Appendix H

Surface water and groundwater impact assessment

Transport for NSW

Townson Road Upgrade between Richmond Road and Jersey Road – Stage 1

Surface water and groundwater impact assessment

December 2020

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1. Introduction

1.1 Overview

Transport for NSW (TfNSW) is proposing to construct a four-lane divided road along Townson Road/Burdekin Road corridor linking Richmond Road, Marsden Park in the west and Burdekin Road, Schofields in the east. The length of the overall program of work is about 3.6 kilometres.

The overall program of work consists of two stages:

- Stage 1 (the proposal) involves an upgrade of about 1.6 kilometres of road extending from Richmond Road to south of Jersey Road (see Figure 1-1)
- Stage 2 is about two kilometres in length involving the construction of a new road between the Stage 1 tie-in and Burdekin Road.

Stage 2 is subject to a separate planning approval.

Staged delivery of the proposal would involve:

- Interim phase – two lanes plus earthworks (Figure 1-2)
- Ultimate phase – completion of remainder of the works for a four-lane dual carriageway.

The proposal is located within the Marsden Park Industrial and West Schofields precincts of the North West Growth Area, about 37 kilometres north-west of the Sydney central business district and three kilometres west of Schofields

Transport for NSW is the proponent of the proposal, and an environmental assessment in the form of a review of environmental factors (REF) is being prepared in accordance with the requirements of Division 5.1 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act).

This report assesses and documents the potential flooding and hydrology impacts of the proposal.

1.2 Proposal outline

The key features of the proposal are shown in Figure 1-1 and include:

- Widening and upgrading about 1.6 kilometres of Townson Road, between Richmond Road and Durham Road/Jersey Road, to provide:
  - Two traffic lanes, about 3.5 metres wide in each direction
  - A new section of Townson Road about 250 metres long, to the east of the existing alignment, between Meadow Road and Durham Road/Jersey Road
  - A temporary connection road extending from the tie-in stub to Durham Road/Jersey Road to maintain access and connectivity until Stage 2 is operational
  - A new southbound sliplane at Richmond Road intersection from Townson Road.
- Providing a wide central median along the length of the proposal narrowing at intersections to allow for turning lanes
- Constructing two bridges, each about 36 metres long, to reduce flooding afflux with one bridge over Bells Creek and another bridge about 50 metres east of Bells Creek
- Providing two new signalised intersection allowing all turning movements to and from Townson Road/Victory Road/a new road, and formalised pedestrian crossings at each leg of the signalised intersection

- Constructing stubs for Victory Road north and the new road to the north and south of the Townson Road intersection, with a traffic lane in each direction about 3.5 metres wide and a footway on either side, about 1.2 metres wide
- Providing a shared path about three metres wide for pedestrians and cyclists on the southern side of Townson Road along the length of the proposal and a pedestrian crossing across the new southbound sliplane from Townson Road to Richmond Road
- Providing a footpath about 1.2 metres wide on the northern side of Townson Road along the length of the proposal and at the intersections.

This interim phase allows the surrounding developments to progress and allows utilities to be relocated to their ultimate location. It is anticipated that construction of the interim phase would commence in early 2022 and would be open to traffic in 2023. Completion of the ultimate phase of the proposal would take place around five years after completion of the interim phase.

1.3 Scope of this assessment

The purpose of this surface water and groundwater report is to assess impacts from the proposal operation and construction of the proposal on surface water and groundwater and its sensitive receptors (including receiving environments, registered users and groundwater dependent ecosystems (GDEs) in accordance with the assessment requirements outlined in the following sections and, where required, identify feasible and reasonable measures to avoid, minimise and mitigate impacts. This report supports the REF for the proposal. The scope of assessment included:

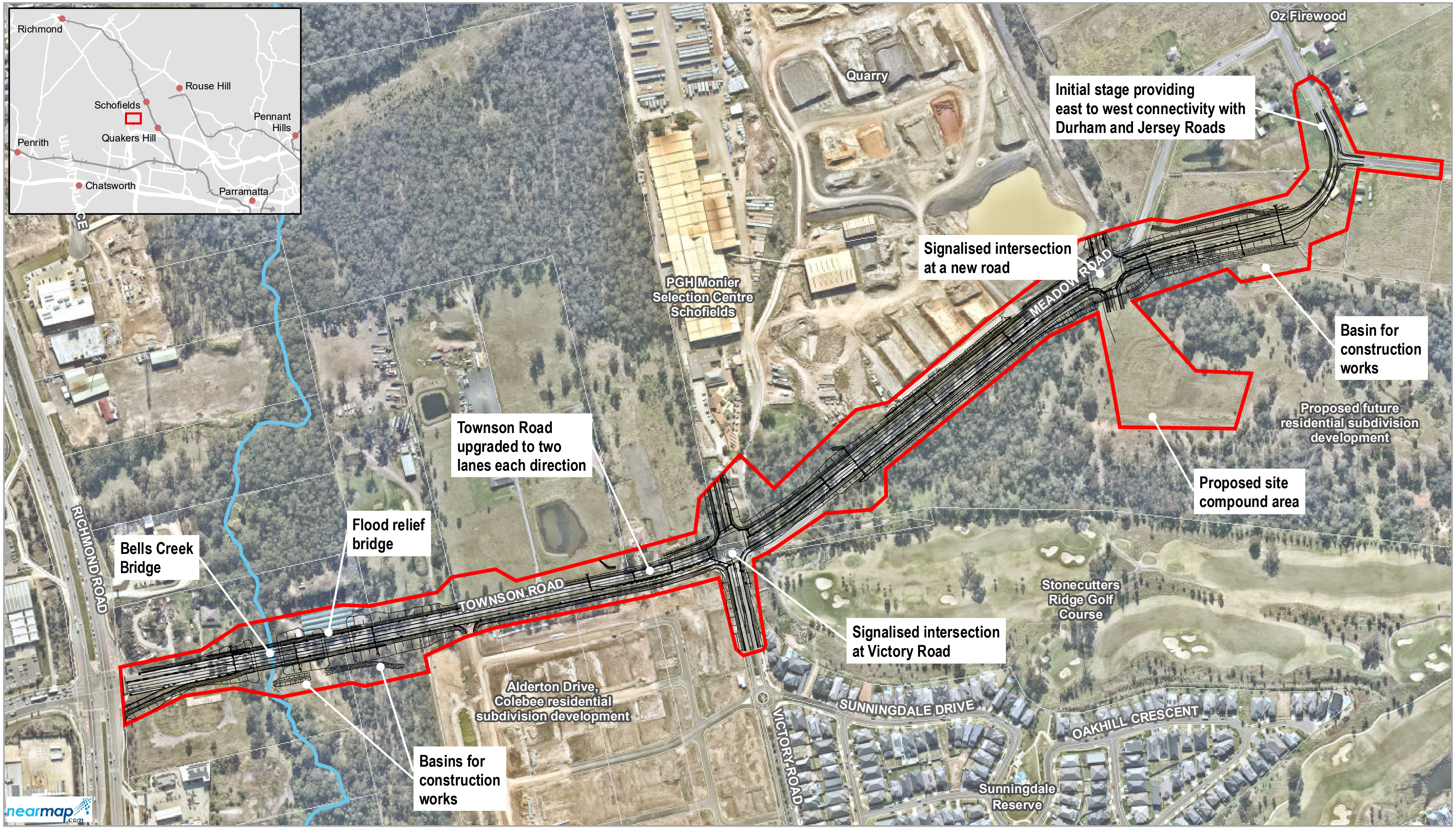
- Identification of the existing surface water and groundwater conditions in the proposal area
- Assess the potential operational surface water and groundwater impacts of the proposal
- Assess the potential construction surface water and groundwater impacts of the proposal based on the proposal description
- Determine suitable mitigation measures in order to minimise or eliminate any surface water or groundwater impacts resulting from the proposal
- Prepare a report summarising the findings of the study.

1.4 Report structure

The report is comprised of the following sections:

- **Section 2 – Methodology:** a brief summary of the methods used for the assessment of the proposal
- **Section 3 – Legislative context:** summarises the relevant legislation, guidelines and policy documents
- **Section 4 – Existing environment:** summarises the existing surface water and groundwater environment
- **Section 5 – The proposal:** summarises aspects of the proposal relevant to surface water and groundwater that informed the assessment of potential construction and operational phase impacts
- **Section 6 – Construction impact assessment:** discusses the construction impacts of the proposal and results of the surface water and groundwater assessment
- **Section 7 – Operational impact assessment:** discusses the operational impacts of the proposal and results of the surface water and groundwater assessment

- **Section 8 – Cumulative impacts:** discusses the impacts of nearvy projects which may be under construction or operational during a similar timeframe
- **Section 9 – Mitigation and management measures:** provides management and mitigation recommendations for the construction and operational impacts of the proposal
- **Section 10 – Conclusion:** presents a summary of the surface water and groundwater impact assessment findings and sets out the principal conclusions for the study.



LEGEND

- The proposal *Subject to detailed design*
- Construction
- Cadastre

Paper Size ISO A4

0 25 50 75 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

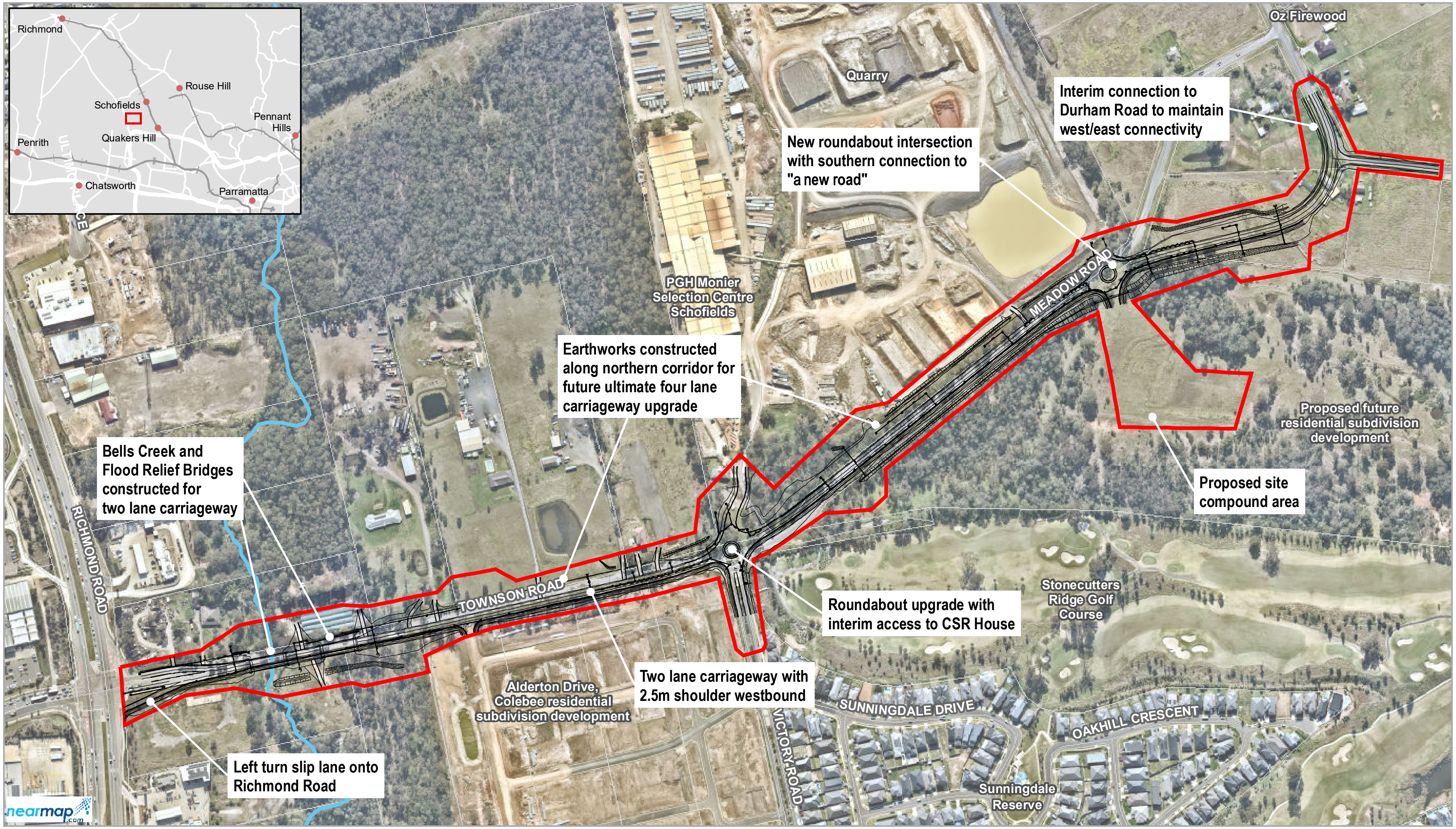
Transport for NSW
Townson Road Upgrade Stage 1
Between Richmond Road and Jersey Road

The Ultimate Phase of the Proposal

Project No. **21-12511195**
Revision No. **-**
Date **6/11/2020**

FIGURE 1-1

Data source: Aerial Imagery - Nearmap 2019 (image date 12/09/2019, image extracted 21/09/2019) and NSW Six Maps, 2019 . Created by: eibbertson



LEGEND

- The proposal *Subject to detailed design*
- Construction footprint
- Cadastre

Paper Size ISO A4

0 25 50 75 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

Transport for NSW
Townson Road Upgrade Stage 1
Between Richmond Road and Jersey Road

Interim phase of the proposal

Project No. **21-12511195**
Revision No. **-**
Date **4/12/2020**

FIGURE 1-2

Data source: Aerial Imagery - Nearmap 2020 (image date 03/08/2020, image extracted 28/09/2020) and NSW Six Maps, 2020 . Created by: eibbertson

2. Methodology

2.1 General

The assessment of potential surface and groundwater related impacts arising from the proposal have been implemented as follows:

- Review of similar assessments and previous projects in the surrounding area
- Identification and review of legislation, policies and guidelines relevant to surface water and groundwater impacts for the proposal
- Characterisation of the existing environment including: climate, topography, geology, hydrology, hydrogeology, water quality and sensitive receiving environments
- Analytical groundwater calculations to predict potential groundwater inflows and radius of influence at specific excavation sites
- Assessment of potential surface water related impacts to satisfy the minimal impact considerations of the *National Water Quality Management Strategy* (NWQMS)
- Assessment of potential groundwater related impacts to satisfy the minimal impact considerations of the *NSW Aquifer Interference Policy* (AIP)
- Recommendations for monitoring and management of identified impacts and risks, including mitigation measures as appropriate.

The specific methodologies used for these components are described in the following sections.

2.2 Proposal setting

Although the proposal directly crosses Bells Creek it is not exclusively located within the Bells Creek catchment. Approximately the western half of the proposal area is located within the Bells Creek catchment and the eastern half is located in the Eastern Creek catchment. Both Bells Creek and Eastern Creek catchments flow from South to North. The Bells Creek catchment drains into the Eastern Creek catchment which ultimately flows into South Creek and the Hawkesbury River.

2.3 Desktop assessment

The desktop assessment involved a review of the existing surface water and groundwater environment across the proposal area to assess the likely and potential impacts of the proposal on flow and quality during construction and operation. This included the consideration of the catchments of Bells Creek and Eastern Creek.

The review included collation and review of background information, previous reports and proposal information including:

- Potential sensitive receiving environments near the proposal area
- Existing water quality information for Eastern Creek and Bells Creek
- Review of relevant legislation and guidelines as outlined in section 3
- Review of proposed construction footrprint and wider proposal area
- Publically available groundwater data.

2.3.1 Public data sources

A summary of various data sources used as part of this assessment are provided in Table 2-1 below.

Table 2-1 Summary of data sources

Data description	Source
Groundwater bore use and status, groundwater level and quality data at monitoring bores	The Pinneena database (NSW Government)
Existing groundwater user data including Water Access Licences (WAL) holders and stock and domestic users	NSW Water Register website (https://waterregister.waternsw.com.au/water-register-frame)
Registered bore data	Water NSW real time data website (https://realtimedata.waternsw.com.au/)
Registered bore data	Bureau of Meteorology (BOM) bore website (http://www.bom.gov.au/water/groundwater/index.shtml)
Data identifying location and groundwater dependence of surface water systems and vegetation	The National Atlas of Groundwater Dependent Ecosystems (http://www.bom.gov.au/water/groundwater/gde/)
Contaminated site locations	The NSW Environment Protection Authority (EPA) list of contaminated sites notified to the EPA (http://www.epa.nsw.gov.au/your-environment/contaminated-land/notification-policy/contaminated-sites-list)
Rainfall and evaporation data	Scientific Information for Land Owners (SILO)
Soil data including the presence of Acid Sulfate Soils (ASS)	The eSPADE website for acid sulphate soil and soils data - https://www.environment.nsw.gov.au/eSpade2Webapp
Regional geology data	1:100,000 scale Sydney Area Coastal Quaternary Geology Map (2015) map
Regional geology data	Penrith Geological Series Sheet 9030 (Edition 1, 1991) map
Soil landscapes data	1:100,000 scale Penrith Soil Landscape Series Sheet 9030 map

2.3.2 Review of previous studies

Burdekin Road and Townson Road extension and upgrade – Preliminary environmental investigation

The *Burdekin Road and Townson Road extension and upgrade – Preliminary environmental investigation* (RMS 2018) report provides a preliminary investigation of the potential social and environmental impacts associated with both the proposal and Stage 2. The purpose of the investigation was to identify social and environmental factors that require more detailed investigation during the concept and detailed design phases. The report findings relevant to the surface water and groundwater impacts are summarised below.

- **Groundwater dependent ecosystems** – the report identified the presence of high potential GDEs in the western part of the investigation are between Richmond Road and Victory Road, and in the central part of the investigation area along the Eastern Creek corridor.

- **Threatened flora and fauna** – the report identified several endangered and a significant number of threatened flora and fauna species within the investigation area. This includes a number of species dependent on riparian habitats and therefore potentially sensitive to surface water impacts.
- **Acid sulfate soils (ASS)** – the report did not identify ASS as being a risk within the investigation area.
- **Salinity** – the report identified the areas near Bells Creek and Eastern Creek within the investigation area as having high salinity potential with the remainder of the site having a moderate salinity potential. Despite this the report found no evidence of salinity indicators such as bare soils patches, salt crystals at the surface or die back of trees.
- **Contamination** – The report identified several areas of environmental concern within the investigation area. All these areas were rated as low-moderate or low risk of contamination.
- **Surface water** – the report identified that new road crossings at Bells Creek and Eastern Creek have the potential to alter existing surface flow patterns while increased impervious surface areas could increase flow volumes.
- **Groundwater** – the report identified that existing groundwater levels and flow paths could be affected by excavation and installation of new road infrastructure.

City of Blacktown: Townson Road to Burdekin Road – Concept Design Stage – Geotechnical Fractual Report

The *City of Blacktown: Townson Road to Burdekin Road – Concept Design Stage – Geotechnical Factual Report* (RMS 2019b) is a concept level geotechnical investigation for the upgrade of Townson Road and extention of Burdekin Road. The purpose of the investigation was to obtain an understanding of subsurface conditions to facilitate development of the road design. The report findings relavant to the surface water and groundwater impacts are summarised below.

- **Groundwater data** – the investigation involved a borehole and test pit sampling regime. Some of these bores yielded groundwater data that has been used to inform this assessment. This data is summarised in section 4.5.3.

Townson and Burdekin Road Design – Contamination Preliminary Site Investigation

The *Townson and Burdekin Road Design – Contamination Preliminary Site Investigation* (GHD, 2019b) report is a preliminary investigation (including site visit) of the magnitude and associated risk of potential contamined land within the footprint of theproposal study area. The report found the following potential sources of contamination:

- Potential for hydrocarbon, metals and asbestos impacts from unknown fill material identified at the Dam wall constructed at 55 Townson Road, within the Townson Road verge and at 46 Durham Road
- Potential hydrocarbon impact of soil and groundwater related to long term quarrying activities at PGH Bricks and Paver quarry at 75 Townson Road, Schofields
- Potential per- and poly-fluoroalkyl substances (PFAS) and hydrocarbon impacts in soil, groundwater and surface water associated with historic defence activities at HMAS Nirimba
- Potential pesticide and herbicide contamination of soil and surface water at Bravo Nursery at 9 Townson Road, Marsden Park
- Potential hydrocarbon impacts of soil and groundwater associated with heavy machinery and truck storage yards observed at 6 and 9 Townson Road.

These sources present a potential contamination risk to both surface and groundwater sources in the proposal area and the report recommended that a detailed site investigation be completed to quatify these risks and provide mitigation recommendations where required.

West Schofields Precinct Plan – Flooding, Water Cycle Management and Riparian Corridor Assessment, prepared by Calibre for Department of Planning and Environment

The *West Schofields Precinct Plan – Flooding, Water Cycle Management and Riparian Corridor Assessment* (Calibre 2018) prepared as part of the precinct planning for the West Schofields Precinct, part of the North West Growth Area in Sydney. The report was prepared to outline the findings of the three engineering investigations of the flooding, water cycle management and riparian corridor assessment.

The extensive flooding within the precinct boundary has shaped the layout of the precinct, with almost half of the land within the precinct located under the 100 year flood level, making it unsuitable for many forms of development. The planning constraints resulting from the outcomes of the flood modelling investigations have been incorporated in the development of the Indicative Layout Plan, which includes the road connection from Townson Road to Burdekin Road. These flood constraints on Bells Creek relate to the proposal.

The overall water management strategy for the West Schofields Precinct involves the implementation of water sensitive urban design features, along with traditional drainage infrastructure to achieve water management objectives. Integrated water cycle management measures have been incorporated into the masterplanning and development controls, with the development of the West Schofields Precinct Indicative Layout Plan incorporating the measures outlined in this report. These measures have been designed to address runoff from Stages 1 of the Townson Road to Burdekin Road upgrade.

2.4 Surface water quality impact assessment

The following methodology was adopted to quantify surface water impacts:

- Consideration of the location of the proposal area in the context of surrounding and upstream catchment areas and potential influence of downstream waterways
- Identification of construction activities likely to impact on surface water quality
- Review of the reference design and activities likely to cause an impact on water quality.
- Identification and assessment of impacts on water quality with respect to potential increases or decreases in pollutant loading both at construction stage and during operation
- Identification of potential impacts and opportunities to stormwater quality during the construction and operational phases
- Develop water quality objectives based on the NWQMS guidelines.

2.5 Groundwater quality impact assessment

The following methodology was adopted to quantify surface water and groundwater impacts:

- Identification of construction activities likely to impact on groundwater
- Review of the reference design and activities likely to cause an impact on groundwater
- Identification and assessment of impacts on water quality with respect to potential increases or decreases in pollutant loading both at construction stage and during operation
- Developing a conceptual model of the hydrogeological environment at site

- Calculation of groundwater inflows for construction elements that may intercept groundwater using the analytical equations and approach outlined in Marinelli and Niccoli (2000)
- Assessment of potential groundwater impacts against the criteria specified in the NSW Aquifer Interference Policy
- Develop water quality objectives based on the NWQMS guidelines
- Identify groundwater dependent ecosystems and determine if they are likely to be impacted by the Proposal.

Analytical groundwater monitoring has been undertaken to quantify any potential inflow or drawdown impacts at excavations at risk of intercepting groundwater. The methodology is described below.

2.5.1 Analytical equations

Several activities are expected to intersect groundwater as part of the proposal and therefore analytical modelling has been undertaken to estimate the potential radius of impacts. Groundwater inflows have also been estimated for the proposed excavations that may intercept groundwater using the analytical equations developed by Marinelli and Niccoli (2000).

The analytical equations are presented below and a conceptual diagram is presented in Figure 2-1.

$$Q_1 = W\pi(r_o^2 - r_p^2)$$

$$Q_2 = 4r_o\left(\frac{K_{h2}}{m_2}\right)(h_o - d)$$

$$m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

$$h_o = \sqrt{h_p^2 + \frac{W}{K_{h1}}\left[r_o^2 \ln\left(\frac{r_o}{r_p}\right) - \frac{\left(r_o^2 - r_p^2\right)}{2}\right]}$$

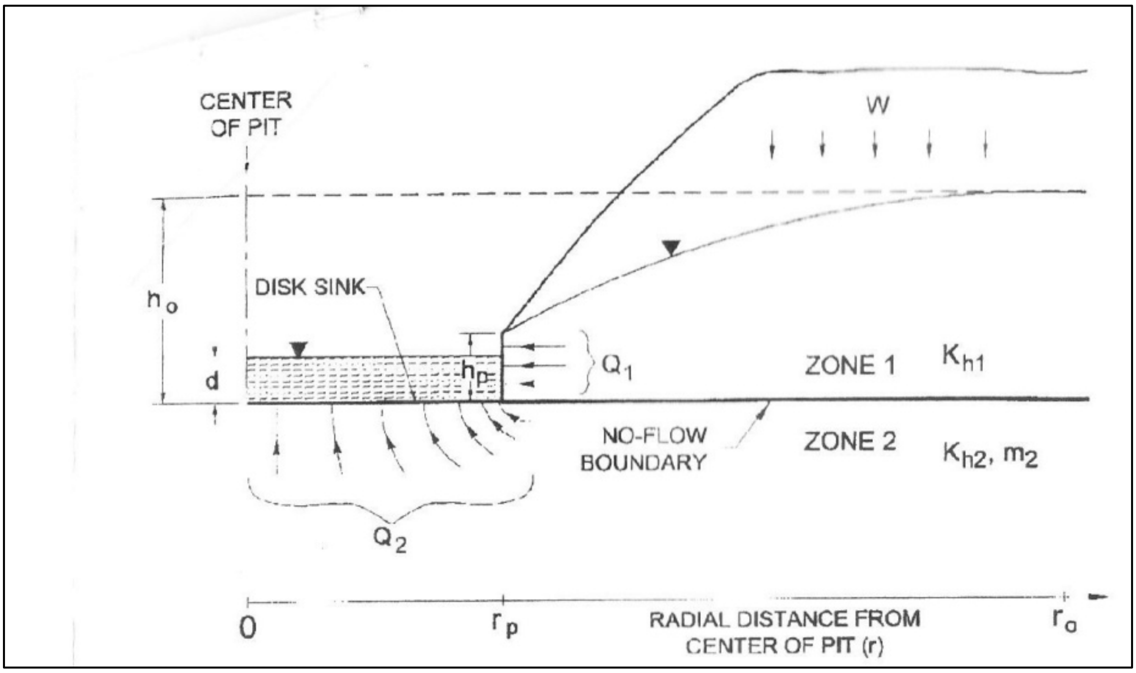

Figure 2-1 Groundwater model conceptual diagram

Where:

Q1 = discharge from the fill/alluvium/residual soils aquifer into the excavation

Q2 = discharge from the bedrock aquifer into the base of the excavation

rp = effective radius of the excavation (m)

ho = initial saturated thickness of the fill/alluvium/residual soils aquifer (m)

hp = saturated thickness above base of zone 1 (m)

d = depth of water in excavation (m)

W = distributed recharge flux (m/s)

Kh1, Kh2 = hydraulic conductivity of zone 1 (fill) and zone 2 (bedrock) aquifers respectively (m/s)

Kv2 = vertical hydraulic conductivity of zone 2 (bedrock).

ro = radius of influence (m)

This equation assumes flow from all sides of the pit for the fill aquifer (zone 1).

2.5.2 Modelling input data

Data sources and assumptions used to derive input values for each of the parameters required for the equations developed by Marinelli and Niccoli (2000) are outlined in the following section:

Initial (pre-construction) saturated thickness (h_o)

The initial (pre-construction) saturated thickness was estimated to be equal to the height of groundwater above the base of the pit. As groundwater level data were not available for the greater proposal area, the minimum observed groundwater depth recorded at BH06 and BH12 have been extrapolated for the length of the excavations required for the proposal.

A sensitivity has also been performed assuming a groundwater level 0.3 metres below ground level.

Saturated thickness at pit wall (h_p)

The excavations are assumed to be fully dewatered during construction. Therefore, the saturated thickness at pit wall (h_p) was assumed to be equal to zero.

Distributed recharge flux (W)

Based on the largely impervious nature of the Wianamatta group shale bedrock in the area, a net recharge rate of one per cent of long term average rainfall at Quakers Hill Weather Station (67076) was adopted for the assessment. Long-term average annual rainfall over 1900 to 2018 was 823 millimetres per year. A net recharge rate of one per cent gives an estimated long-term average recharge rate of 8.23 millimetres per year or 2.25×10^{-5} metres per day.

Hydraulic conductivity Zones 1 and 2 (Kh_1, Kh_2 and Kv_2)

In the absence of hydraulic conductivity data from the site, typical and high values reported within the Sydney basin have been adopted. These values have been taken from the *Context statement for the Sydney Basin bioregion* (DEE 2019)

It was assumed that the horizontal hydraulic conductivity is 10 times greater than vertical hydraulic conductivity. Zone 1 is assumed to constitute Alluvium while Zone 2 is assumed to constitute Bedrock. Adopted hydraulic conductivities are presented in Table 2-2.

Table 2-2 Adopted hydraulic conductivity values

Soil type	Horizontal hydraulic conductivity (m/day)	
	Typical value	High value
Alluvium (Silty Clay)	1×10^{-3}	1×10^{-2}
Bedrock (Siltstone)	1×10^{-5}	1×10^{-3}

Effective pit radius (r_p)

Effective pit radius is equal to the radius of the excavation. The dimensions of the expected excavations are presented in Table 2-3 and are based on the excavations exceeding 1.3 metres depth below ground level. It is assumed for road segments that only 40 metres will be excavated at any one time and therefore these pits are assumed to be 40 metres long by 20 metres wide.The area of this pit was input into the formula for the area of a circle (ie $A = \pi r_p^2$), to give an effective pit radius. The effective pit radius of each excavation is provided in Table 2-3.

Table 2-3 Assumed pit excavation dimensions at excavations a risk of groundwater interception

Excavation activity	Length (m)	Width (m)	Pit depth (m)	Effective radius (m)
Road construction (Ch. 0 m-100 m)	40.0	20.0	1.51	15.96
Road construction (Ch. 480 m-840 m)	40.0	20.0	3.51	15.96
Road construction (Ch. 980 m-1300 m)	40.0	20.0	2.10	15.96
Stormwater basins	10.0	5.0	2.50	3.99
Bells Creek Bridge bored piles excavation	40.0	30.0	4.00	19.54
Overflow Bridges bored piles excavation	40.0	30.0	4.00	19.54
Service relocation pits	20.0	3.0	2.50	4.37

Radius of influence (r_o)

The radius of influence (r_o) of any groundwater abstraction represents a balance between the hydraulic conductivity of the strata and the rate of recharge incident at the water table. The radius of influence has been estimated from the analytical equations presented in Section 2.5.1.

2.5.3 Modelling scenarios

To capture more likely and worst case groundwater inflow predictions, several scenarios have been modelled for each excavation. These scenarios provide a sensitivity of the model to hydraulic conductivity values and groundwater levels. A summary of the scenarios is presented in Table 2-4.

Table 2-4 Groundwater modelling scenarios

Scenario	Groundwater level (mbgl)	Horizontal hydraulic conductivity (m/day)		Vertical hydraulic conductivity (m/day)
		Zone 1	Zone 2	Zone 2
1	1.3	1×10^{-3}	1×10^{-5}	1×10^{-6}
2	1.3	1×10^{-2}	1×10^{-3}	1×10^{-4}
3	0.3	1×10^{-3}	1×10^{-5}	1×10^{-6}
4	0.3	1×10^{-2}	1×10^{-3}	1×10^{-4}

2.6 Development of mitigation measures

Mitigation measures were identified to reduce potential adverse impacts on surface water and groundwater environments. This included:

- Identification of measures and controls to mitigate impacts on surface water quality and groundwater
- Broad assessment of the expected residual impacts on surface water and groundwater following implementation of measures and controls
- Implementation of water quality monitoring prior to and during construction.

3. Legislative context

3.1 NSW Legislation

3.1.1 Protection of the Environment Operations Act 1997

The *Protection of the Environmental Operations Act 1997* (POEO) is NSW legislation administered by the Department of Planning, Industry and Environment (DPIE). The POEO Act regulates air and water pollution, noise control and waste management and outlines the provision of environmental protection licences that owners or occupiers of premises engaged in scheduled activites are required to hold and comply with. The proposal is considered a scheduled activity as it meets the relevant criteria for road construction activities of Schedule 1 of the POEO Act.

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

3.1.2 Protection of the Environment Administration Act 1991

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

3.1.3 Water Act 1912 and Water Management Act 2000

The *Water Act 1912* and the Water *Management Act 2000* (WM Act) are the two major pieces of legislation for the management of water in NSW and contain provisions for the licenceing of water access and use. The *Water Act 1912* has historically been the main legislation for managing water resources in NSW, however, is currently being progressively phased out and replaced by water sharing plans (WSPs) under the WM Act.

The aim of the WM Act is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and in-stream uses as well as to provide for protection of catchment conditions.

Water sharing plans

Water sources in NSW are managed via WSPs under the WM Act. Provisions within WSPs provide water to support the ecological processes and environmental needs of groundwater dependent ecosystems and waterways. WSPs also regulate how the water available for extraction is shared between the environment, basic landholder rights, town water supplies and commercial uses. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

Water access licences (WAL) entitle licence holders to specified share components in the available water that may be sustainably extracted from a particular water source. The actual volume of water available to be extracted may vary, dependent on available water determinations made under the WM Act. Available water determinations are made for each WAL category in each water source and are generally made at the start of a water year, although may be altered at any time.

The proposal area is covered by the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Sources 2011* and the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011.*

Water Sharing Plan for the Greater Metropolitan Region Unregulated River Sources 2011

The proposal area under the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Sources 2011* (NSW Government 2018), is located in the Lower South Creek Management Zone of the Hawkesbury and Lower Nepean Rivers water source. This plan applies to surface water sources and includes rules for protecting the environment, water extraction, managing licence holders' water accounts and water trading within the plan area.

Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011

The proposal area under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* (NSW Government 2015), is located in the Sydney Basin Central Groundwater Source. This plan applies to groundwater sources and includes rules for environmental water provisions, long term average extraction limits and access, trading and works approvals.

Within the Sydney Basin Central Groundwater Source there are currently approximately 160 groundwater access licences with a total licensed extraction volume of approximately 3500 ML/year (RMS 2019a). The long term average annual extraction limit for the Sydney Basin Central Groundwater source is 45,915 ML/year (NSW Government 2015), which is 25 per cent of the estimated annual recharge of the area. This demonstrates that large volumes of unallocated groundwater exist and while the proposal does not require a WAL, any groundwater extraction is unlikely to significantly impact aquifer sustainability.

Water Access Licences

Under Schedule 4, Part 1, clause 2 of the *Water Management (General) Regulation 2018*, roads authorities are exempt from the requirement to hold a water access licence to take water for road construction and road maintenance.

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

The purpose of the *Sydney Regional Environment Plan No. 20 – Hawkesbury-Nepean River – (No2-1997)* (NSW Government 2012) (SREP20) is to protect the environment of the Hawkesbury-Nepean River system by ensuring that impacts of future land uses are considered in a regional context. It contains provisions for total catchment management, the protection of environmentally sensitive areas, water quality and quantity and controls development that may be detrimental to the environment within the river system.

The proposal is located within the Blacktown local government area and the South Creek subcatchment of the Hawkesbury-Nepean River system which means it is covered by the SREP20 legislation. Specific planning policies for consideration in this proposal include:

- **Total catchment management** – the proposal is to be integrated with environmental planning for the total catchment.
- **Environmentally sensitive areas** – the quality of environmentally sensitive areas must be protected and enhanced through careful control of future land use changes and through management and remediation of existing uses.
- **Water quality** – future development must not prejudice the achievement of the goals of use of the river for primary contact recreation and aquatic ecosystem protection in the river system.
- **Water quantity** – Aquatic ecosystems must not be adversely affected by development which changes the flow characteristics of surface or groundwater in the catchment.

3.2 Policies and guidelines

The following policies and guidelines are relevant to this impact assessment.

3.2.1 General policies and guidelines

National Water Quality Management Strategy

Since 1992, the *National Water Quality Management Strategy* (NWQMS) (ARMCANZ & ANZECC 1994) has been developed by the Australian and New Zealand Governments in cooperation with state and territory governments. The NWQMS aims to protect the nation's water resources, by improving water quality while supporting the businesses, industry, environment and communities that depend on water for their continued development.

The NWQMS consists of three major elements: policy, process and guidelines. The main policy objective of the NWQMS is to achieve sustainable use of water resources, by protecting and enhancing their quality, while maintaining economic and social development. The process strives to form a nationally consistent approach to water quality management through the development of high-status national guidelines. The guidelines provide the point of reference when issues are being determined on a case-by-case basis. These include guidance on regulatory and market-based approaches to managing water quality as well as regional water quality criteria.

The Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines are relevant to this assessment.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000b) (hereforth refered to as the ANZECC guidelines) are based on the policies and principles of the NWQMS. The main objective of the guidelines is to provide an authoritative guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand. The guidelines provide a set of tools to enable the assessment and management of ambient water quality in a wide range of water resource types and define the recommended limits to acceptable changes in water quality.

It should be noted that these guidelines have not been designed specifically for direct application in activities such as discharge consents, recycled water quality or stormwater quality. They have been derived to apply to ambient waters that receive effluent or stormwater discharges and protect the environmental values they support. However the ANZECC guidelines have been used as the basis for the surface water and groundwater quality assessment presented in this report.

Using the ANZECC Guidelines and Water Quality Objectives in NSW

The document *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DEC 2006) provides guidance on applying the ANZECC guidelines (2000b) framework for assessing water quality, including the use of water quality objectives for NSW.

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

The *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales* (DEC 2004) document lists the sampling and analysis methods to be used when complying with a requirement to test for the presence or concentration of matter in water and the volume, depth and flow of water or wastewater.

3.2.2 Surface water policies and guidelines

NSW Water Quality and River Flow Objectives

The *NSW Water Quality and River Flow Objectives* (DECCW 2006) are the agreed environmental values and long-term goals for each catchment in NSW. The objectives are intended to be considered in assessing and managing the potential impacts of activities on waterways.

There are no water quality objectives for the Hawkesbury-Nepean River catchment provided by the *NSW Water Quality and River Flow Objectives* guidelines. This is because at the time that water quality objectives were approved by the government (1999) for catchments across NSW the Hawkesbury-Nepean catchment was subject to an independent inquiry by the Healthy Rivers Commission (HRC). Thus water quality objectives for the Hawkesbury-Nepean system were developed by the HRC and agreed to by the NSW Government in 2001.

Healthy Rivers Commision Inquiry

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

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

As the water quality criteria provided in the HRC guidelines were established in the 1990s, they have been superceeded by the more recent ANZECC water quality guidelines developed in the 2000s.

Australian Guidelines for Urban Stormwater management

The *Australian Guidelines for Urban Stormwater Management* (ANZECC & ARMCANZ 2000a) aims to provide current best practive approaches to help managers identify objectives for stormwater management (including protecting social, environmental and economic values) and to integrate management activities at the catchment, waterway and local development level.

Managing Urban Stormwater – Soils and Construction Volume 1

The principles for the management of stormwater during construction are documented in *Managing Urban Stormwater – Soils and Construction Volume 1* (Landcom 2004), which is also commonly referred to in the construction industry as "the Blue Book". The Blue Book outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters. This document relates particularly to urban development sites.

Additional guidelines on specific aspects of development and the application of erosion and sediment controls are also available. The relevant guidelines relating to the proposal are:

- *Managing Urban Stormwater: Soils and Construction – Volume 2D Main road construction* (DECC 2008) provides specific guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the construction and operation of main roads and highways.
- *Managing Urban Stormwater: Source Control* (EPA 1998) provides guidance to local and state government agencies and developers, as well as community and business groups, on a range of source control (water quantity and quality) techniques that can be adopted to minimise impacts of works on surface water environments.
- *Managing Urban Stormwater: Treatment Techniques* (EPA 1997) provides guidance to stormwater planners and designers on the selection and functional (or conceptual) design of a range of stormwater treatment measures.

Water Sesitive Urban Design Guideline

Water Sensitive Urban Design Guideline (RMS 2017) provides guidance on how to best apply water sensitive urban design (WSUD) to NSW transport projects. The guideline also provides a process to ensure that broader infrastructure design aspects are considered in the adoption of WSUD.

Procedure for Selecting Treatment Strategies to Control Road Runoff

The *Procedures for Selecting and Treatment Strategies to Control Road Runoff* (RTA 2003) document applies to stormwater treatment during the operation of roads following construction.

Guide to Road Design: Part 5B: Drainage – Open Channels, Culverts and Floodways

The *Guide to Road Design: Part 5B: Drainage – Open Channels, Culverts and Floodways* (Austroads 2013) document provides design guidelines for open channels, culverts and floodways to support the operation and management of road networks. In particular relevance to this surface water and groundwater impact assessment, the guideline provides design principles for scour protection and erosion controls. Other useful guidelines for the design of scour protection and erosion controls include:

- Rock sizing for Drainage Channels (Catchments & Creeks 2014)
- Rock sizing for Multi-Pipe and Culvert Outlets (Catchments & Creeks 2017)
- Rock sizing for Single Pipe Outlets (Catchments & Creeks 2015).

3.2.3 Groundwater policies and guidelines

NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and groundwater dependant ecosystems, be assessed against the minimal impact considerations outlined in the policy. If the predicted impacts of the proposal are less than the minimal impact considerations, then the potential groundwater impacts of the proposal are acceptable.

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

This policy outlines the water licensing requirements under the Water Act 1912 and WM Act. A water access licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void) even where that water is not being used consumptively as part of the activity's operation.

Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and groundwater dependant ecosystems, be assessed against the minimal impact considerations outlined in the policy. If the predicted impacts of the proposal are less than the minimal impact considerations, then the potential groundwater impacts of the proposal are acceptable.

NSW State Groundwater Policy Framework Document

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

- NSW Groundwater Quantity Management Policy (DLWC 1998a)
- NSW Groundwater Quality Protection Policy (DLWC 1998b)
- The NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002).

NSW Groundwater Quantity Management Policy (DRAFT)

The *NSW Groundwater Quantity Management Policy* (DLWC 1998a) is a component of the NSW State Groundwater Policy. It outlines the mechanisms for making sharing and management decisions with the goals of sustainable management of groundwater extraction while minimising impacts to dependent ecosystems.

NSW Groundwater Quality Protection Policy

The *NSW Groundwater Quality Protection Policy* (DLWC 1998b) is a component of the NSW State Groundwater Policy. The focus of this policy is to protect from pollution water below the ground surface in aquifers, and ecosystems from which these waters are recharged or into which they discharge. It provides a framework for the sustainable management of groundwater quality.

The NSW State Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems Policy (DLWC 2002) is a component of the NSW State Groundwater Policy. It is designed to protect valuable ecosystems which rely on groundwater for survival and provides guidance on how to protect and manage these natural systems in a practical sense.

Guidelines for groundwater quality protection in Australia

The *Guidelines for groundwater quality and protection in Australia* (DAWR 2013) are designed to support the objectives of the NWQMS as they relate to groundwater. They provide currently known principles and key methods for maximising groundwater quality protection under the three following frameworks:

- Groundwater management – which deals with groundwater entitlements and allocations
- Land-use planning – which controls decisions on land development
- Environmental protection – which deals with environmental maintenance and hazardous activities.

Risk Assessment Guidelines for Groundwater Dependent Ecosystems

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (OEH 2012) document assists in support of the requirements of the Water Management Act 2000 in relation to groundwater dependent ecosystems (GDEs). It provides guidance on the methods to identify and value GDEs and risk assessment framework.

Draft RMS Groundwater Assessment Practice Note: Detailed Groundwater Study – Analytical Modelling

The practice note has been developed as a companion to the templates and guidance notes developed as part of the TfNSW Environmental Impact Assessment Procedures and Guidelines. The purpose of the groundwater practice note is to guide the assessment, mitigation and management of groundwater impacts required for TfNSW development projects. This report has used the practice note to guide the report’s structure, format and sections where deemed applicable. Given the practice note has been developed for groundwater impact assessment only there have been modifications to combine it with the surface water impact assessment.

4. Existing Environment

This section includes a description of the existing environment and has been informed by the desktop investigations and any field investigations undertaken for the proposal.

4.1 Climate

To assess long-term average monthly rainfall and evaporation for the study area, rainfall and evaporation data were obtained from the Scientific Information for Land Owners (SILO) database operated by the Department of Science, Information Technology and Innovation (DSITI).

These climate data are patched point data obtained from the Quakers Hill weather station (67067). Historic monthly rainfall and the cumulative rainfall departure for the past 118 years is presented in Figure 4-1. Monthly rainfall and evaporation averages are presented in Table 4-1 and Table 4-2 respectively.

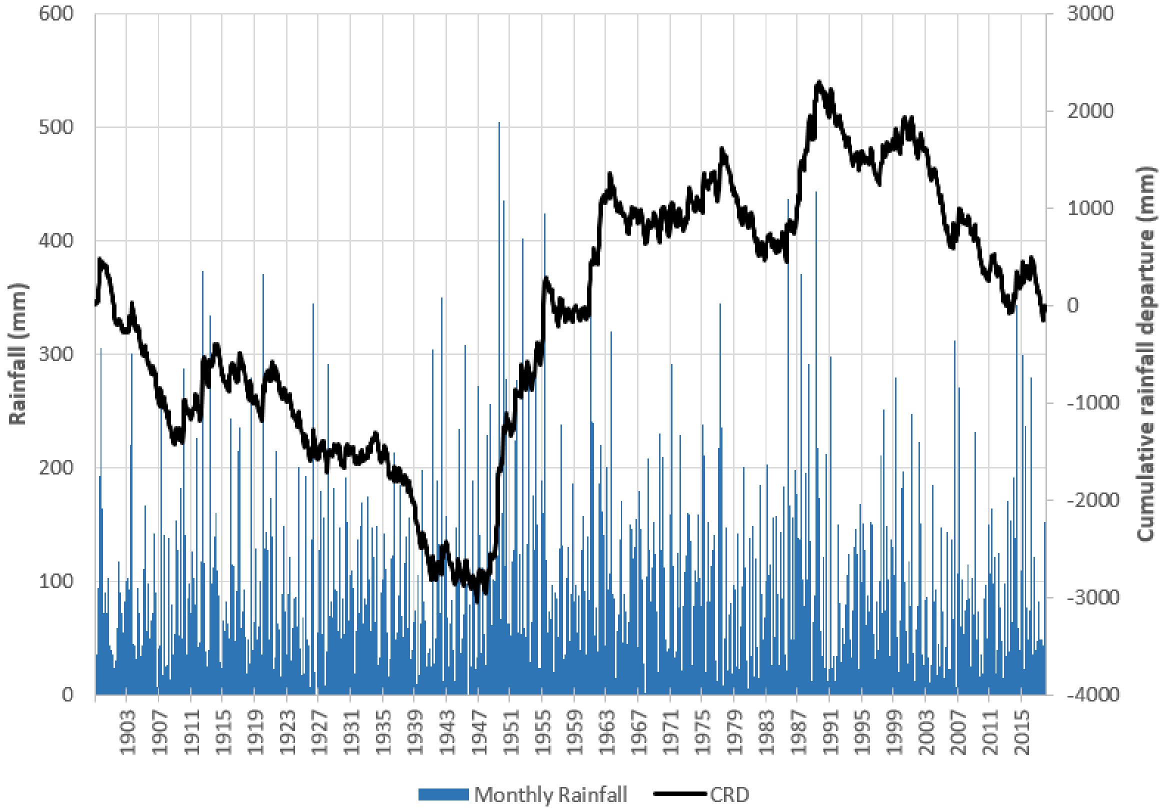

Figure 4-1 Rainfall and cumulative rainfall departure (CRD) for Quakers Hill weather station (67076)

Table 4-1 Average rainfall at Quakers Hill weather station (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
90.4	94.8	89.6	72.1	65.2	68.8	51.9	46.4	43.0	57.4	71.2	72.2	823.0

Table 4-2 Average evaporation at Quakers Hill weather station (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
180.0	142.1	130.0	96.1	66.4	55.3	61.5	85.7	112.6	141.6	162.1	184.3	1417.9

4.2 Regional drainage catchments

The proposal is located within the Hawkesbury-Nepean surface water catchment. The Hawkesbury-Nepean Catchment covers approximately 22,000 square kilometres and flows approximately 470 kilometres from Goulburn to Broken Bay. The catchment provides drinking water, recreational opportunities, agriculture and fisheries produce and tourism resources for the Sydney Metropolitan area.

The proposal lies within the South/Wianamatta Creek subcatchment in the Lower Nepean River Management Zone of the Hawkesbury-Nepean Catchment. The South Creek subcatchment covers about 490 square kilometres and is one of the most degraded subcatchments of the Hawkesbury-Nepean. Historic catchment vegetation clearance and increasing urbanisation have dramatically altered the hydrological and sediment regimes. The hydrology of the catchment has been significantly altered due to increasing impervious surfaces which in turn has altered the geomorphology and ecology of the watercourses (RMS 2019a).

A number of major sewerage treatment plants also discharge into the catchment, resulting in increased flow and pollutant loads (HNCMA 2007).

4.3 Topographical setting

The topography through the proposal area varies from between approximately 20-40 metres Australian Height Datum (AHD). The western and eastern portions of the site are at approximately 30 metres AHD with small variations in the land surface in-between.

4.4 Surface water features

The proposal study area has the potential to interact with several surface water features within the South/Wianamatta Creek sub-catchment the Hawkesbury-Nepean River System. The closest receiving water body is Bells Creek in the western portion of the proposal study area and Eastern Creek to the east. Only Bells Creek intersects the construction footprint of the proposal. However the eastern part of the the proposal study area lies within the Eastern Creek catchment. Both watercourses flows to the north, eventually draining into the Hawkesbury River, approximately 13 kilometres north of the proposal.

The overall program of works area currently consists of a mix of rural residential areas and industrial uses. The overall program of works area is bordered to the north by the CSR Schofields quarry, currently an active quarrying and brick making facility. Brickmaking and quarrying is to be decommissioned over coming years, with the site is proposed to be rehabilitated and suitable for residential development progressively until 2023.

No overland flow paths currently discharge from the quarry site to the overall program of works. Overland flow paths form the final lot layout of the Precinct are proposed to drain across the construction footprint of the proposal as part of the Indicative Layout Plan. These crossings have not been designed as part of the Precinct Plan and can not be incoroporated into the design of this proposal. These crossings will require a separate assessment as part of the development of the precinct.

A dam is located at 55 Townson Road within the study area and multiple retention basins have been excavated within the residential development within the former footprint of HMAS Nirimba, located to the east of Eastern Creek. There are also multiple areas of standing water identified within the study area within the natural environment.

4.4.1 Bells Creek

Bells Creek is a tributary of Eastern Creek located in the Blacktown region of Sydney and ultimately forms part of the greater Hawkesbury–Nepean catchment. The Bells Creek catchment has an area of approximately 14 square kilometres and generally flows from south to north. The upper reaches of the creek generally consist of a large grass lined channel centrally underlined with a stormwater drainage pipeline and stormwater pits at regular intervals. Downstream of the Richmond Road crossing the Creek generally reverts to what appears to be its natural shape and course with significant vegetation along the creek banks. Recent assessment of the riparian vegetation in the creek has determined it to be dominated by weeds (BCC 2018).

Land uses within the Bells Creek catchment include medium density residential buildings, commercial and industrial development, small scale agriculture, sports fields, nature reserves and undeveloped natural vegetation areas. The proposal is located appoximately in the middle of the catchment area and will intersect with Bells Creek.

4.4.2 Eastern Creek

Eastern Creek is a tributary of South Creek located in the Blacktown region of Sydney and ultimately forms part of the greater Hawkesbury-Nepean catchment. The Eastern Creek catchment has an area of approximately 36 square kilometres and generally flows from Prospect Reservoir in the south to South Creek in the north. The Creek generally appears to follow its natural shape and course along its entire length with significant vegetation along the creek banks. Recent assessment of the riparian vegetation in the creek indicates both native species and invasive weeds (BCC 2018). A significant length of the creek is located within natural reserve areas and parkland.

Land uses within the Eastern Creek catchment include medium density residential buildings, commercial and industrial development, small scale agriculture, sports fields and nature reserves areas. The proposal is located appoximately in the middle of the catchment area and will intersect with Eastern Creek.

The proposal does not intersect Eastern Creek but is located partially with the Eastern Creek catchment.

4.5 Geology and soils

4.5.1 Regional geology

Reference to the 1:100,000 scale Sydney Area Coastal Quaternary Geology Map (2015) and Penrith Geological Series Sheet 9030 (Edition 1, 1991) indicates that the proposal alignment is underlain by:

- Quaternary aged alluvial floodplain associated with Bells Creek, between approximate chainages Ch. 140 metres and Ch. 370 metres
- Tertiary aged St Marys Formation between approximate chainages Ch. 690 metres to Ch. 880 metres
- Middle Triassic aged Bringelly Shale of the Wianamatta Group across the remainder of the alignment.

As can be seen in Table 4-3, the Sydney Area Coastal Quaternary Geology map and Penrith Geological Series Sheet provides the following lithological descriptions for these geological units.

Table 4-3 Geological lithology

Geological unit	Sydney Area Coastal Quaternary Geology lithology	Penrith Geological Series Sheet lithology
Quaternary floodplain	Qap – "silt, clay, fluvial sand, gravel"	Qal – "Fine grained sand, silt and clay"
St Marys Formation	G_s – "Oligocene to Miocene laterised sand and clay with ferricrete bands and minor silicrete"	Ts – "Laterised sand and clay with ferricrete bands; includes silcrete, sandstone, and shale boulders"
Bringelly Shale	Twi – "sandstone, siltstone and shale; common bioturbation"	Rwb – "Shale, carbonaceous claystone, claystone, laminite, fine to medium grained lithic sandstone, rare coal and tuff"

The proposed road alignment is mapped to cross through the St Marys Formation near its geological contact with Bringelly Shale. However, based on the completed geotechnical investigations, St Marys Formation lithology was not encountered. Bringelly Shale was recorded at test locations where St Marys Formation was anticipated between approximate chainages Ch. 690 metres to Ch. 880 metres.

4.5.2 Soil landscape

Reference to the 1:100,000 scale Penrith Soil Landscape Series Sheet 9030 shows that the proposal alignment is underlain by the following soil landscape units:

- South Creek alluvial soil landscape near Bells Creek, between approximate chainages Ch. 140 metres and Ch. 370 metres
- Blacktown residual soil landscape across the remainder of the alignment.

The Penrith Soil Landscape Series Sheet and associated report provides the following descriptions of these soil landscape units:

- ***South Creek alluvial landscape:*** characterised by floodplains, valley flats and drainage depressions of the channels on the Cumberland Plan. The landscape is usually flat with incised channels that are mainly clear. The soil profile often consists of very deep layered sediments over bedrock or relict rock. Typically, soils comprise structured plastic clays or structured loams in and immediately adjacent to drainage lines or podzolic soils on terraces. Potential limitations include flood hazard, seasonal waterlogging, localised permanently high water tables, localised water erosion hazard and localised surface movement potential.
- ***Blacktown residual landscape:*** characterised by undulating rises on Wianamatta Group shales, with local relief typically <30 metres and slope gradients > five per cent. Landforms include broad rounded crests and ridges with gently inclined slopes. Soil profiles are typically shallow to moderately deep (>100 centimetres) and include hard-setting mottled texture soil contrast podzolic soil. Potential limitations include moderately reactive highly plastic subsoil, low soil fertility and poor soil drainage.

4.5.3 Geotechnical investigations

A geotechnical investigation for the site was undertaken by TfNSW (2019b) as part of the concept design phase. Numerous bore holes were drilled as part of the investigation along the length of the Satge 1 road alignment. Soil profiles were reported for these boreholes and are summarised in Table 4-4 below.

Table 4-4 Geotechnical investigation bore soil data

Borehole/ Pit ID	Easting	Northing	Soils description	Bedrock depth (mbgl)
BH01	300411.45	6267097.63	1.0 m of fill overlaying 2.2 m of alluvium	3.70
BH02	300450.70	6267105.22	1.0 m of fill overlaying 2.8 m of alluvium	4.00
BH03	301030.08	6267232.02	0.1 m of fill overlaying 2.7 m of residual soils	3.00
BH13	300967.95	6267290.84	0.2 m of fill overlaying 5.0 m of residual soils	5.20

Fill material generally consisted of sandy gravels or sandy clays. Alluvium generally consisted of silty clays, clayey silts or silty sands. Residual soils generally consisted of silty clays. Bedrock generally consisted of shale, siltstone or sandstone.

4.6 Hydrogeology

Groundwater has been encountered at a number of bores within the proposal area and is discussed further in the sections below.

4.6.1 Hydraulic conductivity

The desktop investigation could not identify any testing of hydraulic conductivity within the proposal area.

4.6.2 Storage parameters

The desktop investigation could not identify any testing to quantify groundwater storage parameters within the proposal area.

4.7 Groundwater elevations

A geotechnical investigation for the site was undertaken by Roads and Maritime (2019b) as part of the concept design phase. A number of monitoring bores were drilled as part of the investigation. These were all located outside of the proposal area and are depicted in Figure 4-2. Recent groundwater levels from January 2020 were reported for these boreholes (GHD 2020b). These monitoring bores are summarised in Table 4-5 below.

Table 4-5 Geotechnical investigation bore and pit data

Borehole/ Pit ID	Easting	Northing	Surveyed elevation (m AHD)	Total depth (m bgl)	Standing water level (m bgl)
BH06	302475.80	6267808.09	16.66	20.00	3.05
BH08	302908.69	6267895.85	22.83	15.90	1.77
BH09	303012.51	6267940.77	24.31	20.34	1.30
BH12	303195.38	6267920.85	27.67	11.50	1.77

4.8 Groundwater recharge

The desktop investigation could not identify any groundwater recharge data within the proposal area. For the purposes of analytical modelling the recharge rate was assumed to be one per cent of rainfall, which is generally consistent with the approach applied in the WSP.

4.9 Registered groundwater users

Searches of the NSW groundwater map (WaterNSW) and the Bureau of Meteorology 'Australian Groundwater Explorer' (both undertaken on 2 December 2019) were carried out to identify registered bores near the proposal area. The search identified 12 bores within two kilometres of the proposal boundary. All were registered as monitoring bores and are depicted in Figure 4-2. Key available details for each of these bores are provided in Table 4-6.

Salinity levels were not reported for any of these bores. The total bore depths ranged from nine to 20.2 metres. There are only standing water level data available for four bores. These standing water levels were taken directly following bore construction with no monitoring recorded since.

While there is no groundwater quality data available as part of this assessment, a beneficial use category has been assigned based on groundwater receptors. Overall, based on review of groundwater receptors, groundwater use is limited and the primary beneficial use of groundwater in the vicinity of the site would be environmental (ie providing base flow to waterways).

Table 4-6 Summary of registered bores within 2 kilometres of the proposal area

Bore ID	Purpose	Bore depth (m)	Status	Distance from proposal (m)	Standing water level (mbgl)	Salinity (mg/L)	Year of last sampling
GW110658	Monitoring	10	Unknown	1938.7	8.2		2009
GW103960	Monitoring	20	Unknown	398.6			
GW203379	Monitoring	14.5	Functional	253.5	6.9		2015
GW103957	Monitoring	15	Unknown	398.6			
GW203380	Monitoring	13.1	Functional	226.2	6.1		2015
GW103961	Monitoring	20	Unknown	398.6			
GW104310	Monitoring	9	Functioning	1796.8			
GW203381	Monitoring	14.5	Functional	238.3	6.1		2015
GW103956	Monitoring	20.2	Unknown	398.6			
GW103959	Monitoring	19.2	Unknown	398.6			
GW104311	Monitoring	17	Functioning	1754.8			
GW103958	Monitoring	20	Unknown	398.6			

LEGEND

- Construction boundary
- Watercourse
- Road
- Registered bore
- Monitoring bore

Paper Size ISO A4

0 175 350 525 700

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Transport for NSW
Townson Road Upgrade Stage 1
Between Richmond Road and
Jersey Road

Registered and Monitoring Bore Locations

Project No. 21-12511195
Revision No. -
Date 5/11/2020

FIGURE 4-2

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Print date: 05 Nov 2020 - 14:37

Data source: Aerial Imagery - Six Maps courtesy NSW Govt, 2013-14 © Department of Finance, Services & Innovation 2018. Created by: eibbertson

4.10 Groundwater dependent ecosystems

Dependence or interaction of the vegetation communities within the study area on groundwater was determined by searching the Groundwater Depenedent Ecosystem (GDE) Atlas (BOM 2019). The GDEs mapped by the Atlas include “aquatic” ecosystems that rely on the surface expression of groundwater, and “terrestrial” ecosystems that rely on the subsurface presence of groundwater.

The closest high potential aquatic GDE was identified as South Creek approximately 5.3 kilometres north-west of the proposal area. Given the distance it is not expected that the proposal will have an impact on this specific GDE.

A number of moderate and high potential terrestrial GDEs were located in and surrounding the proposal area. These are presented in Figure 4-3 and summarised in Table 4-7 below.

Table 4-7 Terrestrial Groundwater depenedent ecosystems identified in the proposal area

GDE description	National classification
Castlereagh Ironbark Forest	Moderate potential GDE
Castlereagh Scribbly Gum Woodland	Moderate potential GDE
Castlereagh Shale-Gravel Transition Forest	High potential GDE
Cumberland River Flat Forest	High potential GDE
Cumberland Shale Plains Woodland	High potential GDE

Of these GDEs, there are someCumberland River Flat Forest and Cumberland Shale Plains Woodlands areas (both high potential GDE) that are located within the boundary of the proposal and are therefore at the greatest risk of impacts.

4.11 Conceptual groundwater model

A conceptual groundwater model has been prepared based on the available data for the proposal study area, and has been provided as Figure 4-4. It shows the typical geology comprising a layer of fill or alluvium overlying a layer of residual soils. These loose soils lie over Wianamatta group shales generally consisting of sandstone, siltstone of shalestones. Based on the limited groundwater data, the groundwater level has been conservatively assumed at 1.3 metres below ground level. Groundwater is generally assumed to flow towards Bells Creek or Eastern Creek.

LEGEND

Construction boundary
Watercourse
Road

Groundwater dependent ecosystems

Castlereagh Ironbark Forest
Castlereagh Scribbly Gum Woodland
Castlereagh Shale-Gravel Transition Forest
Cumberland River Flat Forest
Cumberland Shale Plains Woodland

Paper Size ISO A4

0 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Transport for NSW
Townson Road Upgrade Stage 1
Between Richmond Road and Jersey Road

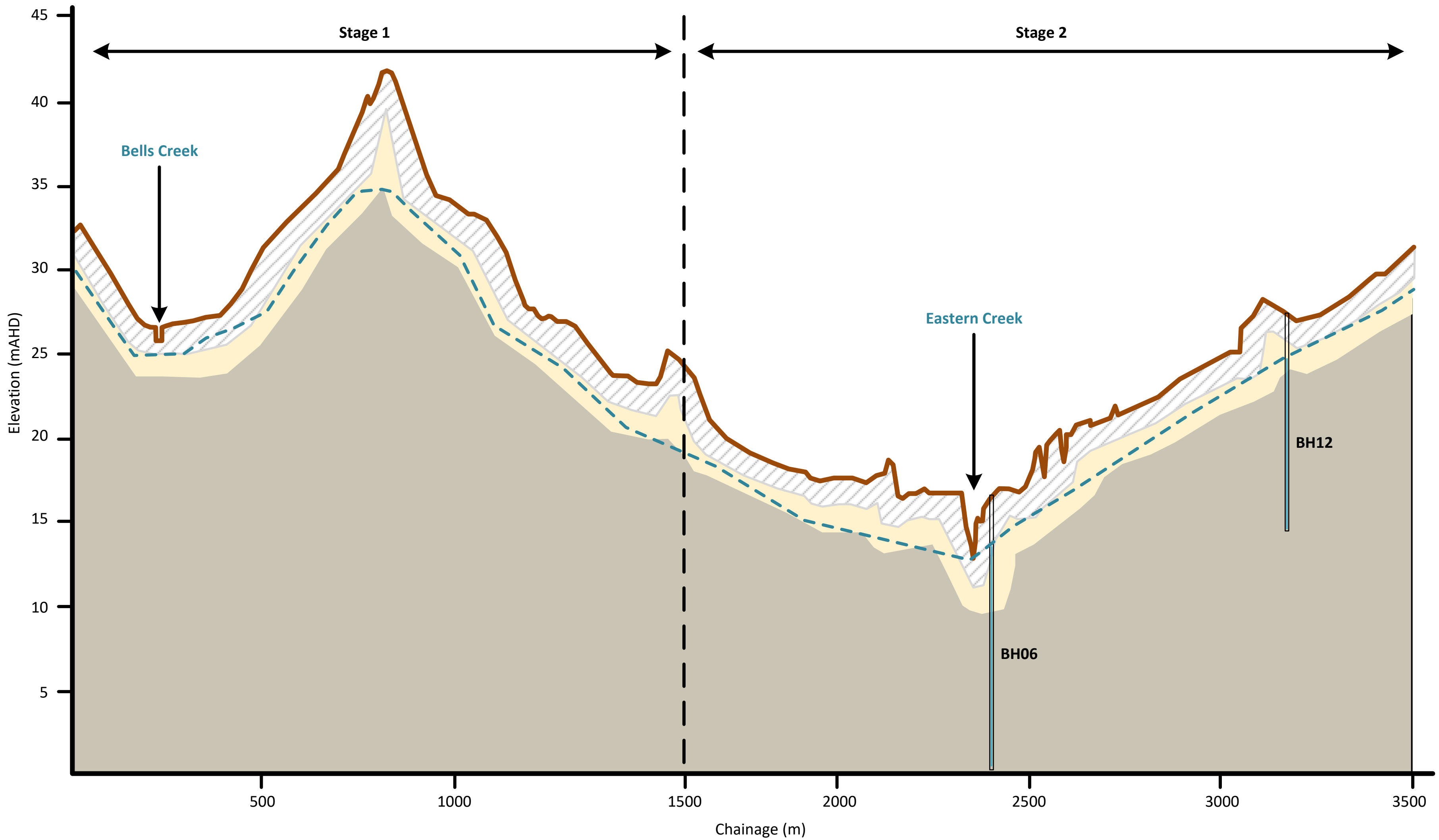
Terrestrial Groundwater Dependent Ecosystems

Project No. **21-12511195**
Revision No. **-**
Date **5/11/2020**

FIGURE 4-3

G:\21\12511195\GIS\Maps\Deliverables\Surface and Groundwater Impact Assessment\21_12511195_Z002_Townson_and_BurdekinRoad_GDE.mxd
Print date: 05 Nov 2020 - 14:35

Data source: Aerial Imagery - Six Maps courtesy NSW Govt, 2013-14 © Department of Customer Service 2020. Created by: eibbertson



Legend

Fill / alluvium	Wianamatta Group Shales
Residual Soils	Inferred groundwater table

Transport for NSW
Townson Road and Burdekin Road
Groundwater Impact Assessment

Conceptual Groundwater Model

Project No. 21-12511195
Revision No. 0
Date 02/04/2020

FIGURE 4-4

Created by: Suzanne MacDonald

Print date: 02/04/2020 14:35

4.12 Contaminated sites

A search of the EPA register for contaminated sites (December 2019) shows no contaminated site listed in the proposal area. However there were several listed sites within a five kilometre radius of the proposal area. These are summarised in Table 4-8. All but one of these sites are operating service stations. The remaining site is approximately 1.7 kilometres north of the proposal area and its type of contamination is not classified at this stage. However the site does contain a sand and soils supply depot.

Table 4-8 Registered contaminated sites near project area

Suburb	Address	Site name	Activity
Marsden Park	226 Grange Avenue	Riverlands sand and soil	Unclassified
Riverstone	55 Garfield Road	7-Eleven Riverstone	Service Station
Emerton	135 Popondetta Road	7-Eleven Emerton	Service Station
Plumpton	260 Jersey Road	Woolworth Service Station Plumpton	Service Station
Glendenning	1 Dublin Street	7-Eleven Plumpton	Service Station
Quakers Hill	83 Lalor Road	7-Eleven	Service Station
Quakers Hill	450 Quakers Hill Parkway	BP Service Station	Service Station
Marayong	Cnr Vardys and Turbo Roads	Woolworths Service Station Marayong	Service Station
Marayong	173 Richmond Road	7-Eleven	Service Station

The Townson and Burdekin Road Design – Contamination Preliminary Site Investigation (GHD, 2019b) report also found the following potential sources of contamination associated with the proposal:

- Potential for hydrocarbon, metals and asbestos impacts from unknown fill material identified at the Dam wall constructed at 55 Townson Road, within the Townson Road verge and at 46 Durham Road
- Potential hydrocarbon impact of soil and groundwater related to long term quarrying activities at PGH Bricks and Paver quarry at 75 Townson Road, Schofields
- Potential per- and poly-fluoroalkyl substances (PFAS) and hydrocarbon impacts in soil, groundwater and surface water associated with historic defence activities at HMAS Nirimba
- Potential pesticide and herbicide contamination of soil and surface water at Bravo Nursery at 9 Townson Road, Marsden Park
- Potential hydrocarbon impacts of soil and groundwater associated with heavy machinery and truck storage yards observed at 6 and 9 Townson Road.

4.13 Acid sulfate soils

Review of online acid sulfate soil (ASS) maps sourced from the Australian Soil Resource Information System, Commonwealth Scientific and Industrial Research Organisation (CSIRO) shows that the site contains an extremely low probability of occurrence of ASS materials at the site.

Several previous studies in the area confirm this finding (RMS 2018).

4.14 Salinity

Reference to the Department of Infrastructure, Planning and Natural Resources Salinity Potential in Western Sydney map (2003) shows that the site contains high salinity potential in the vicinity of Bells Creek and moderate salinity potential for the remainder of the alignment of the proposal.

High salinity potential is defined as areas where soil, geology, topography and groundwater conditions predispose a site to salinity and are most common in lower slopes and drainage systems where water accumulation is high.

Moderate salinity potential is defined as areas on Wianamatta Group shales and Tertiary alluvial terraces where scattered areas of scalding and indicator vegetation have been noted but no concentrations have been mapped. It is noted that saline conditions may occur in this zone, which have not yet been identified or may occur if risk factors change adversely.

4.15 Groundwater quality

The desktop study could not identify any groundwater quality data within the vicinity of the proposal.

4.16 Suface water quality

The proposal is located within the Bells Creek and Eastern Creek catchments. Runoff from the site enters local watercourse both through the constructed stormwater system and as overland flow. The quality of surface water entering local waterways would largely be a function of contaminants on the roads and adjacent areas. Typical surface pollutants from the proposal could include:

- Oils and hydrocarbons
- Heavy metals
- Chemicals from spills or inappropriate waste disposal
- Sediments
- Gross pollutants including litter and debris
- Nutrients including nitrogen and phosphorous.

4.16.1 Bells Creek

The *Waterway Health Report Card 2017-2018* (BCC 2018) shows that the existing health of the Bells Creek waterway has fluctuated between fair (grade C) and good (grade B) since 2014. The most recent assessment for 2018 gave the waterway health a grade of fair (C). The riparian vegetation in the creek is dominated by weed.

4.16.2 Eastern Creek

The *Waterway Health Report Card 2017-2018* (BCC 2018) shows that the existing health of the northern extent of the Eastern Creek waterway has generally been considered good (grade B) since 2014 but has fallen to fair (grade C) in 2018. This has been the due to an observed reduction in water quality and associated waterbug diversity indicating the creek may have been affected by water pollution. The riparian vegetation includes both native species and invasive weeds.

The existing waterway health of the southern extent of Eastern Creek has generally been considered good or fair (grade B or C) since 2014 and remains at good (grade B) in 2018 (BBC 2018). Water quality has been reported to be variable for the year 2018 however the waterbug community is generally consistent with good diversity and abundance.

4.17 Aquatic habitat

Only one waterway, Bells Creek, intersects the construction footprint. Bells Creek crosses the western portion of the proposal area adjacent to the intersection with Richmond Road. It has a Strahler Stream order of 2. Bells Creek is not classified as Key Fish Habitat according to the DPI Key Fish Habitat mapping (DPI 2019) and Policy and *guidelines for fish habitat conservation and management* (DPI 2013).

This creekline and the associated riparian zone provide potential habitat for aquatic macroinvertebrates and fish, birds, microbats, reptiles and amphibians.

Previous surveys completed about 1.1 kilometres north of the current construction footprint, along Bells Creek recorded 18 macroinvertebrate species, with very low numbers of species that are sensitive to changes in their environment, suggesting that the condition of the creekline was degraded at the time of the survey (GHD 2013).

More recent survey of the condition of the aquatic habitat in Bells Creek has been conducted for this proposal and is detailed in the biodiversity assessment report (GHD 2020a).

5. The proposal

This section outlines the proposed works and activities of both the construction and operational phases that have the potential to impact the surface water and groundwater.

5.1 Surface water interference activities

5.1.1 Disturbed soils

The construction phase of the proposal will involve earth moving activities such as excavations and land clearing that will create disturbed soil and expose them to the environment. This has the potential to impact surface water quality by contaminating runoff with sediment during rainfall events.

5.1.2 Pollutants and chemical contaminants

Construction equipment during the construction phase and increased level of vehicular traffic during the operational phase of the proposal increase the potential of pollutant generation and chemical spills. Examples of pollutants that could affect water quality are as follows:

- Contaminated soils including fertilisers and pesticides
- Heavy metals, which may leach from construction materials
- Chemicals including hydrocarbons and fluids associated with construction processes and machinery
- Dust and airborne pollutants.

Typical impacts on surface water quality would be through the transport of these pollutants by runoff. Groundwater quality could be impacted if pollutants or contaminants are allowed to seep into the ground.

5.1.3 Chemical Spills or leaks

The release of potentially harmful substances to the environment may occur accidentally during construction due to spills; as a result of equipment refuelling, malfunction and maintenance; from treatment and curing processes for concrete; as a result of inappropriate storage, handling and use of the substances; or from the disturbance and inappropriate handling of contaminated soils. This has the potential to impact on water quality in receiving waters downstream of the proposal or impact the beneficial use of groundwater.

These contaminants could include chemicals from washing processes, construction fuels, oils, lubricants, hydraulic fluids and other chemicals. Impacts to water quality and aquatic life could result if such contaminants enter receiving watercourses downstream of the works areas.

5.1.4 Impervious area

The operational design will result in an increase to the impervious area relative to the existing conditions. This has the potential to increase runoff volumes in the area and alter groundwater recharge patterns. Both these impacts may affect surface water and groundwater quality.

5.1.5 Construction materials

Site won residual soils are expected to be suitable for re-use as general fill. Appropriate topsoil and fill material won onsite will be stockpiled for later re-use. It has been identified that most site materials are dispersive and therefore migitation measures to minimise dispersive erosion will be required.

Additional road construction materials such as road base materials are not being sourced locally and therefore their extraction does not pose a surface water or groundwater impact risk.

5.2 Aquifer interference activities

Given the limited groundwater data for the study area, the minimum groundwater depth of 1.3 metres recorded by the recent groundwater investigations (GHD 2020b) has been conservatively adopted as the level at which any activities are deemed to potentially interfere with groundwater.

5.2.1 Road design excavations

The road design will require excavation as part of the construction process. There are two components to the excavation that indicate the depth of excavation likely at a given chainage. These include:

- Road cutting – the depth of the road design surface below existing ground levels
- Pavement construction – the depth required to install and construct the road pavement.

The potential depth below the road design surface level required for the proposal is 1500 millimetres for Townson Road and 1200 millimetres for side roads (GHD 2019a). This includes the potential treatement of up to 400 millimetres of subgrade material. Taking into account both the road cutting and pavement construction components to the excavation, a summary of road chainages in with possible excavations in excess of 1.3 metres and the maximum likely excavation depth are provided in Table 5-1.

Table 5-1 Road design cut segment excavation depth summary

Chainage from (m)	Chainage to (m)	Maximum excavation depth (mBGL)	Average excavation depth (m)
0	100	1.51	1.49
480	840	3.51	1.84
980	1300	2.10	1.87

The majority of the road design is not likely to exceed 1.3 metres excavation depth below the existing ground level. The exception to this are several segments of the road outlined in Table 5-1. These are potentially activities that could obstruct groundwater flow or require dewatering during excavation and therefore meet the critiria of aquifer interference.

As these excavation activities are at risk of intercepting groundwater, analytical modelling has been undertaken to quantify the potential groundwater inflows that may be expected. For the purposes of the modelling the excavation is assumed to be a pit 20 metres wide and 40 metres long. This reflects that the road is likely to be constructed progressively with only segments (and not the complete length of road) excavated at any one time before being prepared, filled in and compacted. To be conservative, the pit depth is assumed to be the maximum as identified in Table 5-1.

5.2.2 Stormwater basins

A number of stormwater basins have been proposed as part of the design. These are likely to require excavation depths greater than 1.3 metres and therefore could impact groundwater.

As this excavation activity is at risk of intercepting groundwater, analytical modelling has been undertaken to quantify the potential groundwater inflows that may be expected. For the purposes of the modelling the basin dimension are assumed to be 10 metres long by 5 metres wide by 2.5 metres deep.

5.2.3 Bells Creek Bridge

Two bridges would be constructed as part of the proposal. This includes a bridge over Bells Creek and an additional Bells Creek overflow bridge. These bridges are expected to require bored piling to a depth as yet to be determined. It is likely that pile depth will exceed 1.3 metres and intersect the groundwater level. To facilitate the bored piling it is likely that pits will need to be excavated to the bedrock prior to bored piling commencing. Therefore construction of both bridges is likely to interact with groundwater either through obstruction to flow (bored piles) or potential dewatering (excavation pits).

As this excavation activity is at risk of intercepting groundwater, analytical modelling has been undertaken to quantify the potential groundwater inflows that may be expected. For the purposes of the modelling the excavation is assumed to occur over the entire bridge footprint. Bridge designs are preliminary at the moment but both the Bells Creek crossing bridge and the overflow bridge are assumed to have the same size footprint. This excavation pit is therefore assumed to be 40 metres long and 30 metres wide. The depth is expected to be down to bedrock which is assumed to be four metres below ground level in the area (from BH02 logs).

5.2.4 Utilities and service relocation

Assessment of existing utility services within the proposal area has identified several that are likely to require relocation for the proposal to proceed. It is expected that relocation of these assets will require excavations in excess of 1.3 metres. Therefore there is a risk they will impact groundwater.

As this excavation activity is at risk of intercepting groundwater, analytical modelling has been undertaken to quantify the potential groundwater inflows that may be expected. For the purposes of the modelling the excavation pit is assumed to be the length of the road width design (20 metres), 3 metres wide and 2.5 metres deep. It is not expected that any service relocation excavations would exceed 2.5 metres below ground level.

6. Construction impact assessment

6.1 Construction impacts/ risk assessment

An assessment of the surface water and groundwater risks and potential impacts associated with the construction of the proposal and measures for their avoidance, mitigation or minimisation is summarised in Table 6-1.

Table 6-1 Potential construction risks and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Construction activities mobilising sediment due to disturbed soil from excavation and clearing	Pollution of receiving drainage networks and watercourses with sediment	• Prepare a soil and water management plan and incorporate in the CEMP. • Install sediment and erosion control measures in accordance with the Blue Book (DECC, 2008). • Prepare water quality monitoring plan and incorporate in the CEMP.
Chemical or hydrocarbon spill	Contamination of groundwater via seepage or surface water via runoff	• Storage of hazardous goods and refuelling activities to take place in bunded areas. • Implement water quality monitoring program.
Interception and dewatering of groundwater by excavations	Drawdown in groundwater level (especially close to high potential GDEs)	• Minimise excavations below groundwater table. • Minimise duration of time that excavations below the water table are open.
Discharge of excess groundwater	Pollution of receiving drainage networks and watercourses	• Use of intercepted groundwater for dust suppression or irrigation on-site. • Prepare water quality monitoring plan and incorporate in the CEMP.

6.2 Water quality impacts

The following potential impacts of the construction phase of the proposal on surface water and groundwater quality have been identified:

- Increased erosion from a range of construction activities resulting in an increase in sedimentation in downstream waterways
- Contamination of waterways or groundwater from chemical or hydrocarbon spills
- Discharge of excess groundwater resulting in pollution of receiving drainage networks and watercourses.

To manage these potential impacts a Soil and Water Management Plan (SWMP) would be prepared and implemented and include measures to manage and reduce the risk of water quality impacts associated with the works.

Mitigating any potential impacts will need to consider best practice in managing the site, in accordance with the Blue Book (Landcom 2004/DECC 2008).

Assessment of the water quality outcomes against the ANZECC (2000b) and ANZG (2018) guidelines will be undertaken during detailed design once a water quality monitoring program has been implemented and sufficient water quality data are available. The detailed design would then take into consideration the findings of the assessment and any recommendations for water quality treatment measures, which may include gross pollution traps to removet litter and debris.

6.2.1 Initial construction works

During the initial stages of construction, various preparatory works would be undertaken such as site establishment works and construction access provision. These works would also include:

- Installation of environmental controls, including sediment and erosion controls following best practice guidelines such as the Blue Book (Landcom 2004/DECC 2008)
- Stormwater drainage channel protection and diversion works where necessary to allow function of the system during the construction period
- Any necessary flood mitigation measures to manage overland flows and minimise adverse impacts on surrounding environment where possible.

6.2.2 Erosion and sedimentation

Soil is the most likely potential contaminant that could impact surface water quality during the construction phase if runoff is allowed to mobilise soils from exposed areas. Increased erosion and sedimentation would be influenced by the severity of a storm event and the slope and footprint of the disturbed area.

Where possible, construction and drainage activities would be planned considering the upcoming weather forecast to minimise the risks of potential heavy rainfall and major surface runoff events.

Although planning of activities in this manner would not prevent construction during periods of potentially heavy rainfall, the risk of having disturbed construction areas or unpreparedness during heavy rainfall periods would be reduced.

6.2.3 Spills and leaks

Chemical spills and leaks have the potential to contaminate both surface water via rainfall runoff processes or groundwater through infiltration. Prior to construction the need for spill kits should be assessed along with the best location for such equipment. Storage of hazardous goods, maintenance activities and refuelling activities would be undertaken in bunded areas and away from waterways and stormwater drains. These locations would be identified in the SWMP.

6.2.4 Dewatering discharges

Where excavation activities are deep enough to intercept groundwater, dewatering will be required. Discharge of groundwater without assessment or treatment to receiving environments can introduce pollutants. Where possible the dewatered groundwater should be used on-site for irrigation or dust suppression activities. If on-site use is not possible then testing of the groundwater as outlined in section 9.2.2 should be conducted prior to off-site discharge.

6.3 Groundwater level impacts

This section outlines the potential impacts of the construction phase of the proposal on groundwater levels and those users or ecosystems that may be dependent on them.

6.3.1 Groundwater model prediction of inflow and radius of influence

Groundwater inflows and radius of influence have been estimated for the proposed excavations that may intercept groundwater using the analytical equations developed by Marinelli and Niccoli (2000) as described in section 2.5.1. The results are provided in the following sections.

Road construction pit – Chainage 0 m to 100 m

The inflow rates and radius of influences predicted for the road construction pit at chainage 0 metres to 100 metres are presented in Table 6-2. These demonstrate that even under worst case conditions that any interception of groundwater is likely to be very minor and extremely localised.

Table 6-2 Road construction pit (Chainage 0 m to 100 m) inflow and radius of influence results

Scenario	Predicted groundwater inflow (m^3/day)[1]	Predicted radius of influence (m)[2]
1	0.00	17.3
2	0.02	20.2
3	0.02	23.5
4	0.11	37.9

Notes: 1. Groundwater flows are per 40 m length of open road pit
2. From centreline of pit

Road construction pit – Chainage 480 m to 840 m

The inflow rates and radius of influences predicted for the road construction pit at chainage 480 metres to 840 metres are presented in Table 6-3. These demonstrate that even under worst case conditions that any interception of groundwater is likely to be minor and localised.

Table 6-3 Road construction pit (Chainage 480 m to 840 m) inflow and radius of influence results

Scenario	Predicted groundwater inflow (m^3/day)[1]	Predicted radius of influence (m)[2]
1	0.04	29.1
2	0.23	53.4
3	0.07	34.6
4	0.38	68.1

Notes: 1. Groundwater flows are per 40 m length of open road pit
2. From centreline of pit

Road construction pit – Chainage 980 to 1300 m

The inflow rates and radius of influences predicted for the road construction pit at chainage 980 metres to 1300 metres are presented in Table 6-4. These demonstrate that even under worst case conditions that any interception of groundwater is likely to be very minor and extremely localised.

Table 6-4 Road construction pit (Chainage 980 m to 1300 m) inflow and radius of influence results

Scenario	Predicted groundwater inflow (m^3/day)[1]	Predicted radius of influence (m)[2]
1	0.01	21.0
2	0.07	31.0
3	0.03	26.9
4	0.18	47.3

Notes: 1. Groundwater flows are per 40 m length of open road pit
2. From centreline of pit

Stormwater basin construction pits

The inflow rates and radius of influences predicted for the stormwater basin pits are presented in Table 6-5. These demonstrate that even under worst case conditions that any interception of groundwater is likely to be very minor and extremely localised.

Table 6-5 Bells Creek bridge and Bells Creek overflow bridge pit inflow and radius of influence results

Scenario	Predicted groundwater inflow (m^3/day)	Predicted radius of influence (m)
1	0.01	10.7
2	0.04	22.6
3	0.02	15.5
4	0.10	35.6

Bored piles construction pit

The inflow rates and radius of influences predicted for the bored piles construction pits at Bells Creek Bridge and Bells Creek Overflow Bridge are presented in Table 6-6. These demonstrate that even under worst case conditions that any interception of groundwater is likely to be minor and localised.

Table 6-6 Bells Creek bridge and Bells Creek overflow bridge pit inflow and radius of influence results

Scenario	Predicted groundwater inflow (m^3/day)	Predicted radius of influence (m)
1	0.06	35.7
2	0.34	65.5
3	0.09	41.2
4	0.52	80.2

Service relocation pits

The inflow rates and radius of influences predicted for a worst case service relocation pit are presented in Table 6-7. These demonstrate that even under worst case conditions that any interception of groundwater is likely to be very minor and extremely localised.

Table 6-7 Service relocation pit inflow and radius of influence results

Scenario	Predicted groundwater inflow (m^3/day)	Predicted radius of influence (m)
1	0.01	11.1
2	0.04	23.2
3	0.02	16.0
4	0.10	36.3

6.3.2 Aquifer interference policy

Due to being underlain by Winnamatta Group Shales, the proposal area is classed as a "less productive groundwater source" under the NSW Aquifer Interference Policy. A less productive groundwater source is defined by the AIP as a groundwater source having total dissolved solids greater than 1500 milligrams per litre or does not contain water supply works that can yield water at a rate greater than five litres per second.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and groundwater dependant ecosystems, be assessed against the minimal impact considerations outlined in the policy. If the predicted impacts are less than the Level 1 minimal impact considerations for less productive fractured rock groundwater sources, then the potential groundwater impacts of the proposal are acceptable. The Level 1 minimal impact considerations for less productive porous and fractured rock water sources are:

- Less than or equal to 10 per cent cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, at a distance of 40 metres from any high priority GDEs or high priority culturally significant site listed in the schedule of the relevant water sharing plan
- A maximum of a two metre water table decline cumulatively at any water supply work
- Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres of the activity.

The proposal has been assessed against the adopted Level 1 minimal impact considerations below.

Water supply works

Based on analytical calculations, the potential radius of influence estimated in section 6.3.1 extends up to 68 metres for the road construction pit and up to 80 metres for the bored piles construction pits. There are no water supply works within these ranges of either of the pits. Therefore, the proposal would not result in any impacts to a water supply work.

High priority culturally significant sites

There are no high priority culturally significant sites listed in the WSP for the Greater Metropolitan Region Groundwater Sources. Therefore, the proposal would not result in any impacts to a culturally significant site.

Groundwater dependent ecosystems

As discussed in section 4.10, there are several high potential GDEs located within the proposal area. It is not expected that the radius of influence from the road contruction pits will impact any GDEs in the area. The exception to this is approximately between chainages 460 metres to 620 metres. Here the Cumberland Shale Plains Woodland is within the REF assessment boundary and very close to the road alignment. It is therefore possible that the radius of influence from any road excavations would be large enough to impact on the periphery of the Cumberland Shale Plains Woodland area. This would likely be the case even under more favourable groundwater conditions.

There is also the potential that the bored pile pits constructed at Bells Creek Bridge and Bells Creek Overflow Bridge may impact groundwater levels of high potential Cumberland River Flat Forest and Cumberland Shale Plains Woodland GDE areas located in the proposal area. This would most likely only occur under the worst case conditions and even in that case, would only impacts the very periphery of these GDE areas. Futher discussion of GDEs is provided in section 3.7 of the Biodiversity assessment (GHD 2020a) that accompanies this proposal.

Summary

The proposal is not predicted to result in any decline in groundwater pressure or groundwater head at any water supply works and is not predicted to alter the beneficial use of the groundwater.

No culturally significant sites are expected to be impacted however the excavation activities at Bells Creek Bridge and Bells Creek Overflow Bridge may impact high potential GDEs in or immediately adjacent to the proposal area. The risk of occurance is expected to be low (based on assumed water levels) and any impacts are expected to be minor and temporary.

Further investigations should be conducted to quantify the risk of groundwater interception at these locations.

7. Operational impact assessment

7.1 Operational impacts/risk assessment

An assessment of the surface water and groundwater risks and potential impacts associated with the operation of the proposal and measures for their avoidance, mitigation or minimisation are provided in Table 7-1.

Table 7-1 Potential impacts and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Increases in hard stand areas across the operational proposal area relative to existing conditions	Increases in pollutant generation Changes in groundwater recharge	• Where practical and space allows, adopt WSUD guidelines for drainage infrastructure (detention storage, wetlands, etc) to reduce pollutants and allow for groundwater recharge • Minimise areas of additional hard stand
Increase in vehicle movements on the upgraded street.	Increase in potential for pollutant generation	• Where practical and space allows, adopt WSUD guidelines for drainage infrastructure (detention storage, wetlands, etc) to reduce pollutants and allow for groundwater recharge
Poor stabilisation of soils, inadequate scour protection and failed revegetation	Pollution of receiving drainage networks and watercourses with sediment. Erosion around drainage infrastructure.	• Where practical and space allows, adopt WSUD guidelines for drainage infrastructure (appropriate plant species selection, etc) • Adopt adequate erosion and scour protection measures in the drainage design
Interception of groundwater by permanent excavations (stormwater basins)	Drawdown in groundwater level (especially close to high potential GDEs)	• Install impermeable liners or redesign to shallower depth stormwater basins where they may intercept groundwater

7.2 Water quality impacts

The following potential impacts of the operational phase of the proposal on surface water and groundwater quality have been identified:

- Increases in hard stand areas across the proposal area leading to increases in surface runoff and with it pollutant conveyance to receiving waterways
- Increased potential for pollutant generation as a result of increases traffic movements on the upgraded road
- Poor stabilisation of soils, inadequate erosion control/scour protection and/or failed revegetation leading to pollution of receiving drainage networks and watercourses with sediment laden runoff.

To manage these potential impacts the road design should adopt the principles of WSUD (RMS 2017) and recommended scour protection measures (Austroads 2013, Catchments & Creeks 2014, 2015, 2017).

7.2.1 Stormwater runoff

The widening and upgrade of Townson Road would moderately increase impervious areas. This could result in increased generation of surface runoff, thereby increasing the rate at which litter and other pollutants are conveyed to receiving waterways. The contamination of waterways by these pollutants can result in habitat degradation and negatively impact on the health of aquatic flora and fauna species.

The increase in impervious area due to the proposal is small considering the catchments of the receiving watercourses are already significantly impervious. Consequently, there is little impact on the overall catchment water quality expected. Where practical and space allows, the adoption of WSUD guidelines would minimise pollutants reaching the surrounding watercourses.

7.2.2 Increased vehicle movements

The increase in capacity of Townson Road as a result of the proposal will allow for increased vehicle movements through the corridor in the study area. This will increase the likelihood of pollutants being generated by vehicles using the street. This includes from potential vehicle spills, leaks or accidents. These pollutants may be carried by runoff into receiving watercourses or infiltrate into the groundwater.

Where practical and space allows, the adoption of WSUD guidelines would minimise pollutants reaching the surrounding watercourses. However, the potential for the concentrations of these pollutants to increase substantially from that of the existing conditions is considered low.

7.2.3 Erosion and sedimentation

Once the construction of the proposal is completed, recently disturbed soils will be more susceptible to scour and erosion from stormwater runoff for a period of time.

The modification of overland flow paths can cause an increase in scour of surface soil, banks or bed material, resulting in increased sedimentation in downstream waterways. The potential impacts would occur in the event that appropriate reestablishment of vegetated nature strips was not undertaken, through poor stabilisation of soils or via inadequate scour protection designs.

The potential for sediment transport is influenced by factors such as severity of storm events, the slope and scale of the disturbed area and the quality of revegetation. As the disturbance area and change in impervious areas are in this case small relative to the receiving catchments as a whole, the potential impacts would be expected to be limited in nature and less than the construction phase.

7.3 Groundwater level impacts

7.3.1 Excavations intercepting groundwater

Excavations that may intercept groundwater, such as boreholes for piling and excavations associated with the road or bridges will be backfilled and/or sealed as appropriate after construction. Therefore no long term impacts from interception of groundwater are expected from these activities. Stormwater basins will remain open following construction and may continue to have impacts on groundwater. It is proposed that where stormwater basins intercept groundwater, they be lined with impermeable liners or designed to be shallower so as to prevent groundwater ingress.

Installation of piles or stormwater basins are expected to have negligible impact on groundwater flow paths. This is due to the large extent of the Wiannamatta group bedrock compared to the relatively small footprint of proposed basins or piling.

7.3.2 Changes to groundwater recharge

The increased hard stand areas may result in some local changes to the rates of rainfall infiltration. The main groundwater receptor is considered to be baseflow to waterways. Runoff from hard stand areas will continue to flow towards Bells Creek to the west, or Eastern Creek to the east. Therefore reduction in rainfall infiltration is likely to have a negligible effect in flows available to groundwater receptors in the area such as high potential GDEs identified in section 4.10.

Due to the lack of long term interaction of the proposal with groundwater, the proposal is not predicted to result in any long term impact on groundwater level. Therefore it is predicted that the groundwater impacts from the proposal would be less than the Level 1 minimal impact considerations specified in the NSW Aquifer Interference Policy and are therefore considered acceptable.

8. Cumulative impacts

The broader project area is located on the fringes of the Sydney within the Blacktown City Council. Much of the land surrounding the proposal area can be considered semi-rural and future plans accommodate residential and light industrial developments at much higher densities than exist already. Some of these developments are already in progress but are yet to reach complete development. Others are still in the planning phase and their pace of development is uncertain at this stage. Below is a description of current and future projects that are most relevant to the proposal's cumulative impacts.

- **Luxeland** – The Luxeland project (DIHE Holdings Pty Ltd) is a current residential development immediately to the south of Townson Road.
- **Alltove Development** – The Alltove Development project (Stockland and DHA) is a current residential development immediately to the north and south of Townson Road.
- **Compound site** – The compound site project (CSR) is a residential development of unknown status immediately south of Townson Road.
- **Marsden Park Industrial Precinct** - The Marsden Park Industrial Precinct development is located upstream of the proposal with approximately 200 hectare of its footprint within the Bells Creek catchment. A water cycle management strategy was developed as part of the planning process to minimise flow and water quality impacts of the development (J. Wyndham Prince 2011).

Other future developments include the Marsden Park Precinct which would see an area south of the proposal area and in the Bells Creek catchment converted to low density residential housing (NSWPE 2016). The footprint of this development area would be significantly larger than that of the proposal area. For this development to proceed would require a surface and groundwater impact assessment with management and mitigation strategies designed to minimise impacts.

The construction footprint is extremely small compared to the footprints of existing and proposed developments that may impact the Bells Creek catchment and local groundwater system. Attempts have been made to minimise any surface water and ground water impacts of the proposal and therefore are likely to be negligible over the long term compared to any impacts from other developments. Therefore the proposal is not considered to present a significant risk of cumulative impacts in the broader area.

9. Mitigation and management measures

9.1 Construction phase

9.1.1 Surface water and groundwater management and mitigation

A Soil and Water Management Plan (SWMP) would be prepared as part of the Construction Environment Management Plan (CEMP). The SWMP would define the control and mitigation of potential surface water and groundwater quality impacts during construction. The SWMP would be developed to incorporate the most appropriate or 'best practice' controls and measures in accordance with the Blue Book (Landcom 2004/DECC 2008). The SWMP would be staged to suit the changing needs as the works progress. Due consideration would also be given to the extent of works and situation relative to the sensitivity of the environment surrounding the construction activity.

Both the CEMP and SWMP would typically include strategies such as:

- Bunding of storage areas containing hazardous goods and undertaking of refuelling activities in bunded areas
- The staging of construction to minimise potential impacts
- Separating clean and dirty water and preventing infiltration of impacted surface water into the underlying groundwater system
- Preventing groundwater seepage from contacting potentially contaminating site activities by minimising ponding of water in active areas and making storage facilities impermeable
- Preventing impacted groundwater from entering the surface water management system unless it represents a credible treatment option
- Adequately storing and handling site chemicals
- Identifying and responding to chemical spills and managing their clean-up
- Monitoring for the emergence of diffuse water quality impacts and implementing response procedures to remediate any impact.

With appropriate strategies in place, the risk of increased sedimentation in the receiving watercourses would be substantially reduced.

Further, existing open swale drains and any other open drainage channels provided through construction areas will help provide an opportunity to cut off, via emergency bunding where required, any spills and leaks that may begin running off-site or into underground stormwater drainage networks. This would be in the unlikely event of chemical spills or leaks occurring within the proposal area.

Construction-related risks, such as earthworks, spills, and stockpile and equipment locations, are fairly common for projects of this size and type, and would be managed in accordance with the Blue Book (Landcom 2004/DECC, 2008).

Impacts on groundwater due to excavations below the groundwater table and associated dewatering should be mitigated by minimising time that excavations are left open, minimising size of excavations and siting excavations away from groundwater receptors where possible. Any dewatered groundwater may be used on-site for dust suppression or irrigation, with excess water potentially discharged to stormwater. If excess water is to be discharged then testing is recommended prior to discharge.

Bunding of storage areas containing hazardous goods and undertaking of refuelling activities in bunded areas would reduce the risk of the proposal impacting on groundwater quality. All hazardous goods and re-fuelling activities would be undertaken in these bunded areas. These practices would be outlined in the SWMP.

Surface water flow monitoring

Monitoring of surface water flows is not required as impacts from the proposal are considered negligible.

Groundwater elevations and drawdowns

Where excavation activities are likely to occur in close proximity to GDEs as outlined in section 4.10 and 6.3.2, and groundwater is intercepted, monitoring of the groundwater elevations should be performed.

Groundwater inflow management

Where groundwater is intercepted by excavation activities inflows may require dewatering offsite. Testing of dewatered groundwater is to be undertaken if it is to be discharged off site to stormwater. Requirements for this testing and the management of this water would be included in the SWMP and would include the following at a minimum:

- No visible sheen or odour is noted
- Water pH is between 6.5 and 8.5
- Total suspended solids are less than 60 mg/L (approximately equivalent to a turbidity level of 50 NTU). Water may be dosed with gypsum, alum or a similar product to reduce suspended solids concentrations if required.
- All litter and debris must be filtered out and removed prior to discharge
- Pump-out events are supervised at all times, and the pump is positioned to prevent discharge of sediments from the bottom of the trench or tank
- Water is preferentially reused on site, for wetting down and reducing dust in disturbed areas (within existing erosion and sediment controls), or for irrigation in grassed areas
- Water quality is checked regularly during pump-out events to ensure the pH and suspended solids/turbidity remain within the allowable levels
- Sludge from the bottom of the trench or tank can be placed in a shallow pit lined with heavy duty plastic sheeting to dry (evaporation pit). Once the sludge has dried out sufficiently to allow it to be spaded this waste can be stored with excess excavated spoil and disposed in accordance with the findings of the preliminary waste classification assessment.
- Discharge would preferentially occur during periods of high rainfall. If discharge to Bells Creek is to occur, this would preferentially occur while the receiving watercourse is flowing.

9.1.2 Surface water and groundwater quality monitoring

A monitoring program of surface water and groundwater quality is recommended as part of the CEMP to measure water quality outcomes against the ANZECC (2000b) and ANZG (2018) guidelines. Monitoring should occur prior to commencement of construction activities to obtain a baseline surface water and groundwater quality and then during construction at approximately monthly intervals where possible. Surface water samples should be taken from a location on Bells Creek such that it captures any impacts due to the proposal and preferentially after sufficient rainfall (so as to measure surface runoff quality and not groundwater baseflows). Groundwater samples should be carefully situated to capture any impacts due to the proposal. Water quality sampling should be conducted according the *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales* (DEC 2004) guidelines.

The CEMP should specifiy the water quality criteria against which surface water and groundwater quality would be compared to establish impact. Default guideline values (DGV) for physical and chemical stressors in aquatic ecosystems should be specified from the ANZG guidelines (2018). Baseline water quality should be determined by the monitoring program to assess the current condition of the aquatic ecosystem water quality. This would be used to determine the level of species protection required (and associated DGVs) as well as identify changes to water quality parameters resulting from the proposal.

As a minimum, the analytical suite for both the surface water and groundwater quality sampling should include:

- Total dissolved solids (surface water only)
- pH
- Metals, particularly cadmium, iron, lead, nickel, manganese and zinc
- Chloride, sodium and sulfate
- Nitrate and phosphorus (surface water only)
- Total recoverable hydrocarbons
- BTEX
- Polycyclic aromatic hydrocarbons (PAHs).

The procedures for managing and responding to triggered criteria should be outlined in the CEMP and would generally follow the priciples outlined in the Blue Book (Landcom 2004/ DECC 2008), ANZECC guidelines (2000b), Groundwater quality protection guidelines (DWAR 2013) and WSUD guidelines (RMS 2017). Many of these measures have been outlined in previous sections of this report.

9.1.3 Residual impact

Residual impacts of the construction phase of the proposal may include slightly increased surface runoff and transport of litter and other pollutants to receiving watercourses. Water quality impacts would be managed through implementation of runoff and erosion control measures and the water quality monitoring program.

9.2 Operational phase

9.2.1 Surface water and groundwater management and mitigation

The intent of the proposal design with regard to surface water quality would be to minimise impacts on the receiving systems and implement the design criteria. In general the overall design should adopt the principles set out by the WSUD guidelines (RMS 2017). These include:

- Minimising impervious areas through measures such as porous of permeable pavements
- Incorporation of water treatment and pollutant capture measures into the drainage system design such as Gross Pollutant Traps, vegetated swale drains and bioretention basins
- Erosion control measures such as soil stabilisation, landscaping, planting native vegetation and muching.

In addition to adopting WSUD principles, typical additional measures for reducing the risk of diffuse and acute impacts on surface water quality would include:

- Design and operational procedures to reduce the potential for traffic accidents and thus spills of hazardous substances
- Emergency response procedures for cleaning up accidents and spills
- Design of drainage network scour protection according to recommended guidelines (Austroads 2013, Catchments & Creeks 2014, 2015, 2017).

The intent of the proposal design with regard to groundwater quality would be to balance reduced infiltration as a consequence on increased impervious area with the need to minimise infiltration of compromised surface water into the groundwater system. In general the measures outlined for the management of surface water above should adequately achieve this balance. However the design should ensure that any pollutant traps such as bioretention basins are separated from the groundwater system and that groundwater quality monitoring is conducted to demonstrate that the operational design is not having unacceptable impacts on groundwater quality.

Material re-use

To minimise the potential for dispersive erosion following completion of the construction phase, site won material reused as general fill in embankments should comprise gypsum stabilisation at embankment surfaces. In embankments, gypsum stabilisation to a depth of 200 millimetres prior to application of topsoil would be appropriate. Alternatively, site won materials used in embankments may be encapsulated within a minimum one metre cover of a non-reactive, non-dispersive, low permeability general fill.

Gypsum stabilisation is limited to batter slopes of 3H:1V or flatter. For steeper batters (eg 2H:1V), conventional earth moving equipment is unable to operate. Therefore, any site won materials should not be reused in the upper 200 millimetres of embankments. For both steep embankments and cuts, batter stabilisation such as straw mulching, hydro mulching, erosion control blanket, compost blankets etc will be needed to provide protection to the cut face during vegetation establishment and should be adopted. Additionally, adequate surface drainage will be required to minimise surface water flows and associated erosion on batters.

Existing natural soils or reused dispersive materials adjacent to or beneath drainage lines or culverts should be stabilised with gypsum. Additional treatments to prevent erosion such as rock armour or rip-rap at culvert inlets/outlets should also be considered and designed according to the recommended standards (Austroads 2013, Catchments & Creeks 2014, 2015, 2017).

Surface water flow monitoring

Monitoring of surface water flows is not required as impacts are considered negligible.

Groundwater elevations and drawdowns

There is no requirement to monitor groundwater elevations and drawdowns as impacts are considered negligible during the operational phase.

Groundwater inflow management

All excavations that have the potential to intercept groundwater will be backfilled following the construction phase. As a consequence there is not expected to be any requirement for groundwater inflow management during the operational phase.

9.2.2 Surface water and groundwater quality monitoring

It is not proposed that surface water or groundwater monitoring occur during the operational phase of the Project.

9.2.3 Residual impact

Residual impacts of the operational phase of the proposal may include slightly increased surface runoff and transport of litter and other pollutants to receiving watercourses. Water quality impacts would be managed through implementation of water sensitive urban design measures.

9.3 Reporting

Reporting of monitoring outcomes, significant water quality incidents and associated intervention measures should be performed on a monthly basis. This should begin at a minimum of one month prior to commencement of construction and extending to the end of the construction phase.

10. Conclusion

A summary of the findings of the impact assessment are presented below. Some impacts have been identified. However with the implementation of appropriate mitigation and monitoring controls, it is expected that the impacts identified will be acceptable.

The assessment drew on the following sources of information including:

- A desktop review of available water quality and groundwater information
- The most recent design drawings and documentation
- Various standards and guidelines.

The proposal is located in a semi-rural environment with the broader ctachment substantially altered from its natural state and water quality of runoff from the area is likely to be typical of that for urban catchments in Sydney.

Potential construction stage impacts include contamination from chemical or hydrocarbon spills and increased sediment loads being discharged to downstream systems as a result of runoff from exposed areas. Construction impacts would be managed through implementation of SWMPs in accordance with the Blue Book and detailed planning and management of construction sites to avoid impacting overland flow paths without appropriate mitigation.

Water quality impacts would be managed through implementation of water sensitive urban design measures. A water quality monitoring program will be undertaken to monitor water quality outcomes against long term water quality objectives.

Construction stage impacts on groundwater may occur due to interception of groundwater by excavations associated with construction. These excavations may require dewatering which would result in drawdown in groundwater levels. Impacts on groundwater level due to dewatering would occur during the construction phase only.

It is noted that some excavation activities will occur in close proximity to high potential GDEs and analytical modelling has indicated a potential risk to groundwater levels during the construction phase. Should groundwater be intercepted in these locations, impacts on groundwater level due to dewatering would be managed by minimising the number of excavations below groundwater table, minimising time that excavations are left open, minimising size of excavations and siting excavations away from groundwater receptors.

A summary of the key impacts and proposed mitigation and monitoring measures are presented in Table 10-1.

Table 10-1 Summary of key impacts and mitigation measures

Project phase	Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Construction	Construction activities mobilising sediment due to disturbed soil from excavation and clearing	Pollution of receiving drainage networks and watercourses	• Prepare a soil and water management plan and incorporate in the CEMP. • Install sediment and erosion control measures in accordance with the Blue Book (DECC, 2008). • Prepare water quality monitoring plan and incorporate in the CEMP.

Project phase	Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Construction	Chemical or hydrocarbon spill	Contamination of groundwater via seepage or surface water via runoff	• Storage of hazardous goods and refuelling activities to take place in bunded areas. • Implement water quality monitoring program.
Construction	Interception and dewatering of groundwater by excavations	Drawdown in groundwater level (especially close to high potential GDEs)	• Minimise excavations below groundwater table. • Minimise duration of time that excavations below the water table are open.
Construction	Discharge of excess groundwater	Pollution of receiving drainage networks and watercourses	• Use of intercepted groundwater for dust suppression or irrigation on-site. • Prepare water quality monitoring plan and incorporate in the CEMP.
Operation	Increases in hard stand areas across the operational proposal area relative to existing conditions	Increases in pollutant generation. Changes in groundwater recharge	• Where practical and space allows, adopt WSUD guidelines for drainage infrastructure (detention storage, wetlands, etc) to reduce pollutants and allow for groundwater recharge. • Minimise areas of additional hard stand.
Operation	Increase in vehicle movements on the upgraded street.	Increase in potential for pollutant generation	• Where practical and space allows, adopt WSUD guidelines for drainage infrastructure (detention storage, wetlands, etc) to reduce pollutants.
Operation	Poor stabilisation of soils, inadequate scour protection and failed revegetation	Pollution of receiving drainage networks and watercourses with sediment Erosion around drainage infrastructure	• Where practical and space allows, adopt WSUD guidelines for drainage infrastructure (appropriate plant species selection, etc). • Adopt adequate erosion and scour protection measures in the drainage design.
Operations	Interception of groundwater by permanent excavations (stormwater basins)	Drawdown in groundwater level (especially close to high potential GDEs)	• Install impermeable liners or redesign to shallower depth stormwater basins where they may intercept groundwater.

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