Australian Government

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NSW GOVERNMENT

M12 Motorway

Amendment Report - Appendix J

Groundwater quality and hydrology supplementary technical memorandum

October 2020

Jacobs ARCADIS Design & Consultancy for natural and built assets

Memorandum

Issued by	Ben Rose (Senior Hydrogeologist, Jacobs)
Subject	M12 Motorway amendment report – groundwater quality and hydrology supplementary technical memorandum
Client	Transport for NSW
Project	M12 Motorway
Date	October 2020

1. Introduction and background

1.1 Overview

Transport for New South Wales (TfNSW; formerly Roads and Maritime Services) proposes to build the M12 Motorway between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham (the project), over a distance of about 16 kilometres. The project would provide the main access from the Western Sydney International Airport at Badgerys Creek to Sydney's motorway network and is expected to be opened to traffic before the opening of the Western Sydney International Airport.

TfNSW is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the project. An environmental impact statement (EIS) was prepared to assess the potential impacts of the project and recommend management measures to appropriately address those impacts. The key features of the project as described in the EIS is provided in Section 1.1 of the amendment report. This EIS was placed on public exhibition from 16 October to 18 November 2019.

TfNSW proposes to amend the project following further design development since the exhibition of the EIS. The proposed changes include design changes and construction updates. These provide functional improvements to the design and improved integration with surrounding major transport infrastructure projects and potential future development. They also respond to issues raised in community and stakeholder submissions, and, in some instances, further reduce the potential impacts of the project as described in the EIS.

The proposed changes are described in **Section 1.2**.

1.2 Proposed changes

The proposed changes to the project as described in the EIS are summarised below and are described in detail in Chapter 3 and Chapter 4 of the amendment report:

- Amendments to the motorway-to-motorway interchange at the M7 Motorway, including:
  - Changes to Elizabeth Drive and Cecil Road intersections, proposed exit ramps, the Wallgrove Road connection to Elizabeth Drive and proposed shared user path realignments
  - The widening of Elizabeth Drive under the M7 Motorway and approaches

- An option to provide a new connection between the M12 Motorway and Elizabeth Drive near the M7 Motorway interchange
- Two new signalised intersections into the Western Sydney International Airport, with provisions for future connection to potential developments north of the Western Sydney International Airport
- Additional ancillary facilities to support the delivery of the project.

Refinements have also been made as part of the ongoing development of the project since the EIS was exhibited. Refinements are changes that are consistent with the parameters of the project description as described in the EIS. For completeness, however, these refinements have been factored into the amended construction and operational footprint and included in the impact assessment described in this supplementary technical memorandum. The refinements are described in Section 3.3 and Section 4.2 of the amendment report and include:

- Lowering the height of the M12 Motorway in and around the Western Sydney International Airport interchange
- Reduction in the scope of work associated with the M12 Motorway and The Northern Road intersection
  - This intersection would still be constructed, but the main infrastructure work would be delivered as part of The Northern Road upgrade project
- Relocation of utilities
- Changes to property access and acquisition
- Changes to drainage
- Adjustments to construction access, hours, haulage, timing and material quantities.

The project with all proposed changes is referred to as the amended project.

1.3 Amended project

1.3.1 Overview

The amended project would continue to provide the main access from the Western Sydney International Airport at Badgerys Creek to Sydney's motorway network and be located between The Northern Road in the west and the M7 Motorway in the east. The amended project includes an option for a direct connection between the M12 Motorway and Elizabeth Drive at the eastern extent of the project. This option would include some realignment of Wallgrove Road and widening of Elizabeth Drive at the motorway-to-motorway interchange at the M7 Motorway to facilitate the connection. Therefore, two options are being proposed for the amended project at the interchange with the M7 Motorway.

The two options for the amended project would be consistent from The Northern Road in the west until Duff Road in the east. At the motorway-to-motorway interchange with the M7 Motorway, the project is proposed to be either:

- Option 1 – Without Elizabeth Drive connection
  - Interchange provides entry and exit ramps between the M12 Motorway and the M7 Motorway; in addition, it would maintain the existing connection of the M7 Motorway to Elizabeth Drive with new entry and exit ramps
- Option 2 – With Elizabeth Drive connection
  - Interchange as per option 1 and also provides entry and exit ramps between the M12 Motorway and Elizabeth Drive, Cecil Road and Wallgrove Road.

This section of the amended project is shown in **Figure 1-1,** with the Elizabeth Drive connection associated with option 2 shown in a different colour and detailed in inset A. The decision on which option would be built is dependent on funding being available to include the Elizabeth Drive connection. This will be determined during the detailed design and construction phase of the project. The key features of each option are described in the following sections.

The proposed changes (see **Section 1.2**) would result in an amended construction footprint (**Figure 1-2**) and an amended operational footprint (**Figure 1-3**). The footprints would be the same for both options, with each footprint assuming the worst case scenario (ie option 2).

The assessment of potential impacts described in **Section 4** relates to the worst case scenario and covers both options, unless stated otherwise.

The key features of the amended project are listed in **Section 1.3.2** and include both options.

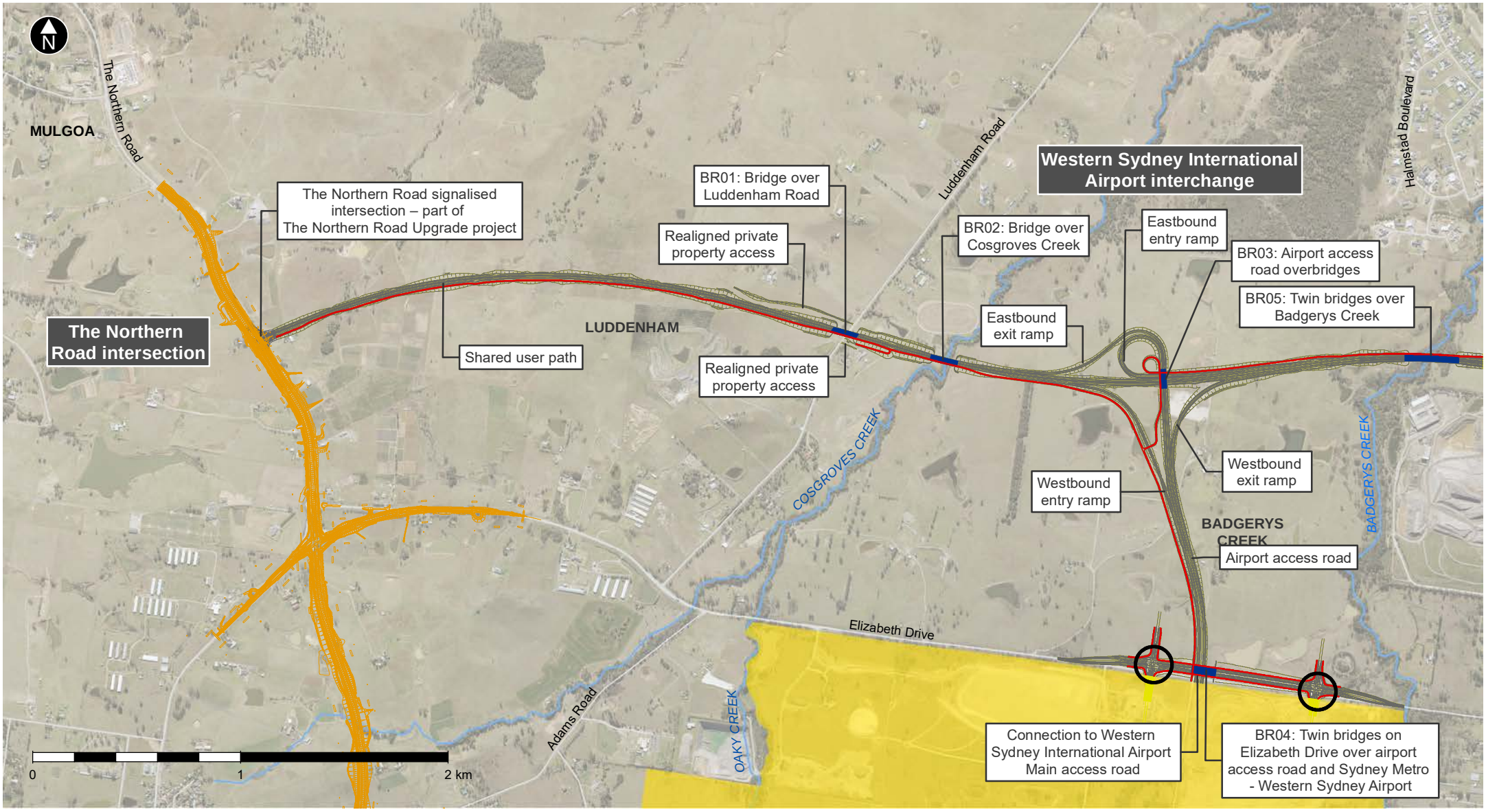
1.3.2 Key features of the amended project

The key features of the amended project are listed below. Where the description of the proposed amended project key features differs from the description listed in the EIS (see Section 1.1 of the amendment report), those changes are shown in **bold** text:

- A new dual-carriageway motorway between the M7 Motorway and The Northern Road with two lanes in each direction with a central median allowing future expansion to six lanes
- Motorway access via three interchanges/intersections:
  - A motorway-to-motorway interchange at the M7 Motorway and associated works (extending about four kilometres within the existing M7 Motorway corridor) **with the following options:**
    - **Option 1 – without connection between the M12 Motorway and Elizabeth Drive**
    - **Option 2 – with connection between the M12 Motorway and Elizabeth Drive**
  - A grade-separated interchange referred to as the Western Sydney International Airport interchange, including a dual-carriageway four-lane airport access road (two lanes in each direction for about 1.5 kilometres) connecting with the Western Sydney International Airport Main Access Road
  - A signalised intersection at The Northern Road with provision for grade separation in the future
- Bridge structures across Ropes Creek, Kemps Creek, South Creek, Badgerys Creek and Cosgroves Creek
- A bridge structure across the M12 Motorway into the Western Sydney Parklands to maintain access to utilities, including the existing water tower and mobile telephone/other service towers on the ridgeline in the vicinity of Cecil Hills, to the west of the M7 Motorway
- Bridge structures at interchanges and at Clifton Avenue, Elizabeth Drive, Luddenham Road and other local roads to maintain local access and connectivity
- Inclusion of active transport (pedestrian and cyclist) facilities through provision of pedestrian bridges and an off-road shared user path, including connections to existing and future shared user path networks

- Modifications to the local road network, as required, to facilitate connections across and around the M12 Motorway including:
  - Realignment of Elizabeth Drive at the Western Sydney International Airport, with Elizabeth Drive overpassing the airport access road and rail infrastructure
  - **Two new signalised intersections from Elizabeth Drive into the Western Sydney International Airport, with provisions for future connection to potential developments to the north**
  - **Widening of Elizabeth Drive under the M7 Motorway and approaches**
  - Realignment of Clifton Avenue over the M12 Motorway, with associated adjustments to nearby property access
  - Relocation of the Salisbury Avenue cul-de-sac, on the southern side of the M12 Motorway
  - **Realignment of Wallgrove Road to connect to Cecil Road, including a connection between Elizabeth Drive and Wallgrove Road via Cecil Road with a signalised intersection with Elizabeth Drive**
- Adjustment, protection or relocation of existing utilities
- Ancillary facilities to support motorway operations, smart motorways operation in the future and the existing M7 Motorway operation, including gantries, electronic signage and ramp metering
- Other roadside furniture, including safety barriers, signage and street lighting
- Adjustments of waterways, where required, including Kemps Creek, South Creek and Badgerys Creek
- Permanent water quality management measures including swales and basin
- Establishment and use of temporary ancillary facilities, temporary construction sedimentation basins, access tracks and haul roads during construction
- Permanent and temporary property adjustments and property access refinements as required.

An overview of the amended project is shown in **Figure 1-1**.



The amended project

Part of The Northern Road upgrade project

Shared user path

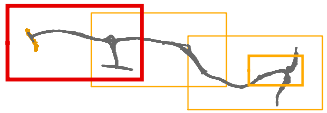
Bridges

Existing roads

Waterways

Western Sydney International Airport

Signalised intersections into the Western Sydney International Airport
Note: Indicative, subject to detailed design



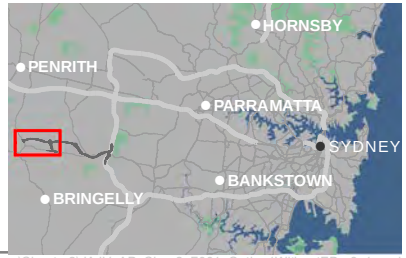


Figure 1-1 Key features of the amended project

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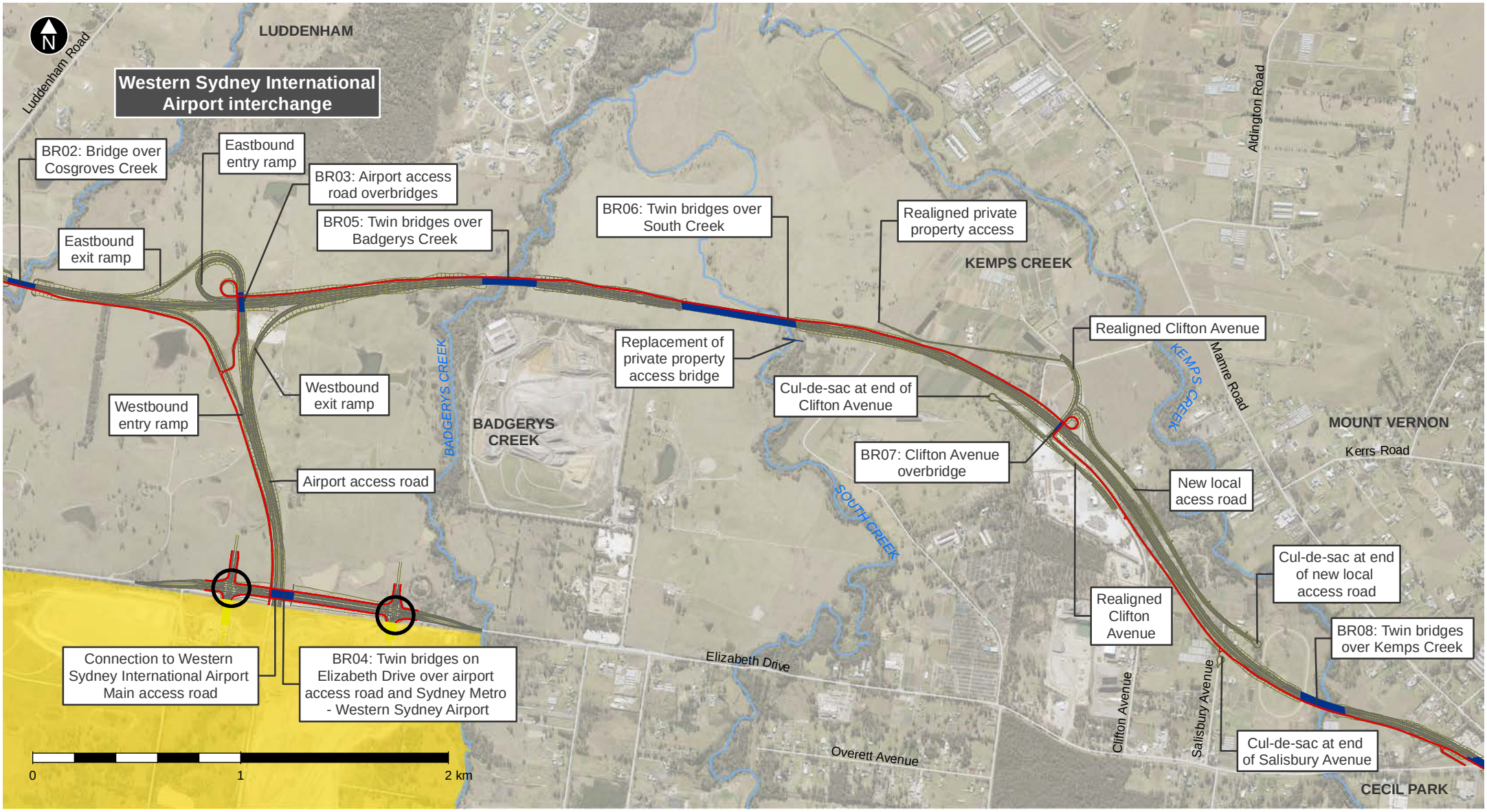
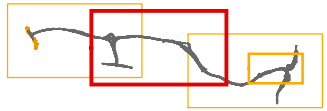


The amended project
Shared user path
Bridges
Existing roads
Waterways
Western Sydney International Airport
Signalised intersections into the Western Sydney International Airport
Note: Indicative, subject to detailed design



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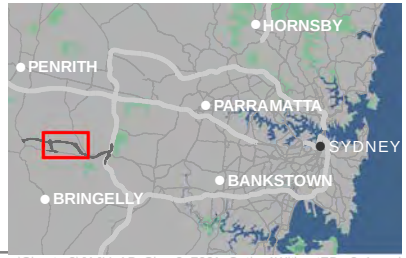

Figure 1-1 Key features of the amended project

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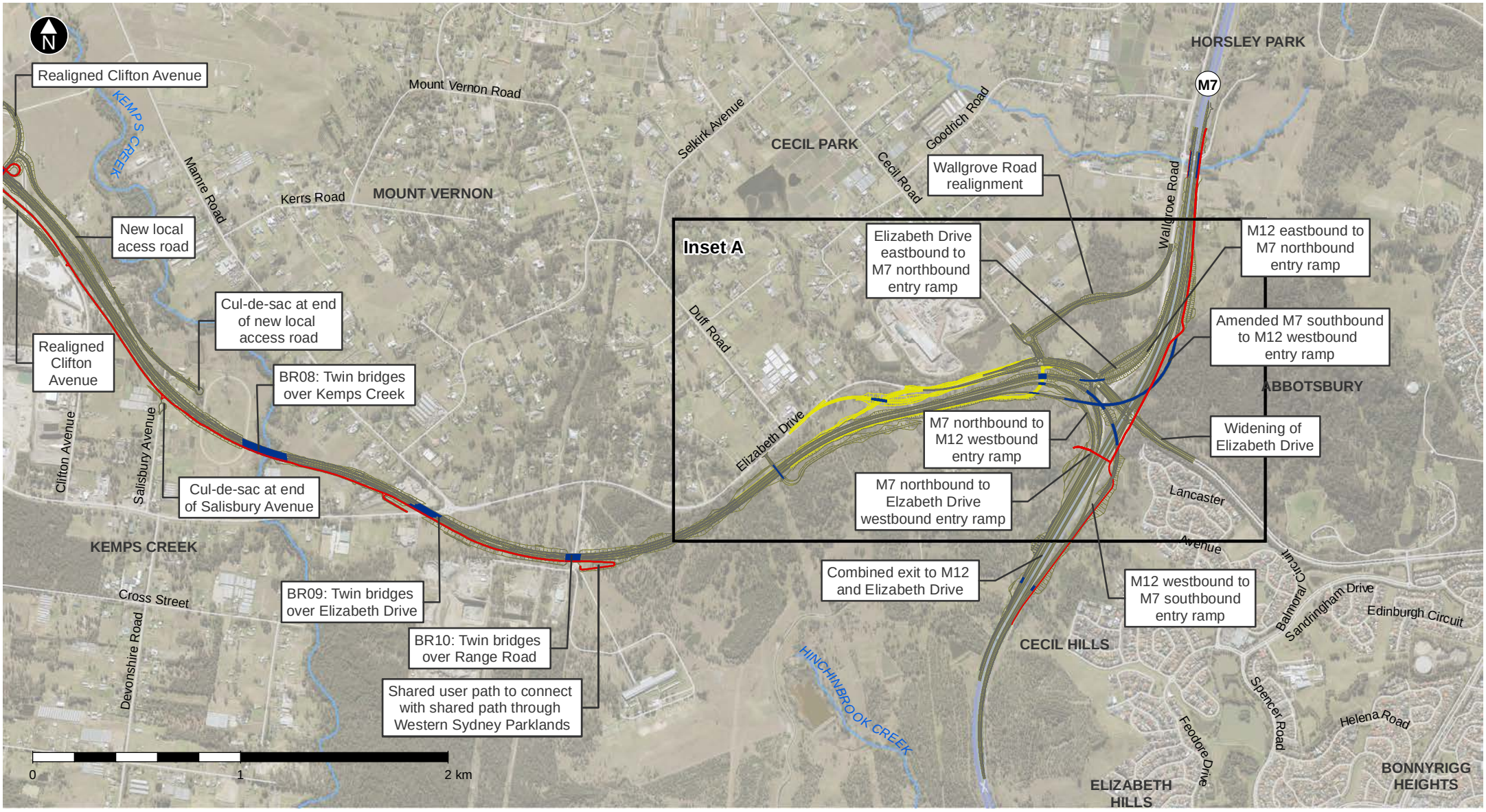


The amended project

The amended project (Elizabeth Drive connection)

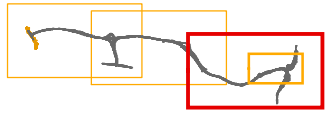
Shared user path

Bridges

Motorway

Existing roads

Waterways



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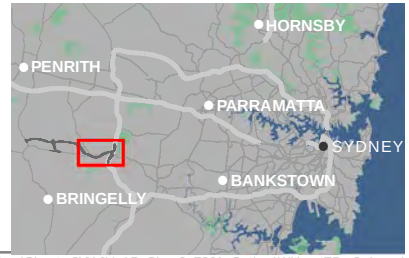

Figure 1-1 Key features of the amended project

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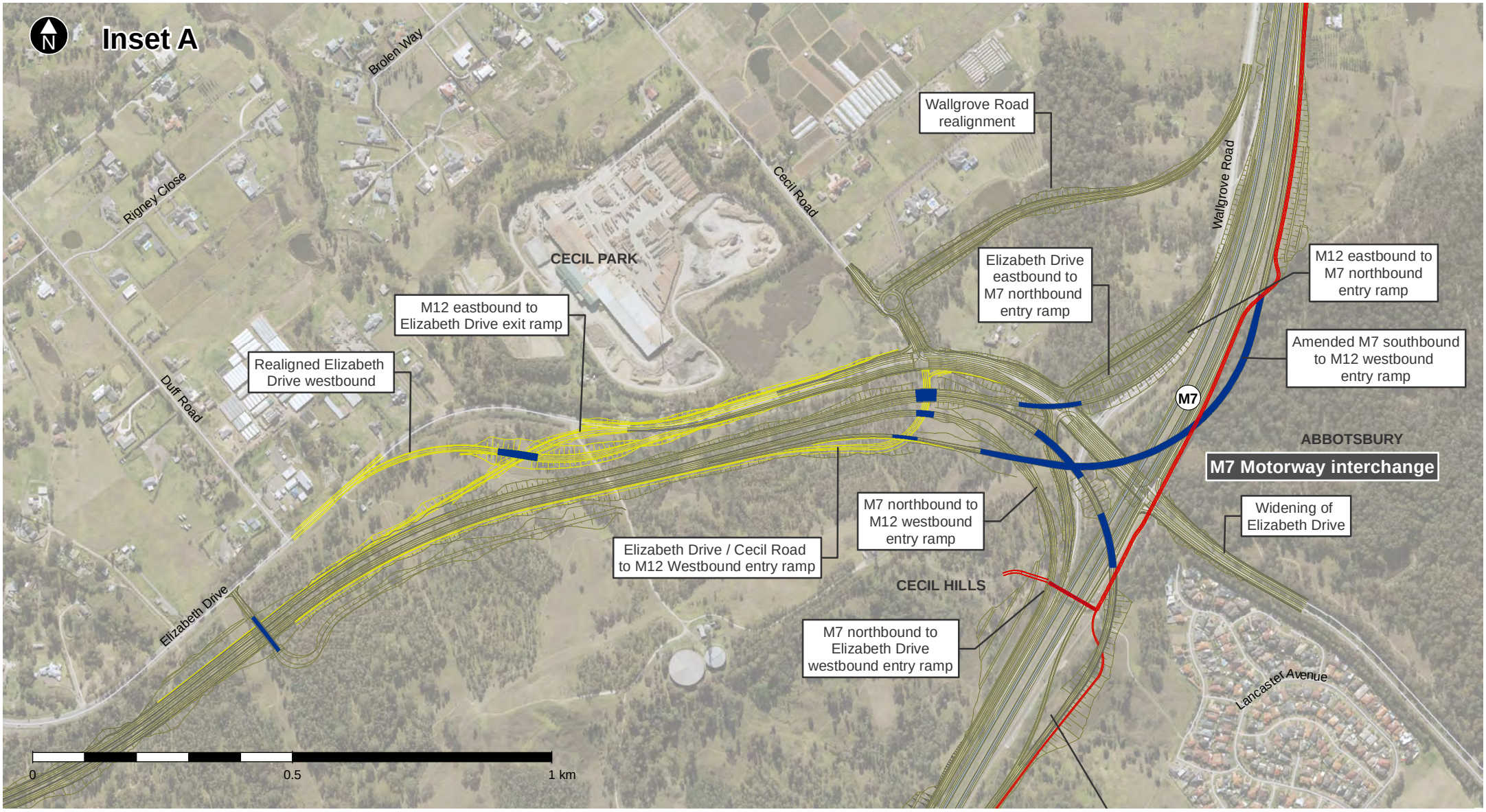
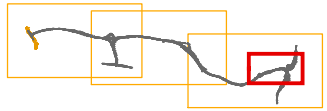


- The amended project
- The amended project with Elizabeth Drive connection
- Shared user path
- Bridges
- Motorway
- Existing roads



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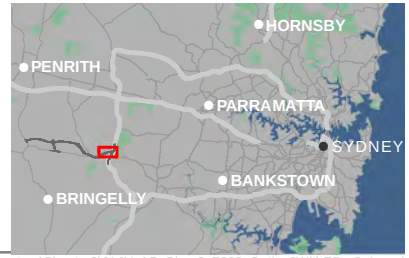

Figure 1-1 Key features of the amended project

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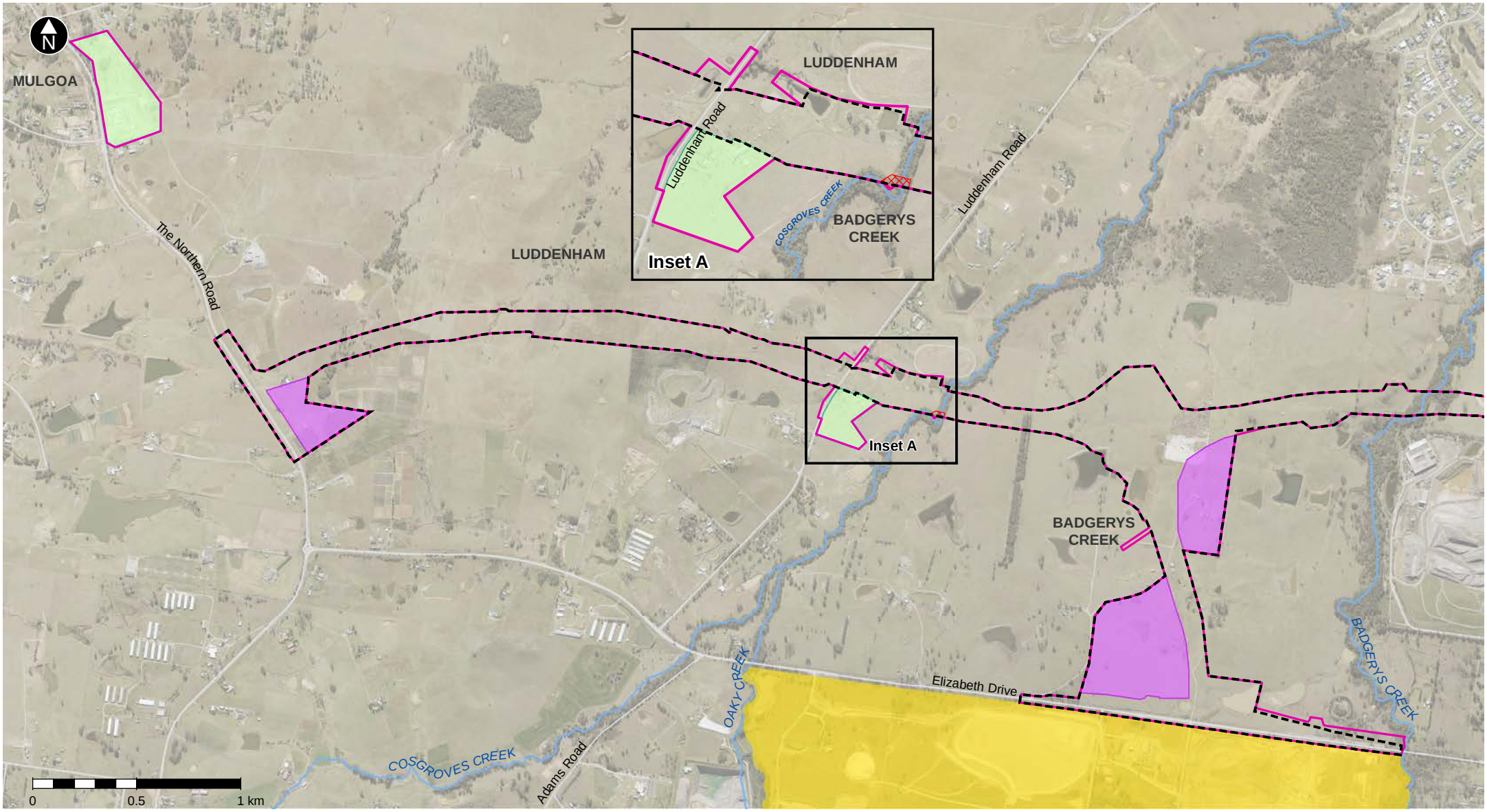


The project construction footprint as per the EIS

The amended project construction footprint

The amended project exclusion zones

Ancillary facilities as per the EIS

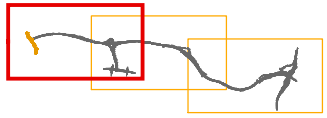
Additional ancillary facilities

Western Sydney International Airport

Waterways

Motorway

Existing roads



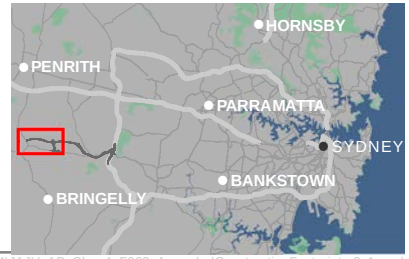


Figure 1-2 Construction footprints of the amended project and the project as described in the EIS

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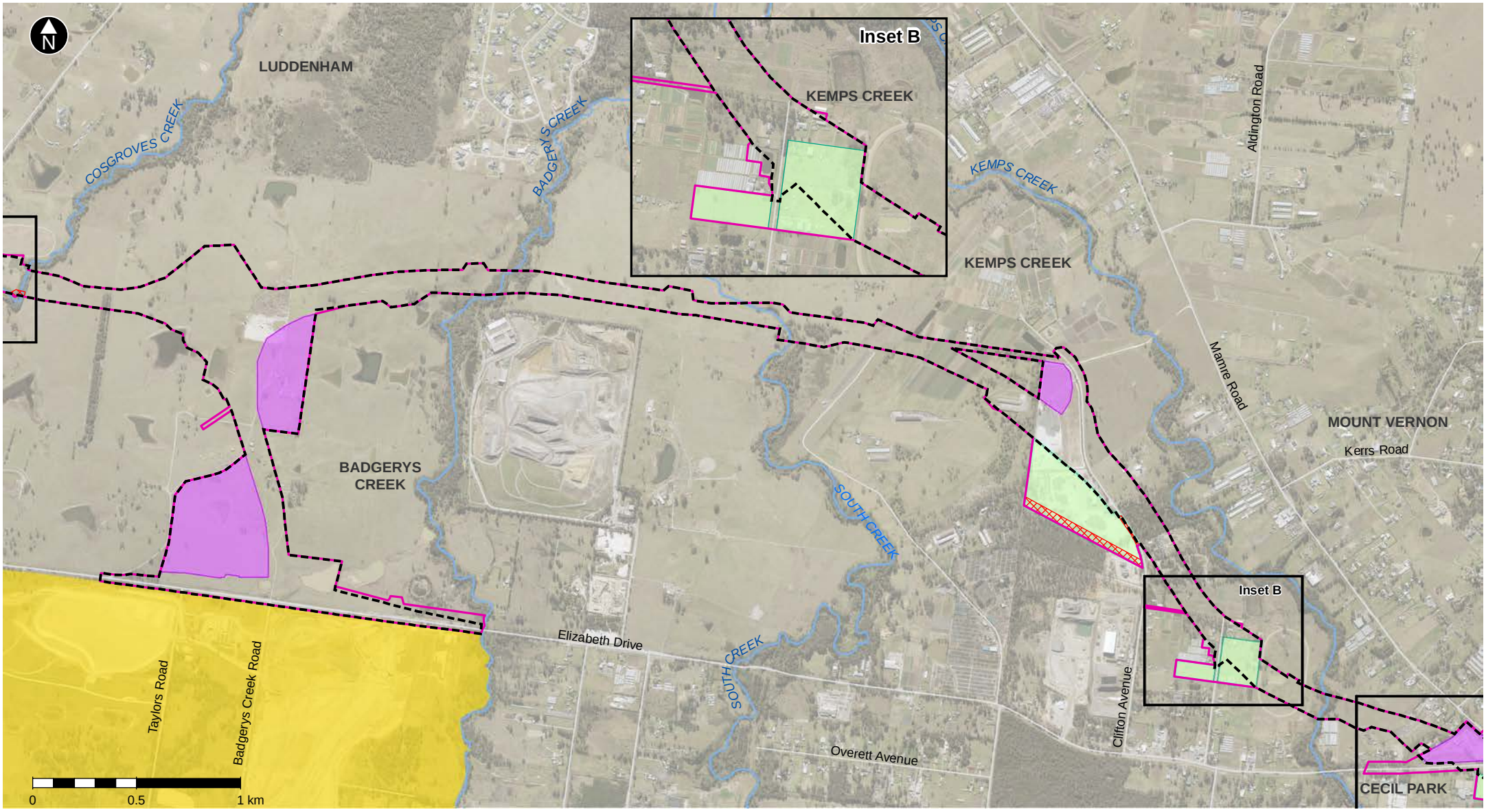


The project construction footprint as per the EIS

The amended project construction footprint

The amended project exclusion zones

Ancillary facilities as per the EIS

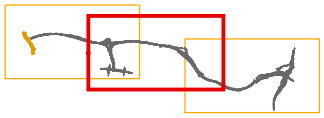
Additional ancillary facilities

Western Sydney International Airport

Waterways

Motorway

Existing roads



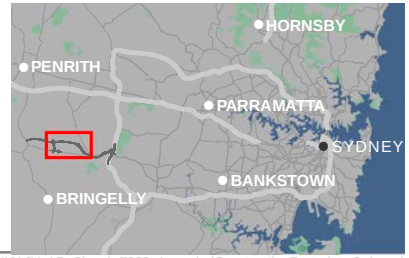


Figure 1-2 Construction footprints of the amended project and the project as described in the EIS

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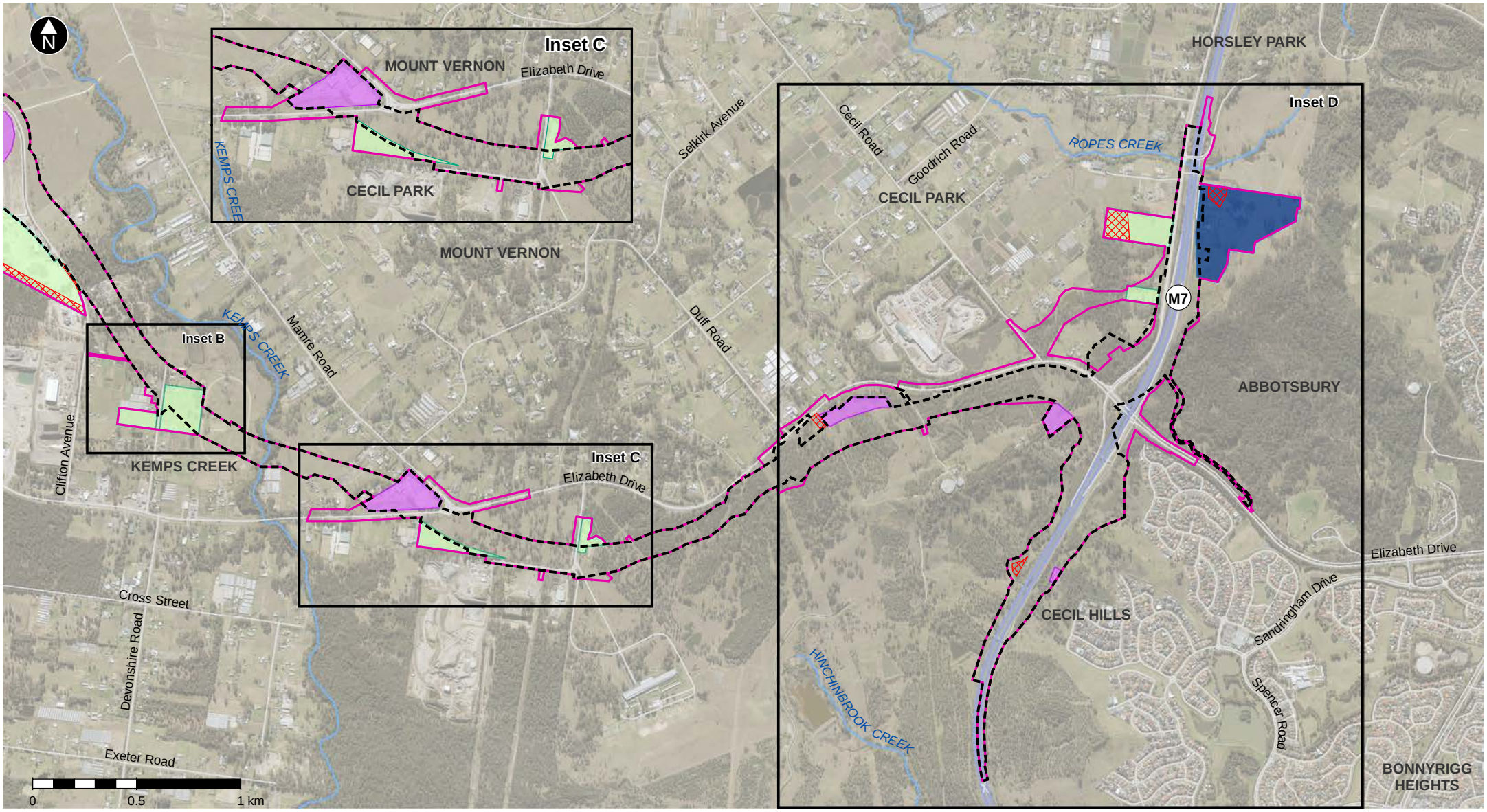


The project construction footprint as per the EIS

The amended project construction footprint

The amended project exclusion zones

Ancillary facilities as per the EIS

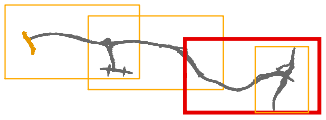
Additional ancillary facilities

Amended ancillary facilities

Waterways

Motorway

Existing roads



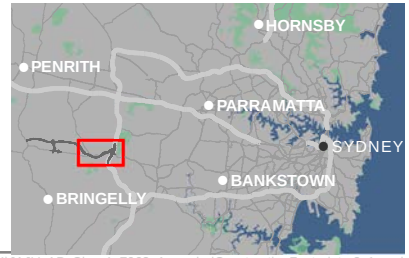


Figure 1-2 Construction footprints of the amended project and the project as described in the EIS

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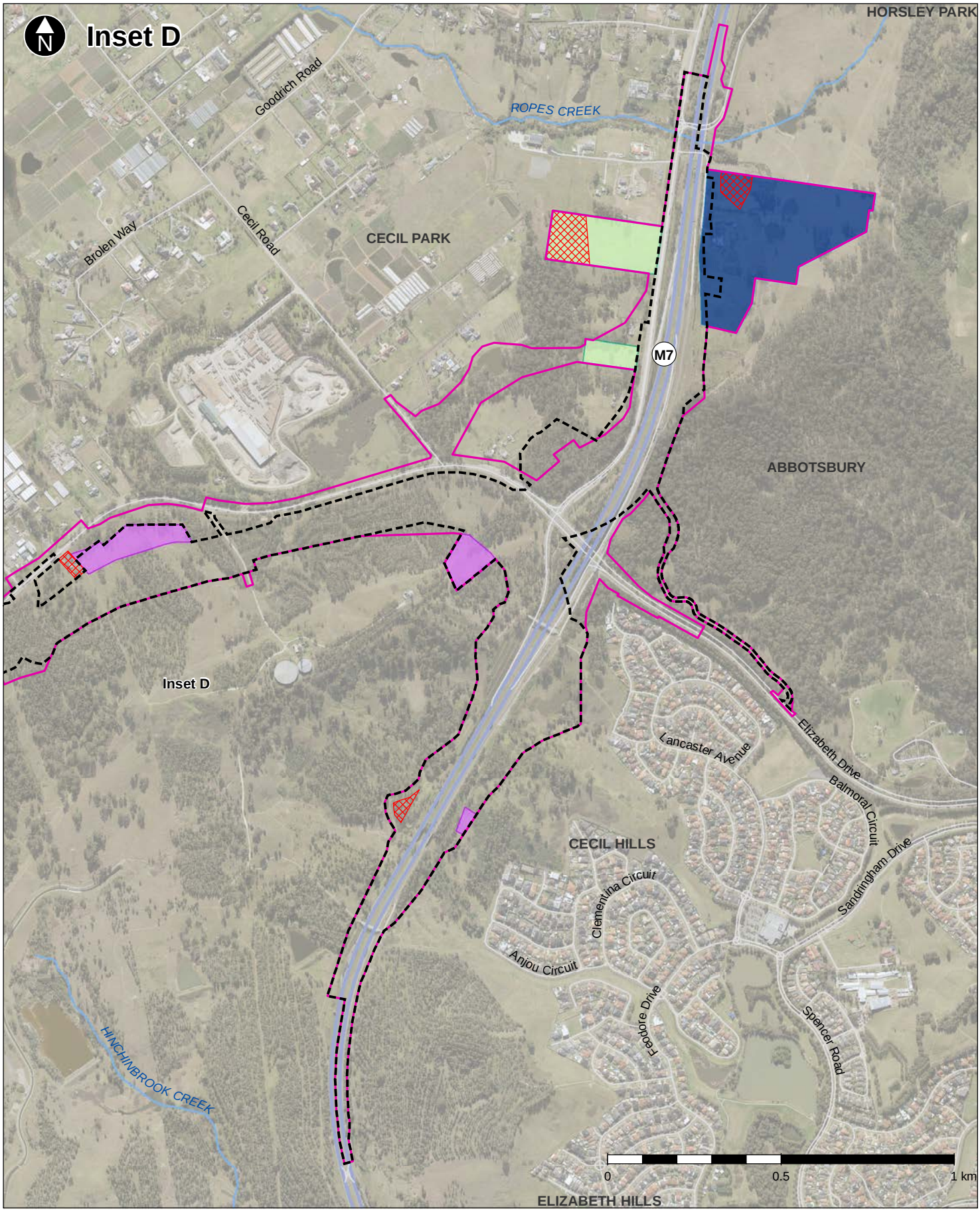


The project construction footprint as per the EIS

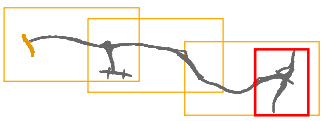
The amended project construction footprint

The amended project exclusion zones

Ancillary facilities as per the EIS

Additional ancillary facilities

Amended ancillary facilities



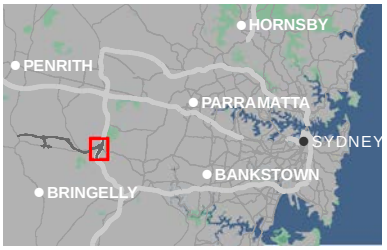


Figure 1-2 Construction footprints of the amended project and the project as described in the EIS

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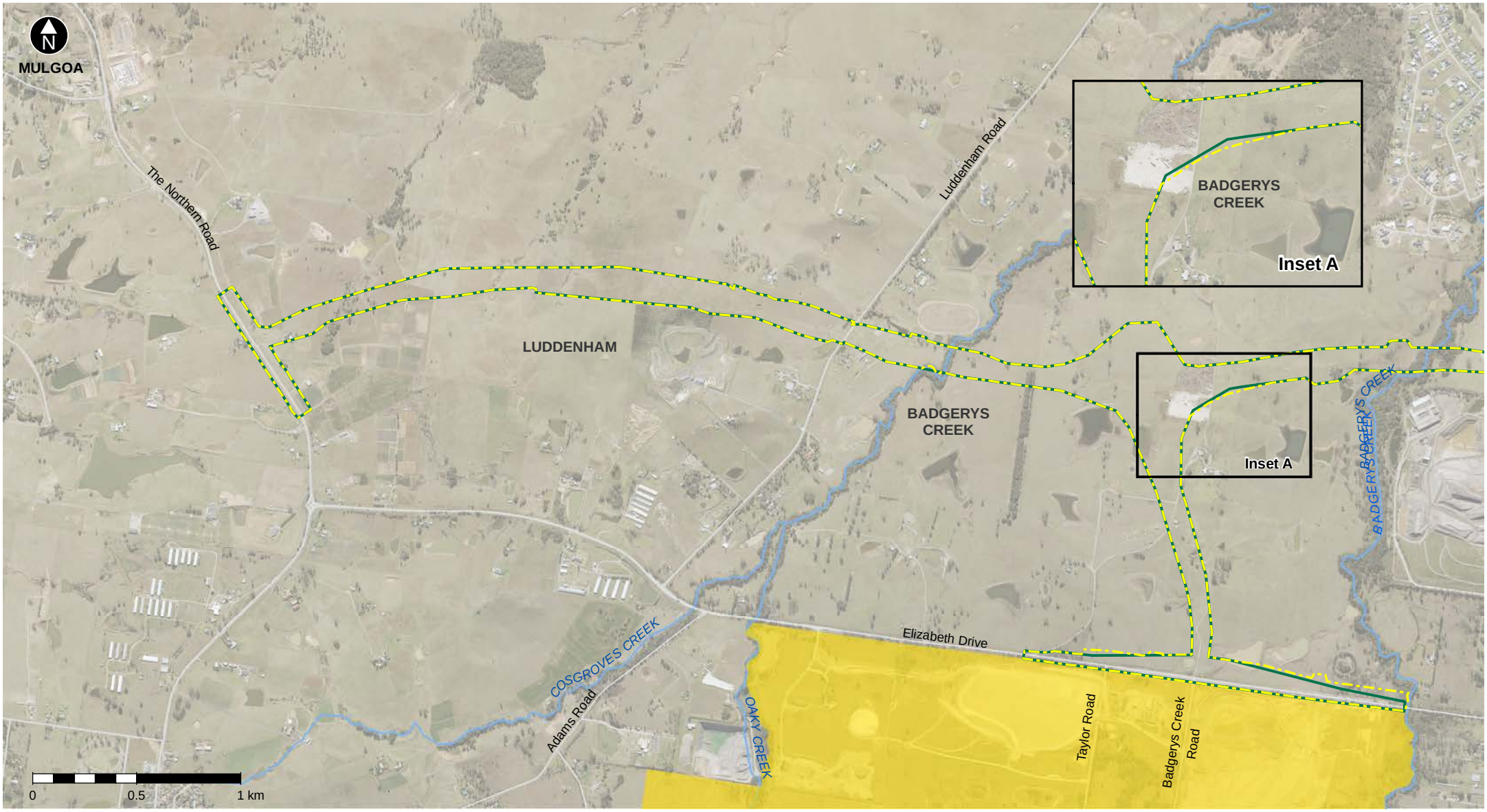


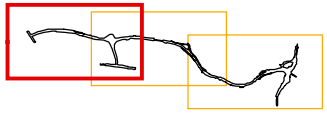
The project operational footprint as per the EIS

The amended project operational footprint

Waterways

Western Sydney International Airport

Existing roads



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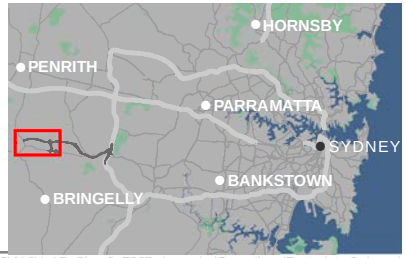

Figure 1-3 Operational footprints of the amended project and the project as described in the EIS

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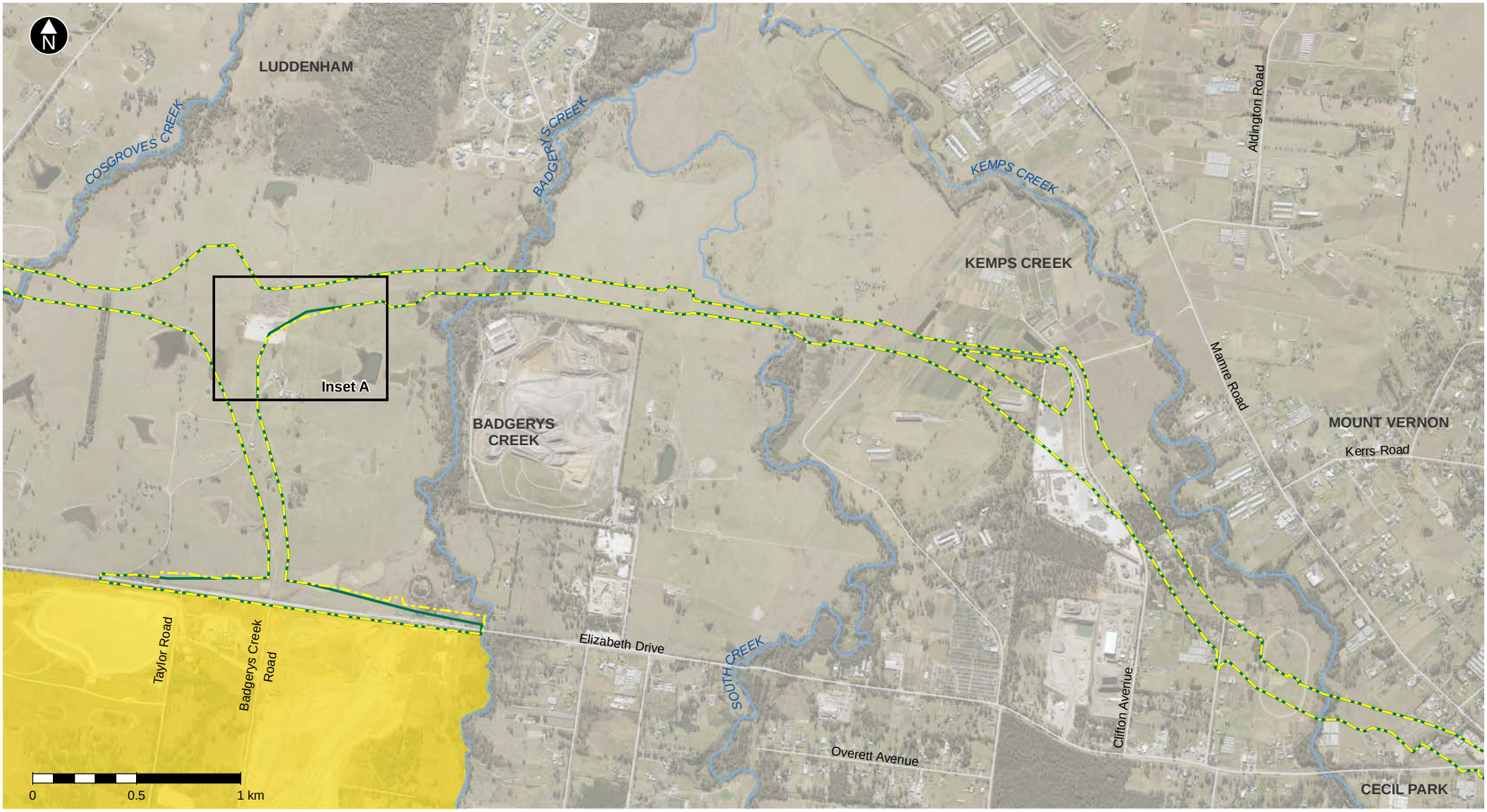

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Figure 1-3 Operational footprints of the amended project and the project as described in the EIS

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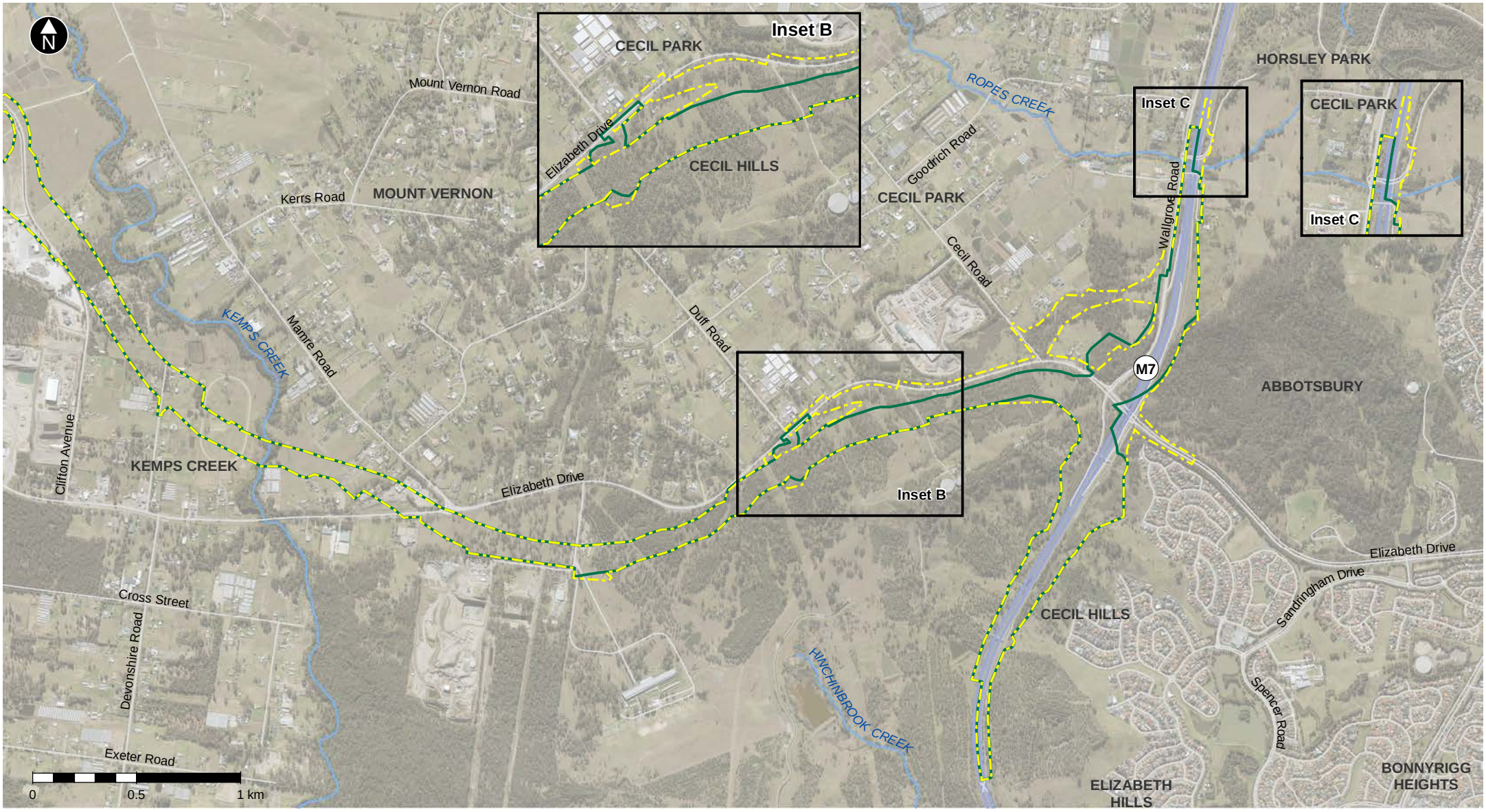


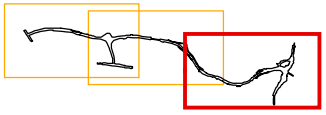
The project operational footprint as per the EIS

The amended project operational footprint

Waterways

Motorway

Existing roads



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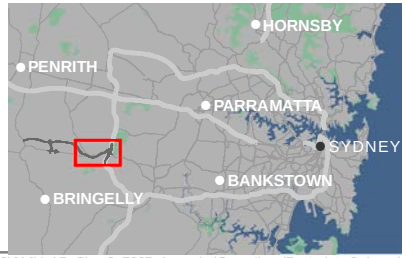

Figure 1-3 Operational footprints of the amended project and the project as described in the EIS

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1.4 Purpose of document

This supplementary technical memorandum has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) issued 30 October 2018 to support the EIS. The purpose of this memo is to:

- Provide clarification to the groundwater and hydrology assessment carried out as part of the EIS.
- Identify and assess the potential construction, operational and cumulative groundwater impacts of the amended project, including an assessment of the proposed design changes against the impacts documented in the EIS
- Where required, recommend any changes or feasible and reasonable additions to the management measures

This supplementary technical memorandum should be read in conjunction with Section 7.10 and Appendix N of the EIS.

2. Assessment methodology

2.1 Overview

The methodology for the supplementary groundwater assessment was prepared in accordance with the policy and planning setting detailed in Section 7.10.1 of the EIS, and generally consistent with the methodology outlined in Section 7.10.2 of the EIS. The methodology for the supplementary groundwater assessment is detailed in **Section 2.2** to **Section 2.6** below.

This supplementary groundwater assessment focuses on the changes in potential impacts to groundwater associated with the changes to the construction and operational footprints, and vertical alignment, as a result of the amended project. The assessments detailed in **Section 5** relate to both options, unless stated otherwise.

2.2 Study area

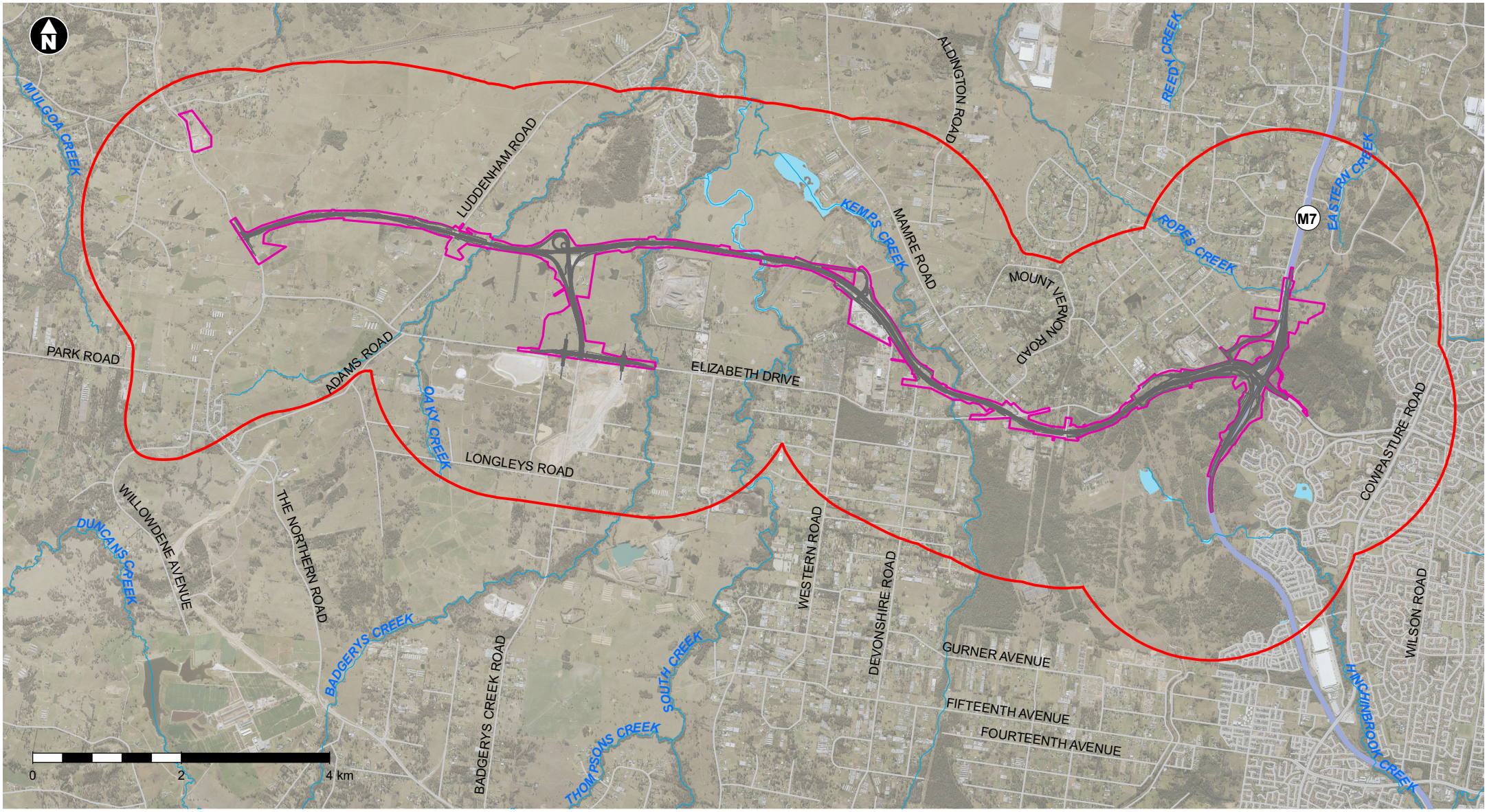
This supplementary groundwater assessment used the same groundwater study area described in Section 7.10 of the EIS. There was no need to amend this as the two kilometre buffer amended project sufficiently captures the amended project construction footprint and its surrounds. The groundwater study area and amended project construction footprint is shown in **Figure 2-1**.

2.3 Desktop assessment

Existing groundwater conditions remains mainly unchanged from that described in Section 7.10.3 of the EIS. As such a desktop assessment of raw data was not required to be repeated. For groundwater level data, however, WaterNSW's (2020) online bore database was used to supplement the Bureau of Meteorology's (BOM) Australian Groundwater Explorer (BOM, 2018a) data used in the EIS. This was done to evaluate if the spatial coverage of groundwater level data in the EIS could be improved.

2.4 Site investigations

As the study area was unchanged from that described in the EIS, no additional site investigations were determined to be required for this this supplementary groundwater assessment.



The amended project (Elizabeth Drive connection)

Waterways

Motorway

Main roads

Groundwater assessment study area

The amended project construction footprint

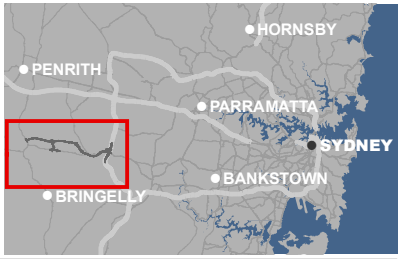


Figure 2-1 Groundwater study area and amended project construction footprint

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2.5 Criteria

The supplementary groundwater assessment used the same groundwater quality objective and assessment criteria and the groundwater level impact assessment criteria as outlined in Section 7.10.2 of the EIS.

2.6 Impact assessment methodology

2.6.1 Overview

An assessment of dewatering impacts was undertaken to estimate potential groundwater inflows and reductions to groundwater levels if road cuttings (excavations) extend below the water table and are drained.

In addition, the potential for cumulative impacts were considered, including the potential of newly identified cuts that may extend below the water table to interact with cuts assessed in the EIS as likely to extend beneath the water table.

The environmental management measures relating to groundwater as per the EIS were then reviewed and revised as required (see **Section 6**).

2.6.2 Dewatering assessment methodology

Potential groundwater inflow zones

Groundwater inflow zones would occur in areas where the amended project's proposed road level is below the water table. To identify potential groundwater inflow zones, separate colour graded maps of the required excavation depth for the project as described in the EIS and the amended project were compared to one another. This enabled new areas of relatively deep cut arising due to the proposed design changes to be identified.

For new deep cut areas, the excavation depth and level were compared to nearby groundwater level data obtained from project groundwater monitoring bores in order for the excavation depth below the water table to be estimated. Maximum monitored groundwater levels were used in this process, which results in a conservative assessment method.

Groundwater inflow volume estimation

To estimate potential groundwater 'take' (inflow) generated by the newly identified amended project cuts intersecting the water table, the Dupuit-Forchheimer well discharge equation for an unconfined groundwater system without recharge was used. This approach represents the areas of excavation which may extend beneath the water table as a large theoretical groundwater well and is formulated as follows:

$$\text{Groundwater inflow (cubic metres per day)} = \pi K ho^2 / \ln(ro/rpit)$$

where:

K = hydraulic conductivity (metres per day)

ho = water table interception depth (metres) of extraction area

ro = radius of influence (m metres

rpit = radius (metres) of excavation area based on excavation area (square metres) represented as an equivalent circular area

In addition, the following were carried for the above equation:

- Radius of influence values were applied in the equation using the calculated areal drawdown extent values (see sub-section below)
- The equation was solved for a time of 365 days and 1825 days (five years), to give a range of inflow rates and areal drawdown extent which may occur once steady state conditions are achieved. The groundwater system achieving approximate equilibrium within 1825 days (five years) is considered likely based on the small drawdowns. Non-equilibrium conditions were not modelled because the range of inflow rates were assessed as sufficiently low that it is not practical or necessary to model potentially higher inflow rates that may occur prior to equilibrium steady state conditions being achieved.

The same range of hydraulic conductivity values and the storage value (0.03) which were used in the assessment described in the EIS were applied. The range of hydraulic conductivity values were applied to account for uncertainty and incorporate sensitivity analysis into the assessment.

Groundwater inflows into new areas of cut which may extend below the water table were integrated into an amended project water balance that is detailed in Sections 6.9 and 6.10 of the amendment report. The amended project water balance is described Sections 6.9 and 6.10 of the amendment report and not in this memo because the proportion of groundwater volumes compared to surface water volumes in the water balance are negligible.

The estimated groundwater inflow to the single road cutting area that may intersect the water table which was identified in the EIS remains applicable and unchanged for the amended project.

Drawdown extent estimation

Due to drainage, interception of groundwater flow by project cuts that extend below the water table could potentially reduce groundwater levels in the region of the cuts. The outer limit of the area that could be subjected to reduced groundwater levels was estimated using the same equation described in Appendix N of the EIS. Due to larger areas and potentially deeper water table penetration for the amended project, however, a duration until equilibrium of five years was simulated, in addition to the one year simulation used in the EIS assessment.

Calculated areal drawdown extents were compared to the locations of GDEs and existing licensed bores mapped in Appendix N of the EIS. The potential for the drawdown to impact regional groundwater flow processes was assessed by considering the magnitude of drawdown.

3. Existing environment

Chapter 7.10.3 of the EIS provides a detailed description of the existing environment within which the project is located, including groundwater conditions. The existing environment has not changed since the preparation of the EIS.

In summary, two main groundwater systems exist in the study area, alluvial groundwater systems and bedrock groundwater systems.

Except for Ropes Creek, the alluvial groundwater systems exist in the region of the major creeks that the project crosses. Based on geological mapping (Geological Survey of NSW, 1991), the widths of the alluvium deposits are of the order of 300 metres, 700 metres, one kilometre and 500 metres for Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek respectively. Boreholes adjacent to the project's creek crossings encountered alluvial clays, silts, sands and gravels above the bedrock, which occurred at depths ranging

from about 2.5 to 7.0 metres below ground level (BGL). Therefore, the alluvium deposits are relatively thin (ie less than seven metres) and predominantly clayey.

The bedrock groundwater systems exist in the areas not occupied by the alluvial groundwater systems, and underneath the alluvial groundwater systems.

The features of the alluvial and bedrock groundwater systems were described in Section 7.10.3 of the EIS and have not changed.

Figure 3-1 shows conceptual hydrogeology and the design surface level of the project as described in the EIS, but remains useful for appreciation of the amended project conceptual hydrogeology, as this is unchanged for the amended project except for two areas of relatively deeper road cuttings that may intersect the water table.

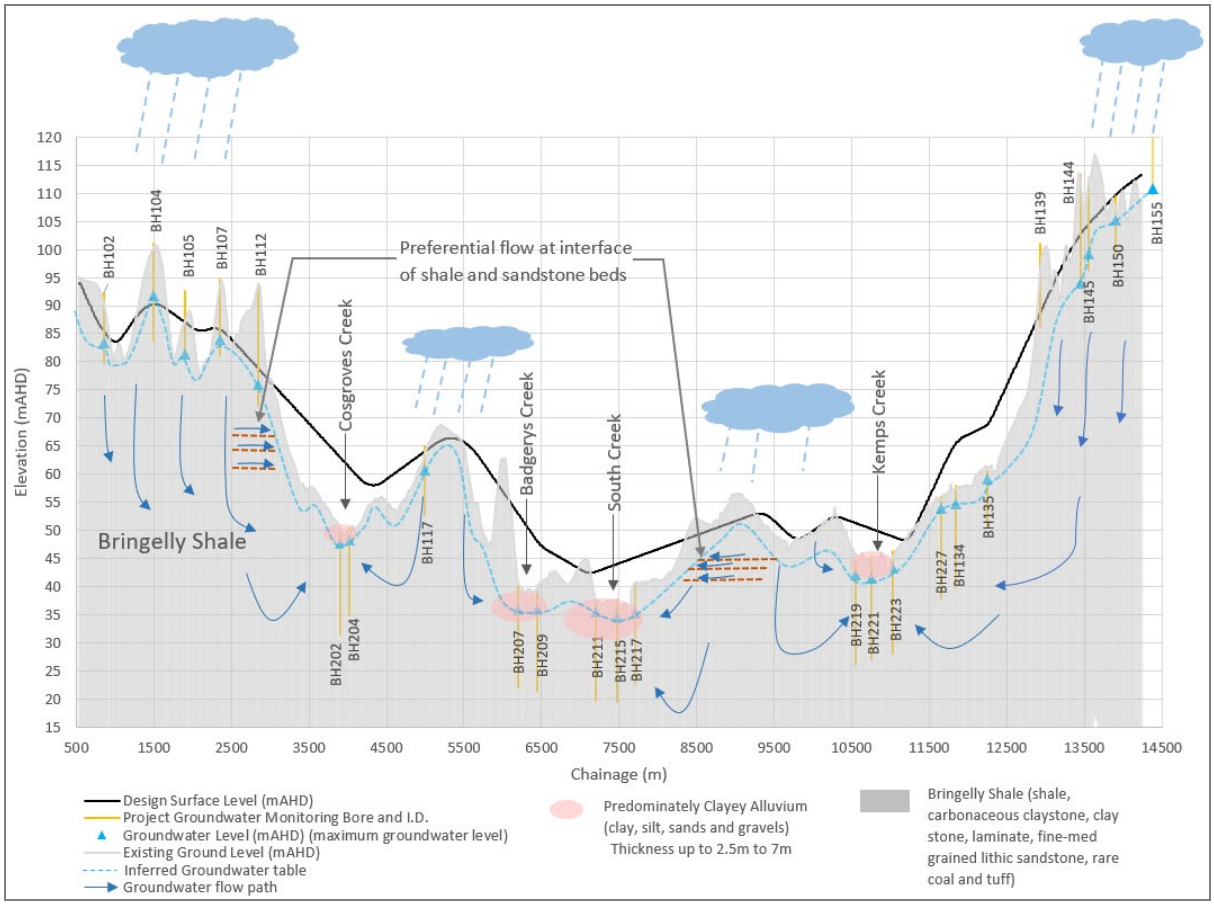


Figure 3-1 Conceptual hydrogeological cross section

4. Clarifications on the assessment undertaken as part of the EIS

NSW DPIE Water provided feedback regarding the EIS's groundwater assessment. The sections that follow provide clarifications in response to this. The clarifications provide further context behind the groundwater assessment in the EIS and are relevant to the amended project groundwater assessment.

4.1.1 Clarifications to the methodology

Groundwater level range – project monitoring bores

As outlined in Section 4.1.2 of the EIS, the months of February 2018 to August 2018 comprise the groundwater level monitoring period documented in the EIS for most monitoring bores. During this period, the observed monthly rainfall at the BOM's Badgerys Creek Station was lower than long-term monthly average values.

Evaporation during these same months ranged from about two to 2.6 times higher than historical long-term average values.

A cumulative rainfall deviation (CRD) plot of rainfall at the BOM's Badgerys Creek AWS station from January 1996 (close to start of available data set) through to February 2019 is provided in Annexure A, Figure 3 of Appendix N of the EIS, along with identification of the EIS groundwater monitoring period. The CRD trends suggest that whilst the project's groundwater monitoring period corresponds with low rainfall and high evaporation, CRD during the monitoring period is quite close to a peak occurring in March 2017. This peak occurred following a pronounced minimum that occurred in December 2006.

Based on the CRD trends and timing of the project's groundwater monitoring period, groundwater levels measured during the monitoring period are anticipated to be higher than long-term averages.

Appendix N of the EIS presented the entire range of available data from project monitoring bores, and from this, for drawdown and groundwater inflow assessment purposes, conservatively adopted the maximum monitored groundwater level. This supplementary groundwater assessment for the amended project used this same data and approach.

Groundwater level range – non-project monitoring bores

In addition to installation and monitoring of project groundwater monitoring bores, the BOM's (2018a) online Australian Groundwater Explorer (the 'Explorer') was reviewed to inform the EIS. The Explorer did not contain water level records for bores in the study area, as defined in the EIS.

Subsequent to the EIS, the online WaterNSW (2020) bore database was reviewed as part of the supplementary groundwater assessment of the amended project. This was done to assess water level records for bores inside the study area. There are some bores in this database which have water level records. However, there is only one location (containing multiple bores) that monitors the shallow groundwater systems applicable to the project. The bore identification numbers at this location are GW075064, GW075065, GW075066, GW075067 and GW075068.

The data from the above bores cannot be used to infer maximum wet weather groundwater levels, as the data periods are either too short or the data is interpreted to be erroneous (many of the bores show constant water levels with zero change).

There are four additional bores with water level data in the WaterNSW (2020) database within the study area. However, these bores have depths between 111 metres to 253 metres and are, therefore, not representative of shallow groundwater system water levels applicable to the project.

'Aquifers' and impacts

Groundwater systems in the vicinity of the project are expected to be low yielding. Aquifers, which are defined by Freeze and Cherry (1979) as a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients, are considered unlikely to be present.

The amended project has a limited vertical extent, with the deepest cut expected to be about 16 metres. Project data, surrounding data and the subsequently developed conceptual hydrogeological model indicate aquifers are not present in the near surface profile which the project is associated with. Groundwater systems near the land surface are conceptualised as low yielding and saline. Potentially relatively higher yielding aquifers, if present, would be substantially deeper than the project, with relatively higher yields and lower salinity likely best obtained from Hawkesbury Sandstone groundwater systems. Hawkesbury Sandstone is anticipated to commence at levels of between about -40 metres AHD to -65 metres AHD in the study area, which is at least about 75 metres deeper than the minimum project design surface level.

As aquifers are not present within the vertical extent of either the project as described in the EIS or the amended project, they would not be cut off or diverted as a result of the amended project.

Modelling

For the EIS, site specific modelling of the drawdown associated with one area of road cutting which may intersect the water table was completed and is described in Section 5.1.2 and Section 5.2.2 of Appendix N of the EIS. The only anticipated potential drawdown for the project as described in the EIS was an area referred to as the 'western cut'. Additional road cuttings associated with the amended project which may intersect the water table have been identified and are discussed in **Section 5**.

4.1.2 Clarifications to the assessment of potential construction impacts

Consolidation

As outlined in **Section 4.1.1**, aquifers are not expected to be present in the upper groundwater systems in the vicinity of the project's vertical extent.

Section 5.1.2 of Appendix N of the EIS outlined that 'there is a potential for the surcharge loading associated with fill placement and the resulting increase in effective stress to cause short-term increases to groundwater levels in areas of fill placement, and/or permanent increases to groundwater levels if the increased stress permanently alters the hydraulic conductivity of the underlying water-bearing ground. This risk is applicable to relatively soft soils and is not expected to occur in areas where the water table lies within the rock'.

Borehole Standard Penetration Test (SPT) data indicates alluvial material is generally sufficiently stiff/dense to circumvent groundwater level impacts due to consolidation. However, it is noted that relatively softer material was observed at Kemps Creek. Bridges are proposed at the major creeks, including Kemps Creek. Consolidation of alluvial material will not occur underneath bridges as such areas will not be filled.

Potential increases in groundwater levels due to surcharge loading, if any, are expected to be minimal and limited to areas in the vicinity of fill placement.

Dewatering

Dewatering is not anticipated across the entire amended project area. It is only anticipated at the western cut, plus two additional road cuttings (see **Section 5.1.1**) associated with the proposed design changes.

Potential impacts to GDEs

Appendix N of the EIS stated that 'Appendix 2 of the water sharing plan legislation (NSW Government 2012) indicated that no High Priority GDEs (karst and wetlands) are mapped within approximately 10 kilometres of the study area'.

With regards to potential non-High Priority GDEs, which are mapped (BOM's GDE Atlas) within the study area and shown in the EIS, generally in the region of the project's major creek crossings, potential groundwater level impacts to the GDEs due to compaction are considered unlikely. Potential increases in groundwater levels due to surcharge loading, if any, are expected to be very small, and limited to areas in the vicinity of fill placement.

Drawdown from the western cut is highly unlikely to impact GDEs. Section 5.1.2 of Appendix N of the EIS indicates that the nearest mapped potential GDE to the Western Cut is about 240 metres away from the cut, which is outside the calculated extent of groundwater level reduction of about 60 metres.

Drawdown at GDEs due to the two additional cuts associated with the amended project is assessed in **Section 5.1.3**.

4.1.3 Clarification to the environmental management measures

Maximum predicted drawdowns associated with road cuttings which may intersect the water table are small in height and areal extent (see **Section 5.1.1**).

Notwithstanding this, as these are the areas where the project is most likely to directly interact with groundwater, specific groundwater monitoring for these areas will be carried out as outlined in **Section 6**. The monitoring measures will enable verification of the predicted impacts.

Replacement monitoring bores

A groundwater monitoring program is provided in Section 7.2 of Appendix N of the EIS. The program indicates that bores BH104, BH107 and BH112 will require replacement during the construction period.

Groundwater monitoring locations for the baseline, construction and operational phases are clarified in **Section 7**.

5. Assessment of potential impacts

This section provides an assessment of the potential groundwater impacts that may result due to the construction and operation of the amended project. The assessment of potential impacts described in this section relates to both options described in **Section 1** unless stated otherwise.

5.1 Construction impacts

The groundwater quality and hydrology assessment undertaken as part of the EIS assessed the potential construction impacts on the following:

- Groundwater inflows – **Section 5.1.1**
- Groundwater levels – **Section 5.1.2**
- Groundwater quality
- Groundwater dependent ecosystems – **Section 5.1.3**
- Groundwater bores – **Section 5.1.4**
- Surface water-groundwater interactions
- Surrounding land uses
- Groundwater take and licensing – **Section 5.1.5**
- Soil and groundwater salinity
- Groundwater contamination – **Section 5.1.6**
- Utilities.

Where the amended project may result in changed construction impacts, this is detailed in the sections listed above. The remaining were also assessed for the amended project. However, as no changes are expected compared to the impacts documented in the EIS, the potential construction impacts are not repeated in this memo. These impacts are described int Section 7.10.4 of the EIS.

The assessment of impacts is based on the amended construction footprint, shown in **Figure 1-2**.

5.1.1 Groundwater inflows

Potential groundwater inflow zones

The EIS identified one area of road cutting likely to intersect the water table based on a review of maximum monitored groundwater levels relative to the road design levels (see Section 7.10.4 of the EIS). This cutting is known as the western cut (see **Figure 5-1**). Groundwater impacts associated with this cut that were discussed in the EIS would not change as a result of the amended project.

The amended project would result in two additional areas of road cuttings that may potentially intersect the water table. Both areas are in the vicinity of the Western Sydney International Airport interchange and are a result of the proposed lowering of this intersection (see **Section 3.3** of the amendment report). These cuts are hereafter referred to as the following:

- Airport interchange northern cut
  - The minimum amended project finished design level is about 57 metres AHD, which is lower than the EIS design level at this location (about 66 metres AHD) by about nine metres AHD
  - The amended project design level is about four metres lower than the maximum monitored groundwater level at BH117 (60.79 metres AHD), which is located about 400 metres west of the centre of the cut and about 100 metres west of the cut's western extent
  - A water table penetration depth of four metres was adopted for assessment as a result of the above
  - An area of 60,000 square metres was used for groundwater inflow estimation purposes; this is conservative as it represents the entire cutting area, including areas where the cut depth is less than the maximum cut depth
- Airport interchange southern cut
  - The minimum amended project finished design level is about 60 metres AHD, which is lower than the EIS design level at this location of about 62 metres AHD
  - The nearest groundwater monitoring bore BH119, located approximately 400 metres south of the cut's southern extent, recorded a maximum monitored groundwater level of 53.32 metres AHD (0.68 metres below ground level (BGL)); this bore is monitoring a perched local groundwater system as evidenced by BH120
  - BH120 was drilled close to BH119, which was 3.7 metres depth and was unsaturated
  - Rock was identified at 3.7 metres depth therefore rock coring was commenced at 3.7 metres depth. Consequently, water could no longer be observed
  - Based on an assumed existing conditions groundwater depth of four metres BGL and a maximum cut depth of approximately eight metres, a water table penetration depth of four metres was adopted for assessment

- The groundwater depth of four metres below ground level was adopted based on the minimum monitored depth to groundwater of 4.26 metres BGL that was observed at groundwater monitoring bore BH117, located north of the cut
- An area of 30,000 square metres was used for groundwater inflow estimation purposes; this is conservative as it represents the entire cutting area, including areas where the cut depth is less than the maximum cut depth.

The locations of these areas of cut are shown in **Figure 5-1**.

It is noted that installation of supplementary groundwater monitoring bores in the area of both airport interchange cuts would be undertaken following project approval, at detailed design stage, to better understand groundwater depths and levels (and groundwater quality) in these areas. However, due to the low risks and conservatism built into the assessment methodology, installing supplementary monitoring bores is not considered necessary for the purpose of groundwater impact assessment for the amended project. Installation of supplementary groundwater monitoring bores has been included as a mitigation measure (**Section 6**).

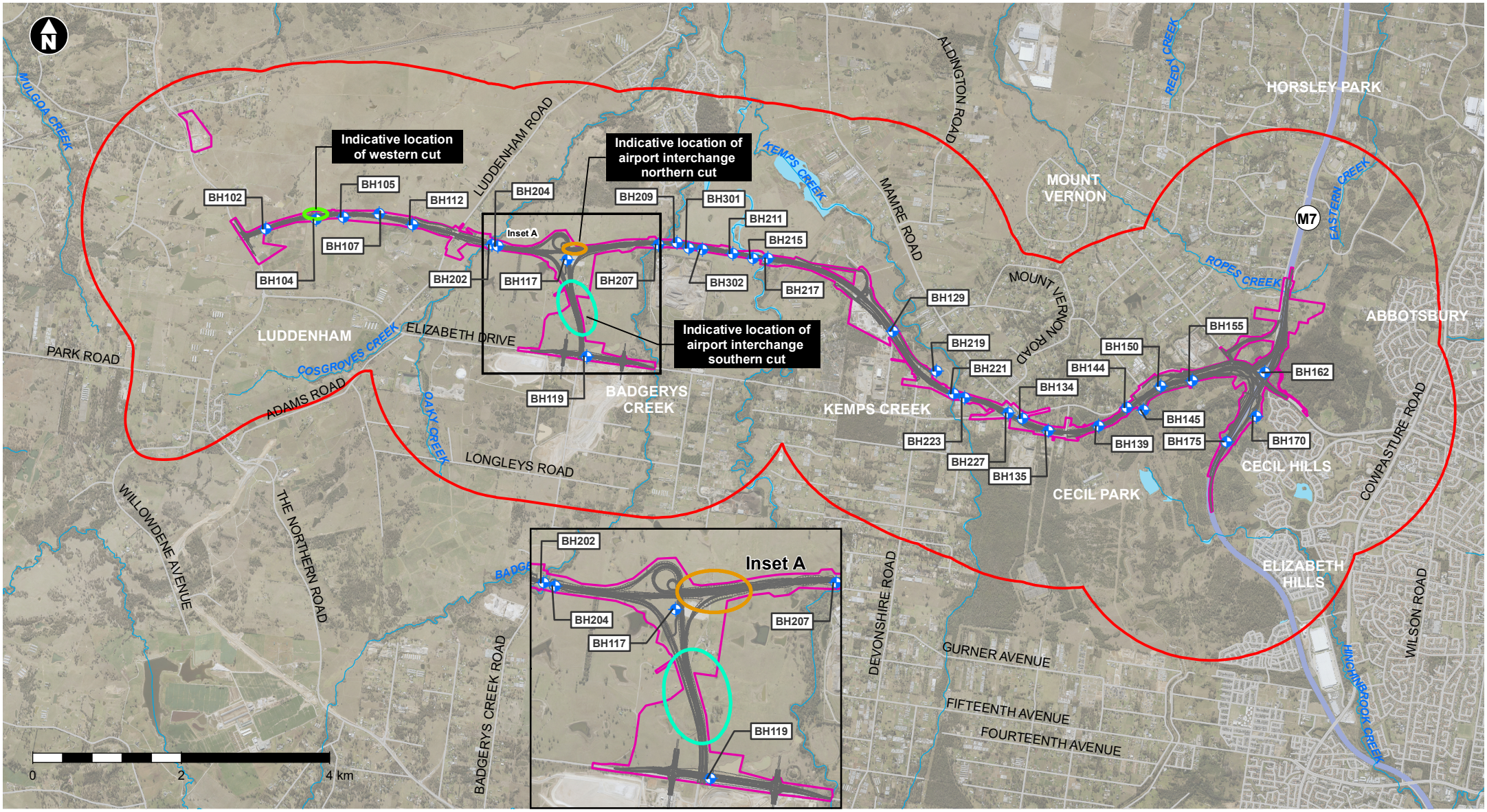
It should be noted that project cuts in general are unlikely to be near 'gullies' or 'rivers'. Such areas would generally be filled (or spanned by bridges) as opposed to cut, as is demonstrated by the hydrogeological cross section (see **Figure 3-1**).

Estimated groundwater inflows

Estimated groundwater inflow rates for the airport interchange northern and southern cuts are summarised **Table 5-1**. The estimated areal groundwater level drawdown extent (that is, the maximum lateral distance that drawdown is predicted to propagate to, measured from the cut face) due to these cuts is also summarised in this table. Estimated groundwater inflow rates to the western cut are covered in Section 5.1.1 of Appendix N of the EIS and **Table 5-2**.

The range of groundwater inflow rate estimates in **Table 5-1** are due to the range of adopted hydraulic conductivity values that were adopted to account for uncertainty and incorporate sensitivity analysis into the assessment, and due to different adopted times till equilibrium and groundwater level drawdown extents from the cuts (this distance controls hydraulic gradient to cut and therefore influences the flow rate). The three different hydraulic conductivity values were included in the groundwater inflow calculations:

- The project's maximum Bringelly Shale hydraulic conductivity estimate from slug tests (0.005 meters per day)
- Upper literature (Hewitt, 2005) bulk value for weathered Wianamatta Group Shale hydraulic conductivity (0.09 meters per day)
- Mid-range literature (Hewitt, 2005) bulk value for weathered Wianamatta Group Shale hydraulic conductivity (0.04 meters per day.



The amended project (Elizabeth Drive connection)

Waterways

Motorway

Main roads

Project groundwater monitoring bores

Groundwater assessment study area

The amended project construction footprint

Indicative location of western cut

Indicative airport interchange northern cut

Indicative airport interchange southern cut

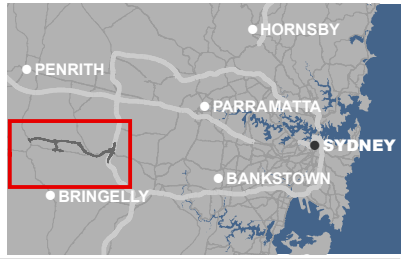


Figure 5-1 Indicative location of cuts likely to intersect the water table

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Table 5-1 Estimated groundwater inflow and groundwater level drawdown extent

Adopted hydraulic conductivity (m/d)	Adopted time to equilibrium (years)	Estimated groundwater inflow rate (kL/day)	Estimated groundwater inflow rate (ML/year)	Estimated groundwater level drawdown extent from cut (m)
Airport interchange Northern cut				
0.04	1	5.14	1.88	66
0.04	5	2.76	1.01	148
0.09	1	8.36	3.05	99
0.09	5	4.72	1.72	222
0.005	1	1.61	0.59	23
0.005	5	0.78	0.29	52
Airport interchange Southern cut				
0.04	1	3.89	1.42	66
0.04	5	2.18	0.80	148
0.09	1	6.45	2.36	99
0.09	5	3.82	1.39	222
0.005	1	1.17	0.43	23
0.005	5	0.59	0.21	52

For the airport interchange northern cut, the estimated groundwater inflow rate ranged from 0.8 to 8.4 kilolitres per day. The probable inflow rate is anticipated to be in the range of 0.8 to 1.6 kilolitres per day, which is based on the scenario that used project specific hydraulic conductivity testing values. Most or all the groundwater inflow is anticipated to be evaporated, even for the scenario with the highest inflow rate. The estimated groundwater level drawdown areal extent (that is, the distance from cut to the edge of drawdown) ranged from 23 to 222 metres.

For the airport interchange southern cut, the estimated groundwater inflow rate ranged from 0.6 to 6.5 kilolitres per day. The probable inflow rate is anticipated to be in the range of 0.6 to 1.2 kilolitres per day, which is based on the scenario that used project specific hydraulic conductivity testing values. Most or all the groundwater inflow is anticipated to be evaporated, even for the scenario with the highest inflow rate. The estimated groundwater level drawdown areal extent ranged from 23 to 222 metres.

The entire range of estimated groundwater inflow rates are considered low and implications are assessed in the following sections.

5.1.2 Groundwater levels

Maximum groundwater level change due to road cuttings intersecting the water table is about four metres at both the airport interchange northern and southern cuts, with a maximum areal drawdown extent of about 220 metres.

The magnitude of potential drawdown associated with the two additional project cuts that may intersect the water table is sufficiently small such that:

- Regional groundwater drawdown will not occur
- Regional groundwater flows directions will not change
- Changes to groundwater system levels, if any, are anticipated to be highly localised to the project footprint and limited to the near surface groundwater systems.

The estimated changes to groundwater levels due to potential drawdown meet the minimal impact considerations outlined in the NSW Aquifer Interference Policy (DPI NOW, 2012) for GDEs (**Section 5.1.3**) and existing bores (**Section 5.1.4**). Potential impacts to groundwater are predicted to be minor and localised.

5.1.3 Groundwater dependent ecosystems

GDE mapping was provided in Figure 7-138, Section 7.10.3 of the EIS.

There are no mapped GDEs within the area of the estimated maximum drawdown areal extent for the airport interchange northern cut or airport interchange southern cut.

The nearest mapped GDE to the airport interchange northern cut is Badgerys Creek riparian zone. This is approximately 620 metres east of the cut. The nearest mapped GDE to the airport interchange southern cut is Badgerys Creek riparian zone, which is approximately 690 metres east of the cut.

Given that the estimated maximum drawdown areal extent for the airport interchange northern cut or airport interchange southern cut does not encroach upon areas of mapped GDEs, the estimated changes to groundwater levels due to potential drawdown meet the minimal impact considerations outlined in the NSW Aquifer Interference Policy (DPI NOW, 2012) for GDEs.

5.1.4 Groundwater bores

The location of existing non-project groundwater bores is provided in Figure 7-138, Section 7.10.3 of the EIS.

There are no existing licensed bores within the area of the maximum drawdown areal extent for the airport interchange northern and southern cuts.

The nearest existing licensed bore to the airport interchange northern cut is located about 450 metres east-south-east of the cut while the nearest existing licensed bore to the airport interchange southern cut is located about 800 metres east of the cut.

The estimated changes to groundwater levels due to potential drawdown meet the minimal impact considerations outlined in the NSW Aquifer Interference Policy (DPI NOW, 2012) for bores.

5.1.5 Groundwater take and licensing

Permanent dewatering in the form of seepage collection from the western cut and airport interchange northern and southern cuts would ordinarily require a water use approval, a water supply work approval and a water access license (WAL). If the dewatering was temporary and occurred only during construction, then ordinarily a water supply work approval would be required. However, as discussed in Section 2.2.1 of EIS, the project is exempt from the need for water use approval, a water supply work approval and a WAL.

For the purpose of assigning a volume for groundwater accounting, groundwater take from the western cut and airport interchange northern and southern cuts is summarised in **Table 5-2** for the amended project. the table presents the maximum estimated groundwater inflow for each groundwater inflow area. Therefore, the inflow volumes are considered conservative.

Table 5-2 Estimated groundwater take for amended project

Road cutting area	Maximum estimated groundwater inflow rate (kL/day)	Maximum estimated groundwater inflow rate (ML/yr)
Western cut	6.75	2.46
Airport interchange northern cut	8.36	3.05
Airport interchange southern cut	6.45	2.36
Maximum total inflow volume = 7.87 ML/yr		

5.1.6 Groundwater contamination and discharge

Discharge of groundwater to surface water systems

As presented in Section 7.10.4 of the EIS, discharging potential groundwater inflows from the western cut was assessed as unlikely to impact sensitive receiving environments. This conclusion was made because the volumes of groundwater drained and discharged from the western cut are estimated to be negligible, with substantial proportions of the discharge expected to evaporate. The conclusion was also made based on groundwater quality laboratory analysis results.

Discharging potential groundwater inflows from the airport interchange northern and southern cuts to receiving environments (eg surface water systems) could potentially lead to water quality impacts if the groundwater water quality is poorer relative to the receiving environment water quality, and if the discharge rates are high and unmanaged.

There is currently no groundwater water quality data for the areas of the airport interchange northern cut and airport interchange southern cut. However, potential discharge of groundwater inflows from these cuts is not anticipated to result in adverse impacts to the receiving environments because the estimated inflow rates are very low. The maximum estimated discharge rate from the airport interchange northern and southern cuts is about 0.1 litres per second at each cut. The estimated inflow rates based on project hydraulic conductivity testing data are only about ten per cent (i.e. about 0.01 litres per second from each cut) of the estimated maximum inflow rate. The inflow rate estimates which are based on site hydraulic conductivity test data are considered more probable than the estimated maximum rates. The entire range of estimated groundwater inflow rates are very low and for all inflow rate scenarios would likely mostly or fully evaporate prior to being discharged.

Although impacts are not expected to sensitive receiving environments, groundwater monitoring (**Section 6**) would enable early detection of groundwater flows and groundwater quality to confirm this.

Groundwater contamination

Section 7.10.4 of the EIS identified the following potential groundwater contamination related risks during construction:

- Accidental spills or leakages of hazardous materials (such as fuels, lubricants and hydraulic oils) during the construction phase of the project have the potential to result in groundwater contamination (ie through runoff and subsequent recharge)
- If groundwater is contaminated, construction workers coming into contact with contaminated groundwater may be subjected to a human health risk
- Construction works may mobilise contaminants towards sensitive receiving environments. This could occur through discharge of groundwater from the cut below the water table (ie the western cut) or through bridge piling excavations, which may increase the vertical connectivity between local groundwater systems.

Section 7.10.4 of the EIS identified the above risks as low and noted that groundwater quality data from the groundwater monitoring bore (BH104) near the western cut does not indicate a risk to human health.

The above risks are applicable to the airport interchange northern and southern cuts and are also assessed as low. This is because estimated groundwater inflow rates to the airport interchange northern and southern cuts are very low and for all inflow rate scenarios would likely mostly or fully evaporate prior to being discharged. Additionally, groundwater monitoring (**Section 6**) would enable early detection of groundwater contamination and enable controls to be implemented, thereby reducing risks to human health and the environment.

5.2 Operational impacts

Except for utilities, the groundwater quality and hydrology assessment undertaken as part of the EIS assessed potential operational impacts on the same categories as that assessed for construction (**Section 5.1**).

For assessment of the amended project, potential operational impacts were assessed for all categories but are only documented in this memo for:

- Groundwater inflows – **Section 5.2.1**
- Groundwater levels – **Section 5.2.2**
- GDEs – **Section 5.2.3**
- Groundwater bores – **Section 5.2.4**
- Groundwater take and licensing – **Section 5.2.5**
- Groundwater contamination and discharge – **Section 5.2.6**.

The above operational impact categories are the same as those which were documented in the construction impact section (**Section 5.1**). These impact categories were primarily assessed and documented due to the airport interchange northern and southern cuts and their implications for groundwater.

Potential operational impacts on groundwater quality, surface water-groundwater interactions, surrounding land uses and soil and groundwater salinity were also assessed for the amended project. However, no changes to these are expected compared to the impacts documented in the EIS. Impacts to these categories have therefore not been assessed further in this memo.

5.2.1 Groundwater inflows

Groundwater inflows during operation are not anticipated to differ greatly from those likely to occur during construction (**Section 5.1.1**). Operational inflows into the cuts would likely be less than during construction, due to reduced hydraulic gradients.

5.2.2 Groundwater levels

Operational impacts to groundwater levels are not expected to differ from those which are likely to occur due to construction impacts (**Section 5.1.2**). No impacts to existing licensed bores, GDEs or regional groundwater systems are predicted because of potential groundwater level drawdown.

5.2.3 Groundwater dependent ecosystems

Operational impacts to GDEs are not expected to differ from those assess during the construction phase (**Section 5.1.3**). Impacts to GDEs are not anticipated.

5.2.4 Groundwater bores

Operational impacts to existing groundwater bores are not expected to differ from those assess during the construction phase (**Section 5.1.4**). Impacts to existing bores are not anticipated.

5.2.5 Groundwater take and licensing

Groundwater take and licensing requirements during operation of the amended project are the same as that assessed for the construction phase (**Section 5.1.5**).

5.2.6 Groundwater contamination and discharge

Operational groundwater discharge impacts and contamination risks are not expected to differ from those which are likely to occur due to construction impacts (**Section 5.1.6**). Operational groundwater inflow rates into the cuts would be less than during construction due to reduced hydraulic gradients and therefore discharge volumes.

Adverse impacts to receiving environments due to potential operational groundwater discharge from the airport interchange northern cut and airport interchange southern cut are not anticipated to result in adverse impacts to the receiving environments.

As a result, groundwater impacts for the operation of the amended project are generally consistent with impacts described in the EIS. Whilst the proposed changes may lead to two additional areas of excavations that may be subjected to low rate groundwater inflows, potential impacts to groundwater are predicted to be minor and localised

5.3 Cumulative impacts

The cumulative groundwater impacts would be likely to remain unchanged from the assessment documented in Section 7.10.5 of the EIS. This is because:

- All areas of identified road cuttings which may extend below the water table (ie western cut and airport interchange northern and southern cuts) are not expected to regionally impact groundwater flows and levels. Drawdown heights at these cuts and the expected areal drawdown extents are minimal and localised
- Groundwater quality impacts of the project are expected to be minimal and highly localised
- Given the project is unlikely to result in significant impacts to groundwater alone, it is therefore also not anticipated to result in cumulative impacts in conjunction with surrounding projects.

6. Revised environmental management measures

Groundwater impacts associated with the amended project are generally consistent with impacts described in the EIS and would therefore be managed through the implementation of the proposed management measures described in Chapter 7 of the amendment report.

Groundwater related environmental management measures for the amended project are summarised in **Table 6-1**. Reference measures GW03 and GW04 are new additions and were not included in the EIS environmental management measures for groundwater. Remaining reference measures in **Table 6-1** are as per the EIS.

Table 6-1 Environmental management measures (groundwater quality and hydrology)

Impact	Reference	Environmental management measure	Responsibility	Timing
Impacts on groundwater quality and flows	GW01	Groundwater monitoring will be carried out as part of the construction water quality monitoring program for the project. The groundwater monitoring will be based on the water quality monitoring methodology, water quality indicators and the monitoring locations shown in Appendix N of the EIS **and Table 7-1 in this memo**. Baseline groundwater monitoring will be carried out at least monthly for at least six months before construction. Monitoring will also be carried out at least monthly during construction and will continue for at least six months of operation to verify that there are no groundwater impacts, and that management measures are adequate.	TfNSW / Contractor	Prior to construction, and during construction
Alteration of groundwater flows and levels	GW02	Potential impacts on groundwater flows will be reconsidered as the detailed design for the project progresses, particularly in relation to the project's vertical alignment and extent of road cuttings. The aim of this will be to ensure that the groundwater controls proposed for the design as set out in this document would remain effective in mitigating groundwater impacts. In the instance that, during detailed design it cannot be demonstrated that the groundwater controls would be effective in mitigating potential impacts, or if observed groundwater inflow rates into the western cut **or airport interchange northern and southern cuts** are higher than estimated, additional measures will be implemented to minimise potential impacts to groundwater.	Contractor	Detailed design
	GW03	**Installation of supplementary groundwater monitoring bores in the area of both airport interchange cuts will be undertaken following project**	**Contractor**	**Detailed design**

Impact	Reference	Environmental management measure	Responsibility	Timing
		approval at detailed design stage, to better understand groundwater depths and levels, and groundwater quality in these areas, and confirm that the project would not have an impact on sensitive receiving environments.		
	GW04	**Groundwater will be monitored at the airport interchange northern and southern cuts and the western cut during the construction phase and operational phase as outlined in Table 7-1 of this document. The groundwater indicators to be monitored will be as per Section 7.2.5 of Appendix N of the EIS.** **Groundwater inflows to the airport interchange northern and southern cuts and the western cut are to be observed by the groundwater monitoring contractor during the construction and operational phases at monthly intervals. As part of observing the airport interchange northern and southern cuts and the western cut groundwater inflows, the groundwater monitoring contractor is to estimate the groundwater inflow rates and note the areas where groundwater inflow is occurring.** **During construction, if groundwater inflows are observed from the airport interchange northern and southern cuts and the western cut, the groundwater quality from the cut is to be sampled.** **Operational phase groundwater quality sampling, including the quality sampling of the airport interchange northern and southern cuts and the western cut inflows, is to occur at a monthly interval for at least 6 months.**	**Contractor**	**Construction and operation**

7. Groundwater monitoring locations for baseline, construction and operational phases

A groundwater monitoring program was described in Section 7.10.6 of the EIS. Updated groundwater monitoring locations, for the baseline, construction and operational phases of the amended project are outlined in **Table 7-1**.

Table 7-1 Groundwater monitoring locations for the baseline, construction and operational phases

Monitoring type	Monitoring locations		
	Baseline phase	Construction phase	Operational phase
Groundwater quality monitoring	EIS dataset locations (BH104, BH112, BH145, BH202, BH207, BH209, BH217, BH223, BH301, BH302), plus supplementary post-EIS monitoring at BH104, BH107, BH112 and BH145	BH104, BH107, BH112 and BH145. However, at some point during construction, bores BH104, BH107, BH112 will be decommissioned and replaced with newly drilled and constructed bores. Once replaced, groundwater quality monitoring is to be undertaken at the replacement bores, plus continue at BH145. Western cut, plus airport interchange northern cut and airport interchange southern cut	BH145, plus the bores that replace BH104, BH107, BH112. Western cut, plus airport interchange northern cut and airport interchange southern cut
Groundwater level monitoring	All project bores (except BH301 and BH302, which were installed to monitor gas)	All project bores (except BH301 and BH302, which were installed to monitor gas) until the bores get progressively decommissioned during construction. All bores except BH145 will be decommissioned. Bores BH104, BH107, BH112 will replaced with newly drilled and constructed bores. Once replaced, groundwater level monitoring is to be undertaken at the replacement bores, plus continue BH145	BH145, plus the bores that replace BH104, BH107, BH112.
Groundwater inflows (observation of inflow rates and areas of inflow)	Not applicable	Western Cut, plus airport interchange northern cut and airport interchange southern cut	Western Cut, plus airport interchange northern cut and airport interchange southern cut

8. Conclusion

This supplementary groundwater assessment for the amended project determined the following:

- Two additional road cuttings may intersect the water table in addition to the western cut area identified in the EIS – the airport interchange northern cut and the airport interchange southern cut; both are located at the proposed lowering of the Western Sydney International Airport interchange
- Groundwater impacts for construction and operational phases of the amended project are generally consistent with impacts described in the EIS. Whilst the proposed changes may lead to two additional areas of excavations that may be subjected to low rate groundwater inflows, potential impacts to groundwater are predicted to be minor and localised
- The estimated groundwater level drawdown impacts during construction and operational phases of the project meet the minimal impact considerations outlined in the NSW Aquifer Interference Policy (DPI NOW, 2012). The magnitude of drawdown associated with areas of road cutting that may experience groundwater inflows is sufficiently small that:
  - Existing surrounding licensed bores are unlikely to be impacted
  - Regional groundwater drawdown will not occur
  - Regional groundwater flows directions will not change
  - Changes to groundwater systems, if any, are anticipated to be highly localised to the project footprint and limited to the near surface groundwater systems.

It is concluded that the amended project would not lead to unacceptable groundwater impacts during either construction or operational phases of the project. This conclusion is based on the determination of potential impacts to groundwater during both construction and operational stages, including potential cumulative impacts, of both options 1 and 2 of the amended project. With the application of the safeguards outlined in the EIS and in **Section 6**, it is anticipated that groundwater impacts from the amended project would be effectively managed.

9. References

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