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The Northern Road Upgrade Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park

NSW Environmental Impact Statement / Commonwealth Draft Environmental Impact Statement

Volume 1: Main Report

June 2017

Roads and Maritime Services

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8 Assessment of other issues

This chapter provides an assessment of the other environmental issues for the project as identified in the SEARs and as per the relevant requirements of Schedule 2, Part 3 of the (NSW) Environmental Planning and Assessment Regulation 2000, Section 97 of the EPBC Act and Schedule 4 of the Commonwealth EPBC Act Regulation 2000.

Chapter 11 Environmental risk analysis, provides an overview of how environmental issues for the project were identified and evaluated through an environmental risk analysis process. This process was followed to assign an environmental risk category to each potential impact, including identification of any additional key issues (in addition to those identified in the SEARs), or other issues to be addressed.

The other environmental issues addressed in this chapter are as follows:

- Hydrology and flooding (Section 8.1)
- Soils, water and contamination (Section 8.2)
- Aboriginal heritage (Section 8.3)
- Non-Aboriginal heritage (Section 8.4)
- Urban design and visual impact (Section 8.5)
- Air quality (Section 8.6)
- Resources and waste management (Section 8.7)
- Climate change and greenhouse gas (Section 8.8)
- Hazard and risk (Section 8.9).

For each key issue the following information is provided:

- A description of the existing environment, which includes (where relevant) all components of the environment as defined in Section 528 of the EPBC Act
- An assessment of the potential direct and indirect impacts of the project during construction and operation, with consideration of the scale, intensity, duration, timing and frequency of the potential impacts. This assessment has been prepared in accordance with:
  - Secretary's Environmental Assessment Requirements (SEARs) issued by the Secretary of the NSW Department of Planning and Environment on 9 March 2016
  - Commonwealth EIS Assessment Requirements issued by the Commonwealth Department of Environment and Energy on 24 August 2016
  - *Significant impact guidelines 1.1 – Matters of national environmental significance* (Department of the Environment, 2013)
  - *Significant impact guidelines 1.2 – Actions on, or impacting upon, Commonwealth Land, and actions by Commonwealth agencies* (Department of Sustainability, Environment, Water, Populations and Communities, 2013)
  - All relevant NSW and Commonwealth assessment guidelines, plans and policies.
- Consideration of the influence of relevant planning matters
- A description of proposed measures to be implemented to avoid, minimise, manage, mitigate, offset and/or monitor the potential impacts of the project
- Identification of potential residual impacts remaining after the implementation of mitigation measures. Where potential residual impacts have been identified as being significant, these impacts have been quantified.

A summary of the environmental risk analysis results for these key issues is provided in Table 11-3, including a summary of potential impacts, environmental management measures, and residual impacts.

The proposed environmental management measures in this chapter are collated in Chapter 12.

The assessment of key issues is supported by detailed investigations, which have been documented in the working papers. To the extent of any inconsistency between this main volume of the EIS and the working papers, the former prevails.

8.1 Hydrology and flooding

This section describes the environmental values relating to hydrology and flooding and identifies the potential impacts to these values as a result of construction and operation of the project. This chapter also recommends environmental management measures to reduce the impacts to and of the project.

The technical working papers, Flood risk assessment (Appendix K), have been used to inform this chapter.

Table 8-1 sets out the Secretary's Environmental Assessment Requirements (SEARs) and Commonwealth EIS guidelines as they relate to flooding and hydrology and states where in this EIS these have been addressed.

Table 8-1 NSW and Commonwealth Environmental Assessment Requirements

Requirement	Where addressed in the EIS
Secretary's Environmental Assessment Requirements	
Hydrology, soils and water - including: Identification of potential impacts and benefits of the proposal on existing flood regimes, consistent with the *Floodplain Development Manual* (Department of Natural Resources, 2005), with an assessment of the potential changes to flooding behaviour (levels, velocities and direction) and impacts on bed and bank stability, through flood modelling, and proposed management and mitigation measures.	Section 8.1.2 Section 8.1.4 Appendix K
Commonwealth EIS Guidelines (Commonwealth EPBC Act)	
The EIS must include a description of the environment of the proposal site and the surrounding areas that may be affected by the action. It is recommended that this include the following information: • A description of the environment in all areas of potential impact, including all components of the environment as defined in Section 528 of the EPBC Act: • Natural and physical resources, including water resources.	Section 8.1.2 Section 8.2.2
• Impacts to the environment (as defined in section 528) should include but not be limited to the following: • Hydrological changes.	Section 8.1.3 Section 8.1.4

8.1.1 Assessment methodology

The hydrology and flooding assessment for the project has been carried out in accordance with the requirement of the SEARs and the Commonwealth EIS guidelines, as outlined in Table 8-1. The assessment has followed the relevant government policy and industry guidelines, including Commonwealth, state and local government policies and plans, and the relevant industry standards.

Hydrologic and hydraulic models of the catchments draining across and through the project were established to assess potential flood related impacts on the project during operation, and potential changes in flood behaviour on the surrounding environment as a result of the project.

The DRAINS rainfall-runoff modelling software package was used to generate discharge hydrographs (a graph showing the volume of water that flows past a point in a waterbody's course per second) for a range of design storm events.

DRAINS is a simulation program which uses hydrologic sub-models (RAFTS and ILSAX) to convert rainfall patterns to stormwater runoff and generates discharge hydrographs. RAFTS is a non-linear runoff routing software. It incorporates subcatchment information such as area, slope, roughness and percentage impervious and is used to simulate the transformation of historic or design rainfall into runoff (i.e discharge hydrographs). ILSAX was used to assess the runoff characteristics of the project.

The discharge hydrographs were then used as input to a hydraulic model that was developed using the TUFLOW two- dimensional (in plan) hydraulic modelling software to define flooding patterns in the vicinity of the project. TUFLOW is a true two-dimensional (in plan), hydraulic modelling system which does not rely on a prior knowledge of the pattern of flood flows in order to set up the various fluvial and weir type linkages which describe the passage of a flood wave in a drainage system.

The key tasks comprising the flooding investigation are broadly described below:

- Develop hydrologic and hydraulic models, to define flood behaviour in the vicinity of the project corridor
- Run the flood models and prepare exhibits showing flooding behaviour under present day (pre-project) conditions for the 2 year, 10 year and 100 year Average Recurrence Interval (ARI) events, as well as the Probable Maximum Flood (PMF) – these were used to establish the baseline
- Iteratively develop the drainage design and develop a preferred set of measures which are aimed at mitigating the impacts of the project on flooding, as well as mitigating the impacts of flooding on the project
- Assess the residual impact the project would have on the 2 year, 10 year and 100 year Average Recurrence Interval (ARI) events, as well as the Probable Maximum Flood (PMF) assuming the preferred set of flood mitigation measures is incorporated into its design
- Assess the impact a partial blockage (20 per cent) of major hydraulic structures (pipes and culverts) would have on flooding behaviour under post-construction conditions
- Assess the impact future climate change (30 per cent increase in the intensity of the 100 ARI event) would have on flooding behaviour under post-construction conditions.

Flooding behaviour in the vicinity of the project was defined for events with ARIs of between 2 and 500 years, as well as the PMF. The Average Recurrence Interval or ARI defines the average frequency of rainfall and/or flood events. For example, the 2 year ARI event describes a smaller, more frequent and therefore more likely event with a statistical probability of occurring once in every two years. Conversely, the 100 year ARI event describes a much larger, but less likely event with a statistical probability of occurring once in every 100 years.

The Probable Maximum Flood (PMF) is the largest flood that could conceivably occur at a particular location. It is usually based on a theoretical amount of rainfall and is much greater than a

100 year ARI flood event. The PMF defines the extent of flood prone land, that is, the floodplain. The PMF is an extremely rare event and no ARI can be meaningfully ascribed. However, it provides an upper limit of flooding and associated consequences, and is usually given an ARI of between 10,000 and 100,000 years.

A brief description of flooding behaviour in the vicinity of the project under present day (pre-project) conditions is presented in Chapter 4 of the technical working paper (Appendix K).

The assessment has included an assessment of the project's residual impacts (see Section 8.4), and has also modelled the effects of partial blockage of major drainage structures.

The findings of the assessment, which includes the potential impacts of future climate change on flooding behaviour with the project, are described in Sections 8.1.3 and Section 8.1.4.

The project's design has been an iterative process wherein the drainage, civil, structural and earthworks designs have developed together. Drainage has been considered at each stage of the design and the hydrologic and hydraulic models have developed as the design has developed in meeting the project's design objectives, including the key flooding and hydrology objectives of achieving 100 year ARI flood immunity, and scour protection at drainage inlets and outlets for storms up to 50 year ARI.

A detailed description of the methodology and models used for the hydrology and flooding assessment is provided in Appendix K - Flood risk assessment.

8.1.2 Existing environment

Catchment and waterways

The project crosses a number of waterways, ephemeral drainage lines and their associated catchments. In particular the project falls within the following catchments:

- Badgerys Creek catchment – the catchment is about 1,370 ha in size and drains east to South Creek which then flows north to join the Hawkesbury River at Windsor. A number of minor drainage lines cross The Northern Road, which are ephemeral and only flow in response to rainfall. Several farm dams have been constructed along these drainage lines. The land use is primarily large lot rural residential development. Downstream of The Northern Road the Badgerys Creek catchment is located within the Western Sydney Airport site (Commonwealth land) and has been identified as an environment conservation zone on the Airport Plan 2016 (Department of Infrastructure and Regional Development, 2016)
- Duncans Creek catchment – the catchment is about 1,560 ha in size and drains west to the Nepean River. The Northern Road follows the ridgeline and forms the divide between Duncans Creek catchment and Cosgroves Creek catchment. A series of both small and large dams are located along drainage depressions within the catchment
- Cosgroves Creek catchment – the catchment is about 1,476 ha in size and similarly to Badgerys Creek, drains east to South Creek. Land use within the catchment varies between urbanised (Luddenham to the west) and rural development to the east
- Unnamed tributary of South Creek catchment – the catchment is about 732 ha in size located to the western side of the road (upslope). It forms part of the South Creek catchment, which ultimately forms part of the Hawkesbury Nepean catchment. Land use within the catchment is rural with several farm dams constructed along drainage depressions
- Mulgoa Creek catchment – the catchment is 3,896 ha in size. Runoff from the catchment drains west to the Nepean River. The catchment is largely rural with large lot rural development. Several farm dams have been constructed along the drainage depressions

- Blaxland Creek catchment – the catchment is about 1,403 ha in size and drains east to South Creek. The drainage lines that cross The Northern Road in this catchment either directly or indirectly discharge into the Defence Establishment Orchard Hills (DEOH) site located east of The Northern Road and north of the WaterNSW Supply Pipelines. Two unnamed drainage lines currently discharge into the trenches of the WaterNSW supply pipelines which have resulted in prolonged ponding and slumping of the trenches. The biodiversity and natural heritage values of the tributaries of Blaxland Creek at Orchard Hills are described in Section 7.3, Biodiversity, and Section 8.4, Non-Aboriginal heritage, as being among the least disturbed catchments remaining on the Cumberland Plain and are regarded as possibly the most pristine creek system on Wianamatta Shale left in Western Sydney (Department of the Environment, 2016b). The natural heritage values of these tributaries are also described as being of moderate to high significance (Godden Mackay Logan, 2013) in terms of its aquatic habitat features and the low level of disturbance of these waterways
- Surveyors Creek catchment – the catchment is about 1,336 ha in size and drains west to the Nepean River. However, a large portion of the catchment that contributes runoff to the existing drainage along The Northern Road is generally rural in nature comprising DEOH land and large lot rural and semi-rural residential development.

At the southern extent of the project, The Northern Road crosses through the Badgerys Creek Catchment before following a natural ridgeline that forms the catchment divide between Cosgroves Creek and Duncans Creek.

North of Luddenham, The Northern Road also follows a natural ridgeline that forms the catchment divide between Mulgoa Creek, Duncans Creek, Cosgroves Creek, an unnamed watercourse and Blaxland Creek (refer Figure 8-1).

Mulgoa Creek and Duncans Creek drain in a westerly direction and discharge directly to the Nepean River, while Cosgroves Creek, the unnamed watercourse and Blaxland Creek drain in an easterly direction where they discharge to South Creek, a major tributary of the Hawkesbury-Nepean River.

The northern extent of the project is located in the upper reaches of the Surveyors Creek catchment. Surveyors Creek is a tributary of Peach Tree Creek, the main arm of which joins the Nepean River downstream of Penrith Weir.

The catchments that contribute runoff to the existing transverse drainage of The Northern Road have generally been cleared of native vegetation, with the predominant ground cover being grass.

The main water supply lines for Sydney, which comprise 3.2 m and 2.4 m diameter steel pipes, run in an east–west direction and cross The Northern Road a short distance north of the Gates Road intersection. The pipelines lie about 13 m below natural surface where they cross The Northern Road, in a series of relatively deep open trenches. The condition of these trenches is affected by catchment runoff which discharges to their base via a series of concrete lined chutes, further discussion on which is contained in Appendix K.

A description of the habitats of watercourses potentially impacted by the project is provided in Section 7.3.2.

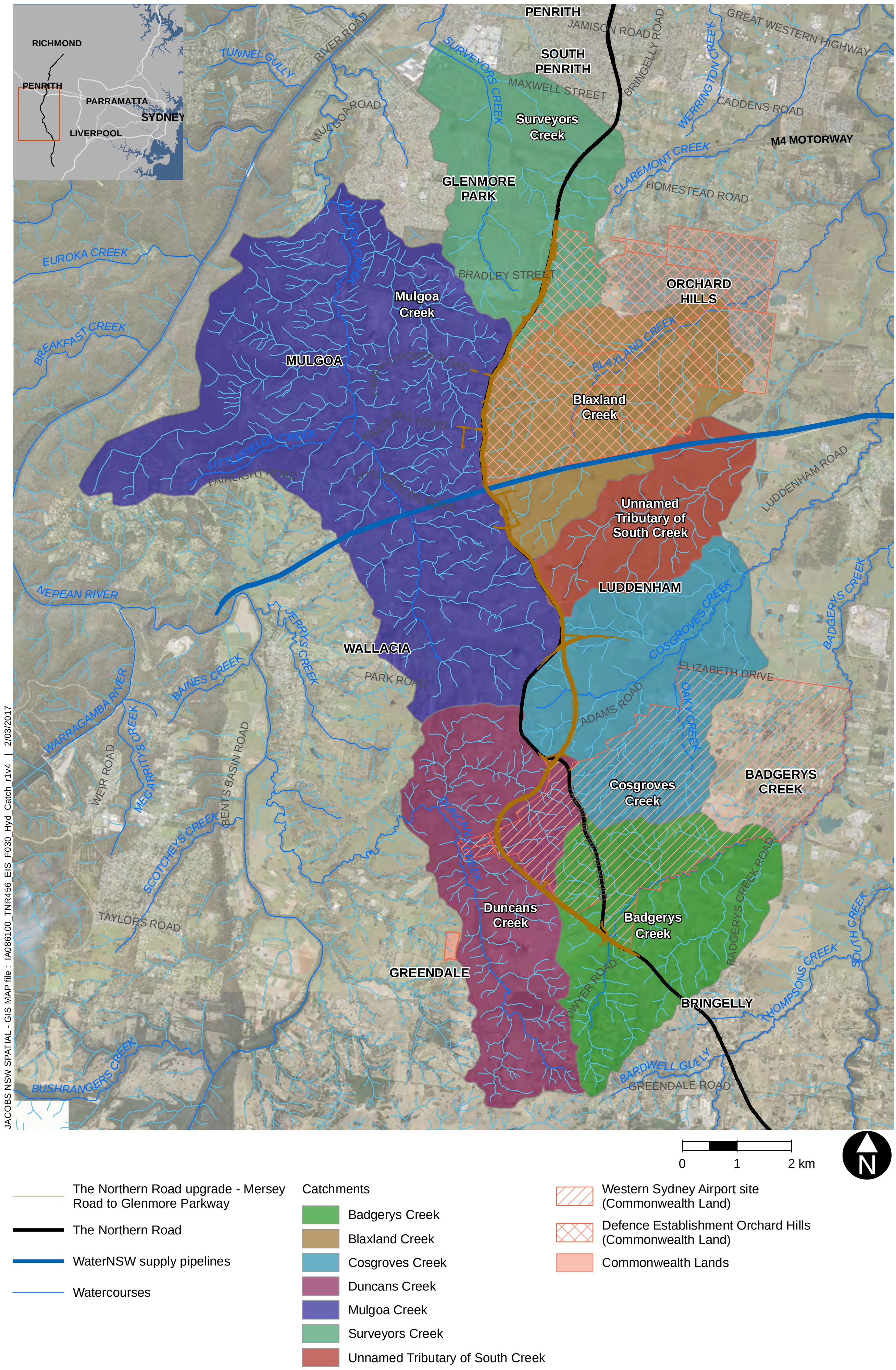


Figure 8-1 | Project catchment plan

Existing flooding

A description of existing flooding behaviour of the catchments traversed by the project is presented in Table 8-2. The location of specific properties discussed in Table 8-2 are further discussed in Chapter 4 of Appendix K.

Table 8-2 Summary of existing flood behaviour

Catchment	Summary of existing flood behaviour
Badgerys Creek catchment	While the Badgerys Creek floodplain is relatively wide in the vicinity of where The Northern Road crosses the main arm of the creek, depths of flow on its overbank are relatively shallow for events up to 100 year ARI. Some dwellings on the western (upstream) side of the road corridor are marginally affected by a 100 year ARI flood event while Lot 94 DP654182 would be surrounded by floodwater during events as frequent as 2 year ARI and that depths of flow in the vicinity of the dwelling would increase to just over 1 m during a PMF event. Similar to the other catchments, higher flooding conditions are generally confined to the farm dams and the incised reaches of the drainage system for events up to 100 year ARI.
Duncans Creek catchment	Flooding behaviour in the Duncans Creek catchment is relatively shallow flow occurring along the various drainage lines where they run between the existing farm dams. It is noted that the project would impact several farm dams where the depth of ponding would be greater than 1 m. Dwellings located in Lot 11 DP248069, Lot 104 DP884343 and Lot 105 DP884343, while above the adjacent peak 100 year ARI flood level, are impacted by a PMF event. While high hazard conditions are generally confined to the existing dams and the incised reaches of the drainage system for events up to 100 year ARI, the confined nature of the floodplain in several areas results in hazardous flooding conditions being present across the full width of the flood affected area (is land susceptible to flooding by a PMF event).
Cosgrove Creek catchment	Depths of ponding exceed 1 m in the various farms dams, flow in the various drainage lines between each water storage is generally relatively shallow for events up to 100 year ARI. There are also no existing dwellings that are presently impacted by flooding for events up to the PMF. High hazard flooding is generally confined to the farm dams and the incised reaches of the drainage system which are typically located downstream of the project corridor for events up to 100 year ARI.
Unnamed Tributary of South Creek Catchment	Flooding is limited to catchment runoff ponding along the upslope side of the existing The Northern Road adjacent to the inlet of the existing transverse (or cross road) drainage structure.
Mulgoa Creek catchment	Flooding is limited to catchment runoff ponding along the upslope side of the road. It is noted that drainage swales have been constructed along the western side of the road corridor in the vicinity of the Chain-O-Ponds Road intersection, along which several pipes are located where it is crossed by local access driveways.

Catchment	Summary of existing flood behaviour
Blaxland Creek catchment	The section of The Northern Road that runs along the catchment divide between Blaxland Creek and Mulgoa Creek is not affected by mainstream or major overland flow. There is the potential for catchment runoff to pond adjacent to the inlet of the existing transverse drainage.
Surveyors Creek Catchment	While details of the existing stormwater drainage system in the Department of Defence's (DoD's) DEOH were not available, it appears that several buildings located near the entrance to the site are subject to flooding during storms as frequent as 2 year ARI. Floodwater would commence to surcharge The Northern Road for storms with ARI's larger than about 10 years, with about a 200 metre length of the road adjacent to transverse drainage structure EXD6 inundated during a 100 year ARI event, albeit to a relatively shallow depth. Several residential properties that are located on the western side of The Northern Road between Bradley Street and Glenmore Parkway that are subject to flooding during a 2 year ARI storm event. During a Probable Maximum Flood (PMF) event, depths of inundation in the vicinity of several dwellings that are located on the western side of The Northern Road between Bradley Street and Glenmore Parkway would exceed 1 metre.

8.1.3 Assessment of potential construction impacts

Potential impact of the project on flooding behaviour

There is potential for a flood event to occur during construction of the project. The impact of a large flood would depend on the stage of construction at the time of the event, and the intensity of the rainfall event. Flooding during construction could potentially impact areas within and near the construction area (specifically, temporary construction ancillary sites) and/or cause damage to construction plant and equipment.

Construction sites could increase potential runoff to the catchments during heavy rainfall due to an increase of impermeable surface. However, this increase would be relatively small in terms of the overall catchment area, and unlikely to significantly increase the severity of any flood events.

Construction compounds and materials stockpiles may also increase potential runoff to the catchments. Potential impacts would be localised and most likely to occur as a result of poorly located stockpiles or compound sites, for example, locating compounds or stockpiles in drainage paths or on low-lying land. Buildings and structures associated with site compounds may obstruct flows and reduce storage capacity, or divert flows into sensitive areas where increased flow velocities can cause scour and erosion. These effects may be exacerbated by large areas of cleared land or exposed soil.

During construction there is also potential for existing drainage infrastructure to be partially blocked or temporarily diverted due to earthworks and other construction activities. Blocking or diverting local drainage lines may result in local flooding upstream of the construction areas. Diverting drainage lines may also create local areas of flooding and scour.

These temporary impacts are expected to be minor and would be managed through the implementation of standard construction techniques and effective protection measures.

8.1.4 Assessment of potential operation impacts

The potential impacts of the project on flooding behaviour and the scour potential within receiving drainage lines have been considered during the design of the project. Detailed flood modelling has been carried out to identify the potential residual flooding and drainage related impacts of the project following the incorporation of a preferred set of transverse drainage upgrade and flood mitigation measures into its design.

Proposed transverse drainage and flood mitigation strategy

The mitigating effects of a range of measures, such as a revised transverse drainage design (see Section 5.4.8) were assessed using the hydrologic and hydraulic models that were representative of operational project conditions. Based on the findings a strategy has been developed which is aimed at mitigating the impact of the project on flooding behaviour and scour potential, as well as providing a minimum 100 year ARI level of flood immunity to the new northbound and southbound carriageways (transverse drainage and flood mitigation strategy). The key features of the transverse drainage and flood mitigation strategy are outlined in Section 5.2.7. They are also outlined in detail in Appendix K.

Broadly, drainage channels would extend from the project boundary to the first farm dam on a number of drainage lines where peak flows would be increased in privately owned land. Where inflows are likely to increase, Roads and Maritime would consult with property owners regarding upgrades to farm dam spillways as part of the project (e.g. with rock armour) to protect the structures. Easements for drainage would be created over each channel to facilitate access for future maintenance. Several dams that are located within the project operational footprint would be either filled or partially infilled. Energy dissipation and scour protection measures would be provided at the outlets of each individual pavement and transverse drainage line.

In addition to the above, appropriate scour protection measures would be provided at the inlet and outlet of each transverse drainage structure. The scour protection measures would typically comprise dumped rock riprap and / or rock gabion mattress.

Further, the design and hydrologic modelling process has concluded that there is a need for the flood mitigation strategy to incorporate stormwater detention ponds, to capture and treat runoff from the road formation and to control its discharge into the downstream catchments.

Potential impacts of the project on scour potential

The project has the potential to cause scour in the receiving drainage lines due to the following reasons:

- Increases in the rate of flow (and hence the depth and velocity of flow) associated with:
  - the enlargement of transverse drainage structures
  - runoff from the widened carriageway, or from newly formed road carriageway in areas where there is currently little or no impermeable surface
  - changes in the distribution of flow along the project corridor
- Increases in the velocity of flow where it discharges from newly lined sections of channel
- The concentration of flow resulting from the formalisation of the drainage system within the project corridor.

Increases in the rate of flow in the receiving drainage lines could result in a lowering of the stream bed through a process of headwater erosion, as well as a possible widening of the watercourse through a process of bank erosion. The lining of channels and the concentration of flow could also result in localised scour in the receiving drainage lines at the downstream limit of the drainage works.

The project would increase the scour potential in the drainage lines which run through DEOH site in Commonwealth land. The increase in scour potential would extend only a short distance from the corridor as the increase in peak flow attributable to the project as a percentage of the total flow reduces in the downstream direction due to the discharge of additional catchment runoff to the affected drainage line.

Hydrologic modelling was carried out to define peak flows and discharge hydrographs for a range of design storms within the study catchments. Table 8-3 provides a comparison of peak flows at key modelled locations under pre-and post-project conditions.

Potential impacts of the project on flooding behaviour and hydrology

Catchment hydrology and flooding behaviour after the implementation of proposed transverse drainage mitigation, has been assessed in each of the catchments for design storms of 2 year, 10 year and 100 year ARI, together with the PMF. Table 7.1 in Appendix K outlines in detail the potential impacts of the project on hydrology and flooding behaviour by catchment. The key assessment findings were as follows:

- The project would result in an increase in both the rate and volume of runoff discharging to a number of receiving drainage lines. Changes in catchment hydrology are attributable to:
  - the increase in impervious area associated with the construction of the new northbound and southbound carriageways
  - the provision of an efficient pavement drainage system which would control runoff discharging from the new carriageways
  - the diversion of surface runoff toward adjacent drainage lines
- While peak flood levels would be increased as a result of the project for events up to 100 year ARI, affected areas are limited to undeveloped pastoral land. As identified in the biodiversity assessment (Section 7.3), increases to the 100 year ARI peak flows are not expected to impact waterways or vegetation communities due to the infrequent and short term nature of the impact. This includes any potential impact to the tributaries of Blaxland Creek within the DEOH site
- Due to the relatively steep sided nature of the drainage lines that cross the project corridor, increases in peak flood levels attributable to the project do not translate into a significant increase in the spatial extent of flood affected land for events up to 100 year ARI
- The project would result in substantial increases in peak flood levels along its upstream side during a PMF event. While the affected areas generally comprise undeveloped pastoral land, four existing dwellings that are located on the Badgerys Creek floodplain would be affected. Given the relatively short catchment response time to intense rainfall events and the fact that depths of inundation would be increased by up to 2 m during a PMF event, the project would result in a significant increase in the flood risk in the affected properties
- Roads and Maritime modelled the potential impact that lowering the road in the affected area would have on reducing the PMF. The results of this modelling indicate that while the affected areas are generally confined to pastoral land, the depth of above-floor inundation in two existing dwellings that are located on the Badgerys Creek floodplain would be increased by a maximum of 0.2 m. Given the very low probability of occurrence of a PMF event in combination with the relatively small increase in the depth of above-floor inundation in the two dwellings, the increase in flood risk attributable to the lowered road would be only minor
- The project would increase the scour potential in the drainage lines which run through DEOH site on Commonwealth land. The increase in scour potential would extend only a short distance from the corridor as the increase in peak flow attributable to the project as a percentage of the total flow reduces in the downstream direction due to the discharge of additional catchment runoff to the affected drainage line
- The removal of the two large dams which are located on either side of Adams Road in the Cosgroves Creek catchment would result in an increase in peak flows (and flood levels) along the main arm of the creek downstream of the project corridor. While no existing development would be impacted by the project as far downstream as Elizabeth Drive, the increase in the rate of flow is likely to increase the scour potential within the in-bank area of the watercourse. The resulting increase in flow would also reduce the hydrologic standard of the existing transverse drainage located along Elizabeth Drive

- While the construction of three permanent ponds along the eastern side of the project corridor would dampen the effects of the project on catchment hydrology, there would still be an increase in the rate and volume of flow discharging to three drainage lines within Blaxland catchment, which runs through the DEOH site (drainage lines BLC DL07, BLC DL08 and BLC DL 09 (refer Appendix K)). As a result, the scour potential along these drainage lines would increase and ground conditions would become wetter. The impact to biodiversity and natural heritage values associated with these tributaries has been assessed in Sections 7.3 and 8.4 respectively. In summary, this increase in scour potential may deepen the waterway and cause some bank erosion; however with the implementation of relevant mitigation measures including scour protection measures identified in this assessment, as well as other erosion and sediment controls identified in the soil and water assessment (Section 8.2), these impacts are expected to be minor. Additionally as identified above, the increase in scour potential would extend only a short distance from the corridor , therefore the moderate to high natural heritage significance of these aquatic environments further inland within the DEOH site are not expected to be impacted (refer to Section 8.4)
- There would be minor increases in both the rate and volume of runoff discharging to the existing dams that are located downstream of the project corridor (refer Appendix K). During detailed design an assessment would be undertaken into the impact the project would have on the characteristics of flow over the spillway of the affected dams. Adjustments would be made to the spillway of affected dams that would include their armouring using dumped rock rip rap.

The results of modelling the 2 year, 10 year and 100 year ARI events, together with the PMF event under post-project conditions were used to prepare a series of diagrams outlining the increase in water level resulting from a constriction in the flow path (refer Appendix K) showing the residual impact of the project on flooding behaviour following implementation of the preferred set of flood mitigation measures.

A partial blockage of the transverse drainage by debris could result in floodwater surcharging onto the road during storms with ARI's less than 100 year ARI. Increases in peak flood levels would be typically confined to land located immediately upstream of The Northern Road with the maximum increase in peak flood level occurring on the main arm of Badgerys Creek to a maximum of 200 mm. Flooding conditions would not be exacerbated in the vicinity of any existing dwellings.

Table 8-3 Comparison of peak flows (m^3/sec) by catchment

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
Badgerys Creek	BC Q01	1.00	1.00	0 [0%]	1.80	1.80	0 [0%]	2.90	2.80	-0.1 [-3%]
	BC Q02	0.90	0.90	0 [0%]	1.80	1.80	0 [0%]	5.10	5.10	0 [0%]
	BC Q03	8.70	8.70	0 [0%]	15.00	15.00	0 [0%]	21.50	21.50	0 [0%]
	BC Q04	10.40	10.60	0.2 [2%]	18.30	18.60	0.3 [2%]	29.10	29.60	0.5 [2%]
	BC Q05	14.40	14.80	0.4 [3%]	25.60	26.30	0.7 [3%]	40.50	41.60	1.1 [3%]
	BC Q06	22.50	22.80	0.3 [1%]	40.40	40.90	0.5 [1%]	63.40	64.70	1.3 [2%]
	BC Q07	1.60	1.60	0 [0%]	2.70	2.70	0 [0%]	4.60	4.60	0 [0%]
	BC Q08	1.70	2.00	0.3 [18%]	2.90	3.30	0.4 [14%]	5.20	5.60	0.4 [8%]
	BC Q09	0.40	0.40	0 [0%]	0.70	0.70	0 [0%]	1.30	1.30	0 [0%]
	BC Q10	0.30	0.30	0 [0%]	0.50	0.50	0 [0%]	1.00	1.00	0 [0%]
	BC Q11	0.90	1.50	0.6 [67%]	1.80	3.00	1.2 [67%]	3.70	6.20	2.5 [68%]
Duncans Creek	DC Q01	0.70	0.60	-0.1 [-14%]	1.20	1.10	-0.1 [-8%]	1.90	1.70	-0.2 [-11%]
	DC Q02	0.70	0.60	-0.1 [-14%]	1.20	1.00	-0.2 [-17%]	1.90	1.70	-0.2 [-11%]
	DC Q03	Minor	0.50	0.5 [-%]	Minor	0.90	0.9 [-%]	Minor	1.30	1.3 [-%]
	DC Q04	1.00	0.90	-0.1	1.60	1.50	-0.1	2.90	2.40	-0.5

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
				[-10%]			[-6%]			[-17%]
	DC Q05	1.70	1.70	0 [0%]	2.90	2.90	0 [0%]	5.20	5.00	-0.2 [-4%]
	DC Q06	1.70	1.80	0.1 [6%]	3.00	3.00	0 [0%]	5.30	5.10	-0.2 [-4%]
	DC Q07	0.80	0.80	0 [0%]	1.40	1.40	0 [0%]	2.70	2.70	0 [0%]
	DC Q08	0.30	0.10	-0.2 [-67%]	0.50	0.20	-0.3 [-60%]	0.90	0.30	-0.6 [-67%]
	DC Q09	1.70	1.80	0.1 [6%]	2.90	3.40	0.5 [17%]	5.20	5.80	0.6 [12%]
	DC Q10	1.80	1.90	0.1 [6%]	3.20	3.80	0.6 [19%]	6.00	6.40	0.4 [7%]
	DC Q11	2.60	2.70	0.1 [4%]	4.60	5.30	0.7 [15%]	9.20	10.10	0.9 [10%]
	DC Q12	1.00	1.10	0.1 [10%]	1.80	1.90	0.1 [6%]	3.10	3.60	0.5 [16%]
	DC Q13	1.20	1.40	0.2 [17%]	2.10	2.30	0.2 [10%]	3.60	4.20	0.6 [17%]
	DC Q14	1.10	1.10	0 [0%]	2.30	2.20	-0.1 [-4%]	4.20	4.10	-0.1 [-2%]
	DC Q15	2.80	3.10	0.3 [11%]	4.90	5.10	0.2 [4%]	9.00	10.10	1.1 [12%]
	DC Q16	1.90	1.90	0 [0%]	3.00	3.00	0 [0%]	5.40	5.40	0 [0%]
	DC Q17	1.80	1.80	0 [0%]	3.50	3.50	0 [0%]	6.70	6.70	0 [0%]
	DC Q18	5.70	6.20	0.5 [9%]	10.00	10.00	0 [0%]	18.20	18.70	0.5 [3%]
	DC Q19	7.40	8.30	0.9 [12%]	14.10	14.00	-0.1 [-1%]	23.70	24.60	0.9 [4%]

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
	DC Q20	7.80	8.90	1.1 [14%]	15.80	15.80	0 [0%]	25.50	25.90	0.4 [2%]
	DC Q21	1.00	1.30	0.3 [30%]	1.90	2.50	0.6 [32%]	4.20	4.20	0 [0%]
	DC Q22	0.60	0.40	-0.2 [-33%]	1.10	0.70	-0.4 [-36%]	2.40	1.60	-0.8 [-33%]
Cosgroves Creek	CC Q01	0.40	0.50	0.1 [25%]	0.60	0.80	0.2 [33%]	1.20	1.50	0.3 [25%]
	CC Q02	2.20	2.20	0 [0%]	3.90	3.90	0 [0%]	8.60	8.60	0 [0%]
	CC Q03	3.00	4.20	1.2 [40%]	5.30	7.30	2 [38%]	11.40	16.00	4.6 [40%]
	CC Q04	3.70	4.60	0.9 [24%]	6.70	7.80	1.1 [16%]	12.90	16.90	4 [31%]
	CC Q05	0.70	0.70	0 [0%]	1.40	1.40	0 [0%]	2.30	2.30	0 [0%]
	CC Q06	1.50	1.50	0 [0%]	2.30	2.30	0 [0%]	5.50	5.50	0 [0%]
	CC Q07	0.30	0.40	0.1 [33%]	0.80	0.80	0 [0%]	1.50	1.50	0 [0%]
	CC Q08	1.10	1.30	0.2 [18%]	2.10	2.30	0.2 [10%]	3.50	3.80	0.3 [9%]
	CC Q09	3.20	3.50	0.3 [9%]	6.60	7.10	0.5 [8%]	10.90	11.70	0.8 [7%]
	CC Q10	4.00	4.50	0.5 [13%]	8.40	8.90	0.5 [6%]	13.90	14.70	0.8 [6%]
	CC Q11	8.80	10.10	1.3 [15%]	16.50	17.80	1.3 [8%]	27.20	31.90	4.7 [17%]
	CC Q12	19.10	20.40	1.3 [7%]	34.20	35.80	1.6 [5%]	55.10	57.50	2.4 [4%]
	CC Q13	0.40	0.80	0.4 [100%]	0.90	1.40	0.5 [56%]	1.50	2.50	1 [67%]

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
	CC Q14	0.80	0.90	0.1 [13%]	1.60	1.70	0.1 [6%]	2.60	2.80	0.2 [8%]
	CC Q15	0.60	0.43	-0.17 [-28%]	1.45	1.02	-0.43 [-30%]	2.72	1.97	-0.75 [-28%]
Unnamed tributary	MCPB	0.36	0.61	0.25 [69%]	0.77	1.06	0.29 [38%]	1.26	1.84	0.58 [46%]
	UT Q01	0.80	1.05	0.25 [31%]	1.93	2.18	0.25 [13%]	3.65	3.99	0.34 [9%]
	MCPB	0.14	0.39	0.25 [179%]	0.34	0.70	0.36 [106%]	0.56	1.17	0.61 [109%]
	UT Q02	0.57	0.70	0.13 [23%]	1.31	1.55	0.24 [18%]	2.60	2.92	0.32 [12%]
Mulgoa Creek	MC Q01	0.64	0.62	-0.02 [-3%]	1.39	1.36	-0.03 [-2%]	2.59	2.52	-0.07 [-3%]
	MC Q02	0.39	0.37	-0.02 [-5%]	0.80	0.76	-0.04 [-5%]	1.60	1.52	-0.08 [-5%]
	MC Q03	0.37	0.22	-0.15 [-41%]	0.79	0.51	-0.28 [-35%]	1.29	0.93	-0.36 [-28%]
	MC Q04	0.31	0.29	-0.02 [-6%]	0.76	0.70	-0.06 [-8%]	1.42	1.32	-0.1 [-7%]
	MC Q05	0.36	0.33	-0.03 [-8%]	0.75	0.69	-0.06 [-8%]	1.49	1.38	-0.11 [-7%]
	MC Q06	0.28	0.27	-0.01 [-4%]	0.63	0.60	-0.03 [-5%]	1.24	1.19	-0.05 [-4%]
	MC Q07	0.70	0.66	-0.04 [-6%]	1.57	1.51	-0.06 [-4%]	3.09	2.96	-0.13 [-4%]
	MC Q08	1.13	1.61	0.48 [42%]	2.54	3.34	0.8 [31%]	4.68	5.77	1.09 [23%]
	MC Q09	3.69	4.04	0.35 [9%]	8.16	8.69	0.53 [6%]	14.20	14.70	0.5 [4%]
	MC Q10	0.37	0.30	-0.07 [-19%]	0.80	0.74	-0.06 [-8%]	1.46	1.35	-0.11 [-8%]

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
	MC Q11	1.36	1.12	-0.24 [-18%]	2.86	2.69	-0.17 [-6%]	5.23	4.96	-0.27 [-5%]
	MCPB	0.22	0.23	0.01 [5%]	0.47	0.45	-0.02 [-4%]	0.74	0.75	0.01 [1%]
	MC Q12	0.59	0.57	-0.02 [-3%]	1.23	1.10	-0.13 [-11%]	1.92	1.76	-0.16 [-8%]
	LRPB	0.78	0.59	-0.19 [-24%]	1.58	1.23	-0.35 [-22%]	3.06	2.49	-0.57 [-19%]
	MC Q13	0.94	0.79	-0.15 [-16%]	1.86	1.73	-0.13 [-7%]	3.63	3.25	-0.38 [-10%]
	MCPB	0.02	0.01	-0.01 [-50%]	0.05	0.02	-0.03 [-60%]	0.08	0.04	-0.04 [-50%]
	MC Q13a	0.06	0.05	-0.01 [-17%]	0.15	0.11	-0.04 [-27%]	0.25	0.21	-0.04 [-16%]
	LRPB	0.15	0.31	0.16 [107%]	0.35	0.62	0.27 [77%]	0.63	0.95	0.32 [51%]
	LRPB	0.20	0.19	-0.01 [-5%]	0.40	0.43	0.03 [7%]	0.74	0.85	0.11 [15%]
	MC Q14	0.42	0.37	-0.05 [-12%]	0.83	0.90	0.07 [8%]	1.60	1.73	0.13 [8%]
	MCPB	0.29	0.25	-0.04 [-14%]	0.57	0.44	-0.13 [-23%]	0.88	0.69	-0.19 [-22%]
	MC Q15	0.79	0.64	-0.15 [-19%]	1.81	1.48	-0.33 [-18%]	3.25	2.81	-0.44 [-14%]
	MC Q16	1.51	1.28	-0.23 [-15%]	3.24	3.01	-0.23 [-7%]	6.06	5.72	-0.34 [-6%]
Blaxland Creek	BLC Q01	0.32	0.30	-0.02 [-6%]	0.80	0.74	-0.06 [-8%]	1.51	1.39	-0.12 [-8%]
	MCPB	Minor	0.41	0.41 [-%]	Minor	0.71	0.71 [-%]	Minor	1.12	1.12 [-%]
	BLC Q02	0.43	0.55	0.12 [28%]	0.84	1.19	0.35 [42%]	1.61	2.16	0.55 [34%]

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
	LRPB	0.29	0.54	0.25 [86%]	0.67	1.19	0.52 [78%]	1.18	2.08	0.9 [76%]
	BLC Q03	0.84	0.84	0 [0%]	1.96	1.88	-0.08 [-4%]	3.50	3.19	-0.31 [-9%]
	BLC Q04	1.88	1.64	-0.24 [-13%]	3.87	3.80	-0.07 [-2%]	7.40	7.07	-0.33 [-4%]
	BLC Q05	2.40	1.99	-0.41 [-17%]	4.68	4.59	-0.09 [-2%]	9.31	8.91	-0.4 [-4%]
	BLC Q06	3.93	3.10	-0.83 [-21%]	7.22	7.11	-0.11 [-2%]	14.00	13.60	-0.4 [-3%]
	LRPB	0.26	0.10	-0.16 [-62%]	0.55	0.23	-0.32 [-58%]	0.83	0.39	-0.44 [-53%]
	LRPB	0.39	0.41	0.02 [5%]	0.78	0.97	0.19 [24%]	1.48	1.71	0.23 [16%]
	BLC Q07	0.93	0.89	-0.04 [-4%]	2.10	1.99	-0.11 [-5%]	3.70	3.38	-0.32 [-9%]
	BLC Q08	0.33	0.36	0.03 [9%]	0.54	0.56	0.02 [4%]	0.63	0.65	0.02 [3%]
	MCPB	Minor	Minor	0.00 [%]	Minor	Minor	0.00 [%]	Minor	Minor	0.00 [%]
	BLC Q09	0.45	0.67	0.22 [49%]	0.94	1.42	0.48 [51%]	1.74	2.40	0.66 [38%]
	BLC Q10	3.49	3.42	-0.07 [-2%]	6.95	7.29	0.34 [5%]	12.40	12.70	0.3 [2%]
	MCPB	Minor	0.60	0.6 [-%]	Minor	1.13	1.13 [-%]	Minor	1.87	1.87 [-%]
	BLC Q11	0.76	1.02	0.26 [34%]	1.72	2.14	0.42 [24%]	3.10	3.67	0.57 [18%]
	MCPB	0.21	0.60	0.39 [186%]	0.48	1.13	0.65 [135%]	0.79	1.87	1.08 [137%]
	BLC Q12	1.35	1.33	-0.02 [-1%]	2.74	3.00	0.26 [9%]	5.09	5.34	0.25 [5%]

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
	MCPB	0.09	0.46	0.37 [411%]	0.19	0.85	0.66 [347%]	0.32	1.38	1.06 [331%]
	BLC Q13	0.48	0.67	0.19 [40%]	1.01	1.38	0.37 [37%]	1.85	2.33	0.48 [26%]
	BLC Q14	1.24	1.20	-0.04 [-3%]	2.48	2.83	0.35 [14%]	4.79	5.27	0.48 [10%]
	MCPB	Minor	Minor	0.00 [%]	Minor	Minor	0.00 [%]	Minor	Minor	0.00 [%]
	BLC Q15	0.63	0.50	-0.13 [-21%]	1.23	1.20	-0.03 [-2%]	2.37	2.31	-0.06 [-3%]
Surveyors Creek	Q01	0.8	0.7	-0.1 [-13%]	1.6	1.5	-0.1 [-6%]	3	2.4	-0.6 [-20%]
	Q02	0.8	0.9	0.1 [13%]	1.6	1.8	0.2 [13%]	3.2	3.7	0.5 [13%]
	Q03	1.8	1.7	-0.1 [-6%]	3.5	3.3	-0.2 [-6%]	6.3	4.7	-1.6 [-25%]
	Q04	2.7	1.4	-1.3 [-48%]	5.6	1.8	-3.8 [-68%]	9.7	2.3	-7.4 [-76%]
	Q05	0.5	0.5	0.00 [%]	1	1.1	0.1 [-10%]	2.1	2.2	0.1 [5%]
	Q06	3.9	2.6	-1.3 [-33%]	7.9	4.1	-3.8 [-48%]	14.4	6.7	-7.7 [-53%]
	Q07	6.9	5.7	-1.2 [-137%]	13.3	9.8	-3.5 [-26%]	24.7	17.2	-7.5 [-30%]
	Q08	8.4	6.6	-1.8 [-21%]	13.4	10.6	-2.8 [-21%]	17.9	13	-4.9 [-27%]
	Q09	0.6	0.3	-0.3 [-50%]	0.6	1.3	0.7 [-117%]	0.6	7.4	6.8 [-133%]
	Q10	0.5	0	-0.5 [-100%]	3.1	1	-2.1 [-68%]	8.8	6.9	-1.9 [-22%]
	Q11	0	0	0.00 [%]	0	0	0.00 [%]	0	0	0.00 [%]

Catchment	Peak flow locator	2 year ARI			10 year ARI			100 year ARI		
		Pre-project	Post-project	Difference	Pre-project	Post-project	Difference	Pre-project	Post-project	Difference
	Q12	7.9	7.7	-0.2 [-3%]	14.6	13.1	-1.5 [-10%]	21.6	17.3	-4.3 [-20%]
	Q13	0.4	0.2	-0.2 [-50%]	3.1	0.4	-2.7 [-87%]	6.5	0.7	-5.8 [-89%]
	Q14	7.9	8.1	0.2 [3%]	15.7	14.4	-1.3 [-8%]	25.5	25.5	0
	Q15	2.5	2.5	0.00 [%]	4.8	5	0.2 [4%]	7.2	9.3	2.1 [29%]
	Q16	0	0	0.00 [%]	0.8	0	-0.8 [-100%]	6.3	0	-6.3 [-100%]
	Q17	9.6	9.4	-0.2 [-2%]	19.7	17.1	-2.6 [-13%]	35.5	30.3	-5.2 [-15%]
	Q18	11.7	9.6	-2.1 [-18%]	20.9	17.5	-3.4 [-16%]	35.6	30.7	-4.9 [-14%]

1. A positive difference indicates an increase in peak flow attributable to the project (refer cells highlighted orange). Conversely, a negative difference indicates a decrease in peak flow attributable to the project (refer cells highlighted green)
2. MCPB = Main Carriageway Project Boundary LRPB = Local Road Project Boundary PFI = Peak Flow Identifier

Potential impacts of flooding on the project

Implementation of the transverse drainage and flood mitigation strategy would ensure that the required 100 year ARI level of flood immunity is achieved. As flow velocities in the vicinity of The Northern Road are relatively mild and depths of inundation typically less than 2 m, damage to the road embankment should not occur provided suitable scour protection measures are incorporated in areas of the project that are subject to flooding.

Depending on flow velocities, such measures could involve grass or rock lining. Suitable scour protection measures would also need to be incorporated in the inlet and outlet of transverse drainage to prevent damage to road infrastructure.

Surcharge of the road would occur during a PMF event, with the full width of the road formation inundated by floodwater between about Eaton Road and Glenmore Parkway. While depths of flow along the northbound and southbound carriageways would be relatively shallow along most of its length (generally in the range 50-300 mm), damage could be expected to occur to the road during an extreme storm event.

Impact of future climate change on flooding behaviour

Appendix K provides figures (Figure 7.32 to Figure 7.37) that show the impact a potential increase of 10 per cent and 30 per cent in 100 year ARI design rainfall intensities would have on flooding behaviour in the vicinity of the project where it runs through the Cosgrove, Duncans and Badgerys Creek catchments, respectively.

In general, a 30 per cent increase in the intensity of 100 year ARI rainfall would result in an increase in peak flood levels along the project corridor by a maximum of 500 mm, but typically 50 mm or less. A 100 year ARI level of flood immunity would still be maintained to both carriageways of The Northern Road in both events.

8.1.5 Summary of potential impacts to the environment of Commonwealth land

The above discussion of the project's potential hydrology and flooding impacts on the respective catchments of Surveyors Creek, Blaxland Creek, the unnamed tributary of South Creek, Cosgroves Creek and Badgerys Creek, has provided a description and assessment of the potential impacts on Commonwealth land at the DEOH, and at the site of the Western Sydney Airport at Badgerys Creek.

The earthworks, drainage works and other civil works proposed for the project's construction and ongoing operation would result in changes to drainage and flooding behaviour in the catchments that flow through and into Commonwealth land. In some cases, without mitigation the project would increase the potential for flooding in terms of the likely extent and depth of inundation. This in turn would increase the potential of scour and erosion, and associated water quality issues.

Potential construction impacts

The project's potential flooding and hydrological impacts on Commonwealth land during construction are assessed in Section 8.1.3 above. The assessment demonstrates that with implementation of the recommended environmental management measures, the impacts would be minor.

Potential operation impacts

The project's potential flooding and hydrological impacts on Commonwealth land during operation are assessed in Section 8.1.4 above.

The project's design has taken account of the potential changes in flood impacts to Commonwealth land, having regard for the existing hydrology of the catchments within which the lands are situated, and the existing topography and drainage infrastructure. The proposed design has incorporated the results of detailed modelling of the catchments and of the proposed road formation and drainage structures, in order to build a predictive model of likely flooding and hydrological impacts that would result from the project during a range of storm events.

The project would result in substantial increases in peak flood levels along its upstream side during a PMF event. While the affected areas generally comprise undeveloped pastoral land, four existing dwellings that are located on the Badgerys Creek floodplain would be affected. Roads and Maritime have modelled the effects of lowering the road and found that while the affected areas are generally confined to pastoral land, the depth of above-floor inundation in two existing dwellings that are located on the Badgerys Creek floodplain would be increased by a maximum of 0.2 m. Given the very low probability of occurrence of a PMF event in combination with the relatively small increase in the depth of above-floor inundation in the two dwellings, the increase in flood risk attributable to the lowered road would be only minor.

There would be an increase in the rate and volume of flow discharging to three drainage lines and existing dams within Blaxland catchment, which runs through the DEOH. As a result, the scour potential along these drainage lines would increase and ground conditions would become wetter. The increase in scour potential would extend only a short distance from the corridor as the increase in peak flow attributable to the project as a percentage of the total flow reduces in the downstream direction due to the discharge of additional catchment runoff to the affected drainage line. As identified above, impacts to the biodiversity and natural heritage values of these tributaries have been assessed in Sections 7.3 and 8.4 respectively, with potential impacts expected to be minor.

Where required, the impact assessment has concluded with recommendations for a number of environmental management measures specifically aimed at controlling or minimising the potential impacts, and achieving Roads and Maritime's required 1 in 100 year flood immunity.

8.1.6 Environmental management measures

Expected environmental outcomes

A strategy has been developed which is aimed at mitigating the impact of the project on flooding behaviour and scour potential, as well as providing a minimum 100 year ARI level of flood immunity to the project (transverse drainage and flood mitigation strategy).

Specific objectives that would be achieved through the implementation of environmental management measures include:

- Minimising scour impacts of the project, in particular to farm dams and sensitive receiving waterways
- Minimising impacts to infrastructure and receivers located near the project from changes to flood behaviour
- Compliance with the relevant legislative requirements and project conditions of approval.

Expected effectiveness

Roads and Maritime has experience in managing potential hydrology and flooding impacts as a result of road developments of similar scale and scope to this project. Project-specific management measures identified in Table 8-4 have been developed with the aim of minimising or mitigating, as far as practical, construction and operational impacts from changes to the existing hydrological regime of the project area.

The potential impacts to flooding of the project area and of flooding on the project as a result of the upgrade have been modelled. As outlined in Section 5.4.8, the drainage design and flood mitigation strategy is effective at mitigating the potential flooding and hydrological impacts of the project as well at providing 100 ARI year ARI level of flood immunity to the project. This transverse drainage and flood mitigation strategy would be iterative throughout detailed design and would continually be updated to provide the best environmental and engineering outcomes for the project.

Implementation of the transverse drainage and flood mitigation strategy would ensure that the required 100 year ARI level of flood immunity is effectively achieved.

Construction of the project may result in minor and temporary impacts that would be managed through the implementation of standard construction techniques and protection measures. Surface water flows would be maintained or managed during construction to a reasonable and practicable extent.

Audits and reporting of the effectiveness of environmental management measures employed during construction is generally carried out to show compliance with management plans and other relevant approvals and would be outlined in detail in the CEMP prepared for the project.

Table 8-4 Environmental Management Measures – hydrology and flooding

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
Impacts on flood behaviour during construction	FH-1	Temporary works would consider flood impacts during construction. Should construction staging require a temporary departure from the design (eg higher embankments for preloading, temporary diversions or temporary crossings), flood impacts would be assessed before finalising the approach.	Construction contractor	Construction	Expected to be effective Monitoring and reporting requirements of the Soils and Water Management Plan (SWMP) to confirm effectiveness of measures.
	FH-2	Appropriate scour protection measures would be implemented along any temporary drainage lines within the project construction area: • Scour protection would be added to the outlets of the upgraded transverse drainage • Scour protection measures would also be incorporated on the inlet of the upgraded transverse drainage in order to prevent damage to the structure during major flood events • Scour protection measures would take the form of dumped rock riprap or reno mattress.	Contractor	Pre-construction	Expected to be effective Monitoring and reporting requirements of the SWMP to confirm effectiveness of measures.
	FH-3	A contingency plan to be prepared to manage a potential flood event during construction that would outline procedures to reduce the likelihood, including removing plant/equipment and stabilising exposed areas. This plan would consider the likelihood of flooding, evacuation routes, warning times, and potential impacts from the site flooding.	Construction contractor	Construction	Proven to be effective. Monitoring and reporting requirements of the SWMP to confirm effectiveness of measures.

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
Impacts on flood behaviour during operation	FH-4	The transverse drainage and flood mitigation strategy would continue to be refined during detailed design. If the properties are still impacted, and if mitigation is required, this would be investigated in consultation with the landowners. It would include, but not be limited to: • Identification of potential flood impacts to the project and adjoining areas, including consideration of local drainage catchment assessments and climate change implications on rainfall, drainage • Design and mitigation measures to protect proposed operations and not worsen existing flooding characteristics during construction and operation, including soil erosion and scouring • Drainage system upgrades and preparation of a Flood and Emergency Management Plan.	Roads and Maritime	Detailed design	Proven to be effective.
	FH-5	The 100 year ARI flood level is to be adopted in the assessment of measures which are required to mitigate any adverse impacts attributable to the project. Changes in flood behaviour under PMF conditions would also be assessed in order to identify impacts on critical infrastructure and substantial changes in flood hazards as a result of the project.	Roads and Maritime	Detailed design	Proven to be effective. Further design development would be carried out at detailed design stage to reduce the potential for flood attributable to the project in the affected properties.
	FH-6	A floor level survey would be undertaken in affected areas to determine whether the project would increase flood damages in adjacent developments (ie in properties where there is a potential for increases in peak flood levels for events up to the 100 year ARI	Roads and Maritime	Detailed design	Proven to be effective. Further design development would be carried out at detailed

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
		flood).			design to reduce the potential for flood attributable to the project
Reductions in water volumes	FH-7	Consultation would be carried out with each affected landholder where reductions in the volume of flow would cause existing dams to fill less frequently, reducing the available yield.	Roads and Maritime	Detailed design	Expected to be effective if carried out in accordance with consultation requirements.

8.1.7 Residual impacts

The assessment of the project's potential impacts on flooding and hydrology documented in this section and in Appendix K has concluded, on the basis of the modelling carried out to support the assessment, that the project can achieve the required 1 in 100 year flood immunity. It has also concluded that the potential hydrological impacts of the range of storm events modelled can be effectively managed to an acceptable level with the implementation of the environmental management measures listed in Table 8-4. The conclusions documented in respect of the project's design, with the implementation of the recommended management measures, effectively represents the description of the project's residual impacts.

Therefore, it can be concluded that after the implementation of the recommended environmental management measures, the project would not result in any significant residual flooding and hydrological impacts.

8.2 Soils, water and contamination

This chapter describes the existing soils, water and contamination within the project and the potential impacts as a result of the construction and operation of the project. This chapter also recommends environmental management measures to reduce the impacts of the project.

The technical working paper, Soils, water and contamination (Appendix L) has been used to inform this chapter.

Table 8-5 sets out the Secretary's Environmental Assessment Requirements (SEARs) and the Commonwealth EIS Guidelines as they relate to soils, water and contamination and states where in this EIS these have been addressed.

Table 8-5 Environmental Assessment Requirements – Soils, water and contamination

Requirement	Where addressed in EIS
Secretary's Environmental Assessment Requirements (NSW EP&A Act)	
The EIS must address the following specific matters: impacts on watercourses, surface water flows (including stormwater drainage systems), quality, quantity, availability and users (commercial and recreational), with particular reference to any likely impacts on surrounding water bodies and their catchments, wetlands and their habitats, including how these are to be monitored;	Appendix K (Flood risk assessment Working paper) Section 8.1.4 Section 8.2.3 Section 8.2.4 Section 8.2.7
An assessment of construction water quality impacts, taking into account impacts from both accidents and runoff (i.e. acute and chronic impacts), having consideration to impacts to surface water runoff, soil erosion and sediment transport, mass movement, and spoil and waste management. The assessment of water quality impacts is to have reference to relevant public health and environmental water quality criteria, including those specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000), any applicable regional, local or site-specific guidelines, water quality objectives, and any licensing requirement.	Section 8.2.1 Section 8.2.3

Requirement	Where addressed in EIS
assessment of waterways to be modified as a result of the proposal, including ecological, hydrological and geomorphic impacts (as relevant), including temporary crossings, and measures to rehabilitate the waterways to preconstruction conditions or better, including fish passage requirements consistent with Policy and Guidelines for Fish Friendly Waterway Crossings (DPI, 2004);	Section 7.3 Section 8.1 Section 8.2.2 Section 8.2.3 Section 8.2.8
groundwater impacts taking into consideration impacts associated with geotechnical ground treatments, dewatering, deep cuttings and fill locations, and cumulative impacts on regional hydrology. The assessment shall consider, where relevant, the extent of drawdown, impacts to groundwater characteristics, quality, quantity, and connectivity, groundwater flow direction and levels, discharge and recharge rates, and implications for water courses, groundwater users, groundwater dependent ecosystems, riparian areas and wetlands. The assessment should be prepared having consideration to the NSW Aquifer Interference Policy;	Section 8.2.1 Section 8.2.3 Section 8.2.4
measures to manage, monitor and/or mitigate impacts;	Section 8.2.7 Section 8.2.8
Identify potential impacts of the development on acid sulfate soils in accordance with the relevant guidelines and a description of the mitigation measures proposed to minimise potential impacts.	Section 8.2.2
Provide a contaminated land assessment in accordance with relevant guidelines.	Section 8.2 Appendix L
Commonwealth EIS Guidelines (Commonwealth EPBC Act) Requirements	
The EIS must include a description of the environment of the proposal site and the surrounding areas that may be affected by the action. It is recommended that this include the following information: A description of the environment in all areas of potential impact, including all components of the environment as defined in Section 528 of the EPBC Act: • Landscapes and soils • Natural and physical resources, including water resources.	Section 8.2.2
Impacts to the environment (as defined in section 528) should include but not be limited to the following: • Changes to water quality on site and downstream of the site • Changes to siltation • Changes in recreational use and amenity of natural areas.	Section 8.2.3 Section 8.2.4

8.2.1 Assessment methodology

The process of assessing the potential impacts of the project and developing impact mitigation measures for the various aspects of this report are outlined below.

The information sources used in carrying out the assessment are identified below, where applicable, and comprise Government databases and mapping, and previous assessments. A complete list of information sources used in the assessment is provided in the technical working paper. The assessment methodologies described below identify where those sources of information have been verified through ground-truthing or may require further testing (such as contamination). The assessment methodologies also note any uncertainties in the information sources.

Study area

The study area for the assessment of soils, water and contamination generally comprises the construction and operational footprints for the project as well as the following extents specific to each discipline:

- Surface water was assessed in the context of potentially impacted hydrological catchments draining the project
- The identified Areas of Environmental Interest (AEIs) form the basis of the study area with respect to contamination
- Groundwater was assessed based on the regional and local shallow and deep geological units underlying the project.

Surface water

Surface water was assessed based on the potentially impacted hydrological catchments draining the project. Assessment of the existing environment and potential impacts of the project on surface water quality during construction and operation has included the following with reference to applicable guidelines and procedures:

- Review of existing literature relating to the project, available water quality data and existing conditions using available non-project literature to obtain background information on catchment history and land use to aid in interpreting the existing conditions
- Assessment of the impact of operational activities on water quality with reference to the Australian and New Zealand Environment Conservation Council (ANZECC/ARMCANZ, 2000) *water quality guidelines* and the *Healthy Rivers Commission Independent inquiry into the Hawkesbury Nepean* (HRC, 1998) with regard to the relevant environmental objectives of aquatic ecosystems and visual amenity
- Review of water quality treatment measures that could be used to mitigate the impact of construction on water quality, following the principles of *Managing Urban Stormwater ‐Soils and Construction Volume 1* (Landcom, 2004) and Volume 2D (DECC, 2008)
- Review of water quality treatment measures that could be used to mitigate the impact of the operation of the project on water quality following the principle of *Procedure for Selecting Treatment Strategies to Control Road Runoff* (RTA, 2003), *RMS Water Policy* (RTA, 1997) and *RMS Code of Practice, Water Management* (RTA, 1999).

Water quality modelling using the eWater MUSIC - Model for Urban Stormwater Improvement Conceptualisation, was also carried out to determine the pollutant load reductions that can be achieved by permanent water quality swales (with rock check dams) for Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP).

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

The eWater MUSIC model was set up to represent proposed catchment conditions. Models of the swales were created by adopting the sub-catchment areas estimated in the catchment analysis. Rock check dams were also added to the model as per the detailed design typical swale details.

For the protection of aquatic ecosystems in this region, the ANZECC/ARMCANZ (2000) default trigger values for physical and chemical stressors for 'South-East Australian slightly to moderately disturbed lowland rivers' have been applied. The NSW Healthy Rivers Commission (HRC) nutrient guidelines (1998) listed are for mixed use rural areas.

Further detail regarding relevant water quality guidelines and objectives that were applied in the assessment of surface water quality is presented below and summarised in Table 8-6.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000)

The Australian and New Zealand Environment Conservation Council (ANZECC) water quality guidelines (2000) provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters. They form part of the National Water Quality Management Strategy and list a range of environmental values assigned to that waterbody. The ANZECC/ARMCANZ (2000) *National Water Quality Guidelines for Fresh and Marine Water Quality* have been applied to understand the current health of the waterways in the study area and the ability to support nominated environmental values, particularly the protection of aquatic ecosystems. The Guidelines provide recommended trigger values which have been applied to understand the existing water quality and key indicators of concern.

The Healthy Rivers Commission – Hawkesbury Nepean River *(HRC 1998)*

The Healthy Rivers Commission was established in 1995 (under section 23 of the *Pollution Control Act, 1970*) by the NSW Government to make recommendations on:

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

Table 8-6 Guidelines for Protection of Aquatic Ecosystems

Indicator	ANZECC/ARMCANZ (2000)	HRC (1998)
Conductivity (µs/cm)	125 - 2200	
pH	6.5 - 8.5	
Dissolved oxygen (% saturation)	85 - 110	
Turbidity (NTU)	6 - 50	
Suspended Solids (mg/L)	< 40	
Ammonia (µg/L)	< 20	
Oxidised nitrogen (µg/L)	< 40	

Indicator	ANZECC/ARMCANZ (2000)	HRC (1998)
Total nitrogen (µg/L)	< 350	700
Total Phosphorus (µg/L)	< 25	35
Chlorophyll-a (µg/L)	< 3	
Arsenic (µg/L)	<13	
Cadmium (µg/L)	<0.2	
Chromium (µg/L)	<1	
Copper (µg/L)	<1.4	
Lead (µg/L)	<3.4	
Nickel (µg/L)	<11	
Zinc (µg/L)	<8	
Mercury (µg/L)	<0.6	

There is the potential for the current water quality to not meet the existing guidelines and trigger values for protecting nominated environmental values. Irrespective of the current condition of waterways, the project should not further degrade water quality. As such the key objective of the project is to minimise the potential impacts on downstream receiving waters, so that the project changes the existing water regime by the smallest amount practicable. This objective is consistent with the Roads and Maritime's *Water Policy, 1997* (RTA, 1997) and *Code of Practice for Water Management, 1999* (RTA, 1999).

Sensitive receiving environments have been identified using aquatic habitat as an indicator which was assessed against the *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management*, 2013 and *Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge, 2003) (see Appendix L).

Contaminated land

The following guidelines were considered (where relevant) as part of the contamination assessment:

- Managing Land Contamination: Planning Guidelines State Environmental Planning Policy (SEPP 55) – Remediation of Land, (NSW Department of Urban Affairs and Planning & NSW Environmental Protection Authority, 1998)
- Guidelines for Consultants Reporting on Contaminated Sites (NSW Office of Environment and Heritage, 2000).

A Stage 1 Contamination Assessment has been carried out to identify potential Areas of Environmental Interest (AEI) which would assist in identifying construction limitations and constraints within the project with respect to contamination. These AEI form the study area for the assessment of contamination potential for the project.

The AEI were considered to be those with the potential to impact soil and groundwater which may be present as a result of historic and/or current activities undertaken on and/or adjacent to the project. To achieve these objectives, Jacobs undertook the following scope of works:

- Review of publically available information (NSW EPA, CSIRO ASRIS database, NSW Department of Primary Industries groundwater database, Commonwealth Department of Defence Unexploded Ordinance (UXO) database)
- Review of historical aerial photography of the project
- Site walkover and inspection.

A search of the NSW EPA Contaminated Sites Register and Record of Notices (under Section 58 of the *Contaminated Land Management Act 1997*) undertaken as part of the desktop assessment was based on a one kilometre radius of the project.

The historical and site information was sourced from NSW Government departments with no known interest in the site. While there is a small margin for error in interpretation, the information presented in the assessment is considered to be accurate.

Preparation of a Stage 1 contamination assessment report was based on the data obtained from the desktop background review and observations from the inspection of the project. Intrusive site sampling was not carried out; therefore the results provided are indicative of the sub-surface conditions. The ground conditions are presented together with any contamination issues identified and recommendations for further investigations, where or if required. The Stage 1 Contamination Assessment is provided within Appendix L.

Where the scale or type of potential contaminant is unknown or unpredictable (such as the quality of existing stockpiles) the Stage 1 Assessment has stated that the details are unknown and suggested further actions where required.

The framework for the soil and land contamination assessment was developed in accordance with guidelines 'made or approved', by the EPA, under section 105 of the (NSW) *Contaminated Land Management Act 1997*.

Groundwater

Groundwater was assessed based on the regional and local shallow and deep geological units underlying the project. The process outlined below has been used to determine impact to groundwater along the project and to identify the appropriate groundwater management and mitigations measures for implementation during the construction and operational phases of the project.

Assessment of potential impact of the project on groundwater has included the following, with reference to applicable guidelines and procedures:

- Review of existing literature relating to the project, including consideration of climate conditions, geological maps (regional and local shallow and deep geological units, structural geology, acid sulphate soils (ASS) and salinity maps), available groundwater level and quality data (including a NSW Pinneena bore search based on a 400 m search radius) and existing conditions using available non-project literature to obtain background information to aid in interpreting the existing groundwater conditions
- Assessment of the impact of construction activities on water quality with reference to the ANZECC 2000 water quality guidelines with regard to groundwater quality
- Review of the Aquifer interference policy (NOW, 2012), and development of a conceptual groundwater model water balance
- Assessment of the groundwater impacts of the project during construction and operation, including assessment of potential impact to groundwater levels, flows and connectivity, as well as potential impacts to groundwater quality and groundwater users. Review of water quality treatment measures that could be used to mitigate the impact of the operation of the project on water quality following the principle of Procedure for Selecting Treatment Strategies to Control Road Runoff' (RTA, 2003), RMS Water Policy (RTA, 1997) and RMS Code of Practice, Water Management (RTA, 1999).

Aquifer Interference Policy

The Aquifer Interference Policy (DPI Water, 2012) outlines the requirements for the assessment of aquifer interference activities administered by the *Water Management Act 2000*. The groundwater assessment includes an assessment of the project against the Level 1 Minimal Impact Considerations of the NSW Aquifer Interference Policy (DPI Water, 2012) including:

- All water taken must be properly accounted for
- The activity must address minimal impact considerations with respect to water table, water pressure and water quality
- Planning for measures in the event that actual impacts are greater than predicted, including making sure there is sufficient monitoring in place.

As identified in Section 2.2 of the EIS, various approvals under the *Water Management Act, 2000*, including water use approvals under section 89, water management work approvals under section 90, and activity approvals (other than aquifer interference approvals) under section 91 are not required for the project under Part 5.1 of the EP&A Act (refer to section 115ZG of the EP&A Act).

An aquifer interference approval under the *Water Management Act, 2000* would be required if construction requires intersection of a groundwater source. There are no planned groundwater dewatering activities, therefore no aquifer interference approvals are expected to be required for the project.

8.2.2 Existing environment

The following sections outline the existing environmental conditions relevant to soils, water and contamination. This is considered to provide a baseline of existing conditions from which potential impacts from the project have been assessed.

Baseline water quality monitoring was not carried out for the project. Monthly sampling carried out at three sites relevant to the project, as part of the Western Sydney Airport EIS, were used as a baseline for comparison to a range of ANZECC/ARCMANZ trigger values. Prior to construction, baseline water quality monitoring would be undertaken upstream and downstream of waterways that have been identified as potentially being impacted to identify site specific trigger values as per ANZECC to ensure there is no further degradation in water quality.

Landscape context

The project is located on the Cumberland Plain, a low lying and gently undulating sub-region of the Sydney Basin. The Sydney Basin is a large geological feature stretching from Batemans Bay to the south to Newcastle in the north and Lithgow in the west. The formation of the basin began between 250 to 300 million years ago when river deltas gradually replaced the ocean that had extended as far west as Lithgow (Clark and Jones, 1991).

The project area traverses a north–south oriented ridge that forms the watershed separating the catchment areas of South Creek in the east and the Nepean River in the west. The ridge is characterised by gentle to moderately inclined slopes with narrow to broad crests and drainage lines. The eastern side of the project contains several north-east flowing creeks including Badgerys Creek, Cosgroves Creek and Oaky Creek which join South Creek about 7 km to the east. On the western side of the project, several creeks including Duncans Creek, Surveyors Creek and Mulgoa Creek flow north-west to join the Nepean River about 4.5 km to the west. To the south-west of Luddenham and the proposed new alignment of The Northern Road, undulating areas including creeks in gullies are present. There are a number of farm dams along the entire alignment.

East of the existing The Northern Road (which runs along a ridge line) the land is gently undulating with two ridgelines forming the main topographical features. One is located to the west of Luddenham Road and the other is in the Aldington Road / Mt Vernon Road areas.

Landscape character varies from generally semi-rural in the majority of the study area to occasional pockets of suburban areas including at Luddenham and Glenmore Park.

Regional geology

The Penrith 1:100,000 Geological Series Sheet 9030 (NSW Department of Mineral Resources, 1991) indicated that the project is predominately underlain by Bringelly Shale (Rwb), Quaternary alluvium (Qal) and Cranebrook Formation (Qpc). Bringelly Shale (Rwb) is composed of shale, carbonaceous claystone, claystone, laminate, fine to medium-grained lithic sandstone, rare coal and tuff (Clark and Jones 1991) and underlies the crests, slopes and drainage lines of the majority of the project.

A description of the geological formations underlying the project is provided in Table 8-7 and outlined on Figure 8-2.

Table 8-7 Geological units underlying the project

Unit	Description
Bringelly Shale (Rwb)	Shale, carbonaceous claystone, laminate, coal in parts
Luddenham Dyke	Basalt, dolerite
Cranebrook Formation (Qpc)	Pebbles and cobbles of quartz, quartzite, chert, porphyry, granite, hornfels and silcrete
Quaternary Alluvium (Qal)	Fine grained sand, silt, clay

Soils

The Penrith 1:100,000 Soil Landscape sheet 9030 (Soil Conservation Service of NSW, 1990) indicated that the soil landscape groups within the project consist three principal soil landscapes. These are erosional Luddenham (lu), residual Blacktown (bt) and fluvial South Creek (sc) soil landscape groups. Table 8-8 describes the soil landscape groups within the project.

The basal geology is overlain by South Creek soils within the immediate vicinity of major creeks, transitioning to Blacktown soils on crests and low rises and Luddenham soils on hills and ridge slopes. The alluvial South Creek soil landscape is characterised by flat landforms with incised channels that are subject to frequent episodes of inundation, erosion and aggradation.

Soil landscapes in the project are shown on Figure 8-3.

Table 8-8 Soil units underlying the project

Unit	Description
Luddenham (lu)	• Landscape – found on undulating to rolling hills on Wianamatta Shales, with slopes between 5-20 per cent and local relief between 50 and 80 m, narrow ridges, hills and valleys • Soils – shallow podzolic soils and massive clays on crests, moderately deep red podzolic soils on upper slopes and moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines • Limitations – high soil erosion hazard, localised impermeable highly plastic subsoil, moderately reactive.
Blacktown (bt)	• Landscape - found on gently undulating rises on Wianamatta Group shales with local reliefs of up to 30 m and slopes of less than 5 per cent • Soils - shallow to moderately deep hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines

Unit	Description
	• Limitations - moderately reactive, highly plastic subsoil, with low fertility and poor drainage.
South Creek (sc)	• Landscape - found on floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain • Soils – deep layered sediments over bedrock or relic soils. Structured plastic slays and loams in and adjacent to drainage lines, red and yellow podzolic soils on terraces • Limitations – erosion hazard, frequent flooding.

Acid Sulfate Soils (ASS)

ASS are soils and sediments that contain iron sulfides that when disturbed to oxygen, generate sulphuric acid and toxic quantities of aluminium and other heavy metals. The sulfuric acid and heavy metals are produced in forms that can be readily released into the environment with potential adverse effects on the natural and built environment, as well as human health. The majority of ASS are formed by natural process under specific environmental conditions, which generally limits its occurrence in low lying sections of coastal floodplains, rivers and creeks where surface elevations are less than 5.0 m AHD.

The Australian Soil Resource Information System (ASRIS, 2015) provides online access to the best publicly available information on soil and land resources across Australia. ASRIS provides a national map of available ASS mapping that is classified with a nationally consistent legend that includes risk assessment criteria and correlations between Australian and International Soil Classification Systems. The ASRIS ASS map was consulted to determine the presence and risk of ASS along the proposed alignment. The ASS Probability within the proposed alignment was classified as Extremely Low Probability of occurrence. ASS is therefore not considered to be a risk to the project.

Soil salinity

Surface water and groundwater can dissolve and mobilise salts and cause their accumulation in other areas. Excessive concentrations of salt in such areas can affect plant growth, soil chemistry and cause weakening and degradation of construction materials such as masonry, concrete and bitumen. The assessment of salinity potential along the alignment was undertaken using the map of the salinity potential in western Sydney (NSW Department of Infrastructure, Planning and Natural Resources, 2002). The majority of the alignment occurs in areas of moderate salinity potential.

It is understood that durability and aggressivity samples of soil material would be collected and analysed prior to the construction phase, to determine potential impacts of soil salinity on pavement infrastructure.

Soil salinity potential for the project is mapped on Figure 8-4.

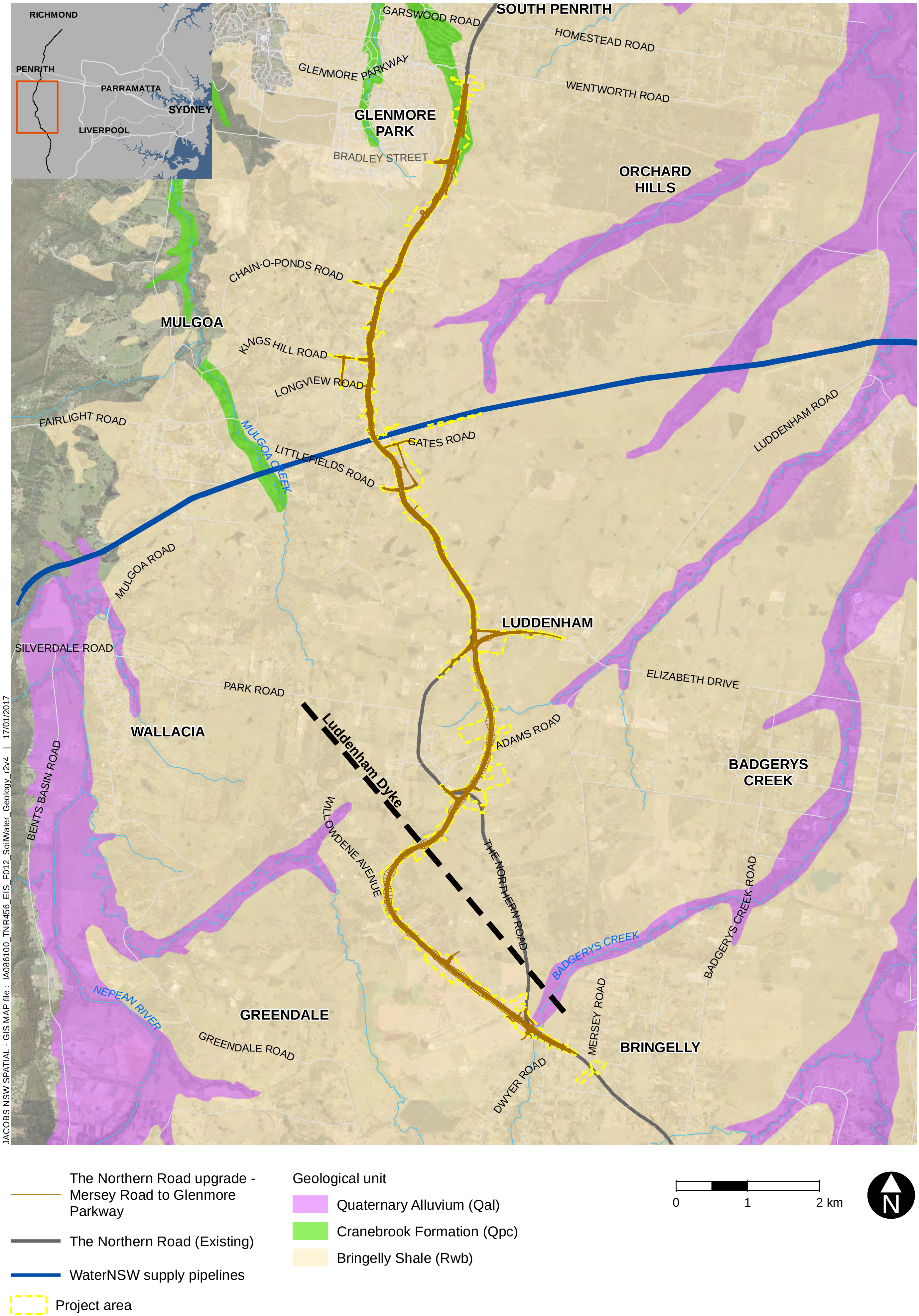


Figure 8-2 | Regional Geology

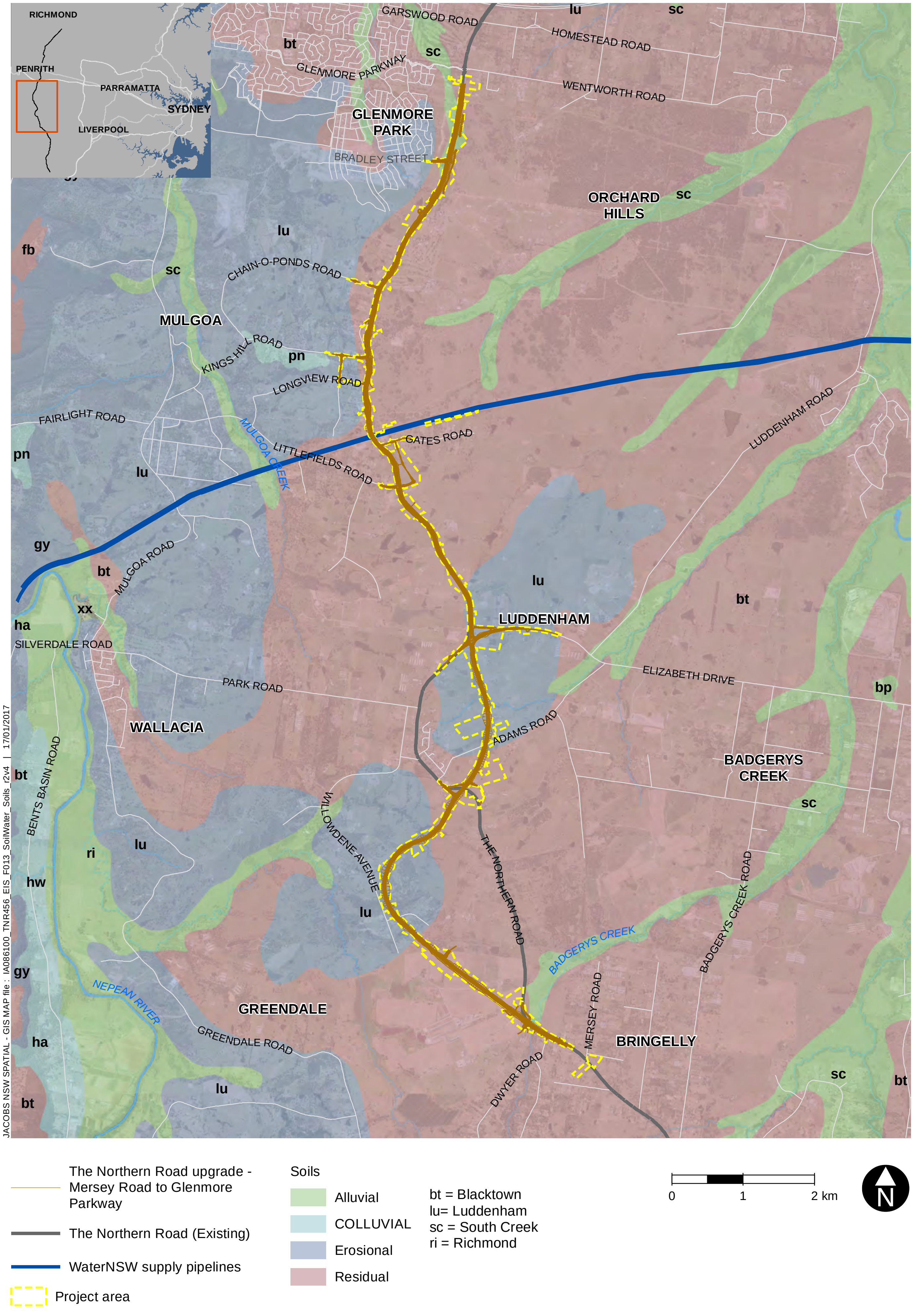


Figure 8-3 | Soil Landscapes

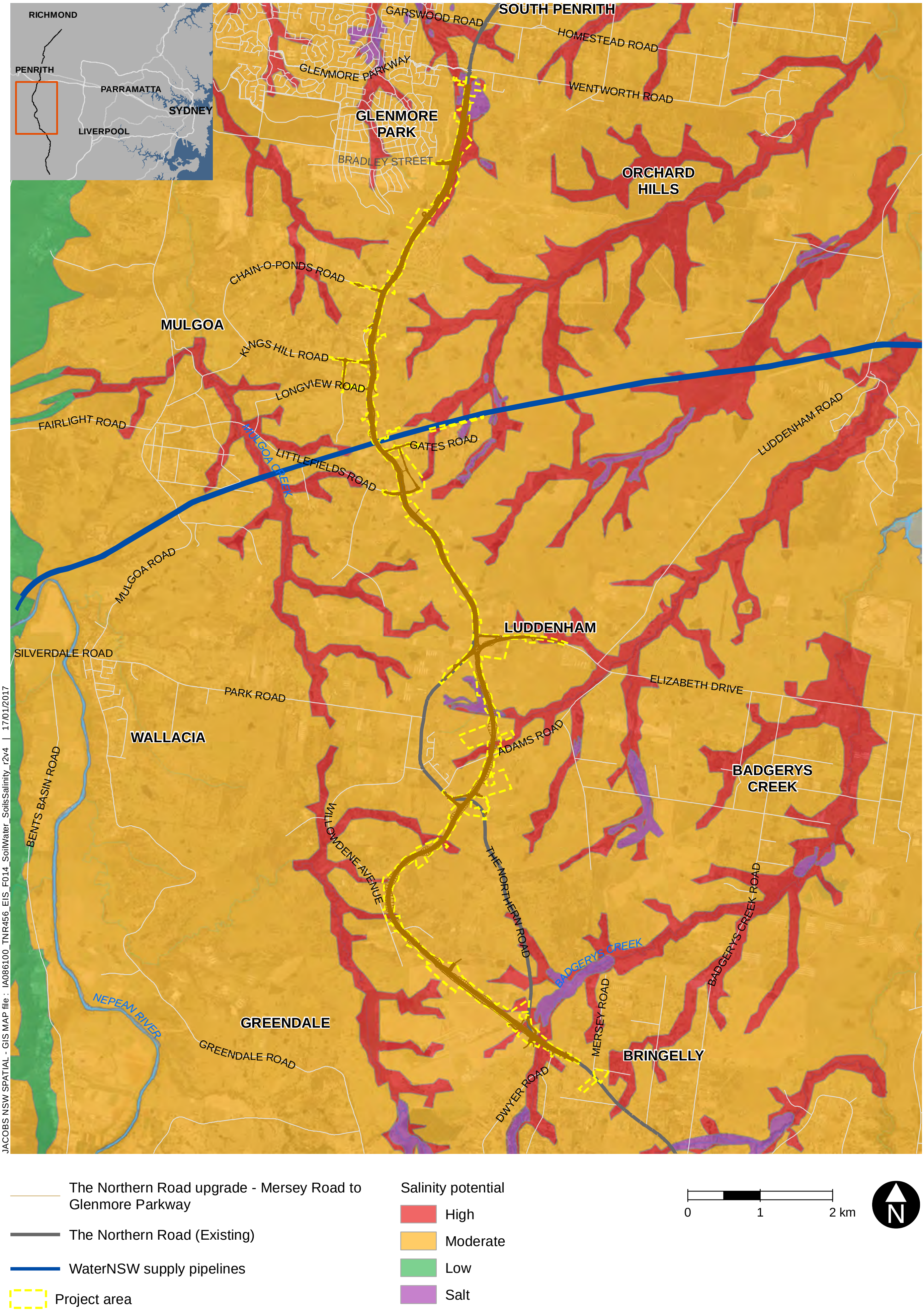


Figure 8-4 | Soil salinity potential

Contaminated land

NSW contaminated sites register

At the time of preparing the Stage 1 contamination assessment, a search of the NSW EPA Contaminated Sites Register and Record of Notices (under Section 58 of the *Contaminated Land Management Act 1997*) was undertaken to ascertain the presence of registered sites that were either regulated or had been notified within the suburbs within the project. The notified/regulated sites within one kilometre of the project are summarised in Table 8-9.

Table 8-9 Notified sites within one kilometre of the project

Suburb	Notified site address	Notified site activity	Contamination status	Location relative to project
Luddenham	Caltex Service Station The Northern Road	Service Station	Under assessment	Outside project (> 250 m)

Based on the location of notified site relative to the project, the Luddenham service station site is unlikely to be in the near vicinity of the construction footprint and as such is unlikely to be a source of contamination to the project.

A search of areas of concern from the UXO website was undertaken in March 2016. At the time of undertaking this assessment, no known areas of concern with respect to UXO were identified within or adjacent to the project including DEOH. Additionally the likelihood of encountering UXO during construction activities has been assessed as low.

Site inspection

A site inspection was conducted on 19 November 2015 by a Jacobs environmental scientist. The site inspection focused on the project, as well as adjacent land uses and potential AEIs. The site inspection was only undertaken from areas which were accessible to the public.

At the time of the site inspection the project consisted mostly of agricultural and rural residential land use, with low density residential land use in the suburbs of Glenmore Park and Mulgoa. The remaining areas generally comprised rural residential land use with more intensive agricultural land use within the southern portion of the project (Greendale) and the DEOH. Roads were generally sealed. A number of AEI were identified during the site inspection as detailed in Table 8-10 and Figure 8-5.

Table 8-10 Site inspection AEIs

AEI	Location	Contaminants of Potential Concern	Potential Contamination Distribution	Exposure Likelihood
Stockpiles	Private Property, western side of The Northern Road between Glenmore Parkway and Bradley Street, Glenmore Park	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
DEOH (Commonwealth land)	Eastern side of The Northern Road, Orchard Hills	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls,	Surface and shallow soils	Low - Contamination (if present) from the use of the site for military purposes unlikely to be in the

AEI	Location	Contaminants of Potential Concern	Potential Contamination Distribution	Exposure Likelihood
		asbestos, explosive residues		vicinity of the project area.
DEOH (Commonwealth land)	Eastern side of The Northern Road, Orchard Hills	UXO	Surface and shallow soils	Moderate – Likelihood of encountering UXO during construction activities is likely to be low; however the consequence if encountered could be high.
Stockpiles	Eastern side of The Northern Road between Kingshill and Longview Roads, Orchard Hills	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Moderate – Stockpiles may need to be removed during construction activities.
Sub-station	Eastern side of The Northern Road, Orchard Hills	Heavy metals, hydrocarbons, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and substantial construction activities are unlikely on the site. Should construction activities occur on the site, then exposure likelihood would increase.
WaterNSW Supply Pipelines	Eastern and western sides of The Northern Road, Orchard Hills	Heavy metals	Surface and shallow soils	Moderate – Increased with excavation in areas of potential contamination.
Filling	Private property, eastern side of Galaxy Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Stockpiles	Private property, eastern side of Galaxy Road,	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls,	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely

AEI	Location	Contaminants of Potential Concern	Potential Contamination Distribution	Exposure Likelihood
	Luddenham	asbestos		on the site.
Market Gardens	Private property, north-east of the intersection of The Northern Road and Elizabeth Drive.	Heavy metals, hydrocarbons, pesticides, nutrients	Soils and groundwater	Moderate – Contamination could be both localised and diffuse. Agricultural areas are likely to be disturbed as part of the upgrade.
Stockpiles	Western side of The Northern Road, north of Park Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Moderate – Stockpiles may need to be removed during construction activities.
Roads and Maritime Stockpile	North of the intersection of The Northern Road and Park Road, Luddenham.	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Service Station	South of the intersection of The Northern Road and Park Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Cemetery	South of the intersection of The Northern Road and Roots Avenue, Luddenham.	Heavy metals, nutrients, formaldehyde, biological	Deeper soils and groundwater	Low – Site and contamination (if present) likely to be too far away to impacts construction activities
Non-operational service station	Shops – The Northern Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Moderate – likelihood increased if deep excavations occur in the vicinity of the site
Service Station	Shops – The Northern Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Moderate – likelihood increased if deep excavations occur in the vicinity of the site.
Dumped tyres	Southern side of Adams Road,	Heavy metals, hydrocarbons	Surface and shallow soils	Low - Contamination (if present) likely to be localised and

AEI	Location	Contaminants of Potential Concern	Potential Contamination Distribution	Exposure Likelihood
	Luddenham			substantial construction activities are unlikely on the site.
Filling	Private property, western side of Willowdene Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Stockpile	Western side of Willowdene Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Septic Systems	Numerous tanks and pump out points observed within the project area	Heavy metals, nutrients, biological	Deeper soils and groundwater	Low – Contamination source likely to be highly degraded
Agricultural Land Use	Numerous locations within and adjacent to the project area	Heavy metals, hydrocarbons, pesticides, asbestos	Soils and groundwater	Moderate – Contamination could be both localised and diffuse. Agricultural areas are likely to be disturbed as part of the upgrade.
Vehicle Accidents	Numerous locations within and adjacent to the project area	Hydrocarbons, aqueous firefighting foam (AFFF).	Surface and shallow soils	Low to Moderate – Very localised contamination (if present) likely to be disturbed as part of the upgrade.

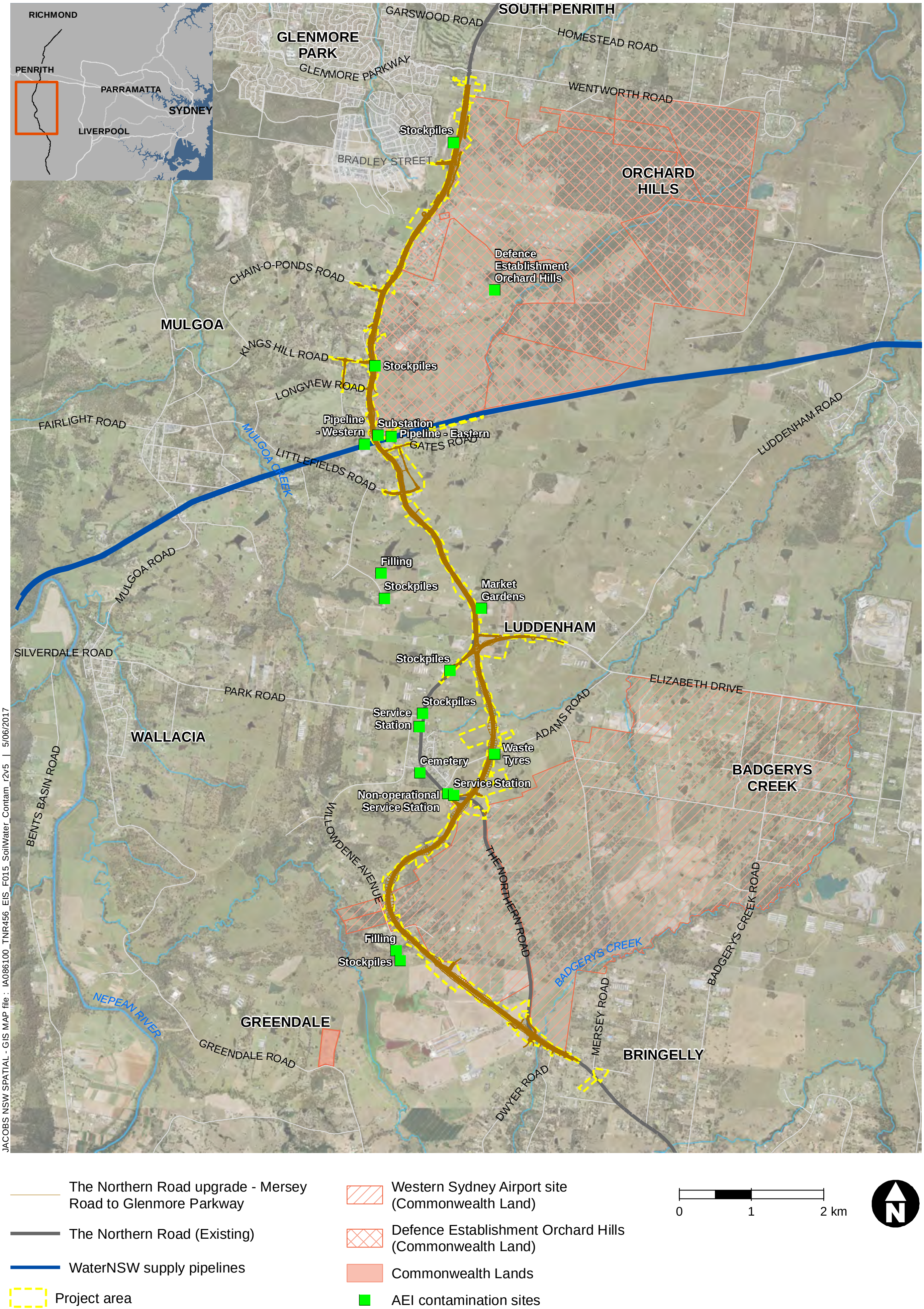


Figure 8-5 | Contaminated land - Site inspection AEIs

Catchment context

The northern portion of the project lies within the Lower Nepean River Management Zone of the Hawkesbury-Nepean River Catchment, while the southern portion lies within the Mid Nepean River Catchment Management Zone and the Upper South Creek Management Zone. The Nepean River is the ultimate downstream receiving environment to the project area. It is significant both environmentally and economically and provides for a range of domestic and irrigation uses. However, the project itself is located a long distance from the river (about 5.0 km at the closest point) and close to the catchment divide, just west of the eastern boundary of the catchment.

The catchment is shale-based and is characterised by meandering streams. It is also highly disturbed due to increasing urbanisation and associated land clearing. The study area falls within the hydrological catchments of Duncans Creek, Badgerys Creek, Cosgroves Creek, Mulgoa Creek, unnamed tributary of South Creek, Blaxland Creek and Surveyors Creek. The watercourses of the Badgerys Creek, Cosgroves Creek, the unnamed tributary of South Creek and Blaxland Creek catchments drain east to South Creek which then flows north to join the Hawkesbury River at Windsor. The watercourses of Duncans Creek, Mulgoa Creek, and Surveyors Creek catchments drain west to the Nepean River.

The project directly traverses a number of unnamed tributaries and drainage lines (sometime associated with farm dams), as well as the following named creeks:

- Cosgroves Creek, an intermittent stream which is a tributary of South Creek
- Badgerys Creek, an intermittent stream containing permanent residual pools.

Key fish habitat

Five receiving waterways have been identified as Type 1 – Key Fish Habitats (DPI, 2013), as they had a combination of native aquatic plants and/or woody snags. These watercourses are impacted, intermittently flowing waterways which are also identified as Class 2 – Moderate Key Fish Habitat (Fairfull & Witheridge, 2003) due to the presence of limited in stream aquatic vegetation. The waterways are:

- Badgerys Creek (287912.65E / 6244897.30N)
- Cosgroves Creek (287247.11E / 6249490.76N)
- 'Site 29a' (286060.62 E / 6246544.14N), an intermittent stream
- The large dam at 'Site 39' (286460.594 E, 6247352.348N), fed by several minor 1st and 2nd order streams. These streams are ephemeral with minimal channel definition, only flowing when the upstream dams overflow
- Unnamed tributary of Surveyors Creek (286887.04E/6257728.90N).

Key hydrological features of the project area, including these key waterways, are shown on Figure 8-6.

Whilst the waterways have been surveyed and generally contain suitable habitat for fish, the water quality of these site is generally poor to moderate and flow at times intermittent. As such no threatened or protected fish species are expected to occur within the creeks located in the study area. Further information on potential fish habitat is provided in the Section 7.3.

Water quality

A visual inspection was undertaken for waterway crossings along the proposed alignment. A summary of the water quality condition of the main waterways is provided in Table 8-11.

Table 8-11 Water quality condition based on a visual site inspection of key waterways

Site	Water quality condition
Badgerys Creek	Water quality to appeared moderate, tannin stained and with some frothing and instream rubbish. Runoff from surrounding agriculture is likely to impact upon water quality.
Cosgrove Creek	Water quality appeared to be poor, with a thick algae bloom, oily film and frothing present in some of the stagnant pools.
'Site 29a'	Water Quality appeared moderate, with anoxic odour within residual pools, tannin staining and filamentous algae present. Some rubbish such as tyres were present.

Monthly sampling carried out at three sites relevant to the project as part of the Western Sydney Airport (immediately downstream of the proposed crossing of Badgerys Creek) suggests particularly poor conditions with water quality generally described as turbid and brown. Monitoring locations are shown on Figure 8-6.

Table 8-12 provides water quality monitoring results from the three Western Sydney Airport monitoring sites, with a comparison to the ANZECC/ARCMANZ trigger values. Monitoring highlights low levels of dissolved oxygen and very high levels of total nitrogen across all sites. At the 'U/S airport new' site on Badgerys Creek, it highlights large exceedances of the trigger levels for turbidity, suspended solids, total nitrogen, ammonia, NOx, phosphorus and sometimes Chlorophyll-a. Waterways in the area are known to exhibit elevated nutrient concentrations, hence the higher trigger values recommended by the HRC for TN and TP. Nutrient concentrations at the site monitored were well in excess of these trigger values on every occasion for TN and all but one occasion for TP.

As such the waterways in the study area are considered eutrophic and generally exceed the both the nominated HRC and ANZECC/ARMCANZ guidelines for protection of aquatic ecosystems. The water surface conditions reported during sampling infer that the visual amenity of the creeks is generally poor.

Table 8-12 Water quality monitoring data (phys-chem and nutrients)

Site	Date	Conductivity (µS/cm)	pH (in situ)	Dissolved Oxygen (% sat)	Turbidity (NTU)	Suspended Solids (mg/L)	Ammonia (mg/L)	TN (mg/L)	TP (mg/L)	Chl-a (mg/ m^3)	NOx (µg/L)
ANZECC/ARMCANZ (2000) trigger levels	Min:	125	6.5	85	6	-	-	-	-	-	
	Max:	2200	8.5	110	50	40	20	350	25	3	40
HRC trigger values	Max:	-	-	-	-	-	-	700	35	-	-
D/S Basin 7 @ Adams Rd	2/11/2015	228.4	6.85	49.7*	39	6	20	1,100*	90*	2	30
	8/12/2015	2273	7.98	23.7*	2.42*	6	40*	1,300*	40*	7	40
	5/01/2016	172	7.9	69.1*	20.7	<5	30*	700*	40*	1	20
	4/02/2016	527	7.62	49.5*	11.1	<5	10	1,000*	5	2	<10
	2/03/2016	2322	8.16	5.9*	24.8	16	10	1,800*	130*	9	<10
D/S Basin 8 Willowdene Ave	2/11/2015	2168	8.04	51.2*	32.4	24	40*	2,600*	170*	<1	30
	8/12/2015	2019	8	43.6*	9.39	26	280*	1,700*	111*	145*	40
	5/01/2016	1045	7.8	63.3*	32.8	11	40*	800*	70*	3	50*
	4/02/2016	432	7.78	65.7*	19.7	9	10	800*	70*	4	30
	2/03/2016	2253	8.33	26.4*	16	10	160*	1,000*	50*	16*	30

Site	Date	Conductivity (µS/cm)	pH (in situ)	Dissolved Oxygen (% sat)	Turbidity (NTU)	Suspended Solids (mg/L)	Ammonia (mg/L)	TN (mg/L)	TP (mg/L)	Chl-a (mg/ m³)	NOx (µg/L)
U/S Airport New	2/11/2015	1841	7.44	39.5*	511*	52*	1,700*	9,800*	2,020*	46*	3,940*
	8/12/2015	3744	7.95	11.7*	450*	180*	95,200*	100,000*	13,800*	3	210*
	5/01/2016	1638	7.75	13.6*	296*	159*	3,980*	46,600*	6,330*	4	22,200*
	4/02/2016	1839	7.28	28*	70.6*	40	4,950*	19,300*	8,450*	<1	10
	2/03/2016	1877	7.73	11*	127.5*	23	4,750*	7,800*	3,670*	28*	<10

*Outside maximum or minimum HRC *and* ANZECC/ARCMANZZ (2000) trigger levels

^ Exceed HRC trigger values but do not exceed ANZECC/ARCMANZZ (2000) trigger levels

Table 8-13 provides water quality monitoring results from the three Western Sydney Airport monitoring sites with regards metal concentrations. Metal concentrations varied throughout the sites. Arsenic, cadmium and mercury were either not detected or detected in very low concentrations at all sites. Chromium levels were elevated in Badgerys Creek and exceeded the recommended guideline on all occasions but generally not detected or in low concentrations at the other sites with the exception of one exceedance at Cosgroves Creek. Copper and zinc concentrations were consistently elevated in Badgerys Creek exceeding the recommended limit for protection of 95 per cent of aquatic species. These metals were only detected in excess on a few occasions at the other sites.

Overall metal concentrations, particularly copper and zinc are elevated, most noticeably in Badgerys Creek, which also exhibits high concentrations of chromium and nickel.

Table 8-13 Water quality monitoring data (metals)

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Mercury (mg/L)
ANZECC/ARMCANZ (2000) Toxicant Values		0.013	0.0002	0.001	0.0014	0.0034	0.011	0.008	0.0019
D/S Basin 7 @ Adams Rd	2/11/2015	<0.0014	<0.0001	0.002*	0.012*	0.001	0.001	0.014*	<0.0001
	8/12/2015	<0.001	<0.0001	<0.001	0.001	<0.001	0.003	<0.005	<0.0001
	5/01/2016	<0.001	<0.0001	<0.001	0.006*	<0.001	<0.001	<0.005	<0.0001
	4/02/2016	0.001	<0.0001	<0.001	0.002*	<0.001	0.001	<0.005	<0.0001
	2/03/2016	0.005	<0.0001	<0.001	<0.001	<0.001	0.004	<0.005	<0.0001
D/S Basin 8 Willowdene Ave	2/11/2015	0.001	<0.0001	0.001	0.003*	<0.001	0.002	0.009*	<0.0001
	8/12/2015	0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
	5/01/2016	<0.001	<0.0001	<0.001	0.005*	<0.001	0.003	0.010*	<0.0001
	4/02/2016	<0.001	<0.0001	<0.001	0.002*	<0.001	0.001	<0.005	<0.0001
	2/03/2016	0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
U/S Airport New	2/11/2015	0.006	<0.0001	0.002*	0.018*	0.002	0.006	0.032*	<0.0001
	8/12/2015	0.010	0.0001	0.003*	0.076*	0.004*	0.021*	0.293*	<0.0001
	5/01/2016	0.009	<0.0001	0.004*	0.069*	0.003	0.014*	0.082*	<0.0001
	4/02/2016	0.007	<0.0001	0.002*	0.024*	0.002	0.011*	0.058*	<0.0001
	2/03/2016	0.008	<0.0001	0.002*	0.005*	0.001	0.007	0.011*	<0.0001

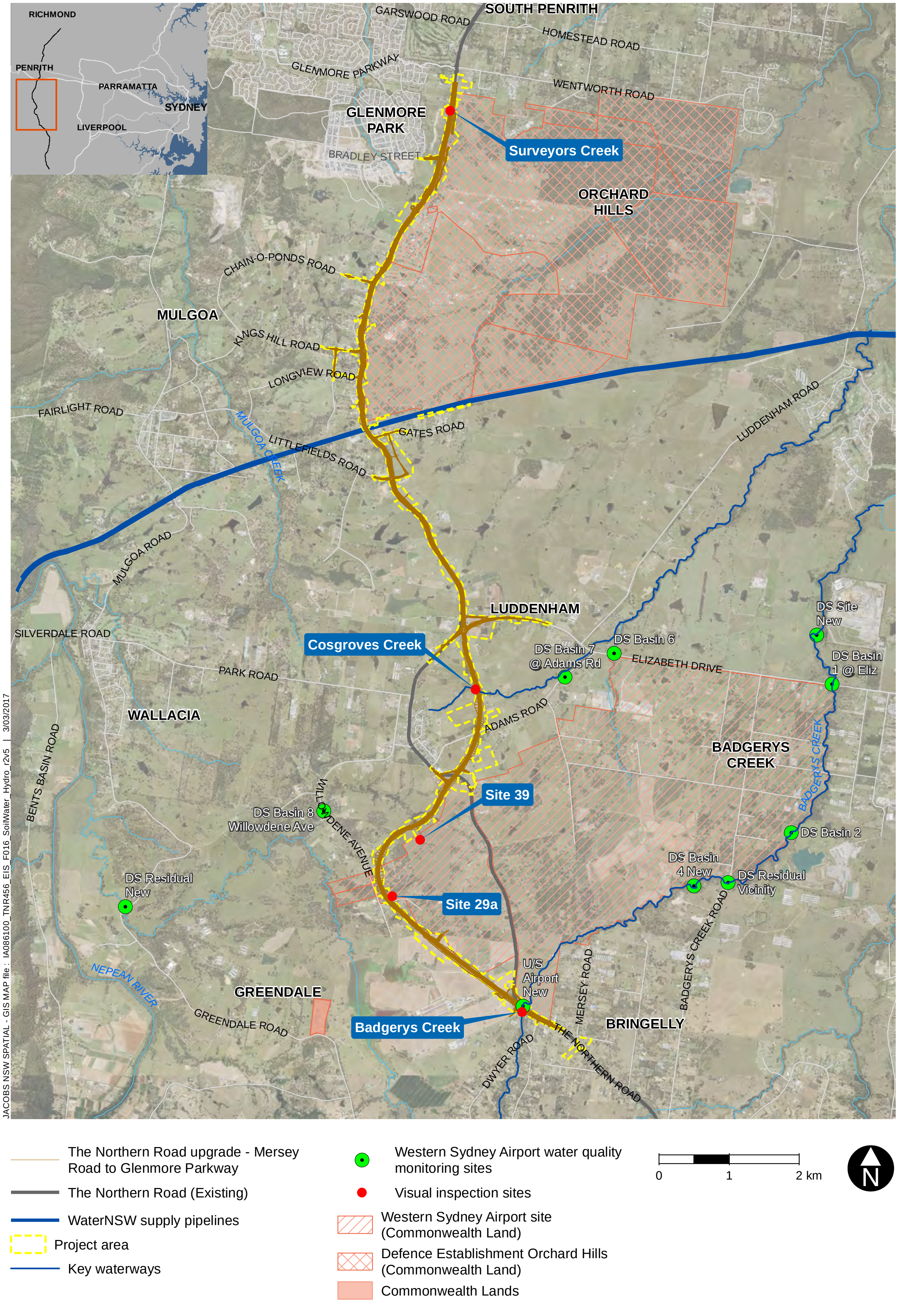


Figure 8-6 | Key hydrological features

Groundwater

It is expected that three groundwater systems exists along the project alignment including shallow incidental perched aquifers, a regional shallow unconfined water table, and a deep confined aquifer unit.

The perched and shallow regional aquifers are contained within the weathered and fresh Wianamatta Group. The Wianamatta Group shales are characterised by saline groundwater due to marine deposition, and are generally not considered beneficial aquifers. The Wianamatta shales are generally low in permeability and occasionally have minor aquifers and perched water tables. These units behave as aquitards. The Wianamatta Shale is a low permeability formation and therefore the contribution of this aquitard to baseflow in surface water courses is expected to be minor to negligible.

The regional water table has an approximate depth of 35mbgl (metres below ground level) as indicated by works summaries obtained from DPI Water. If present the shallow perched water tables, are expected to range from 2 to 30 mbgl depending on the depth of weathering and are anticipated to act in an unconfined manner.

The deep groundwater system comprises the Hawkesbury Sandstone. Recharge to the Hawkesbury Sandstone is expected to occur from rainfall and surface water interaction along the Lapstone Monocline along the far eastern edge of the Blue Mountains (west of the project alignment) and to a minor extent vertical percolation from the overlying Wianamatta Shale. Groundwater flow direction is expected to be north-easterly within the Hawkesbury Sandstone. There are some faults in the area that could indicate enhanced connectivity between the shallow and deeper groundwater systems. The deep groundwater system is considered to behave as a confined aquifer.

Surrounding groundwater users and licences

Registered groundwater works were identified during a review of the DPI Water's Groundwater PINNEENA online database (accessed March 2016), which provides current groundwater works data across NSW. One work (GW108906) was identified within the study area and was drilled into un-weathered shale and sandstone. Data obtained from PINNEENA indicates the groundwater work (GW108906) is currently inactive. Other groundwater works within the study area are monitoring piezometers installed into the Wianamatta Shale. It is presumed these monitoring piezometers refer to local, site specific investigation for geotechnical or due diligence purposes.

There are no active Water Access Licences within 400 m of the proposed alignment.

Groundwater dependent ecosystems

A review of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* indicates there are no listed high priority groundwater dependent ecosystems located in the project area.

As identified in the Biodiversity Assessment Report (Appendix I), the location of GDEs within the within the Hawkesbury Nepean CMA area is mapped by Kuginis *et al.* (2012). No high probability GDEs are mapped within or near the study area. Additionally the majority of watercourses within the study area are ephemeral and most flow events occur in direct response to major rainfall, with no evidence of baseflow feeding any of the streams within the study area. As such, none of the riparian zones within the study area are considered to be GDEs.

Similarly, a review of the Bureau of Meteorology Groundwater Dependent Ecosystems (GDE) Atlas did not indicate the presence of other groundwater dependent ecosystems.

8.2.3 Assessment of potential construction impacts

Geology and soils

Construction activities would result in the removal of existing vegetation during early works and clearing and grubbing. Excavations would be required at cut and fill locations along the proposed alignment, generally around the planned airport site bypass. The construction of a culvert at Adams Road and near the Leppington Pastoral Company would also require substantial earthworks. These types of construction activities have the potential to expose bare ground and soils.

Excavation would involve the stockpiling of spoil prior to reuse or removal from site. Without effective mitigation, these and related construction activities would give rise to potential for erosion of unconsolidated material and entrainment by runoff and subsequent transported off site.

The existing soil landscape groups within the project area consist of three principal soil landscapes. This includes the Luddenham and South Creek soil landscape groups which have been identified as having a high soil erosion hazard. Soil erosion and sedimentation have the potential to result in negative impacts to surface water quality throughout the construction phase through increased sediment loads entering downstream environments. Soil loss could occur due to the effects of wind or water.

Without effective mitigation, soils transported into local drainage channels could have a number of impacts, including:

- Reduced hydraulic capacity due to deposition of material within waterway channels
- Degraded water quality including lower DO levels, increased nutrients (nitrogen (N), phosphorus (P)), increased turbidity, and altered pH
- Increased levels of nutrients, metals and other pollutants transported via sediment and runoff to receiving waterways leading to increased potential for bioaccumulation of heavy metals in aquatic species
- Increased sedimentation smothering aquatic life and affecting aquatic ecosystems.

The Acid Sulfate Soil Probability within the proposed alignment was classified as Extremely Low Probability of occurrence. ASS is therefore not considered to be a risk to the project.

The assessment of salinity potential along the alignment was undertaken using the map of the salinity potential in western Sydney (NSW Department of Infrastructure, Planning and Natural Resources, 2002). The majority of the alignment occurs in areas of moderate salinity potential. Construction activities are not expected to increase the potential for salinity impacts along the project corridor. Durability and aggressivity samples of soil material would be collected and analysed prior to the construction phase, to determine potential impacts of soil salinity on pavement infrastructure.

The geology of the site is not anticipated to be impacted by construction of the project.

Contaminated land

Construction of the project, including the establishment of compound sites would partly occur in the existing road corridor (generally north of Littlefields Road) and generally within greenfield areas for the bypass sections of the project.

Potential environmental impacts associated with these construction activities include:

- Inappropriate handling or disposal of contaminated or hazardous excavated materials
- Adverse effects on human health (construction personnel, travelling public or nearby communities)
- Release of contaminants into underlying soils
- Release of contaminants into groundwater
- Movement of contaminated sediments into stormwater systems
- Adverse effects on flora and fauna.

For the project, there is a potential for contaminated material to be disturbed through construction activities. The majority of AEIs identified are unlikely to be exposed to site users and environmental receptors to contamination during construction of the upgrade.

Despite the low to moderate rating of the remainder of the potential AEIs within and adjacent to the project, the likelihood of contamination impacting upon proposed construction activities would be increased if excavation works take place within these areas. As outlined in Section 8.2.8, a Contaminated Land Management Plan would be prepared to effectively manage contaminated material during construction of the project. Further discussion of the likelihood of impacts from the identified AEIs is presented in Appendix L.

Surface Water

The construction phase of the project has the potential for further degradation of downstream water quality and impacts on the status of key fish habitats if effective management measures are not implemented, monitored and maintained throughout the construction phase.

One of the main impacts to water quality and aquatic habitat from any construction project is sediment entering nearby waterways. Sediment is generated when rain or runoff comes into contact with exposed areas and stockpiles, becomes suspended and transported to receiving waters located downstream. Once sediment enters waterways, it can directly and indirectly impact on the aquatic environment. Direct impacts include reducing light penetration (limiting the growth of macrophytes), clogging fish gills, altering stream geomorphology, smothering benthic organisms and reducing visibility for fish. Indirect impacts of increased sediments occur over the longer term and include accumulation and the release of attached pollutants such as nutrients and heavy metals.

The potential impacts outlined above would be effectively reduced through the mitigation measures outlined in Section 8.2.8.

General construction works would occur upstream of waterways such as Surveyors Creek, Cosgroves Creek and Badgerys Creek. A number of construction activities would occur within the catchments draining the project and the project would require traversing a number of these waterways and farm dams as follows:

- Badgerys Creek
- Cosgroves Creek
- A number of unnamed tributaries of Duncan’s Creek
- An unnamed tributary of Surveyors Creek
- A number of unnamed farm dams and watercourses.

Watercourse crossings would be designed and constructed to minimise impacts on natural flow regimes and to not present any barriers. All waterway crossings would be designed in conjunction with *Why do fish need to cross the road – Fish Passage requirements for Waterway Crossings (*Fairfull and Witheridge, 2003) and the *Policy and Guidelines for Fish Friendly Waterway Crossings (*DPI, 2004).

Additionally, temporary watercourse crossings may be required for some or all watercourses traversed by the project to facilitate construction activities. If required, these watercourse crossings would likely comprise a temporary causeway with culverts to maintain the low flows, and they would likely be maintained for the duration of construction. Temporary watercourse crossings may have a short term, minor impact on water quality due to the disturbance of bed and banks resulting in erosion and sedimentation, alteration of downstream flows potentially creating isolated stagnant pools of water and scouring of the bed near culvert inlets and outlets. A total of 11 culverts would be installed and/or replaced at the various waterway crossing locations as identified above.

The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of the river banks, lake shore or estuary mean high water mark. All works on waterfront land would be carried out in accordance with the *DPI Water Guidelines for Controlled Activities on*

Waterfront Land (2012), including but not limited to those related to instream works and waterway crossings.

As identified in the Flood risk assessment Working Paper (Appendix K of the EIS), increases in the rate of flow in the receiving drainage lines could result in a lowering of the stream bed through a process of headwater erosion, as well as a possible widening of the watercourse through a process of bank erosion. The lining of channels and the concentration of flow could result in localised scour in the receiving drainage lines at the downstream limit of the drainage works. Scour protection measures such as dumped rock rip rap would be incorporated in the design of the project in order to reduce the scour potential in the receiving drainage lines (refer to Appendix K for further details).

Disturbance/mobilisation of sediment associated with general earthworks including vegetation removal, may also have a short-term impact on local waterways. Fill requirements throughout the project are generally minor, however loose fill has the potential to be eroded during rainfall events by runoff, thereby increasing the potential for mass movements of soils and sedimentation of local waterways. This has the potential to smother vegetation and change the soil surface characteristics and habitat of adjacent areas.

Clearing and subsequent erosion from construction in areas comprising of fine silt and clay can result in siltation of downstream watercourses and storages, particularly in relation to works in and around Cosgroves Creek and Badgerys Creek as identified as being likely to contain alluvium deposits comprising fine sands, silt and clay.

Construction works undertaken within 50 m of the nominated sensitive receiving waterways (Type 1 Key Fish Habitat) have the potential to impact on bank stability and water quality through excavation, clearing or placement of construction stockpiles.

Dewatering activities during construction may mobilise sediments and contaminants, and increase the turbidity at of the receiving environments along the project, potentially having an adverse impact on water quality if not effectively managed. Dewatering of farm dams has the potential to release water of unknown quality into receiving waterways. Disposal of dam water would be done in accordance with the farm dam dewatering plan.

Ancillary facilities to support construction would be required at various locations along the project. Ancillary facilities would include construction compounds, stockpile areas, material and waste storage areas including spoil stockpiles and other waste materials, sediment basins and concrete/asphalt batching plants. The Flood risk assessment working paper (Appendix K) has identified that there is the potential for flooding where proposed ancillary sites are proposed near Badgerys Creek. This has the potential to impact on the water quality at this site through flood waters mobilising sediments within stockpile and sediment basins, waste materials and chemicals associated with the ancillary facilities

Stockpile sites would be used to temporarily store excess spoil and wastes such as concrete from demolition before their reuse on-site or disposal off-site. As stockpile sites present the potential for sediment-laden runoff to wash offsite into the storm water systems and receiving environment, all stockpile sites would include proven effective environmental protection measures outlined in a construction Soil and Water Management Plan (SWMP) prepared in accordance with the Blue Book.

Construction activities adjacent to waterways could introduce contaminants such as oil or greases and disturb contaminated sediments, potentially having an adverse impact on water quality. There is also the potential for tannin leachate from clearing and mulching activities.

Changes to hydrology and flow have the potential to impact on artificial wetlands which comprise of farm dams, roadside drains and effluent treatments systems.

Relocation of utilities would involve soil disturbance by trenching and underboring. The disturbance of soil by machinery could increase the potential for soil erosion. Potable water is chlorinated which has the potential to impact on downstream water quality. This has the potential to impact aquatic biodiversity if not managed appropriately

Accidental spills of chemical or hazardous materials could also affect the quality of surrounding water and soils.

There is the potential for asbestos fibres to be present in existing stockpiles along the alignment which could potentially migrate through surface water flows if disturbed during construction and not appropriately controlled.

Chemical, heavy metal, oil and grease, and petroleum hydrocarbon spills from construction machinery could, if unmitigated, directly contaminate downstream waterways

The potential impact on receiving waterways during construction would be effectively mitigated through erosion and sediment controls including appropriately sized temporary sediment basins in accordance with the requirements of the Blue Book. Waste storage and management procedures would also be developed and implemented during construction to ensure appropriate waste storage, transport and disposal management measures are implemented, in particular in relation to the proposed ancillary facilities. Waste management is discussed in Section 8.7 Resources and waste management.

Additionally preconstruction water quality monitoring would be undertaken upstream and downstream of proposed waterways that have the potential to be impacted during the construction of the project. This would provide further information on the existing water quality and allow the development of site specific trigger values as per ANZECC/ARMCANZ (2000) to ensure there is no further degradation in water quality or impact on the nominated environmental values.

Chronic impacts to water quality are expected to be minimal as sediment basins would be designed for the 80th percentile, five day rainfall depth for most basins. The Blue Book (Table 6-1 Vol 2D) requires that the 85th percentile be used construction projects with a duration of more than 6 months. Therefore some basins have been designed for the 85th percentile which means that they would be slightly larger.

Potentially acute water quality impacts during construction would primarily be related to spills or leaks of fuel/oil from machinery due to accidents or negligence. Given that sediment basins are proposed throughout the project area and are of an appropriate size to capture spills of this nature the likelihood of impacts to waterways is minimised. Additionally, onsite and offsite diversion drains, sediment fences, spill procedures, spill kits and erosion controls at the source would provide additional protection of waterways.

Overall, potential impacts on surface water quality during construction are considered minor and manageable with the application of proposed mitigation measures outlined in Section 8.2.8.

Groundwater

The main potential construction phase groundwater impacts relate to:

- Groundwater levels, flows and connectivity: These include changes to groundwater connectivity, groundwater flow direction, groundwater levels and recharge rates
- Groundwater chemistry: these include pollution of groundwater and changes to groundwater quality
- Groundwater users: Interference to aquifers resulting in a decrease or change in groundwater levels that subsequently affect groundwater users and/or groundwater dependent ecosystems and riparian areas and wetlands.

The majority of cuttings are not likely to be deep enough to intercept the shallow groundwater table. Additionally the Wianamatta Shale is a low permeability formation and therefore the contribution of this aquitard to baseflow in surface water courses is expected to be minor to negligible. In this regard there are no expected material changes to groundwater levels or flow direction to the shallow groundwater table.

The depths of cuttings are generally 4-8 mbgl along the project alignment with the exception of several planned cuttings ranging from 10-12mbgl. It should be noted that groundwater works GW108906 is located 170 m east of one of the planned major cuttings. This groundwater works is inactive, is screened at 48mbgl and has a historic standing water level at 30 mbgl. The groundwater level in GW108906 is likely representative of the deeper groundwater system. The road cutting is therefore unlikely to have any impact on this site.

A perched shallow water table may be encountered; however, the spatial extent of drawdown would be minor to negligible. Similarly, the magnitude of seepage through the road cuttings is expected to be negligible, presumably much less than 0.1L/s/km. This is calculated based on the expected transmissivity of weathered shale and clay. In this regard, no material changes are expected to groundwater levels, flow direction or groundwater connectivity as the unit itself is made up of a geological unit that is already of low permeability.

Imported fill material has the potential to change the hydraulic characteristics of the underlying geology during compaction and when used to fill excavations that intersect the water table creating a connection between aquifers. The existing surface geology is comprised of low permeability material which is expected to match the material characteristics of the compacted fill used for the road alignment which would also be low permeability. Therefore because the fill is all surficial and would match the characteristics of the underlying geology, the proposed fill locations are not expected to impact the groundwater. Compaction is the only expected geotechnical ground treatment, and as outlined above this activity is not expected to impact on the hydraulic properties of the shallow aquifer. Additionally, there is a minor potential for spills or leaks to allow oil and grease contamination to enter shallow aquifers. Any petroleum hydrocarbon spill from construction machinery has the potential to seep into the shallow groundwater system. However this would be avoided where possible or potential impacts minimised through the implementation of relevant safeguards as identified in Section 8.2.8.

There is no expected drawdown to the regional shallow unconfined water table. There is therefore no expected groundwater impact to groundwater users including water supply users, GDEs, riparian areas or wetlands.

8.2.4 Assessment of potential operational impacts

Geology and soils

The geology of the site is not anticipated to be impacted by the project. After construction, cleared areas would be paved/landscaped and scour protection installed at drainage outlets. There would be no exposed areas of topsoil and therefore only a minor potential of soil erosion and entrainment of unconsolidated material by wind or runoff. During operation, the potential for soil erosion would be minimal as all areas impacted during construction would be asphalt or rehabilitated and landscaped to avoid soil erosion from occurring.

Several treatments, including retaining walls and fill embankments, would be provided to suit the existing conditions and to integrate the project with the surrounding landscape.

Assessment of hydrological impacts of the project is presented in Appendix K – Flood risk assessment and Section 8.1. This report identifies the potential for the project to cause scour in the receiving drainage lines as a result of the rate, velocity and concentration of flow. Increases in the rate of flow in the receiving drainage lines could result in a lowering of the stream bed through a process of headwater erosion, as well as a possible widening of the watercourse through a process of bank erosion. The lining of channels and the concentration of flow could result in localised scour in the receiving drainage lines at the downstream limit of the drainage works. Measures such as dumped rock rip rap protection would be incorporated in the design of the project in order to reduce the scour potential in the receiving drainage lines.

Contaminated land

Incidents such as vehicle accidents on the road could result in spillage of contaminants or hazardous materials on to the roadway. If not contained and/or cleaned up promptly, there is potential for these to enter the drainage system and be discharged to receiving waterways and groundwater. Accidental spills could impact negatively upon both human health (mainly through direct contact and inhalation exposure pathways) and environmental receptors including receiving soil and water ecosystems.

The operational vegetated swales would function as a containment area for any accidental on-road spills. These water quality controls are subject to operational maintenance and, in the event of an accident or spill, would be assessed for immediate clean-up.

Overall, the project would only represent a minor increase in the potential for contamination compared with current operation of the road, associated increased vehicle traffic in the future.

Surface water

Operation of the project would impact on water quality due to discharge of drainage at new locations or increased discharge at existing locations where road and drainage upgrades have occurred. This has the potential to alter existing hydrology and flooding regimes which may impact on water quality due to increased runoff volumes and peak flow rates resulting in erosion.

Increased flow rates can impact on the bed and bank stability of the existing watercourses making them highly susceptible to erosion (refer to the Hydrology and Flooding working paper for more information). Stream erosion increases sediment and nutrient loads leading to decreased water quality which would affect the protection of the nominated environmental values.

The project also has the potential to affect existing local water quality due to the generation of additional or new pollutants directly attributable to the widened or new sections of road respectively and associated increased vehicle traffic in the future. The most important pollutants of concern relating to road runoff are:

- Sediments from the paved surface from pavement wear and atmospheric deposition
- Heavy metals attached to particles washed off the paved surface
- Oil and grease and other hydrocarbon products
- Increased stormwater runoff from new impervious surfaces created by the project would result in a deterioration of water quality due to increased sediment, nutrient loads, oil and grease and floating debris.

Similarly to the construction of the project, impacts to water quality are expected to be localised to the creeks, waterways directly impacted by the project, namely Surveyors Creek, Badgerys Creek, Cosgroves Creek and other unnamed tributaries. The operation of the project, even with increased flow and runoff is expected to result in negligible impacts to downstream waterways and the nominated uses of these waterways would not be affected.

The emphasis in stormwater quality management for road runoff is that of managing the export of suspended solids and associated contaminants – namely heavy metals, nutrients and organic compounds (Austroads, 2001). Pollutants such as nutrients, heavy metals and hydrocarbons are usually attached to fine sediments (RTA, 2003). The key concern with increases of these contaminants is the runoff and discharge to the identified receiving environments which contain key fish habitat. Therefore trapping suspended solids is the primary focus of the water quality management strategy for the operational phase of the project.

Twenty four operational water quality swales have been proposed for the project to effectively manage water quality. The location and size of each swale has been optimised to maximise the filtering out of suspended materials and pollutants, including those proposed upstream of identified sensitive receiving waterways (i.e. Key Fish Habitat).

MUSIC modelling was carried out to estimate the pollutant load reductions of each swale. The results of the modelling for these 24 swales (S1-S24) indicate that pollutant load reduction can be achieved as follows:

- Suspended Solids (81 per cent to 90 per cent)
- Total Phosphorus (43 per cent to 55 per cent)

- Total Nitrogen (14 per cent to 49 per cent).

This is based on the results of modelling as summarised in Table 8-14. Further detail is provided in Appendix L.

Table 8-14 Annual average pollutant load reductions for proposed operational water quality swales

Swale	Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)
S1	88	48	24
S2	86	43	18
S3	88	43	23
S4	89	55	49
S5	89	55	48
S6	87	45	32
S7	87	47	22
S8	86	46	17
S9	86	46	19
S10	90	51	28
S11	90	48	29
S12	88	48	29
S13	84	44	16
S14	81	45	14
S15	87	44	31
S16	87	46	19
S17	87	44	20
S18	86	46	17
S19	86	44	18
S20	86	46	18
S21	88	45	22
S22	88	48	24
S23	87	44	26
S24	87	46	26

The proposed swales are highly effective at providing suspended solid capture and reasonably effective at reducing nutrients.

Accidental spills could occur on any road; however the improved horizontal and vertical geometry of the upgrade and the improved layout of the signalised intersections would reduce the current likelihood of accidental spills, therefore no spill basins are proposed.

Groundwater

The project is not expected to interact with groundwater during operation. Therefore there is not expected to be any material impact on groundwater levels, flow or connectivity. The installation of the road infrastructure would result in reduced local recharge into the groundwater along the new paved sections of road, as precipitation that would normally fall on the recharge surface would be drained away. However impacts are expected to be minimal. The impact on the local groundwater system is expected to be minor and short-term as the surface water runoff is expected to infiltrate into the regional groundwater system regardless of the increased paved area.

There is no expected operational impact on groundwater chemistry given the unlikely occurrence of accidental spills as well as the proposed operational control of runoff. Any impact is likely to be minor and short-term.

There is no expected drawdown to the regional shallow unconfined water table therefore any impact to groundwater users during operation including water supply users, GDEs, riparian areas or wetlands is likely to be minor and short-term.

8.2.5 Summary of potential impacts to the environment of Commonwealth land

A summary of potential impacts to the environment of Commonwealth land as a result of construction and operation of the project is provided in this section.

Potential construction related soil, water and contamination impacts are outlined in Section 8.2.3, including potential impacts to Commonwealth land.

During construction there is the potential for soil and water impacts as a result of erosion and sedimentation from general construction activities, in particular those at proposed waterway crossings as well as activities associated with ancillary facilities and stockpile sites. Two of the proposed compound sites (C7 and C17) would be located on Commonwealth land. With the exception of Cosgrove's Creek, four of the proposed sensitive receiving waterways are located within or immediately adjacent to Commonwealth land and would potentially be impacted during construction of waterway crossings at these locations. Groundwater impacts are expected to be minimal across the project.

In relation to the AEIs identified during the Stage 1 contamination assessment one of these, the DEOH, is located on Commonwealth land. Although the likelihood of encountering UXO during construction on these lands is low, the consequence if encountered would be high; therefore the exposure likelihood has been assessed as moderate.

The project would generally result in minor temporary construction impacts which would be mitigated through the measures outlined in Section 8.2.8.

Potential impacts during operation of the project are outlined in Section 8.2.4. These generally relate to potential surface water quality impacts resulting from runoff from the road into local waterways, including those on Commonwealth land. However this would be effectively mitigated through the implementation of water quality controls in the form of vegetated swales as outlined in Section 8.2.6 below. These swales have been assessed as providing sufficient water quality control to sensitive receiving environments for the project, including those on Commonwealth land. Therefore impacts during operation would be minimal.

In summary, the potential soil, water and contamination impacts to the environment of Commonwealth land during both construction and operation of the project are not anticipated to be greater or different to those outlined above, and the residual impacts are considered to be consistent with those outlined in Section 8.2.9.

8.2.6 Water quality controls

Construction phase sediment basins

An assessment of the construction phase catchments and the selected sediment basin locations have been carried out to confirm all sediment basin locations. In order to minimise the number of sediment basins, and the impact of the construction of these basins on the local natural environment, the Blue Book criteria of 'Minimum 150 m^3' of annual sediment loss has been adopted. As such, 50 temporary sediment basins are required along the proposed alignment during construction.

The proposed locations and sizes of the 50 construction phase sediment basins for the construction phase of the road upgrade are presented in Table 8-15 and shown in Figure 8-7. The design of the sediment basins would be confirmed during detailed design.

Table 8-15 Temporary sediment basins for the project

Basin no.	Minimum volume required (M^3)	Receiving waterway
B560R	882	Badgerys Creek
B670R	935	Badgerys Creek
B880R	209	Badgerys Creek
B940R	468	Badgerys Creek
B1320R	1835	Badgerys Creek
B2200L	632	Duncans Creek
B2580L	589	Duncans Creek
B2820L	335	Duncans Creek
B3250L	830	Duncans Creek
B3340L	781	Duncans Creek
B3740L	761	Duncans Creek
B3800L	650	Duncans Creek
B4400L	714	Duncans Creek
B4500L	329	Duncans Creek
B4760L	714	Duncans Creek
B5140L	1439	Duncans Creek
B5060L	329	Duncans Creek
B5710R	403	Cosgroves Creek
B6260R	695	Cosgroves Creek

Basin no.	Minimum volume required (M^3)	Receiving waterway
B6660R	787	Cosgroves Creek
B6800L	436	Cosgroves Creek
B7040L	293	Cosgroves Creek
B7100L	532	Cosgroves Creek
B7420L	417	Mulgoa Creek
B7440R	406	Cosgroves Creek
B7660R	444	Cosgroves Creek
B7680R	350	Cosgroves Creek
B7960R	331	Cosgroves Creek
B8420R	499	South Creek
B8480R	481	South Creek
B9000R	645	South Creek
B240R	476	Blaxland Creek
B260R	323	Blaxland Creek
B580L	659	Blaxland Creek
B620R	891	Mulgoa Creek
B900R	275	Blaxland Creek
B1280R	1110	Blaxland Creek
B1780L	446	Mulgoa Creek
B1820L	251	Mulgoa Creek
B2140R	659	Blaxland Creek
B2540L	300	Blaxland Creek
B2860R	977	Blaxland Creek
B2900R	676	Blaxland Creek
B3680R	589	Blaxland Creek
B4600R	695	Surveyors Creek
B5120R	891	Surveyors Creek

Basin no.	Minimum volume required (M^3)	Receiving waterway
B5520R	731	Surveyors Creek
B6020R	1161	Surveyors Creek
B6320L	589	Surveyors Creek
B6660R	730	Surveyors Creek

Operational phase water quality controls

Twenty four vegetated swales, including those upstream of identified sensitive receiving waterways, are proposed to convey pavement runoff to the receiving waterways and creeks. Pollutant removal is facilitated by the interaction between the flow and the vegetation along the length of the swale. Rock check dams are also proposed to provide additional treatment by slowing down the runoff and allowing it to temporarily pond during storm events.

The proposed swales have been optimised by increasing their base width to provide additional water quality treatment.

The approximate location of these proposed swales are shown in Figure 8-7. Further detail regarding the volume of the basins is provided in Appendix L.

Other swales for the sole purpose of controlling flow would also be provided elsewhere throughout the project.

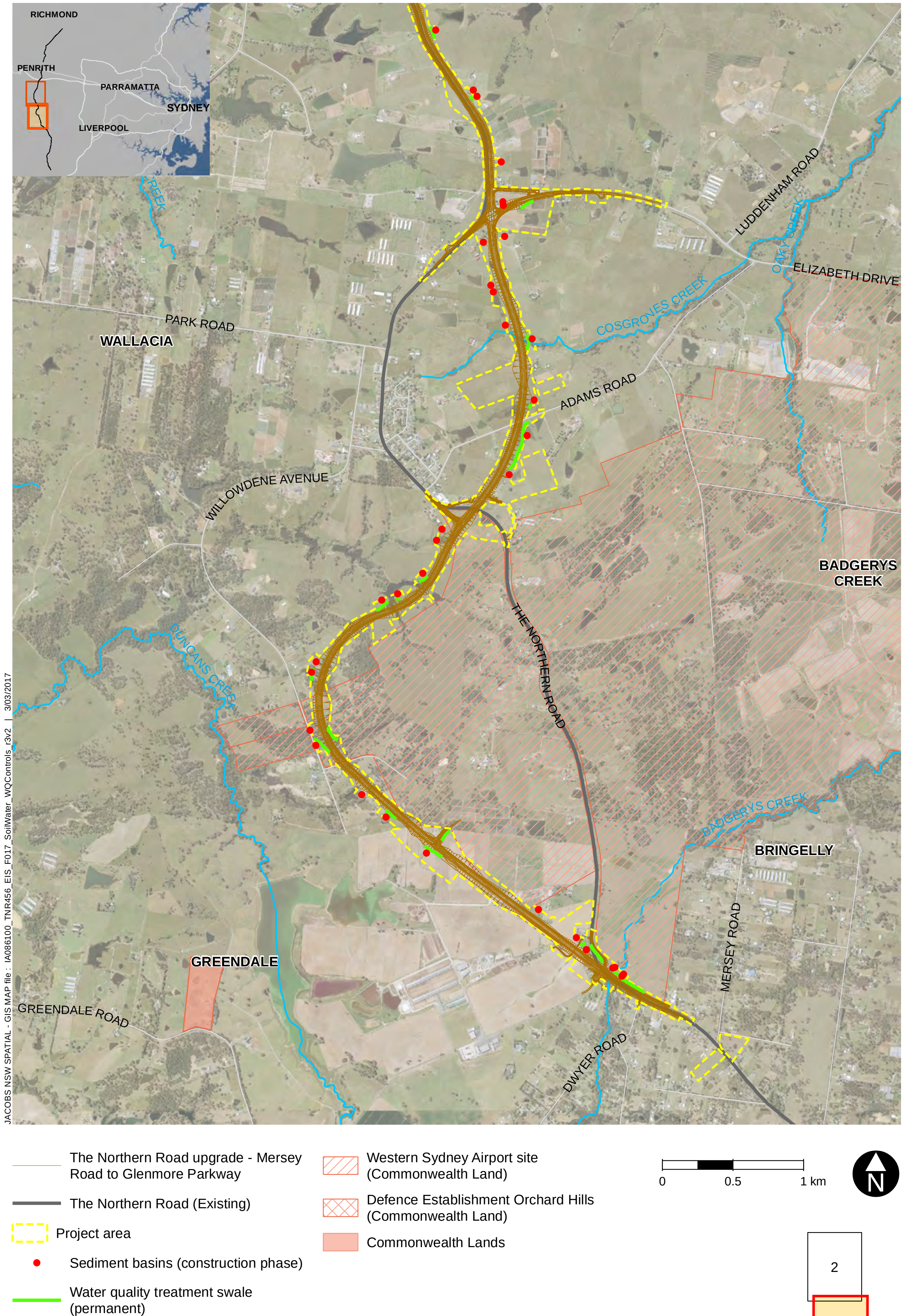
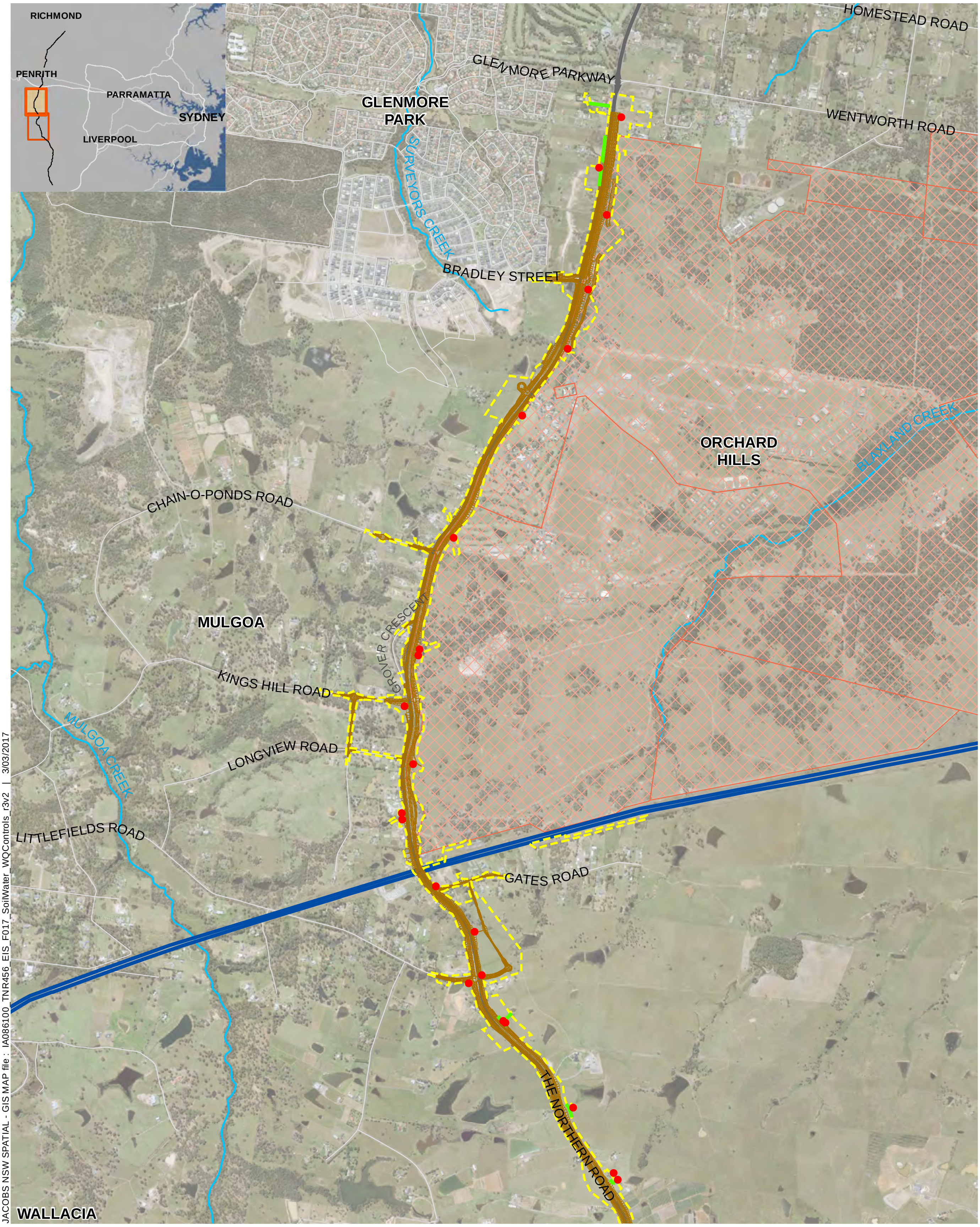


Figure 8-7 | Water quality controls



The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

WaterNSW supply pipelines

Project area

Sediment basins (construction phase)

Water quality treatment swale (permanent)

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

0 0.5 1 km

N

2

1

Figure 8-7 | Water quality controls

8.2.7 Water Quality Monitoring

Prior to construction, baseline water quality monitoring would be undertaken to identify parameters for monitoring surface water during construction and to determine indicative existing surface water quality. Sampling locations and monitoring methodology would be determined during the detailed design stage and in accordance with Roads and Maritime's *Guideline for Construction Water Quality Monitoring* (RTA, 2003). Site sampling locations would also be selected to comply with the Australian Standard AS*/NZS 5667.1 1998 – Water quality – Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.* Any sample locations or access requirements within the DEOH site would be determined in consultation with DoD.

In accordance with the *Guideline for Construction Water Quality Monitoring* (RTA, 2003) the following parameters would be monitored:

- pH, electrical conductivity, dissolved oxygen, turbidity and temperature
- Total suspended solids
- Oils and grease
- Other parameters as identified from existing literature, previous water quality monitoring or recommendations from government organisations such as NSW OEH, EPA, DPI and Council.

Data collected during the preconstruction monitoring would be used to develop site specific trigger values so that monitoring undertaken during the construction phase can be compared to these values. This would identify if any changes in water quality are a result of construction activities and demonstrate compliance with any monitoring requirements or targets (RTA, 2003).

Operational phase monitoring of surface water quality would be undertaken in order to:

- Assess and manage impacts on the receiving waters as the site stabilises
- Assist in deciding when the site has stabilised
- Identify water quality conditions after development.

Monitoring would be undertaken in line with the Roads and Maritime *Guidelines for Construction Water Quality Monitoring* (RTA, 2003).

These water quality monitoring requirements would be documented in a water quality monitoring program to be developed for both the construction and operational stages of the project.

It is not proposed to monitor groundwater during construction or operation of the project due to the low to very low permeability of Wianamatta Shale and subsequently minor to negligible extent of drawdown and negligible seepage through identified road cuttings during construction. However, if groundwater is encountered during excavation works, a groundwater monitoring plan would be required to be developed and implemented.

8.2.8 Environmental management measures

Expected environmental outcomes

Project-specific management measures identified in Table 8-16 have been developed with the aim of minimising or mitigating, as far as practical, soils, water and contamination impacts as described above. Specific outcomes that would be achieved through the implementation of environmental management measures include:

- Minimising water quality impacts of the project, in particular to sensitive receiving waterways
- Minimising the disturbance of potentially contaminated materials
- Compliance with the relevant legislative requirements and project conditions of approval.

Expected effectiveness

The potential impacts on water quality as a result of the upgrade would be minimised by implementing effective temporary and permanent water quality controls for the construction and operational phases respectively.

For the construction phase, the erosion and sediment control measures to be implemented are outlined in Table 8-16 and are in accordance with the requirements of the Blue Book (Soils and Construction, 2008 Volume 2D Main Road). The measures contained in the Blue Book are based on field experience and have been previously demonstrated to be effective in mitigation during construction. Strict conformance with the requirements of the Blue Book during the construction period would be required to ensure that the predicted effectiveness is achieved.

As per the Blue Book, a construction Soil and Water Management Plan (SWMP) would be prepared as part of the CEMP (see SWC-1) and would contain the construction phase erosion and sediment control measures from Table 8-16. The SWMP would include the requirement for monitoring the effectiveness of mitigation measures through site inspections, monitoring reports and audits. The SWMP includes the provision for continuous improvement through reviews and updates where opportunities for improvement have been identified.

The construction phase sedimentation basins are expected to be effective as they have been designed to provide sufficient volume for settling and storage of sediments. Where construction phase water quality sedimentation basins are required, the design criteria are defined in the Blue Book which requires that sediment basins be designed for the 85th percentile, five day rainfall depth for basins located near sensitive receiving environments, and for the 80th percentile for non-sensitive receiving environments. At the locations where sediment basins are not required (i.e. catchment areas less than 1.0 ha), impacts to waterways would be effectively managed through the implementation of controls as outlined in the SWMP.

Monitoring and inspections would include, but not be limited to:

- Construction sediment basin water quality prior to discharge
- Weekly and post rainfall inspections to evaluate the effectiveness of erosion and sediment control measures.

For the operational phase, 24 operational water quality (vegetated) swales are proposed for the project. The size of these swales has been optimised where possible and rock check dams have been added. As outlined in Section 8.2.7, the vegetated swales have been modelled to show their effective treatment of suspended solids and particle bound heavy metals.

Additionally, surface water monitoring is proposed for the pre-construction, construction and operational phases of the project to monitor the effectiveness of the implemented surface water quality controls and identify if any additional measures are required.

It is not expected that specific controls for groundwater would be required given the minimal impact and low permeability of Wianamatta Shale.

Table 8-16 outlines environmental management measures that have been developed to effectively manage potential impacts which have been predicted as a result of the proposed works.

Table 8-16 Environmental Management Measures – Soils, water and contamination

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
General construction impacts	SWC-1	A Soil and Water Management Plan (SWMP) would be developed in accordance with the Roads and Maritime specification G38 – Soil and Water Management and the Blue Book – Soils and Construction – Managing Urban Stormwater Volume 1 (Landcom, 2004) and Volume 2D (DEC, 2008a). The SWMP would include but not be limited to: • An erosion and sedimentation control plan and maintenance schedule for ongoing maintenance of temporary erosion and sediment controls • A Sediment Basin Management Plan to guide appropriate management of runoff during construction and operation • An incident emergency spill plan which would include measures to avoid spillages of fuels, chemicals and fluids onto any surfaces or into any nearby waterways • Preparation of a wet weather rain event which includes a process for monitoring potential wet weather and identification of controls to be implemented in the event of wet weather • Provision of a maintenance schedule for ongoing maintenance of erosion and sedimentation controls • A review process by a soil conservationist and a process for updating the report to address any recommendations	Construction contractor	Pre-construction	Proven to be effective. Monitoring and reporting requirements of the SWMP to confirm effectiveness of measures.

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
		• A farm dam dewatering plan to be prepared include: - A map showing locations of farm dams to be dewatered - Methodology for dewatering dams with consideration to aquatic ecology - Location of any offsite discharge points - Requirements to manage encounters of contaminated water.			
Water quality during construction	SWC-2	A water quality monitoring program would be developed during detailed design which would outline the pre-construction baseline water quality monitoring to be undertaken, as well as the ongoing construction and operational water quality monitoring requirements. The program would be updated once the construction and operational phase water quality monitoring parameters have been determined (based on the results of the baseline water quality monitoring). The program would include specific monitoring locations, frequency, parameters, and relevant procedures to be implemented. This would include a procedure to be followed in the event that monitoring results during construction or operation indicate an exceedance of the specified criteria, including any stop works requirements, relevant non-conformance, corrective and preventative actions, reporting and review procedures. This would include a requirement to review the effectiveness of control measures and identify any potential additional controls or revised work procedures or management measures that may need to be implemented. It is	Construction contractor / Roads and Maritime	Pre-construction/ construction /operation	Proven to be effective.

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
		noted that any sample locations or access requirements within the DEOH site would be determined in consultation with DoD.			
	SWC-3	The realignment of the tributary of Surveyors Creek would be progressively stabilised to avoid potential scour and sedimentation and permanent stabilisation measures would be implemented as soon as practicable.	Construction contractor	Construction	Expected to be effective. Monitoring and reporting to confirm effectiveness of measures. Continuous improvement to be achieved through ongoing evaluation of monitoring results.
	SWC-4	50 temporary sediment basins are proposed during construction of the project (See Table 8-15).	Construction contractor	Construction	Proven to be effective. Temporary basins have been designed to provide sufficient volume for settling and storage of sediments.
Soil salinity impacts	SWC-5	Durability and aggressivity samples of soil material would be collected and analysed prior to the construction phase, to determine potential impacts of soil salinity on pavement infrastructure.	Contractor	Pre-construction	Proven to be effective.
Sedimentation and Erosion	SWC-6	Erosion and sediment controls would implemented before construction starts in accordance with Blue Book requirements: • Sediment basins would be regularly serviced and maintained to comply with water quality and	Construction contractor	Construction	Proven to be effective. Monitoring and reporting built into the SWMP to confirm effectiveness of measures.

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
		capacity requirements • Clearing of vegetation and site stabilisation of disturbed areas would be undertaken progressively to limit the time disturbed areas are exposed to erosion prices • High risk soil and erosion activities such as earthworks would not be undertaken immediately before or during high rainfall or wind events • Stockpiling of topsoil separately for potential reuse in landscaping and rehabilitation works • Permanent catch drains would be installed behind cut faces to act as diversion drains during the construction phase • Erosion and sediment control measures would be maintained until the works are complete and areas are stabilised by revegetation.			
Sedimentation and Erosion	SWC-7	A soil conservationist from RMS Erosion, Sedimentation and Soil Conservation Consultancy Services would be engaged to review the erosion and sedimentation plans and conduct routine inspections of the construction works.	Roads and Maritime	Pre-construction	Proven to be effective. Monitoring and reporting requirements of the SWMP to confirm effectiveness of measures.
Impacts to water pollution (surface water and groundwater)	SWC-8	• All fuels, chemicals, and liquids would be stored at least 50 m away from the existing stormwater drainage system and would be stored in an impervious bunded area within the compound site • The refuelling of plant and maintenance	Construction contractor	Construction	Expected to be effective. Monitoring and reporting to confirm effectiveness of measures. Continuous

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
		machinery would be undertaken in impervious bunded areas in the designated compound area • Vehicle wash downs and/or concrete truck washouts would be undertaken within a designated bunded area of an impervious surface or undertaken off-site • Disposal of dam water would be done in accordance farm dam dewatering plan.			improvement to be achieved through ongoing evaluation of monitoring results.
Impacts to water pollution (surface water and groundwater)	SWC-9	It is not expected that specific controls for groundwater would be required. This is primarily due to the low to very low permeability of Wianamatta Shale and subsequently minor to negligible extent of drawdown and negligible seepage through identified road cuttings. The expected groundwater inflows are anticipated to be in the order of 0.1 L/s/km of cuttings, although probably much less. It is considered prudent that if groundwater is encountered during excavation works the groundwater monitoring plan detailed below should be implemented.	Construction contractor	Construction	N/A
Disturbance of contaminated or potentially contaminated land	SWC-10	• Intrusive investigations should be undertaken in the vicinity of moderate risk areas including service stations (operational and non-operational), stockpiles and market gardens • A Contaminated Land Management Plan would be prepared in accordance with the Contaminated Land Management Act 1997, relevant EPA Guidelines and Roads and Maritime Guideline for Management of Contamination (Roads and Maritime,2013) and would include at	Construction contractor	Construction	Proven to be effective. Monitoring and reporting requirements of the CLMP to confirm effectiveness of measures.

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
		a minimum: - Contaminated land legislation and guidelines including any relevant licences and approvals to be obtained - Identification of locations of known or potential contamination and preparation of a map showing these locations - Identification of rehabilitation requirements, classification, transport and disposal requirements of any contaminated land within the construction footprint - Measures to manage stockpiled potentially contaminated soil in accordance with the requirements of NSW EPA Waste Guidelines - Contamination management measures including waste classification and reuse procedures and unexpected finds procedures for unanticipated discovery of contaminated material during construction - Asbestos handling and disposal requirements in accordance with NSW EPA guidelines. • Excavated material that is not suitable for on-site reuse or recycling would be transported to a site that may legally accept that material for reuse or disposal.			
Encountering UXO	SWC-11	For UXOs, an investigation should be undertaken to confirm the likelihood of UXOs being present within	Construction contractor	Construction	Proven to be effective

Impact	Ref #	Environmental management measures	Responsibility	Timing	Effectiveness of measures
		the areas of the project within DEOH. The investigation should be undertaken prior to construction activities by a suitably qualified consultant registered on the Commonwealth Department of Defence UXO Panel (DUXOP) now subsumed into the Defence Environment and Heritage Panel (DEHP).			
Operational water quality	SWC-12	24 water quality swales are proposed, including those upstream of identified sensitive receiving waterways.	Roads and Maritime	Operation	Expected to be effective. The proposed swales have been optimised by increasing their base width to provide additional water quality treatment Monitoring and reporting requirements of the WQMP to confirm effectiveness of measures and if any additional measures are required.