# CHAPTER 18

# Hydrology, flooding and water quality

**ALBURY TO ILLABO** ENVIRONMENTAL IMPACT STATEMENT

ARTC | INLAND RAIL
An Australian Government Initiative

# Contents



## Figures



## Tables

# 18. Hydrology, flooding and water quality

This chapter is a summary of the potential impacts of the Albury to Illabo (A2I) section of the Inland Rail program (the proposal) on hydrology, flooding and water quality. The complete assessment is in Technical Paper 11: Hydrology, flooding and water quality.

## 18.1 Summary

The proposal site crosses a number of watercourses within the Murray and Murrumbidgee catchments. The majority of watercourses crossed by the proposal are non-perennial, with water ceasing to flow for weeks or months at a time (intermittent watercourses) or flowing only for short durations following rainfall (ephemeral watercourses). There is limited water quality data available for watercourses within the proposal site; however, given the high proportion of land developed for rail infrastructure, urban and agricultural purposes, it is considered likely that runoff from these areas contributes to degradation of water quality.

During construction there is potential for activities associated with the construction of new culverts and a temporary creek crossing to temporarily disturb watercourses and reduce water quality in downstream catchments if not managed appropriately. Once operational, 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 enhancement sites. As there are no significant changes to hydrologic regimes downstream of the enhancement sites in the operational phase, impacts are not predicted on the water balance or water availability within the downstream catchments.

The proposal site is partially located on flood-prone land. During construction there is potential for inundation of the proposal site affecting construction activities and infrastructure, including earthworks, compounds and stockpiles. This could pose a risk to construction workers and the public, and result in the mobilisation of construction materials in flood waters. Establishment of temporary construction infrastructure also has the potential to temporarily affect flooding behaviour; however, these impacts would be manageable with the implementation of mitigation measures.

Drainage works have been designed to mimic or improve the existing drainage, hydrology, flooding conditions and associated water quality impacts, where possible, to minimise the operational impacts of the proposal. During operation, there would be minor changes to flood conditions, overland flows and afflux conditions where the vertical alignment of existing track has been altered. In many cases, changes would result in minor improvements to existing rail flood immunity; however, where track lowering is proposed, the design would provide flood immunity in the 1 per cent annual exceedance probability (AEP) event. Where flood storage is predicted to be reduced as a result of operational infrastructure, impacts are predicted to be minor to negligible, and no houses or other sensitive properties would become affected by flooding. The proposal is expected to satisfy the quantitative design limits (QDLs) (or impact criteria) adopted for the proposal by Inland Rail, including at classified roads managed by Transport for NSW (TfNSW). An afflux increase in an industrial area downstream of the Wagga Wagga Yard clearances enhancement site was identified; however, it is expected to be attenuated by including additional drainage and topography data in the flood model for the area, supplemented by discharge controls from the Wagga Wagga Yard if necessary. Further modelling would be completed during detailed design to confirm drainage at this location and compliance with the QDLs. Overall, the proposal would not result in any broad-scale changes in flood behaviour.

## 18.2 Approach

### 18.2.1 Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEARs) related to hydrology, flooding and water quality, and where in the environmental impact statement (EIS) these requirements have been addressed, are detailed in Appendix A: Secretary's Environmental Assessment Requirements.

### 18.2.2 Relevant legislation, policies and guidelines

The assessments were undertaken in accordance with the SEARs and with reference to the requirements of relevant legislation, policies and/or assessment guidelines, including:

- The *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act), *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Water Act 2007* (Cth), *Water Amendment Act 2008* (Cth), *Water Act 1912* (NSW), *Water Management Act 2000* (NSW), *Protection of the Environment Operations Act 1997* (NSW)
- *Floodplain Development Manual: The Management of Flood Liable Land* (Department of Infrastructure, Planning and Natural Resources (DIPNR), 2005)

- *Australian Rainfall and Runoff: A Guide to Flood Estimation* (ARR, 2019, prepared by Ball et al., 2019) and *Floodplain Risk Management Guide—Incorporating 2016 ARR in studies* (Office of Environment and Heritage (OEH), 2019a)
- *Guidelines for controlled activities on waterfront land* (Department of Primary Industries (DPI), 2012b)
- *Guidelines for developments adjoining land and water* (OEH, 2013b)
- *Murray–Darling Basin Plan 2012* (including water resource plans and water quality management plans) (Murray–Darling Basin Authority, 2012) (the Basin Plan 2012)
- The flood-related planning controls contained in local planning instruments relevant to the study area— *Albury Local Environmental Plan 2010*, *Greater Hume Local Environmental Plan 2012*, *Lockhart Local Environmental Plan 2012*, *Wagga Wagga Local Environmental Plan 2010*, *Junee Local Environmental Plan 2012*
- Relevant local flood studies and plans—*Albury Floodplain Risk Management Study and Plan* (WMAWater, 2016), *Culcairn Floodplain Risk Management Study and Plan* (WMAWater, 2017a), *Henty Floodplain Risk Management Study and Plan* (WMAWater, 2017b), *The Rock Flood Study* (WMAWater, 2014), *NSW Murray and Lower Darling Water Quality Management Plan* (NSW DPI, 2019a), *Murrumbidgee Water Quality Management Plan* (NSW DPI, 2019b), *Tarcutta, Ladysmith and Uranquinty Floodplain Risk Management Studies and Plans* (GRC Hydro, 2021), *Draft Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan* (WMAWater, 2021), *Wagga Wagga Major Overland Flow Flood Study (*WMAWater, 2011), *The Lower Butlers Gully Flood Study* (Lyall & Associates, 2009), *Bungambrawatha Creek, Lavington, South Albury and West Albury flood study* (Lyall & Associates, 2011), *Eight Mile Creek Flood Study* (URS, 2012)
- *Australian Disaster Resilience Handbook 7, Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (Australian Institute for Disaster Resilience, 2017)
- *National Water Quality Management Strategy* (Australian and New Zealand Environment and Conservation Council (ANZECC), 2018)
- *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC/ARMCANZ, 2000a) (the ANZECC guidelines)
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Governments, 2018) (the Water Quality Guidelines)
- *NSW Water Quality and River Flow Objectives* (Department of Environment, Climate Change and Water (DECCW), 2006) (the NSW Water Quality Objectives)
- *Managing Urban Stormwater—Soils and Construction: Volume 1* (Landcom, 2004), *Volume 2C Unsealed Roads* (Department of Environment and Climate Change (DECC), 2008a) and *Volume 2D Main Road Construction* (DECC, 2008b) (collectively referred to as the 'Blue Book')
- *Climate Change Impacts & Risk Management: A Guide for Business and Government* (Department of Environment and Heritage, Australian Greenhouse Office, 2006)
- *PS 21-006 circular—Considering flooding in land use planning: guidance and statutory requirements* (NSW Department of Planning, Industry and Environment, 2021g)
- *Sustainable Design Guidelines Version 4.0* (TfNSW, 2017b)
- *AS/NZS 3100:2018 Risk Management—Principles and Guidelines*.

The SEARs refer to *Practical consideration of climate change – flood risk management guidelines* (Department of Environment and Climate Change (DECC), 2007). In this assessment, more recent guidance provided by the *Australian Rainfall and Runoff: A Guide to Flood Estimation* has been applied.

The area in which the proposal site is located is subject to the following water-sharing plans for surface water:

- 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.

### 18.2.3 Methodology

## Study area

The study area for the hydrology, flooding and water quality assessment includes the watercourses, catchment areas and associated floodplains within 200 metres (m) of the proposal site, described in section 18.3.

## Key tasks

### Hydrology

The assessment involved:

- characterising the current hydrological conditions in the study area
- assessing potential impacts on surface water hydrology during construction and operation, with consideration of water balance, water availability and take, stormwater and wastewater discharges, and water flow changes
- recommending mitigation and management measures, including baseline monitoring of hydrological attributes.

### Flooding

The assessment involved:

- identifying the existing flooding and geomorphology conditions of the watercourses traversed by the proposal site, including review of available spatial data; existing flood studies and models; existing climatic conditions; existing stream gauge data; and hydrological modelling and analysis
- using the existing data and QDLs to assess the potential impacts of constructing and operating the proposal on watercourse geomorphology, buildings, infrastructure and land uses in a range of events from the 20% AEP up to the 1% AEP and Probable Maximum Flood (PMF) events
- recommending mitigation and management measures for identified impacts.

Quantitative or qualitative assessment was carried out for each enhancement site based on the hydraulic complexity of the existing conditions and the nature of proposed work.

#### Quantitative assessment

Quantitative assessment was carried out for the following enhancement sites:

- Riverina Highway bridge
- Billy Hughes bridge
- Uranquinty Yard clearances
- Pearson Street bridge
- Edmondson Street bridge
- Wagga Wagga Yard clearances.

These enhancement sites are generally of moderate-to-high complexity and are either affected by flooding or involve proposed works that may impact the existing flood or drainage conditions. The proposed works at these sites generally involve changes to the vertical or horizontal alignment of the track, earthworks or changes to drainage structures.

Drainage models were developed for Riverina Highway bridge, Billy Hughes bridge and Edmondson Street bridge. Flood modelling was undertaken for Uranquinty Yard clearances, Pearson Street bridge and Wagga Wagga Yard clearances enhancement sites using existing flood models developed by Wagga Wagga City Council. These models were reviewed to ensure they were fit for purpose. Flood model parameters were maintained to ensure consistency with Wagga Wagga City Council's published mapping.

Further information on the existing flooding data adopted is in section 3.3 of Technical Paper 11: Hydrology, flooding and water quality.

#### Qualitative assessment

Qualitative assessment was carried out for the remainder of the enhancement sites as these sites are generally of low complexity and are either not affected by flooding or the proposed work at the enhancement sites does not interact with the existing flood or drainage conditions.

#### Quantitative design limits

The SEARs require the preparation of 'flood management objectives'. For consistency with other Inland Rail projects, these objectives have been termed QDLs.

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 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 to 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 QDLs proposed for the proposal are provided in Table 18-1. The QDLs are broken down into the following key flood parameters and criteria or limits, and are only applicable beyond the CSSI corridor unless otherwise noted. The QDLs do not apply to model noise[1].

**TABLE 18-1 QUANTITATIVE DESIGN LIMITS**

| Parameter | Criteria / limits | Proposed QDL |
|---|---|---|
| **Afflux** i.e. increase in flood level resulting from implementation of CSSI. | Habitable floors[2] | 10 mm increase[3] |
| | Non-habitable floors[2] | 20 mm increase |
| | Surrounds of residential building, other urban, open space and recreational land and infrastructure (excluding sensitive infrastructure) | 100 mm increase |
| | Agricultural | 200 mm increase |
| | Forest and unimproved grazing land | 300 mm increase |
| | Classified roads managed by TfNSW[4] | 50 mm on areas flooded under existing conditions. Otherwise, no increase.[5] |
| | Highways and sealed roads >80km/hr[6] | No afflux where aquaplaning risk exists and remains unmitigated; otherwise, 50 mm increase |
| | Unsealed roads and sealed roads <80 km/hr[4] | 100 mm increase |
| **Scour/Erosion potential** i.e. increase in flood velocity resulting from implementation of CSSI.[4] | 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 1 m/s[7] |
| | Classified roads managed by TfNSW[4] | 10% increase in velocity where existing velocity already exceeds 1 m/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 0.5 m/s is to be adopted in the absence of a site-specific assessment(s).<br>Where existing velocity exceeds ETV, velocity is limited to a 0.025 m/s increase.[9]<br>Where existing velocity is less than ETV, velocity is limited to the lesser of:<br>▸ ETV<br>▸ 20% increase[10] or 0.5m/s, whichever is greater. |

| Parameter | Criteria / limits | Proposed QDL |
|---|---|---|
| **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<0.1 $m^2/s$). | Urban, commercial, industrial, highways[4] and sealed roadways[4] | 10% increase in vd |
| | Classified roads managed by TfNSW[4] | 10% increase in vd where this does not result in an increase in hazard category. Otherwise, no increase.[10] |
| | 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 100 $m^2$). | Habitable floors[2] | Where existing above floor flooding is:<br>▸ less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour<br>▸ greater than 1 hour in duration, up to 5% increased inundation duration<br>Where existing below floor flooding is:<br>▸ less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour<br>▸ greater than 1 hour in duration, up to 10% increased inundation duration. |
| | Classified roads managed by TfNSW[4] | No increase in duration of flood inundation to sections of road not already inundated.[11]<br>Otherwise 10% increase in inundation duration. |
| | Highways and sealed roads >80 km/hr[4] | 10% increase in inundation duration. |
| | Elsewhere | Where existing inundation is less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour.<br>Where existing inundation is greater than 1 hour in flood duration, up to 10% increase in duration of inundation<br>No duration limits apply to newly flooded land no greater than 1000 $m^2$ 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. 3  10 mm 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. Any variation must be negotiated with the roads authority
5. Any afflux on newly inundated sections of road must be negotiated with the roads authority
6. Including where located within CSSI corridor.
7. Local variations in velocity can exceed a 20% change provided that when assessed over a 30 m 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.

### Water quality

The assessment involved:

- reviewing existing environmental conditions and publicly available water quality data in the study area to understand the existing physical and chemical water quality characteristics and environmental values
- identifying assessment criteria for the proposal based on:

- the NSW Water Quality Objectives for catchments affected by the proposal
- default trigger values in the ANZECC guidelines, which are the same as those adopted by the new *NSW Water Quality Guidelines*
- the water quality objectives and targets for the Murray and Murrumbidgee catchments under the Basin Plan 2012

- reviewing the existing and the proposed hydrological conditions (described in section 18.3.1) to identify risks to water quality that are related to hydrology
- assessing the potential impacts on water quality during construction and operation of the proposal
- recommending mitigation and management measures, including water quality monitoring for identified impacts.

The *NSW Water Quality Objectives* provide the agreed environmental values and long-term goals for NSW's surface waters. The objectives are consistent with the national framework for assessing water quality set out in the *NSW Water Quality Guidelines*, which supersedes the ANZECC guidelines. The water quality objectives provide environmental values for NSW waters and the *NSW Water Quality Guidelines* provide the technical guidance to assess the water quality needed to protect those values. The water quality assessment considered protection of the following values:

- aquatic ecosystems
- visual amenity
- primary and secondary contact recreation
- livestock water supply
- irrigation water supply
- homestead water supply
- drinking water at the point of supply
- aquatic foods (cooked).

While all of these values apply, some of them have less relevance, given the characteristics of the watercourses (the majority are ephemeral). The water quality objective for aquatic ecosystems is to 'maintain or improve the ecological condition of waterbodies and their riparian zones over the long term', which is relevant in all watercourses within the study area. The indicators and criteria (trigger values) for this objective are listed in Table 18-2. A detailed list of the indicators and criteria for the other water quality objectives for watercourses within the proposal site is provided in Technical Paper 11: Hydrology, flooding and water quality.

**TABLE 18-2 TRIGGER VALUES FOR AQUATIC ECOSYSTEMS**

| Indicator | Lowland river | Upland river |
|---|---|---|
| Total phosphorus | 50 µg/L for rivers in the Murray–Darling Basin | 20 µg/L |
| Total nitrogen | 500 µg/L for rivers in the Murray–Darling Basin | 250 µg/L |
| Chlorophyll-a | 5 µg/L | Not applicable |
| Turbidity | 6-50 NTU | 2–25 NTU |
| Salinity (electrical conductivity) | 125–2200 µS/cm | 30–350 µS/cm |
| Dissolved oxygen | 85–110% | 90–110% |
| pH | 6.5–8.5 | 6.5–8.0 |
| Temperature | ANZECC 2000 Guidelines, Table 3.3.1 | |
| Chemical contaminants or toxicants | ANZECC 2000 Guidelines, Chapter 3.4 and Table 3.4.1 | |
| Biological assessment indicators | 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). | |

The water quality management plans developed under the Basin Plan 2012 support water quality management within the catchments. The water quality assessment considered the following objectives for the Murray and Murrumbidgee catchments under the Basin Plan 2012:

- maintain water quality to protect the water-dependent values and uses of Indigenous peoples
- maintain water quality to protect and restore water dependent ecosystems
- maintain the quality of raw surface water for treatment for human consumption
- maintain the quality of surface water for irrigation use

- maintain the quality of surface water for recreational use
- maintain good levels of water quality.

A detailed list of the indicators, criteria and targets for watercourses within the proposal site, provided by the *NSW Water Quality Objectives* and the Basin Plan 2012, is in Technical Paper 11: Hydrology, flooding and water quality.

### 18.2.4 Key risks

An environmental risk assessment was undertaken for the proposal (refer Appendix E: Environmental risk assessment). Potential impacts on hydrology, flooding and water quality risks with an overall assessed risk rating of medium or above included:

- potential temporary impacts on flood-prone areas (e.g. increase in flood risk outside the proposal site) due to new temporary structures, changes to overland flows or displacing flood storage areas
- potential impacts on construction activities due to flooding
- potential impacts on flood-prone areas (e.g. increase in flood risk outside the proposal site) due to new/modified structures or displacing flood storage areas
- flooding impacts on proposal infrastructure and immunity during operation
- impacts on upstream and downstream drainage due to the modification of built structures such as embankments, culverts and bridges.

The assessments considered the potential risks identified by the environmental risk assessment, in addition to potential risks and impacts identified by the scoping report, the SEARs, and relevant guidelines and policies (as appropriate).

## 18.3 Existing environment

### 18.3.1 Hydrology

#### Catchments

The proposal site is located within the Murray and Murrumbidgee catchments of the Murray–Darling Basin.

The catchment boundaries and key watercourses within and near the proposal site are shown in Figure 18-1 and described on the following pages.

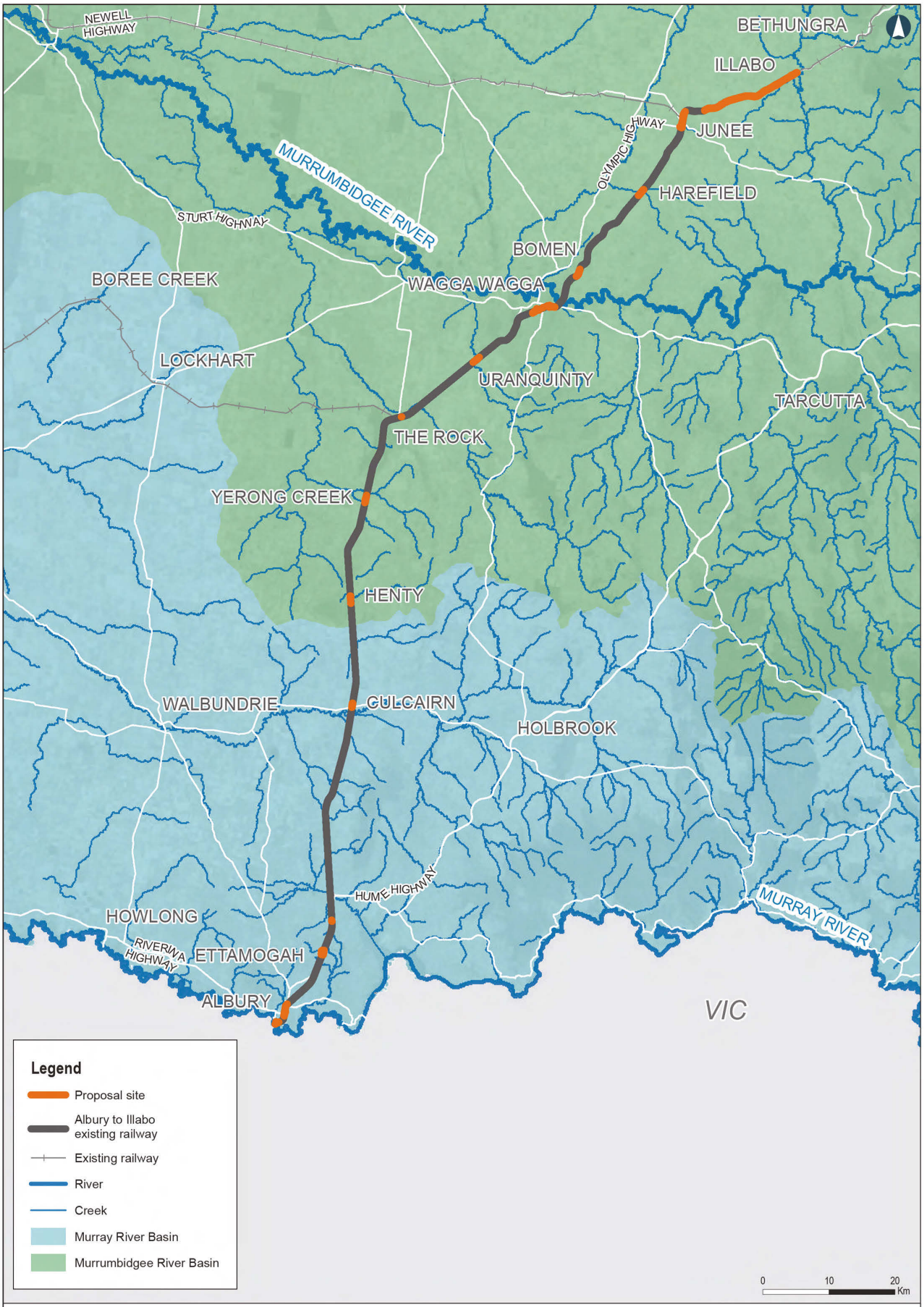


Figure 18-1 Catchments and watercourses

Data Sources: ARTC, NSWSS

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:750,000
Paper size: A3
Date: 19/09/2021

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### Murray catchment

Enhancement sites within the Albury precinct, the Culcairn pedestrian bridge enhancement site, and Culcairn Yard clearances enhancement site are located in the mid-Murray catchment. The mid Murray catchment extends from the Hume Dam in Albury, west to the confluence of the Murray and Darling Rivers in Wentworth.

Agriculture and urban development are the key land uses within the catchment. The catchment supports extensive floodplains and wetlands, including nationally and internationally significant sites such as the Barmah–Millewa Forest and the Gunbower–Koondrook–Perricoota Forest in the west of NSW. Tourism based around the river environment and water activities is also economically important to the region.

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

### Murrumbidgee catchment

The enhancement sites within the Greater Hume–Lockhart, Wagga Wagga and Junee precincts are located in the Murrumbidgee catchment. The Murrumbidgee catchment extends from the Kosciuszko National Park in eastern NSW to Balranald in western NSW, with inflows primarily sourced from the Great Dividing Range.

Agriculture is the primary land use in the catchment. The catchment supports extensive food production, including fruit and vegetables, rice and wine.

## Watercourses

Watercourses in proximity to the hydrology, flooding and water quality study area are listed in Table 18-3 and are shown in Figure 18-1. The majority of the watercourses are non-perennial (i.e. either intermittent or ephemeral). Intermittent watercourses cease flowing for weeks or months at a time, while ephemeral watercourses flow for short durations following rainfall. The proposal site also crosses several unnamed tributaries in each catchment.

**TABLE 18-3 WATERCOURSES IN PROXIMITY TO THE PROPOSAL SITE**

| Enhancement site | Watercourse | Flow type |
|---|---|---|
| **Albury precinct** | | |
| Murray River bridge | Murray River, Albury | Major perennial river |
| | Oddies Creek, Albury | Ephemeral |
| Albury Station pedestrian bridge<br>Albury Yard clearances | Concrete lined drainage channel | N/A |
| | Browns Lagoon | N/A |
| Billy Hughes bridge | Eight Mile Creek, Ettamogah | Ephemeral |
| | Unnamed tributary of Eight Mile Creek | Ephemeral |
| Culcairn Yard clearances | Billabong Creek, Culcairn | Partly perennial |
| **Greater Hume–Lockhart precinct** | | |
| Henty Yard clearances | Buckaringah Creek, Henty | Mostly perennial |
| Yerong Creek Yard clearances | Sandy Creek, Yerong Creek | Ephemeral |
| | Yerong Creek, Yerong Creek | Ephemeral |
| The Rock Yard clearances | Burkes Creek, The Rock | Ephemeral |
| **Wagga Wagga precinct** | | |
| Uranquinty Yard clearances | Sandy Creek, Uranquinty | Ephemeral |
| Pearson Street bridge | Tributary of Flowerdale Lagoon<br>Flowerdale Lagoon | Ephemeral |
| Cassidy Parade pedestrian, Edmondson Street bridge, Wagga Wagga Station pedestrian bridge, Wagga Wagga Yard clearances and Bomen Yard clearances | No water courses | Perennial |

| Enhancement site | Watercourse | Flow type |
|---|---|---|
| **Junee precinct** | | |
| Harefield Yard clearances | Reedy Creek, Harefield | Ephemeral |
| | Bucks Creek, Harefield | Ephemeral |
| Kemp Street bridge | Butlers Gully, Junee (tributary of Houaghans Creek) | Ephemeral |
| Olympic Highway underbridge | Tributary of Houaghans Creek | Ephemeral |
| Junee to Illabo clearances | Jeralgambeth Creek, Illabo | Ephemeral |
| | Unnamed tributaries | Ephemeral |

### Surface water supply

Surface water supply in the study area is provided by the Murray and Murrumbidgee rivers, rainfall collected via rainwater tanks, farm dams and from the reticulated water network operated by local government agencies. With the exception of the Murray River bridge enhancement site, all enhancement sites in the study areas are 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.

## 18.3.2 Flooding

### General

The frequency of flood events is generally referred to in terms of their annual exceedance probability (AEP). For example, for a 5% AEP flood, there is a five per cent probability (or a one in 20 chance) that there would be floods of a greater magnitude in any given year. For a 1% AEP flood, there is a one per cent probability (or a one in 100 chance) that there would be floods of greater magnitude each year. The probable maximum flood (PMF) is the largest flood that could be expected to occur at a particular location, usually estimated from probable maximum precipitation.

Existing spatial data, flood studies and models for the study area are limited. A number of enhancement sites are known to be affected by overland flooding, which involves flooding caused by water than runs across the land after rain (rather than overflow from a watercourse). The Murray River bridge enhancement site is also located within the Murray River floodplain, which includes the Murray River watercourse and adjacent land.

A summary of the existing flood conditions for each precinct is provided where available in the following sections. Where site-specific data is unavailable due to the absence of local council flood studies, information on the relevant catchment areas has been used to characterise existing flood conditions and inform the flood assessment. Further information is in Technical Paper 11: Hydrology, flooding and water quality.

### Albury precinct

The existing flood conditions for each enhancement site and surrounds in the Albury precinct for a range of flood events are summarised in Table 18-4 where data is available.

**TABLE 18-4 EXISTING FLOOD CONDITIONS—ALBURY PRECINCT**

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| Murray River bridge | ▸ Rail bridge alterations | ▸ Located within the Murray River floodplain<br>▸ No flood impacts within the rail corridor. | ▸ No information available | Not affected | Not affected |

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| 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 | ▸ Overland flooding within the rail corridor in the PMF<br>▸ Peak flood depth of 1m within the rail corridor in the PMF. | ▸ No information available | Not affected | Greater than 1 m |
| Albury Yard clearances | ▸ Track realignment | | | | |
| Riverina Highway bridge | ▸ Track lowering and realignment | ▸ Overland flooding within the rail corridor from the 20% AEP<br>▸ Flood depth of 0.2–0.3 m within the rail corridor in the 1% AEP<br>▸ Overland flows from the culverts spill into the rail corridor and follow the terrain slope. | ▸ Three box culverts allow water to pass under the rail corridor into Mudges Canal at chainage 644.770 km | 20% AEP and greater events | Greater than 1 m |
| Billy Hughes bridge | ▸ Track lowering and realignment | ▸ No flood impacts within the rail corridor | ▸ Two rail culverts allow water to pass under the rail corridor | Not affected | Greater than 1 m |
| Table Top Yard clearances[1] | ▸ Gantry removal | ▸ Not located on flood-prone land | ▸ No formal drainage infrastructure | Not affected | Not affected |

1. This enhancement site is not covered by an existing local council flood study. Flood behaviour at the enhancement site is of low complexity as the site is subject to local runoff as a result of rainfall across the site only.

## Greater Hume–Lockhart precinct

The existing flood conditions for each enhancement site in the Greater Hume–Lockhart precinct for a range of flood events are summarised in Table 18-5 where data is available.

**TABLE 18-5 EXISTING FLOOD CONDITIONS—GREATER HUME—LOCKHART PRECINCT**

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| Culcairn pedestrian bridge | ▸ Pedestrian bridge removal | ▸ Overland flooding adjacent to the rail corridor<br>▸ No flood impacts within the rail corridor | ▸ Concrete culvert near Victoria Street allows water to pass under the rail corridor | Not affected | 1 to 2 m |
| Culcairn Yard clearances | ▸ Track realignment | | | | |

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| Henty Yard clearances | ▸ Track realignment<br>▸ Level crossing modifications | ▸ No flood impacts within the rail corridor | ▸ No information available | Not affected | Up to 0.75 m |
| Yerong Creek Yard clearances[1] | ▸ Track realignment | ▸ No information available | ▸ No information available | No information available | No information available |
| The Rock Yard clearances | ▸ Gantry modification | ▸ No flood impacts within the rail corridor | ▸ No information available | Not affected | 0.5 to 1 m |

1. This enhancement site is not covered by an existing local council flood study. Flood behaviour at the enhancement site is of low complexity as the site is subject to local runoff as a result of rainfall across the site only.

## Wagga Wagga precinct

The existing flood conditions for each enhancement site in the Wagga Wagga precinct for a range of flood events are summarised in Table 18-6 where data is available.

**TABLE 18-6 EXISTING FLOOD CONDITIONS—WAGGA WAGGA PRECINCT**

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| Uranquinty Yard clearances | ▸ Track realignment<br>▸ Rail bridge alterations<br>▸ Level crossing modifications | ▸ Located within Sandy Creek floodplain<br>▸ Overland flooding depth of 0.5–1 m within the rail corridor in the 1% AEP | ▸ Concrete culvert at chainage 535.52km<br>▸ No other formal drainage infrastructure | 1% AEP | Greater than 1 m |
| Pearson Street bridge | ▸ Track lowering and realignment | ▸ Overland flooding depth of up to 1m within the rail corridor to the west of the rail line from Glenfield Drain in the 1% AEP | ▸ Glenfield Drain allowing water to pass under the rail corridor at chainage 523.56 km<br>▸ Cut-off channels west of Pearson Street bridge directing flows into the Glenfield Drain<br>▸ Concrete culvert at chainage 523.52 km<br>▸ Overland flow path south of the rail corridor flowing towards a council-operated basin. | Not affected | Up to 0.7 m in overland flooding events<br>Not affected by Murrumbidgee River flooding |
| Cassidy pedestrian bridge | ▸ Pedestrian bridge replacement | ▸ Overland flooding within the rail corridor<br>▸ Peak flood depth of 0.15–0.3 m within the | ▸ Surface water discharge into Council drainage system at | 5% AEP and greater events | Greater than 0.75 m in overland flooding events |
| Edmondson Street bridge | ▸ Road bridge replacement | | | | |

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| Wagga Station pedestrian bridge | ▸ Pedestrian bridge replacement | rail corridor in the 1% AEP<br>▸ Rail corridor within the study area categorised as 'flood storage' and 'floodway' in the 1% AEP. | Edmondson Street bridge<br>▸ No formal drainage infrastructure at other sites | | Not affected by Murrumbidgee River flooding |
| Wagga Yard clearances | ▸ Track realignment | | | | |
| Bomen Yard clearances | ▸ Track realignment<br>▸ Level crossing modifications | ▸ Overland flooding within the rail corridor in the vicinity of the level crossing at Bomen Road<br>▸ Peak flood depth of 0.15 m within the rail corridor in the 1% AEP. | ▸ Concrete culvert at chainage 513.82 km<br>▸ No other formal drainage infrastructure. | 20% AEP and greater events | Greater than 0.75 m |

## Junee precinct

The existing flood conditions for each enhancement site in the Wagga Wagga precinct for a range of flood events are summarised in Table 18-7 where data is available.

**TABLE 18-7 EXISTING FLOOD CONDITIONS—JUNEE PRECINCT**

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| Harefield Yard clearances[1] | ▸ Track realignment<br>▸ Rail bridge alterations | ▸ No flood impacts within the rail corridor | ▸ No information available | Not affected | No information available |
| Kemp Street bridge | ▸ Road bridge replacement | ▸ Overland flooding within the rail corridor in the 1% and 5% AEP<br>▸ The bridge and adjacent connecting roads are not impacted by flooding. | ▸ Surface water discharge into council drainage system | 5% AEP and greater events | No information available |
| Junee Station pedestrian bridge | ▸ Pedestrian bridge removal | ▸ Not located on flood-prone land | ▸ No information available | Not affected | No information available |
| Junee Yard clearances | ▸ Track realignment | ▸ Not located on flood-prone land | ▸ Five box culverts under the rail corridor conveying Lower Butlers Gully<br>▸ No other formal drainage infrastructure | Not affected | No information available |
| Olympic Highway underbridge | ▸ Track realignment | ▸ Overland flooding adjacent to the rail corridor in the 1% and 5% AEP | ▸ Three box culverts under the rail corridor | 5% AEP and greater events | No information available |

| Enhancement site | Key features | Existing flood conditions | Drainage | Flood risk within and around the enhancement site for events up to the 1% AEP | PMF flood depth |
|---|---|---|---|---|---|
| | ▸ Rail bridge alterations | ▸ No flood impacts within the rail corridor. | conveying Rock Creek | | |
| Junee to Illabo clearances | ▸ Track realignment<br>▸ Culvert replacement | ▸ Not located on flood-prone land | ▸ Four bridges and nine culverts allow water to pass under the rail corridor | Not affected | No information available |

1. This enhancement site is not covered by an existing local council flood study. Flood behaviour at the enhancement site is of low complexity as the site is subject to local runoff as a result of rainfall across the site only.

### 18.3.3 Water quality

#### Existing surface water quality

Site-specific water quality data for the enhancement sites is not available. Existing water quality data from the broader catchment areas was reviewed to understand the existing water quality of the catchments that would receive runoff from the enhancement sites. The existing data generally use pH, dissolved oxygen (DO), total suspended solids (TSS), total nitrogen (TN), total phosphorus (TP) and salinity as key indicators of water quality. This data was considered sufficient to characterise the existing surface water quality due to the largely non-perennial nature of the watercourses within the study area and the low risk of impacts during construction and operation of the proposal.

Based on a review of publicly available information, water quality in the Murray and Murrumbidgee catchments varies from 'poor' to 'excellent'. Water quality ratings are developed for each catchment using NSW Water Quality Index (WaQI), which calculates the key quality indicators both individually and as an overall integrated index and assigning a rating of 'poor', 'fair', 'good' or 'excellent' (NSW DPI, 2019a,b). There is limited water quality data available for watercourses within the study area; however, given the high proportion of land developed for urban and agricultural purposes, it is likely that runoff from these areas contributes to degradation of water quality. Based on the available water quality data and the existing land uses, it is likely that many watercourses within the study area would not achieve the water quality criteria as laid out in the *NSW Water Quality Guidelines* and Basin Plan 2012, particularly for nutrient content (NSW EPA, 2018).

**Murray catchment**

The condition of the Murray catchment within the study area is considered 'good' against the total phosphorus and total nitrogen key water quality indicators, indicating an acceptable nutrient load in the catchment's watercourses (NSW DPI, 2019a). Water quality data collected by Water NSW from the Murray River at four monitoring sites located downstream of the Murray River bridge enhancement site is shown in Table 18-8. Water quality at the monitoring sites meets the target values for the catchment in the Basin Plan 2012 for pH and dissolved oxygen levels but is below target values for electrical conductivity (indicating salinity) and turbidity (WaterNSW, 2021).

**TABLE 18-8 WATER QUALITY MONITORING DATA ON THE MURRAY RIVER NEAR ALBURY**

| | Water quality indicators (mean measured value) | | | |
|---|---|---|---|---|
| Monitoring locations | pH | Electrical conductivity (indicates salinity) | Dissolved oxygen | Turbidity |
| **Water quality target** | 6.5–7.5 | Peak (80th percentile): 412 µS/cm | >7.7 mg/L | 15 NTU |
| Albury (Union bridge) (station 409001) | 7.3 | 55.3 µS/cm | **9.2 mg/L** | – |
| Howlong (station 409037) | – | 64.5 µS/cm | – | – |
| Downstream of the Hume Dam (Heywoods) (station 409016) | 6.9 | 49.5 µS/cm | **8.3 mg/L** | 5.1 NTU |
| Doctors Point (station 409017) | – | 51.8 µS/cm | – | – |

Note: bold text indicates exceedances of water quality indicators in the Murrumbidgee catchment

**Murrumbidgee catchment**

Water quality in the Murrumbidgee catchment nearest the study area is rated 'fair' to 'good' based on the total nitrogen and phosphorus, pH levels and dissolved oxygen key indicators. There is a general trend towards increasing turbidity concentration with distance down the catchment, due to the cumulative impacts of land use, soil

disturbance and human activity. High flow from rainfall and runoff also results in higher turbidity, nutrients, possible pesticides and pathogens and lower in-stream salinity within the catchment (NSW DPI, 2019b).

Water quality data collected from the Murrumbidgee River and a number of tributaries at four monitoring sites near Wagga Wagga by WaterNSW is shown in Table 18-9. The monitoring data shows that the mean electrical conductivity (indicating salinity) values on the Murrumbidgee and at Tarcutta Creek were below or close to the target values given under the Basin Plan 2012. The mean electrical conductivity values at Kyeamba Creek and Billabong Creek were both two to three times the target electrical conductivity (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, which reflects the cumulative impacts of land use, soil disturbance and human activity on water quality within the catchment (WaterNSW, 2021).

**TABLE 18-9 WATER QUALITY MONITORING DATA ON THE MURRUMBIDGEE RIVER NEAR WAGGA WAGGA**

| | Water quality indicators (mean measured value) | |
|---|---|---|
| **Monitoring locations** | Electrical conductivity (indicates salinity) | Turbidity |
| **Water quality target** | Peak (80th percentile): 258 µS/cm | 35-50 NTU |
| Murrumbidgee River at Wagga Wagga (station 410001) | 142.0 µS/cm | **71.6 NTU** |
| Tarcutta Creek at Old Borambola (station 410017) | **266.8 µS/cm** | – |
| Kyeamba Creek at Ladysmith (station 410048) | **733.7 µS/cm** | **54.6 NTU** |
| Billabong Creek downstream Ten Mile Creek and Mountain Creek (station 410186) | **856.0 µS/cm** | – |

Note: bold text indicated exceedances of water quality indicators

## Sensitive receiving environments

A sensitive receiving environment is one that has a high conservation value or supports human uses of water that are particularly sensitive to degraded water quality. In the context of this proposal, sensitive receiving environments are considered to be:

- nationally important wetlands
- national parks, nature reserves and state conservations areas
- threatened ecological communities associated with aquatic ecosystems
- known and potential habitats for threatened fish
- key fish habitats
- recreational swimming areas
- areas that contribute to aquaculture and commercial fishing
- groundwater dependent ecosystems (refer to Chapter 16: Biodiversity and Chapter 19: Groundwater).

The study area is located 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 listing applies to all native fish and aquatic invertebrates within all natural creeks, rivers and associated waterbodies within the study area.

The majority of the watercourses in the proposal site are ephemeral and do not contain sensitive environments. Watercourses and other surface water features in the vicinity of the proposal site, which are considered to be sensitive receiving environments, are listed in Table 18-10.

The design measures considered in section 18.1, and the mitigation measures provided in section 18.6, have been developed to protect identified sensitive receiving environments and their associated environmental values, where relevant to the proposal. The biodiversity and heritage (both Aboriginal and non-Aboriginal) values of these environments are considered in Chapter 16: Biodiversity, Chapter 10: Aboriginal heritage and Chapter 11: Non-Aboriginal heritage respectively.

**TABLE 18-10 SURFACE WATER SENSITIVE RECEIVING ENVIRONMENTS**

| Sensitive receiving environment | Enhancement site | Reason for classification |
|---|---|---|
| **Albury precinct** | | |
| Murray River | Within Murray River bridge | ▸ Key fish habitat<br>▸ Potential for threatened species |
| Oddies Creek | Within Murray River bridge | ▸ Key fish habitat |

| Sensitive receiving environment | Enhancement site | Reason for classification |
|---|---|---|
| **Greater Hume–Lockhart** | | |
| Buckargingah Creek, Henty | In proximity to Henty Yard clearances | ▸ Key fish habitat<br>▸ Potential for threatened species<br>▸ Discharges to Doodle Comer Swamp (listed in the Directory of Important Wetlands (DAWE,2021) |
| 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<br>▸ Potential for threatened species |
| **Junee precinct** | | |
| Jeralgambeth Creek | Within Junee to Illabo clearances | ▸ Key fish habitat |

## 18.4 Impact assessment—construction

### 18.4.1 Hydrology

#### Water balance

As described in Chapter 8: Construction of the proposal, water would be required during construction to control dust, compact soil, undertake site concrete works, and for site amenities (toilets, sinks, showers, drinking). It is estimated that about 56.9 megalitres (ML) of water would be required over the course of construction. Indicative construction water requirements for each precinct are provided in Table 18-11. The actual amount of water required at the time of construction would depend on final design details, weather and the final construction methodology.

During construction, water would be sourced from local council and water utility companies (such as Riverina Water and Goldenfields Water), quarry sources and recycled water suppliers where available (such as Junee Shire Council recycled water).

No direct water take is proposed from surface watercourses within or around the proposal site. As a result, there would be no impact on water availability within those watercourses that are designated water sources under the surface water sharing plans listed in section 18.2.2.

About 0.7 ML of groundwater and 11.4 ML of groundwater would be taken from the Upper Murray groundwater source and Lachlan Fold Belt MDB groundwater source respectively under a water access licence (refer to Chapter 4: Statutory context) as a result of excavation works at the Riverina Highway Bridge and Kemp Street bridge enhancement sites respectively. As assessed in Chapter 19: Groundwater, 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.

Given the total amount of water required during construction, the proposal would unlikely impact the overall water supply for the region and would not affect water availability for other users.

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 presented in Chapter 25: Climate change risk adaptation and greenhouse gas.

**TABLE 18-11 INDICATIVE CONSTRUCTION WATER BALANCE**

| Precinct | Type | Megalitres |
|---|---|---|
| **Demand** | | |
| Albury | Construction water | 9.7 |
| Greater Hume–Lockhart | Construction water | 3.4 |

| Precinct | Type | Megalitres |
|---|---|---|
| Wagga Wagga | Construction water | 13.5 |
| Junee | Construction water | 30.3 |
| Total demand | | 56.9 |
| **Supply** | | |
| Albury | Groundwater dewatering[1] | 0.7 |
| Junee | Groundwater dewatering[1] | 11.4 |
| Total supply | | 12.1 |
| **Difference** | | **44.8[1]** |

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

## Watercourse hydrology

The proposal would involve works within and around perennial and non-perennial watercourses, including on waterfront land, as described in Chapter 8: Construction of the proposal.

These works present key geomorphological risks during construction that could result in:

- disturbance of watercourse channels and substrates associated with installation of culverts and temporary creek crossing, resulting in erosion and changes to flow regimes
- disturbance of soil, loss of vegetation, increased erosion, runoff from laydown areas and construction access tracks, and changes to water quality or quantity entering the watercourse
- clearing of riparian vegetation that could reduce the hydraulic roughness and resistance of these surfaces to scour and erosion
- disturbance of areas resulting in creation of preferred flow paths, potentially triggering further erosional processes and the migration of flow paths away from their existing alignment.

During construction, some temporary localised flow diversions may be required to install new culverts and cess drains, installation of temporary bridges, or facilitate earthworks adjacent to existing drainage lines and overland flow paths. This may involve excavations and embankments that could alter localised flow patterns and impact the stability of surrounding surface water receivers. Changes would be temporary and limited to the construction phase.

The downstream hydrologic regimes and stormwater discharges from the rail corridor would not be altered during construction due to the proposed design measures, including scour protection at outlets and preservation of existing points of stormwater discharge (refer to Chapter 8: Construction of the proposal). These measures would preserve the existing hydrological regime within the study area. As such, there are no risks of increased erosion, sedimentation or destabilisation of watercourses downstream of the sites and hydrologic regime impacts during the construction phase would be negligible.

Water quality impacts during construction are discussed further in section 18.4.3.

## Stormwater and wastewater

Wastewater would result from the construction of the proposal (refer to Chapter 8: Construction of the proposal), particularly during:

- use of site amenities at construction compounds
- use of vehicle wash-down areas.

Surface water at construction sites would be managed by implementing standard erosion and sediment control measures. In addition, the construction works would retain 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 (refer to Chapter 8: Construction of the proposal).

Wastewater from site amenities would be removed via vacuum trucks on a regular basis and would be disposed of in accordance with relevant regulatory requirements, with no additional wastewater discharges to downstream environments.

### 18.4.2 Flooding

#### General

Construction activities on flood-prone land, including earthworks, concrete works, compounds, stockpiles, have the potential to temporarily affect flooding behaviour. Without the implementation of appropriate management measures, potential impacts include:

- cause damage to construction sites, machinery, plant and equipment
- detrimentally impact downstream watercourses through increased flow rates in drainage lines, changes in scour, bank erosion and transport of sediments
- obstruct the passage of floodwater and overland flow, which could exacerbate existing flooding conditions and pose a safety risk to the public.

Construction activities at each enhancement site would be short term and be prepared with consideration of flooding behaviour. For enhancement sites located in flood prone land and where temporary obstruction of overland flows or drainage systems cannot be avoided, further consideration of flood risk would be undertaken to develop the staging of works to ensure proper management of a flood event at all stages of construction.

The proposal has been designed to minimise the duration of onsite work in watercourses, which would enable increased flexibility when scheduling works around forecast rain periods (refer to Chapter 8: Construction of the proposal).

Overall, the enhancement sites represent a small area of the total catchments in which they are located, and any impacts of the proposal on drainage and flooding would be minor to negligible. Impacts would be temporary, localised and managed using the mitigation measures outlined in section 18.6. minor to negligible.

A summary of the key results of the flood modelling undertaken for the assessment is provided in the sections below. Further information, included mapping and full results, is provided in Technical Paper 11: Hydrology, flooding and water quality.

#### Albury precinct

The potential construction impacts for each enhancement site in the Albury precinct are summarised in Table 18-12.

**TABLE 18-12 POTENTIAL FLOODING IMPACTS DURING CONSTRUCTION—ALBURY PRECINCT**

| Enhancement site | Location on flood prone land? | Indicative duration of construction works | Potential impacts |
|---|---|---|---|
| Murray River bridge | Yes | 12 months | ▸ No impacts are expected, as the majority of the construction works would be limited to the existing bridge deck, with short-term storage within the rail corridor. Works within the floodplain and scaffolding around the bridge would not impact flood behaviour. |
| Albury Station pedestrian bridge | No | 7 months in total (with construction at individual enhancement sites occurring for 3 to 6 months) | ▸ No impacts, as the enhancement site is not affected by flooding. |
| Albury Yard clearances | | | |
| Riverina Highway bridge | Yes | 16 months | ▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure<br>▸ Potential flooding impacts within the rail corridor at the low point under the existing Riverina Highway bridge. |
| Billy Hughes bridge | No | 16 months | ▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |
| Table Top Yard clearances | No | Less than1 month | ▸ No impacts, as the enhancement site is not affected by flooding. |

#### Greater Hume–Lockhart precinct

The potential construction impacts for each enhancement site in the Greater Hume–Lockhart precinct are summarised in Table 18-13.

**TABLE 18-13 POTENTIAL FLOODING IMPACTS DURING CONSTRUCTION—GREATER HUME–LOCKHART PRECINCT**

| Enhancement site | Location on flood-prone land? | Indicative duration of construction works | Potential impacts |
|---|---|---|---|
| Culcairn pedestrian bridge | Yes | 3 months | ▸ No impacts, as the enhancement site is not affected by flooding. |
| Culcairn Yard clearances | | | |
| Henty Yard clearances | Yes | 3 months | ▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |
| Yerong Creek Yard clearances | No | 3 months | ▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |
| The Rock Yard clearances | Yes | Less than 1 month | ▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |

## Wagga Wagga precinct

The potential construction impacts for each enhancement site in the Wagga Wagga precinct are summarised in Table 18-14.

**TABLE 18-14 POTENTIAL FLOODING IMPACTS DURING CONSTRUCTION—WAGGA WAGGA PRECINCT**

| Enhancement site | Location on flood-prone land? | Indicative duration of construction works | Potential impacts |
|---|---|---|---|
| Uranquinty Yard clearances | Yes | 2 months | ▸ Construction stockpiles, materials and temporary creek crossing at this enhancement site may be impacted in a flood event<br>▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |
| Pearson Street bridge | Yes | 16 months | ▸ Construction stockpiles, materials and temporary creek crossing at this enhancement site may be impacted in a flood event<br>▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |
| Cassidy Parade pedestrian bridge | Yes | 17 months in total (with construction at individual enhancement sites ranging from 3 to 11 months) | ▸ Construction stockpiles, materials and temporary creek crossing at this enhancement site may be impacted in a flood event<br>▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |
| Edmondson Street bridge | | | |
| Wagga Wagga Station pedestrian bridge | | | |
| Wagga Wagga Yard clearances | | | |
| Bomen Yard clearances | Yes | 2 months | ▸ Construction stockpiles, materials and temporary creek crossing at this enhancement site may be impacted in a flood event<br>▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |

### Junee precinct

The potential construction impacts for each enhancement site in the Junee precinct are summarised in Table 18-15.

**TABLE 18-15 POTENTIAL FLOODING IMPACTS DURING CONSTRUCTION—JUNEE PRECINCT**

| Enhancement site | Location on flood prone-land? | Indicative duration of construction works | Potential impacts |
|---|---|---|---|
| Harefield Yard clearances | No | 2 months | ▸ No impacts, as the enhancement site is not affected by flooding. |
| Kemp Street bridge | Yes | 10 months | ▸ Construction stockpiles, materials and temporary creek crossing at this enhancement site may be impacted in a flood event<br>▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |
| Junee Station pedestrian bridge | No | 1 month | ▸ No impacts, as the enhancement site is not affected by flooding. |
| Junee Yard clearances | No | 2 months | ▸ No impacts, as the enhancement site is not affected by flooding. |
| Olympic Highway underbridge | No | 3 months | ▸ No impacts, as the enhancement site is not affected by flooding. |
| Junee to Illabo clearances | Yes | 10 months | ▸ Construction stockpiles, materials and temporary creek crossing at this enhancement site may be impacted in a flood event<br>▸ Temporary redistribution of overland flows and stormwater due to construction infrastructure. |

## 18.4.3 Water quality

### Potential water quality impacts

Construction presents a risk to downstream water quality if management measures are not implemented, monitored and maintained throughout the construction period. If inadequately managed, construction activities could potentially impact water quality if they disturb soil or watercourses, result in the uncontrolled discharges of substances to watercourses, or generate contamination.

Potential sources of water quality impacts include:

- increased sediment loads from exposed soil transported offsite to downstream watercourses during rainfall events and from discharge of sediment-laden wastewater
- exposure of actual or potential acid sulfate soils (ASS), which may generate acidic runoff
- increased levels of nutrients, metals and other pollutants, transported in sediments to downstream watercourses or via discharge of wastewater to watercourses
- increased alkalinity of pH of downstream watercourses and groundwater sources due to runoff from concrete pumps and agitators (concrete dust, slurry or washout water)
- chemicals, oils, grease and petroleum hydrocarbon spills from construction machinery directly polluting downstream watercourses
- litter from construction activities polluting downstream watercourses
- contamination of watercourses due to runoff from contaminated land.

Potential impacts as they relate to water quality, including impacts caused by increased sediment loads, are considered below. The potential impacts on aquatic flora and fauna as a result of water quality impacts are considered in Chapter 16: Biodiversity. The potential for soil and contamination impacts during construction, including the potential for contamination of surface water due to the exposure of ASS or saline soils, spills and leaks, and/or the mobilisation of contaminants encountered during demolition of structures, are considered in Chapter 20: Soils and contamination. Air quality (dust) impacts are considered in Chapter 22: Air quality. Waste management impacts are considered in Chapter 23: Waste and resource management.

### Ground disturbance and stockpiling

The following construction activities have the potential to impact water quality in downstream watercourses as a result of erosion and sedimentation:

- stripping topsoils for site preparation
- vegetation removal
- construction of site access roads, crane pads, construction compounds and other site infrastructure
- cut, fill and piling
- ground disturbance for removal of rail infrastructure
- track realignment including removal, treatment and fill of formation
- stockpiling and transport of materials and soils.

The downstream effects of water quality impacts could potentially include:

- smothering aquatic life and/or inhibiting photosynthesis conditions for aquatic and riparian flora
- impacts on breeding and spawning conditions of aquatic fauna
- changes to water temperature due to reduced light penetration
- increased turbidity levels above the design levels of water treatment infrastructure
- reduced visibility in recreation areas.

The proposal has the potential to temporarily reduce water quality from pollutants and runoff at all enhancement sites; however, with the implementation of standard soil and water construction management measures (refer to section 18.6) the proposal would not cause significant impacts on the overall condition of surrounding watercourses. As such, construction would not result in any long-term water quality impacts in the study area and would be unlikely to cause changes to the water quality environment against the *NSW Water Quality Objectives* and *Basin Plan 2012* objectives, identified in section 18.2.2 and in Technical Paper 11: Hydrology, flooding and water quality.

### Works in watercourses

The proposal involves works in watercourses to construct temporary bridges and culverts at the following enhancement sites:

- Uranquinty Yard clearances
- Pearson Street bridge.

The works at the Uranquinty Yard clearances enhancement site would disturb bed and bank substrates, potentially leading to localised erosion and sediment transport downstream. As described in section 18.1, the proposal includes a number of design features to minimise the extent of disturbance to watercourses. The works at the Pearson Street bridge enhancement site would be undertaken in an existing concrete drain and would therefore be less likely to generate erosion and sediment impacts. Any impacts on water quality in these watercourses would be managed by implementing standard erosion and sediment controls in accordance with the construction soil and water management plan (see section 18.6).

### Concreting

Concrete pumps and agitators would be used at the following sites for construction of new or modified infrastructure:

- Albury Station pedestrian bridge
- Table Top Yard clearances
- Culcairn Yard clearances
- Henty Yard clearances
- Yerong Creek Yard clearances
- Pearson Street bridge
- Cassidy Parade pedestrian bridge
- Edmondson Street bridge
- Wagga Wagga Station pedestrian bridge
- Wagga Yard clearances.

Spills of concrete slurry and wastewater from concrete infrastructure have the potential to impact aquatic and riparian ecosystems by changing soil chemistry of receiving environments. Spills also have the potential to contaminate groundwater sources. Concreting works would be managed by implementing standard erosion and sediment controls in accordance with the construction soil and water management plan to ensure there are no impacts to surface water or groundwater environments (see section 18.6).

## 18.5 Impact assessment—operation

### 18.5.1 Hydrology

#### Water balance

No water would be required from surface or groundwater water sources during operation. There would be no substantial changes to the hydrology of the catchments in which the proposal would operate and therefore no impacts to the water balance. Maintenance regimes would not change as a result of the proposal. Any water required during maintenance activities would be brought to site in accordance with ARTC's existing maintenance procedures; therefore, there would be no impact on water availability due to operation of the proposal.

#### Watercourse hydrology

The proposed changes to the existing drainage arrangements are limited to those described in Table 18-16; however, where new or modified drainage arrangements are proposed, flow paths across floodplains would be modified. The installation or modification of culverts and cess drains may change the patterns of erosion and scouring within existing watercourses and drainage lines, and within broader floodplain areas. Operational impacts are likely to be minor to negligible; as noted in section 18.4.1, culverts and cess drains would be designed to have a minimal impact on existing surface flow paths, with scour protection provided to further mitigate impacts.

New or modified drainage would be designed to consider climate change projections for rainfall. The climate change sensitivity analysis carried out for the proposal assumed a 20 per cent increase in rainfall intensity based on ARR 2019 (Ball et al., 2019). While rail flood immunity would be reduced in a climate change scenario with increased rainfall, projected increases in stormwater runoff would be catered for within the existing rail corridor and there would be no impact beyond the study area.

Maintaining the culverts (as described in section 7.6.2) could disturb watercourses and/or waterfront land, which could impact riparian vegetation and contribute to erosion, sedimentation and water quality impacts. Any such impacts would be minor and managed by implementing ARTC's existing standard operating procedures.

Operational impacts at enhancement sites are summarised in Table 18-16.

**TABLE 18-16 OPERATIONAL IMPACTS TO WATERCOURSE HYDROLOGY**

| Enhancement site | Operational impacts |
|---|---|
| **Albury precinct** | |
| Riverina Highway bridge | ▸ Altered drainage arrangements within the rail corridor with minor changes to the flows discharged into the existing stormwater drainage network at Wilson Street. No impacts to overall watercourse hydrology<br>▸ Changes mimic existing drainage conditions. |
| Billy Hughes bridge | ▸ Altered drainage arrangements within the rail corridor with a minor increase in catchment area (about 0.6 ha). No impacts to overall watercourse hydrology<br>▸ No redistribution or diversion of surface runoff through or from the enhancement site<br>▸ Indicative 3.7 per cent increase in flows to the unnamed drainage line within the site (a tributary of Eight Mile Creek). No impacts to overall watercourse hydrology. |
| **Greater Hume–Lockhart precinct** | |
| Henty Yard clearances | ▸ New cess drainage designed to mimic existing flow conditions<br>▸ Limited changes to the drainage catchment to manage surface water run-off with no redistribution or diversion of surface runoff through or from the enhancement site. |
| **Wagga Wagga precinct** | |
| Uranquinty Yard clearances | ▸ Modified drainage arrangements with no change to the catchment or drainage flow paths, except during flood events (where minor changes to the overland flows would occur). No impacts to overall watercourse hydrology<br>▸ Overland flows directed to Sandy Creek with negligible changes to the hydrologic regime. |

| Enhancement site | Operational impacts |
|---|---|
| Pearson Street bridge | ▸ Minor changes to the discharges to Glenfield Drain (less than 0.003% in the 1% AEP event) as a result of formalisation of drainage arrangements within the rail corridor. No impacts to overall watercourse hydrology<br>▸ Minor change in overland flow due to proposed bunding at the site (less than 0.004% of the upstream flood area). No impacts to overall watercourse hydrology |
| Cassidy Parade pedestrian bridge | ▸ Minor changes to the local drainage catchment associated with Edmondson Street bridge; however, the changes would have a negligible impact on the existing drainage conditions. No impacts to overall watercourse hydrology<br>▸ Minor re-distribution of the flow that causes afflux to the industrial area east of Wagga Wagga Station Yard Clearances with negligible effects in the hydrological regime. |
| Edmondson Street bridge | |
| Wagga Wagga Station pedestrian bridge | |
| Wagga Wagga Yard clearances | |
| Bomen Yard clearances | ▸ Minor changes to the drainage infrastructure. No impacts to overall watercourse hydrology<br>▸ No change to drainage catchments or surface water runoff behaviour. |
| **Junee precinct** | |
| Harefield Yard clearances | ▸ New cess drainage discharging to existing shallow drainage line. No impacts to overall watercourse hydrology<br>▸ No change to drainage catchments or surface water flows. |
| Kemp Street bridge | ▸ New road drainage connecting to the existing council stormwater drainage network<br>▸ Minor change to the sub-catchment (0.7% of the total catchment area). No impacts to overall watercourse hydrology |
| Junee to Illabo track clearances | ▸ Replacement and/or modified culverts<br>▸ No change to drainage catchments or surface water flows. |

### Stormwater and wastewater

The enhancement works have been designed to closely mimic the existing stormwater drainage arrangements at the sites during the operational phase (refer to Chapter 7: Proposal features and operation). Minor increases in downstream flows may occur at some sites; however, would remain within the capacity of the existing stormwater systems that drain the catchments. There would be no substantial changes to the hydrology of the catchments in which the proposal would operate.

The maintenance regime of rail line would not change as a result of the proposal. Surface water during maintenance activities would continue to be managed by implementing standard erosion and sediment control measures in accordance with the Blue Book. There would not be any activities undertaken during operation that would generate wastewater requiring discharge.

## 18.5.2 Flooding

### Flooding characteristics

During operation, there would be minor changes to flood conditions, overland flows and afflux conditions where the vertical alignment of existing track has been altered. In many cases, changes would result in minor improvements to existing rail flood immunity; however, where track lowering is proposed, the design would provide flood immunity in the 1% AEP event. Where flood storage is predicted to be reduced as a result of operational infrastructure, impacts would be minor to negligible. Drainage works have been designed to mimic or improve the existing drainage and flooding conditions, where possible, to minimise operational impacts of the proposal.

Overall, flooding impacts would be minor to negligible and satisfy the QDLs set out for the proposal, with the exception of Wagga Wagga Yard clearances where an increase in afflux was predicted (refer to section 18.2.3 for the QDLs). 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, supplemented by discharge controls from the Wagga Wagga Yard if necessary.

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

The impacts to flooding conditions as a result of the proposal are summarised in Table 18-17. Further information and full results are provided in Technical Paper 11: Hydrology, flooding and water quality.

**TABLE 18-17 OPERATIONAL IMPACTS TO FLOODING CHARACTERISTICS**

| Enhancement site | Key features | Operational impacts | Compliance with quantitative design limits |
|---|---|---|---|
| **Albury precinct** | | | |
| Murray River bridge | ▸ Rail bridge alterations | ▸ No impacts—the proposal would not result in any new or modified structures that could alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Yes |
| 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 | ▸ No impacts—the proposal would not result in any alteration to existing overland flow paths or flood behaviour at or around these enhancement sites. The change to the vertical alignment of the rail line would not alter the existing flood immunity for the rail corridor. | ▸ Yes |
| Albury Yard clearances | ▸ Track realignment | | ▸ Yes |
| Riverina Highway bridge | ▸ Track lowering and realignment | ▸ Lowered track designed to provide 1% AEP flood immunity<br>▸ Drainage works designed to mimic the existing drainage and flooding conditions, and water would be discharged into the stormwater network at Wilson Street; however, the storage tank that would be provided at the lowered section of track would reduce the peak flow downstream of the enhancement site. This would generate a reduction in existing condition flood impacts (about -0.17 $m^3/s$). | ▸ Yes |
| Billy Hughes bridge | ▸ Track lowering and realignment | ▸ Minor change to the drainage catchment (about 0.6 ha), surface water flows (about 3.7%) and afflux conditions (40mm) within the rail corridor. There would be no change to afflux conditions outside the rail corridor. Changes would satisfy the QDLs for the proposal.<br>▸ Lowered track designed to provide 1% AEP flood immunity. | ▸ Yes |
| Table Top Yard clearances | ▸ Gantry removal | ▸ No impact—the proposal would not result in any new or modified structures that could alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Not relevant given the type of work (gantry removal). There would be no changes to flood and drainage conditions. |
| **Greater Hume–Lockhart precinct** | | | |
| Culcairn pedestrian bridge | ▸ Pedestrian bridge removal | ▸ No impacts—the proposal would not alter the flooding regimes or drainage conditions at or around these enhancement sites. | ▸ Not relevant given the type of work (pedestrian bridge removal). There would be no changes to flood and drainage conditions. |
| Culcairn Yard clearances | ▸ Track realignment | | ▸ Yes |
| Henty Yard clearances | ▸ Track realignment<br>▸ Level crossing modifications | ▸ Drainage works designed to mimic the existing drainage conditions, with minor reduction to surface flow path at the Sladen Street culvert (about -0.002 $m^3/s$). Changes would satisfy the QDLs for the proposal. | ▸ Yes |

| Enhancement site | Key features | Operational impacts | Compliance with quantitative design limits |
|---|---|---|---|
| Yerong Creek Yard clearances | ▸ Track realignment | ▸ No impacts—the proposal would not result in any alteration to existing overland flow paths or flood behaviour at or around this enhancement site. The change to the vertical alignment of the rail line would not alter the existing flood immunity for the rail corridor. | ▸ Yes |
| The Rock Yard clearances | ▸ Gantry modification | ▸ No impacts—the proposal would not result in any modification to the gantry that could alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Not relevant given the type of work (gantry modification). There would be no changes to flood and drainage conditions. |
| **Wagga Wagga precinct** | | | |
| Uranquinty Yard clearances | ▸ Track realignment<br>▸ Rail bridge alterations<br>▸ Level crossing modifications | ▸ Minor improvement to flood conditions (less than 10 mm) and minor change to afflux (about 10 mm) and overland flow velocities (about 0.021 m/s) between the rail corridor and the Olympic Highway in the 1% and 2% AEP due to change in the vertical alignment of the track (up to 50 mm). Changes would satisfy the QDLs for the proposal.<br>▸ Track drainage works designed to mimic the existing drainage conditions<br>▸ Negligible change in flood levels, flow velocities and flood hazard. | ▸ Yes |
| Pearson Street bridge | ▸ Track lowering and realignment | ▸ Lowered track designed to provide 1% AEP flood immunity using a 500 mm flood bund near the Glenfield Drain<br>▸ Negligible reduction in local flood storage due to flood bund (about 0.01%). Changes would satisfy the QDLs for the proposal.<br>▸ Minor changes to rail corridor drainage due to formalisation of existing surface runoff paths into the Glenfield Drain resulting in negligible changes to discharges from the rail corridor<br>▸ No change in flood levels, flow velocities and flood hazard. | ▸ Yes |
| Cassidy Parade pedestrian bridge | ▸ Pedestrian bridge replacement | ▸ No impacts—the proposal would not alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Yes |
| Edmondson Street bridge | ▸ Road bridge replacement | ▸ No change to flood behaviour or flow paths. Changes would satisfy the QDLs for the proposal.<br>▸ No adverse afflux, no increase in flow velocities and no change in flood hazard<br>▸ Minor change to drainage catchment areas (about 1 per cent) and upgrades to the existing stormwater drainage network within the study area<br>▸ Drainage works designed to mimic the existing drainage conditions where possible. | ▸ Yes |
| Wagga Wagga Station pedestrian bridge | ▸ Pedestrian bridge replacement | ▸ No impact—the proposal would not alter the flooding regime or drainage conditions at or around this enhancement site | ▸ Yes |

| Enhancement site | Key features | Operational impacts | Compliance with quantitative design limits |
|---|---|---|---|
| Wagga Wagga Yard clearances | ▸ Track realignment | ▸ Changes to flood levels and afflux conditions in the 2% AEP, 1% AEP and PMF due to change in the vertical alignment of the track (up to 80 mm). Flow velocities would be compliant with the QDLs (peak increase of 1.1m/s in the 1% AEP event). There would be no change to flood hazard or hydraulic function<br>▸ Changes would satisfy the QDLs for the proposal, except at one location at the rear of industrial properties on Railway Street. In the 1% AEP event, the area affected is around 0.4 hectares (ha) and would experience an average afflux of 14 mm; however, there would be an isolated increase of up to 79 mm within an existing area of depression.<br>▸ Afflux at this location is a result of a reduction in overland flow that can overtop the rail line. This additional flow is conveyed into a depression in the terrain that has no outlet drainage allowed for within the flood model.<br>▸ As drainage via an existing culvert was not included in the Wagga Wagga City Council flood model, the predicted afflux in this area is expected to be attenuated by this culvert. At detailed design stage the flood model would be updated to include the culvert in the model, which is expected to reduce afflux in this area.<br>▸ During the PMF event, afflux would be up to 30 mm immediately north and south of the rail line. | ▸ QDLs are met except at one location where the afflux in the 1% AEP flood event has been predicted in the industrial area at the east of the site.<br>▸ Further investigation would be undertaken at a detailed design stage. |
| Bomen Yard clearances | ▸ Track realignment<br>▸ Level crossing modifications | ▸ No change to flood conditions, afflux conditions and overland flows due to change in the vertical alignment of the track (up to 78 mm). Changes would satisfy the QDLs for the proposal.<br>▸ Drainage works designed to mimic the existing drainage conditions. | ▸ Yes |
| **Junee precinct** | | | |
| Harefield Yard clearances | ▸ Track realignment<br>▸ Rail bridge alterations | ▸ No impacts—the proposal would not alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Yes |
| Kemp Street bridge | ▸ Road bridge replacement | ▸ Altered drainage network designed to provide 1% AEP flood immunity to the new bridge and existing connecting roads. Changes would satisfy the QDLs for the proposal.<br>▸ Minor change to drainage catchment areas within the study area due to bridge widening with a negligible impact on the existing drainage system capacity. | ▸ Yes |
| Junee Station pedestrian bridge | ▸ Pedestrian bridge removal | ▸ No impacts—the proposal would not alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Yes |
| Junee Yard clearances | ▸ Track realignment | ▸ No impacts—the proposal would not alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Yes |

| Enhancement site | Key features | Operational impacts | Compliance with quantitative design limits |
|---|---|---|---|
| Olympic Highway underbridge | ▸ Track realignment<br>▸ Rail bridge alterations | ▸ No impacts—the proposal would not alter the flooding regime or drainage conditions at or around this enhancement site. | ▸ Yes |
| Junee to Illabo track clearances | ▸ Track realignment<br>▸ Culvert replacement | ▸ Minor to negligible changes to peak flow discharges at replacement culverts (about -0.006 $m^3/s$). Changes would satisfy the QDLs for the proposal. | ▸ Yes |

## Flood hazard and hydraulic function (conveying and storing water)

As described in Table 18-17, the proposal would have negligible effects on the existing flood conditions and mechanisms. There would be no change to the existing flood hazards, floodway or hydraulic functions of impacted areas within the proposal footprint.

## Velocity and scour

As described in in Table 18-17, the proposal would have no (or negligible) impact on flood velocities in the watercourses and receiving systems downstream of the proposal sites; therefore, no scouring, erosion or sedimentation in the downstream systems is anticipated.

Where drainage system modifications are required for the proposal at Riverina Highway bridge, Billy Hughes bridge, Pearson Street bridge and Junee to Illabo clearances, appropriate scour protection measures would be provided at outlets and transitions to the receiving systems.

The proposal would not require modifications of piers, abutments or other sub-structural elements of bridges that span waterways; therefore, no scouring, erosion or sedimentation erosion in waterways is anticipated.

## Consistency with floodplain management plans

The local floodplain management plans applicable to the study area are listed in section 18.2.2. While the approval provisions of these plans do not apply to SSI projects, the operational flood impact assessment concluded:

- the proposed enhancement works would not impact the regional flood conditions
- where enhancement sites are affected by existing overland flooding, operational infrastructure has been designed to maintain the existing surface water flow paths. Only minor flood impacts would occur at these enhancement sites, with no changes to the overall flood behaviour.

The proposal would not result in significant permanent alterations to flood behaviour to which local floodplain management plans apply.

## Emergency management arrangement impacts

There are a number of local flood plans relevant to the proposal site that outline the existing emergency management arrangements for flooding, including preparedness measures before a flood, response operations during a flood and recovery measures after a flood. These plans are held by local councils within the study area and the State Emergency Services (SES).

The proposal would not significantly 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. As such, no significant impacts on the existing property protection measures, flood preparedness and recovery measures, flood evacuation, road traffic control and road closure arrangements identified in the relevant local flood plans would occur as a result of the proposal. Emergency road access during operation of the proposal is discussed in Chapter 9: Transport and traffic. Engagement with local and regional emergency management committees and the SES in relation to the EIS and potential flooding impacts is documented in section 3.3.9 of Technical Paper 11: Hydrology, flooding and water quality.

As outlined in Appendix F: Engagement report, flooding was raised as a key issue by government officials/ agencies during EIS engagement. Several stakeholders raised particular concern about flooding impacts at track lowering sites. During operation, there would be negligible change to the flood behaviour, 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 in the 1% AEP event and, where required, this is supported by additional drainage infrastructure including the pump and storage tank at the Riverina Highway bridge enhancement site and the flood bund at the Pearson Street bridge enhancement site.

### Social and economic impacts of flooding

Social impacts of flooding relate to intangible impacts such as the stress, anxiety and ill health that can be associated with the effects of flood inundation. These are often caused by the disruptions that flooding can have to daily life, such as restricted vehicular access; potential isolation; property damage; odour associated with flood water debris and rubbish; sewage spills; the risk of infection; clean-up work; reduced access to supplies; ponding and slow drainage (time of inundation) after the flood event.

Economic impacts of flooding are those tangible financial impacts as a result of damage or loss caused by floodwaters to buildings, infrastructure and agricultural activity, as well as costs associated with loss of wages, loss of production and clean-up costs.

Overall, the proposal would not result in any broad-scale changes in flood behaviour. The proposed enhancement works have been designed to maintain the existing overland flow paths and mimic the existing drainage conditions. As such, the proposal would not result in any significant flood-related socio-economic impacts.

### 18.5.3 Water quality

During operation, the proposal has the potential to result in the following water-quality impacts:

- release of sediment from brake dust of operational trains and maintenance of access roads
- leaks and spills of chemicals, oils, grease and petroleum hydrocarbons from maintenance and operation of freight trains
- changes to flow regimes, including localised scour and erosion impacts, following installation of new or modified drainage structures (refer to sections 7.2 and 7.3).

Given the enhancement sites are located within the existing operational rail corridor, risks associated with the maintenance and operation of freight trains are managed in line with ARTC's standard operating procedures. There would not be any additional impacts from operation of rollingstock and no change to the existing water quality condition of the study area.

New or modified drainage structures would be designed to mimic existing waterway catchments, flows and flow paths to minimise changes to local and regional flow regimes and associated water quality impacts. Scour protection would be provided at new and modified drainage structures to minimise water quality impacts during operation.

Overall, the operation of the proposal would not cause changes to the water quality environment against the NSW Water Quality Objectives and Basin Plan 2012 objectives identified in section 18.2.2. The implementation of appropriate scour protection and the design control measures would not prevent or hinder the development or implementation of any future strategies that may assist in meeting overall water quality objectives for the catchments over the long term.

## 18.6 Mitigation and management

### 18.6.1 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: Approach to mitigation and management and Appendix H: Construction environmental management plan outline of the EIS.

A soil and water management sub-plan would be prepared and implemented as part of the Construction Environment Management Plan (CEMP). The sub-plan would include measures, processes and responsibilities to minimise the potential for soil and water impacts during construction. This would include (but is not limited to) erosion and sediment control plans and spill management protocols.

For sites located within flood-prone land, a flood and emergency response plan would be prepared and implemented as part of the CEMP. The flood and emergency response plan would comply with the proposal conditions and would:

- include measures, process and responsibilities to minimise the potential impacts of construction activities on flood behaviour as far as practicable
- include measures to manage flood risks and in-stream works during construction and address flood recovery during construction
- be developed in consultation with TfNSW, local councils, emergency services and key affected landholders/managers (as applicable), and in accordance with *Australia Disaster Resilience handbook, Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, Handbook 7* (Australian Institute for Disaster Resilience, 2017).

### 18.6.2 Mitigation measures

Measures that will be implemented to address potential impacts on hydrology, flooding and water quality are listed in Table 18-18.

**TABLE 18-18 HYDROLOGY, FLOODING AND WATER QUALITY MITIGATION MEASURES**

| Stage | Ref | Impact/issue | Mitigation measure |
|---|---|---|---|
| Detailed design / pre-construction | HFWQ1 | Construction water supply | Construction phase water supply options will continue to be explored during detailed design and would include ongoing consultation with water suppliers to access the local reticulated network, use of water tanks within construction compounds and/or use of farm dams.<br>Alternative water supply options, including recycled water, would also be investigated. |
| Detailed design / pre-construction | HFWQ2 | Construction water supply | Opportunities to reduce the need for water would be further explored during detailed design and construction planning. Such options include:<br>▸ use of additives<br>▸ alternative construction techniques<br>▸ reduced dust suppression regime where there is minimal potential for impacts. |
| Detailed design / pre-construction | HFWQ3 | Flooding impacts | Further consultation will be undertaken with local councils and other relevant authorities to identify opportunities to coordinate the proposal with flood mitigation works committed to as part of the council's flood management plans, or other strategies. |
| Detailed design / pre-construction | HFWQ4 | 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 QDLs for Inland Rail. This would be informed by building floor surveys (if required). |
| Construction | HFWQ5 | Flooding impacts | Construction planning and the layout of construction work sites and compounds will be carried out with consideration of overland flow paths and flood risk, avoiding flood-liable land and flood events, where practicable.<br>For the sites located in flood-prone land, and where temporary obstruction of overland flows or drainage systems cannot be avoided, further consideration of flood risk will 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.<br>A flood and emergency response plan will be prepared for the sites located within a flood-prone area. |
| Construction | HFWQ6 | Water quality | Sediment and erosion control devices will be installed in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom, 2004). |
| Construction | HFWQ7 | Discharge to surface water | Discharge to surface water will be undertaken in accordance with the environment protection licence for construction of the proposal and would consider the hydrological attributes of the receiving waterbody. |

#### 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.

### 18.6.3 Interactions between mitigation measures

Mitigation measures to minimise the potential impacts to hydrology, flooding and water quality will also be implemented as part of those identified for Chapter 19: Groundwater and Chapter 20: Soils and contamination.

### 18.6.4 Residual risk

Residual impacts are impacts of the proposal that may remain after implementation of the management and mitigation measures detailed in sections 18.6.1 and 18.6.1. Residual impacts are summarised in Table 18-19.

Further information on the approach to the environmental risk assessment, including descriptions of criteria and risk ratings, is in Appendix E: Environmental risk assessment.

**TABLE 18-19 RESIDUAL RISK MANAGEMENT—HYDROLOGY, FLOODING AND WATER QUALITY**

| Stage | Potential impact | Pre-mitigated Rating | Mitigation measures[1] | Residual risk rating | Residual risk management[2] |
|---|---|---|---|---|---|
| Construction | Impact to regional or local water supply due to construction water demands | Low | HFWQ1 | Low | N/A |
| Construction | Potential temporary impacts on flood-prone areas (e.g. increase in flood risk outside the proposal site) due to new temporary structures, changes to overland flows or displacing flood storage areas | Medium | HFWQ2 | Low | N/A |
| Construction | Potential impacts on construction activities due to flooding | Medium | HFWQ5 | Low | N/A |
| Construction | Changes to flow patterns and altered hydrology due to construction over/in watercourses resulting in significant impact to water quality or hydrological processes. | Medium | HFWQ6, CEMP | Low | N/A |
| Construction | Sedimentation and changes to geomorphology in watercourses | Low | HFWQ6, HFWQ7, CEMP | Low | N/A |
| Construction | Erosion and sediment transport downstream due to works in watercourses | Medium | HFWQ6, HFWQ7, CEMP | Low | N/A |
| Construction | Impacts on water quality from contamination from spills and leaks during construction | Medium | CEMP | Low | N/A |
| Construction | Lead-based paint flakes entering the waterway during works on the Murray River bridge | High | SC8, SC10, H4 | Low | N/A |
| Construction | Potential exposure of acid sulfate soils during construction resulting in off-site discharge of acidic water | Low | HFWQ6, HFWQ7, SC1, CEMP | Low | N/A |
| Construction | Potential exposure of soil salinity/saline soils/saline groundwater during construction resulting in off-site discharge of saline water resulting in exceedances of water quality trigger levels | Medium | HFWQ6, HFWQ7, SC4, CEMP | Low | N/A |
| Operation | Potential impacts on flood-prone areas (e.g. increase in flood risk outside the proposal site) due to new/modified structures or displacing flood storage areas | Low | HFWQ4, Quantitative design limits | Low | N/A |
| Operation | Impact to surface water quality and receiving environments due to increased runoff from an increase in impervious surfaces | Low | N/A | Low | N/A |

| Stage | Potential impact | Pre-mitigated Rating | Mitigation measures[1] | Residual risk rating | Residual risk management[2] |
|---|---|---|---|---|---|
| Operation | Impacts on upstream and downstream drainage due to the modification of built structures such as embankments, culverts and bridges, resulting in water quality impacts (including scour and discharges from lowered track) | Medium | QDLs | Low | N/A |
| Operation | Potential capture of saline groundwater resulting in off-site discharge of saline water resulting in exceedances of water quality trigger levels | Low | GW2 | Low | N/A |
| Operation | Impacts on water quality from contamination from spills and leaks during maintenance | Medium | Managed in accordance with ARTC procedures | Low | N/A |

1. As described in Table 18-18.
2. For residual impacts with a risk rating of medium or above.