have the potential to be impacted due to erosion of soils during rainfall events by runoff. This can result in sedimentation of downstream drainage lines through mass movement of soils
- ground disturbance for removal of rail infrastructure. This would be required at all sites, although the level of disturbance would be higher at sites that require track realignment

- disturbance in waterway for construction of culverts and bridges through waterways – would expose and potentially destabilise the banks of waterways, causing increased likelihood of erosion and sedimentation
- stockpiling and transport of materials and soils – presents risk of runoff of contaminants and sediments from stockpile if materials are not properly contained and stabilised in the stockpile.

High-risk sites in the proposal are those located over or adjacent to watercourses. These include the Murray River bridge site, over the Murray River; Billy Hughes bridge near Eight Mile Creek; Henty Yard clearances near Buckargingah Creek; Uranquinty Yard clearances over Sandy Creek; and the Junee to Illabo clearances over Jeralgambeth Creek.

Potential impacts from erosion and sediment impacts would be accounted for in the Construction Environmental Management Plan (CEMP) and associated Soil and Water Management Plan (SWMP). Site-specific erosion and sediment control plans would be required at each proposal site to manage and minimise the risks of impacts to water quality. These would include requirements for progressive erosion and sediment control measures such as sediment fences, silt traps and bunds. These plans would be prepared in accordance with the Blue Book (Landcom, 2004). Rainfall events for the sediment and erosion control measures would be defined in accordance with the Blue Book.

Implementation of appropriate soil and water construction management measures would minimise impacts to water quality impacts from erosion and sedimentation during construction of the proposal. Additionally, impacts would be limited to the duration of construction and would be short term; as such, construction of the proposal would not cause significant changes to the water quality environment.

5.3.1.2 CONCRETING

Concrete pumps and agitators would be used at a number of sites for construction of new or modified infrastructure. These sites include Albury Station pedestrian bridge, Tabletop Yard Clearances, Culcairn, Henty and Yerong Creek Yard clearances, Pearson Street bridge, Cassidy Parade pedestrian bridge, Wagga Wagga Station pedestrian bridge and Yard Clearances, and Edmondson Street bridge.

Other sites would not require concrete pumping onsite and pre-cast concrete structures would be transported to the site.

Rainwater polluted with concrete washwater can percolate down through the soil and alter the soil chemistry, inhibit plant growth and contaminate the groundwater. These sites would require provision for containment of concrete washout. Any mobile and fixed concrete batching plants would be established with appropriate erosion and sediment controls, consistent with current best practice, which would minimise the risk of impacts as a result of concrete washout.

5.3.1.3 DISTURBANCE OF CONTAMINATION

Earthworks and track realignment works pose the risk of exposing contamination. Potential contamination would include heavy metals, TRH, BTEX, PAHs, OCPs, OPPs, PCBs and VOs that may be present in the existing rail line, sidings and ballast. Disturbance of soils would increase the risk of runoff of these contaminants to waterways and may affect the health of aquatic organisms in receiving waterways. There is also noted to be lead contamination in some rail structures, which, if not properly managed during removal, may pose a risk to water quality. A risk assessment would be carried out prior to commencing earthworks and contaminated materials would be managed in accordance with the Waste Management Plan and Soils Management Plan. Implementation of proper mitigation measures would minimise the risk of contamination entering the waterways.

5.3.1.4 SPILLS AND LEAKS

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

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

These activities are likely to be carried out at all proposal sites. Pollutants from these activities may be picked up in runoff from the site, and enter the waterways and be transported downstream of the proposal. Water quality and ecological impacts may result from release of these contaminants into the catchment. Mitigation and management measures would be implemented as part of the design and planning of the construction phases. This would reduce the potential for release of chemicals from construction sites and into waterways.

5.3.1.5 STOCKPILING AND GENERAL LITTER

The construction of the proposal would generate spoil and other wastes that would be stored in stockpiles. Materials that may be generated through the construction phase would include vegetation waste, general construction and demolition waste, and excess spoil from bulk earthworks for embankments and piling.

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

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

General staff activities and facilities would generate gross pollutants that may enter the waterways if not properly disposed of. Staff litter and waste would be managed in accordance with the standard site waste management procedures.

5.3.1.6 NSW WATER QUALITY OBJECTIVES

The key water quality objectives for the proposal, based on the Basin Plan 2012, are to appropriately manage water quality, including salinity, for environmental, social, cultural, and economic activity and therefore protect downstream environments from the potential impacts of surface runoff and discharge during construction. The detailed water quality objectives for the proposal are defined in Appendix A.

While the risk of impacts would occur at numerous discrete sites along the alignment, there is a risk of additive impacts across the catchment. Despite this, works across the proposal site would be minor and short term, and it is anticipated that there would be minimal impacts to the existing water quality condition of the study area with the implementation of the standard mitigation measures.

As such, construction and operation of the proposal is unlikely to cause changes to the water quality environment against the identified NSW Water Quality Objectives.

5.3.2 OPERATION

Installation of new or upgraded culverts and cross-drainage structures may cause localised scour and erosion impacts during operation of the proposal. Scour protection has been provided at all relevant culverts and structures; as such, there would be no impacts to water quality from scour during operation of the proposal.

New infrastructure may cause changes to flow regimes by displacing flow or changing flow characteristics, such as velocity, which may increase runoff and sediment volumes to the receiving waterways. The proposed drainage scenario is designed to mimic existing waterway catchments, flows and flow paths; therefore, avoiding water quality impacts as a result of changes to flow regimes where practical. There are no changes to flood afflux, velocity or duration at the proposal sites and all proposal sites achieve the required drainage immunity; as such, there would be no changes to the local and regional flow regime that would cause impacts to the water quality in the surrounding environment.

Operation of the proposal has potential to release the following pollutants to the watercourses:

- sediment – from brake dust of operational trains, maintenance of access roads, changes to flow regimes and in the event that rehabilitation of disturbed areas are not effective
- chemicals, oils, grease and petroleum hydrocarbons – due to leaks and spills from maintenance and operation of freight trains; and
- gross pollutants and litter from operating vehicles.

Given the proposal sites are located along an existing rail line, these are existing risks that are managed in line with ARTC's standard operating procedures. There would not be anticipated to be any additional impacts from operation of rollingstock along the rail line and, as such, there would be no change to the existing water quality condition of the proposal study area as a result of the proposal.

5.3.2.1 NSW WATER QUALITY OBJECTIVES

The key water quality objectives for the proposal, based on the Basin Plan 2012, are to appropriately manage water quality, including salinity, for environmental, social, cultural, and economic activity, and therefore protect downstream environments from the potential impacts of surface runoff and discharge during operation. The detailed water quality objectives for the proposal are defined in Appendix A.

During the operation of the proposal there are not expected to be any activities that would generate wastewater. Stormwater runoff would be captured and released via overland flow. The operation of the proposal would not change the existing land uses and, as such, would not change the export of annual pollutant loads to downstream watercourses, and is therefore unlikely to decrease water quality. Additionally, implementation of appropriate scour protection and the design control measures would not prevent or hinder the achievement of future strategies aimed at meeting the water quality objectives. Additionally, any contribution of contaminants due to operation of the proposal is expected to be minimal.

As such, construction and operation of the proposal is unlikely to cause changes to the water quality environment against the identified NSW Water Quality Objectives.

6 CUMULATIVE IMPACT ASSESSMENT

6.1 OVERVIEW

Cumulative impacts can be defined as the successive, incremental and combined effect of multiple impacts, which may in themselves be minor but could become significant when considered together. The methodology for the cumulative impact assessment is provided in detail in Chapter 26 of the EIS.

Projects identified with sufficient information to undertake assessment of potential cumulative impacts from the proposal include:

- Adjacent sections of Inland Rail, including:
  - Tottenham to Albury (Victoria)
  - Illabo to Stockinbingal.
- Other projects, including:
  - Thurgoona Link Road
  - Nexus Industrial Precinct
  - Jindera Solar Farm
  - Glenellen Solar Farm
  - Walla Walla Solar Farm
  - Culcairn Solar Farm
  - Uranquinty Solar Farm
  - Sandy Creek Solar Farm
  - Gregadoo Solar Farm
  - Solar farm (five MW) – Uranquinty
  - Solar farm (five MW) – Bomen
  - Wagga Wagga SAP
  - Riverina Intermodal Freight and Logistics Hub
  - Olympic Highway intersection upgrades
  - Project EnergyConnect (NSW—Eastern Section)
  - HumeLink
  - Junee Station Upgrade
  - Junee to Griffith Line Upgrade
  - Illabo Solar Farm
  - Grade separating road interfaces.

6.2 CUMULATIVE IMPACTS DURING CONSTRUCTION AND OPERATION

The cumulative flood and water quality impacts assessment for both construction and operation are summarised in Table 6.1 and displayed in Figure 6.1.

Table 6.1 Cumulative impact assessment

PROJECT NAME	POTENTIAL IMPACT DURING CONSTRUCTION AND OPERATION
Inland Rail – Tottenham to Albury (Victoria)	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Thurgoona Link Road	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Nexus Industrial Precinct	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Jindera Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Glenellen Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Walla Walla Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Culcairn Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Sandy Creek Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Uranquinty Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Solar Farm (five MW) - Bomen	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Solar Farm (five MW) – Uranquinty	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Gregadoo Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Wagga Wagga Special Activation Precinct	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Riverina Intermodal Freight and Logistics Hub	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Olympic Highway intersection upgrades	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Project Energy Connect (NSW – Eastern Section)	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.

PROJECT NAME	POTENTIAL IMPACT DURING CONSTRUCTION AND OPERATION
HumeLink	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Junee Station Upgrade	Construction works for Junee Station pedestrian bridge and Yard clearances might occur at the same time as the Junee Railway Station Upgrade. If construction works occur at the same time, construction mitigation measures need to be reviewed to confirm their consistency with the overall site works. No impact during operation – both projects would not change existing drainage, flooding and hydrological processes downstream of the site.
Junee to Griffith Line Upgrade	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Illabo Solar Farm	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Inland Rail – Illabo to Stockinbingal	None – project is remote from and located in different surface water sub-catchments to the A2I enhancement sites.
Grade separating road interfaces	As the proposal would not have an impact during operation, cumulative impacts are not expected. If construction was to occur concurrently, cumulative construction impacts on water quality may occur and would need to be managed. ARTC would continue to consult with Transport for NSW to be aware of the final design solution of the grade separation project and proposed construction timeframe.

The A2I enhancement works have minimal and localised impacts on surface water that do not have regional scale effects, nor do they have the potential to have combined effects with other infrastructures projects in the region. Therefore, cumulative impacts of the A2I enhancement works and other projects in the region are not expected with respect to drainage, flooding, hydrology and surface water quality.

There is potential for cumulative impacts at the Junee site where the proposed station upgrade project may occur at the same time as the enhancement works (pedestrian bridge and yard clearances). The construction mitigation measures and plans for Junee Railway Station Upgrade and Junee Yard clearances may need to be coordinated to ensure no cumulative impacts on the local surface water environment if construction of both projects would occur at the same time.

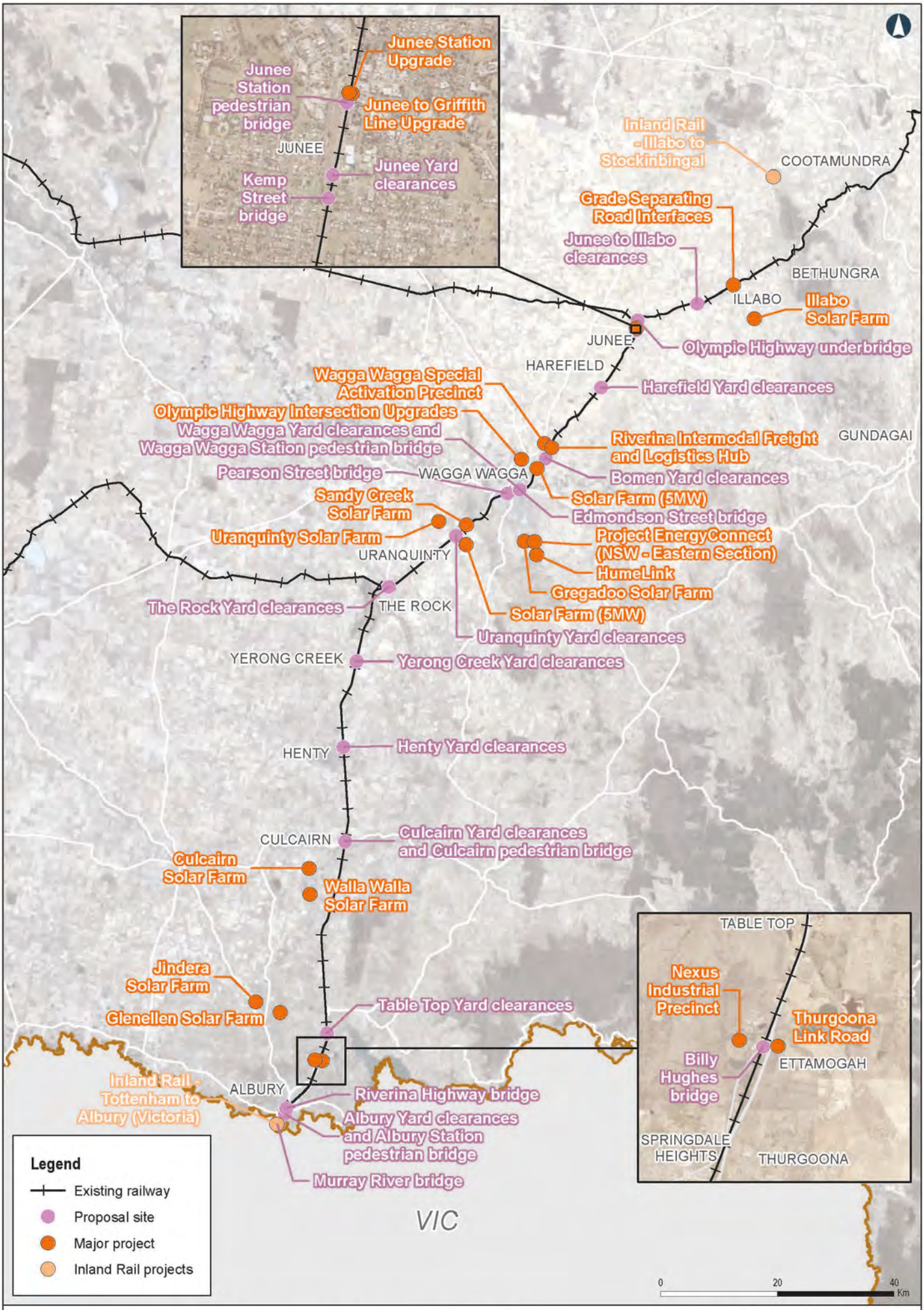

Figure 6-1 Major projects in the vicinity of the proposal

Data Sources: ARTC, NSWSS

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:850,000
Paper size: A3
Date: 24/05/2022

210_EAP_F2601_CumulativeImpacts_r1v4.mxd

7 MITIGATION AND MANAGEMENT MEASURES

7.1 APPROACH TO MITIGATION AND MANAGEMENT

Environmental management for the proposal would be carried out in accordance with the environmental management approach as detailed in Chapter 27 of the EIS (Approach to mitigation and management).

The design of the proposal has been developed in accordance with existing hydrological conditions in order to avoid flooding, drainage and water quality impacts.

As demonstrated in Chapter 5, impacts during the operation phase are expected to be compliant with the QDLs criteria, except at one location in Wagga Wagga where an increase in afflux was predicted. This impact would be further investigated during detailed design through flood modelling that includes additional drainage and topography survey data which are expected to result in a reduction in the predicted afflux.

For the construction phase, impacts are limited for the duration of the construction works. Furthermore, the proposal sites represent small areas in the wider local surface water catchments; as such, the impacts on drainage, flooding and water quality are likely to be temporary, localised and minor. Mitigation measures discussed in section 7.2 have been implemented to mitigate the potential residual impacts of the proposed enhancement works.

No baseline flow monitoring is required as the proposal would not alter downstream hydrologic regimes.

7.2 SUMMARY OF MITIGATION AND MANAGEMENT MEASURES

The mitigation measures to manage impacts to flooding and water quality from the proposal during detailed design/pre-construction, construction and operation are outlined in Table 7.1.

Table 7.1 Summary of mitigation and management measures for the proposal sites

ISSUE/IMPACT	MITIGATION MEASURE	PROJECT PHASE
Construction water supply	Construction water supply options would continue to be explored during detailed design and would include ongoing consultation with water provided to access the local reticulated network, use of water tanks within construction compounds and/or use of farm dams. Alternative water supply options, including recycled water, would also be investigated.	Detailed design/ pre-construction
Construction water supply	Opportunities to reduce the need for water would be further explored during detailed design and construction planning. Such options include: — use of additives — alternative construction techniques — reduced dust suppression regime where there is minimal potential for impacts.	Detailed design/ pre-construction

ISSUE/IMPACT	MITIGATION MEASURE	PROJECT PHASE
Flooding impacts	Further consultation would be undertaken with local councils and other relevant authorities to identify opportunities to coordinate the proposal with proposed flood mitigation works.	Detailed design/ pre-construction
Flooding impacts	At Wagga Wagga Yard enhancement site, flood modelling would be carried out during detailed design to confirm predicted afflux at industrial properties located at Railway Street and compliance with the Quantitative Design Limits for Inland Rail. This would be informed by building floor surveys (if required).	Detailed design/ pre-construction
Flooding impacts	Construction planning and the layout of construction work sites and compounds would be carried out with consideration of overland flow paths and flood risk, avoiding flood-liable land and flood events, where practicable. For the sites located in flood-prone land, and where temporary obstruction of overland flows or drainage systems cannot be avoided, flood modelling would be carried out to develop the staging of works to minimise impacts of the proposal and ensure proper management of a flood event at all stages of construction. The staged flood modelling would then be used to inform a flood and emergency response plan (i.e. for the sites located within a flood-prone area).	Construction
Water quality	Sediment and erosion control devices would be installed in accordance with Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom, 2004).	Construction
Discharge to surface water	Discharge to surface water would be undertaken in accordance with the environment protection licence for construction of the proposal and would consider the hydrological attributes of the receiving waterbody.	Construction

7.3 EFFECTIVENESS OF MITIGATION MEASURES

Erosion and sediment control measures would be implemented in accordance with the requirements of the Blue Book. Rainfall events for the sediment and erosion control measures would be defined in accordance with the Blue Book. The measures contained in the Blue Book are based on field experience and have been previously demonstrated to be effective. In general, implementing measures in accordance with the Blue Book would reduce the potential for the impact to be realised (by using controls such as hay bales, covers on stockpiles, etc.) or enable the impact to be avoided completely (e.g. by not undertaking works during wet weather). As a result, the proposed mitigation measures are expected to be effective.

The proposal would cause minimal change to flood behaviour. Further assessment would be carried out during detailed design in accordance with the objective of meeting the QDLs for this proposal.

The implementation of the mitigation measures indicated in Table 7.1 would ensure that the proposed work would not generate adverse impacts during the construction phase.

8 CONCLUSION

This report describes the existing surface water environments for the proposal sites and assesses the potential surface water impacts (considering hydrology, flooding, drainage and water quality) for both the construction and operation phases of the proposal.

The proposal is located within local sub-catchments of the Murray River and Murrumbidgee catchments and most enhancement sites interact with local streams, drainage lines or overland flow paths rather than main rivers, with the exception of the Murray River bridge site.

No streamflow records are available for the watercourses in the vicinity of the enhancement sites. As site-specific water quality data was not available, water quality data from the broader catchment areas was reviewed to assess the general water quality of the downstream catchments that ultimately receive runoff from the proposal sites.

Local council hydraulic and hydrology models have been used to inform the existing flood conditions at the sites. These models have also been used to identify the flood impacts of the proposal.

Drainage models have been developed, where required, to represent the surface water runoff from the rail catchments. Drainage models have been developed for the existing and post-development conditions.

The flood and drainage impact assessment has been based on comparing the baseline and proposed scenario flooding conditions (using flood/drainage model outputs) and appropriate QDLs that have been identified for the proposal.

The design process for the proposed enchantment sites has aimed to avoid impacts to the existing surface water environment (i.e. hydrology, flooding, drainage and water quality).

8.1 FLOODING

The flood impacts assessment undertaken has demonstrated that there are minor impacts to the flood conditions as a result of the proposed enhancement works.

The flood impact assessment demonstrated that the proposed enhancement works do not cause impacts to the regional flood conditions.

In the areas where the sites are affected by overland flooding, the proposed enhancement works have been designed to maintain the existing flow paths (and floodways). For these sites only minor flood impacts are expected. The sites are expected to be compliant with the QDL criteria, except at one location in Wagga Wagga where an increase in afflux was predicted. This would be re-modelled during detailed design with additional drainage and topography data which is expected to result in a reduction in the predicted afflux.

The proposed drainage features (i.e. cross-drainage extensions, cess drains, cut-off drains, etc.), implemented to manage runoff within and through the rail corridor, improve the existing drainage conditions and do not cause non-compliant flood impacts.

The minor (low) flood impacts of the works, and the proposed drainage improvements, are consistent with state and local government flood management policies and plans; therefore, existing council and SES flood emergency management plans would not be affected nor require updating to account for flood risk changes caused by the proposal.

For the construction phase, some temporary localised flow diversions may be required to install new culverts and cess drains or to facilitate earthworks adjacent to existing drainage lines and overland flow paths. Such diversions would aim to preserve the existing points of stormwater discharge from the rail corridor and avoid changing discharge points. Given construction of the proposal would be short term, and the proposal sites represent small areas in the overall catchment, the impacts on drainage and flooding are likely to be temporary, localised and minor.

8.2 HYDROLOGY

The proposal would not divert or alter flow regimes in downstream receivers as the works have been designed to mimic the existing drainage and surface water flow conditions at the sites. Minor increases in downstream flows would occur at some sites but these would connect to existing stormwater systems that drain catchments significantly larger than the rail corridor sub-catchments; therefore, any minor flow increases would be negligible when combined with the total catchments flows downstream of the sites. There would be no impact on flow regimes at downstream sensitive environmental receivers such as wetlands and GDEs. Temporary diversions of surface flows during construction would aim to maintain existing drainage patterns and stormwater discharge points to avoid impacts on downstream flows.

As there are no significant changes to hydrologic regimes downstream of the sites in the operational phase, there are no impacts on the water balance or water availability within the downstream catchments. The enhancement sites would not take surface water from the environment in the operational phase. For the construction phase, water for construction would be sourced from existing licenced sources, including council and other licenced surface and groundwater supplies. No new surface water abstractions or harvesting of surface/stormwater is proposed to meet the construction water demand.

As the downstream hydrologic regimes and stormwater discharges from the rail corridor would not be altered significantly during construction or operation, there are no risks of increased erosion, sedimentation or destabilisation of watercourses downstream of the sites. Any culverts or cess drains subject to modification would include scour protection measures at outlets and points of discharge to locally manage any potential scour impacts. Standard erosion and sediment control measures would be applied during construction, as detailed in Chapter 6, to minimise impacts in downstream receivers.

The operational phase would not involve wastewater discharges from the sites. During construction, wastewater from construction worker facilities would be locally managed at the sites and disposed of offsite with no additional wastewater discharges to the downstream environment.

8.3 WATER QUALITY

The construction activities have the potential to impact the water quality of the surrounding environment if not appropriately managed.

Standard construction management and mitigation strategies (as recommended in the Blue Book and widely adopted across the construction industry) to minimise sediment disturbance, mobilisation and runoff are recommended to be adopted during construction of the proposal. All construction impacts and mitigation measures would be documented in a SWMP. It is considered that implementation of the recommended mitigation measures would ensure that construction of the proposal would not further degrade the water quality environment of the proposal site regarding the NSW Water Quality Objectives. Potential construction impacts would be short term and manageable with application of appropriate construction mitigation measures.

8.4 CUMULATIVE IMPACT ASSESSMENT

Cumulative impacts with respect to flooding, hydrology and water quality have not been identified for the proposal sites.

For the Junee Yard clearances element of the proposal, construction mitigation measures and plans for the site may need to be coordinated and integrated with the Junee Station Upgrade project if construction of both projects would occur at the same time. This would be required to ensure that construction phase mitigation measures are implemented for the cumulative impacts of both projects on the surface water environment.

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TECHNICAL PAPER

11

Hydrology, flooding and water quality

Appendix A NSW environmental values, water quality objectives and criteria

ALBURY TO ILLABO ENVIRONMENTAL IMPACT STATEMENT

Table A.1 NSW Water quality objectives and trigger values for environmental values in the Murrumbidgee and Murray catchments

WATER QUALITY OBJECTIVE	INDICATOR	TRIGGER VALUE OR CRITERIA
Aquatic ecosystems		
Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	Total phosphorus	Upland rivers: 20µg/L Lowland rivers: 50µg/L for rivers in the Murray Darling Basin
	Total nitrogen	Upland rivers 250µg/L Lowland rivers: 500µg/L for rivers in the Murray Darling Basin
	Chlorophyll-a	Upland rivers: Not applicable Lowland rivers: 5µg/L
	Turbidity	Upland rivers: 2–25 NTU Lowland rivers: 6-50 NTU
	Salinity (electrical conductivity)	Upland rivers: 30–350µS/cm Lowland rivers: 125–2200µS/cm
	Dissolved oxygen	Upland rivers: 90–110% Lowland rivers: 85–110%
	pH	Upland rivers: 6.5–8.0 Lowland rivers: 6.5–8.5
	Temperature	See ANZECC 2000 Guidelines, table 3.3.1.
	Chemical contaminants or toxicants	See ANZECC 2000 Guidelines, chapter 3.4 and table 3.4.1.
	Biological assessment indicators	This form of assessment directly evaluates whether management goals for ecosystem protection are being achieved (e.g. maintenance of a certain level of species diversity, control of nuisance algae below a certain level, protection of key species, etc). Many potential indicators exist and these may relate to single species, multiple species or whole communities. Recognised protocols using diatoms and algae, macrophytes, macroinvertebrates, and fish populations and/or communities may be used in NSW and interstate (e.g. AusRivAS).

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

WATER QUALITY OBJECTIVE	INDICATOR	TRIGGER VALUE OR CRITERIA
Primary contact recreation		
Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed	Turbidity	A 200mm diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 m (approximately 6 NTU).
	Faecal coliforms	Beachwatch considers waters are unsuitable for swimming if: — the median faecal coliform density exceeds 150 colony forming units per 100 millilitres (cfu/100 mL) for five samples taken at regular intervals not exceeding one month, or — the second highest sample contains equal to or greater than 600 cfu/100mL (faecal coliforms) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: — median over bathing season of <150 faecal coliforms per 100mL, with 4 out of 5 samples <600/100mL (minimum of 5 samples taken at regular intervals not exceeding one month).
	Enterococci	Beachwatch considers waters are unsuitable for swimming if: — the median enterococci density exceeds 35 cfu/100mL for five samples taken at regular intervals not exceeding one month, or — the second highest sample contains equal to or greater than 100 cfu/100mL (enterococci) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: — median over bathing season of <35 enterococci per 100mL (maximum number in any one sample: 60–100 organisms/ 100mL).
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water. (Note, it is not necessary to analyse water for these pathogens unless temperature is greater than 24 degrees Celsius).
	Algae & blue-green algae	<15,000 cells/mL
	Nuisance organisms	Use visual amenity guidelines.
	Faecal coliforms	Large numbers of midges and aquatic worms are undesirable.
	pH	5.0–9.0
	Temperature	15°–35°C for prolonged exposure.
	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 the concentrations provided in Tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines 2000.

WATER QUALITY OBJECTIVE	INDICATOR	TRIGGER VALUE OR CRITERIA
	Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
	Visual clarity and colour	Use visual amenity guidelines.
	Surface films	Use visual amenity guidelines.
Livestock water supply		
Protecting water quality to maximise the production of healthy livestock	Algae & blue-green algae	An increasing risk to livestock health is likely when cell counts of microcystins exceed 11 500 cells/mL and/or concentrations of microcystins exceed 2.3µg/L expressed as microcystin-LR toxicity equivalents.
	Salinity (electrical conductivity)	Recommended concentrations of total dissolved solids in drinking water for livestock are given in Table 4.3.1 (ANZECC 2000 Guidelines).
	Thermotolerant coliforms (faecal coliforms)	Drinking water for livestock should contain less than 100 thermotolerant coliforms per 100mL (median value).
	Chemical contaminants	Refer to Table 4.3.2 (ANZECC 2000 Guidelines) for heavy metals and metalloids in livestock drinking water. Refer to Australian Drinking Water Guidelines (NHMRC and NRMMC 2004) for information regarding pesticides and other organic contaminants, using criteria for raw drinking water.
Irrigation water supply		
Protecting the quality of waters applied to crops and pasture	Algae & blue-green algae	Should not be visible. No more than low algal levels are desired to protect irrigation equipment.
	Salinity (electrical conductivity)	To assess the salinity and sodicity of water for irrigation use, several interactive factors must be considered including irrigation water quality, soil properties, plant salt tolerance, climate, landscape and water and soil management. For more information, refer to Chapter 4.2.4 of ANZECC 2000 Guidelines.
	Thermotolerant coliforms (faecal coliforms)	Trigger values for thermotolerant coliforms in irrigation water used for food and non-food crops are provided in Table 4.2.2 of the ANZECC Guidelines.
	Heavy metals and metalloids	Long term trigger values (LTV) and short-term trigger values (STV) for heavy metals and metalloids in irrigation water are presented in Table 4.2.10 of the ANZECC 2000 Guidelines.

WATER QUALITY OBJECTIVE	INDICATOR	TRIGGER VALUE OR CRITERIA
Homestead water supply		
Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	Blue-green algae	Recommend twice weekly inspections during danger period for storages with history of algal blooms. No guideline values are set for cyanobacteria in drinking water. In water storages, counts of <1000 algal cells/mL are of no concern. >500 algal cells/mL – increase monitoring. >2000 algal cells/mL – immediate action indicated; seek expert advice. >6500 algal cells/mL – seek advice from health authority.
	Turbidity	5 NTU; <1 NTU desirable for effective disinfection; >1 NTU may shield some micro-organisms from disinfection (see supporting information).
	Total dissolved solids	< 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.
	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 (see supporting information)
	Chemical contaminants	See Guidelines for Inorganic Chemicals in the Australian Drinking Water Guidelines (NHMRC & NRMMC 2004).

WATER QUALITY OBJECTIVE	INDICATOR	TRIGGER VALUE OR CRITERIA
Drinking water at point of supply – Disinfection only, Groundwater, Clarification and disinfection		
Refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment	Blue-green algae	Recommend twice weekly inspections during danger period for storages with history of algal blooms. >500 algal cells/mL – increase monitoring. <2000 algal cells/mL – water may be used for potable supply. >2000 algal cells/mL – immediate action indicated; seek expert advice. >6500 algal cells/mL – seek advice from health authority. >15,000 algal cells/mL – may not be used for potable supply except with full water treatment, which incorporates filtration and activated carbon. Source: Australian Drinking Water Guidelines (NHMRC & NRMMC 2004).
	Turbidity	Site-specific determinant.
	Salinity (electrical conductivity)	<1500µS/cm >800µS/cm causes a deterioration in taste.
	Faecal coliforms*	0 faecal coliforms per 100mL (0/100mL)
	Total coliforms*	95% of samples should be 0 coliforms/100mL throughout the year. Up to 10 coliform organisms may be accepted occasionally in 100mL. Coliform organisms should not be detected in 100mL in any two consecutive samples.
	Dissolved oxygen	> 6.5mg/L (> 80% saturation)
	pH	6.5–8.5
	Chemical contaminants	See ANZECC 2000 guidelines, Section 6.2.2.

WATER QUALITY OBJECTIVE	INDICATOR	TRIGGER VALUE OR CRITERIA
Aquatic foods (cooked)		
Refers to protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities. (Note: The ANZECC 2000 Guidelines lists this environmental value as Aquaculture and human consumption of aquatic foods)	Algae & blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulate in other aquatic organisms.
	Faecal coliforms	Guideline in water for shellfish: The median faecal coliform concentration should not exceed 14 MPN/100 mL; with no more than 10% of the samples exceeding 43 MPN/100 mL. Standard in edible tissue: Fish destined for human consumption should not exceed a limit of 2.3 MPN E Coli/g of flesh with a standard plate count of 100,000 organisms/g.
	Toxicants (as applied to aquaculture activities)	Copper: less than 5µgm/L. Mercury: less than 1µgm/L. Zinc: less than 5µgm/L. Organochlorines: Chlordane: less than 0.004µgm/L (saltwater production) PCB's: less than 2µgm/L.
	Physico-chemical indicators (as applied to aquaculture activities)	Suspended solids: less than 40 5µgm/L (freshwater). Temperature: less than 2 degrees Celsius change over one hour.