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Soils, Surface and Groundwater Assessment

# Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Program Improvements on The Northern Road and Londonderry Road Flood Evacuation Routes

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# Executive summary

## Background

The NSW and Australian Governments have committed $33 million towards planning for more than 100 improvements that will make the Hawkesbury-Nepean Valley flood evacuation routes more resilient to flooding. Road infrastructure improvements have been identified across four Western Sydney Local Government Areas: Penrith, Hawkesbury, Blacktown, and The Hills. The proposed improvements include road shoulder widening, culvert upgrades, new bridge structure, road raising, pinch point upgrades, and drainage improvements. These improvements will make evacuation routes better able to withstand local flash flooding which can cause early closure of evacuation routes.

The Hawkesbury-Nepean Valley faces the highest flood risk in NSW due to its unique landscape and large existing population. Floods in the Hawkesbury-Nepean Valley can and have had a significant impact on people's lives, livelihoods, and homes.

The key objective of the Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Program is to improve drainage on the road network to better withstand local flash flooding and to increase capacity to evacuate by road during major flood events.

The Hawkesbury-Nepean Valley (HNV) Flood Evacuation Road Resilience Program has two components – State Road Improvements (on the Transport for NSW managed roads of The Northern Road and Londonderry Road) and Regional/Local Road Improvements (on the mostly local council managed road network), this proposal refers to the State Road Improvements only, being The Northern Road and Londonderry Road flood evacuation routes.

A Review of Environmental Factors (REF) has been prepared to identify the environmental impacts of the State Roads component of the program (HNV State Roads) and propose mitigation measures. This Soils, Surface and Groundwater Assessment (SSGA) has been prepared to inform the REF in terms of the potential impacts of the proposal on soils, surface water and groundwater.

## Approach to soils, surface water and groundwater assessment

This SSGA presents an assessment of the potential impacts on soils, surface water and groundwater of constructing and operating the proposal. The proposal does not materially change the general road usage and stormwater discharge outlets.

The assessment of potential impacts on soils includes characterisation of the existing environment and soil conditions within the proposal based on public data. The erosion and sedimentation potential of soils and the risks and constraints relating to the soils within the proposal have been assessed based on publicly available data and the concept design for the proposal. A Preliminary Erosion and Sedimentation Assessment (PESA) was conducted, the outcome of which identified the need for an Erosion and Sediment Management Report (ESMR), to be prepared during the detailed design phase prior to construction.

A qualitative assessment was undertaken on the potential impacts on surface water quality from construction and operation of the proposal. The groundwater assessment included review of publicly available data and water level information collected by TfNSW to characterise the existing environment and assess potential groundwater risks as well as potential impacts of the proposal on groundwater levels and quality. The assessment of the concept design identified the potential for groundwater to be intercepted in the excavations for seven drainage improvement locations and an analytical groundwater inflow assessment was undertaken.

## Overview of potential impacts

### Construction

Construction of the proposal would involve a range of activities, including excavations and trenching, vegetation clearing and mulching, the establishment of ancillary facilities, and road construction including widening of the road shoulder. These construction activities have the potential to impact on soils, surface water and groundwater.

If not adequately managed, potential impacts include:

- Erosion of soil and sedimentation of watercourses

- Reduced water quality from elevated turbidity, increased nutrients and other contaminants
- Impacts on aquatic organisms from increased sediments and low dissolved oxygen
- Potential weed and algal blooms associated with reduced water quality
- Contamination of soils and water from accidental leaks or spills of chemicals and fuels, and
- Reduction in groundwater levels from dewatering of excavations.

Construction is anticipated to intercept the water table in the excavations for seven drainage upgrade structures. Works are not anticipated to be more than one metre below the water table and would not result in significant volumes of dewatering. The proposal is anticipated to be exempt from the requirement for a Water Access Licence under the NSW *Water Management Act 2000* with the volume of groundwater extracted likely to be less than 3 ML/annum.

The proposal has the potential to impact groundwater dependant ecosystems within proximity to dewatered excavations, however, the level of drawdown of the water table is anticipated to below the Level 1 minimal impact considerations under the NSW Aquifer Interference Policy. The proposal is not predicted to impact on surrounding water supply bores and groundwater quality.

### Operation

Operation of the proposal has the potential to impact on surface water quality due to erosion of newly stabilised or planted areas during the establishment period, resulting in sedimentation of watercourses. During operation, the main impact is the increased impervious area that would increase stormwater runoff to surface water receptors and decreased rainfall infiltration to groundwater aquifers. The proposal does not change the traffic volume and normal operation of the road. The increased impervious area over the proposal is unlikely to result in measurable changes to the water quality of downstream receiving environments of the minor tributaries of the Hawkesbury-Nepean River catchment.

It is noted that the evacuation lane would typically only be used in the event of a major flood evacuation. The proposal would not increase the volume of traffic on Londonderry Road or The Northern Road during normal operation.

## Conclusion

To minimise impacts to soil, surface water and groundwater, a range of mitigation measures would be implemented during the detailed design, construction and operational phases of the proposal, such as the preparation and execution of:

- A Soil and Water Management Plan (SWMP) as part of the Construction Environment Management Plan (CEMP) to mitigate soil erosion and water pollution during construction
- Erosion and Sediment Control Plans (ESCPs) as part of the SWMP to minimise soil erosion and sediment transport to nearby waterways
- A Dewatering Management Protocol (DMP) as part of the SWMP to mitigate groundwater drawdown and manage disposal impacts from dewatered groundwater
- Site-specific emergency spill plans to address accidental spills and leaks of hydrocarbons, oil and grease.

Additionally, the construction methodologies would consider the following:

- Appropriately designed scour protection for drainage culverts, table drains and stormwater discharge points according to recommended guidelines (Austroads 2013, Catchments & Creeks 2014, 2015, 2017)
- Stockpile site locations, material laydown and chemical storage to prevent water pollution, and
- Progressive rehabilitation of disturbed areas as stages are completed.

During detailed design, opportunities to mitigate operational phase surface water quality would be explored.

It is considered that, with the implementation of the mitigation measures recommended in this report, potential impacts on soils, surface water and groundwater, resulting from the construction and operation of the proposal are expected to be acceptable and minimal.

# Contents

# Appendices



# Figures



# Tables

# Abbreviations

| Abbreviation | Description |
|---|---|
| AHD | Australian Height Datum |
| AIP | Aquifer Interference Policy |
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| ANZG | Australian and New Zealand Guidelines |
| ASRIS | National Acid Sulfate Soil Atlas |
| ASS | Acid Sulfate Soils |
| ASSMAC | Acid Sulphate Soil Management Advisory Committee |
| AWS | Automated Weather Station |
| BC SEPP | State Environmental Planning Policy (Biodiversity and Conservation) 2021 |
| BOM | Bureau of Meteorology |
| CEMP | Construction Environment Management Plan |
| CRD | Cumulative Rainfall Departure |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DCCEEW | NSW Department of Climate Change, Energy, the Environment and Water |
| DMP | Dewatering Management Protocol |
| EHA | Erosion Hazard Assessment |
| ESCP | Erosion and Sediment Control Plan |
| ESMR | Erosion and Sediment Management Report |
| GDE | Groundwater Dependent Ecosystems |
| GIR | Geotechnical Interpretive Report |
| ha | Hectares |
| HGL | Hydrogeological Landscapes |
| ID | Identification name |
| km | Kilometres |
| LGA | Local Government Area |
| L/sec | Litres per second |
| m | Metres |
| mbgl | Metres below ground level |
| ML | Megalitres |
| m/d | Metres per day |
| mg/L | Milligrams per litre |
| $m^3$ | Cubic metres |
| NGIS | National Groundwater Information System |
| NPWS | NSW National Parks and Wildlife Service |
| NWQMS | National Water Quality Management Strategy |
| PESA | Preliminary Erosion and Sedimentation Assessment |
| POEO Act | NSW *Protection of the Environmental Operations Act 1997* |

| Abbreviation | Description |
|---|---|
| PN | Practice Note |
| REF | Review of Environmental Factors |
| RH SEPP | State Environment Planning Policy (Resilience and Hazards) 2021 |
| RIS | Reduced Inorganic Sulfur |
| RMS | NSW Roads and Maritime Services |
| RTA | Former NSW Roads and Traffic Authority |
| SEPP | State Environmental Planning Policy |
| SSGA | Soils, Surface and Groundwater Assessment |
| SWMP | Soil and Water Management Plan |
| TfNSW | Transport for New South Wales |
| WAL | Water Access Licence |
| WM Act | NSW *Water Management Act 2000* |
| WM Regulation | NSW Water Management Regulation 2018 |
| WSUD | Water Sensitive Urban Design |
| WSP | Water Sharing Plan |

# 1. Introduction

## 1.1 General

SMEC Australia Pty Ltd (SMEC) has been engaged to provide design services to Transport for NSW (TfNSW) for the Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements – State Roads proposal. This Soils, Surface Water and Groundwater working paper has been prepared to assess the potential impacts of the proposal to soil, surface water and groundwater.

## 1.2 Project overview

The NSW and Australian Governments have committed $33 million towards planning for more than 100 improvements that will make the Hawkesbury-Nepean Valley flood evacuation road network more resilient to flooding. Road infrastructure improvements have been identified across four Western Sydney Local Government areas: Penrith, Hawkesbury, Blacktown, and The Hills. The proposed improvements include road shoulder widening, culvert upgrades, new bridge structure, road raising, pinch point upgrades and drainage improvements. These improvements will make evacuation routes better able to withstand local flash flooding which can cause early closure of evacuation routes.

The Hawkesbury-Nepean Valley has the highest flood risk in NSW due to its unique landscape and large existing population. Floods in the Hawkesbury-Nepean Valley can and have had a significant impact on people's lives, livelihoods, and homes.

The key objective of the Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Program is to improve drainage on the road network to better withstand local flash flooding and to increase capacity to evacuate by road during major flood events.

The Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Program has two components – State Road Improvements (on the Transport for NSW managed roads of The Northern Road and Londonderry Road) and Regional/Local Road Improvements (on the mostly local council managed road network), this proposal refers to the State Road Improvements only, being The Northern Road and Londonderry Road flood evacuation routes.

## 1.3 Proposal description

The proposal area generally includes the road corridors of The Northern Road, Londonderry Road, Andrews Road and Vincent Road as follows:

- The Northern Road between the intersection with Richmond Road/Blacktown Road, Bligh Park in the north, and Borrowdale Way, Cranebrook in the south
- Londonderry Road from 270m south of Southee Road, Hobartville to the intersection with The Northern Road, Llandilo excluding approximately 270m north and 300m south of the existing intersection at The Driftway, Londonderry
- Route A9 (The Northern Road/Richmond Road) from 130m north of Andrews Road, Cranebrook to Boomerang Place, Cambridge Gardens in the south
- Andrews Road, Cranebrook from The Northern Road to the Andrews Road Baseball Complex west of Greygums Road, Cranebrook
- Vincent Road, Cranebrook, for approximately 70m west from The Northern Road
- Identified isolated areas along Route A9 (Richmond Road/Parker Street) between Gascoigne Street and Great Western Highway, Kingswood for the installation of flood evacuation signage.

The proposal area includes a buffer from the outer edge of the designed works to facilitate construction work. The buffer is generally 10m in width but is reduced to 6m or less in specific areas, to minimise impacts on sensitive areas. In some locations the proposal area comprises the entire road corridor, for example the area where drainage will be installed along Andrews Road and south of Andrews Road along The Northern Road.

Key features of the proposal include:

- Widening of the southbound shoulder pavement on the following roads, a total of approximately 20km, to provide a second outbound lane reserved for drivers to use during emergency flood evacuations. This will include culvert and drainage extensions to accommodate a wider road corridor, and connecting drainage along:
  - Londonderry Road between 270m south of Southee Road and The Northern Road, Londonderry
  - The Northern Road between Richmond Road and Borrowdale Way, in Londonderry, Berkshire Park, Cranebrook, Llandilo, and Jordan Springs
- Drainage improvements including upgrades to culvert crossings, drainage channels, and pit and pipe networks at identified locations to improve resilience in localised flooding events. Work would include:
  - Culvert upgrades, and associated drainage channel work:
    - Along sections of The Northern Road associated with raising of low points as outlined below
    - On Carrington Road at the intersection with The Northern Road, Londonderry
    - At two locations on The Northern Road approximately 50m and 130m north of the intersection of Carrington Road, Londonderry
    - On The Northern Road approximately 250m north of Toorah Road, Londonderry
    - On Vincent Road at the intersection with The Northern Road, Cranebrook
    - On Fifth Avenue at the intersection with The Northern Road, Llandilo
  - New roadside drainage channels (including vegetated and concrete of various widths):
    - Along Londonderry Road (adjacent to the southbound shoulder), from 270m south of Southee Road, Hobartville to the intersection with The Northern Road, Llandilo
    - Along The Northern Road (adjacent to the southbound shoulder), from the intersection with Blacktown Road/Richmond Road, Bligh Park to Ninth Avenue, Llandilo
    - Along The Northern Road (adjacent to the northbound shoulder) at road raising areas (described in further detail below)
  - Underground drainage network upgrades:
    - Along The Northern Road (southbound), Cleeve Place and Star Crescent, Cambridge Gardens from Trinity Drive to Boomerang Place, including approximately 60m along Trinity Drive, Cambridge Gardens
    - Along The Northern Road, Cranebrook (northbound) from approximately 115m north of Andrews Road, Cranebrook to Trinity Drive, Cambridge Gardens including new drainage crossings underneath The Northern Road
    - Along Andrews Road from The Northern Road up to the Andrews Road Baseball Complex in Cranebrook
  - Raising of low points along sections of The Northern Road, affecting all road lanes located:
    - Starting from around 120m North of Whitegates Road, Londonderry heading northwards (about 345m length)
    - Starting from around 200m North of Spinks Road, Llandilo heading northwards (about 920m length)
    - Starting from around 270m north of Fifth Avenue to around 435m south of Fifth Avenue, Llandilo
    - Starting from around 185m north of Vincent Road to around 105m south of Vincent Road, Cranebrook
    - Starting from around 50m south of Ninth Avenue to about 365m south of Ninth Avenue, Cranebrook
- Extend, replace or add new culverts at selected locations along Londonderry Road and The Northern Road to maintain property access (e.g. driveways) as required.
- Realignment of The Northern Road, Cranebrook (within the road corridor), between around 330m north of Seventh Avenue, Llandilo to around 280m south of Vincent Road, Cranebrook to reduce project impacts on adjacent sensitive receivers and improve road safety.

- Adjustments to the following intersections to facilitate a secondary outbound lane for drivers to use during a flood evacuation event. These may include changes to existing median, traffic islands, kerbs and line marking at:
  - The Northern Road and Richmond Road and Blacktown Road, Bligh Park
  - Londonderry Road and The Northern Road and Cranebrook Road, Cranebrook
  - The Northern Road and Vincent Road, Cranebrook
  - The Northern Road and Ninth Avenue, Jordan Springs
- Installation of new signage to be displayed during emergency flood evacuations to facilitate a second left turn at the existing Parker Street/Great Western Highway intersection in Penrith under traffic control.
- Adjustments as required to connect Londonderry Road and The Northern Road to local roadways, side roads and access roads.
- Relocation and/or adjustments of various road furniture (such as signage, road safety barriers, street lighting, kerb and island adjustment etc) throughout the proposal area.
- Relocation of bus stops at:
  - The Northern Road (northbound) approximately 30m south of Vincent Road. To relocate this bus stop approximately 130m to the south
  - The Northern Road (southbound) approximately 210m south of Ninth Avenue. To relocate this bus stop approximately 20m to the north
- Utility and driveway adjustments as required within the proposal area.
- Landscaping as required.
- Provision of temporary ancillary facilities to support the construction works including office and staff amenities, site compound and laydown areas:
  - Road reserve adjacent to the Francis Greenway Correctional Complex, Berkshire Park (site 1)
  - Road reserve adjacent to 245 The Northern Road, Berkshire Park (site 2)
  - 557 The Northern Road, Berkshire Park (site 3)
  - Road reserve adjacent to 107 Fifth Avenue, Llandilo (site 4)
  - Road reserve adjacent to 902 The Northern Road, Llandilo (site 5)
  - 1042 The Northern Road, Llandilo (site 6)
  - Council reserve, Greenwood Parkway, Jordan Springs (site 7)
  - Part of the Richmond Race Club, Londonderry Road, Londonderry (site 8)
  - Council reserve, Andrews Road, Penrith (site 9)
  - Council reserve, Parker Street, Penrith (site 10)

Refer to Figure 1–1 for the proposal area.

The final construction staging of the proposal would be determined by Transport and the construction contractor. However, it is anticipated that the permanent works would be carried out in stages, with an early works component. Subject to funding availability, the construction is expected to commence in 2026 and completed in 2030.

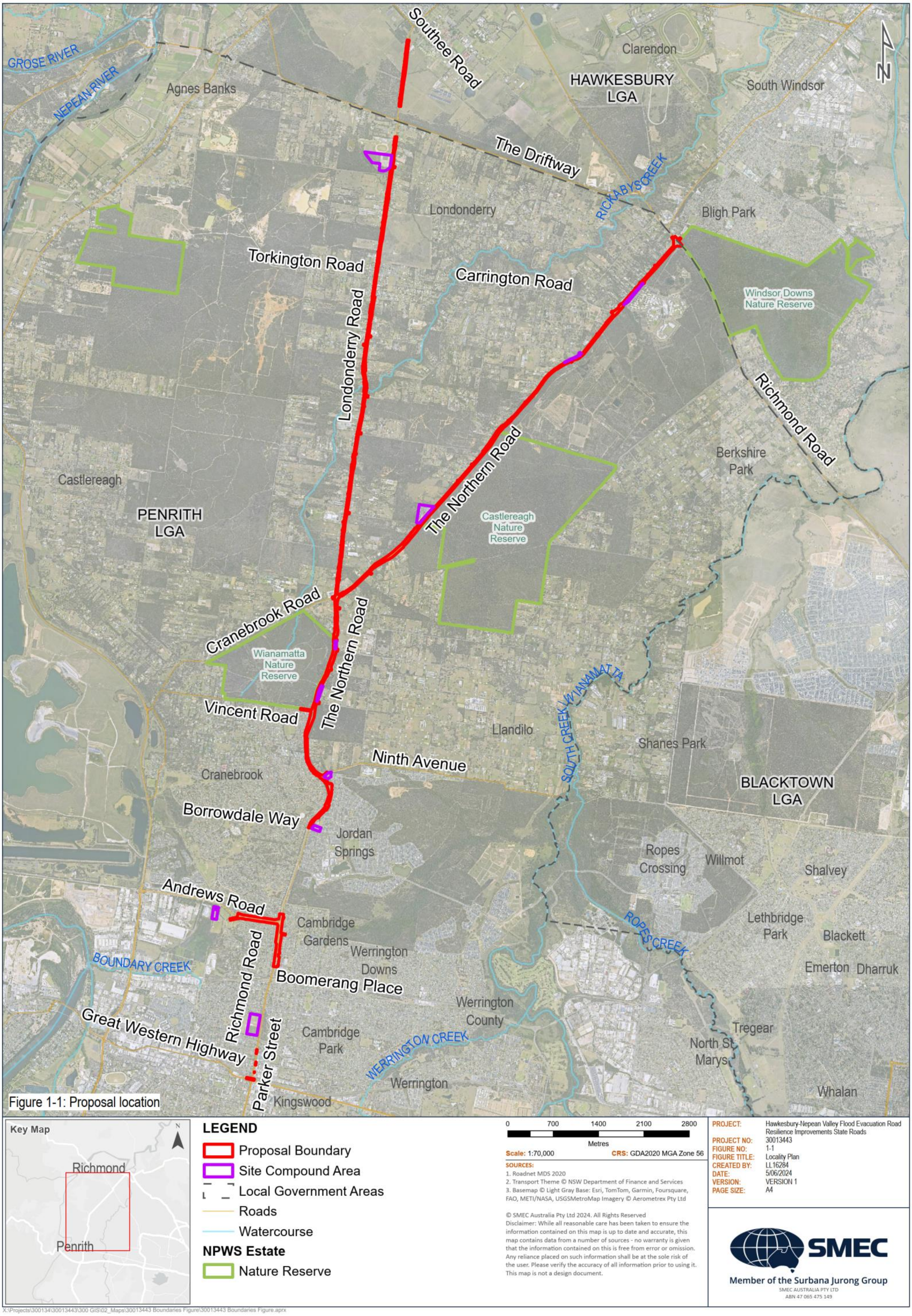


Figure 1-1: Proposal location

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## 1.4 Scope of assessment

The following tasks were carried out during the preparation of this assessment:

- A desktop review of relevant information, including:
  - Review of available published information relating to the study area including soils, geology and hydrogeology, acid sulfate soils, naturally occurring asbestos, national and state parks, listed wetlands, littoral rainforest, and drinking water catchments
  - Review of previous reports and proposal information
  - Review of relevant legislation and guidelines
  - Review of publicly available surface water and groundwater data
  - Review of relevant online records and resources
- Assessment of drainage features likely to intersect groundwater
- Erosion and sediment assessment in accordance with RTA (2008) PN 143P Erosion and Sedimentation Management Procedure
- Analytical assessment of inflows and radius of influence of excavations associated with drainage features, and
- Preparation of this report, which presents the findings of the impact assessment including appropriate mitigation measures.

The working paper has considered the following relevant guidelines:

- PN 143P Erosion and Sedimentation Management Procedure (RTA, 2008)
- Blue Book, Managing Urban Stormwater – Soil and Construction (Landcom, 2004)
- Transport for New South Wales (TfNSW) Groundwater Impact Assessment Guideline and TfNSW draft Guidelines for Assessing the Impacts of Treated Water Discharge from Water Quality Treatment Controls
- Acid sulfate soil and rock assessment prepared in accordance with Guidelines for the Management of Acid Sulfate Soil Manual, ASSMAC (Stone and Hopkins, 1998).

Key considerations for the assessment of potential soil, surface water and groundwater impacts associated with the proposal are outlined in Table 1–1.

Table 1–1: Key considerations for soil, surface water and groundwater impact assessment

| Soil | Surface water | Groundwater |
|---|---|---|
| Soil contamination | Surface water quality | Groundwater users |
| Salinity | Geomorphology | Groundwater quality |
| Acid sulphate soils / acid rock | Sediment impacts | Groundwater drawdown |
| Naturally occurring asbestos | Water supply and disposal | Groundwater Dependant Ecosystems |
| Erosion risks | | |

## 1.5 Data sources

The following reports were reviewed for this assessment:

- SMEC (2023a) Preliminary Site investigation - Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements State Roads Concept Design and REF. Prepared for TfNSW.
- SMEC (2023b) Acid Sulfate Soil Technical Memorandum - Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements State Roads Concept Design & REF. Prepared for TfNSW. Refer to Appendix A.

- TfNSW (2023) Hawkesbury-Nepean Valley Flood Resilience – Geotechnical Factual Report. Report No: 2023/003, dated 18 July 2023.
- TfNSW (2024) HRFP Monitoring Report February 2024 standpipe readings and hydrographs.

Table 1–2 outlines other relevant available data sources used in the preparation of this report.

Table 1–2: Data types and sources used in this report

| Data type | Source |
|---|---|
| Registered groundwater bore data including intended use, status, depth, standing water level and quality | • Water NSW:<br>– Water Register website (https://waterregister.waternsw.com.au/water-registerframe)<br>– Real time data website (https://realtimedata.waternsw.com.au/)<br>• Bureau of Meteorology (BOM):<br>– Bore website (http://www.bom.gov.au/water/groundwater/index.shtml)<br>– National Groundwater Information System (NGIS) Bore Hydro dataset (version 1.7.1) available from Australian Groundwater Explorer (http://www.bom.gov.au/water/groundwater/explorer/index.shtml) |
| Groundwater dependant systems | • BOM National Atlas of Groundwater Dependent Ecosystems (http://www.bom.gov.au/water/groundwater/gde/)<br>• NSW Government Water Sharing Plan for Greater Metropolitan Region Groundwater Sources 2011 (https://legislation.nsw.gov.au/view/pdf/asmade/sl-2011-111) |
| Climate data | • BOM:<br>– Rainfall (www.bom.gov.au/climate/data))<br>– Temperature (www.bom.gov.au/climate/data)<br>– Evaporation and relative humidity (http://www.bom.gov.au/watl/eto/tables/nsw/penrith_lakes/penrith_lakes.shtml)<br>– Climate classification (http://www.bom.gov.au/climate/maps/averages/climate-classification/)<br>– Climate summaries (http://www.bom.gov.au/climate/current/statement_archives.shtml) |
| Regional geology data | • 1:100,000 scale Sydney Area Coastal Quaternary Geology Map (2015) map<br>• Penrith Geological Series Sheet 9030 (Edition 1, 1991) map<br>• Minview (https://minview.geoscience.nsw.gov.au/) |
| Soils landscapes data | • 1:100,000 scale Penrith Soil Landscape Series Sheet 9030 map<br>• eSPADE v 2.2 (https://www.environment.nsw.gov.au/eSpade2Webapp/)<br>• Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian Soil Resource Information System (https://www.asris.csiro.au/about.html) |
| Naturally occurring asbestos<br>Soil salinity potential mapping | • SEED Map (seed.nsw.gov.au) |
| Analytical inflow tools | • SS Papadopulos and Associates (https://www.sspa.com/software/open-excavation-flow-calculator) |
| Catchment water quality objectives | • NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) (https://www.environment.nsw.gov.au/ieo/) |
| Littoral rainforest and Listed wetlands | • State Environmental Planning Policy (Resilience and Hazards) 2021 (https://www.planningportal.nsw.gov.au/opendata/dataset/state-environmental-planning-policy-resilience-and-hazards-2021) |

| Data type | Source |
| --- | --- |
| National Parks, Nature Reserves and State Conservation Areas | • NSW National Parks and Wildlife Service (NPWS) (https://www.nationalparks.nsw.gov.au/conservation-and-heritage/our-parks) |
| Sydney water catchments | • WaterNSW Water Catchments and Special Areas (https://mapprod.waternsw.com.au/portal/apps/Embed/) |
| Land Use and Zoning | • Department of Planning, Heritage and Infrastructure (DPHI) Spatial Viewer (https://www.planningportal.nsw.gov.au/spatialviewer/) |

# 2. Methodology

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

- Desktop review of available information and data collation
- Assessment of the proposal against relevant requirements, evaluated on a qualitative basis
- Characterisation of the existing environment including climate, topography, geology, hydrology, hydrogeology, water quality and sensitive receiving environments
- Review of the geotechnical factual report prepared by TfNSW to inform the concept design development
- Preliminary Erosion and Sedimentation Assessment (PESA) to assess if the proposal poses a high risk for erosion and sediment
- Assessment of the potential for naturally occurring asbestos, soil salinity and acid sulfate soil impacts based on desktop review of online risk mapping and geotechnical investigations
- Analytical assessment of potential groundwater inflows and radius of influence for excavations
- Surface water and groundwater impact assessment using a risk matrix approach and assessment of groundwater impacts in accordance with the NSW Aquifer Interference Policy 2012
- Assessment of potential cumulative impacts, and
- Outline management measures for the potential impacts.

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

## 2.1 Desktop assessment

The desktop assessment was carried out to gain an understanding of the existing condition by accessing available relevant soil, surface water and groundwater information for the study area. This included:

- Review of existing reports and proposal concept design
- Assessment of the proposal against relevant requirements, evaluated on a qualitative basis
- Collation of relevant information on the existing environment including land use, climate, topography, surface water features, geology, hydrogeology, soil landscapes, naturally occurring asbestos
- Collation of relevant existing surface water and groundwater quality information, and
- Developing a conceptual model of the hydrogeological environment.

The data sources used to undertake the desktop review are outlined in Section 1.5.

## 2.2 Erosion and sediment assessment

The erosion and sediment assessment included:

- PESA in accordance with the RTA (2008) PN 143P Erosion and Sedimentation Management Procedure
- Review of soil landscapes and assessment of catchment slopes, and
- Erosion Hazard Assessment (EHA) in accordance with the Blue Book 'Managing Urban Stormwater – Soil and Construction' (Landcom, 2004).

The relevant provisions for wetlands and littoral rainforests of State Environmental Planning Policy (Resilience and Hazards) 2021 were also considered.

## 2.3 Analytical groundwater inflow assessment

The proposal concept design indicates the potential for proposed drainage works to intercept groundwater at some locations. Analytical modelling has been undertaken to estimate the potential groundwater inflows and radius of influence using the analytical spreadsheet 'Steady groundwater inflows into open excavations' and the 'Radial unconfined flow into a circular excavation' model developed by SS Papadopulos and Associates for flow into open excavations, V02: (https://www.sspa.com/software/open-excavation-flow-calculator).

Individual drainage structures have not been assessed. A selected combination of excavation size and depth to water have been assumed to represent the range of excavations likely to be carried out to provide an indicative assessment of inflows and radius of influence to inform the impacts assessment. Assumptions are made given the limited existing information.

### 2.3.1 Modelling input data

To estimate the potential radius of influence and inflows to excavations the following input data is required:

- Initial preconstruction saturated thickness of the aquifer intercepted by the proposal
- Depth of excavation below the water table (all excavation assumed to be in unconfined water table aquifers)
- Hydraulic conductivity of the intercepted aquifer
- Effective excavation radius or length when estimating lateral flow to a long trench, and
- Radius of influence.

Where this information is not available assumptions have been made. The following assumptions have been adopted:

- The aquifer system is assumed to be laterally extensive and homogeneous
- Hydraulic conductivity based on literature values for the material types
- The conditions are unconfined water table aquifers, and
- Steady state conditions (with respect to recharge and discharge) have been achieved.

### 2.3.2 Model approach and scenarios

For modelling purposes three scenario types (refer to Table 2–1) were adopted to assess the likely and high case for inflows and radius of influence. They are:

- Small culverts with excavations that would likely be less than one meter below existing level in alluvium
- Bridge culverts with slightly larger excavations that are up to a meter below existing level in alluvium, and
- Trenches with excavations in residual soil and Bringelly Shale.

The likely case assumes the greater depth to groundwater and lower end of the hydraulic conductivity. The high case assumes the shallow depth to groundwater and the high-end hydraulic conductivity. There is no site-specific hydraulic conductivity information in the vicinity of structures assessed as potentially interacting with groundwater. Therefore, for each material type a likely and higher literature value for hydraulic conductivity has been adopted from within the range of published values as shown in Figure 2–1, which indicates the hydraulic conductivity in metres per day of selected consolidated and unconsolidated geological materials. The red circle indicates the possible range of materials anticipated to be encountered by the proposal.

Table 2–1: Groundwater modelling scenarios and parameters

| Scenario | Excavation depth range (mbgl) | Depth to Groundwater (mbgl) | Material type | Hydraulic conductivity range (Likely to high) m/day |
|---|---|---|---|---|
| 1. Culverts (small) | 0.3 to 0.8 | 0.0 to 2 | Alluvium – Londonderry Clays, possible sands and gravels clay bound | 0.001 to 0.01 |

| Scenario | Excavation depth range (mbgl) | Depth to Groundwater (mbgl) | Material type | Hydraulic conductivity range (Likely to high) m/day |
|---|---|---|---|---|
| 2. Culverts (bridge sized) | 0.5 to 1.0 | 0.0 to 1.0 | Alluvium -Rickabys Creek Gravels, Sands and Clays | 0.01 to 1 |
| 3. Trench excavations | 1.0 to 4.9 | 2.0 to 6.0 | Bringelly Shale and derived clayey soils | 0.0005 to 0.001 |

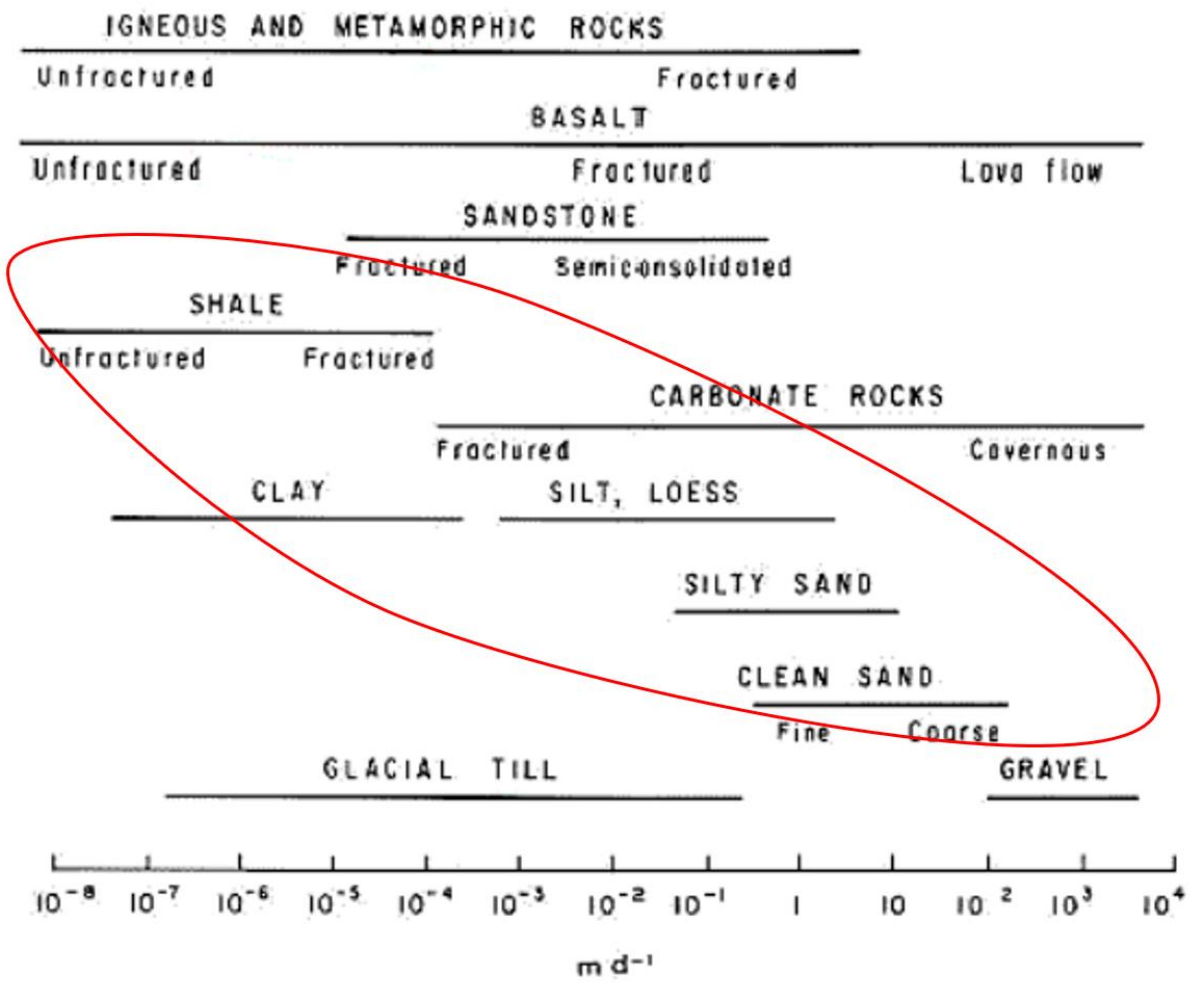



Figure 2–1: Hydraulic conductivity in metres per day (Heath, 1983)

For estimating groundwater inflow for the culverts, the excavations are assumed to be 10 m long, 3 m wide and either 0.5 m and or 1 m deep. This is based on the width of the road and the average culvert width. The groundwater table is assumed to be either at surface or 0.5 m below ground level. This approach is considered conservative as the base slab excavation will only be to 0.5 m while the cut off trench will be a further 0.5 m deep and only 1 m wide.

Culvert extensions in creeks and drainage lines will consist of shallow excavations for placement of the new culvert slab to a depth not more than 0.5 m below the existing slab level and excavation of the cut off wall to a depth of not more than 0.5 m below the slab invert running perpendicular to the drainage line or creek. It is likely that inflows to these excavations will be both from groundwater and surface water.

The modelling for the purpose of this assessment assumes that the construction methodology has the full excavation length open at one time, however actual construction methods will be to excavate the new culvert slab and cut off trenches in sections to minimise inflows.

For estimating groundwater inflow all culvert footing excavations are assumed to be 10 m long, 6 m wide and 1 m deep. The groundwater table is assumed to be either at surface or 0.5 m below ground level. This approach is considered conservative as the base slab excavation will only be to 0.5 m while the cut off trench will be a further 0.5 m deep and only 1 m wide.

For estimating groundwater inflow to trench excavations trenches are assumed to be 100 m long, 2 m wide and either 1 m or 2 m below the standing water table. The modelling for the purpose of this assessment has assumed that 100 m is considered the maximum reasonable length to be open at one time. This is to minimise the resultant groundwater inflows. Actual construction methods may utilise shorter trench lengths. Longer trench lengths may have increased groundwater inflows.

Drainage trenches for installation of box culverts and pipes will be undertaken at the southern end of the proposal in the vicinity of Andrews Road, Penrith. The trench excavations will be to a maximum depth of 4.9 m and excavated in residual soils derived from Bringelly Shales. The construction methodology is proposed to open limited sections of trench at a time, limited to less than 100 m to minimise groundwater inflows.

When considering inflows into excavations, it is worth noting that if the footprint size of the excavation is doubled (i.e. length and or width) the inflow may increase by up to 10 %. However, if the depth of the excavation below the water table is doubled the inflows may increase by 100 %.

## 2.4 Surface water and groundwater impact assessment

The impact assessment is based on assessed key construction and operation activities and their associated direct and indirect impacts on soil, surface water and groundwater and the requirements of the NSW Aquifer Interference Policy. Table 2–2 presents the qualitative risk matrix for the impact assessment. Table 2–3 outlines the likelihood ratings and Table 2–4 outlines the consequence ratings. Mitigation measures are presented in Section 9. Residual impacts assessment using the risk matrix assume the application of mitigation measures.

Table 2–2: Qualitative risk assessment matrix

| Risk Assessment | | Consequence Level | | | | |
|---|---|---|---|---|---|---|
| | | Insignificant | Minor | Moderate | Major | Severe |
| Likelihood | Almost Certain | Medium | High | High | Extreme | Extreme |
| | Likely | Medium | Medium | High | High | Extreme |
| | Possible | Low | Medium | Medium | High | High |
| | Unlikely | Low | Low | Medium | Medium | High |
| | Rare | Low | Low | Low | Medium | Medium |

Table 2–3: Likelihood ratings

| Descriptor | Frequency | Probability |
|---|---|---|
| Almost Certain | Twice or more per year | Event will occur during the proposal period<br>High number of known incidents |
| Likely | Once per year | Event likely to occur during the proposal period<br>Regular incidents known |
| Possible | Once in 5 years | Event may occur in some instances during the proposal period<br>Occasional incidents known |
| Unlikely | Once in 10 years | Event is not likely to occur during the proposal period<br>Some occurrences known |
| Rare | Once in 20 years | Event will occur in exceptional circumstances during the proposal period<br>Very few or no known occurrences |

Table 2–4: Consequence ratings

| Level | Descriptor |
|---|---|
| Insignificant | Negligible change to hydrological/hydrogeological processes, water availability or water quality |
| Minor | Short-term modification of hydrological/hydrogeological processes, water availability and quality within the study area but no change in beneficial use |
| Moderate | Medium-term modification of hydrogeological processes, water availability and water quality within the study area but no change in beneficial use.<br>Short-term modification of hydrological/hydrogeological processes, water availability and water quality outside the study area but no change in beneficial use. |
| Major | Long-term modification of hydrological / hydrogeological processes, water availability and water quality within the study area but no change to beneficial use.<br>Medium-term modification of hydrological / hydrogeological processes, water availability and water quality outside the study area but no change in beneficial use. |
| Severe | Long-term or permanent modification of hydrologic / hydrogeological processes, water availability or water quality outside study area, with impacts to a water dependent environmental value and or change in beneficial use. |

# 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 Act) is the principal NSW legislation for pollution control administered by the Environmental Protection Authority (EPA). 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 activities are required to hold and comply with.

The proposal does not meet the relevant criteria for road construction activities of Schedule 1 of the POEO Act. Similarly, at this stage of design development, the quantity of extracted material required for construction of the project is not anticipated to exceed the threshold for extractive activities. The requirements for an environment protection licence would be reviewed prior to commencement of construction.

### 3.1.2 Water Act 1912, Water Management Act 2000 and Water Management (General) Regulation 2018

The *Water Act 1912* and the *Water Management Act 2000* (WM Act) comprise the principal legislation for the management of water in NSW, and contain provisions for the licencing of water access and use. The Water Management (General) Regulation 2018 supports the WM Act. The *Water Act 1912* is being progressively phased out and replaced by Water Sharing Plans (WSPs) under the WM Act.

Under the WM Act, activities that require approvals for water use and water supply are outlined, along with activities that may be exempt. Controlled activity guidelines and approvals apply to activities within 40 m of the high bank of a waterway, river, lake or estuary.

The proposal is considered an exempt controlled activity under the WM Act as the works would be carried out by a public authority under Subdivision 4, clause 41 of the Water Management (General) Regulation 2018.

#### 3.1.2.1 Water Sharing Plans

The proposal falls within the area where the Water Sharing Plans (WSPs) apply:

- *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Sources* 2023
  - Hawkesbury and Lower Nepean Rivers Extraction Management Unit which includes Upper Hawkesbury River, Lower Nepean Rivers water source and Wianamatta – South Creek Water sources
- *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* 2023
  - Sydney Basin Central Groundwater Source, which is part of the Sydney Basin Groundwater sources includes all water contained within rocks of Tertiary to Permian age and Cenozoic sediments, except the Botany Sands Groundwater Source, the Hawkesbury Alluvium Groundwater source and the Metropolitan Coastal Sands Groundwater Source.

WSPs 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 Water Access Licences (WALs) are required and how licence holders can access water and how water can be traded.

WALs are required whether water is taken for consumption or whether it is taken by aquifer interference activities even where that water is not being used as part of the activity’s operation. WALs are required for all water taken from a groundwater and surface water source as a result of the aquifer interference activity, both for the duration of the interference activity and after the interference activity has ceased.

The proposal is not anticipated to take surface water and is considered exempt under Schedule 4, Part 1, clause 2 of the Water Management (General) Regulation 2018 (WM Regulation), as the works would be carried out by a roads authority, which are exempt from the requirement to hold WAL to take water for road construction and road maintenance.

The proposal is anticipated to take groundwater through an aquifer interference activity during construction. Under Schedule 4, Part 1, clause 2 of the WM Regulation, public authorities are exempt from the requirement to hold a WAL where the proposal is below 3 ML / annum in active or passive groundwater take.

The exemptions under the WM Act and WM Regulation do not include ongoing operational groundwater take whether passive or intentional. Review of the proposal suggests groundwater take during construction is anticipated to be less than 3 ML/ annum and groundwater take during operation is unlikely.

### 3.1.3 State Environment Planning Policy (Resilience and Hazards) 2021

State Environment Planning Policy (Resilience and Hazards) 2021 (RH SEPP) identifies, amongst other matters, sensitive coastal wetlands and littoral rainforest locations in NSW and provides measures for the consideration of impacts on these sensitive areas in development assessment.

The RH SEPP was reviewed. No coastal wetlands or littoral rainforest locations mapped under the RH SEPP are located within the study area or are likely to be affected by drainage from the proposal.

## 3.2 Policies and guidelines

The following policies and guidelines are relevant to this assessment.

### 3.2.1 National Water Quality Management Strategy 2018

The purpose of the National Water Quality Management Strategy (NWQMS) is to protect the nation’s water resources by maintaining and improving water quality, while supporting dependent aquatic and terrestrial ecosystems, agricultural and urban communities, and industry. The NWQMS consists of three major elements: policy, process and guidelines. The guidelines include the Australian and New Zeeland Guidelines for Fresh and Marine Water Quality.

The proposal has the potential to impact water quality within the Hawkesbury-Nepean River catchment and should integrate water quality management strategies consistent with NWQMS such that environmental values of the receiving waterways are not adversely impacted.

### 3.2.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) are based on the policies and principles of the NWQMS. They are an update to the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines. 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. 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.

The proposal has the potential to impact surface water quality. Review of the proposal finds an absence of site-specific values or *NSW Water Quality Objectives* (2006) for Rickabys Creek and as such the ANZG give directions to default guideline values for a range of stressors. Review of the proposal finds limited water quality and flow objectives may have been developed for South Creek under the risk based framework of Dela-Cruz et. al, 2017. In the absence of site-specific data the proposal would likely adopt ANZG guidelines for freshwater species, 95% protection level, and trigger criteria for slightly to moderately disturbed ecosystems and the south-east Australia lowland river ecosystem type.

### 3.2.3 NSW Aquifer Interference Policy 2012

The NSW Aquifer Interference Policy (NSW Office of Water, 2012) clarifies the water licencing and approval requirements for aquifer interference activities in NSW.

The NSW Aquifer Interference Policy (AIP) 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. The WM Act defines an aquifer interference activity as that which involves the following:

- Penetration of an aquifer
- Interference with water in an aquifer
- Obstruction of flow in an aquifer
- Taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations, and
- Disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

There are two levels of minimal impact considerations, divided into categories based on highly productive and less productive groundwater sources. Highly productive groundwater is based on the following criteria:

- Has total dissolved solids of less than 1,500 mg/L, and
- Contains water supply works that can yield water at a rate of greater than 5 L/sec.

Based on these criteria the proposal likely falls within the highly productive groundwater source of alluvial and less productive fractured rock.

If the predicted impacts of the proposal are less than the Level 1 minimal impact considerations, then the potential groundwater impacts of the proposal are acceptable. The Level 1 minimal impact considerations for highly productive alluvial groundwater sources are shown in Table 3–1.

Table 3–1: Level 1 minimal impact considerations for aquifer interference activities for highly productive groundwater sources (Table 1 of AIP)

| Water source | Water table | Water pressure | Water quality |
|---|---|---|---|
| Alluvial water | Less than or equal to 10 % cumulative variation in the water table allowing for typical climatic 'post-water sharing plan' variations, 40 m from any:<br>(a) high priority groundwater dependant ecosystems or<br>(b) high priority culturally significant site<br>listed in the schedule of the relevant water sharing plan<br>Or<br>a maximum of 2 m decline cumulatively at any water supply work | A cumulative pressure head decline of not more than 40 % of the post-water sharing plan pressure head above the base of the water source to a maximum of a 2 m decline at any water supply work | (a) A change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity<br>(b) No increases of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity<br>(c) No mining activity to be below the natural ground surface within 200 m laterally from the top of high bank or 100 m vertically beneath (or the three-dimensional extent of the alluvial water source whichever is the lesser distance) of a highly connected surface water source that is defined as a reliable water supply<br>(d) Not more than 10% cumulatively of the three-dimensional extent of the alluvial material in this water source to be excavated by mining activities |

The Level 1 minimal impact considerations for less productive porous and fractured rock water sources are:

- Less than or equal to 10 % cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, at a distance of 40 m from any high priority Groundwater Dependent Ecosystems (GDEs) or high priority culturally significant sites 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, and
- Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m of the activity.

The proposal contains aquifer interference activities and requires assessment of their impact on groundwater users, GDE and culturally significant sites that are groundwater dependant.

### 3.2.4 TfNSW Groundwater Assessment Guideline

The purpose of the groundwater guideline is to guide the assessment, mitigation and management of groundwater impacts that may occur during construction and operation. It includes guides for:

- Determining the level of groundwater assessment required
- Groundwater field investigations
- Groundwater modelling
- Describing the existing environment, potential impacts on groundwater resources, and potential impacts on groundwater receptors including water supply works and GDEs, and
- Monitoring and management requirements.

The key guidelines for assessments include:

- Australian Groundwater Modelling Guidelines 2021
- NSW WM Act
- The NSW Aquifer Interference Policy 2012, and
- WSPs approved under the WM Act.

The proposal has been reviewed in accordance with the TfNSW Groundwater Assessment Guideline flow chart and finds:

- The proposal does potentially impact groundwater
- The proposal does not potentially exceed minimal impact considerations, and
- The proposal does not require a numerical groundwater model.

# 4. Existing environment

This section provides an outline of the existing soil, surface water and groundwater environment and has been informed by existing reports and this desktop assessment.

## 4.1 Location and land use

A summary of information about location and land use of the proposal is presented below in Table 4–1.

Table 4–1: Summary of proposal location and land use information.

| | |
|---|---|
| **Location** | The Northern Road from Richmond Road to Great Western Highway, Penrith and Londonderry Road from 270m south of Southee Road, Richmond to the intersection with The Northern Road and Cranebrook Road, Cranebrook (refer to Figure 1–1). |
| **Local Government Area (LGA)** | Mostly Penrith LGA with the northern extent of Londonderry Road within the Hawkesbury LGA. |
| **Proposal size** | Covers approximately 102.7 hectares |
| **Land Use** | Public road corridor |
| **Zoning** | Reference to Department of Planning and Environment's Environmental Planning Instruments dataset (accessed via NSW ePlanning Portal 29 May 2023), indicates that the study area is a mix of:<br>• SP2 Infrastructure (Classified Road)<br>• R2 Low Density Residential<br>• R3 Medium Density Residential<br>• R4 High Density Residential<br>• IN1 General Industrial<br>• RU4 Primary Production Small Lots<br>• RU5 Village<br>• RE1 Public Recreation<br>• SP1 Special Activities (Education Agriculture)<br>• SP2 Infrastructure (Waste or Resource Management Facility)<br>• SP2 Infrastructure (Future Road)<br>• SP2 Infrastructure (Water Supply System)<br>• SP2 Infrastructure (Correctional Centre)<br>• C1 National Parks and Nature Reserves<br>• C2 Environmental Conservation. |
| **Surrounding Land Use** | **The Northern Road (to the south of the junction of The Northern Road and Vincent Road)**<br>• Developed urban area with low density housing and associated infrastructure, schools, light industry and public open space<br>• Nepean Hospital<br>**The Northern Road (north of Vincent Road)**<br>• Rural and agricultural properties<br>• Natural reserves<br>• Former Castlereagh Regional Waste Disposal Depot, NSW Firefighting Training facility and former auto wrecker yard<br>• Francis Greenway Correctional Complex<br>**Londonderry Road**<br>• Rural land and agricultural properties<br>• Nature reserves and public open spaces<br>• St Paul's Grammar School<br>• RAAF Base |

## 4.2 Climate and rainfall

Climatic data is available from the Bureau of Meteorology (BOM). The proposed alignment is located within the Temperate climate classification for Australia and is characterised by warm summers and cold winters.

There are three weather stations located near the proposed alignment:

- Castlereagh (Castlereagh Road) BOM number 67022, with data from 1940 to 1955 and 1965 to present.
- Penrith Lakes Automated Weather Station (AWS), BOM number 67133 with data from September 1995 to present.
- Richmond UWS Hawkesbury, BOM number 67021 with data from 1881 to present.

The mean annual rainfall for the region is typically between 700 mm and 900 mm. Higher seasonal rainfall is typical in the summer months. Table 4–2 presents a summary of the mean monthly and annual rainfall for the three weather stations, for data up to February 2024.

Table 4–2: Mean monthly and annual rainfall from selected BOM weather stations

| BOM No. | Jan (mm) | Feb (mm) | Mar (mm) | Apr (mm) | May (mm) | Jun (mm) | Jul (mm) | Aug (mm) | Sep (mm) | Oct (mm) | Nov (mm) | Dec (mm) | Annual (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 67022 | 107.0 | 116.4 | 96.3 | 67.3 | 53.5 | 62.1 | 36.5 | 43.1 | 39.0 | 60.5 | 79.5 | 70.6 | 856.0 |
| 67133 | 95.1 | 118.8 | 108.3 | 50.2 | 35.2 | 45.2 | 37.2 | 30.4 | 30.8 | 54.9 | 83.5 | 65.0 | 733.3 |
| 67021 | 97.1 | 94.4 | 94.0 | 67.1 | 55.8 | 60.1 | 45.3 | 41.8 | 41.9 | 57.1 | 73.5 | 75.4 | 802.4 |

The cumulative rainfall departure (CRD) compares the cumulative monthly rainfall with the long-term average and is most effective where more than 50 years of continuous records exist. It establishes a trend line in terms of above or below average rainfall conditions. The CRD is calculated after the method of Ferdowsian et al (2001) for Richmond UWS between 1881 and 2023 and Castlereagh Road weather station between 1966 and 2023. It is the trend (i.e. slope) of the line that is important not a numerical value. Figure 4–1 shows that in general both weather stations show the same period of above average and below average rainfall trend. Figure 4–2 shows annual rainfall totals at Castlereagh between 1966 and 2023 with the mean annual rainfall and CRD trend. 2020 to 2022 have been consecutive years of total rainfall above the mean annual rainfall.

Between 2001 and 2017 is a period of generally average to below average rainfall conditions with below average rainfall conditions from 2017 to 2020. From 2022 to mid-2023 is a period of above average rainfall conditions. The highest rainfall year on record was 1950 with 1677 mm at Castlereagh 1718 mm at Richmond UWS and the second highest year on record was 2022 with 1581 mm at Castlereagh and 1471 mm at Richmond UWS.

The climatic period of existing information and investigation periods have been collected during periods of both above and below average rainfall conditions. This should be considered when using the information to infer existing conditions and the interpretation and assessment of results trends. The concept investigation data for the Geotechnical Factual Report (TfNSW, 2023) was collected in February 2023 during a period of below average rainfall conditions and subsequent monitoring data for the period July to September 2023 has been collected during below average rainfall conditions.

The Penrith Lakes AWS station has climate records for temperature, evapotranspiration and relative humidity. Temperature data is available from September 1995 to February 2024 and summarised below in Table 4–3. From 2009 evapotranspiration and relative humidity records are available. These are summarised in Table 4–3 for monthly mean for data up to February 2024.

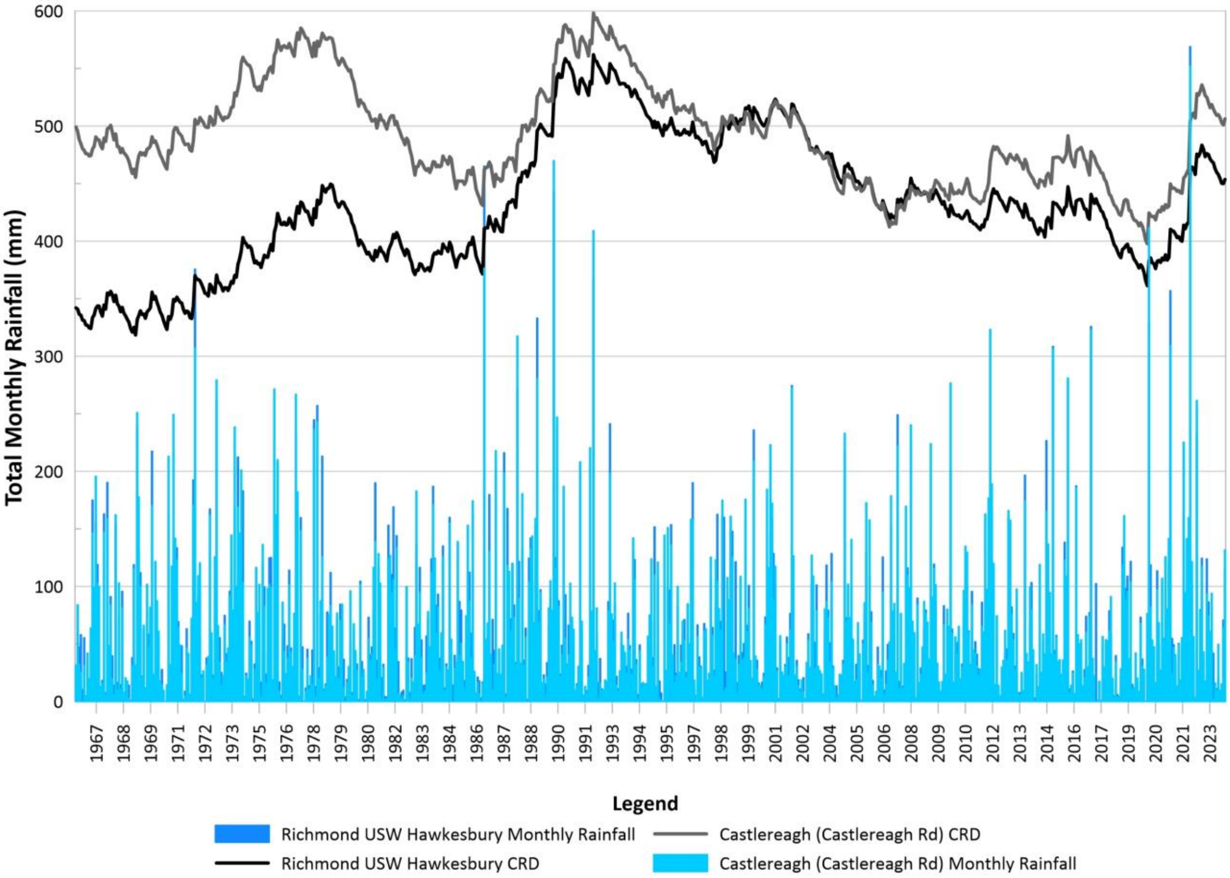



Figure 4–1: Total monthly rainfall at Castlereagh Road and Richmond USW weather stations with cumulative rainfall departure trends

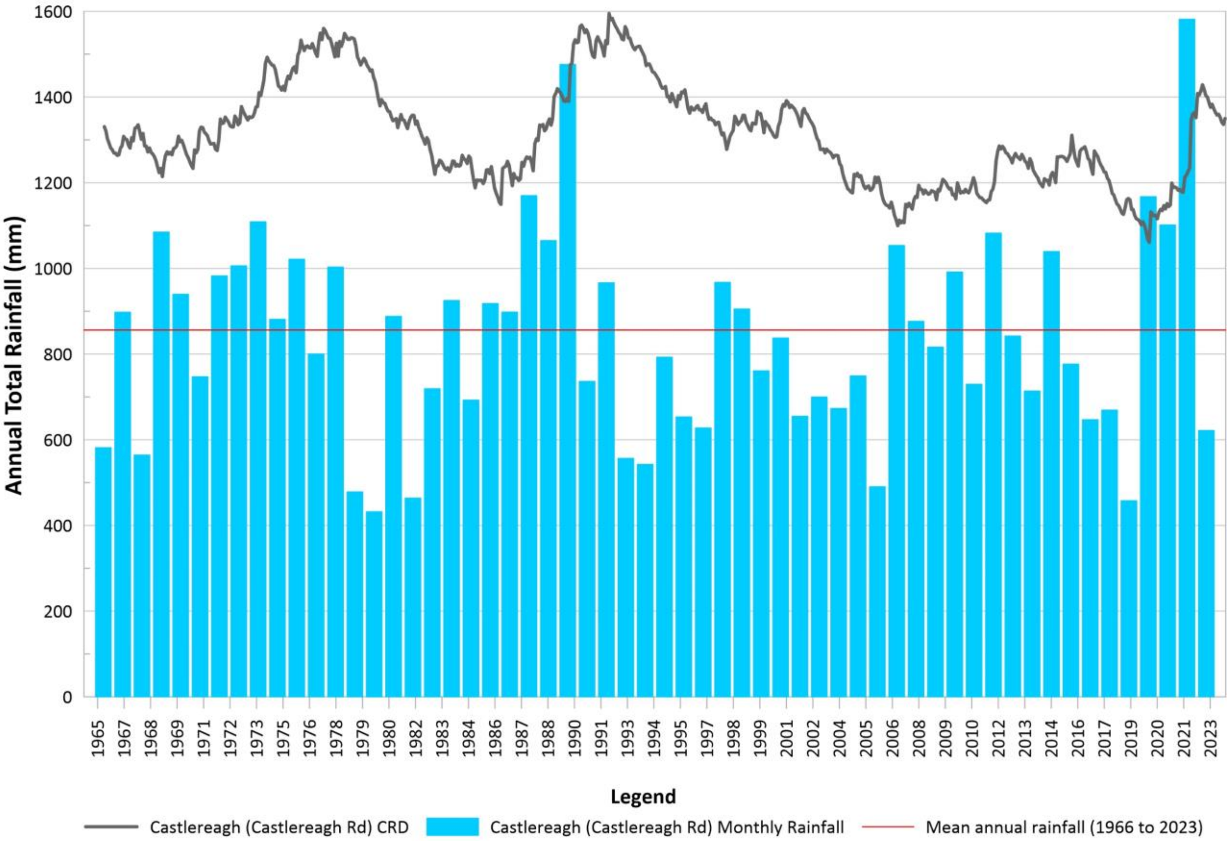



Figure 4–2: Annual total rainfall – Castlereagh Road, 1966-2023 with mean annual rainfall and cumulative rainfall departure trend

Table 4–3: Climate data compilation from Penrith Lakes AWS

| Statistic | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Minimum Temperature (°C) | 27.4 | 26.0 | 25.7 | 21.8 | 19.7 | 16.7 | 16.1 | 18.2 | 20.7 | 23.0 | 23.8 | 24.8 |
| Mean Maximum Temperature (°C) | 34.9 | 32.7 | 30.5 | 28.6 | 23.5 | 20.1 | 20.4 | 21.9 | 26.4 | 28.9 | 31.8 | 33.5 |
| Mean Temperature (°C) | 31.0 | 29.6 | 27.6 | 24.7 | 21.2 | 18.2 | 18.1 | 20.0 | 23.4 | 25.9 | 27.5 | 29.7 |
| Highest Daily Temperature (°C) (date / year) | 48.9 (4th 2020) | 46.9 (11th 2017) | 40.6 (13th 1998) | 36.6 (6th 2016) | 29.4 (1st 2016) | 26.0 (14th 2004) | 28.2 (30th 2017) | 29.7 (27th 2004) | 37. (23rd 2017) | 38.91 (14th 2004) | 44.9 (23rd 2014) | 46.3 (31st 2019) |
| Lowest Daily Temperature (°C) (date / year) | 18.8 (5th 2016) | 18.2 (14th 2009) | 16.8 (14th 2020) | 14.6 (20th 2015) | 13.1 (24th 2012) | 8.3 (10th 2021) | 11.2 (26th 2009) | 12.3 (10th 2010) | 12.9 (17th 2019) | 14.2 (11th 2021) | 13.6 (22nd 1996) | 16.5 (23rd 1995) |
| Mean Evapo-transpiration (mm) | 5.24 | 4.44 | 3.46 | 2.57 | 1.78 | 1.33 | 1.59 | 2.37 | 3.5 | 4.36 | 4.99 | 5.43 |
| Mean Minimum Relative Humidity (%) | 44.38 | 47.93 | 50.53 | 48.63 | 46.48 | 53.06 | 46.25 | 38.1 | 34.75 | 36.98 | 39.75 | 40.49 |
| Mean Maximum Relative Humidity (%) | 94.9 | 94.54 | 95.91 | 94.47 | 94.11 | 95.91 | 95.67 | 93.78 | 93.93 | 93.15 | 93.81 | 93.6 |

## 4.3 Topography and drainage

The Northern Road and Londonderry Road are key arterial roads located within the Hawkesbury-Nepean Valley that connect Richmond and Windsor in the north to Penrith in the south. Both typically comprise a single lane in each direction and partially sealed shoulders. The proposed alignment is located south and east of the Hawkesbury River and Nepean River, respectively, and spans across the north-east draining Rickabys Creek catchment.

Within the study area the topography is characterised by a generally low-lying and flat landscape within the Hawkesbury-Nepean Valley floodplain, with the existing ground surface elevation ranging in elevation between 20 metres Australian Height Datum (mAHD) and 40 mAHD. The topography and surface water catchments of the study area are presented in Figure 4–3 and Figure 4–4. The north-east trending Rickabys Creek and its various tributaries intersect both alignments at several crossings and is the main drainage feature of the proposal. The topography at the southern end of the study area, along The Northern Road, comprises a section of undulating terrain with steeper natural slopes and higher elevations typically between elevations of 50 mAHD to 60 mAHD.

Surface drainage of the study area comprises four catchments (Lyall and Associates, 2024):

- Rickabys Creek Catchment (part of the Upper Hawkesbury River Catchment)
- South Creek Catchment (part of the Wianamatta-South Creek Catchment)
- Penrith Lakes Catchment (part of the Lower Nepean River Catchment), and
- Peachtree Creek Catchment (part of the Lower Nepean River Catchment).

Rickabys Creek flows north-east through to South Windsor before discharging to the Hawkesbury River at Windsor. The majority of the proposal is within the Rickabys Creek catchment. South Creek flows north-east through towards Windsor before discharging to the Hawkesbury River. A small portion of the southern part of the proposal, around the suburb of Jordan Springs, falls within the South Creek catchment. Small portions of the southern part of the proposal are also within the Penrith Lakes Catchment and Peachtree Creek Catchment which flow west towards the Nepean River.

The topography and drainage map showing the study area is presented in Figure 4–3.

## 4.4 Water quality objectives

The NSW Water Quality Objectives are the agreed environmental values and long-term goals for NSW's surface waters. They set out:

- the community's values and uses for rivers, creeks, estuaries and lakes, and
- a range of water quality indicators to help NSW Government agencies assess whether the current condition of waterways supports those values and uses.

Water Quality Objectives have been agreed for fresh and estuarine surface waters, and marine waters. The Objectives are consistent with the agreed national framework for assessing water quality set out in the ANZECC 2000 Guidelines. These guidelines provide an agreed framework to assess water quality in terms of whether the water is suitable for a range of environmental values.

At the time of the preparation of this paper, the NSW Government had not nominated NSW Water Quality Objectives for the Hawkesbury-Nepean Valley (refer to https://www.environment.nsw.gov.au/ieo/whatsnot.htm). For the purposes of this assessment, it has been assumed that the objectives nominated by the NSW Government for the ‘Waterways affected by urban development’ of the Georges River catchment would be a useful guide for the Hawkesbury-Nepean Valley.

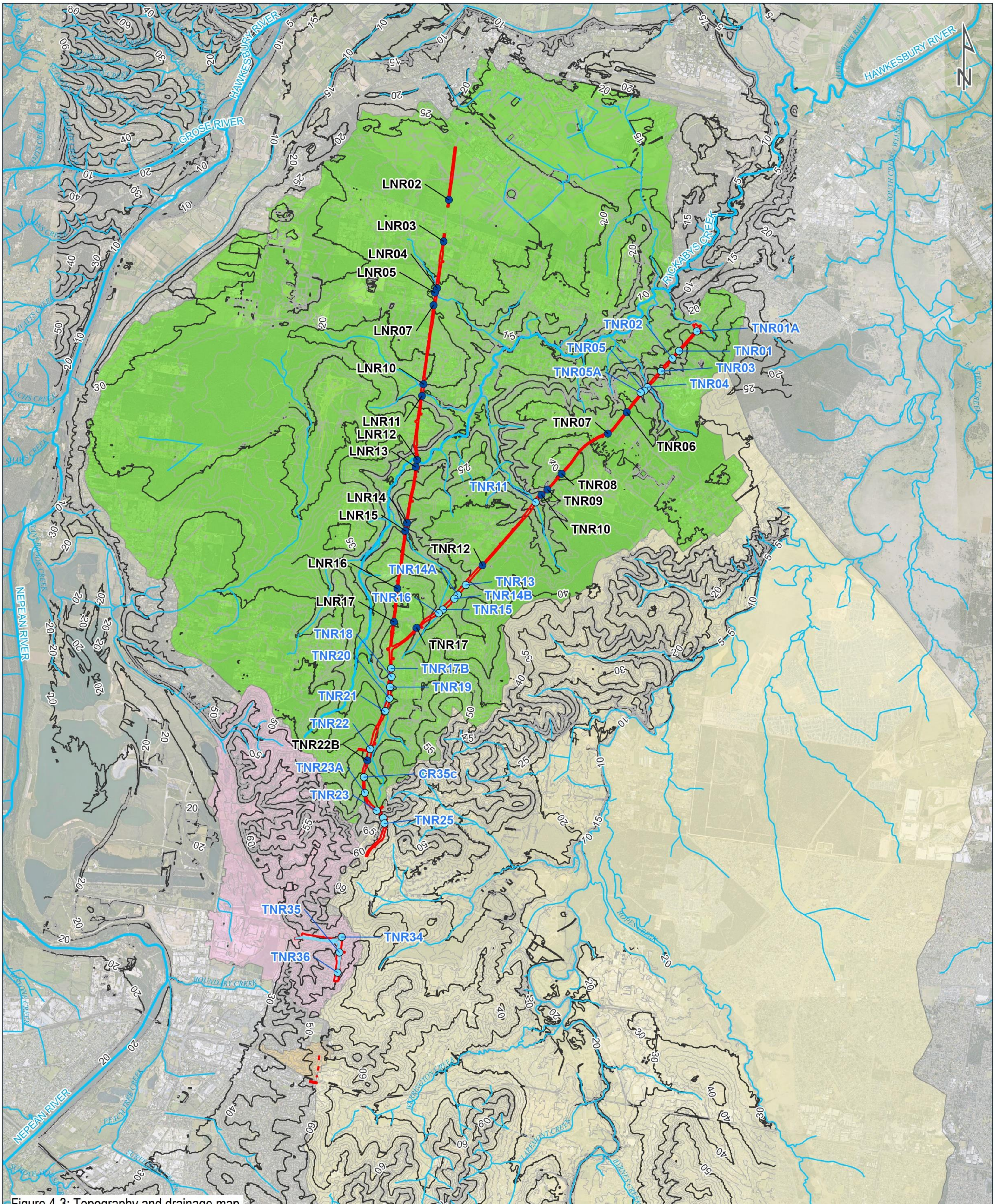
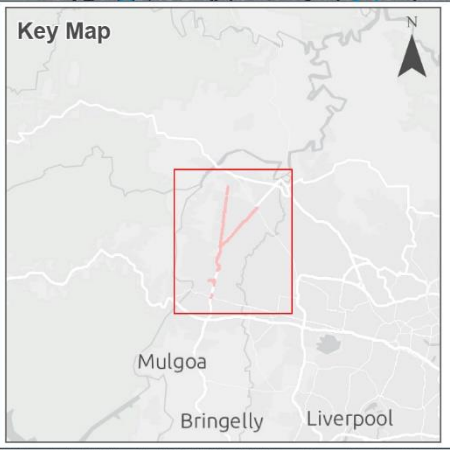



Figure 4-3: Topography and drainage map




**LEGEND**

- Study Area
- Contour (1m)
- Contour (5m)
- Rickabys Creek Catchment
- South Creek Catchment
- Penrith Lakes Catchment
- Peachtree Creek Catchment
- Drainage Improvements
- Culvert Extensions due to Shoulder Widening
- Drainage Improvements

0 500 1000 1500 2000 2500 3000

Metres

**Scale:** 1:60,000 **CRS:** GDA2020 MGA Zone 56

**SOURCES:**

1. Roadnet MDS 2020
2. Transport and Water Theme © NSW Department of Finance and Services
3. MetroMap Imagery © Aerometrex Pty Ltd
4. Basemap: Light Gray Reference: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS

Light Gray Base: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS





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| **PROJECT:** | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| **PROJECT NO:** | 30013443 |
| **FIGURE NO:** | 4-3 |
| **FIGURE TITLE:** | Topography, Drainage and Catchment |
| **CREATED BY:** | FA13847 |
| **DATE:** | 11/06/2024 |
| **VERSION:** | VERSION 4 |
| **PAGE SIZE:** | A3 |

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## 4.5 Soil landscapes

The *Soil Landscapes of the Penrith 1:100,000 Sheet* (Bannerman and Hazelton, 2011) indicates that the study area is underlain by the Berkshire Park, South Creek, Luddenham and Disturbed Terrain soil landscapes, as presented in Figure 4–4.

The dominant soil landscape across the proposal alignment is the Berkshire Park alluvial soil landscape unit. This landscape comprises gently undulating low rises on the Tertiary alluvial terraces of the Hawkesbury-Nepean River system that have been dissected by present day drainage channels. The soils within this landscape are the result of multiple depositional phases of alluvial/colluvial origin, including the Londonderry Clay and Rickabys Creek Gravel formations, and comprise heavy clays and clayey sands with frequent ironstone nodules. The soils have very high wind erosion potential if stripped of vegetation, and surface water erosion can also occur in exposed areas.

Within the central part of the alignment, fluvial soils of the South Creek soil landscape are located along the creek channels and drainage depressions of Rickabys Creek. These soils comprise deep layered sediments overlying bedrock or relict soils and leached clays (residual soil) deposited along the active drainage lines of the Cumberland Plain which flow north-easterly across the proposal. The limitations of this soil landscape include erosion and frequent flooding.

The southern part of the alignment is characterised by erosional soils of the Luddenham soil landscape, typically comprising moderately reactive and highly plastic clays derived from weathering of the Bringelly Shale formation. Soil depths are generally shallow on the top of crests and ridgelines, with deeper soil profiles found in valleys and drainage lines. Development limitations include high erosion and localised mass movement hazards coupled with highly plastic, impermeable and potentially dispersive soils that exhibit shrink-swell potential.

An area between The Northern Road and Llandilo Road is mapped as the Disturbed Terrain soil landscape, which is associated with the former Castlereagh Waste Management Centre. This area is a closed landfill undergoing rehabilitation works that include acceptance of clean fill for recontouring and tree planting. The soils within this landscape comprise artificial fill that may include demolition rubble, industrial and household waste.

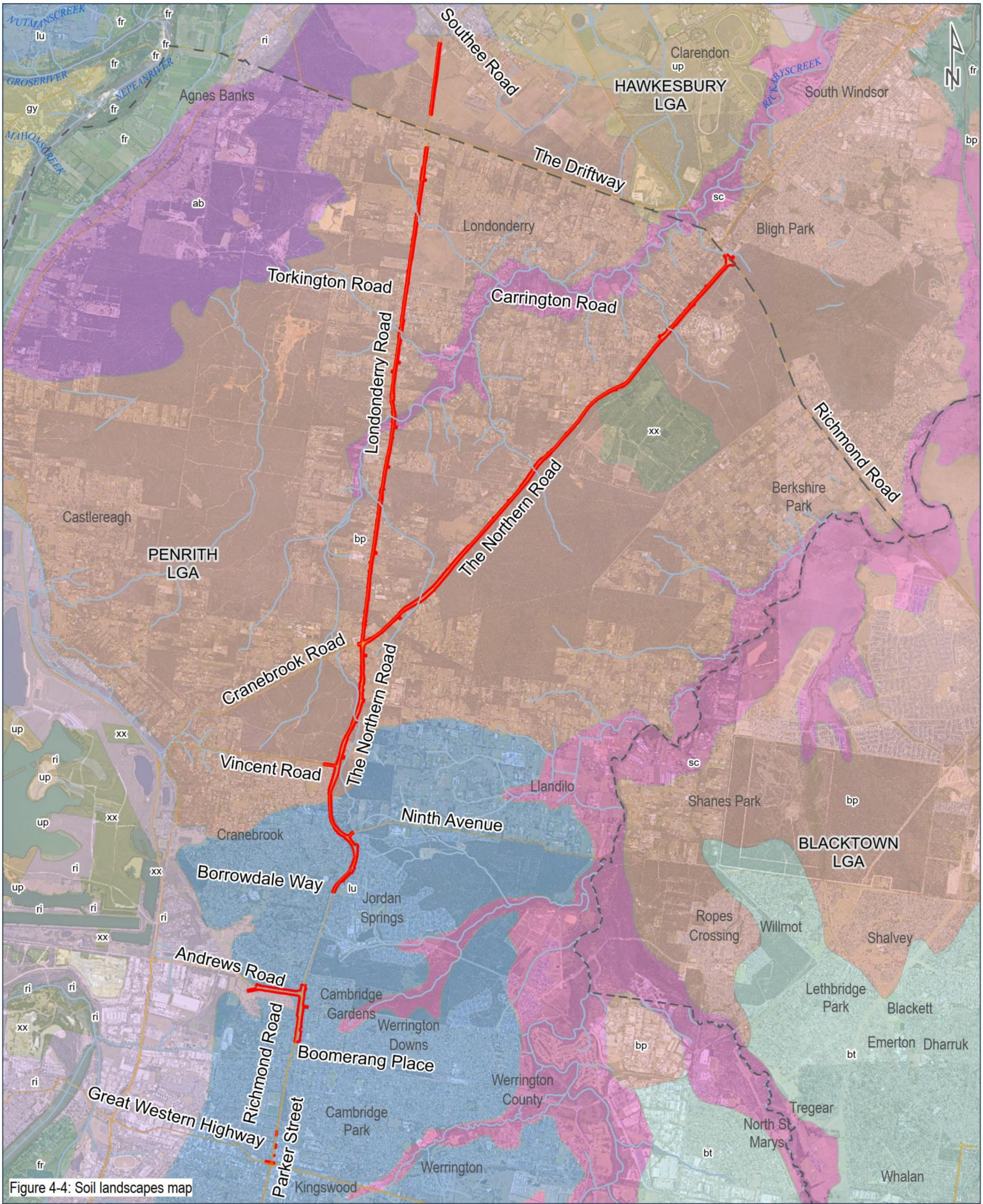
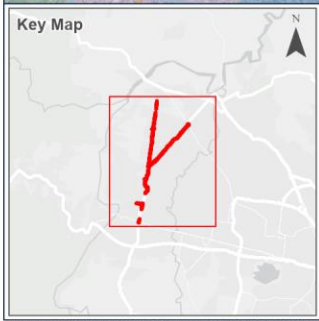



Figure 4-4: Soil landscapes map




**LEGEND**

- Study Area
- Local Government Areas
- Roads
- Watercourses

**Soil Landscapes**

- Agnes Banks (ab)
- Berkshire Park (bp)
- Blacktown (bt)
- Disturbed Terrain (xx)
- Freemans Reach (fr)
- Gymea (gy)
- Luddenham (lu)
- Richmond (ri)
- South Creek (sc)
- Upper Castlereagh (up)

0 700 1400 2100 2800
Metres

Scale: 1:70,000 CRS: GDA2020 MGA Zone 56

SOURCES:
1. Roadnet MDS 2020
2. Soil landscape © State Government of NSW and NSW Department of Climate Change, Energy, the Environment and Water 2024
3. Basemap © Light Gray Base: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGSMetroMap Imagery © Aerometrex Pty Ltd



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| PROJECT: | Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements State Roads |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 4-4 |
| FIGURE TITLE: | Soil Landscape |
| CREATED BY: | FA13847 |
| DATE: | 6/06/2024 |
| VERSION: | VERSION 1 |
| PAGE SIZE: | A4 |

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### 4.5.1 Soil salinity

Salinity outbreaks are most common on lower slopes and drainage systems where salt concentrations develop due to the presence of shallow groundwater or poorly drained clayey soils which have the potential to become waterlogged.

Figure 4–5 shows the salinity potential within the study area, as informed by the *Salinity Potential in Western Sydney Map* (DIPNR, 2003). This illustrates the distribution and potential for surface soil salinity based on areas of known salinity and the contributing factors, including soil landscapes, geology, topography and groundwater conditions.

Localised areas of high salinity potential are shown at creek crossings and drainage lines, typically underlain by Quaternary Alluvium associated with the tributaries of Rickabys Creek. The study area is dominated by soils with moderate salinity potential due to their elevated position in the landscape.

The Geotechnical Factual Report (TfNSW, 2023) documents the laboratory soil salinity testing performed on eight samples obtained during the concept design investigations. The results indicate that the soils tested range from non-saline (five samples) to moderately saline (three samples). Laboratory testing of soil aggressivity to in-ground structures was undertaken on the eight samples. The results indicate that the soil conditions are typically 'mild' to 'non-aggressive' for buried concrete and steel structures.

### 4.5.2 Acid sulphate soils

Acid Sulfate Soils (ASS) are naturally occurring soil and sediment, distinguished from other soil or sediment materials by having properties and behaviour that have either been affected by the oxidation of Reduced Inorganic Sulfur (RIS) (principally the mineral iron pyrite), or the capacity to be affected considerably by the oxidation of their RIS constituents.

The factor common to all ASS is that RIS components have either had, or may have, a major influence on the properties or behaviour of these soil materials. These soils are typically found in low-lying coastal areas and saline inland areas. However, they have been found in a wide range of environmental settings (Sullivan et al., 2018).

Coastal ASS are generally found on land with elevation less than 5 mAHD (Sullivan et al, 2018). These conditions are typical of marine or estuarine sediments of the recent Quaternary aged sediments which are deposited in low-lying areas (typically below elevations of 5 mAHD) of coastal floodplains, rivers and creeks. Figure 4–6 indicates the probability of ASS occurring, as informed by the *CSIRO Atlas of Australian Acid Sulfate Soils map* (Fitzpatrick et al., 2011) and shows for the proposal the area is indicated as an extremely low (1 % to 5 %) to low (6 % to 70 %) probability of ASS occurrence for an inland landscape.

A technical memorandum (SMEC, 2023b) on occurrence of ASS within the study area is provided in Appendix A. The technical memo may be summarised as follows:

- Review of coastal ASS risk mapping available online (NSW Government eSPADE v2.2) indicates the study area is outside areas of known coastal ASS occurrence, therefore in areas of 'no known occurrence'.
- Review of the National Acid Sulfate Soil Atlas (ASRIS) indicates the majority of the study area is mapped as 'Extremely Low Probability' with a portion in the north mapped as 'Low Probability'. The area is indicated as an extremely low (1 % to 5 %) to low (6 % to 70 %) probability of ASS occurrence for an inland landscape.
- Review of topographic information sourced from NSW Spatial Services dataset (accessed through MinView) indicates that the surface elevations within the study area range from approximately 19 mAHD to 60 mAHD.

The technical memo concluded that the likelihood for ASS to be present within shallow soils that may be disturbed by the proposal is considered to be low, in particular due to the elevation of the study area.

ASS has the potential to be present at higher elevations inland and can be associated with saline environments. The presence of Quaternary age sediments along the Rickabys Creek catchment and associated tributaries does not preclude ASS occurring within the study area if the conditions for formation of RIS were favourable.

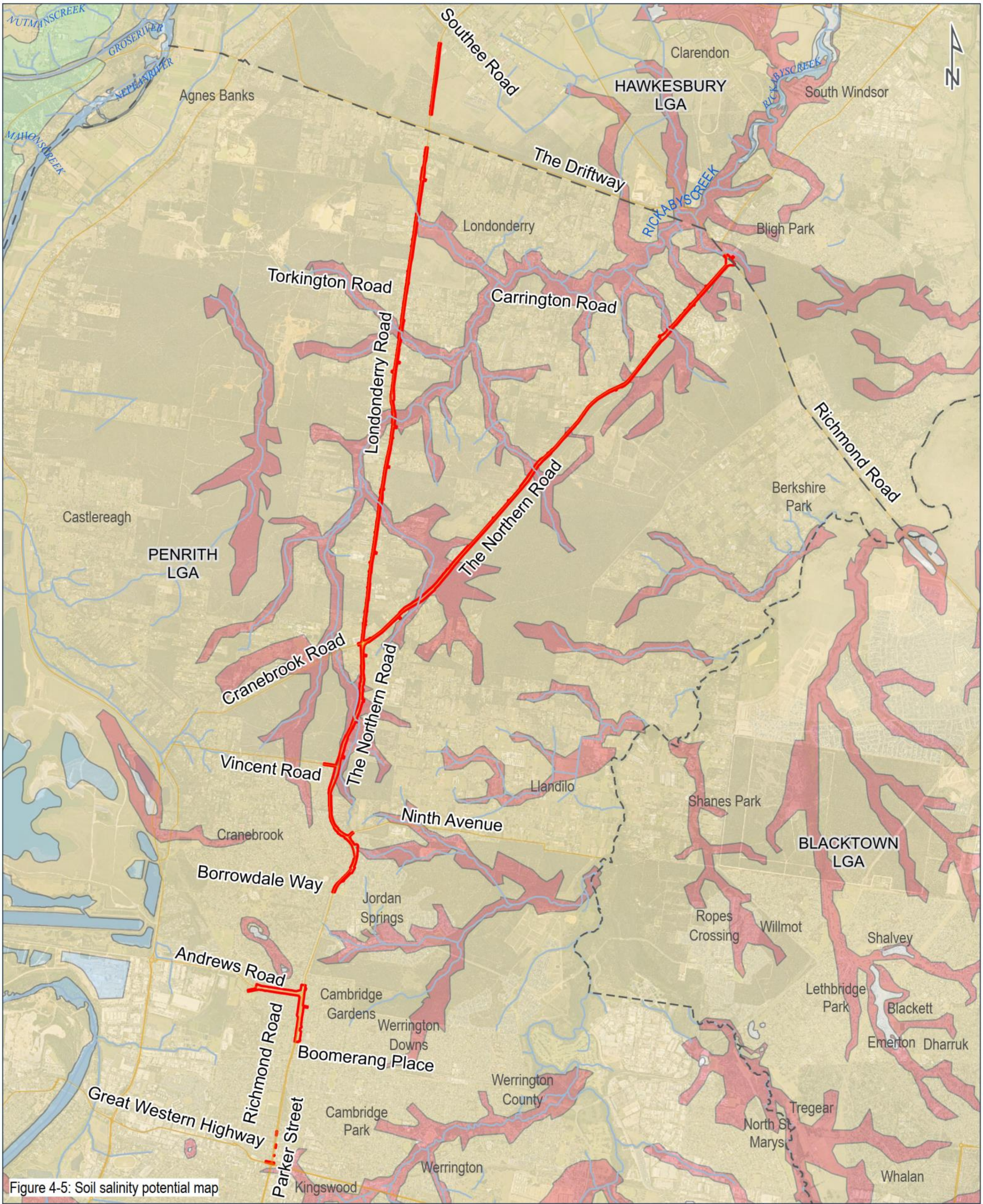
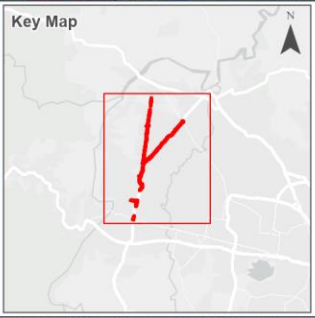



Figure 4-5: Soil salinity potential map

Key Map



**LEGEND**

- Study Area
- Local Government Areas
- Roads
- Watercourses

**Soil Potential of Western Sydney**

- Low
- Moderate
- High
- Known Salinity
- Water

0 700 1400 2100 2800

Metres

Scale: 1:70,000 CRS: GDA2020 MGA Zone 56

SOURCES:

1. Roadnet MDS 2020
2. Salinity Potential of Western Sydney © State Government of NSW and NSW Department of Climate Change, Energy, the Environment and Water 2002
3. Basemap © Light Gray Base: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGSMetroMap Imagery © Aerometrex Pty Ltd



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| PROJECT NO: | 30013443 |
| FIGURE NO: | 4-5 |
| FIGURE TITLE: | Salinity Potential of Western Sydney |
| CREATED BY: | FA13847 |
| DATE: | 6/06/2024 |
| VERSION: | VERSION 1 |
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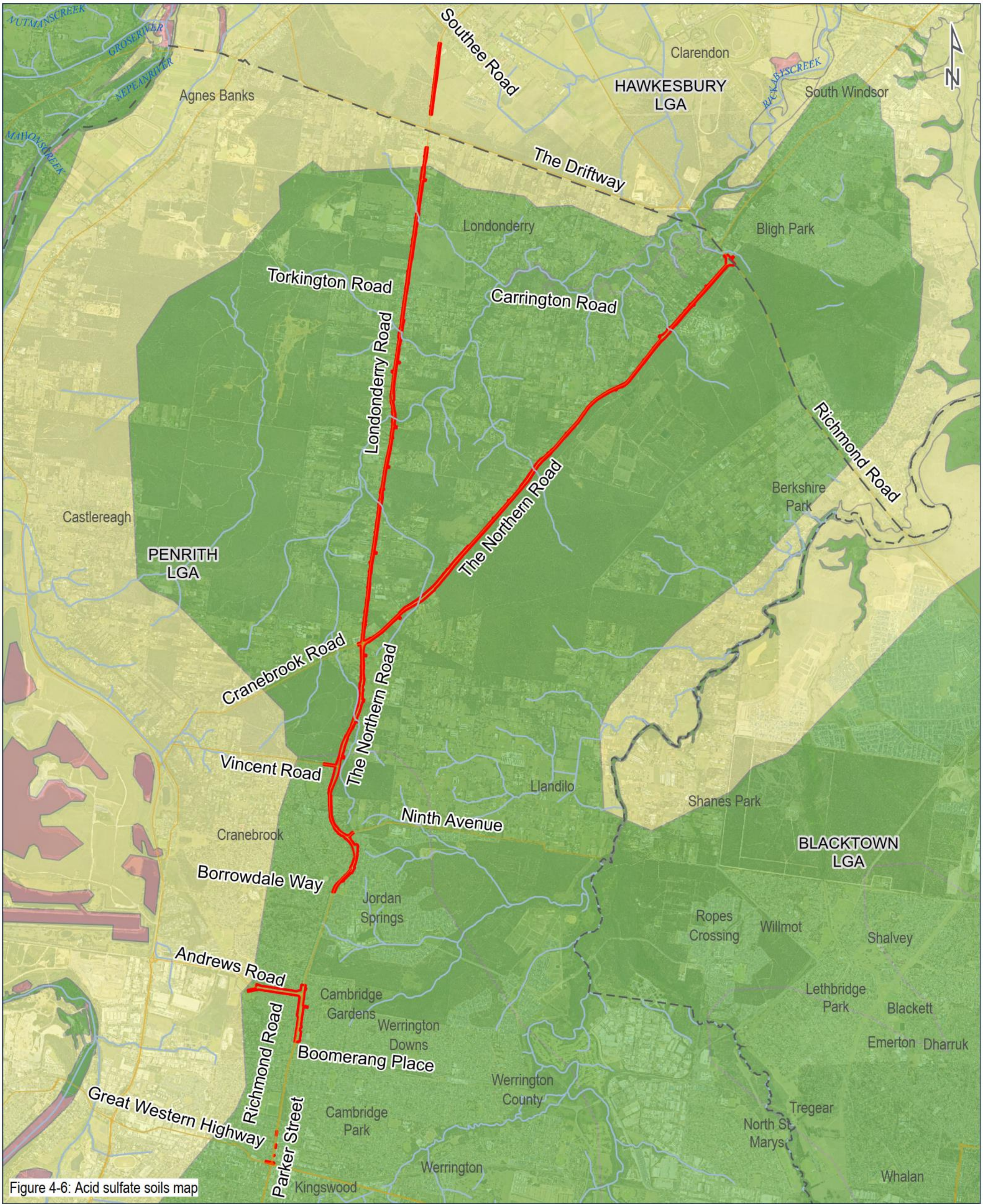
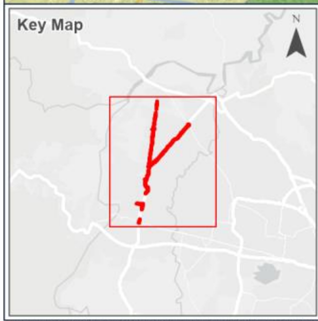



Figure 4-6: Acid sulfate soils map




**LEGEND**

- Study Area
- Local Government Areas
- Roads
- Watercourses

**Acid Sulfate Soils**

- High Probability (>70%)
- Low Probability (6-70%)
- Extremely Low Probability (1-5%)

0 700 1400 2100 2800
Metres

**Scale:** 1:70,000 **CRS:** GDA2020 MGA Zone 56

**SOURCES:**
1. Roadnet MDS 2020
2. Fitzpatrick, Rob; Powell, Bernie; Marvanek, Steve (2011): Atlas of Australian Acid Sulphate Soils. v2. CSIRO.
3. Basemap © Light Gray Base: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGSMetroMap Imagery © Aerometrex Pty Ltd



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|---|---|
| PROJECT: | Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements State Roads |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 4-6 |
| FIGURE TITLE: | Acid Sulfate Soils |
| CREATED BY: | FA13847 |
| DATE: | 6/06/2024 |
| VERSION: | VERSION 1 |
| PAGE SIZE: | A4 |

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The Geotechnical Factual Report (TfNSW, 2023) documents preliminary laboratory screening for ASS conducted during the site investigations of targeted lower lying areas adjacent to natural drainage depressions and watercourses. Seven samples were collected across three boreholes at various depths, from 0.1 metres below ground level (mbgl) to 4.5 mbgl. The results were compared with assessment guidelines sourced from the Acid Sulfate Soil Manual (Stone et al., 1998).

The field peroxide ($pH_{FOX}$) readings were typically greater than 5 which indicates the absence of oxidized sulfates and little net acid generating ability, and therefore potential ASS was not present. Two samples from BH06 and BH09, both at 2.5mbgl, returned $pH_{FOX}$ values between 3 and 4, which indicates that sulfidic material may be present. Stone et al. (1998) note that the field peroxide test is most useful for clays containing low levels of organic matter and may not be as suitable on sands or gravels and this may be reflected in the results.

## 4.6 Naturally occurring asbestos

Review of the Department of Regional New South Wales Naturally Occurring Asbestos dataset shows the study area is not in an area known to have naturally occurring asbestos.

## 4.7 Surface water features

The study area interacts with four main surface water catchments (see Section 4.3), however, most of the proposal is within the Rickabys Creek catchment. There are numerous unnamed drainage lines and tributaries associated with Rickabys Creek, and the proposal directly crosses Rickabys Creek (see Figure 4–3) on Londonderry Road. Information on the existing surface water quality for Rickabys Creek within study area and its tributaries is limited. In February 2024 limited field water quality probe measurements were taken in Rickabys Creek on both sides of the crossing underneath Londonderry Road as part of the site investigations for the Biodiversity Assessment Report (SMEC, 2023c) for the proposal.

The results show:

- pH in the range of 6.27 to 6.36
- Electrical conductivity around 1200 µS/cm
- Temperature around 22°C, and
- Dissolved oxygen around 4.3 to 4.8 ppm.

A small part of the southern area of the proposal may interact with drainage lines within the South Creek catchment. Some monitoring has been undertaken within the Wianamatta-South Creek catchment (Cruz et al., 2021) which included two locations in South Creek. The 80$^{th}$ percentiles of selected water quality measurements, which are from the least disturbed areas of the catchment, are outlined in Table 4–4 with the default ANZECC (2000) guideline for lowland rivers and the ambient water quality objective.

Table 4–4: 80$^{th}$ percentile water quality measurements from South Creek and water quality objectives for Wianamatta-South Creek Catchment

| Parameter | South Creek Site NS26 | South Creek Site NS23 | ANZECC (2000) | Water Quality Objective |
|---|---|---|---|---|
| Total Nitrogen (mg/L) | 1.72 | 9.04 | 0.5 | 1.72 |
| Dissolved Inorganic Nitrogen (mg/L | 0.74 | 7.57 | No Criteria | 0.74 |
| Ammonia (mg/L) | 0.08 | 0.11 | 0.02 | 0.08 |
| Oxides of Nitrogen (mg/L) | 0.66 | 7.46 | 0.04 | 0.66 |
| Total Phosphorous | 0.14 | 0.29 | 0.05 | 0.14 |
| Dissolved Inorganic Phosphorus (mg/L) | 0.04 | 0.25 | No Criteria | 0.04 |
| Turbidity (NTU) | 50 | 35 | 50 | 50 |
| Total Suspended Solids (mg/L) | 37 | 20 | No Criteria | 37 |

| Parameter | South Creek Site NS26 | South Creek Site NS23 | ANZECC (2000) | Water Quality Objective |
|---|---|---|---|---|
| Conductivity (µS/cm) | 1103 | 897 | 2200 | 1103 |
| pH | 7.16 to 7.60 | 7.19 to 7.69 | 6.5 to 8 | 6.20 to 7.60 |
| Dissolved Oxygen (%) | 43 to 75 | 64 to 90 | 85 to 110 | 43 to 75 |

# 4.8 Regional geology

The *NSW Seamless Geology dataset* (Colquhoun et al., 2023) indicates that the study area is dominated by Quaternary and mid to late Tertiary aged alluvial deposits including the Londonderry Clay and Rickabys Creek Gravel. These unconsolidated sediments overlie the Permio-Traissic aged bedrock of the Bringelly Shale of the Wianamatta Group. Refer to Figure 4–7 for a map of the regional geology.

## 4.8.1 Alluvial sediments

Quaternary and mid to late Tertiary aged deposits, mainly of alluvial origin, occur in the Cumberland Basin associated with the Hawkesbury-Nepean River system. These soils have varying stratigraphic descriptions as listed in Table 4–5.

More recent Quaternary alluvial sediments have been deposited along drainage lines associated with the tributaries of Rickabys Creek. The older alluvial sediments were formed on an elevated terrace deposited within the Hawkesbury and Nepean River floodplains.

Table 4–5: Alluvium stratigraphy

| Geology Code | Period | Name | Stratigraphy description |
|---|---|---|---|
| Q_af | Quaternary | Alluvial floodplain deposits | Silt, very fine- to medium-grained lithic to quartz-rich sand, clay |
| CZ_a | Tertiary | Alluvium | Unconsolidated alluvial clay, silt, sand, and gravel deposits |
| CZ_ath | Tertiary | Alluvial terrace deposits – high-stand facies | High-level terrace deposits of sand and gravel |
| NM_d | Tertiary | Londonderry Clay | Clay with patches of ferruginised, consolidated sand |
| NM_i | Tertiary | Rickabys Creek Gravel | Conglomerate, matrix-supported |

The following key Tertiary aged alluvial lithologies are described by Jones and Clark (1991):

- Londonderry Clay forms the upper part of the Tertiary alluvial sequence, occurring as a relatively continuous sheet between 1 m and 9 m thick. The unit primarily consists of a moderately to highly plastic, relatively impervious clay, with sand lenses, iron-cemented sand-clay aggregates and abundant ironstone nodules.
- Rickabys Creek Gravel is the basal unit of the terrace formation varying in thickness from 2 m to 12 m and is exposed on the banks of Rickabys Creek where the overlying Londonderry Clay has been eroded. The gravel is poorly sorted and set in a sandy clay matrix, with clasts of sedimentary and igneous origin ranging in size from pebbles to cobbles up to 0.5 m. Sand lenses occur sporadically, along with clay cemented by iron oxides. In the Londonderry area, the gravel clasts generally make up 30 % of the unit followed by sand (40 %) and clay (30 %).

## 4.8.2 Bringelly Shale

The Bringelly Shale formation is the uppermost member of the Wianamatta Group sedimentary sequence within the Sydney Basin. It comprises shale, carbonaceous claystone, claystone, laminite, lithic sandstone, trace coal and tuff. Near-surface sections of the subsurface profile are weathered to residual clayey soil which typically exhibit the following characteristic material properties:

- Moisture sensitive – high potential for expansive behaviour and shrink-swell volume changes, and
- Weakly cemented – susceptible to breakdown and potentially erodible/dispersive.

The proposal is not anticipated to intersect the bedrock of the Bringelly Shale.

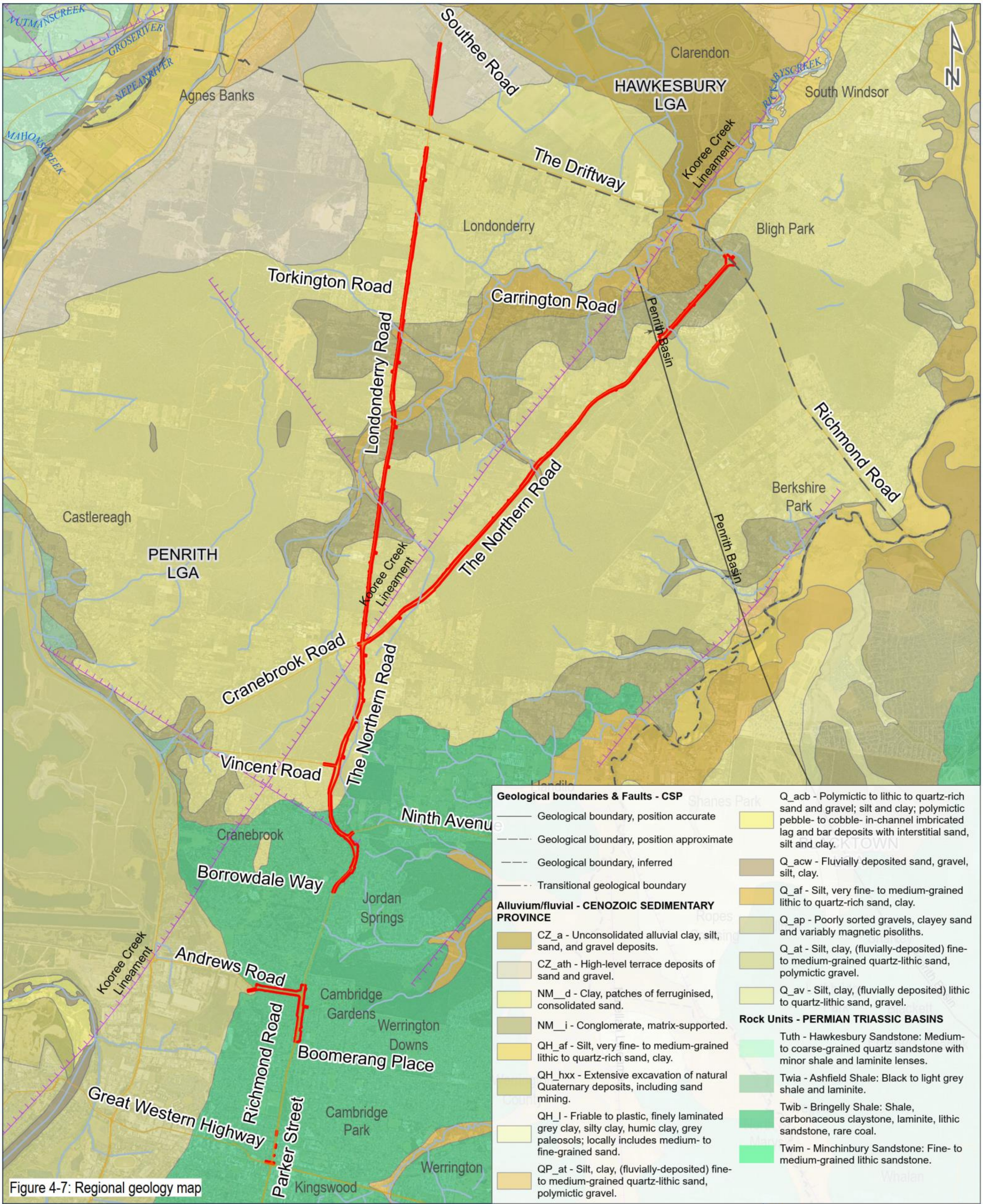
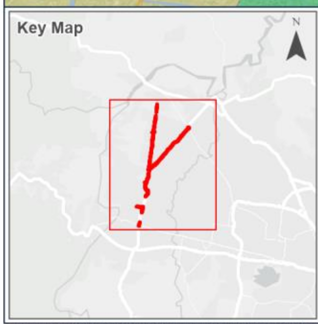



Figure 4-7: Regional geology map




**LEGEND**

- Study Area
- Local Government Areas
- Roads
- Watercourses

0 700 1400 2100 2800
Metres

Scale: 1:70,000 CRS: GDA2020 MGA Zone 56

SOURCES:
1. Roadnet MDS 2020
2. Soil landscape © State Government of NSW and NSW Department of Climate Change, Energy, the Environment and Water 2024
3. Basemap © Light Gray Base: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGSMetroMap Imagery © Aerometrex Pty Ltd



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| PROJECT: | Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements State Roads |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 4-7 |
| FIGURE TITLE: | Regional Geology |
| CREATED BY: | FA13847 |
| DATE: | 6/06/2024 |
| VERSION: | VERSION 1 |
| PAGE SIZE: | A4 |

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### 4.8.3 Structural geology

The study area is located within the Cumberland Basin, as shown on the *Penrith 1:100,000 Geological Sheet* (Clark and Jones, 1991), and is structurally controlled and influenced by the Lapstone Structural Complex at the western edge of the Basin. The Kooree Creek Lineament passes through the study area, shown as a north-easterly trending deflection of South Creek which is situated to the east of the project extent. The lineament runs sub-parallel to Rickabys Creek and may be the structural control of the creek alignment.

## 4.9 Hydrogeology

Hydrogeological conditions and groundwater levels along the study area are expected to vary based on topography, ground conditions and proximity to watercourses/drainage features. Groundwater is expected to be encountered at shallow depth within the low-lying alluvial deposits, and within weathered bedrock at higher elevations. With reference to observations on landforms and geological units across the site, the following hydrogeological conditions are anticipated:

- Shallow groundwater tables can be expected at lower lying creek channels and recent alluvial deposits
- Shallow rainfall dependent, transient seepage or perched groundwater in areas of residual soils and within the weathered Bringelly Shale bedrock profile, and
- Deeper regional groundwater table within the Bringelly Shale and Hawkesbury Sandstone bedrock, occurring below the base of weathering.

### 4.9.1 Recharge/discharge

Recharge to the groundwater system in the vicinity of the proposal is dominated by rainfall infiltration. Minor recharge may occur through irrigation from surface water and groundwater sources and infiltration from drainage lines and creeks during periods of high flow.

The study area is within a groundwater discharge area. Discharge from the groundwater system is likely to be dominated by evapotranspiration followed by discharge to drainage lines and creeks and groundwater pumping. Discharge to drainage lines and creeks is known to bring salts (from the Wianamatta Group Bringelly Shale) to the surface, which are evident at the break of slope, and influence the water quality of ephemeral creeks and drainage lines.

### 4.9.1 Groundwater flow and gradients

The topography is generally low-lying and flat with the existing ground surface elevation ranging between 20 mAHD and 40 mAHD. Groundwater flows from areas of higher elevation towards the north-east trending Rickabys Creek and its various tributaries. The groundwater gradients are in the range of 0.0005 to 0.001. Groundwater underlying the alluvial soils in the Bringelly Shales is anticipated to follow the same general pattern of flow towards points of discharge along drainage lines, creeks and rivers.

### 4.9.2 Regional hydrogeology and conceptual model

An overview of the regional hydrogeological processes in the project area is presented in *Hydrogeological Landscapes for the Hawkesbury-Nepean Catchment Management Authority* (Nicholson et al., 2011), which makes the following observations to describe the characteristics of the following Hydrogeological Landscapes (HGL):

- Most of the study area is located within the Londonderry HGL, which typically includes saline regional groundwater systems that flow through the Wianamatta Group shales that underlie alluvial deposits. Salt sites within this HGL are typically associated with the Quaternary deposits of current day drainage lines, as illustrated on Figure 4–8. This is attributed to two possible flow paths:
  - the movement of saline groundwater along the Rickabys Creek Gravels, expressing on the edges of the alluvial channel of Rickabys Creek, and/or
  - possible upwelling of saline groundwater flows where groundwater meets the Kooree Creek Lineament. The Londonderry Clay formation and other thick alluvial deposits impede the rise of groundwater stored over most of the HGL, preventing a larger area being affected by salts stored within the groundwater.

The southern extent of the study area is associated with the Upper South Creek HGL. Water predominantly moves laterally though shale layers (although vertical movement through fracturing does occur) and vertically through interbedded sandstone. The water table is typically intermediate in depth but local and seasonal perching above clay-rich layers can be expected along with flow through unconsolidated alluvial sediments.

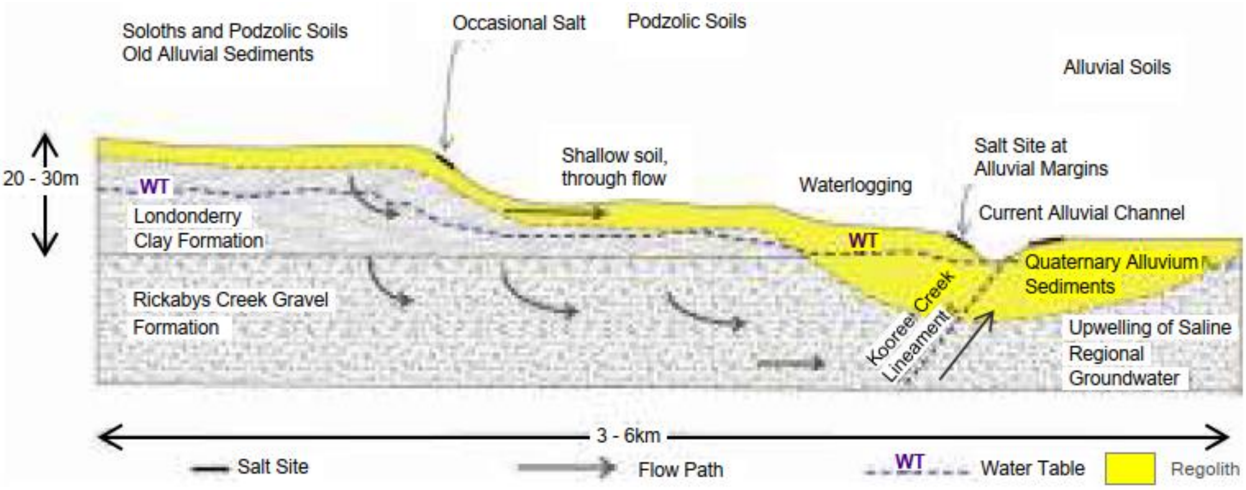


Figure 4–8: Conceptual sketch of the Londonderry Hydrogeological Landscape (Nicholson et al., 2011)

### 4.9.3 Registered groundwater users

The registered bores within two kilometres radius of the proposal boundary are presented on Figure 4–9. A 2 km radius from the study area is considered reasonable for this assessment. There are a total of 195 registered bores in the area. Details regarding bore type, registered status and depth range are summarised in Table 4–6. Most of the registered bores are classed for monitoring. Monitoring may include Water NSW dedicated long term monitoring locations or site-specific short-term monitoring such as for geotechnical or environmental applications. Monitoring bores are generally not considered for assessments of beneficial use and groundwater users. There are 41 bores registered as water supply, and four bores registered for Stock and Domestic use. The number of irrigation, commercial and industrial and other/unknown use bores are low. There is one listed as a dewatering bore and one bore listed for exploration.

The registered bores range in depth from 2.2 m to 270 m. The reported bore depth within each use category is variable, with the exception of the monitoring bores, and likely reflects the different aquifers of water take (i.e. alluvial sources compared to fractured rock). Monitoring bores are typically shallow, ranging from 2.2 m to 45 m, although one reported to be 198 m deep. In general, the bores in the area are screened in either the alluvium sediments, shallow Bringelly Shale or the deeper more potable Hawkesbury Sandstone aquifers.

Table 4–6: Summary of registered bores identified within 2km of the proposal boundary (WaterNSW, 2024)

| Bore use | Number | Depth Range (m) | Status | | |
|---|---|---|---|---|---|
| | | | Abandoned | Functioning/in use | Unknown |
| Commercial / Industrial | 2 | 13 and 120 | | | 2 |
| Dewatering | 1 | 250 | | 1 | |
| Exploration | 1 | 15.4 | | 1 | |
| Irrigation | 15 | 4.3 to 210 | 1 | 6 | 8 |
| Monitoring | 118 | 2.2 to 45 (198) | 1 | 56 | 61 |
| Stock and Domestic | 4 | 18.3 to 240 | | 2 | 2 |
| Water supply | 41 | 7.6 to 270 | | 27 | 14 |
| Other or Unknown | 13 | 7 to 210 | | 3 | 10 |

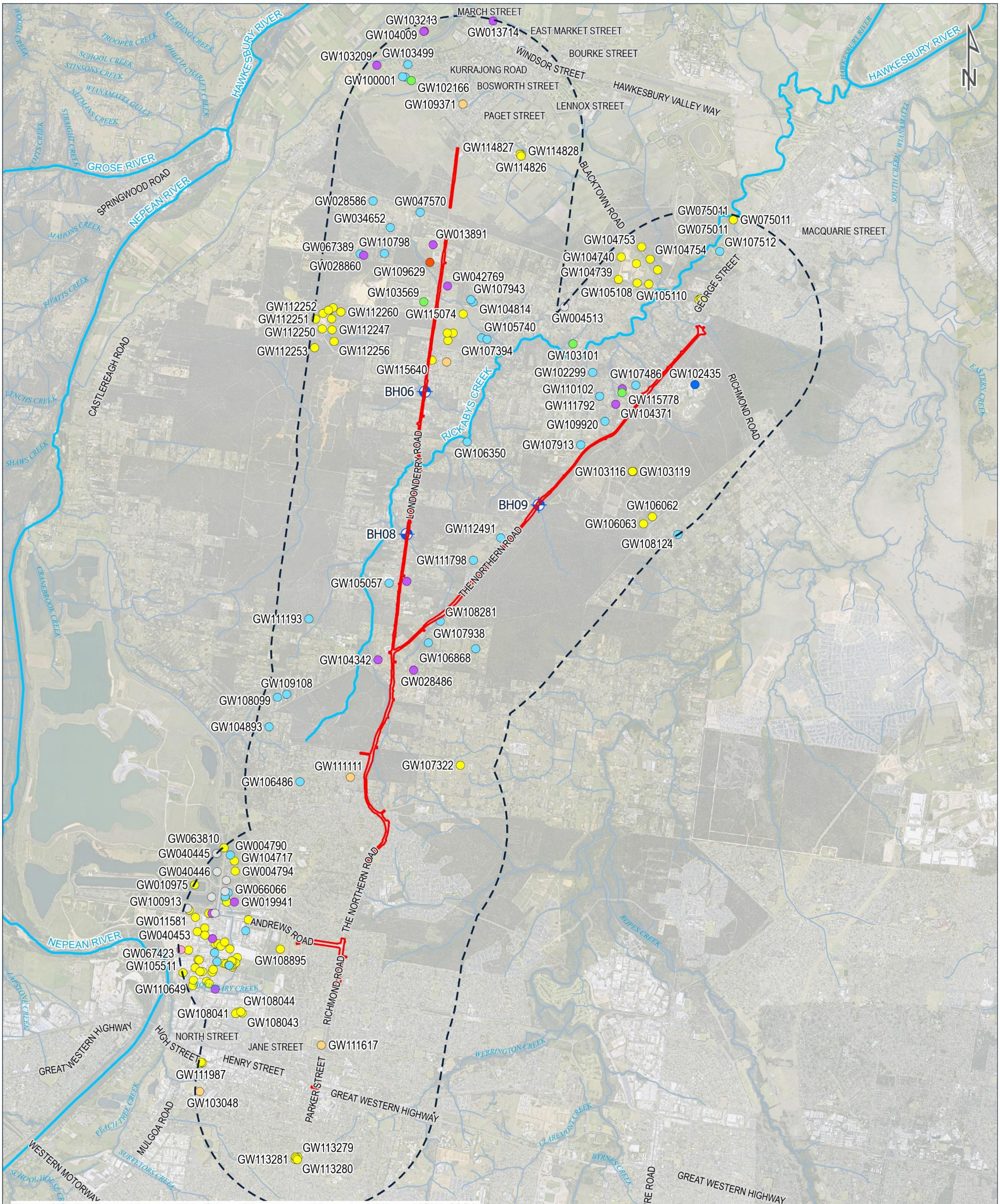


Figure 4-9: Registered bores within 2 km of the proposal boundary (Water NSW, 2024)

**Key Map**


**LEGEND**

- Study Area
- Buffer (2km)
- Borehole with Piezometer

**Bore Location Purpose**

- Monitoring
- Water Supply
- Dewatering
- Commercial and Industrial
- Exploration
- Irrigation
- Stock and Domestic
- Other
- Unknown

0 500 1000 1500 2000 2500 3000
Metres

**Scale:** 1:60,000 **CRS:** GDA2020 MGA Zone 56

**SOURCES:**
1. Roadnet MDS 2020
2. Transport and Water Theme © NSW Department of Finance and Services
3. MetroMap Imagery © Aerometrex Pty Ltd
4. Bore Data © WaterNSW
5. Basemap: Light Gray Reference: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS
Light Gray Base: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS



Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, this map contains data from a number of sources - no warranty is given that the information contained on this is free from error or omission. Any reliance placed on such information shall be at the sole risk of the user. Please verify the accuracy of all information prior to using it. This map is not a design document.

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| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 4-9 |
| FIGURE TITLE: | Registered Bores |
| CREATED BY: | FA13847 |
| DATE: | 28/06/2024 |
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### 4.9.4 Groundwater level

Existing registered bores show the depth to groundwater is variable and ranges from just below ground surface to greater than 100 metres below ground level (mbgl), depending on the aquifer. The deeper drainage lines, particularly Rickabys Creek, likely reflect the groundwater table being the discharge point. Rickabys Creek is incised by 2 m below its local floodplain and in places more than 10 m in broader area. Groundwater levels near Rickabys Creek are likely to reflect the water level in the creek.

Recent geotechnical investigations within the study area, undertaken in February 2023 indicate groundwater seepage was not typically encountered within test pit excavations undertaken within the residual soil and weathered rock profile. Borehole investigations completed within the Rickabys Creek catchment between February 2023 and May 2023 noted groundwater levels between 2 mbgl and 4mbgl during drilling operations within the Quaternary aged alluvial material. It is noted however that the introduction of water to facilitate the drilling methods, including coring, may mask the true groundwater level as further observation of seepage flows and levels, as drilling progresses, are precluded.

Water levels may fluctuate with seasonal rainfall trends and seepage or perched groundwater may be encountered within shallow excavations. Three shallow groundwater monitoring bores were installed in geotechnical boreholes located within the study area with monitoring results available for the period between April 2023 and February 2024 (Figure 4–10 to Figure 4–12). Groundwater observations from these monitoring bores show the depth to groundwater ranges from 2 mbgl to 8 mbgl and there appears limited response to rainfall events. The water levels show a general decline over the monitoring period and likely reflect the below average rainfall climatic conditions.

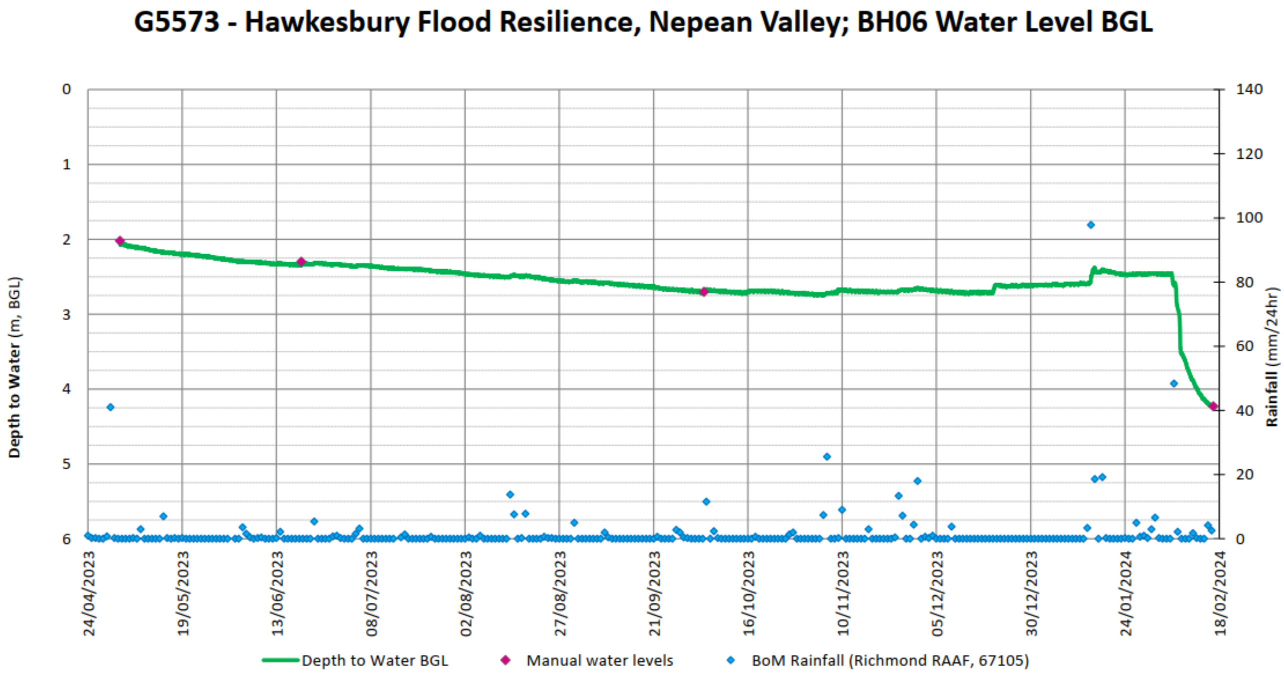


Figure 4–10: Groundwater hydrograph with daily rainfall for BH06, source TfNSW

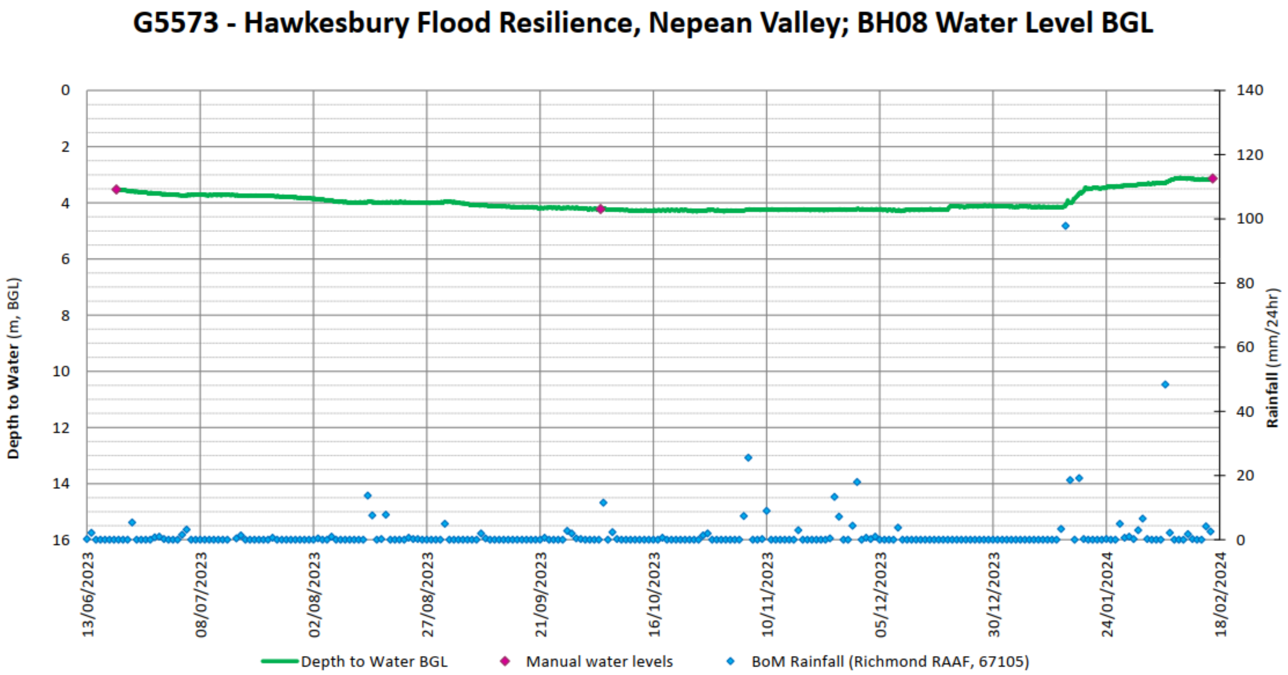


Figure 4–11: Groundwater hydrograph with daily rainfall for BH08, source TfNSW

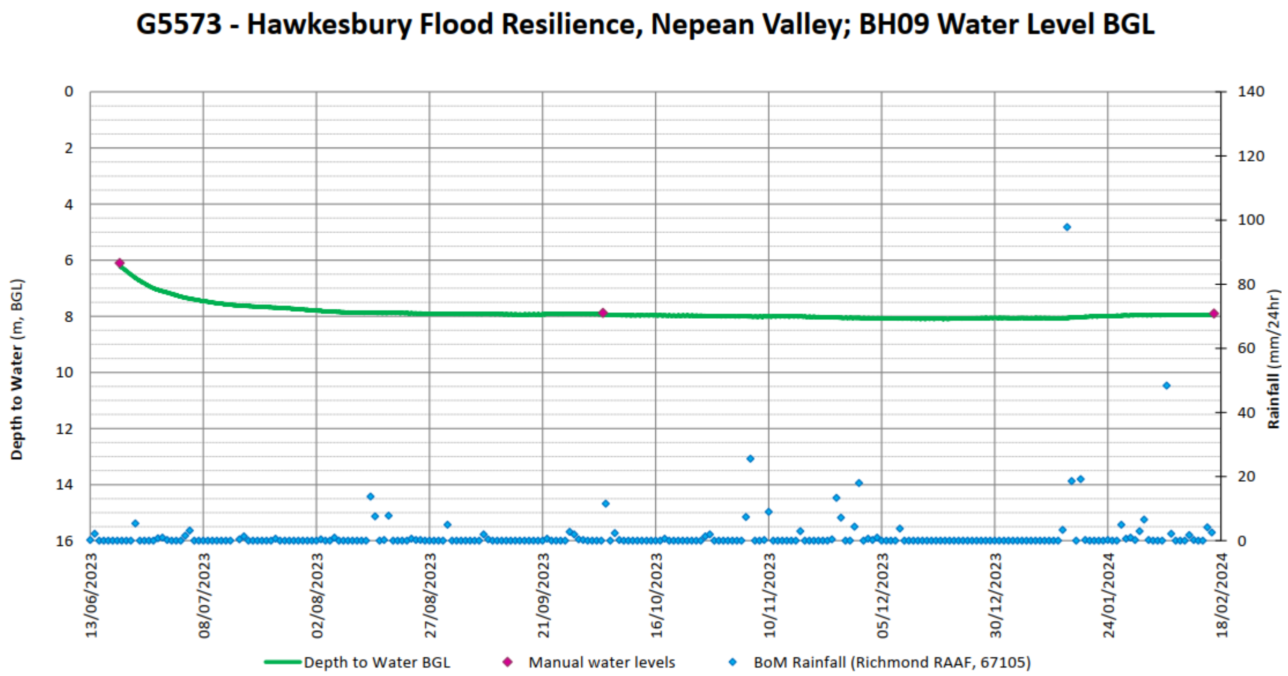


Figure 4–12: Groundwater hydrograph with daily rainfall for BH09, source TfNSW

BH06, located near a tributary of Rickabys Creek, shows a sudden decline in water level in February 2024 which may be related to nearby local activities (i.e. groundwater extraction) and the prevailing below average rainfall conditions. BH08 and BH09 show a slight increase in groundwater level in response to the significant rainfall event in January 2024.

### 4.9.5 Groundwater dependant ecosystems

Dependence on or interaction with the vegetation communities within the study area on groundwater was assessed by searching the 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. A 2 km buffer is applied for consideration of potential GDEs with proximity to the study area.

Two moderate to high potential aquatic GDEs are shown on Figure 4–13. One is located at Rickabys Creek approximately 1.5 km north of The Northern Road. The other is located on an unnamed creek approximately 1.6 km north of Londonderry Road. These potential aquatic GDEs are some distance away from the study area. Within the applied 2 km buffer the area is covered with many low to high potential terrestrial GDEs. These potential terrestrial GDEs comprise mainly woodlands and forests. The WSP for the Greater Metropolitan Regional Groundwater Sources, Schedule 4 Table D, outlines the high priority GDEs for the WSP. Review of the WSP finds no listed high priority GDEs within the study area.

### 4.9.6 Groundwater quality

There is limited groundwater quality information for the area. Data from the WaterNSW registered bore works reports may contain limited salinity information for registered bores. Available information from bores within the study area buffer from the National Groundwater Information System (NGIS) Hydro bore dataset are summarised in Table 4–7. Groundwater salinity is likely to be highly variable depending on the bore's location, its depth and the aquifer intersected. Groundwater quality has not been assessed at BH06, BH08 and BH09.

Table 4–7: Registered bore salinity data (Water NSW, 2024)

| Bore Works Number | Bore depth (m) | Screened Lithology | Registered Use | Salinity (µS/cm) | Date of Measurement |
|---|---|---|---|---|---|
| GW100001 | 24 | Shale | Water Supply | 3125 | 1996-06-02 |
| GW028860 | 21.3 | Not Recorded | Irrigation | 404 | 1969-01-07 |
| GW013891 | 100.5 | Sandstone | Irrigation | 1500 | 1960-01-13 |
| GW047570 | 13.1 | Not Recorded | Water Supply | 107 | 1982-10-18 |
| GW034652 | 16.4 | Sandstone | Water Supply | 404 | 1972-01-14 |
| GW028486 | 32.3 | Not Recorded | Irrigation | 8711 | 1966-06-20 |
| GW044015 | 9.8 | Not Recorded | Monitoring | 560 | 1984-08-10 |
| GW040459 | - | Not Recorded | Monitoring | 870 | 1984-05-10 |
| GW040456 | 8.4 | Not Recorded | Monitoring | 535 | 1972-08-01 |
| GW040454 | 12.8 | Not Recorded | Monitoring | 590 | 1971-08-01 |
| GW004794 | 7.3 | Not Recorded | Monitoring | 1200 | 1984-05-10 |
| GW011581 | 7.3 | Not Recorded | Monitoring | 350 | 1983-05-04 |
| GW019941 | 10.4 | Not Recorded | Irrigation | 727 | 1960-04-05 |
| GW040453 | 9 | Not Recorded | Monitoring | 125 | 1971-01-01 |
| GW040452 | 8.3 | Not Recorded | Monitoring | 240 | 1978-07-04 |
| GW019496 | 8.5 | Gravel | Water Supply | 526 | 1961-09-26 |
| GW019940 | 8.7 | Gravel | Monitoring | 450 | 1984-02-10 |
| GW040457 | 10.2 | Not Recorded | Monitoring | 2410 | 1971-03-01 |

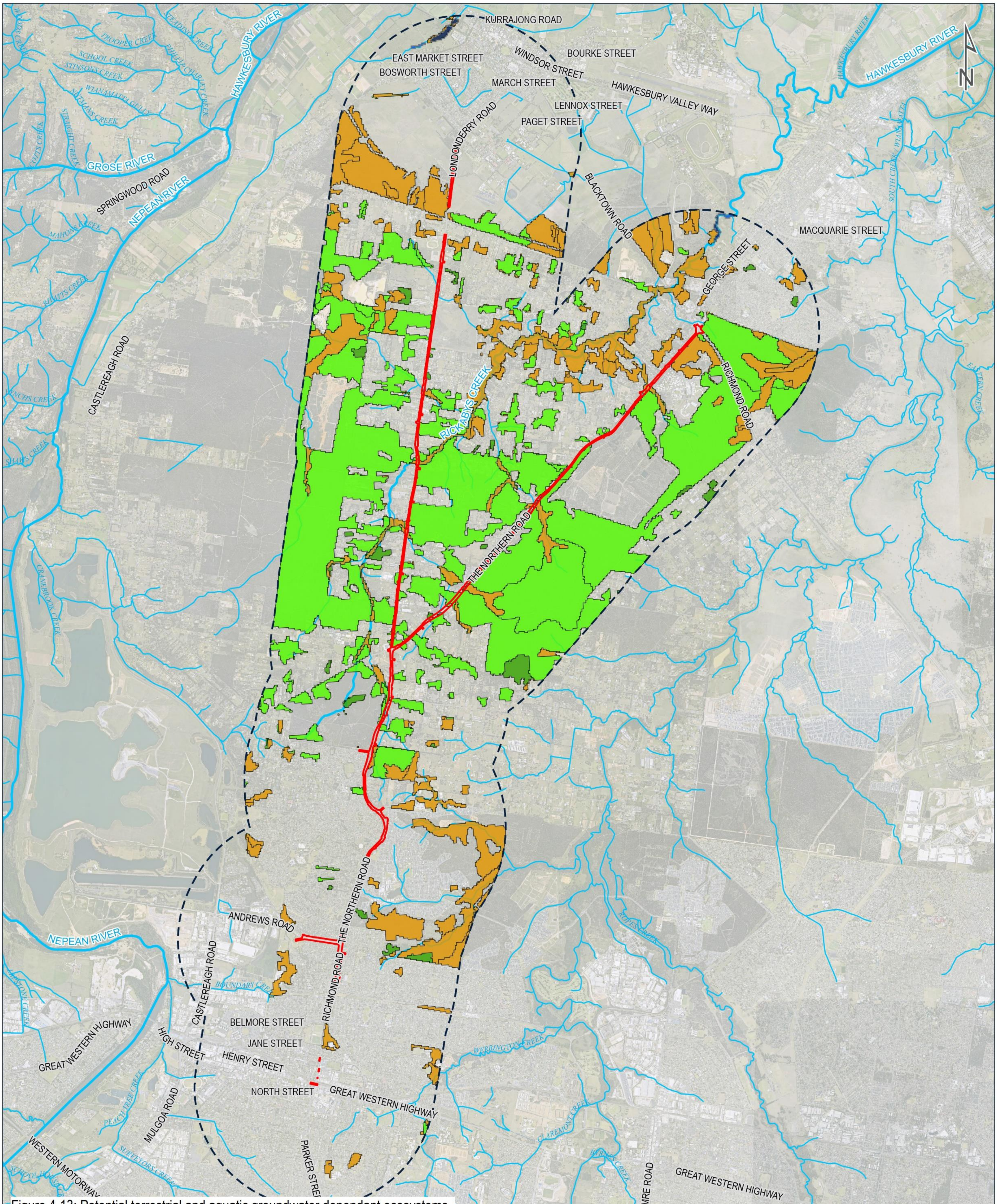


Figure 4-13: Potential terrestrial and aquatic groundwater dependant ecosystems


**LEGEND**

- Study Area
- Buffer (2km)

**Aquatic Groundwater Dependant Ecosystems**

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

**Terrestrial Groundwater Dependant Ecosystems**

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

0 500 1000 1500 2000 2500 3000
Metres

Scale: 1:60,000 CRS: GDA2020 MGA Zone 56

SOURCES:
1. Roadnet MDS 2020, MetroMap Imagery © Aerometrex Pty Ltd
2. Transport and Water Theme © NSW Department of Finance and Services
3. GDA Atlas © Commonwealth of Australia (Bureau of Meteorology) 2017.
5. Basemap: Light Gray Reference: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS
Light Gray Base: Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS



| | |
|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 4-13 |
| FIGURE TITLE: | Groundwater Dependent Ecosystems |
| CREATED BY: | FA13847 |
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The proposal is likely to intersect groundwater in the vicinity of drainage lines and creeks where drainage structures will be enlarged and or lengthened and where trenching to install pipes will be undertaken. In these locations groundwater is generally expected to be more saline as these locations are associated with discharge during dry periods.

Groundwater salinity testing has not been carried out, however, the study area typically includes saline regional groundwater systems that flow through the Wianamatta Group shales. Experience from nearby projects indicates that the water quality in the shale is consistent with a saline groundwater table.

### 4.9.7 Hydraulic conductivity

Hydraulic conductivity testing values were not available within the study area.

# 5. Preliminary Erosion and Sediment Assessment

The RTA (2008) PN 143P Erosion and Sedimentation Management Procedure requires that at concept stage a PESA be completed to assess if the proposal poses a high risk for erosion and sediment. If the proposal is considered a high risk, then a Soil Conservation Consultant is required to be appointed to assist in the preparation of an Erosion and Sedimentation Management Report (ESMR).

The proposal will provide additional capacity for the drainage under the road, as well as raising the road in several locations above the modelled flood levels, and road shoulder widening. The proposal involves a large number of existing drainage structures including table drains, pipe culverts and box culverts, that require extension to accommodate the shoulder widening and/or upgrading to provide additional drainage capacity.

Construction of the proposal has the potential to impact on water quality due to erosion and sedimentation, particularly during heavy rainfall events. From the review of the concept design construction staging strategy, the longest duration construction stage would be ten months and the shortest two weeks with an average of three months. The assessment of exposed work surface posing an erosion risk, for various construction activities, is discussed in Section 6. Mitigation measures to minimise impacts during construction are proposed in Table 9–1.

The existing environment is described in Section 4 with the Soil Landscapes discussed in Section 4.5. Table 5–1 outlines the soil landscapes, location and erosion hazard. Table 5–2 summarises the preliminary assessment of erosion and sedimentation risk. The erosion hazard assessment is discussed in Section 5.1 and potential impacts during construction are discussed in Section 6.

Table 5–1: Soil landscapes summary

| Soil landscape | Located | Soil limitations | Erosion hazard |
|---|---|---|---|
| Berkshire Park Alluvial | Located North of Andromeda Drive along both The Northern Road and Londonderry Road | High wind erosion potential<br>Very high aluminium toxicity | The topsoil has low erodibility as it is well graded but low in organic matter.<br>The erosion hazard for non-concentrated flows is low to moderate. For concentrated flows the erosion hazard is high. However the soil loss calculation for 12 months does not trigger sediment basin requirements.<br>Individual work sites are not expected to exceed and trigger basin requirement. |
| South Creek Alluvial | Occurs at Rickabys Creek near the intersection with Cherrybrook Chase along Londonderry Road for about 200 m to the creek | High erodibility<br>Surface movement potential (localised) | The erosion hazard for South Creek soil landscape is potentially very high to extreme. This is an active floodplain and is presently being reworked by fluvial processes. Apparent stability is probably short term.<br>Total works exposure is expected to be less than 12 months construction time and soil loss is not expected to trigger sediment basin requirements. |
| Luddenham Erosional | Occurs south of Vincent Road south to the end of the alignment to the south | High erodibility | The erosion hazard for non-concentrated flows ranges from moderate to very high. The calculated soil loss for the first twelve months of urban development ranges below soil loss thresholds for exposed subsoil and do not trigger sediment basin requirements as individual works durations at this location average 3 months. |
| Richmond Alluvial | Occurs in a small area near Andrews Road at the southern end of The Northern Road<br>This area is near drainage (trenching) works only | High erodibility | Due to low slopes and generally good vegetation cover the erosion hazard for non-concentrated flows on the Richmond soil landscape is low. During periods of drought or dry seasons this may increase in some areas. The calculated soil loss on the terrace surface in the first twelve months of urban development is low and below the trigger for sediment basin requirements. The erosion hazard for concentrated flows is moderate to high. |

Table 5–2: Preliminary erosion and sedimentation assessment

| Triggers | | Yes/ No | Comments to support decision |
|---|---|---|---|
| 1 | Does the complexity or size of the project result in it being inherently high risk as ongoing installation and maintenance of controls will require extensive coordinated resources? | Yes | The study area is divided into three manageable sections (refer to the figures in Appendix B-1):<br>• The Northern Road – North (MC10)<br>• The Northern Road – South (MC20)<br>• Londonderry Road (MC30).<br>The Northern Road is split between North and South at the intersection with Londonderry Road and Cranebrook Road. The sections have been divided into 13 catchments (refer to the figures in Appendix B-1).<br>Table 5–3 concludes that the individual site risk is low, however, due to the overall size and complexity of the proposal and the unknown construction methodology, an ESMR will be required as a result of this risk assessment. |
| 2 | Assess the erosion hazard of each catchment area to be disturbed for the proposed project using Attachment 1b.<br>Are any of the proposed construction areas defined as High Erosion Hazard? | No | Slope percentage and R-factor plot below the A-line (Figure 5–1) and therefore the proposal is considered a low erosion risk, as shown in Table 5–3 and the figures in Appendix B-1. |
| 3 | Are there known site constraints that limit the implementation of appropriate erosion and sedimentation control measures? | Yes | The proposal is located within an existing road corridor with constrained availability of residual land for the implementation of water quality treatments during construction. Private land holdings, National Parks estates, heritage items, native vegetation and other land uses (e.g. Western Sydney University, Francis Greenway Correctional Complex) are located adjacent to the works area. Where available, an additional buffer has been identified for construction access, water quality controls and other uses during construction. |
| 4 | Are there identified sensitive receiving environments that will receive stormwater discharge from the construction project? For example:<br>• Listed wetlands<br>• State and National Parks<br>• Littoral Rainforest<br>• Drinking water catchments | Yes | The proposal will not discharge to:<br>• Coastal wetlands<br>• Littoral rainforest<br>• Sydney drinking water catchments<br>Land reserved under the *National Parks and Wildlife Act 1974* including Wianamatta Regional Park, Wianamatta Nature Reserve, Windsor Downs Nature Reserve and Castlereagh Nature Reserve are adjacent to the proposal.<br>Road raising, culvert extensions and other drainage works will take place in the catchments of drainage lines that pass through these sensitive receiving environments. Mitigation measures to minimise impacts during construction are proposed in Table 9–1.<br>Refer to the figure in Appendix B-3 for the location of the nature reserves/regional parks, Appendix B-4 for the drinking water catchments and Figure 4–3 for the drainage lines in the vicinity of the proposal. |

As outlined in Table 5–2, the PESA has assessed that an ESMR is triggered due to the complexity and size of the proposal, the constraints of the existing road corridor and the location of lands reserved under the *National Parks and Wildlife Act 1974* adjacent to the proposal.

TfNSW has committed to preparing the ESMR during detailed design. A safeguard for the preparation of the ESMR would be included in the REF for the proposal.

## 5.1 Erosion Hazard Assessment

The methodology is derived from the Blue Book 1 Managing Urban Stormwater – Soils and Construction, (Landcom, 2004).

The potential erosion hazard for each of the catchments defined within the study area as shown on the figures in Appendix B-1 is assessed using Figure 5–1, based on:

1. The R-factor that is a measure of the rainfall erosivity relating to the project geographical location in Appendix B of the Blue Book Table C19 Penrith Soil Landscapes Rainfall Erosivity of Sydney Map 10 p B-12. R-factor = 2500
2. The Slope (%) being the typical upper slope gradient of the site landform. The concept design has been considered and where road levels are adjusted it generally reduces the gradient of the road with low areas being filled in. The study area is generally characterised as Western Sydney Plain with gradients <6%. See Appendix B-1 and Table 5–3.

The A-line is derived from the Blue Book Section 4.4.1, assuming a typical maximum K-factor of 0.05, slope length of 80 m, P-factor of 1.3 and C-factor of 1.0. Sites that plot below the A-line on Figure 5–1 have low potential erosion hazards.

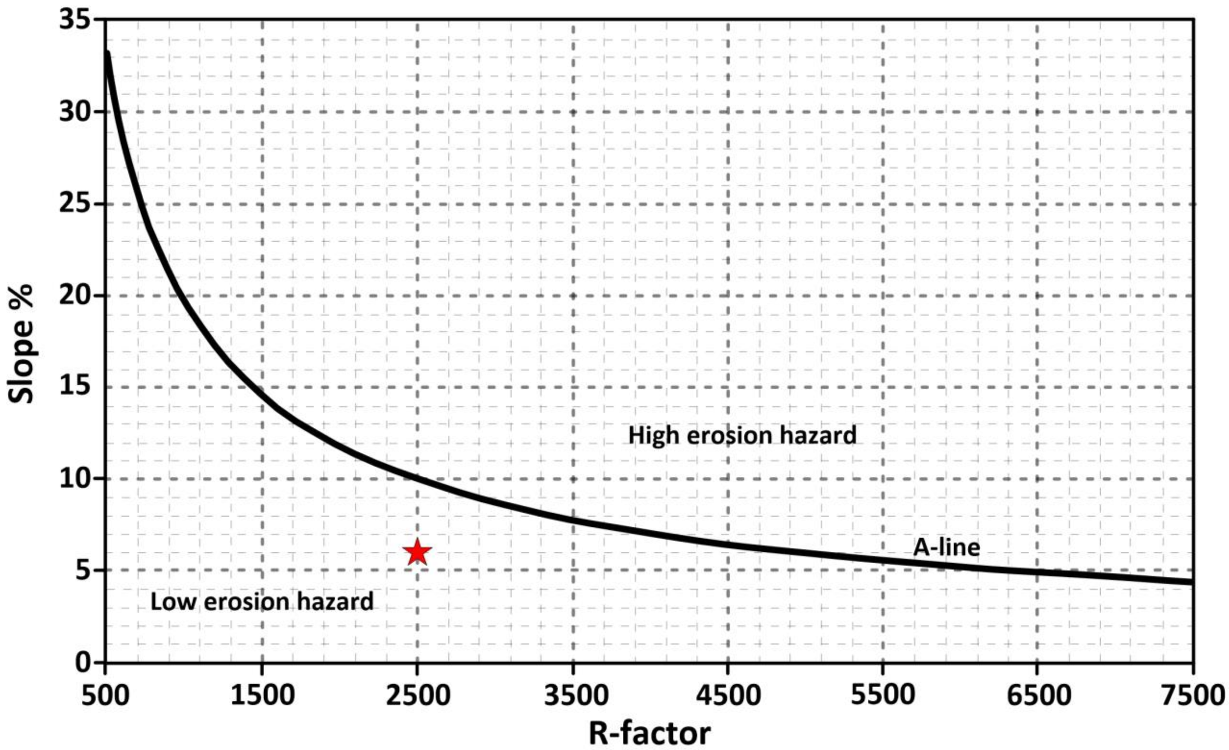


Figure 5–1: Assessment of potential erosion hazard (after Landcom, 2004)

The study area was divided into four segments with 13 catchments (refer to Appendix B-1 for the definition of the catchments). For each catchment the individual maximum slope was calculated, based on the length and change in elevation, at multiple chainages within the catchment, and the results are presented in Table 5–3. For each chainage within each catchment the erosion hazard is assessed using an R factor of 2500 (refer to Section 4.4.1 Landcom, 2004) and the calculated ground slope. Figure 5–1 is used to assess the erosion hazard as either high or low for each catchment and the results are summarised in Table 5–3.

The maximum ground slope of 6 % occurs for an 80 m section between Chainage 1460 to 1540 on The Northern Road – North (MC10) near Carrington Road. This is indicated on Figure 5–1 by the red star, which demonstrates the worst-case scenario for the project. The potential erosion hazard for each catchment is assessed as low as the results plot below the A-line. See Appendix B-1 for chainage locations.

Table 5–3: Catchment potential erosion hazard assessment

| Segment | Catchment | Chainage Start (m) | Chainage End (m) | Elevation Start (m) | Elevation end (m) | Run (m) | Rise (m) | Slope (%) | Potential Erosion Hazard |
|---|---|---|---|---|---|---|---|---|---|
| The Northern Road – North (MC10) | 1 | 60 | 260 | 19.7 | 22.5 | 200 | 3 | 1.5 | Low |
| | 2 | 340 | 440 | 22.4 | 18.8 | 100 | 4 | 4 | Low |
| | | 460 | 640 | 18.4 | 18.7 | 180 | 0 | 0 | Low |
| | | 700 | 940 | 19.4 | 21.5 | 240 | 2 | 1 | Low |
| | | 1020 | 1140 | 22.9 | 26.8 | 120 | 4 | 3.5 | Low |
| | 3 | 1180 | 1300 | 27.6 | 23.0 | 120 | 5 | 4 | Low |
| | | 1320 | 1420 | 22.6 | 23.0 | 100 | 0 | 0.5 | Low |
| | | 1460 | 1540 | 24.0 | 28.8 | 80 | 5 | 6 | Low |
| | | 1600 | 1800 | 30.0 | 30.4 | 200 | 0 | 0 | Low |
| | | 1900 | 2100 | 30.7 | 32.7 | 200 | 2 | 1 | Low |
| | | 2100 | 2720 | 32.7 | 35.3 | 620 | 3 | 0.5 | Low |
| | | 2820 | 2940 | 37.1 | 39.8 | 120 | 3 | 2.5 | Low |
| | | 3100 | 3280 | 41.5 | 42.2 | 180 | 1 | 0.5 | Low |
| | 4 | 3300 | 3400 | 41.9 | 40.0 | 100 | 2 | 2 | Low |
| | | 3520 | 3720 | 40.4 | 36.5 | 200 | 4 | 2 | Low |
| | | 3780 | 3940 | 33.9 | 29.9 | 160 | 4 | 2.5 | Low |
| | | 4000 | 4100 | 28.6 | 26.9 | 100 | 2 | 2 | Low |
| | | 4220 | 4380 | 29.1 | 34.2 | 160 | 5 | 3 | Low |
| | | 4460 | 4680 | 35.9 | 37.1 | 220 | 1 | 0.5 | Low |
| | | 4600 | 5600 | 36.9 | 38.8 | 1000 | 2 | 0 | Low |
| | 5 | 5860 | 5960 | 34.5 | 31.7 | 100 | 3 | 3 | Low |
| | | 6000 | 6320 | 31.2 | 31.4 | 320 | 0 | 0 | Low |
| | | 6340 | 6440 | 31.7 | 32.7 | 100 | 1 | 1 | Low |

| Segment | Catchment | Chainage Start (m) | Chainage End (m) | Elevation Start (m) | Elevation end (m) | Run (m) | Rise (m) | Slope (%) | Potential Erosion Hazard |
|---|---|---|---|---|---|---|---|---|---|
| | | 6500 | 6700 | 32.6 | 33.6 | 200 | 1 | 0.5 | Low |
| | | 6760 | 6900 | 34.7 | 39.3 | 140 | 5 | 3.5 | Low |
| | | 6920 | 7160 | 39.5 | 40.7 | 240 | 1 | 0.5 | Low |
| | | 7200 | 7600 | 41.1 | 42.4 | 400 | 1 | 0.5 | Low |
| The Northern Road – South (MC20) | 6 | 0 | 100 | 42.6 | 43.1 | 100 | 0 | 0.5 | Low |
| | | 100 | 400 | 43.1 | 40.7 | 300 | 2 | 1 | Low |
| | | 400 | 780 | 40.7 | 38.8 | 380 | 2 | 0.5 | Low |
| | | 800 | 1140 | 38.8 | 40.4 | 340 | 2 | 0.5 | Low |
| | | 1180 | 1500 | 40.8 | 46.7 | 320 | 6 | 2 | Low |
| | 7 | 1560 | 1780 | 47.1 | 45.9 | 220 | 1 | 0.5 | Low |
| | | 1880 | 2200 | 46.2 | 53.9 | 320 | 8 | 2.5 | Low |
| | | 2300 | 2580 | 56.1 | 59.3 | 280 | 3 | 1 | Low |
| | 8 | 2600 | 2980 | 59.3 | 55.5 | 380 | 4 | 1 | Low |
| | | 3020 | 3100 | 54.1 | 51.4 | 80 | 3 | 3.5 | Low |
| | | 3140 | 3540 | 51.1 | 55.5 | 400 | 4 | 1 | Low |
| | 9 | 3580 | 3720 | 55.6 | 55.2 | 140 | 0 | 0.5 | Low |
| | | 3740 | 3873 | 54.9 | 53.0 | 133 | 2 | 1.5 | Low |
| Londonderry Road (MC30) | 10 | 0 | 900 | 24.5 | 23.2 | 900 | 1 | 0 | Low |
| | | 900 | 2100 | 23.2 | 22.2 | 1200 | 1 | 0 | Low |
| | | 2100 | 2400 | 22.2 | 21 | 300 | 1 | 0.5 | Low |
| | | 2420 | 2500 | 20.9 | 19.8 | 80 | 1 | 1.5 | Low |
| | | 2540 | 3000 | 19.6 | 19.7 | 460 | 0 | 0 | Low |
| | | 3100 | 3320 | 20.1 | 23.8 | 220 | 4 | 2 | Low |
| | | 3360 | 3740 | 24.1 | 21.7 | 380 | 1 | 1 | Low |

| Segment | Catchment | Chainage Start (m) | Chainage End (m) | Elevation Start (m) | Elevation end (m) | Run (m) | Rise (m) | Slope (%) | Potential Erosion Hazard |
|---|---|---|---|---|---|---|---|---|---|
| | 11 | 3800 | 3940 | 20.6 | 18.5 | 140 | 1 | 1.5 | Low |
| | | 4000 | 4120 | 18.4 | 18.7 | 120 | 0 | 0 | Low |
| | | 4120 | 4180 | 18.7 | 18.4 | 60 | 0 | 0.5 | Low |
| MC30 Londonderry Road | | 4180 | 4300 | 18.7 | 19.4 | 120 | 1 | 0.5 | Low |
| | | 4320 | 4560 | 19.4 | 18.4 | 240 | 1 | 0.5 | Low |
| | | 4600 | 4740 | 18.9 | 24.2 | 140 | 5 | 4 | Low |
| | | 4800 | 5040 | 25.1 | 27.5 | 240 | 2 | 1 | Low |
| | | 5100 | 5260 | 27.8 | 28.3 | 160 | 1 | 0 | Low |
| | 12 | 5320 | 5520 | 28.1 | 20.4 | 200 | 1 | 4 | Low |
| | | 5580 | 5800 | 19.4 | 19.4 | 220 | 0 | 0 | Low |
| | | 5860 | 6320 | 20.2 | 30.6 | 460 | 10 | 2 | Low |
| | | 6400 | 6540 | 32.2 | 33.0 | 140 | 1 | 0.5 | Low |
| | 13 | 6620 | 6820 | 32.1 | 25.9 | 200 | 6 | 3 | Low |
| | | 6860 | 7000 | 25.5 | 25.5 | 140 | 0 | 0 | Low |
| | | 7020 | 7380 | 25.9 | 31.8 | 360 | 6 | 2 | Low |
| | | 7460 | 7740 | 33.1 | 36.8 | 280 | 4 | 1.5 | Low |
| | | 7840 | 8360 | 38.1 | 40.3 | 520 | 2 | 0.5 | Low |
| | | 8440 | 8480 | 40.5 | 39.8 | 40 | 1 | 2 | Low |
| | | 8520 | 8880 | 39.9 | 42.3 | 360 | 2 | 1 | Low |

# 6. Construction impact assessment

The construction works associated with the proposal include:

- Site establishment, including ancillary facilities, stockpiling and material laydown
- Construction access provisions
- Utilities and services relocation
- Road raising and realignment
- Culvert excavations and trenching, and
- Widening of the road shoulder with associated drainage works, including table drains and open channels.

These works would involve a range of activities including vegetation clearing, the establishment of ancillary facilities, the construction of access tracks, earthworks and trenching, road pavement construction, and drainage works. These construction activities have the potential to impact on soil, surface water and groundwater. Key construction activities are discussed in Section 6.1 and a summary of the potential impacts to soil, surface water and groundwater are presented in Section 6.2 and Table 6–3.

## 6.1 Construction activities

This section provides a summary of the key construction activities that may potentially impact the soils, groundwater or surface water environment.

### 6.1.1 Ancillary facilities and stockpiles

To support construction, a range of ancillary facilities would be required. These facilities may include:

- Site offices, parking, sheds, workshops and storage
- Areas for material delivery and storage including culvert structural elements
- Stormwater capture and treatment locations, and
- Stockpile locations for materials.

Ancillary facilities would be temporary sites and structures that would be developed for the sole purpose of construction of the proposal and be returned to pre-existing conditions or rehabilitated once construction is complete. Ten potential ancillary facility sites have been identified for the proposal as shown in Figure 1–1.

### 6.1.2 Utilities and services relocation

The proposal requires utilities and services relocation due to the proposed drainage improvements and shoulder widening. Relocations due to drainage improvements are expected to be within the footprint of the drainage trench excavations and are unlikely to require substantial additional excavations above those required for the drainage works at these locations.

### 6.1.3 Culvert excavations and trenching

The proposal comprises extensions of existing culverts, new drainage structures and drainage trenching for installation of drainage culverts. Table 6–1 outlines the existing culvert dimensions and the proposed modification, the anticipated depth of excavation and estimated depth to groundwater. Refer to Figure 1–1 and Appendix B-1 for the location of the proposed works. It is expected that culvert construction would include:

- Vegetation and/or pavement removal
- Earthworks and backfilling
- Concreting, and
- Temporary diversion of surface water where required in waterways.

Table 6–1: Drainage structure number, proposed modification and estimated groundwater interaction

| Structure ID | Existing culvert dimension | Proposed modification | Proposed excavation depth (mbgl) | Estimated groundwater depth (mbgl) | Potential to intersect groundwater (Y/N) | Surface water catchment |
|---|---|---|---|---|---|---|
| TNR01A | 1 x 1800 x 600 | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR01B | 1 x 450 diameter | Upgrade longitudinal system to 1 x 750 diameter | 1 | 2 | N | Rickabys Creek |
| TNR01 | 2 x 450 diameter | Extension to accommodate shoulder widening<br>Additional 4 x 450 dia. culverts adjacent to existing culverts | 1 | 2 | N | Rickabys Creek |
| TNR02 | 1 x 375 diameter | Extension to accommodate shoulder widening | 1 | 1.5 | N | Rickabys Creek |
| TNR03 | 1 x 600 diameter | Extension to accommodate shoulder widening | 1 | 1 | N | Rickabys Creek |
| TNR04 | 3 x 1200 diameter | Upgrade to 3 x 3600 x 2400 and extend for shoulder widening | 1 | 0.5 | Y | Rickabys Creek |
| TNR05 | 1 x 600 diameter | Upgrade to 2 x 2400 x 900 and extend for shoulder widening | 1 | 1.5 | N | Rickabys Creek |
| TNR05A | 1 x 375 diameter | Upgrade to 1 x 2400 x 600 and extend for shoulder widening | 1 | 1.5 | N | Rickabys Creek |
| TNR06 | 1 x 600 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR07 | 2 x 450 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR08 | 1 x 450 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR09 | 1 x 750 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR10 | 2 x 600 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR11 | 3 x 2400 x 900 | Upgrade to 5 x 3000 x 1200 and extend for shoulder widening | 1 | 1 | Y | Rickabys Creek |
| TNR12 | 1 x 600 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR13 | 2 x 1200 x 600 | New culvert proposed: upgrade to 6 x 2400 x 600 proposed adjacent to TNR13 | 1 | 2 | N | Rickabys Creek |
| TNR14A | 2 x 600 diameter | Upgrade to 2 x 2700 x 1200 and extend for shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR14B | 1 x 900 diameter | Upgrade to 2 x 2700 x 1200 and extend for shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR15 | 1 x 600 diameter | Upgrade to 3 x 3000 x 900 and extend for shoulder widening | 1 | 2 | N | Rickabys Creek |

| Structure ID | Existing culvert dimension | Proposed modification | Proposed excavation depth (mbgl) | Estimated groundwater depth (mbgl) | Potential to intersect groundwater (Y/N) | Surface water catchment |
|---|---|---|---|---|---|---|
| TNR16 | 3 x 900 diameter | Upgrade to 5 x 3600 x 1200 and extend for shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR17 | 1 x 450 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR18 | 2 x 450 diameter | Upgrade to 1 x 2400 x 600 and extend for shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR19 | 1 x 1200 x 450 | Upgrade to 4 x 2400 x 900 and extend for shoulder widening | 1 | 1.5 | N | Rickabys Creek |
| TNR20-1 | 2 x 1200 x 600 | Upgrade to 5 x 3600 x 600 and extend for shoulder widening | 1 | 1.5 | N | Rickabys Creek |
| TNR20-2 | 1 x 1200 x 300 | Upgrade to 1 x 1800 x 450 | 1 | 1.5 | N | Rickabys Creek |
| TNR21 | 2 x 2200 x 1050 | Upgrade to 5 x 3000 x 900 and extend for shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR22 | 2 x 375 diameter | Upgrade to 5 x 2400 x 600 and extend for shoulder widening | 1 | 2 | N | Rickabys Creek |
| CR35c | 1 x 1200 x 150 | Upgrade to 2 x 2100 x 600 | 1 | 2 | N | Rickabys Creek |
| TNR22B | 1 x 600 diameter | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| TNR23 | 1 x 1800 x 600 | Upgrade to 2 x 1800 x 600 (i.e. additional 1 x 1800 x 600) | 1 | 2.5 | N | Rickabys Creek |
| TNR24 | 1 x 600 diameter | Upgrade to 3 x 3000 x 750 and extend for shoulder widening | 1 | 2.5 | N | South Creek |
| TNR25 | 1 x 450 diameter | Upgrade to 1 x 1200 x 600 and extend for shoulder widening | 1 | 3 | N | South Creek |
| TNR34 | 1 x 1200 diameter | Upgrade longitudinal system to 2 x 1200 dia. | 1 | 3 | N | Penrith Lakes |
| TNR35 | 1 x 900 x 450 | Additional 2 x 1350 dia. | 1 | 3 | N | Penrith Lakes |
| LNR01 | 6 x 1650 diameter | No change | 1 | 1 | N | Rickabys Creek |
| LNR02 | 1 x 600 x 300 | Extension to accommodate shoulder widening | 1 | 1.5 | N | Rickabys Creek |
| LNR03 | 1 x 900 x 300 | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| LNR04 | 3 x 3600 x 1200 + 1 x 3600 x 1800 | Extension to accommodate shoulder widening | 1 | 1 | Y | Rickabys Creek |
| LNR05 | 1 x 375 diameter pipe | Retain existing (not impacted by widening) | 1 | 2 | N | Rickabys Creek |

| Structure ID | Existing culvert dimension | Proposed modification | Proposed excavation depth (mbgl) | Estimated groundwater depth (mbgl) | Potential to intersect groundwater (Y/N) | Surface water catchment |
|---|---|---|---|---|---|---|
| LNR06 | 1 x 375 diameter pipe | Retain existing (not impacted by widening) | 1 | 2 | N | Rickabys Creek |
| LNR07 | 2 x 3600 x 600 | Extension to accommodate shoulder widening | 1 | 1.5 | N | Rickabys Creek |
| LNR10 | 4 x 3600 x 2400 +<br>5 x 3600 x 2100 +<br>2 x 3600 x 1500 +<br>4 x 3600 x 1200 | Extension to accommodate shoulder widening | 1 | 1 | Y | Rickabys Creek |
| LNR11 | 4 x 3600 x 1200 +<br>3 x 3600 x 1500 | Extension to accommodate shoulder widening | 1 | 1 | Y | Rickabys Creek |
| LNR12 | 2 x 3600 x 2400 +<br>1 x 3600 x 2700 +<br>8 x 3600 x 1500 +<br>10 x 3600 x 1200 | Extension to accommodate shoulder widening | 1 | 0 | Y | Rickabys Creek |
| LNR13 | 2 x 525 diameter pipe. | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| LNR14 | 1 x 600 diameter pipe. | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| LNR15 | 2 x 3600 x 1500 +<br>3 x 3600 x 1200 +<br>6 x 3600 x 1050 | Extension to accommodate shoulder widening | 1 | 1 | Y | Rickabys Creek |
| LNR16 | 1 x 450 diameter pipe. | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |
| LNR17 | 2 x 1200 x 600 | Extension to accommodate shoulder widening | 1 | 2 | N | Rickabys Creek |

The estimated depth to groundwater was assessed based on the proximity to major drainage features and topography. Note that groundwater level information within the study area is limited. On the floodplain the depth to the water table is assumed to be between 2 mbgl and 4 mbgl based on limited monitoring data. Along Rickabys Creek the depth to the water table is likely to coincide with the surface water elevation. At the tributaries, which are ephemeral, groundwater is anticipated to be at depths that range from 0.5 mbgl to 2 mbgl.

The existing bridge sized drainage culverts are positioned at creek crossings and drainage lines associated with Rickabys Creek and its tributaries, and the tributaries associated with South Creek. For the purpose of assessing potential impacts all culvert slab and cut off wall excavations are assumed to be 1 m deep, and that the entire excavation for the culvert width will be open at once. This is considered conservative as the slab excavation will likely be 0.5 m deep on average, with the cut off wall being a narrow trench of roughly 0.5 m deep by 1 m wide at both ends of the slab excavation.

Seven of the drainage structures listed in Table 6–1 are estimated to potentially require excavation below the water table. One culvert (LNR12) over Rickabys Creek is likely to have the most interaction with groundwater as Rickabys Creek is the lowest point in the landscape and forms the main groundwater discharge.

The inflow rates and radius of influences predicted for the drainage structures, which are assessed to intercept groundwater and the drainage trench system, are presented in Table 6–2. Note that due to the uncertainty in aquifer hydraulic properties, boundaries and limited groundwater level information, the results are rounded up to the nearest decimal place. Estimated inflows represent steady state conditions. Initial inflows may be higher as the cone of depression develops and more permeable units dewater in proximity to the excavation.

The results show that even under high case conditions (i.e. higher permeability and shallow water table) any interception of groundwater is likely to be very minor and extremely localised. An estimation of the total volume inflow, assuming the worst-case inflow rate and with seven excavations open for 30 days, would be 300 $m^3$ which is equivalent to 0.3 ML/annum.

Table 6–2: Estimated culvert slab and cut of wall excavation and drainage trench inflows and radius of influence

| Scenario / Excavation type | Predicted groundwater inflow likely case ($m^3$/day) | Predicted groundwater inflow worst case ($m^3$/day) | Radius of influence (m) (worst case) |
|---|---|---|---|
| 1. Small Culverts<br>0.5 m below SWL, 10 m by 3 m excavation dimensions | <0.1 | 0.4 | <15 |
| 2. Bridge sized culverts<br>1m below SWL, 10 m by 3 m excavation dimensions | 0.1 | 0.8 | <25 |
| 3. Trench<br>3m below SWL 100 m long, 2 m wide in Bringelly Shale / residual clays | 0.2 | 1.2 | <35 |

#### 6.1.3.1 Dewatering and discharges

Groundwater is assumed to be shallow within close proximity to floodplains, Rickabys Creek and tributaries and drainage lines. Excavations and shallow earthworks may intersect the groundwater table. Where excavation activities are deep enough to intercept groundwater, dewatering will be required, either by discharged to the environment or offset disposal, depending on the nature and volume of the groundwater. Should dewatering activities produce larger volumes of water or the water quality is degraded, water licences and or dewatering management plans will be required.

### 6.1.4 Widening of the road shoulder

The proposal would generally retain the existing road pavement and level, with widening of the shoulder requiring vegetation clearing, shallow earthworks and concrete/asphalt. Some site leveling with cut and fill would be employed for the roadworks.

### 6.1.5 Concrete/asphalt activities

The proposal would require concrete and asphalt during construction. The aspects of the proposal that would require concrete/asphalt include:

- Pavement for roads including the shoulder widening
- Structures including kerbing, table drains and culverts, and
- Footpaths.

### 6.1.6 Works on waterfront land

The proposal includes works within waterways and within proximity to waterways that would be classed as works on waterfront land under section 91E of the *Water Management Act 2000*. These works would otherwise be deemed a controlled activity, however TfNSW is exempt from the requirement to obtain an approval under clause 41 of the Water Management (General) Regulation 2018.

## 6.2 Summary of potential construction impacts

A summary of the potential construction impacts for soil, surface water and groundwater is provided in Table 6–3. Refer to Section 9 for mitigation measures.

Table 6–3: Summary of potential construction risks and potential impacts for soils, surface water and groundwater

| Activity / Event | Description of Impact | Receptors | Significance | Mitigation measures (see Table 9–1) | Residual impacts |
|---|---|---|---|---|---|
| Vegetation removal and earthworks - soil erosion | Clearing of vegetation and topsoil would increase the risk of soil erosion and sediment laden runoff reaching waterways that may cause a reduction in water quality.<br>Tannins and other organic leachate from vegetation stockpiles could enter watercourses via runoff and discharge which may cause a reduction in water quality. | Surface water<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution and vegetation clearing* | Low |
| Ancillary facilities and stockpiling | Materials stored within the ancillary facilities transported to waterways via wind or sediment-laden stormwater runoff may cause a reduction in water quality. | Surface water<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Water pollution due to stockpiles* | Low |
| Ancillary facilities and stockpiling | Leaching of metals and salts from materials stored as a result of interaction with water infiltrating the soil may cause pollution to groundwater. | Groundwater | Medium | *Water pollution due to stockpiles* | Low |
| Ancillary facility – Site 3 | This location is a former auto wrecker yard and disturbance of the soil has the potential to mobilise potential contaminants. Disturbance of the soil, from earthworks, or surface water recharge may lead to mobilisation of contaminants. This could potentially cause pollution to surface waterways and groundwater and result in a reduction in water quality. | Surface water and groundwater<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* | Low |
| Leak, spills and waste | Potentially harmful chemicals (e.g. hydrocarbons, oil, grease, heavy metals, nutrients) could accidently be released to the surface water environment during construction spills, refuelling and due to inappropriate storage and handling. Leakage from construction worker facilities or wastewater collection points could runoff into soils and receiving water ways. This could potentially contaminate exposed soils or mobilise contaminated solids and liquids into local watercourses which could result in water quality impacts. There is potential to leach into groundwater sources and contaminate the alluvial aquifer.<br>Spillage of waste or construction materials during transportation could lead to pollutants being conveyed in surface runoff to nearby drainage pathways and downstream waterways. | Surface water and groundwater<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil and water pollution from accidental spills* | Low |

| Activity / Event | Description of Impact | Receptors | Significance | Mitigation measures (see Table 9–1) | Residual impacts |
|---|---|---|---|---|---|
| Leak spills and waste - culvert excavation in Rickabys Creek and other waterways | Leaks and spills from plant and equipment operating in waterways could potentially contaminate exposed soil in the waterway, be conveyed directly into the watercourse or leach into the groundwater source. | Surface water and groundwater<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | High | *Soil and water pollution from accidental spills* | Low |
| Work on waterfront lands | Construction activities including earthworks or clearing can change the geomorphological conditions and increases the likelihood of sediment and other construction materials being mobilised into waterways. This could lead to water quality impacts within the stream and downstream. | Surface water and groundwater<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution and works on waterfront lands* | Low |
| Trenching construction | Exposed open excavations have the potential for surface runoff to enter the trench. Water entering the trench would increase recharge to the groundwater and this may result in temporary localised mounding of the water table. Pollutants from the surface runoff could potentially contaminate the soil and leach into groundwater.<br>The impact of localised water table mounding is considered to be low given the time the trench is likely to be open for, the depth to the water table typically being below the base of the trench and the likely hydraulic conductivity of the soils. | Groundwater | Low | *Soil erosion and water pollution* | Low |
| Culvert construction | Impacts will be highly localised as they affect a small specific extent. Excavation for the culverts increases the likelihood of sediment and other construction materials being mobilised into waterways. This could lead to water quality impacts within the stream and downstream.<br>Temporary diversion of surface water could change the flow velocity within the waterway and may result in erosion of sediments. This could lead to changes in channel geomorphology and water quality impacts downstream.<br>At least seven locations are anticipated to intercept the water table and would require dewatering for construction, resulting in drawdown of the local water table.<br>Increased drainage structure size and length may result in changes to surface water flow volume and velocity that has the potential to alter the geomorphology of the receiving waterway due to erosion and scouring. Mobilisation of sediment may result in a reduction in water quality within the stream and downstream. | Surface water and Groundwater<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* | Low |

| Activity / Event | Description of Impact | Receptors | Significance | Mitigation measures (see Table 9–1) | Residual impacts |
|---|---|---|---|---|---|
| Discharges | During excavation works for culvert construction and trenching, if the groundwater table is encountered and dewatering is required, the water would have to be disposed of by either discharging to the environment or offsite disposal. If water is discharged to the environment this may degrade surface water, depending on the quality of the groundwater. | Surface water<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* | Low |
| Dewatering | Shallow groundwater is likely around the floodplains, drainage lines, tributaries and at Rickabys Creek. There is the potential for groundwater levels to rise in response to rainfall conditions, and to fluctuate in response to climatic cycles. This could lead to potential saturation of planned excavations, therefore requiring dewatering.<br>Dewatering would result in temporary and localised impact to the water table level which may extend away from the excavation and cause an increase in the depth to groundwater.<br>Water table drawdown, if more than the natural variation, could lead to oxic conditions within the dewatered portion within the area of drawdown and may result in a reduction in water quality within the groundwater aquifer. | Groundwater<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Groundwater dewatering during excavation* and *Groundwater impacts* | Low |
| Disturbance of salinity, ASS or contaminants of concern | Construction activities have the potential to interact with soils where there may be localised areas of moderate to high salinity potential and construction could disturb soils in areas with unidentified salinity potential. Excavation could lead to erosion and may cause a reduction in water quality within watercourses. | Surface water<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* | Low |
| Shoulder widening construction | During excavation works for site leveling, construction of table drains and cut and fill activities there is the potential for sediment to be transported to waterways via wind or sediment laden stormwater runoff and may cause a reduction in water quality within the waterways.<br>Cut areas may fill with surface runoff following rainfall events that has the potential for localised recharge to groundwater through infiltration and if discharged to the environment may result in a reduction in surface water quality. | Surface water<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* | Low |

| Activity / Event | Description of Impact | Receptors | Significance | Mitigation measures (see Table 9–1) | Residual impacts |
|---|---|---|---|---|---|
| Shoulder widening construction | Concrete / asphalt transportation and pouring operations can lead to soil and water pollution (e.g. increase in pH, total dissolved solids, total suspended solids and minor levels of aluminium, iron and manganese oxides) from cement laden runoff not being properly contained or being accidently released to surface waters. This may lead to a reduction in water quality within watercourses. | Surface water<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* | Low |
| Regional flooding event | Floodwater has the potential to erode material from stockpiles, open excavation, culvert excavations in progress and newly stripped soil areas which would lead to impacts in downstream waterways through the transportation of sediments and construction materials. | Surface water<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* | Low |
| Recently disturbed soils | Proposal earthworks will disturb soils from the removal of vegetation, stripping of topsoil and construction of features. These areas would require revegetation and/or stabilisation to avoid erosion during wet weather events. Mobilisation of sediment may impact waterways and result in a reduction in surface water quality.<br>Exposed ground may increase recharge to groundwater that could result in localised mounding of the groundwater table. | Surface water and Groundwater<br>Sensitive Receptors:<br>Terrestrial and Aquatic GDE | Medium | *Soil erosion and water pollution* and *Soil erosion and sedimentation* | Low |

### 6.2.1 Potential soil impacts

The assessment has identified the following potential soil impacts associated with the proposal.

#### 6.2.1.1 Salinity

Construction activities have the potential to interact with soils where there may be localised areas of moderate to high salinity potential and construction could disturb soils in areas with unidentified salinity potential. Excavation could lead to erosion and may cause a reduction in water quality within watercourses.

#### 6.2.1.2 Acid sulfate soils

Construction activities have the potential to interact with soils where there may be localised areas of low acid sulfate soil potential. Excavation could lead to erosion and may cause a reduction in water quality within watercourses.

#### 6.2.1.3 Naturally occurring asbestos

Construction of the proposal is not anticipated to encounter naturally occurring asbestos.

#### 6.2.1.4 Soil mobilisation

Proposal earthworks will disturb soils from the removal of vegetation, stripping of topsoil and construction of features. These areas would require revegetation and or stabilisation to avoid erosion during wet weather events. Mobilisation of sediment may impact waterways and result in a reduction in surface water quality.

Floodwater has the potential to erode material from stockpiles, open excavation, culvert excavations in progress and newly stripped soil areas which would lead to impacts in downstream waterways through the transport of sediments and construction materials.

Temporary soil stabilisation would be required immediately following completion of a portion of construction to prevent erosion, topsoil loss or soil migration. This could occur in areas of shoulder widening, around the embankments of drainage culverts and in the reinstatement of temporary ancillary facilities where topsoil is settling and vegetation is establishing.

### 6.2.2 Potential surface water quality impacts

The following summarises the potential effects on waterways and downstream from water quality impacts:

- Reduced hydraulic capacity of the watercourse or drainage system
- Increased pollutant and nutrient loads within the catchment
- Potential for accumulation of heavy metals in aquatic species
- Reduced dissolved oxygen levels that could impact aquatic species
- Increased sedimentation impacting aquatic life and affecting aquatic ecosystems
- Increased turbidity levels affecting aquatic species and the aesthetics of water
- Changes to water temperature due to reduced light penetration, and
- Increased nutrient loads leading to eutrophication affecting aquatic species, recreation and visual aesthetics.

Potential impacts to water quality, including the sensitive receiving environment of the Hawkesbury-Nepean River would be minimised by implementing the measures provided in Section 9 of this report. The CEMP would define the water quality objectives, measures and procedures, including those defined by the Blue Book (Landcom, 2008) and TfNSW (2022) guideline for treated water, to minimise potential impacts to water quality during construction.

### 6.2.3 Aquifer Interference Policy Review

The proposal is assessed to have aquifer interference activities that require review against the Level 1 minimum impact considerations of the NSW Aquifer Interference Policy (AIP). The proposal is located within the Londonderry HGL, which typically includes saline regional groundwater systems that flow through the Wianamatta Group shales that underlie alluvial deposits. The Wianamatta Group Shales are classed as a 'less productive groundwater source' under the AIP. A less productive groundwater source is defined by the AIP as a groundwater source having total dissolved solids greater than 1500 mg/L or does not contain water supply works that can yield water at a rate greater than five litres per second. The alluvial deposits are generally more productive and of lower salinity than the Wianamatta Group Shales but of limited saturated thickness. The water table within the alluvial system is also closely linked to the prevailing climate and will be higher in wet periods and lower (relative to ground level) in dry periods.

Seven excavations have the potential to intersect the water table, potentially requiring dewatering for the purpose of constructing the feature. The predicted groundwater inflows are low and the radius of influence, that is the distance away from the centre of the excavation, is generally less than 40 m in the scenarios assessed. The drawdown of the groundwater table is greatest at the excavation and reduces away from it. Drawdown at the excavation is temporary and would only occur during the construction of the base slab. The excavations are assumed to be one metre deep, and drawdown will be to the base of the excavation. The risk of occurrence and impacts are based on assumed water levels. Further investigations during detailed design would be conducted at these locations.

### 6.2.4 Water supply works

Based on analytical assessment, the potential radius of influence estimated in Table 6–2 is not likely to extend more than 40 m from the proposed drainage works excavations. Water table drawdown due to dewatering for construction activities would not exceed the depth of excavation. The depth of excavation is 1 m, accordingly a drawdown of more than 2 m at a nearby water supply work in the same aquifer is not likely. Changes to the water table would be localised and within the 2 m drawdown criteria of the AIP Level 1 minimum impact consideration. The risk of changes to groundwater level impacting groundwater users within the same aquifer is considered to be low.

The risk of impact to groundwater quality from salinity, ASS and contamination from the proposal is considered to be moderate. It is noted that the ASS field screening method is a qualitative method that is not a substitute for analytical laboratory testing in the identification of acid sulfate soils. Further ASS testing would be performed during detailed design to verify the findings of the field screening completed for the proposal to date.

The risk of change to groundwater quality as a result of this impact and groundwater becoming unsuitable for groundwater users is considered to be low. This is due to limited areas of interaction with groundwater, low volumes and the study area being located within a groundwater discharge area. The proposal is considered unlikely to result in a change in beneficial use category.

### 6.2.5 High priority culturally significant sites

There are no high priority culturally significant groundwater dependant sites listed in the WSP for the Greater Metropolitan Region Groundwater Sources.

### 6.2.6 Groundwater dependent ecosystems

There are several medium to high potential terrestrial GDEs located within the study area. They are dominated by woodland species. Potential high priority aquatic GDEs are more than 40 m from the proposal works and considered to be outside the radius of influence for potential impacts. There are no WSP listed high priority GDEs within the study area.

Interaction with the groundwater table will be limited to upgrading or extending existing drainage structures along drainage lines and creeks. Whilst the radius of influence of drawdown may interact with potential moderate and high terrestrial GDEs the actual change in the water table level would be short lived and likely to be within the range of natural variation. The impacts during construction are expected to be temporary and will not significantly contribute to cumulative variations in the water table. The risk of changes to groundwater level impacting a potentially high priority GDE is considered to be low as high priority GDEs are more than 40 m from the proposal.

# 7. Operational impact assessment

The proposal is anticipated to have limited operational impacts as the study area is already an active road corridor for which there is no proposed increase in traffic loads. The widening of the shoulder, to be used during flood evacuations only, is within the current corridor and the widening area is currently partially compacted and paved. Operational activities that may potentially impact on surrounding soils, surface water and groundwater are considered in this section.

## 7.1 Soils

There is potential for recently disturbed soils to be susceptible to erosion, particularly during initial periods of landscaping and re-establishment of vegetation, particularly following severe storms. Temporary soil stabilisation would be required immediately following construction to prevent erosion, topsoil loss or soil migration. This could occur in areas of shoulder widening, around the embankments of drainage culverts and in the reinstatement of temporary ancillary facilities where topsoil is settling and vegetation is establishing. Effective implementation of management measures during construction would minimise the potential for impacts extending into the operational phase.

There is a minor risk of increased settlement of the alluvial soils under the road due to increased loading where the road level has been raised, and this settlement would preferentially affect low permeability sediments such as clays. The potential for settlement has been considered in the road design as informed by geotechnical investigations. Settlement risk would continue to be addressed in detailed design.

Operation is not likely to result in any significant impacts on soil, topography or geology. The risk of soil erosion during operation would be minimal, as areas impacted during construction would be sealed or rehabilitated and landscaped to prevent soil erosion. Maintenance activities involving ground disturbance would be undertaken in accordance with TfNSW QA Specification R179 Landscape planting, 2019.

## 7.2 Surface water

During operation there is the potential for surface water quality to be impacted by erosion of newly stabilised or planted areas during the establishment period, resulting in sedimentation of waterways and a reduction in water quality within the waterway and downstream. The risk is considered to be low with effective implementation of management measures during construction. The proposal is not anticipated to increase erosion of sediments to receiving surface water bodies during operation.

The proposal has a relatively confined corridor and the main discharge outlets for stormwater within the study area remain consistent with current conditions, although the capacity of the system in some areas is increased. Increased capacity may lead to increased volumes of water reporting to the discharge outlet that could result in alteration of the geomorphology of the receiving waterways and mobilisation of sediment that may result in a reduction in water quality. However, the drainage design of the outlets, culverts and stormwater system are anticipated to include appropriate scour protection, therefore scour and erosion are unlikely to occur and the risk is considered to be low.

The increase in impervious area from the widening of the shoulder, compared to current conditions, is negligible when compared to the overall catchment surface area. Most of the shoulder widening will occur within the Rickabys Creek catchment. The impervious area of the subject State Roads within the study area is currently 0.22% of the total surface area of the Rickabys Creek catchment, which will increase to 0.27% after the shoulder widening. The additional impervious area would result in increased surface runoff to waterways in proportion to the percentage increase in impervious surface. The proposal is not anticipated to increase pollutants to waterways from increased surface runoff as there is no change in traffic volumes for the proposal, noting that the shoulder will not be trafficked during normal operation. Nutrients (including nitrogen and phosphorous) derived from atmospheric deposition, deposited on the widened parts of the road, would have a lower rate of soil infiltration relative to existing conditions.

Given the nature and scale of the Proposal and the associated modest widening of a pre-existing road, and compared to the substantial urbanisation in the catchment, the Proposal has a negligible impact on the NSW Government's capacity to achieve the water quality objectives.

## 7.3 Groundwater

Due to the increase in impervious areas there is likely to be a minor reduction in the overall recharge rate to the underlying unconfined aquifer as a result of the proposal. The main groundwater receptor is considered to be baseflow to watercourses. Runoff from the impervious areas would continue to flow towards the Hawkesbury-Nepean River. Any reduction in rainfall infiltration is likely to have negligible effect in recharge to groundwater and is unlikely to produce an effect that would constitute aquifer interference, and the potential impacts such as changes to groundwater level or quality, are considered to be low.

The proposal is in a groundwater discharge area, where groundwater levels naturally fluctuate. The proposal drainage structures are unlikely to permanently intercept groundwater and no active or passive dewatering is required. As such there would be no ongoing drawdown associated with these drainage structures. Groundwater would continue to discharge to waterways consistent with current conditions and overall groundwater discharge within the broader system and therefore there is no risk to changes in groundwater level for groundwater users and GDEs. The proposal would not require a WAL for operation as there is no ongoing groundwater take.

Obstruction of groundwater flow due to the proposal is considered unlikely as there is very limited interaction with groundwater. There is the potential for highly localised and slight changes to groundwater flow paths in areas where drainage structures intersect the water table. This is not anticipated to alter the volume of groundwater reporting to the natural discharge zone or the location of the groundwater discharge zone. The risk to changes in groundwater flow are considered to be low.

The proposal has been assessed against the Level 1 minimal impact considerations for the construction phase. The potential impacts during the operational phase are less than it would be for construction. Overall the groundwater impacts from the proposal would be less than the Level 1 minimal impact considerations specified in the AIP. The proposal is not predicted to result in any decline in groundwater pressure or groundwater head and is not predicted to alter the beneficial use of the groundwater at any water supply work, culturally significant groundwater dependant sites or GDEs.

# 8. Cumulative impact assessment

The proposal is part of the regional area of the Penrith and Hawkesbury Local Government Areas (LGAs). Much of the land surrounding the study 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 completion. Others are still in the planning phase and their pace of development is uncertain. Cumulative impacts are those that result from successive, incremental and/or combined effects of a proposal when added to other existing, planned and/or reasonably anticipated future projects.

The proposal is part of a broader Hawkesbury-Nepean Valley Road Resilience Program, comprising State Road and Local/Regional Road proposed works, in delivering a part of the Hawkesbury-Nepean Valley Flood Strategy. This proposal is for the State Roads component of the Hawkesbury-Nepean Valley Road Resilience Program, with the other part including the following Local/Regional Roads that are in proximity to the State Road project:

- Castlereagh Road – shoulder widening (southbound lane) and drainage improvements
- Llandilo Road – shoulder widening (southbound lane) and drainage improvements
- Cranebrook Road, near The Northern Road intersection – drainage improvements
- Coreen Avenue, Derby Street, Jamison Road and Maxwell Street – pinch point corridor improvements
- Wedmore Road, Palomino Road, Old Bathurst Road, Russell Street and Leonay Parade – drainage improvements and/or new bridges.

The road upgrade projects outlined above are within existing road corridors. Potential impacts from the construction of these projects are anticipated to be similar to the construction impacts of this proposal. The proposal, along with the above upgrade projects, contributes to land use change within the wider catchment through increased impervious areas that results in a reduction in recharge to groundwater and increase stormwater run-off to receiving water courses.

Other key local projects and developments outside of the Hawkesbury-Nepean Valley Road Resilience Program are:

- New Richmond Bridge and traffic improvements – Stage 1
- New Richmond Bridge and traffic improvements – Stage 2
- Mulgoa Road/Castlereagh Road corridor upgrade between Andrews Road in the north to south of M4 Motorway.

Major projects and developments within the region include:

- Western Sydney Airport and adjacent Aerotropolis, with associated rail link (Sydney Metro West) and rapid bus service to Penrith
- Greater Penrith to Eastern Creek Growth Area, including six areas suitable for residential and related urban development, redevelopment and renewal
- Outer Sydney Orbital Stage 1, a north-south corridor for a future motorway and freight rail connection between Richmond Road (north) and Hume Motorway near Menangle (south), passing near new Western Sydney airport
- Penrith Health and Education Precinct, a 400 ha area between Penrith and St Marys train stations building on existing the TAFE university campuses and nearby hospital.

Cumulative water quality impacts from potential urban developments around the proposal would be managed in accordance with the Penrith Development Control Plan (DCP) and Hawkesbury DCP which outline objectives and controls for developments within the Penrith and Hawkesbury LGAs. In accordance with the objectives and controls of the DCPs future developments would include measures to minimise impacts on water quality. Cumulative impacts of the proposal are expected to be low risk with these projects utilising appropriate soil and water controls. The proposal is not considered to result in long-term changes to soil, surface water and groundwater and is not considered to present a significant risk of cumulative impacts within the broader catchment.

# 9. Management measures and safeguards

## 9.1 Overview of mitigation measures

The proposal has the potential to impact surface water, groundwater and increase erosion during construction. To manage these potential impacts a Soil and Water Management Plan (SWMP) will be prepared and implemented as part of the Construction Environmental Management Plan (CEMP). The SWMP would assess reasonably foreseeable risks relating to soil erosion and water pollution and describe how these risks will be addressed during construction. Due to proximity of the proposal to waterways, and work within waterways, a construction water quality monitoring plan would be prepared and implemented as part of the SWMP. The plan would be prepared in accordance with the TfNSW Guideline for Construction Water Quality Monitoring (2003) and Approved Methods for the sampling and analysis of water pollutants in NSW (EPA, 2022).

Construction generally reduces ground cover through vegetation removal and excavation, as such a PESA was completed for the proposal. Due to the size and complexity of the proposal, and the location of lands reserved under the *National Parks and Wildlife Act 1974*, the PESA outcome identifies the need for an ESMR to be prepared during the detailed design phase. The ESMR will include site specific preliminary erosion and sediment control plans.

During detailed design, opportunities to mitigate operational phase surface water quality would be explored.

Groundwater levels are generally below the base of proposed works, with the exception of seven excavations which are anticipated to intercept groundwater. The estimated volume of groundwater discharge into excavations is not anticipated to exceed the 3 ML/annum exemption. A Dewatering Management Protocol (DMP) would be prepared at detailed design to assess the groundwater volumes and the dewatered quality, and will provide an outline of the details for disposal and possible licencing requirements.

A summary of mitigation measures and the impacts addressed by those measures are presented in Table 9–1.

Table 9–1: Summary of mitigation measures

| Impact | Mitigation measure | Responsibility | Timing |
|---|---|---|---|
| Soil erosion and water pollution | Prepare an Erosion and Sedimentation Management Report (ESMR) in accordance with the RTA (2008) Erosion and Sedimentation Management Procedure PN 143P. The ESMR will include site specific preliminary Erosion and Sediment Control Plans (ESCPs).<br>The final ESCPs will be developed by the construction contractor and would include the need to implement progressive ESCPs and the continual updating of these plans during construction. | TfNSW/ Contractor | Detailed design/ Pre-construction/ Construction |
| | A Soil and Water Management plan (SWMP) will be prepared and implemented as part of the CEMP. The SWMP will identify all reasonably foreseeable risks relating to soil erosion and water pollution and describe how these risks will be addressed during construction. Site specific ESCPs will be prepared and implemented as part of the CEMP. These plan/s will include:<br>• arrangements for managing wet weather events, including monitoring of potential high-risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather<br>• erosion and sediment controls<br>• stabilisation measures to control discharge from stormwater outlets to manage erosion and scour<br>The SWMP will be reviewed by a soil conservationist on the TfNSW list of Registered Contractors for Erosion, Sedimentation and Soil Conservation Consultancy Services. The SWMP will then be revised to address the outcomes of the review. | TfNSW/ Contractor | Pre-construction |
| Soil erosion and sedimentation | During any construction and maintenance work where soils are exposed, sediment and erosion control devices would be installed in accordance with Blue Book 'Managing Urban Stormwater – Soil and Construction' (Landcom, 2004). | Contractor | Construction/ Operation |
| | The rehabilitation of disturbed areas will be undertaken progressively, where possible, as construction stages are completed, in accordance with Blue Book 'Managing Urban Stormwater – Soil and Construction' (Landcom, 2004). | Contractor | Construction |
| Contamination of surface water | Regular visual water quality checks (including for turbid plumes and hydrocarbon spills or slicks) will be carried out when working in or near waterways.<br>Construction water quality monitoring will be undertaken upstream and downstream of the proposal to ensure that controls and site practices are effective at maintaining current water quality conditions. Monitoring will be undertaken in accordance with the TfNSW Guideline for Construction Water Quality Monitoring (2003). | Contractor | Construction |
| Water quality monitoring | A water quality monitoring program will be developed and implemented as part of the SWMP in the CEMP in accordance with the TfNSW Guideline for Construction Water Quality Monitoring (2003) and Approved Methods for the sampling and analysis of water pollutants in NSW (EPA, 2022).<br>The program will define:<br>• monitoring parameters<br>• monitoring locations<br>• frequency (including provision for wet weather and specific construction activities) and duration of monitoring<br>The monitoring program will include monitoring prior to the commencement of construction and during construction to inform the implementation of the CEMP. | TfNSW/ Contractor | Pre-construction/ Construction |

| Impact | Mitigation measure | Responsibility | Timing |
|---|---|---|---|
| Water pollution due to stockpiles | Stockpile site locations would be confirmed during detailed design and where applicable managed in accordance with Environmental Procedure Management of Wastes on Roads and Maritime Services Land (RMS, 2014) and the Stockpile Site Management Guideline (RMS, 2015). This would consider measures to manage cross contamination within a stockpile area.<br>Consideration of how to manage stockpiles, materials laydown and chemical storage with respect to floodwaters would be undertaken by the construction contractor. | Contractor | Pre-construction/ Construction |
| Soil and water pollution from accidental spills | A site-specific emergency spill plan would be developed and will include spill management measures in accordance with the Transport for NSW Code of Practice for Water Management (RTA, 1999) and relevant EPA guidelines. The plan would address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including TfNSW and EPA offices). | Contractor | Pre-construction/ Construction |
| | An emergency spill kit will be kept on site at all times. Spill kits will be located at all ancillary facilities and main construction work areas with all staff made aware of the locations of spill kits and trained in their use. | Contractor | Construction |
| | The refuelling and maintenance of plant and equipment will be undertaken in a designated sealed bunded area at ancillary facilities and/or off-site where possible.<br>Vehicle wash downs and concrete washouts will be carried out within designated sealed bunded areas at construction ancillary facilities or carried out off-site. | Contractor | Construction |
| Stormwater discharges leading to pollution | A construction water quality discharge assessment will be completed during detailed design in accordance with the EPA Assessing and managing water pollution from road works and TfNSW Guidelines for Assessing the Impacts of Treated Water Discharge from Construction Sites (2022). | TfNSW | Detailed design |
| Works on waterfront land | Works within creeks and drainage lines and within 40 m of waterfront land will be undertaken with consideration of the design and construction considerations outlined in the Guidelines for instream works on waterfront land (DPIE 2012), Guidelines for watercourses crossings on waterfront land (DPIE, 2012) and in accordance with relevant TfNSW specifications and guidelines. | TfNSW/ Contractor | Detailed design/ Pre-construction/ Construction |
| Groundwater dewatering during excavation | A Dewatering Management Protocol would be developed if groundwater/aquifer dewatering is required to lower the groundwater table to reduce or prevent groundwater ingress into excavations.<br>Assessment must include the volume of groundwater, dewatered quality and disposal procedure and monitoring. Relevant approvals and permits must be obtained prior to groundwater dewatering.<br>Qualitative assessment must include assessment of the magnitude and duration of the drawdown and whether impacts are likely to adversely affect the habitat conditions and ecological communities within the GDEs. | TfNSW/ Contractor | Detailed Design/ Pre-construction |
| Groundwater impacts | Impacts on groundwater during construction will be minimised as far as practicable by:<br>• avoiding the need to extract groundwater<br>• minimising groundwater inflows and volumes into excavations<br>• managing any groundwater encountered during excavations in accordance with the Technical Guideline – Environmental Management of Construction Site Dewatering (RMS, 2011) | Contractor | Pre-construction/ Construction |

| Impact | Mitigation measure | Responsibility | Timing |
|---|---|---|---|
| Vegetation clearing | Clearing and grubbing will be conducted in accordance with RMS QA Specification G40 Clearing and Grubbing 2020. | Contractor | Pre-construction/ Construction |

# 10. Conclusion

This report includes a desktop review of available information to assess the potential risks to soil, surface water and groundwater during the construction and operation of the proposal. This report has assessed that impacts could occur as a result of the construction and operation of the proposal. Most of the impacts are expected to occur during the construction phase.

The assessment indicated that the proposal is unlikely to result in serious adverse impacts to soil, surface water and groundwater and that the potential construction and operational impacts discussed in this report are common on major road projects. The main impacts of concern during construction include erosion and sedimentation and contamination. Vegetation removal and earthworks may destabilise soils and erode exposed soils, and run-off from construction sites could result in a reduction in water quality within the waterways downstream and/or leach into groundwater aquifers. The PESA result triggers an ESMR to be prepared during detailed design, which will inform the SWMP prepared for construction. Other impacts include contamination from accidental leaks and spills of hydrocarbons and grease.

Construction of the proposal is anticipated to have minimal interception of groundwater, predominantly at seven culvert locations, and the potential impact to groundwater receptors is temporary and localised drawdown of the water table. The volume of groundwater potentially to be dewatered is below 3 ML/annum and an exemption applies. Impacts to groundwater receptors are below the Level 1 minimal impact considerations of the AIP. Operation of the proposal is not predicted to intercept groundwater and therefore not predicted to impact groundwater receptors.

The widening of the road shoulder, for use during flood evacuations only, results in an increase in impervious area. During operation the main impact of the increased impervious area is increased stormwater runoff to surface water receptors and decreased rainfall infiltration to groundwater aquifers. The proposal does not change the traffic volumes and operation of the road. The increased impervious area over the proposal is unlikely to result in measurable changes to the water quality of downstream receiving environments of the minor tributaries of the Hawkesbury-Nepean River catchment.

To minimise impacts to soil, surface water and groundwater, a range of measures would be implemented during the detailed design, construction and operational phases of the proposal, such as the preparation of:

- SWMP as part of the CEMP to mitigate soil erosion and water pollution during construction
- ESCPs as part of the SWMP to minimise soil erosion and sediment transport to nearby waterways
- DMP as part of the SWMP to mitigate groundwater drawdown and manage disposal impacts from dewatered groundwater
- Site-specific emergency spill plans to address accidental spills and leaks of hydrocarbons, oil and grease.

Additionally, the construction methodologies would consider the following:

- Appropriately designed scour protection for drainage culverts, table drains and stormwater discharge points according to recommended guidelines (Austroads 2013, Catchments & Creeks 2014, 2015, 2017)
- Stockpile site locations, material laydown and chemical storage to prevent water pollution, and
- Progressive rehabilitation of disturbed areas as stages are completed.

With the implementation of the proposed mitigation measures, the proposal is expected to have acceptable and minimal impacts on existing soil, surface water and groundwater resources and environmental values during both the construction and operation phases.

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## Appendix A

# Acid Sulfate Soils Technical Memo

Member of the Surbana Jurong Group

# Technical Memorandum

| | | | |
|---|---|---|---|
| **Document No.** | HNV-PS231-TCH-000002 | **Date of Issue** | 27 March 2024 |
| **Subject** | Acid Sulfate Soils | **Revision** | 1 |
| **Project Title** | Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements – State Roads: Concept Design and REF | **Project No.** | 30013443 |
| | | **Discipline** | Environmental |
| **Author** | Manuel Fernandez, Principal Environmental Engineer | | |
| **Reviewed by** | Daniel Cramer & Aaron Bowden | **Approved by** | Awie Malan |
| **Prepared for** | Transport for NSW | **Attention to** | Devika Sitinamaluwe |
| **Attachments** | Important Notice | | |

## 1. Introduction

This technical memorandum provides supplementary information on Acid Sulfate Soils (ASS) to that presented in the Preliminary Site Investigation Report (HNV-PS211-RPT-000010) prepared by SMEC for the Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Improvements – State Roads Concept Design and REF. The purpose of this document is to assess the need for an ASS Management Plan for this Proposal.

## 2. Acid Sulfate Soil Occurrence

ASS materials are naturally occurring soil and sediment, distinguished from other soil or sediment materials by having properties and behaviour that have either:

1. Been affected considerably by the oxidation of Reduced Inorganic Sulfur (RIS) (principally the mineral iron pyrite), or
2. The capacity to be affected considerably by the oxidation of their RIS constituents.

The factor common to all ASS materials is that RIS components have either had, or may have, a major influence on the properties or behaviour of these soil materials. These soils are typically found in low-lying coastal areas and saline inland areas, however, they have been identified in a wide range of environmental settings. Coastal ASS are generally found on land with elevation less than 5 m Australian Height Datum (AHD) (Sullivan et al, 2018). These conditions are typical of marine or estuarine sediments of the recent Quaternary geological age which are deposited in low-lying sections (typically below relative level (RL) 5m AHD) of coastal floodplains, rivers and creeks.

A review of coastal ASS risk mapping available online (NSW Government eSPADE v2.2) indicates the study area is outside areas of known coastal ASS occurrence, therefore in areas of 'no known occurrence', as shown in Figure 1 below.

A review of the National Acid Sulfate Soil Atlas (ASRIS) indicates that the majority of the study area is mapped as 'Extremely Low Probability' with a portion in the north mapped as 'Low Probability', as shown in Figure 2 below.

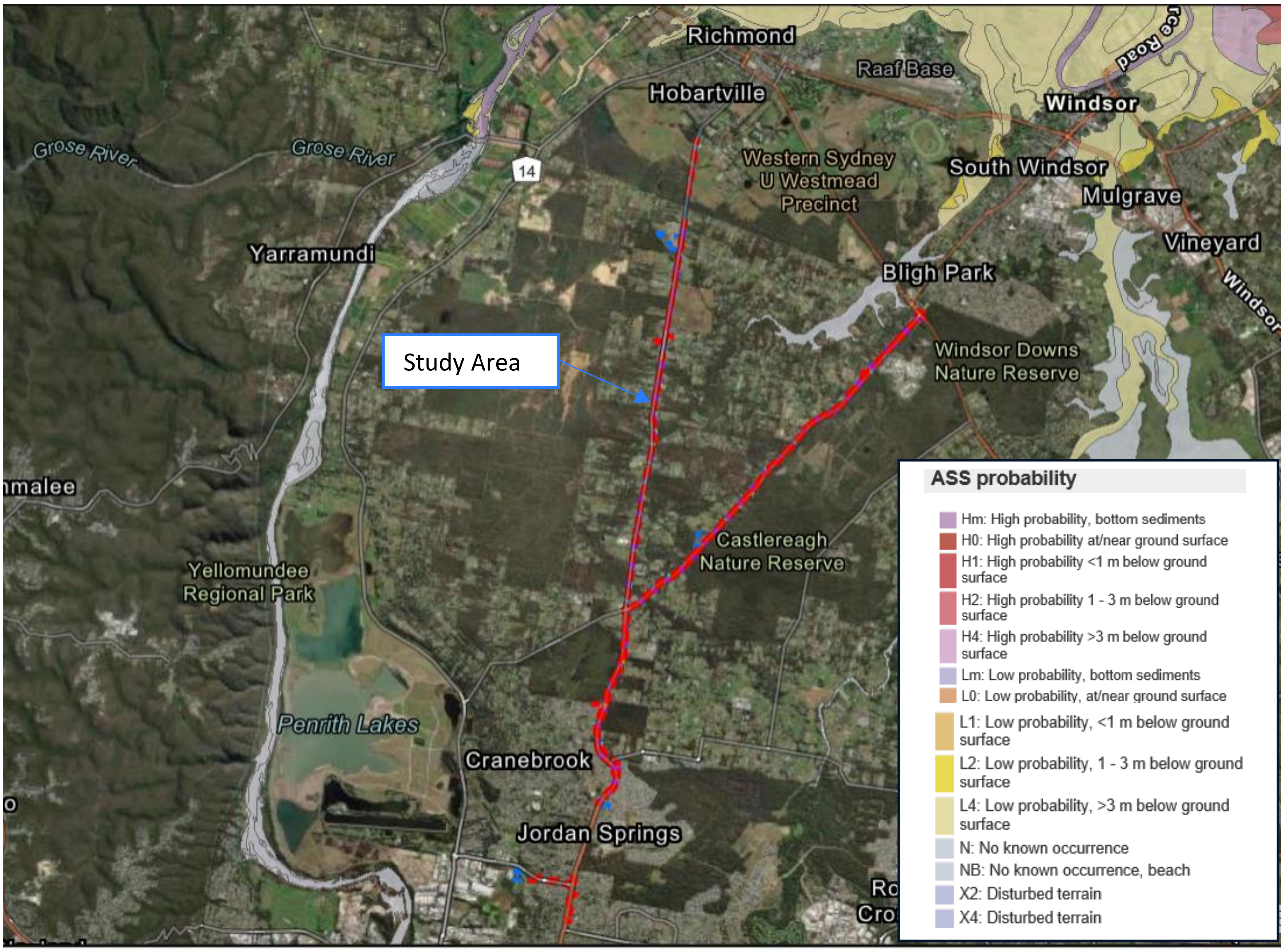


*Figure 1 – Acid Sulfate Soil Risk Map (eSPADE)*

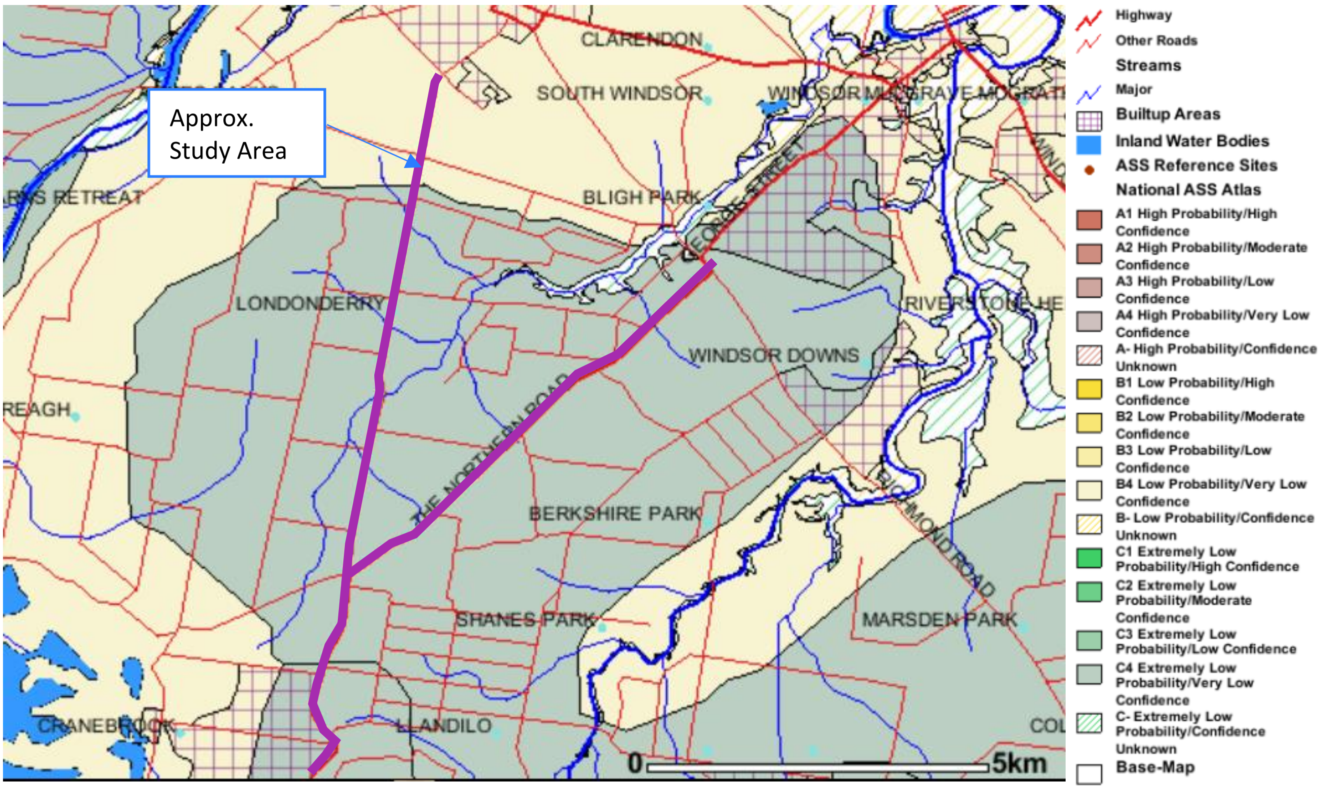


*Figure 2 – National Acid Sulfate Soil Atlas (ASRIS)*

A review of topographic information sourced from NSW Spatial Services dataset (accessed through MinView) indicates that the surface elevations within the study area range from approximately 19m above ~~Australian Height Datum~~ AHD to 60m above AHD.

ASS can be present at higher elevations inland and can be associated with saline environments. Therefore, the presence of Quaternary age sediments along the Rickabys Creek catchment and associated tributaries does not preclude ASS occurring within the Proposal area if the conditions for formation of RIS were favourable.

The Geotechnical Factual Report (TfNSW, 2023) conducted preliminary laboratory screening testing for ASS during site investigations targeting lower lying areas adjacent to natural drainage depressions and watercourses. Seven selected samples were screened with field ($pH_F$) and field peroxide ($pH_{FOX}$) pH testing across three boreholes. The Geotechnical Interpretive Report (SMEC, 2024) indicated that two samples collected at 2.5m depth reported $pH_{FOX}$ values between 3 and 4, indicating that sulfidic material may be present. The report noted that based on Stone et, al, (1998), the peroxide test is most useful for clays containing low levels of organic matter, and least useful on sands or gravels which may give false results, and field screening is a qualitative method that is not a substitute for analytical laboratory testing in the identification of acid sulfate soils. The report recommended that further ASS testing be performed during detailed design to confirm the field screening results.

# 3. Conclusions

Based on the information reviewed the likelihood for ASS to be present within shallow soils that may be disturbed for the Proposal is considered to be low, in particular due to the elevation of the site. Quaternary age sediments along the Rickabys Creek catchment and associated tributaries could be present if the conditions for formation of RIS were favourable.

Some soils that can have acid sulfate like characteristics can sometimes form in drains and waterlogged areas if conditions are conducive such as high organics, sources of sulfate and reducing conditions. These may typically be small or sporadic. Based on this information reviewed, we consider that an ASS Management Plan is not considered warranted at this stage. Further targeted investigations are recommended in lower lying parts of the alignment in the Rickabys Creek catchment where disturbances are proposed such as for culverts extensions. Assessment of these areas should be carried out in accordance with national guidance (Sullivan et al, 2018) comprising sufficient sampling and laboratory testing (including but not necessarily limited to soil analysis using the chromium reducible sulfur suite method with full acid base accounting). The need for an ASS Management Plan should be re-assessed at detailed design stage based on the results of the additional assessment.

In the context of this memorandum, ASS are differentiated from naturally saline or naturally acidic soils which may need management for other reasons.

This technical memorandum should be read with the attached Important Notice.

# 4. References

Australian Soil Resource Information System (https://www.asris.csiro.au/about.html accessed 25/10/2023)

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**Important Notice**

This technical memorandum is confidential and is provided solely for the purposes of providing information on acid sulfate soils. This technical memorandum is provided pursuant to a Consultancy Agreement between SMEC Australia Pty Limited (“SMEC”) and Transport for NSW under which SMEC undertook to perform a specific and limited task for Transport for NSW. This technical memorandum is strictly limited to the matters stated in it and subject to the various assumptions, qualifications and limitations in it and does not apply by implication to other matters. SMEC makes no representation that the scope, assumptions, qualifications and exclusions set out in this technical memorandum will be suitable or sufficient for other purposes nor that the content of the report covers all matters which you may regard as material for your purposes.

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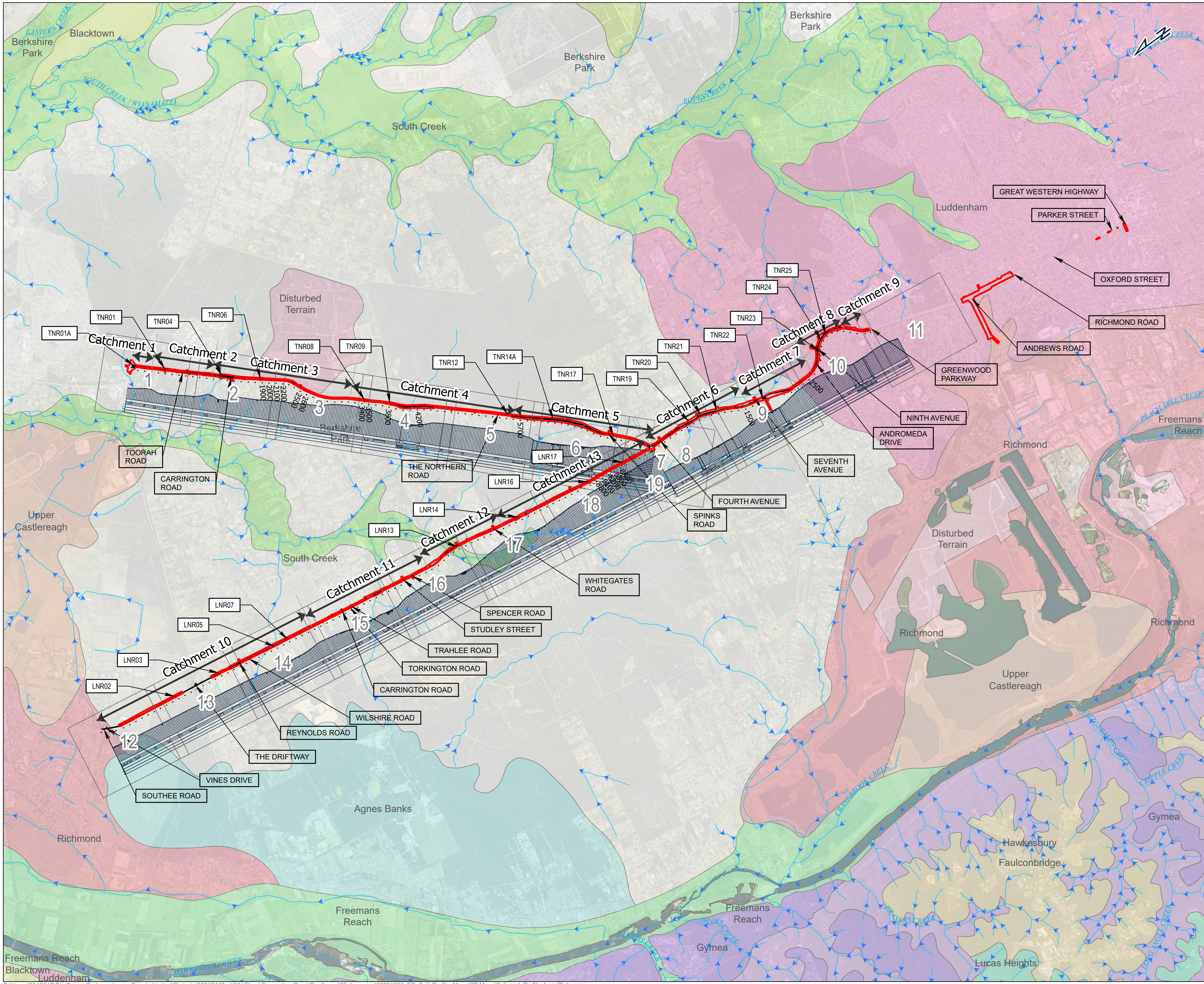
## Appendix B

# Erosion and Sediment Assessment Figures

# B-1 PESA Trigger 2 - Soil Landscape and Proposal Elevation in Catchments

Note that this series of figures comprises 20 sheets.

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SMEC AUSTRALIA PTY LTD
ABN 47 065 475 149

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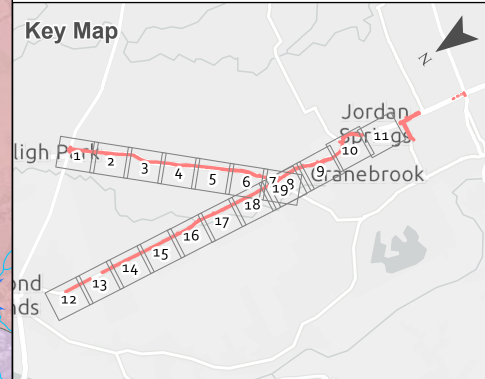
## LEGEND

- Study Area
- Catchment
- Dimension

**Soil Landscape**

- Agnes Banks
- Berkshire Park
- Blacktown
- Disturbed Terrain
- Faulconbridge
- Freemans Reach
- Gymea
- Hawkesbury
- Lucas Heights
- Luddenham
- Richmond
- South Creek
- Upper Castlereagh

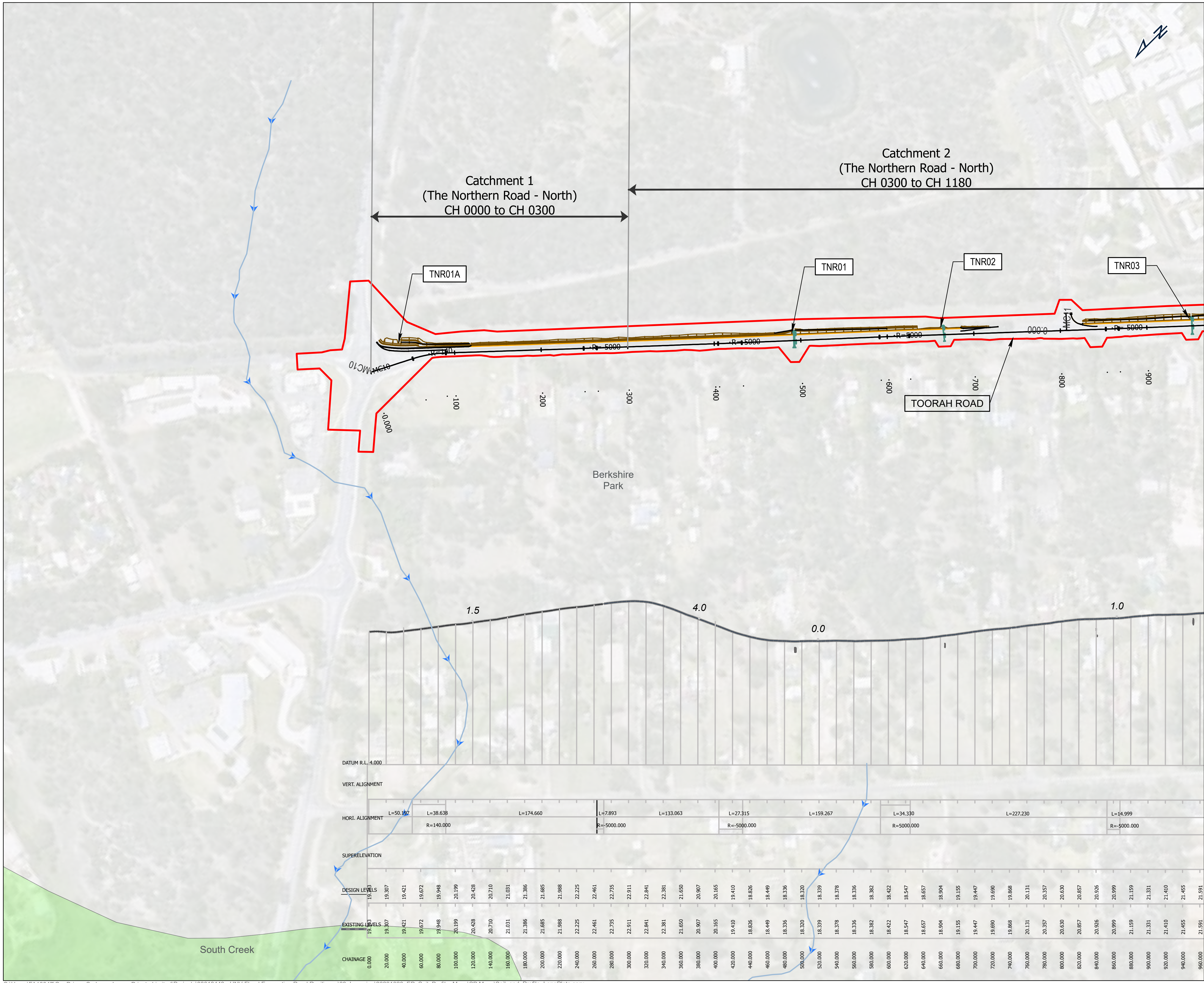
**Key Map**




SOURCES:
1. Roadnet MDS 2020
2. Transport and Water Theme © NSW Department of Finance and Services
3. MetroMap Imagery © Aerometrex Pty Ltd
4. Soil Landscape © State Government of NSW and Department of Planning and Environment 2023
5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



| | |
|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | Index |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
| CREATED BY: | FA13847 |
| DATE: | 13/06/2024 |
| VERSION: | DRAFT 1 |
| PAGE SIZE: | A3 |

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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

**Soil Landscape**

- Berkshire Park
- South Creek

**Design 80% and Interface Projects**

- Road Edge
- Clearway
- Earthworks
- Linemarkings
- Culvert Head Walls

Key Map

SOURCES:
1. Roadnet MDS 2020
2. Transport and Water Theme © NSW Department of Finance and Services
3. MetroMap Imagery © Aerometrex Pty Ltd
4. Soil Landscape © State Government of NSW and Department of Planning and Environment 2023
5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 1 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
CREATED BY: FA13847
DATE: 11/06/2024
VERSION: DRAFT 1
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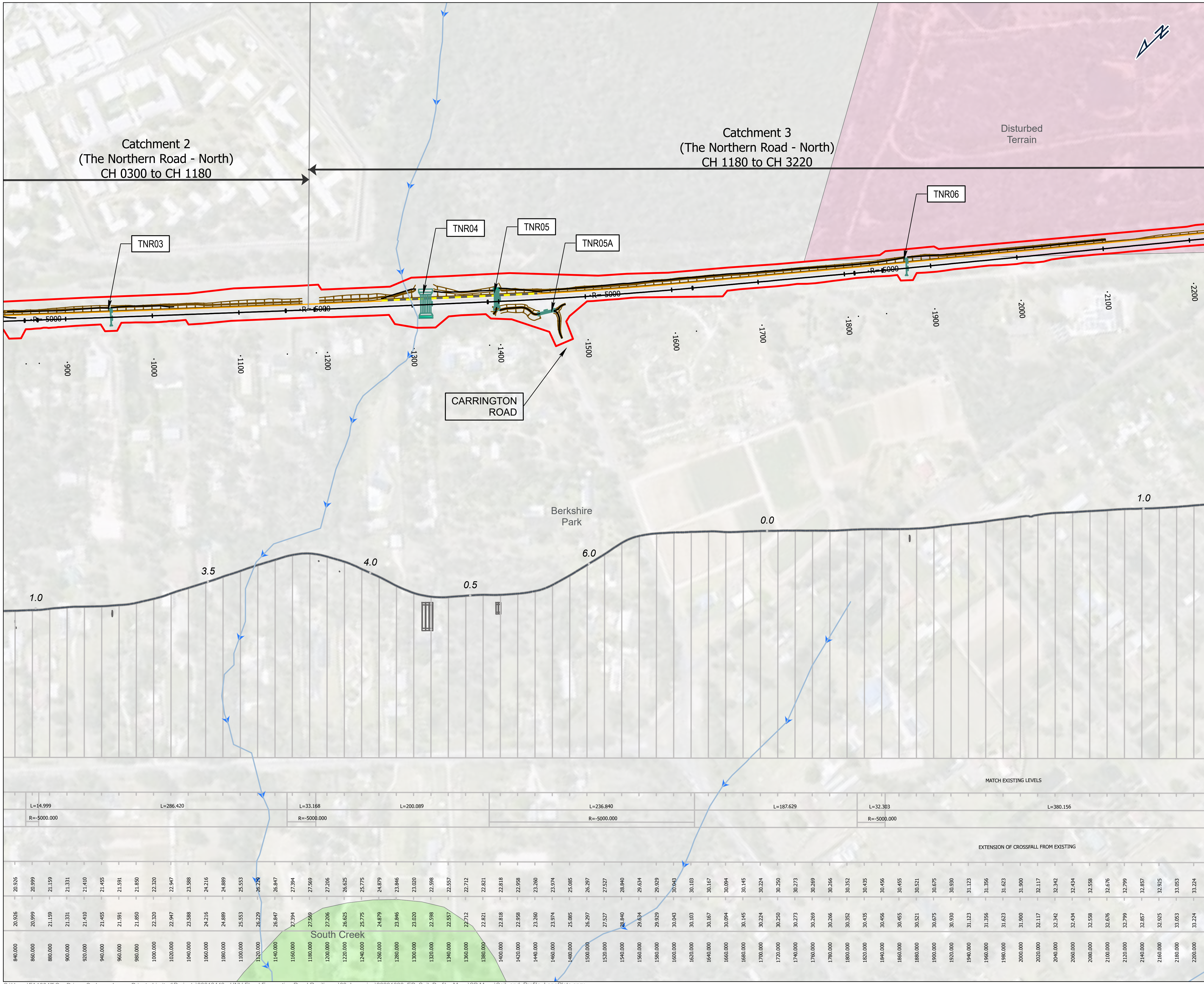


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## LEGEND

- Catchment
- Dimension
- Ground and Slope (%)
- Study Area

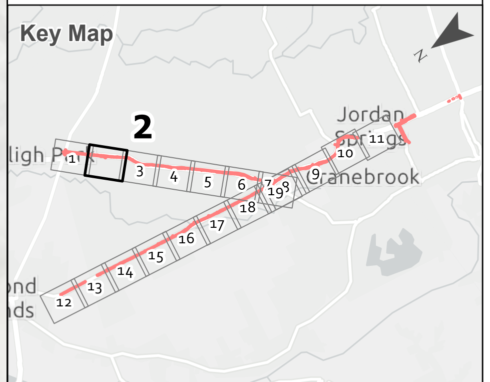
**Soil Landscape**

- Berkshire Park
- Disturbed Terrain
- South Creek

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map




SOURCES:
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5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 2 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
| CREATED BY: | FA13847 |
| DATE: | 11/06/2024 |
| VERSION: | DRAFT 1 |
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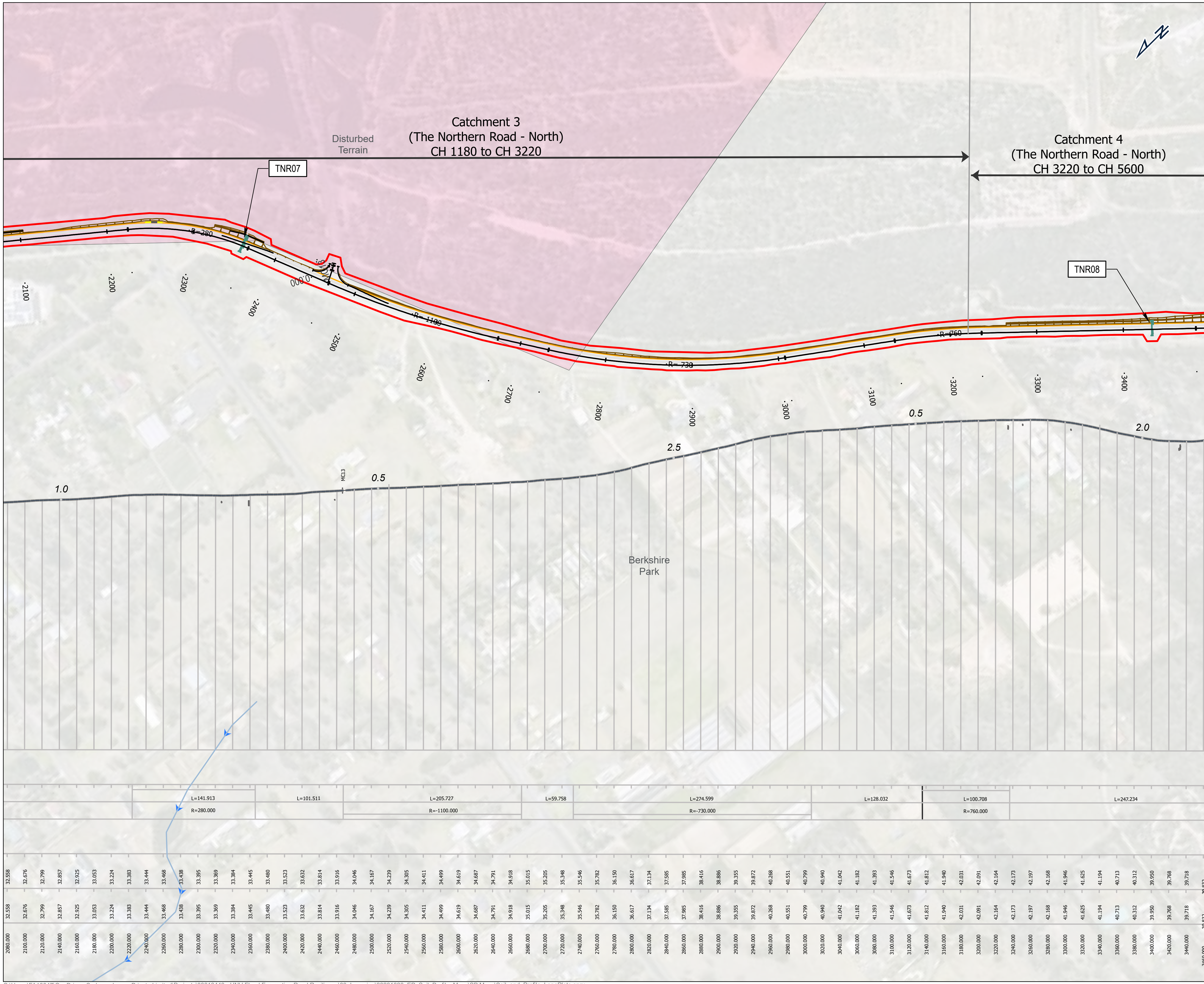


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

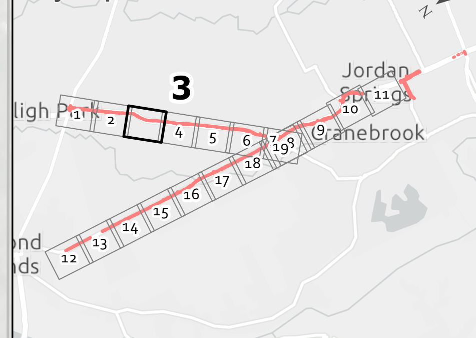
**Soil Landscape**

- Berkshire Park
- Disturbed Terrain

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 3 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
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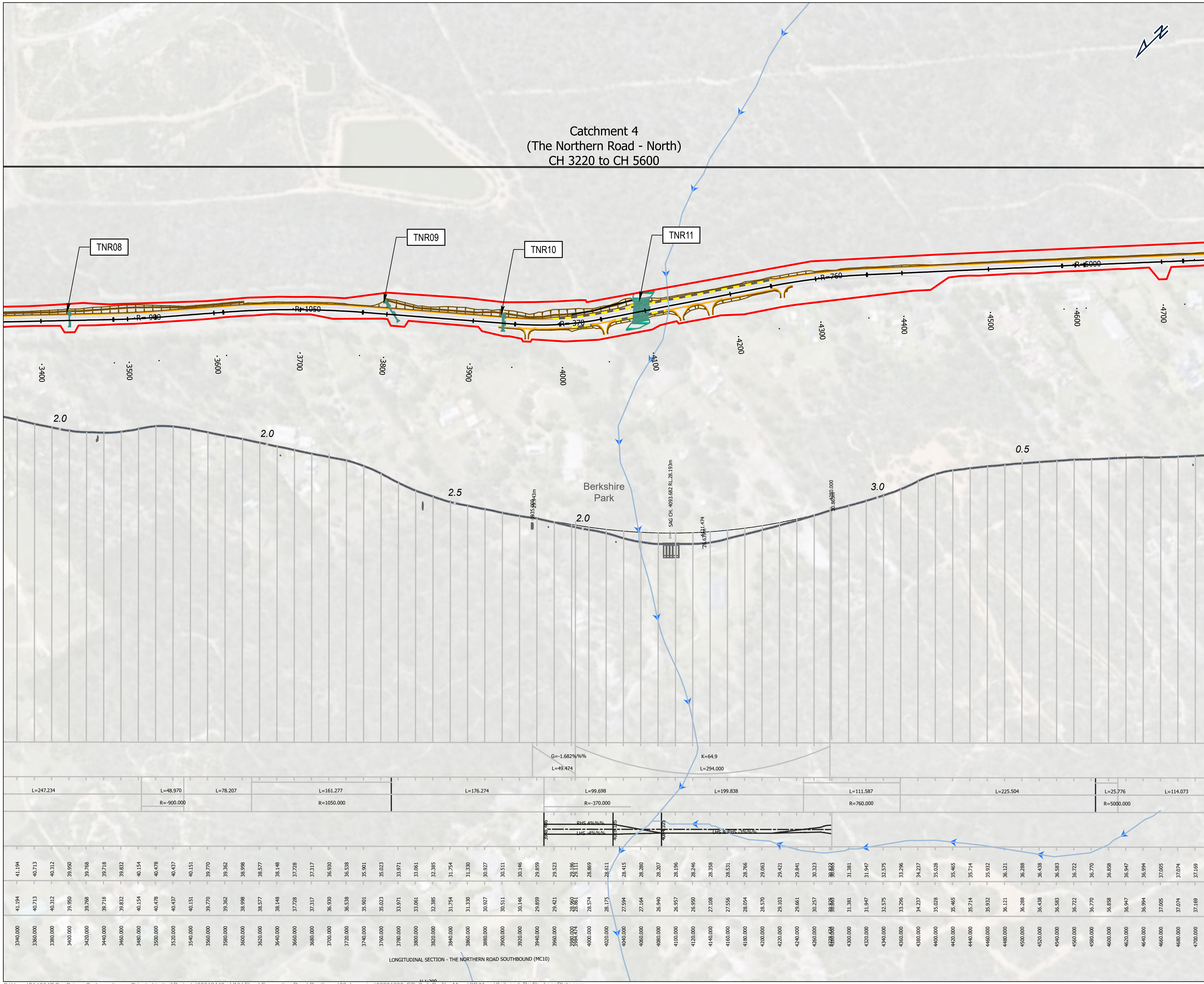


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map


SOURCES:
1. Roadnet MDS 2020
2. Transport and Water Theme © NSW Department of Finance and Services
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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 4 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
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DATE: 11/06/2024
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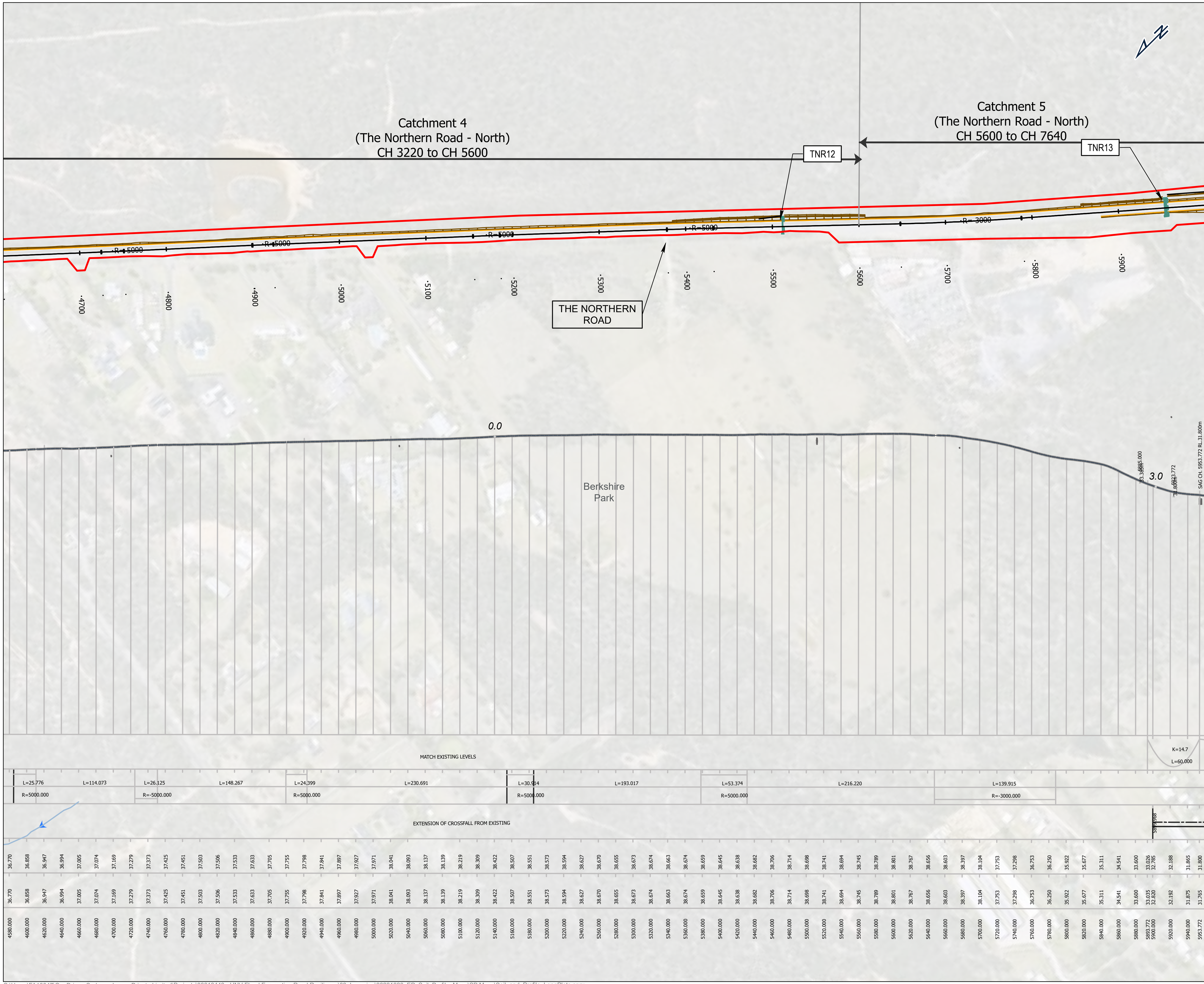


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

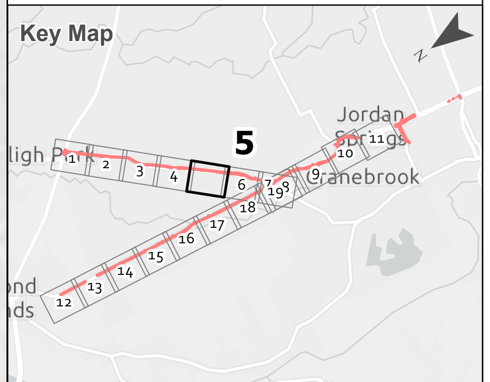
**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Linemarkings
- Culvert Head Walls

Key Map

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5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 5 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
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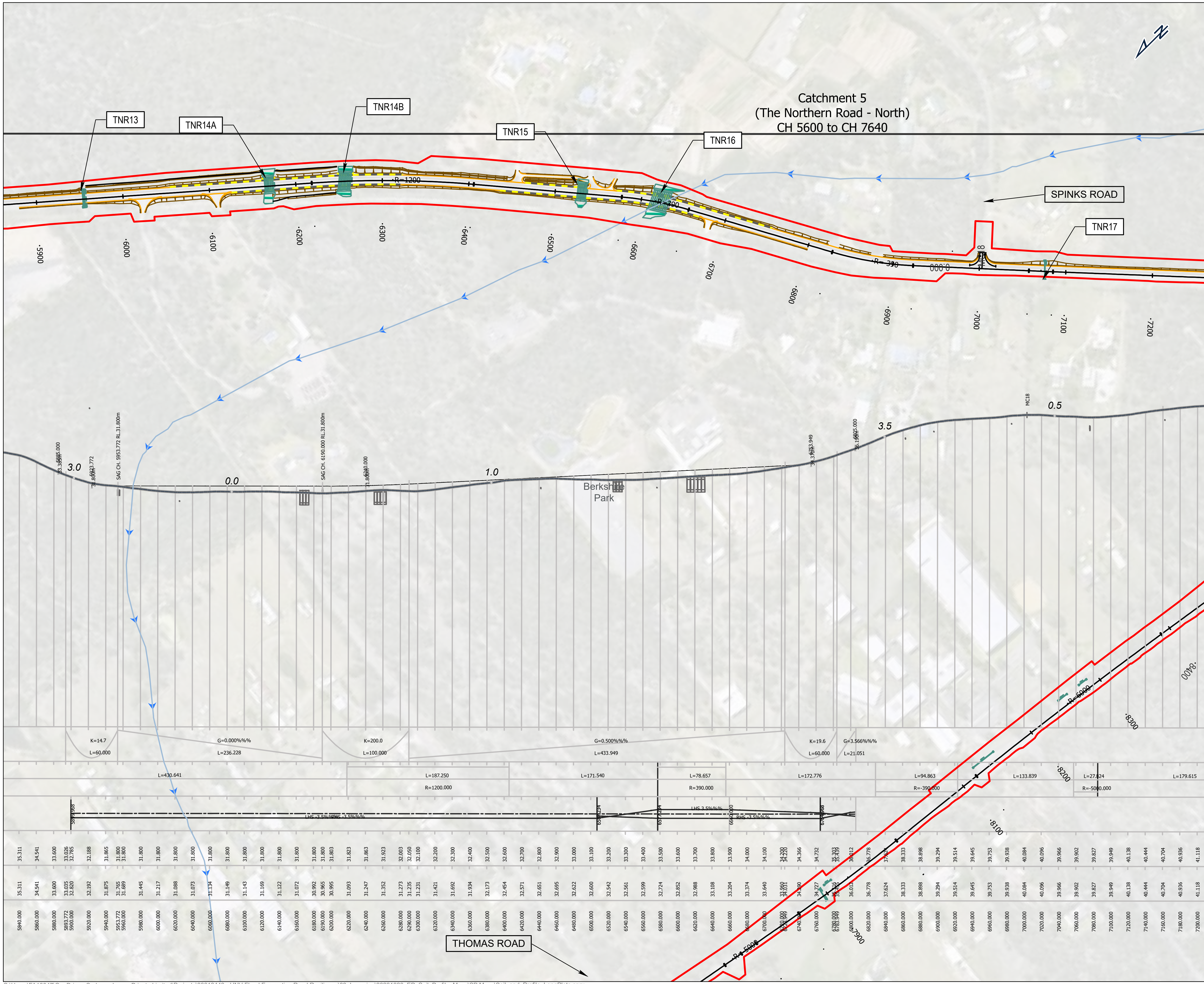


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## LEGEND

- Catchment
- Dimension
- Ground and Slope (%)
- Study Area

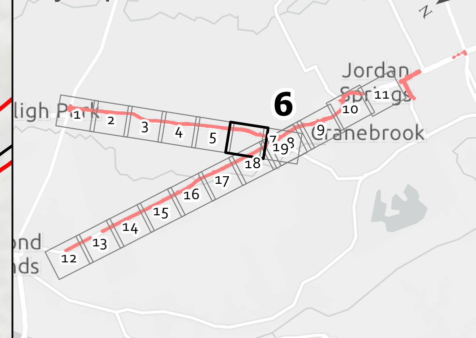
**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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3. MetroMap Imagery © Aerometrex Pty Ltd
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5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 6 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
| CREATED BY: | FA13847 |
| DATE: | 11/06/2024 |
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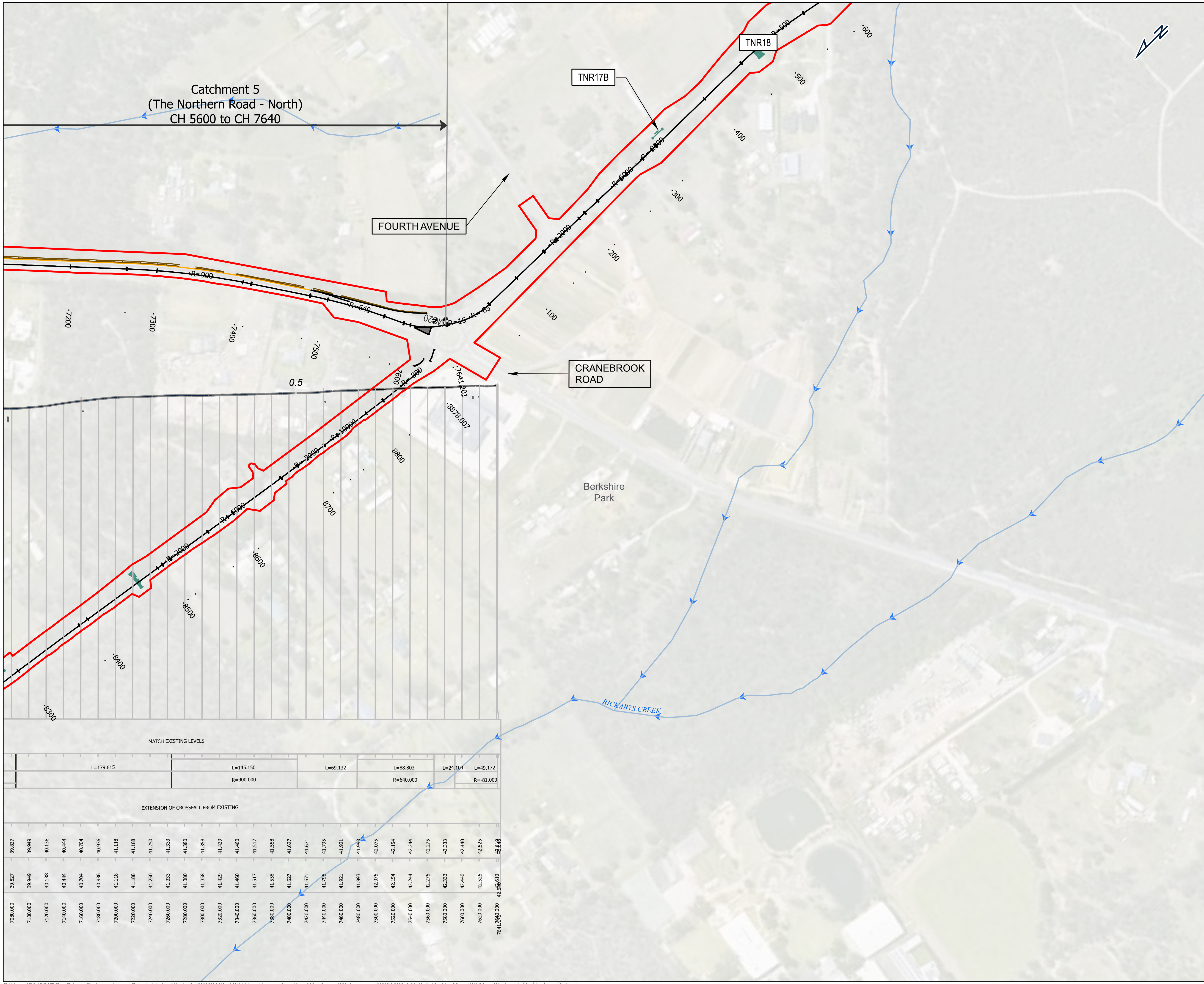


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

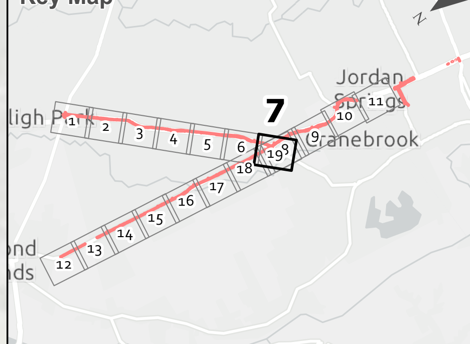
**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Control Line
- Road Edge
- Clearway
- Earthworks
- Linemarkings
- Culvert Head Walls

Key Map

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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 7 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
CREATED BY: FA13847
DATE: 11/06/2024
VERSION: DRAFT 1
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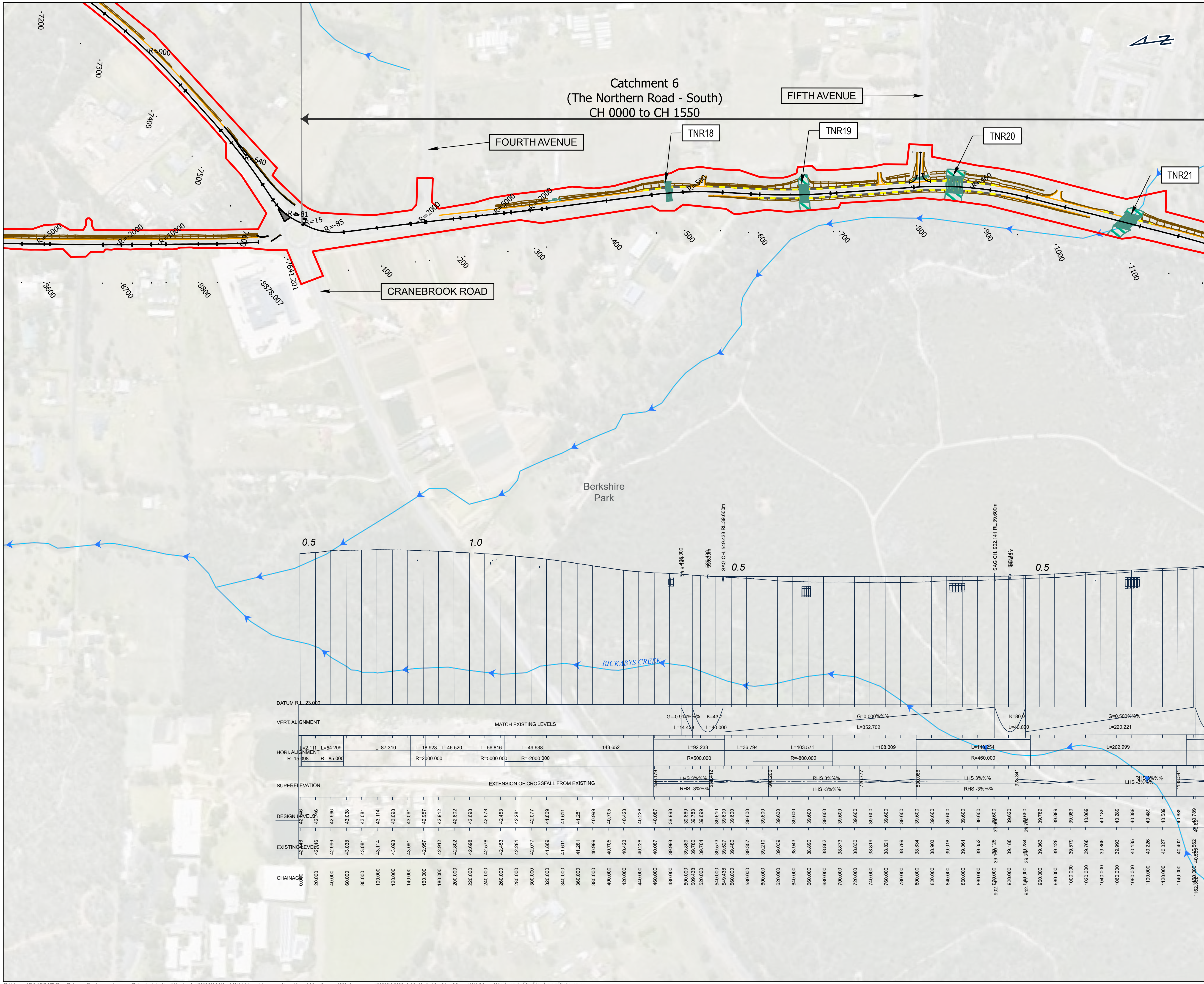


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

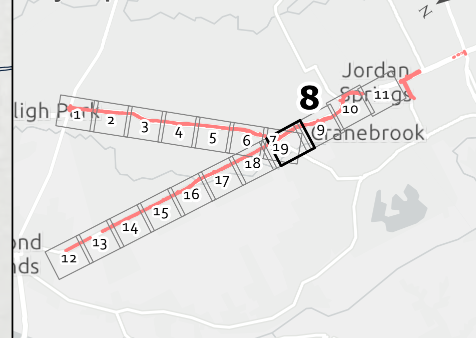
**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Control Line
- Road Edge
- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 8 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
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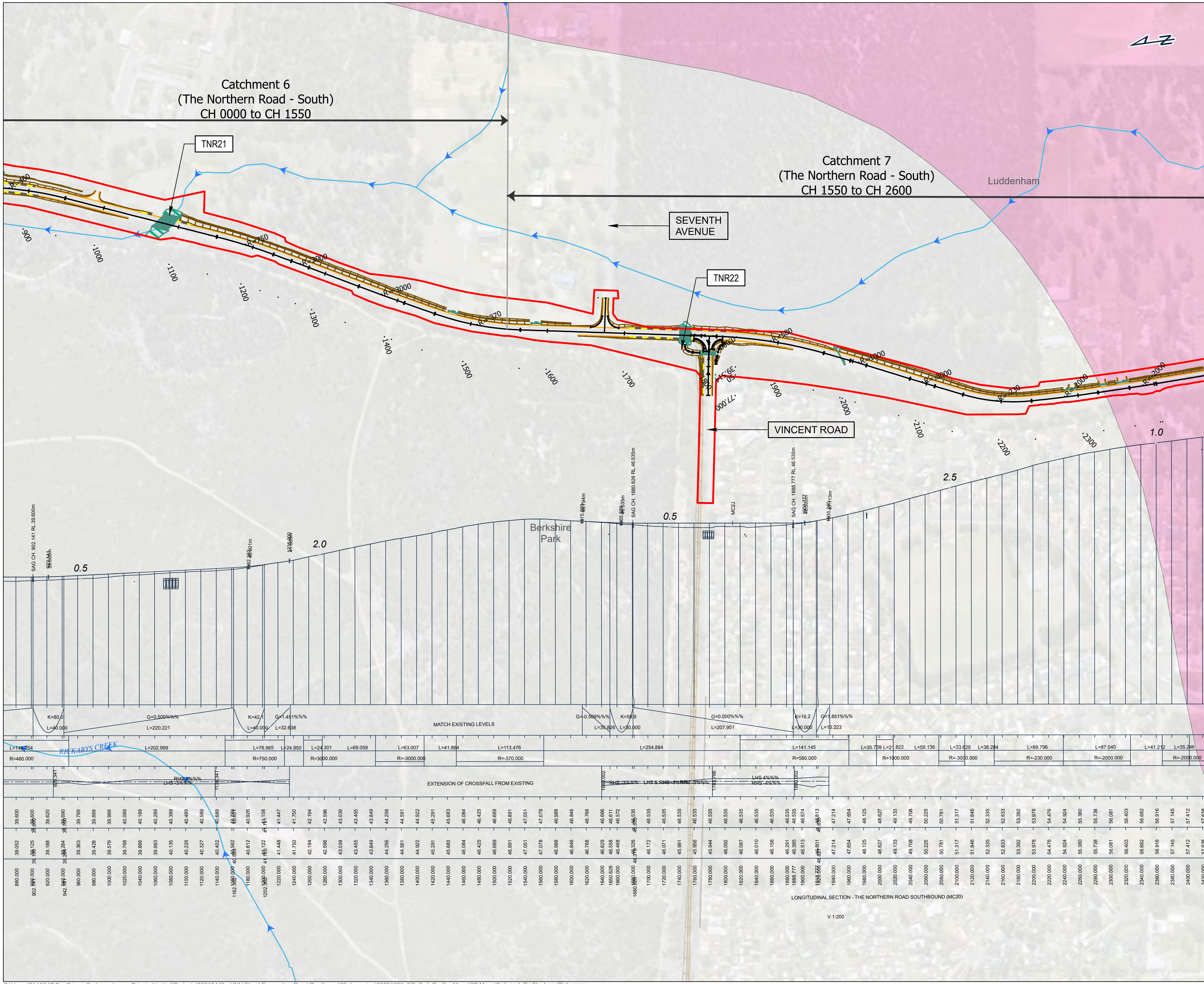


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

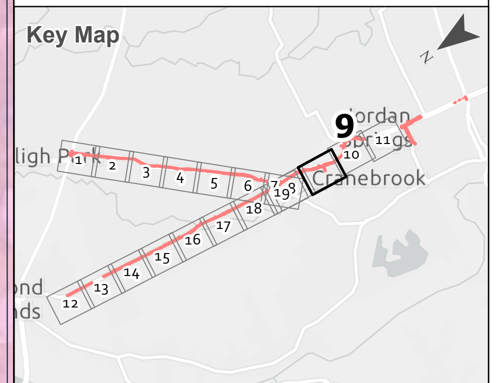
**Soil Landscape**

- Berkshire Park
- Luddenham

**Design 80% and Interface Projects**

- Road Edge
- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 9 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
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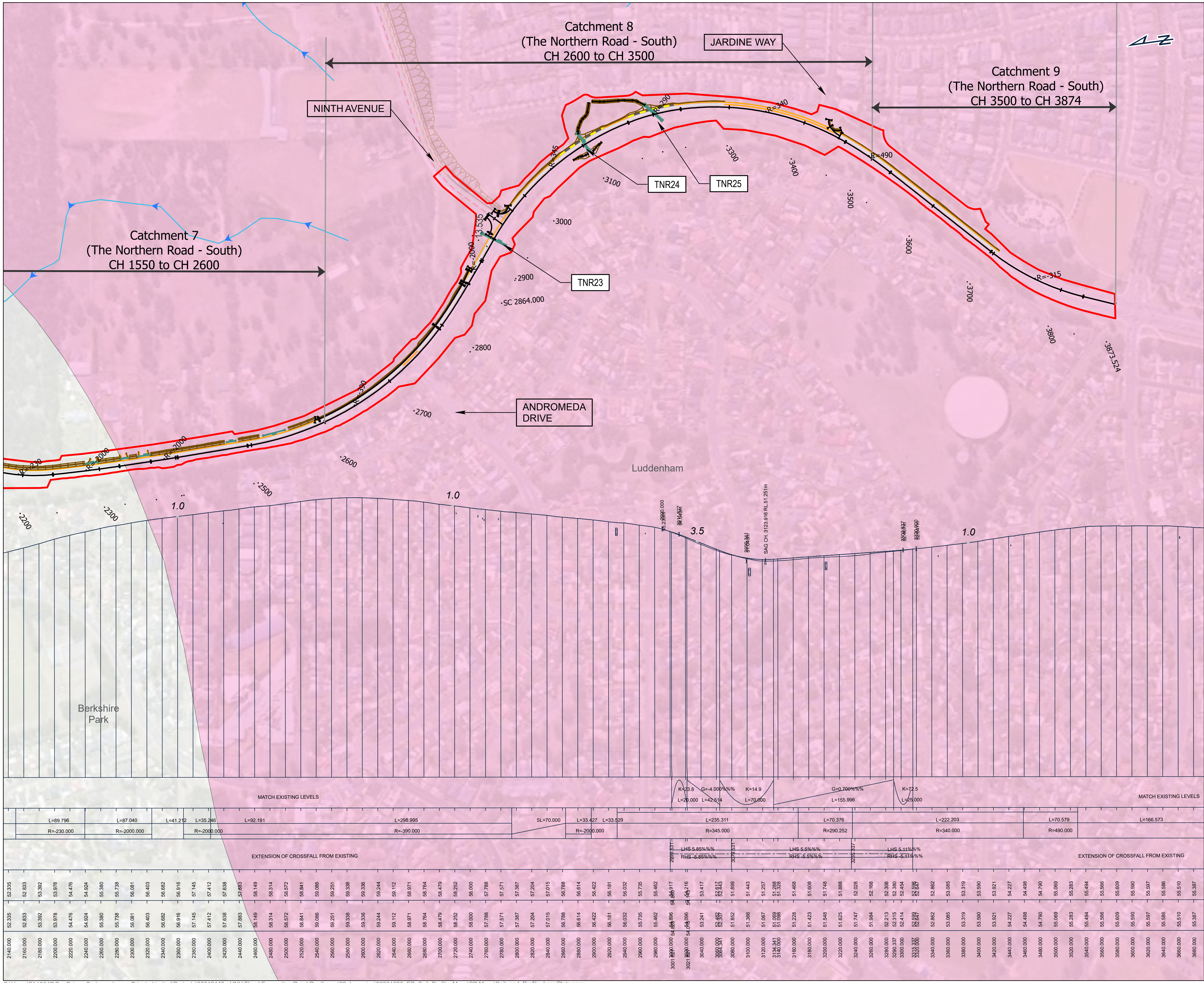


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

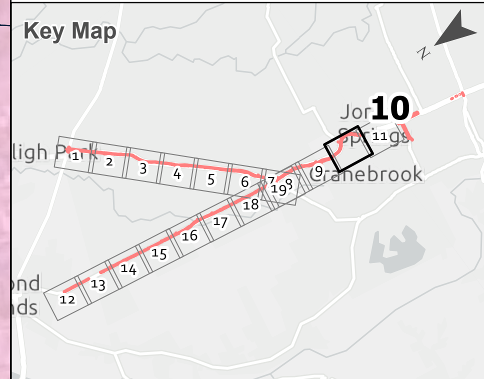
**Soil Landscape**

- Berkshire Park
- Luddenham

**Design 80% and Interface Projects**

- Road Edge
- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map



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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 10 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
CREATED BY: FA13847
DATE: 11/06/2024
VERSION: DRAFT 1
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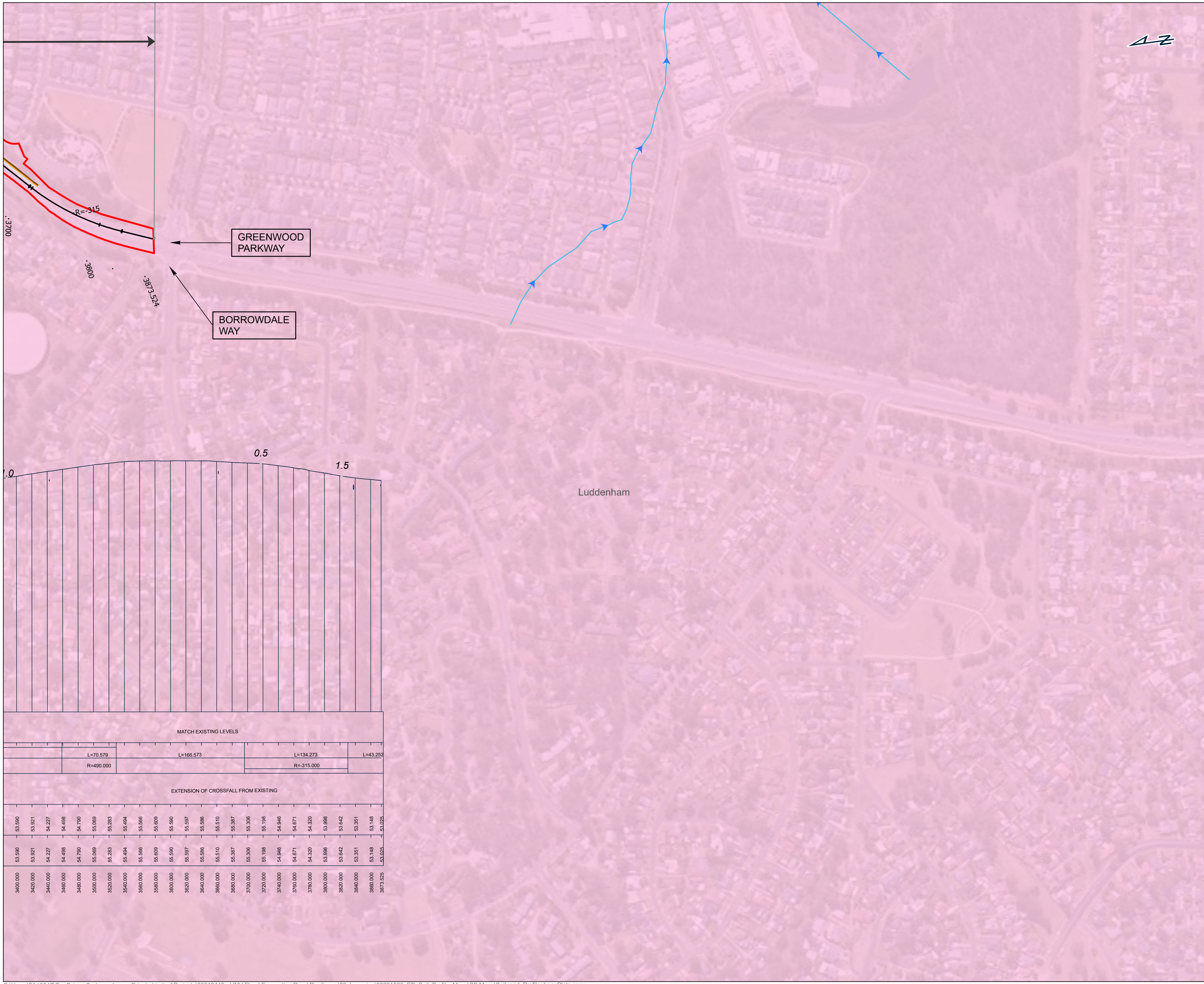


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## LEGEND

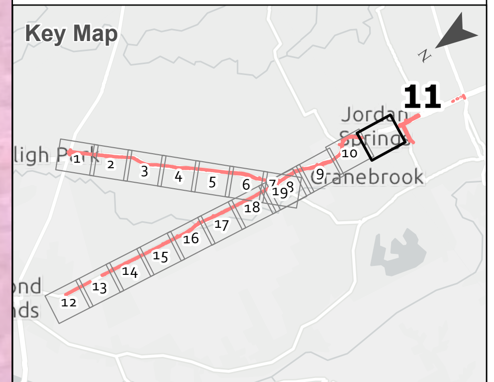
- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

**Soil Landscape**

- Luddenham

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Linemarkings

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5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 11 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
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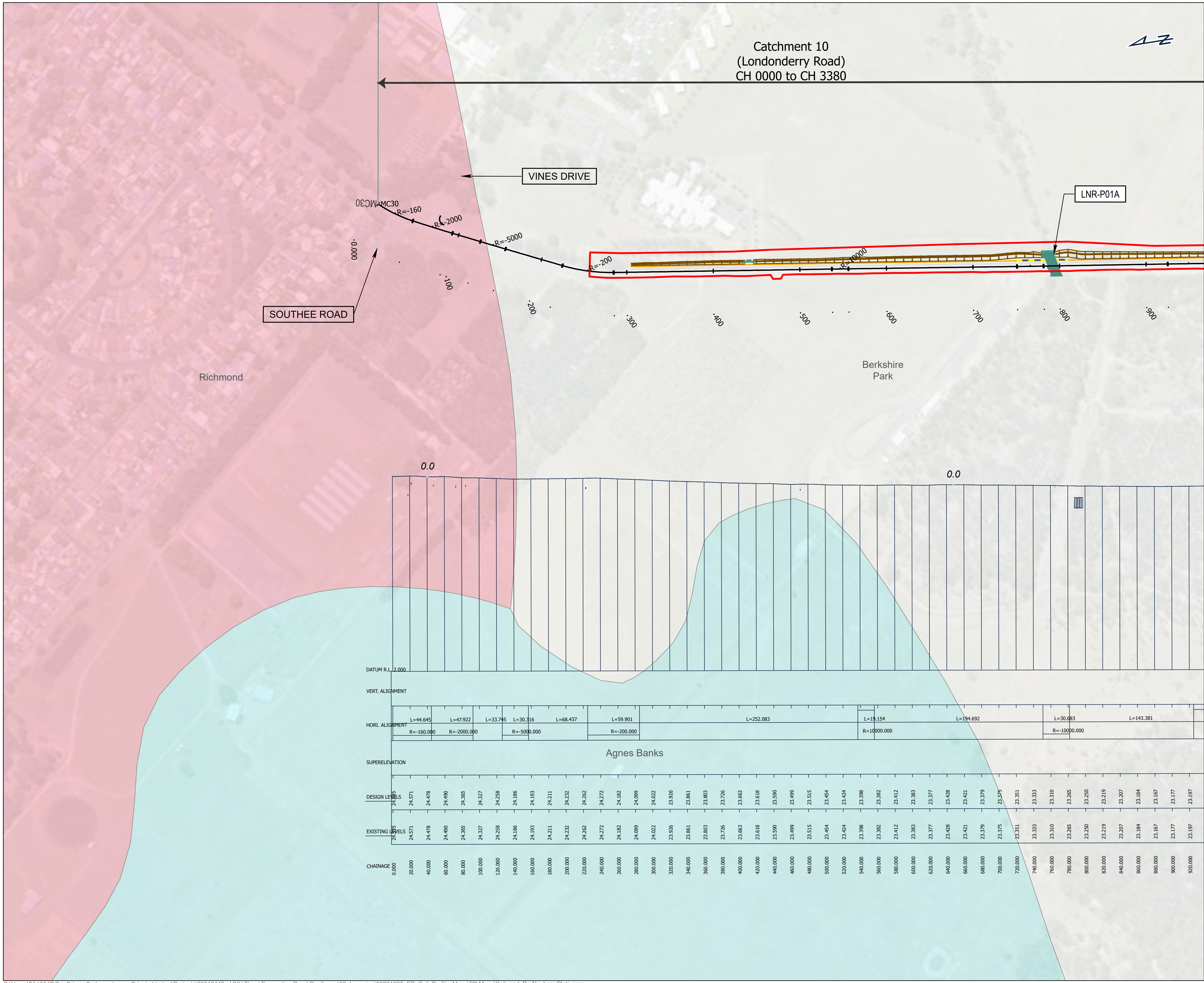


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

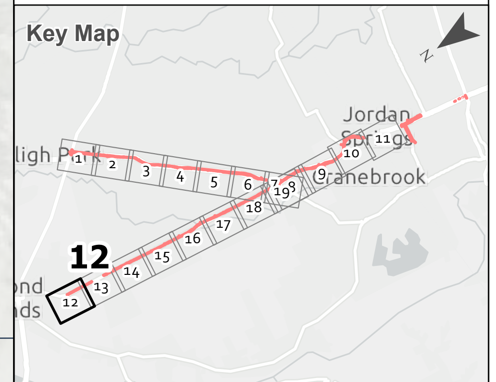
**Soil Landscape**

- Agnes Banks
- Berkshire Park
- Richmond

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 12 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
CREATED BY: FA13847
DATE: 13/06/2024
VERSION: DRAFT 1
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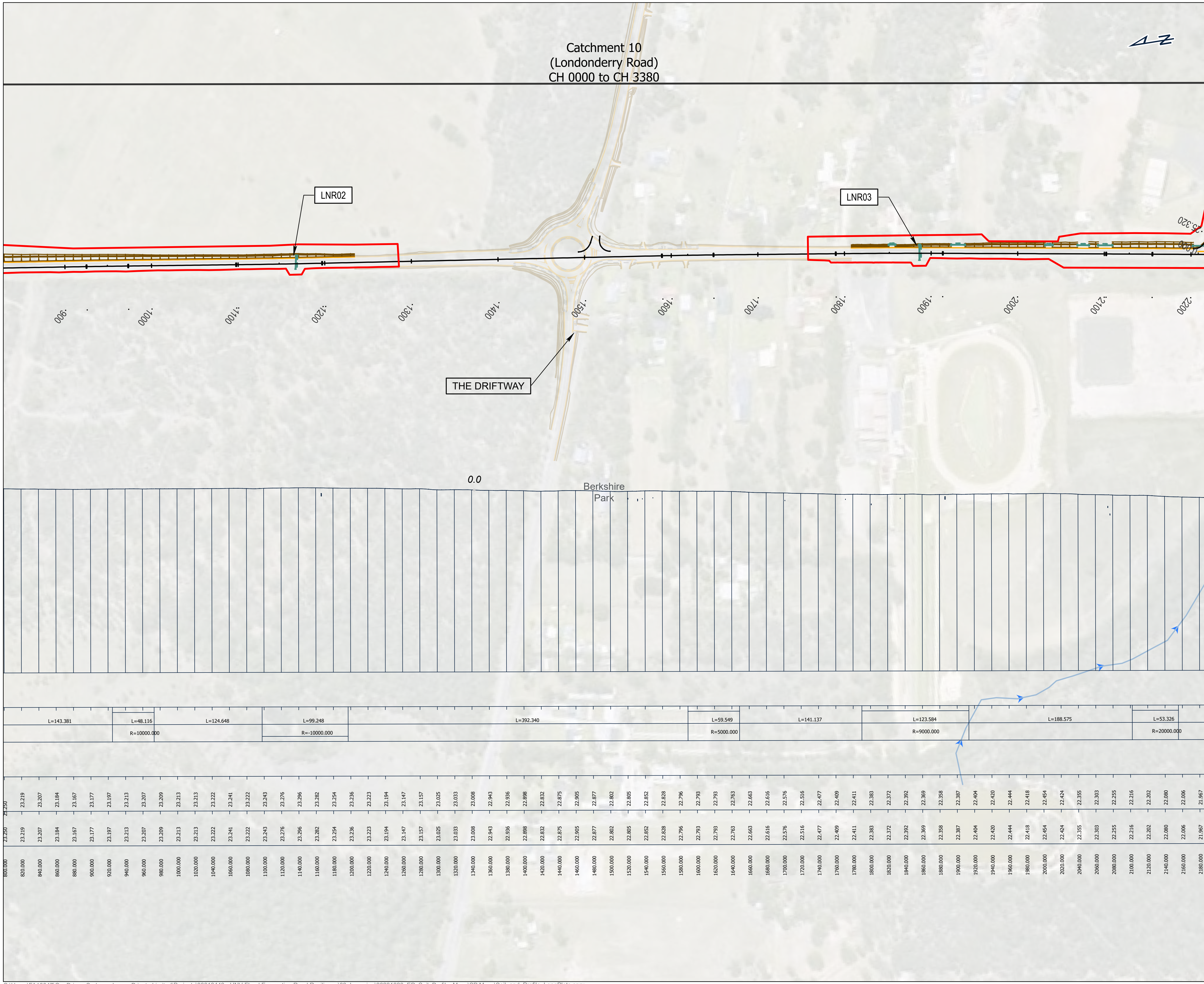


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## LEGEND

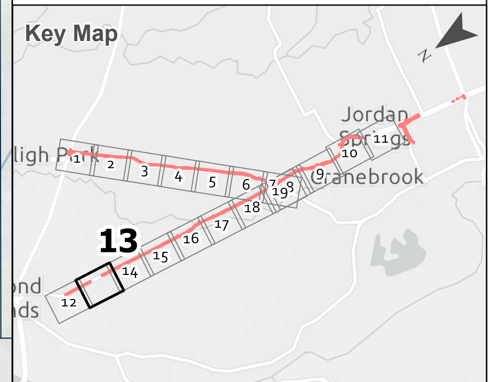
- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Control Line
- Clearway
- Earthworks
- Linemarkings
- Culvert Head Walls

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5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 13 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
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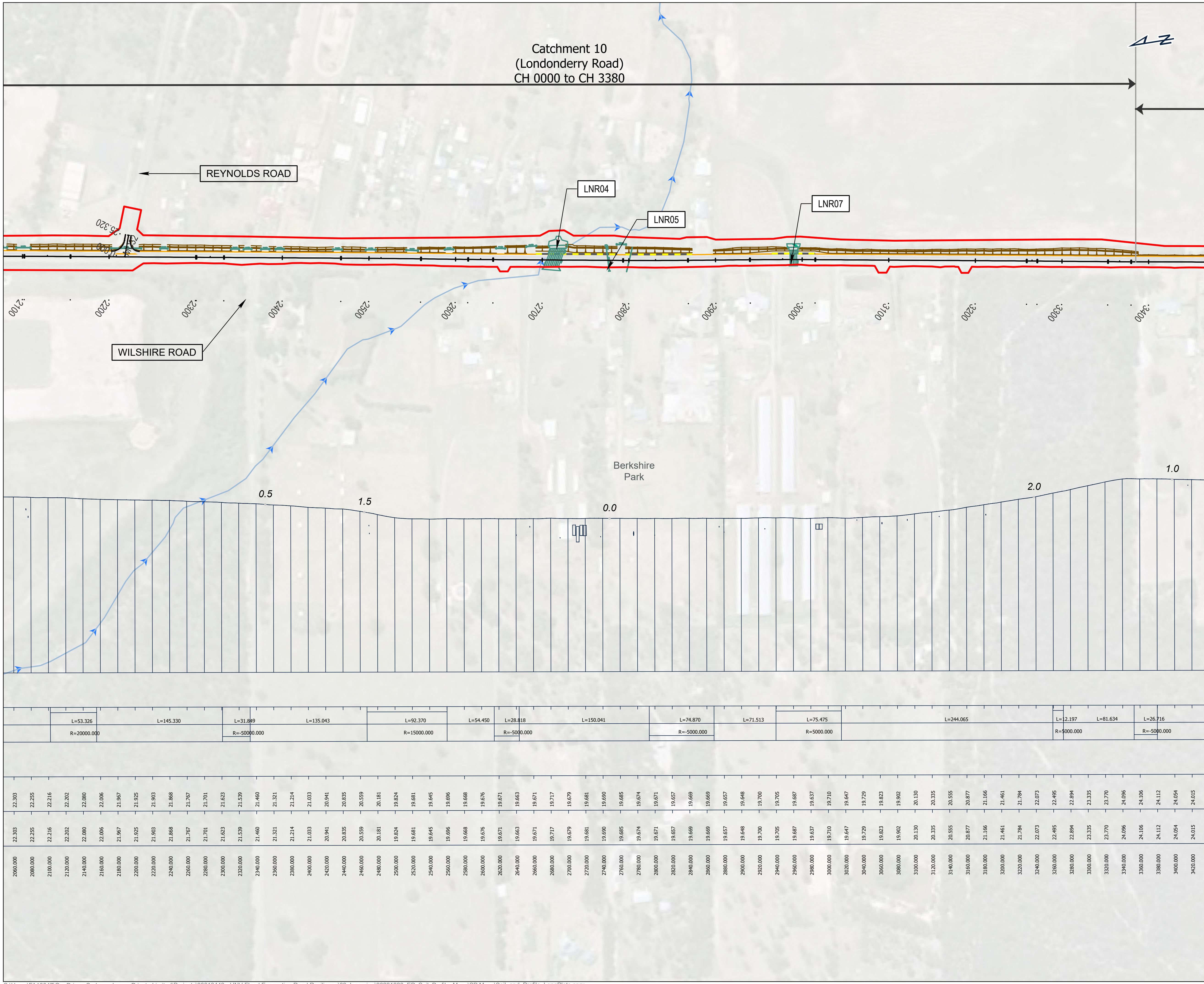


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0 50 100 150
Meters
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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

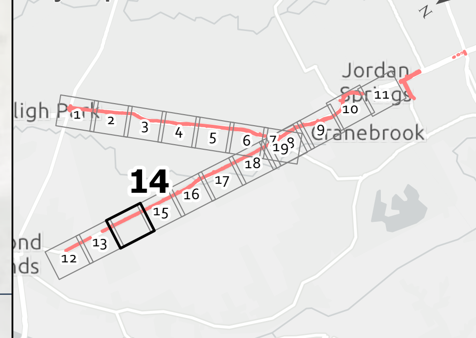
**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Control Line
- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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5. Basemap: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



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|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 14 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
| CREATED BY: | FA13847 |
| DATE: | 12/06/2024 |
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| PAGE SIZE: | A3 |

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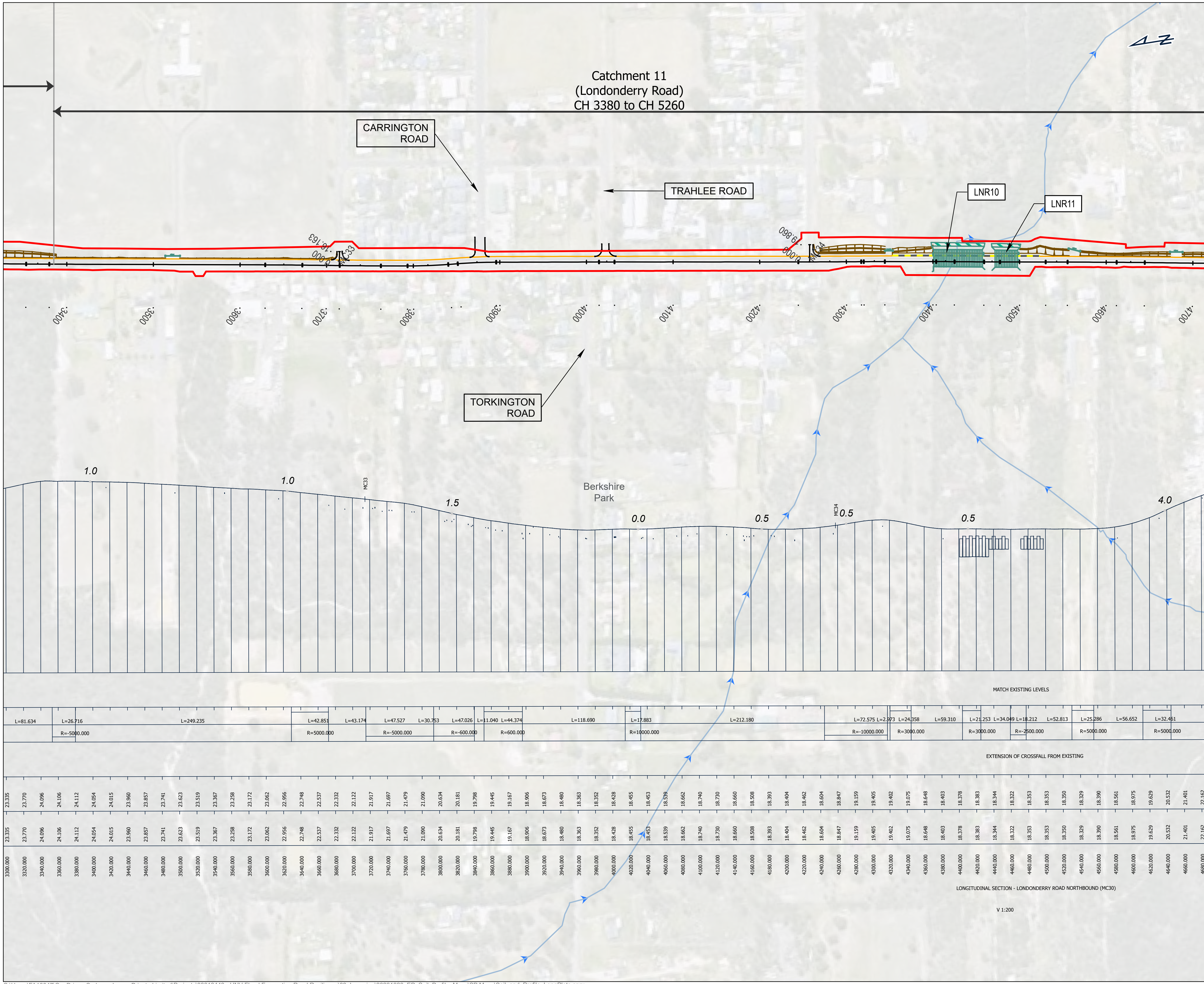


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

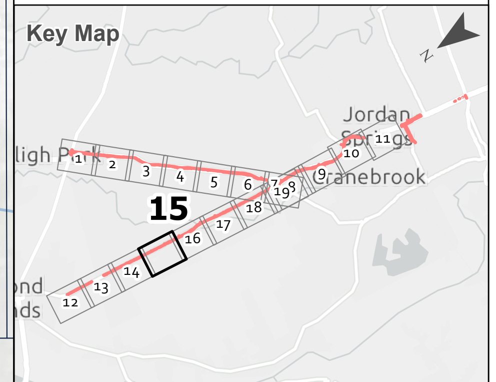
**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 15 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
CREATED BY: FA13847
DATE: 12/06/2024
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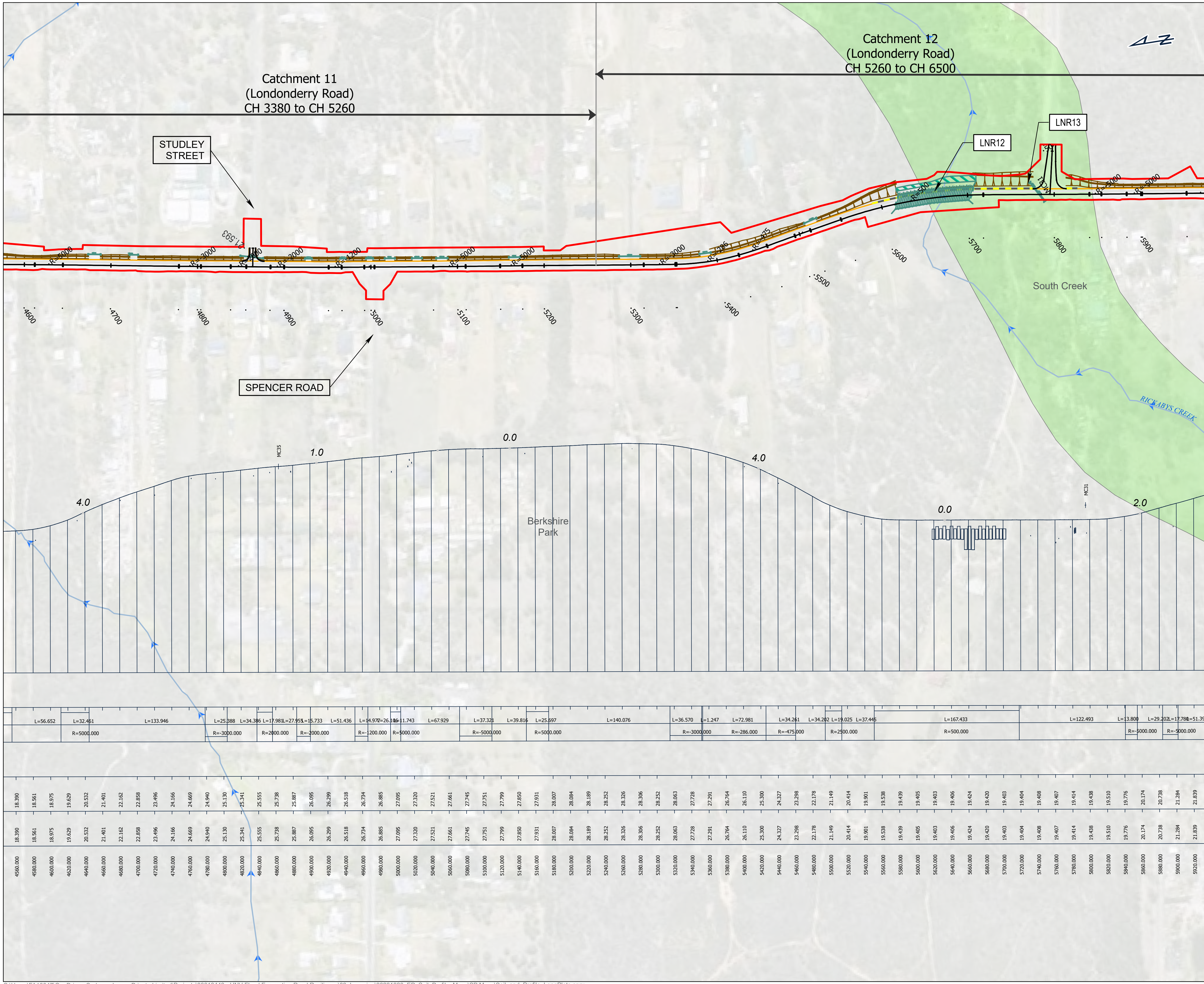


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

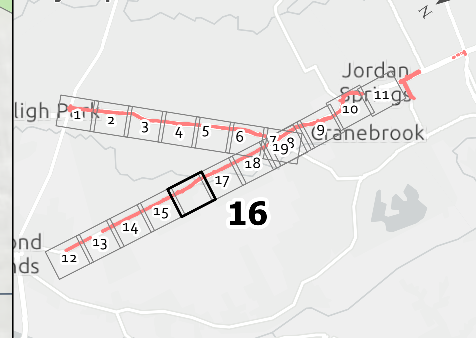
**Soil Landscape**

- Berkshire Park
- South Creek

**Design 80% and Interface Projects**

- Control Line
- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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| | |
|---|---|
| PROJECT: | Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project |
| PROJECT NO: | 30013443 |
| FIGURE NO: | 16 of 19 |
| FIGURE TITLE: | Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment |
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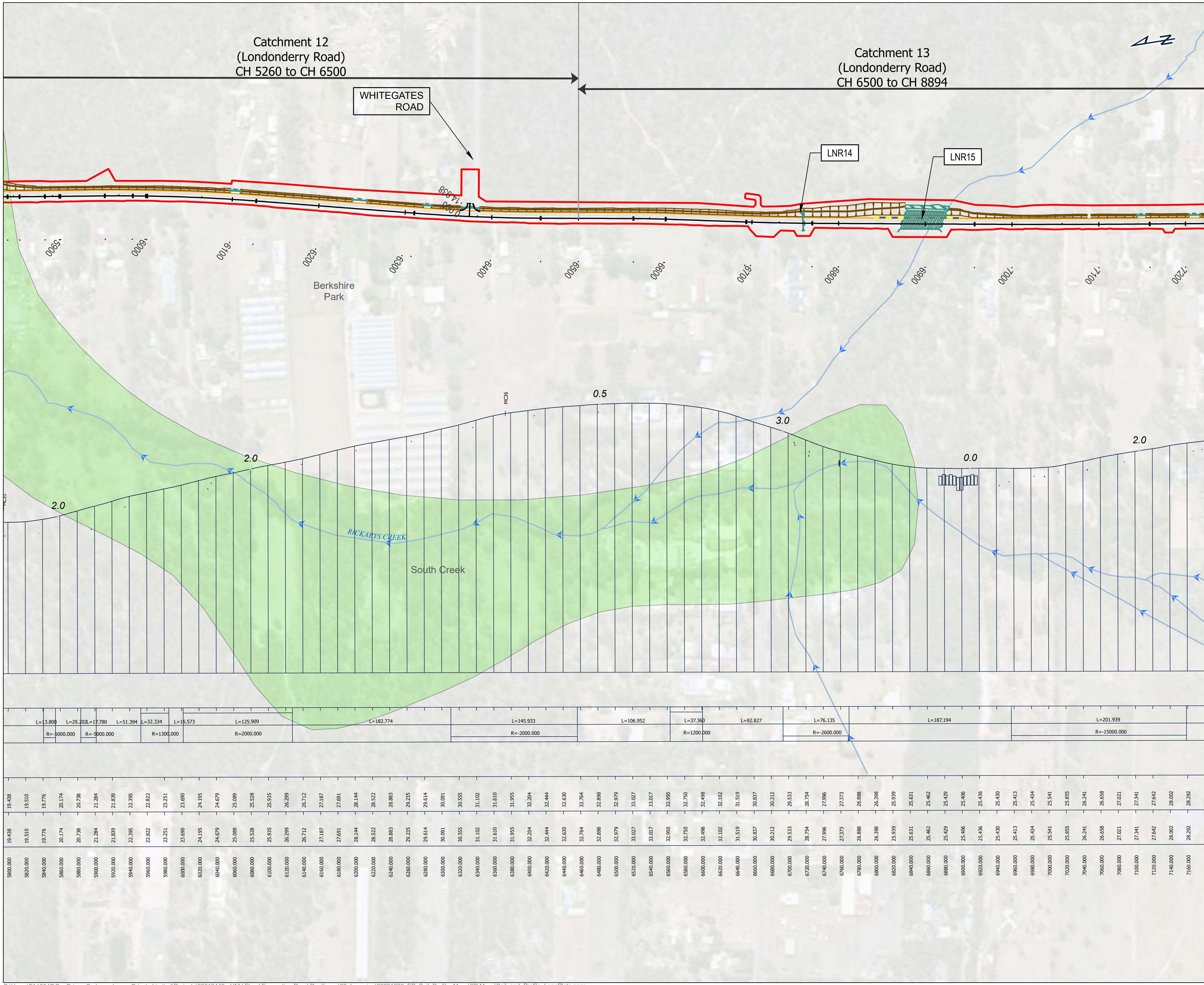


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

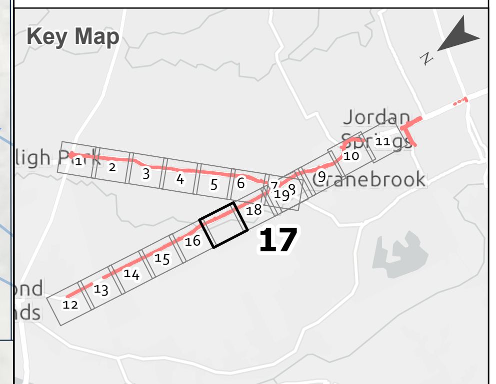
**Soil Landscape**

- Berkshire Park
- South Creek

**Design 80% and Interface Projects**

- Control Line
- Clearway
- Earthworks
- Safety Barrier
- Linemarkings
- Culvert Head Walls

Key Map

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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 17 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
CREATED BY: FA13847
DATE: 12/06/2024
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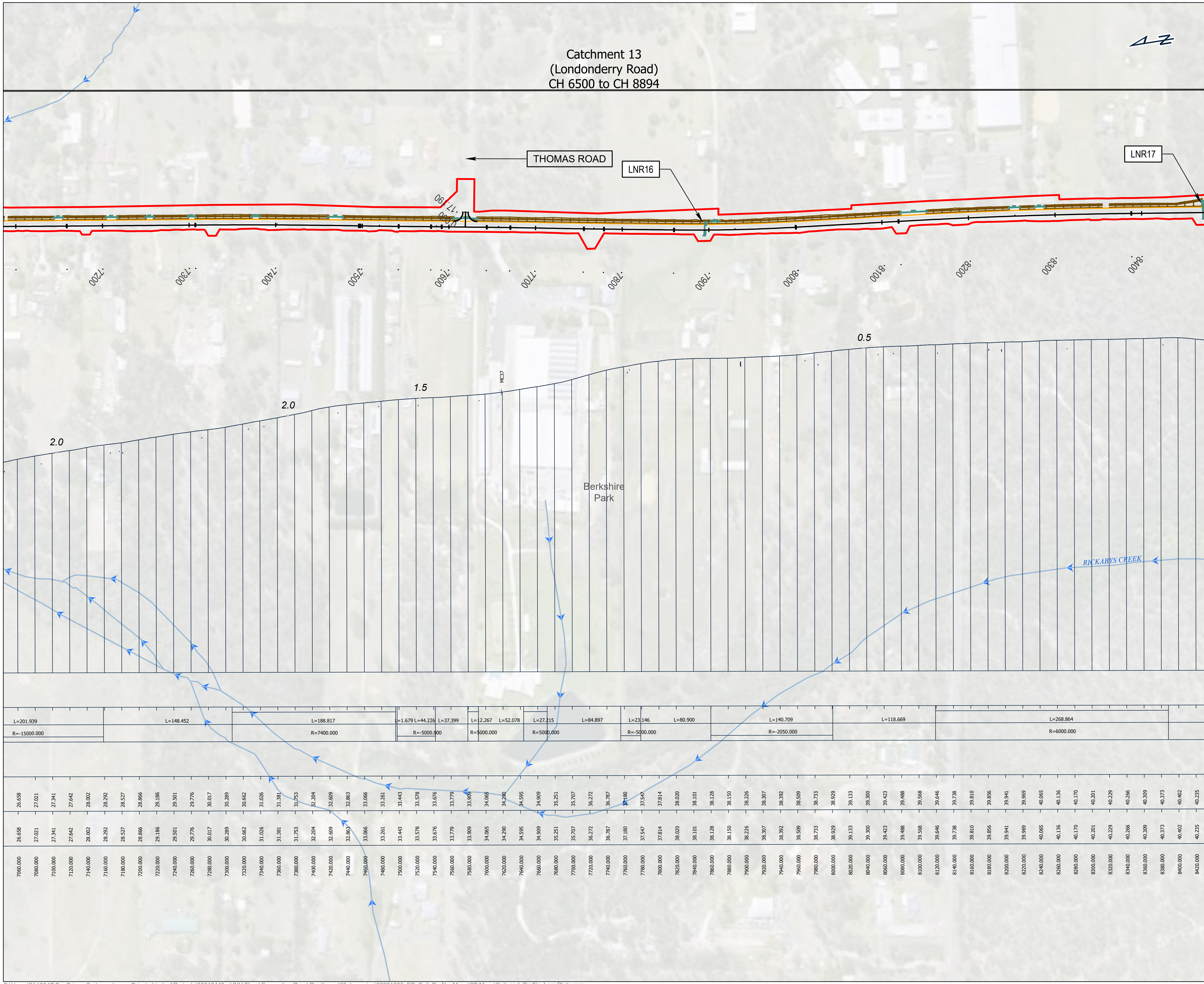


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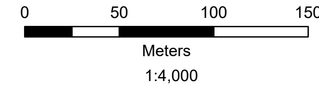



## LEGEND

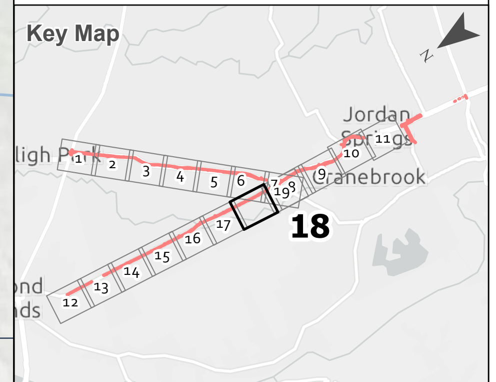
- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Control Line
- Clearway
- Earthworks
- Linemarkings
- Culvert Head Walls

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**PROJECT NO:** 30013443
**FIGURE NO:** 18 of 19
**FIGURE TITLE:** Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
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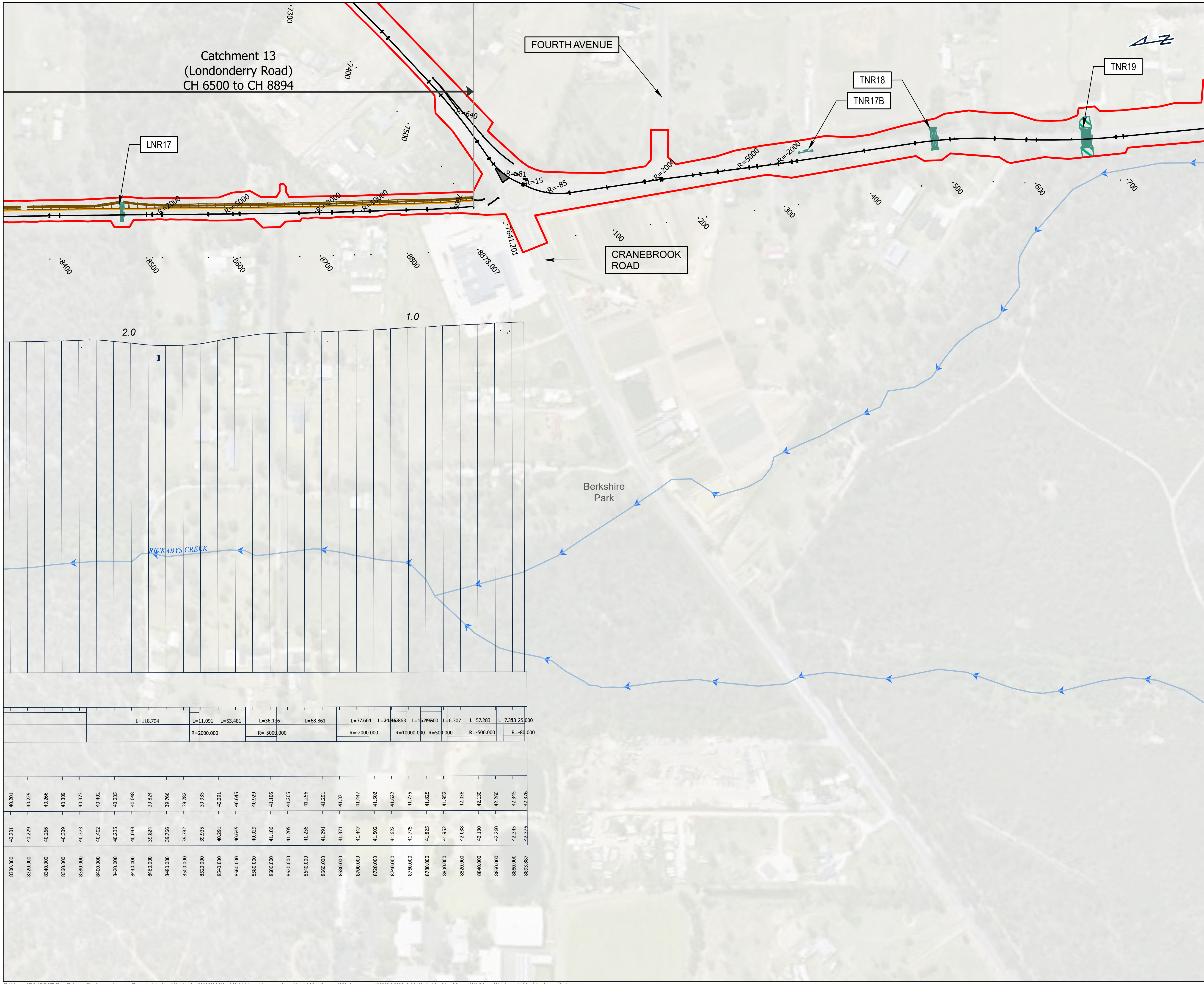


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## LEGEND

- Catchment
- Dimension
- 2.0 Ground and Slope (%)
- Study Area

**Soil Landscape**

- Berkshire Park

**Design 80% and Interface Projects**

- Control Line
- Road Edge
- Clearway
- Earthworks
- Linemarkings
- Culvert Head Walls

Key Map

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PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 19 of 19
FIGURE TITLE: Appendix B1 PESA Trigger 2 Soil Landscape and Proposal Elevation in Catchments for Erosion Hazard Assessment
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# B-2 Regional Geology

Note that this series of figures comprises 9 sheets.


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**LEGEND**

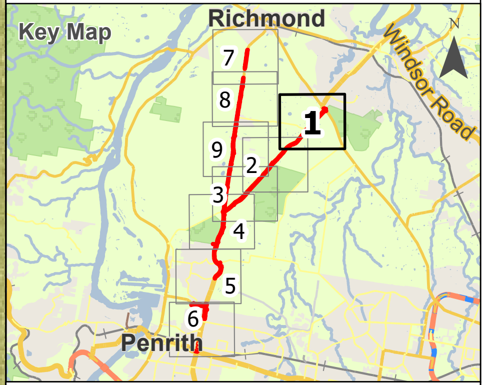
- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Geological boundary, position approximate
- Linearment
- Syncline, position accurate

**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- CZ_a - Unconsolidated alluvial clay, silt, sand, and gravel deposits.
- NM__d - Clay, patches of ferruginised, consolidated sand.
- NM__i - Conglomerate, matrix-supported.
- Q_af - Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.

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3. Colquhoun GP, Hughes KS, Deyssing L, Ballard JC, Folkes CB, Phillips G, Troedson AL and Fitzherbert JA (2023) 'New South Wales Seamless Geology dataset (Single Layer)', version 2.3 [dataset]. Geological Survey of New South Wales, Department of Regional NSW, Maitland.
4. Basemap:



**PROJECT:** Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
**PROJECT NO:** 30013443
**FIGURE NO:** 1 of 9
**FIGURE TITLE:** Appendix B2 - Regional Geology
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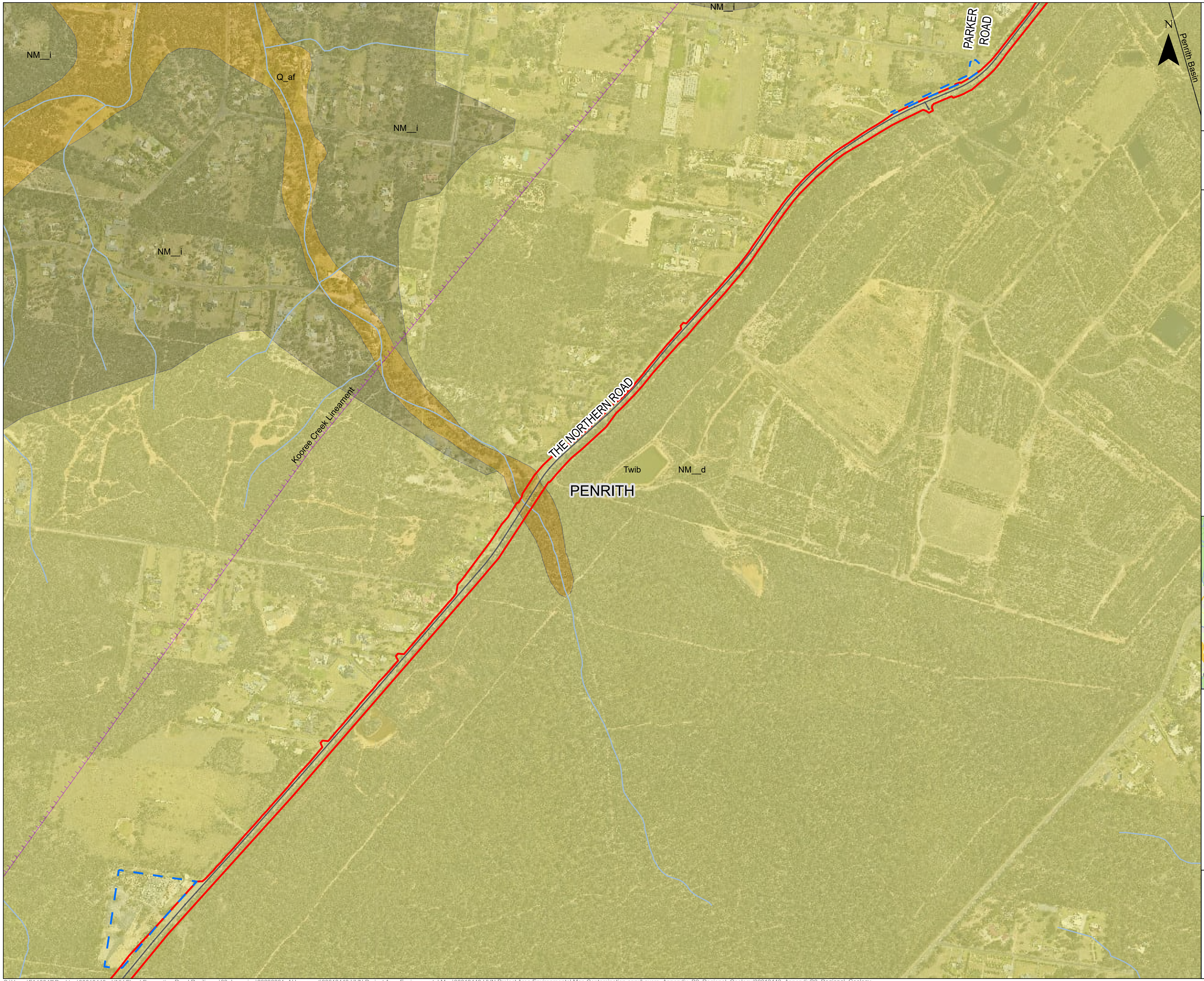


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## LEGEND

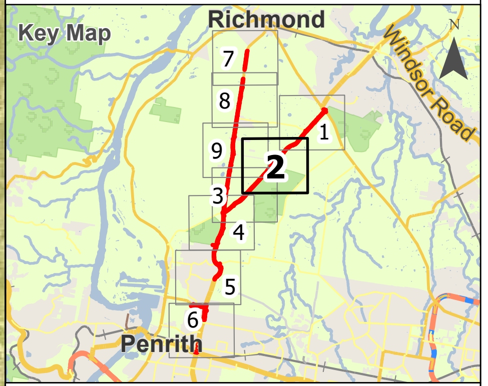
- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Lineament
- Syncline, position accurate

**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- NM__d - Clay, patches of ferruginised, consolidated sand.
- NM__i - Conglomerate, matrix-supported.
- Q_af - Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.

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4. Basemap:



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**PROJECT NO:** 30013443
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**FIGURE TITLE:** Appendix B2 - Regional Geology
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## LEGEND

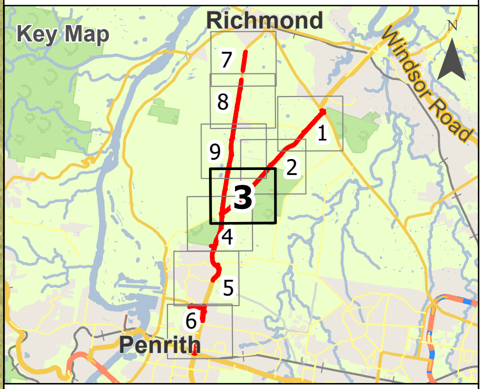
- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Lineament

**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- NM__d - Clay, patches of ferruginised, consolidated sand.
- NM__i - Conglomerate, matrix-supported.
- Q_af - Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.

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4. Basemap:



**PROJECT:** Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
**PROJECT NO:** 30013443
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**FIGURE TITLE:** Appendix B2 - Regional Geology
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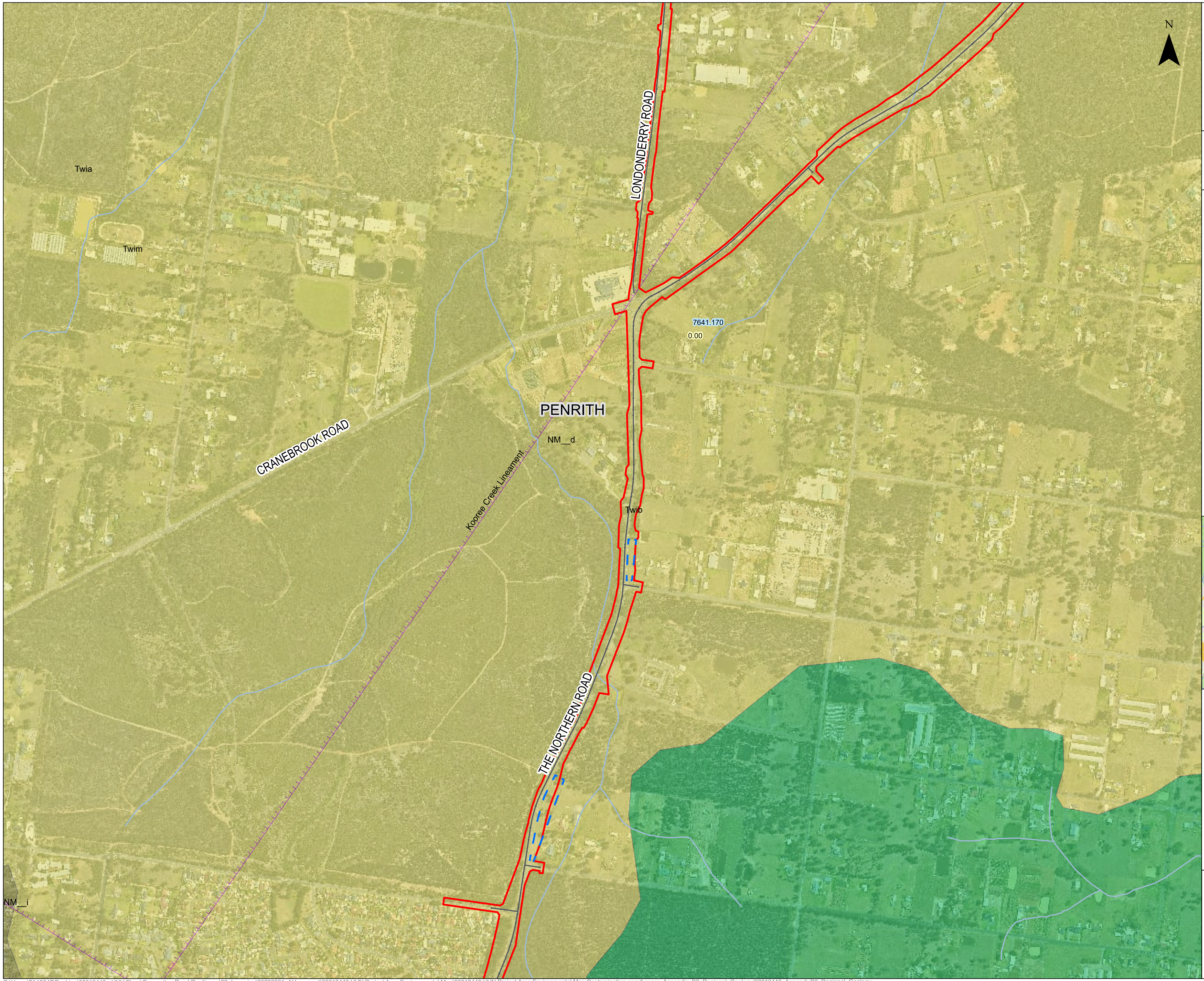


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## LEGEND

- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Geological boundary, inferred
- Linearment

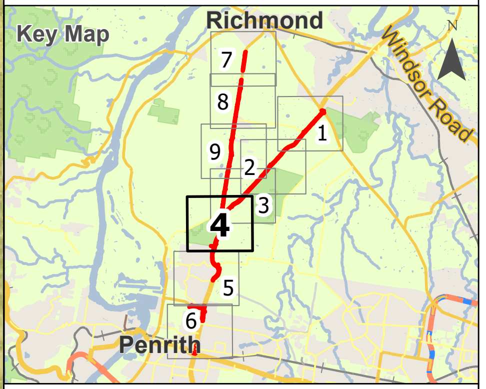
**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- NM__d - Clay, patches of ferruginised, consolidated sand.
- NM__i - Conglomerate, matrix-supported.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twia - Ashfield Shale: Black to light grey shale and laminite.
- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.
- Twim - Minchinbury Sandstone: Fine- to medium-grained lithic sandstone.

Key Map

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4. Basemap:



**PROJECT:** Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
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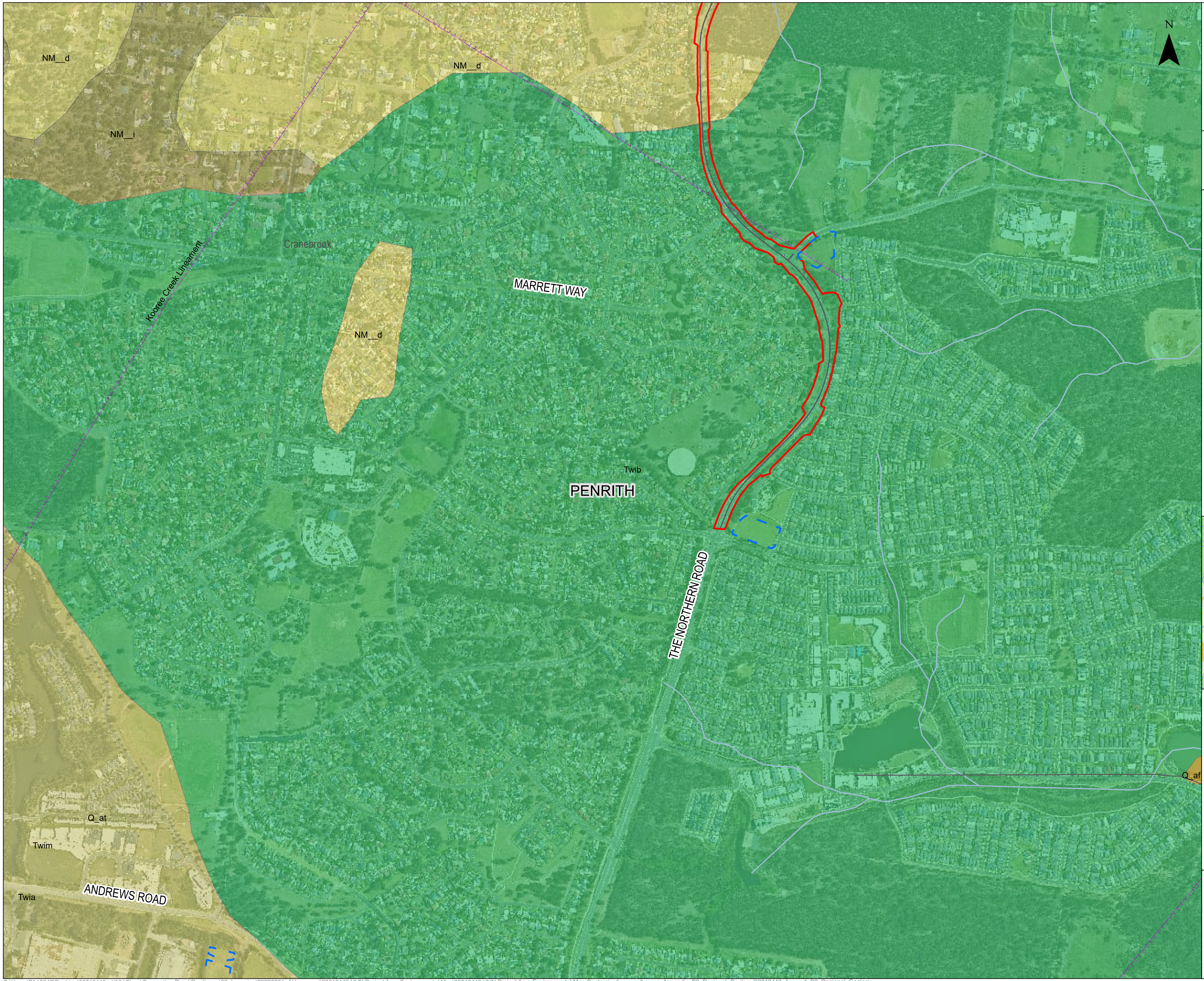


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**LEGEND**

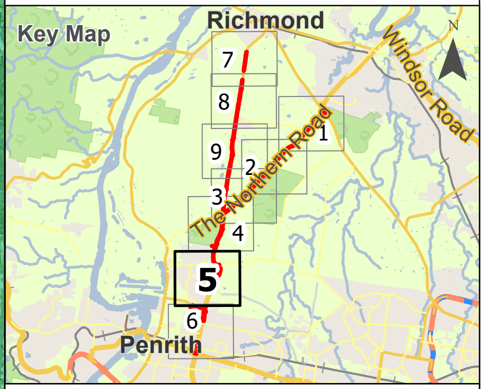
- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Geological boundary, inferred
- Lineament

**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- NM__d - Clay, patches of ferruginised, consolidated sand.
- NM__i - Conglomerate, matrix-supported.
- Q_af - Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.
- Q_at - Silt, clay, (fluvially-deposited) fine- to medium-grained quartz-lithic sand, polymictic gravel.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twia - Ashfield Shale: Black to light grey shale and laminite.
- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.
- Twim - Minchinbury Sandstone: Fine- to medium-grained lithic sandstone.

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4. Basemap:



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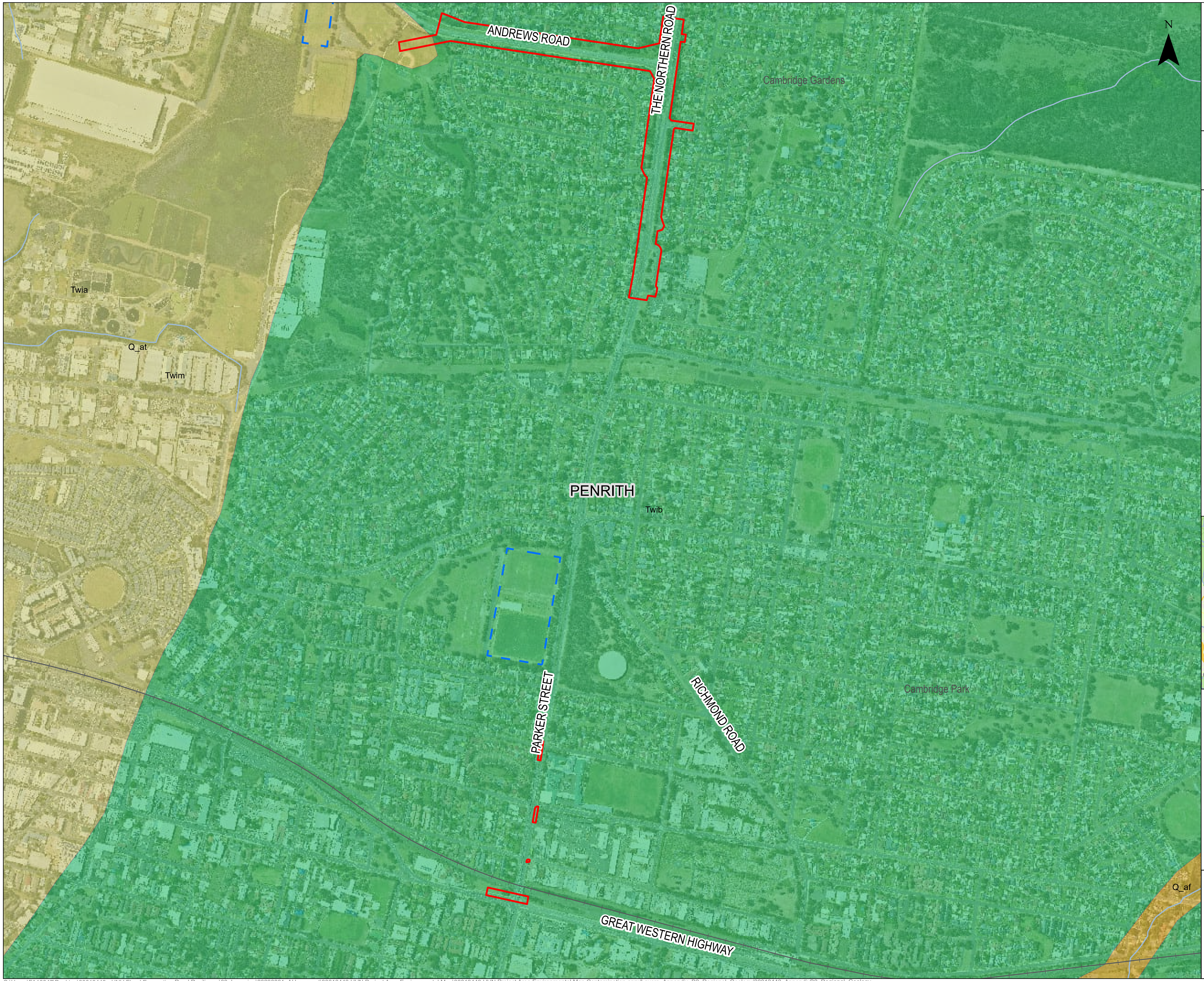


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**LEGEND**

- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Geological boundary, inferred

**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- Q_af - Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.
- Q_at - Silt, clay, (fluvially-deposited) fine- to medium-grained quartz-lithic sand, polymictic gravel.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twia - Ashfield Shale: Black to light grey shale and laminite.
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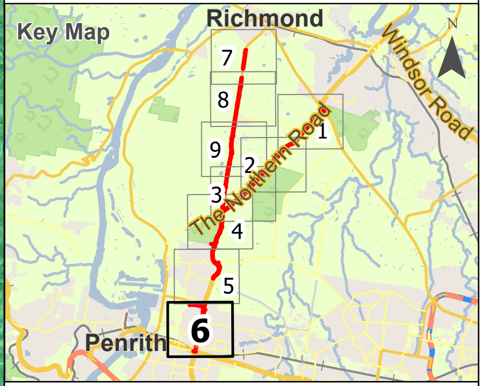
- Twim - Minchinbury Sandstone: Fine- to medium-grained lithic sandstone.

Key Map

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**PROJECT:** Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
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**LEGEND**

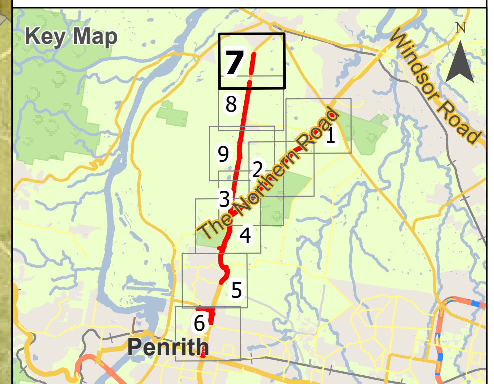
- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Geological boundary, position approximate
- Geological boundary, inferred

**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- CZ_a - Unconsolidated alluvial clay, silt, sand, and gravel deposits.
- CZ_ath - High-level terrace deposits of sand and gravel.
- NM__d - Clay, patches of ferruginised, consolidated sand.
- QP_at - Silt, clay, (fluvially-deposited) fine- to medium-grained quartz-lithic sand, polymictic gravel.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twia - Ashfield Shale: Black to light grey shale and laminite.
- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.
- Twim - Minchinbury Sandstone: Fine- to medium-grained lithic sandstone.




SOURCES:
1. Roadnet MDS 2020, MetroMap Imagery © Aerometrex Pty Ltd
2. Transport and Water Theme © NSW Department of Finance and Services3. Cadastre © State of New South Wales (Spatial Services, a business unit of the Department of Customer Service NSW)
3. Colquhoun GP, Hughes KS, Deyssing L, Ballard JC, Folkes CB, Phillips G, Troedson AL and Fitzherbert JA (2023) 'New South Wales Seamless Geology dataset (Single Layer)', version 2.3 [dataset]. Geological Survey of New South Wales, Department of Regional NSW, Maitland.
4. Basemap:



PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: 7 of 9
FIGURE TITLE: Appendix B2 - Regional Geology
CREATED BY: FA13847
DATE: 17/06/2024
VERSION: VERSION 1
PAGE SIZE: A3

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0 100 200 300 400
Meters
1:10,000

**LEGEND**

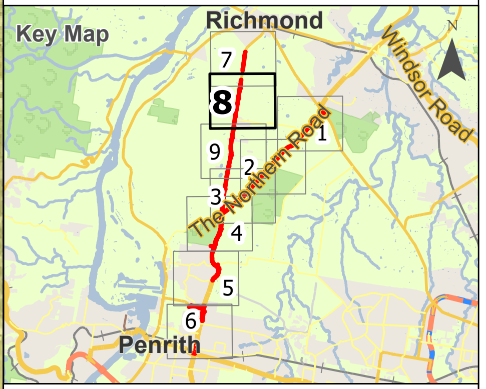
- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Geological boundary, position approximate
- Geological boundary, inferred

**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- CZ_a - Unconsolidated alluvial clay, silt, sand, and gravel deposits.
- CZ_ath - High-level terrace deposits of sand and gravel.
- NM__d - Clay, patches of ferruginised, consolidated sand.
- NM__i - Conglomerate, matrix-supported.
- Q_af - Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twia - Ashfield Shale: Black to light grey shale and laminite.
- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.
- Twim - Minchinbury Sandstone: Fine- to medium-grained lithic sandstone.

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4. Basemap:



**PROJECT:** Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
**PROJECT NO:** 30013443
**FIGURE NO:** 8 of 9
**FIGURE TITLE:** Appendix B2 - Regional Geology
**CREATED BY:** FA13847
**DATE:** 17/06/2024
**VERSION:** VERSION 1
**PAGE SIZE:** A3

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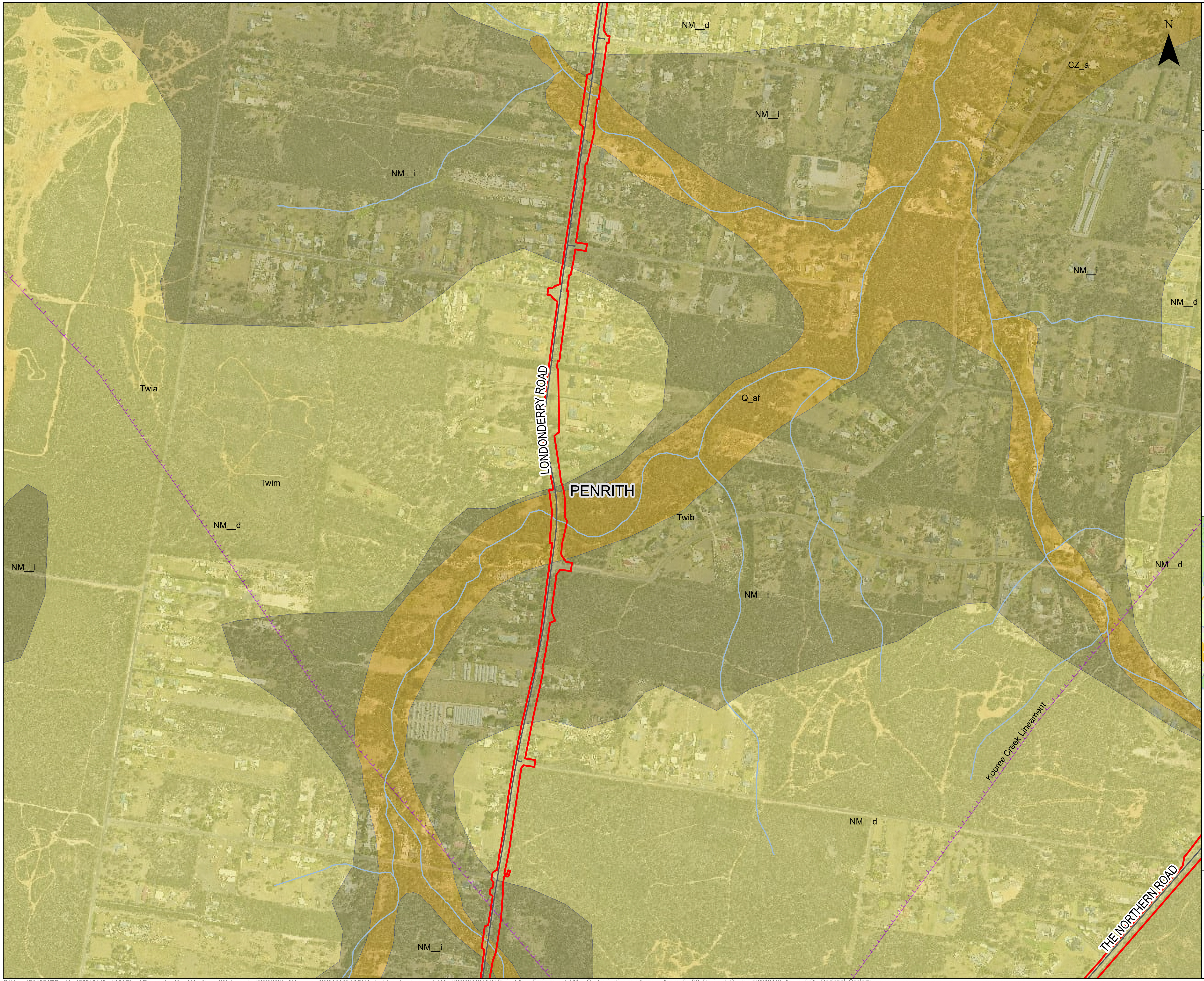


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0 100 200 300 400
Meters
1:10,000

**LEGEND**

- REF Boundary
- Site Compound
- Watercourses
- Geological boundary, position accurate
- Geological boundary, position approximate
- Geological boundary, inferred
- Linearment

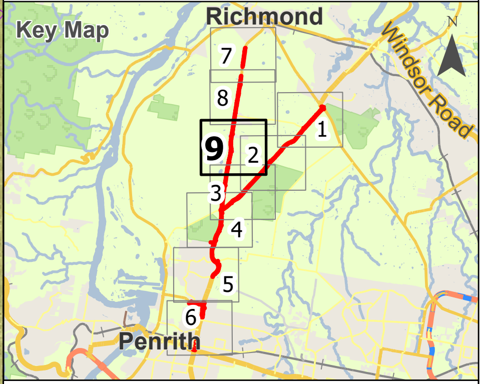
**Alluvium/fluvial - CENOZOIC SEDIMENTARY PROVINCE**

- CZ_a - Unconsolidated alluvial clay, silt, sand, and gravel deposits.
- NM__d - Clay, patches of ferruginised, consolidated sand.
- NM__i - Conglomerate, matrix-supported.
- Q_af - Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.

**Rock Units - PERMIAN TRIASSIC BASINS**

- Twia - Ashfield Shale: Black to light grey shale and laminite.
- Twib - Bringelly Shale: Shale, carbonaceous claystone, laminite, lithic sandstone, rare coal.
- Twim - Minchinbury Sandstone: Fine- to medium-grained lithic sandstone.

Key Map

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4. Basemap:



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**PROJECT:** Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
**PROJECT NO:** 30013443
**FIGURE NO:** 9 of 9
**FIGURE TITLE:** Appendix B2 - Regional Geology
**CREATED BY:** FA13847
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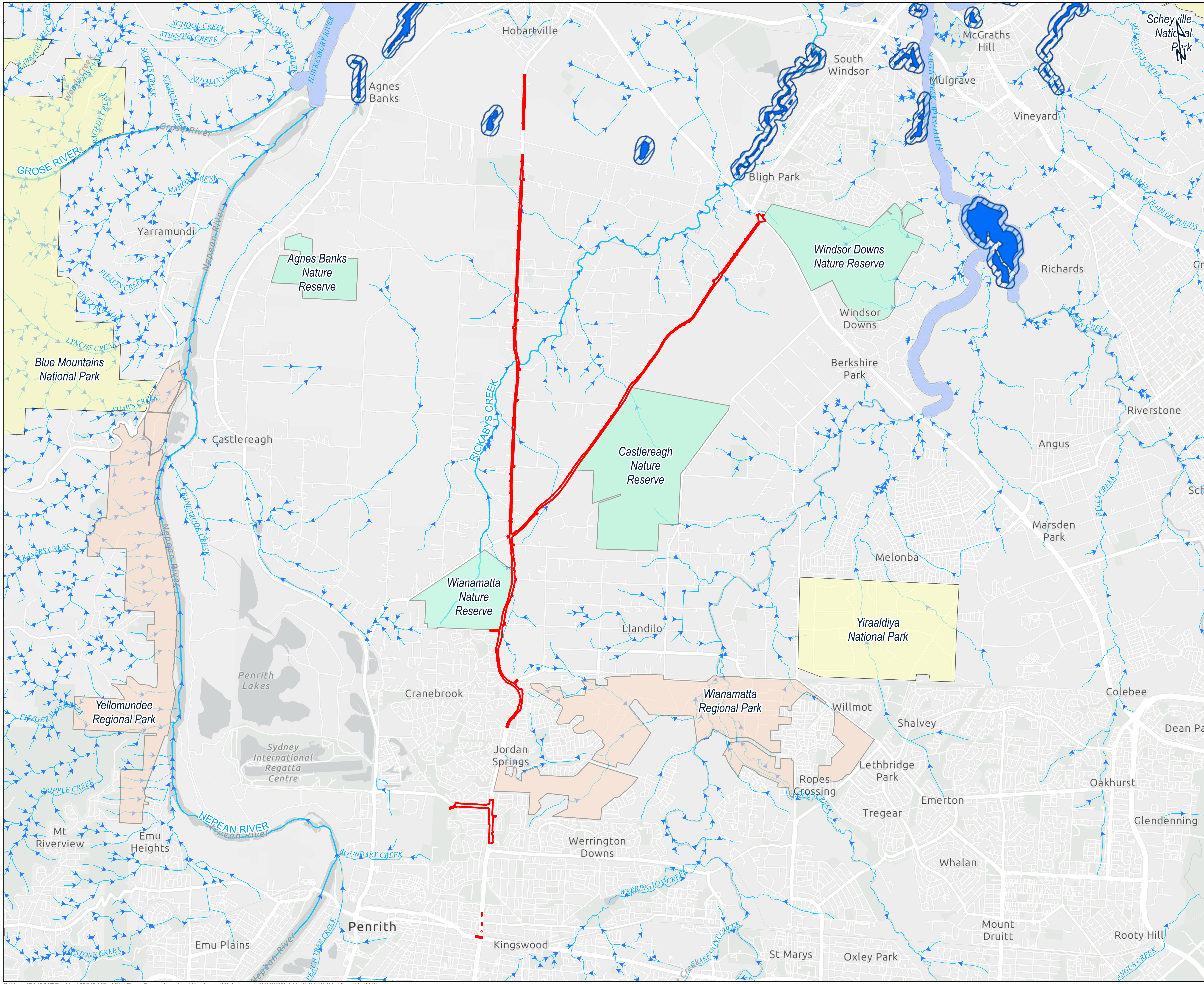
# B-3 PESA Trigger 4 – Listed Wetlands, State and National Parks and Littoral Rainforest

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Meters
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## LEGEND

- Study Area
- Watercourse

**Coastal Wetlands**
- Coastal Wetlands
- Proximity Area for Coastal Wetlands

**Littoral Rainforest**
- Littoral Rainforest
- Proximity Area for Littoral Rainforest
- Coastal Environment Area Map
- Coastal Use Area Map

**NPWS Estate**
- National Park
- Nature Reserve
- Regional Park

Key Map


SOURCES:
1. Roadnet MDS 2020, MetroMap Imagery © Aerometrex Pty Ltd
2. Transport and Water Theme © NSW Department of Finance and Services
3. SEPP and NPWS © State Government of NSW and Department of Planning and Environment
4. Basemap: Esri, TomTom, Garmin, FAO, NOAA, USGS, Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS



PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: Appendix B3
FIGURE TITLE: Appendix B3 PESA Trigger 4 Listed Wetlands, State and National Parks and Littoral Rainforest
CREATED BY: FA13847
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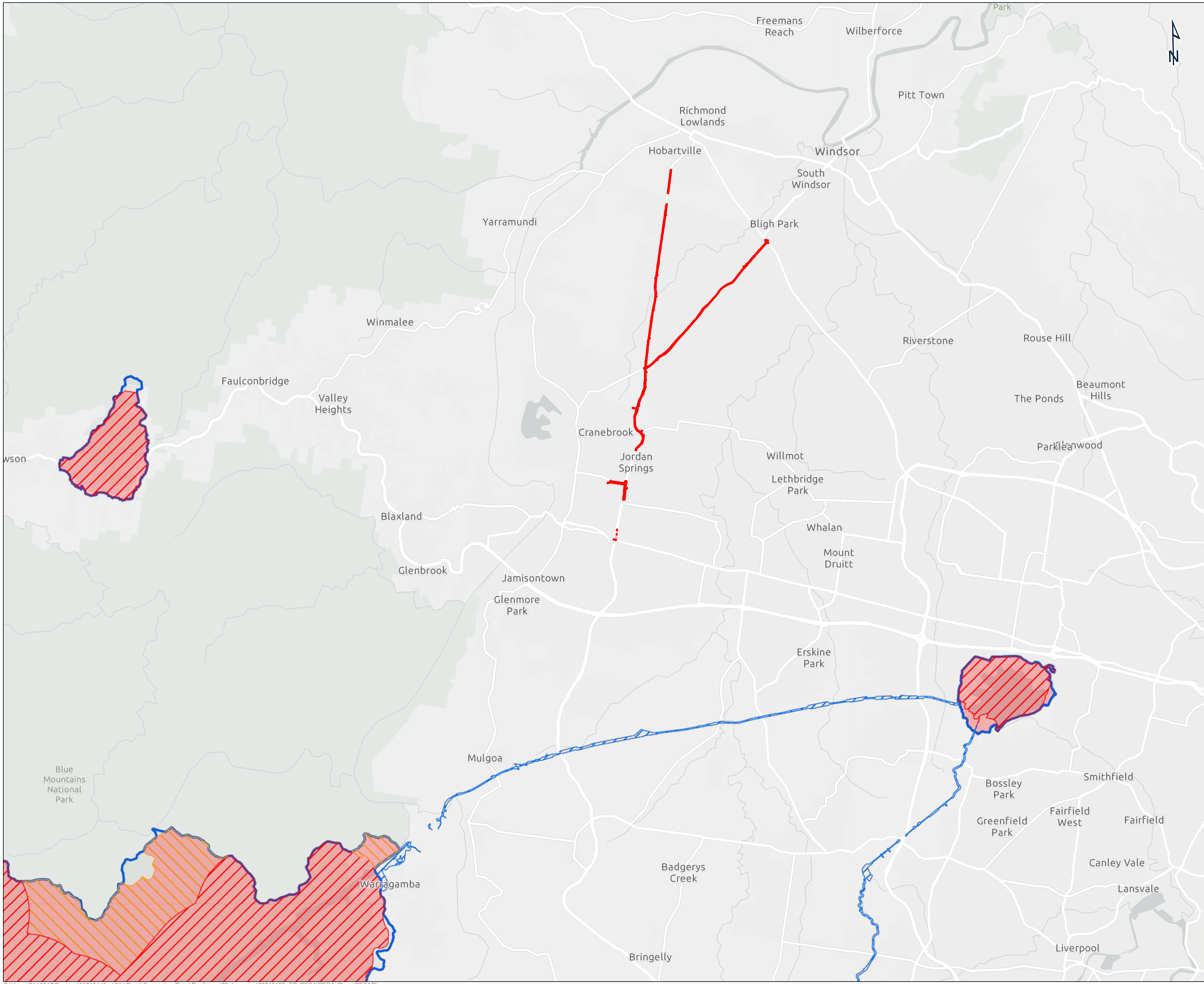
# B-4 PESA Trigger 4 – Drinking Water Catchments

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Kilometers
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## LEGEND

- Study Area
- RAMSAR Wetlands

**Water NSW Special & Controlled Areas**

- Schedule 1 Controlled Area
- Schedule 1 Special Area
- Schedule 2 Special Area
- WaterNSW Declared Catchment - Total Area

**WaterNSW Declared Catchment - Inner & Outer**

- Inner Catchment
- Outer Catchment

**Key Map**


SOURCES:
1. Roadnet MDS 2020, MetroMap Imagery © Aerometrex Pty Ltd
2. Transport and Water Theme © NSW Department of Finance and Services
3. Water Catchments and Special Areas © WaterNSW
4. NPWS © State Government of NSW and Department of Planning and Environment 2015
5. Basemap: Esri, TomTom, Garmin, FAO, NOAA, USGS, Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS, WaterNSW



PROJECT: Hawkesbury Nepean Valley Flood Evacuation Road Resilience Improvement Project
PROJECT NO: 30013443
FIGURE NO: Appendix B4
FIGURE TITLE: Appendix B4 PESA Trigger 4 – Drinking Water Catchments
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