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Sydney Metro – Western Sydney Airport

Chapter 15
Groundwater and geology

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15 Groundwater and geology

This chapter provides a summary of the assessment of the impact of potential changes to the groundwater and geological environment (i.e. groundwater inflows, groundwater quality and ground movement) during construction and operation of the project. The full groundwater assessment is provided in Technical Paper 7 (Groundwater).

15.1 Overview

To limit potential groundwater inflows and groundwater drawdown, the metro tunnels would be tanked (designed to prevent the inflow of groundwater, typically using concrete lining and waterproofing membranes). Similarly, the cross passages and the station structures would be tanked. As a result, limited change is expected to groundwater levels.

During construction, groundwater drawdown may occur at locations with drained excavations, such as at St Marys, Airport Terminal and the Aerotropolis Core. These excavations would allow groundwater ingress to occur which would result in a lowering of the groundwater levels in the adjacent soils and bedrock. Water levels at those locations which were drained during construction would recover during the operational phase.

Long term changes in water levels are anticipated to be relatively small and within the range of seasonal and long-term groundwater fluctuation, and localised around the structures. Detailed hydrogeological and geotechnical models would be developed and progressively updated during design development and groundwater monitoring would be carried out to confirm the predictions.

15.2 Legislative and policy context

The relevant legislation, policies and assessment guidelines considered in the preparation of the groundwater and geology impact assessment are listed for on-airport and off-airport in Section 15.2.1 and Section 15.2.2 respectively.

15.2.1 Off-airport

A list of the relevant off-airport legislation, assessment guidelines, standard and policies is provided below:

- *Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
- *National Water Quality Management Strategy 2018*
- *Water Management Act 2000* (NSW)
- *Aquifer Interference Policy* (AIP) (Department of Primary Industries, 2012a)
- *State Groundwater Policy Framework Document 1997* (including the Groundwater Quantity Management Policy, the Groundwater Quality Protection Policy and the Groundwater Dependent Ecosystems Policy)
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems 2012* (Department of Primary Industries, 2012b).

15.2.2 On-airport

A list of the relevant on-airport legislation is provided below:

- *Airports Act 1996* (Cth)
- *Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
- Airports (Environmental Protection) Regulations 1997 (Airports Regulations).

15.3 Assessment approach

Due to the nature of potential groundwater and geology impacts, the assessment approach was considered at both a regional level and, with respect to specific off-airport and on-airport impacts, at a more localised level. This assessment approach is summarised below. Further detail regarding the assessment methodology and key considerations of the groundwater assessment is provided in Technical Paper 7 (Groundwater).

15.3.1 Overview

Groundwater

Study area

For the purposes of the groundwater assessment, the study area consisted of the project alignment plus a two-kilometre radius around the project alignment.

The assessment considered key groundwater attributes and features of the environment within the study area in order to develop conceptual models of the baseline groundwater environment which applies to both on-airport and off-airport environments. The regional geological and hydrological setting was used to inform impact assessments for both off-airport and on-airport environments.

Geotechnical investigations

A preliminary phase of geotechnical investigation was undertaken at key locations as part of the design development process. This included hydrogeological testing and monitoring undertaken as part of the project. The results of these investigations are provided in greater detail in Technical Paper 7 (Groundwater).

In addition to the geotechnical investigations, groundwater monitoring data from within the study area was obtained from other historic geotechnical investigations, including investigations at Western Sydney International.

A larger second phase of geotechnical investigations is currently ongoing. The scope includes drilling geotechnical boreholes across the alignment with hydrogeological monitoring and testing at a number of locations identified in Appendix A of Technical Paper 7 (Groundwater).

Aquifer Interference Policy 2012 requirements

The AIP requires that potential impacts on groundwater sources, including their users and groundwater dependent ecosystems, be assessed against the minimal impact considerations. If the predicted impacts are less than the Level 1 minimal considerations, then the impacts of the project are acceptable. The key criteria/requirements of the AIP relate to elements such as; impacts to the existing water table, changes to water pressure, and changes to water quality. The criteria outlined in the AIP provide an appropriate reference to assess the impact of the project on groundwater. The impact of the project in relation to these criteria is addressed in Section 15.6.4.

Ground movement

Ground movement refers to a localised lowering of the ground level typically associated with either the release or redistribution of stress in rock formations during tunnelling and excavation, or from ground consolidation following the drawdown of groundwater (during construction and/or operation). Movement caused by stress redistribution in rock generally occurs shortly after excavation, while consolidation settlement from groundwater drawdown can occur over a longer period of time.

Assessment has been carried out as part of the design process to identify buildings and structures, road and rail infrastructure and utility assets at risk of potential ground movement associated with the project. This included assessment of movement associated with groundwater drawdown as well as excavation for tunnelling, cut and cover stations and service facility shafts associated with the project.

Groundwater drawdown is likely to be an issue for structures such as cut and cover station boxes which are drained (un-tanked) during the construction phase. Groundwater drawdown during operation is not likely to be a substantial issue and would be limited to drained structures and would occur over a longer period of time.

The ground movement assessment identified properties/buildings, road and rail infrastructure and utility assets within areas potentially subject to ground movement as a result of the project. The ground movement assessment is undertaken in a phased manner to minimise the number of structures or assets requiring a detailed assessment. At this stage of the project, a preliminary assessment has been undertaken for assets deemed to be critical along the alignment and within a pre-defined zone of influence of the ground movement.

The specific risk to buildings and structures due to ground movement during construction depends on geotechnical conditions, relevant elements of the project design (such as depth of tunnelling, size and depth of station boxes and indicative construction methodology), distance from construction activities and building characteristics including condition and type of masonry.

For the preliminary assessment, the Rankin risk classification, has been adopted for the project. The criteria used are provided in Table 15-1.

Table 15-1 Ground movement risk levels (Rankin 1988)

Risk level	Description	Maximum slope of ground	Maximum settlement of building (mm)
1	*Negligible*: superficial damage unlikely	<1:500	<10
2	*Slight*: Possible superficial damage which is unlikely to have structure significance	1:500 to 1:200	10 to 50
3	*Moderate*: Expected superficial damage and possible structural damage to buildings, possible damage to relatively rigid pipelines	1:200 to 1:50	50 to 75
4	*High*: Expected structural damage to buildings. Expected damage to rigid pipelines, possible damage to other pipelines.	> 1:50	>75

These criteria specify the maximum settlement of the building and the maximum slope of the ground below building foundations for each risk level. Buildings and structures assessed as having a risk level of two or greater (slight, moderate or high risk) would be subject to more detailed assessment during design development.

As part of this detailed assessment appropriate criteria would be determined for ground movement, angular distortion, tensile strain and building damage depending on the type of building and structure and having regard to accepted industry practice. Appropriate criteria would also be determined for significant heritage items. Ground movement criteria for road and rail infrastructure and utility assets would be determined in consultation with the relevant infrastructure and asset owners.

15.3.2 Off-airport

Assessment of potential groundwater impacts was undertaken through a process of qualitative and quantitative assessment. The assessment considered the regional geological and groundwater setting and a conceptual model was established to further investigate potential impacts on groundwater in the off-airport environment. A review of recent environmental impact assessments, including for the future M12 Motorway project, was also undertaken.

Two methods were used to evaluate potential changes to the groundwater levels for the project:

- simplified 2D numerical modelling assessment was undertaken across the project to estimate groundwater inflow and changes to groundwater level
- analytical element modelling was undertaken for Orchard Hills Station to supplement the numerical modelling across the project and to evaluate the potential for long term drawdown associated with the drained cutting south of the station.

The modelling outputs provide an understanding of groundwater impacts associated with construction and operation of the project. The outputs are used to determine the potential impacts on groundwater dependent ecosystems, groundwater users and the project (groundwater ingress). Further detail regarding the hydraulic modelling is provided in Section 3.6 of Technical Paper 7 (Groundwater).

Further geotechnical investigations have commenced, and groundwater monitoring data would be available to support further design development. Additional groundwater assessment would be undertaken during further design development to supplement the current investigations.

15.3.3 On-airport

The methodology for assessment of groundwater and geology impacts within the on-airport site was similar to that for the off-airport elements, with a focus on the potential impacts associated with the Airport Terminal Station and the proposed tunnel portal and cutting between Airport Business Park Station and Airport Terminal Station.

The *Western Sydney Airport – Environmental Impact Statement* (Department of Infrastructure and Regional Development, 2016b) included a detailed groundwater assessment. This information was reviewed for this assessment. As a result, there is more baseline groundwater information for the on-airport environment, allowing detailed cross-sectional groundwater modelling to be undertaken to assess the potential impacts associated with the project on-airport.

The cross-sectional modelling was undertaken at two locations perpendicular to the rail alignment:

- at Western International tunnel portal
- at Airport Terminal Station.

A series of conceptual groundwater models was used to estimate groundwater inflows and changes to groundwater levels associated with the project (on-airport). The model outputs are used to understand the potential impacts on groundwater dependent ecosystems, groundwater users and the project (groundwater ingress). Further detail regarding the modelling undertaken is provided in Section 3.6 of Technical Paper 7 (Groundwater).

15.4 Existing environment

A summary of the existing groundwater and geological environment for the project is presented below. Further detail regarding the existing groundwater and geological environment is provided in Section 4 of Technical Paper 7 (Groundwater).

15.4.1 Regional geology and groundwater context

Groundwater is relatively consistent across a regional scale and this section describes the regional geology and groundwater setting, which is applicable to both off-airport and on-airport environments.

Regional geology

The project is located within the Cumberland Basin, forming part of the Sydney Basin, which is the southernmost part of the Sydney-Bowen Basin, a major structural basin which extends from Durras Lake near Batemans Bay to central coastal Queensland. The Western Sydney area is characterised by the Middle Triassic-aged sedimentary rocks of the Wianamatta Group. The Wianamatta Group (from oldest to youngest) consists of the Ashfield Shale, the Minchinbury Sandstone and the Bringelly Shale. Only the Bringelly Shale is expected to be present within the study area.

The Bringelly Shale bedrock is overlain by Quaternary alluvial soils (younger sedimentary unit) in creek channels and older, historic riverbeds. The Quaternary alluvial deposits represent active and historical stream deposits and are associated with the active drainage channels in the area, including South Creek, Blaxland Creek, Cosgroves Creek and Badgerys Creek. The Quaternary alluvial deposits are variable in nature but were found to be predominantly cohesive, comprising silts and clays with fine to coarse sand and trace fine gravel.

In addition to these natural soils, fill is also likely to be encountered in some areas along the alignment, in particular around built up areas such as St Marys, and associated with existing infrastructure and around farm dams.

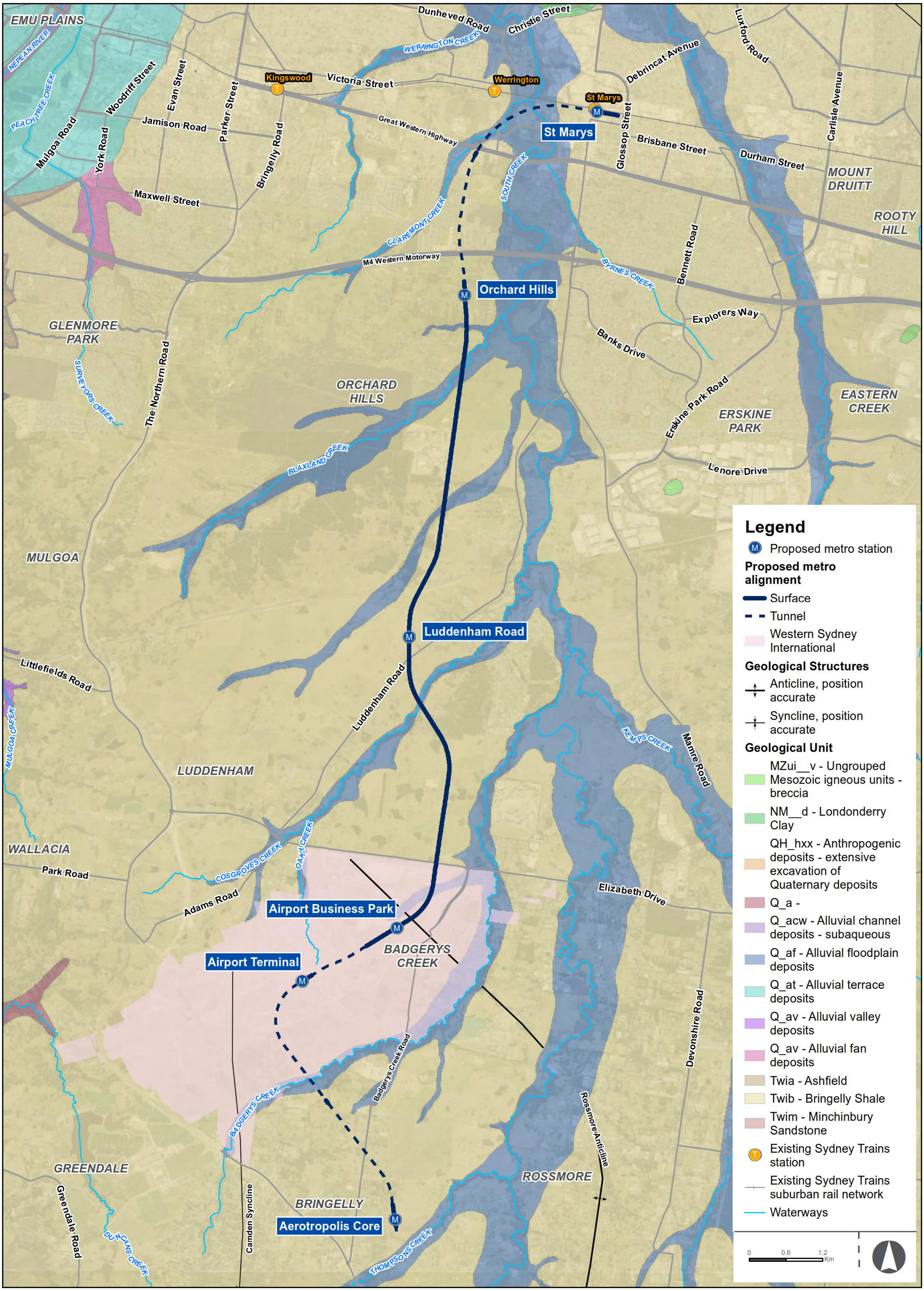
Regional groundwater setting

The groundwater quality and yield (amount able to be extracted) is variable, and dependent on the rock unit, with the Hawkesbury Sandstone providing abundant clean water and the Bringelly Shale providing small amounts of near saline water.

The Hawkesbury Sandstone aquifer is used for some irrigation and local water supply purposes, due to the water quality and the ability for the water to move (conductivity). This aquifer sits beneath the Bringelly Shale, which acts as a barrier between the aquifer and the surficial alluvial soils.

The bedrock units (Hawkesbury Sandstone and Bringelly Shale) form ‘heterogenous fractured rock aquifers’ where groundwater flow occurs within defects within the rock. The ability for water to move within the rock mass is dependent on the number and connectedness of the cracks and faults within the rock. In the Bringelly Shale, vertical movement of groundwater is restricted because of the subhorizontal rock bedding.

Groundwater within the Quaternary alluvial deposits is generally variable in flow, as a result of the mixed nature of the deposits. The aquifer has some connection to the groundwater systems within the bedrock, with creek lines acting either as discharge points for the aquifers or as sources of supplemental recharge into the underlying aquifers. Figure 15-1 provides an overview map of the surface geology for the project. Hawkesbury Sandstone is not shown as it is at depth.



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Regional geology of the study area

Figure 15-1

Indicative only, subject to design development

15.4.2 Off-airport

Groundwater levels

Groundwater in the off-airport environment was identified predominantly within the Bringelly Shale bedrock at varying depths along the project alignment. Table 15-2 provides a summary of groundwater levels at key locations along the off-airport sections of the project.

Table 15-2 Summary groundwater level information – off-airport

Location	Groundwater level (mbgl)	Groundwater elevation (m AHD)
St Marys Station	-1.7[1] to 7.7	26.7 to 36
Claremont Meadows services facility	Groundwater monitoring location installed, currently no data available	
Orchard Hills Station	4.1 to 5.7	36.3 to 38.1
Aerotropolis Core Station	1.8 to 5.0	57.6 to 67.3

Note 1: Rapid pressure response observed in VWP following extreme rainfall event on 10 February 2020. Water pressure observed above ground level for around 1.5 days. No similar response was observed in nearby groundwater standpipe.

In the off-airport areas of the project, geomorphological conditions are typically repetitive, consisting of a series of north-east to south-west oriented creek channels interspersed with broad hilly areas. Groundwater within each of these smaller catchment areas is likely to follow similar flow directions and gradients, following the topography of the land. Groundwater within the Bringelly Shale can therefore be expected to be nearest the surface close to creek lines, and deepest in topographically higher areas and near catchment watersheds.

Groundwater quality

Groundwater sampling results from the geotechnical investigations carried out for the project and from historical geotechnical investigation reports were used to assess groundwater quality. Groundwater testing was undertaken at five off-airport locations at St Marys Station, South Creek, Werrington, Gipps Street landfill and Orchard Hills Station as part of geotechnical investigations for the project. The groundwater quality test results are detailed in Section 4.3.2 and 4.4.2 of Technical Paper 7 (Groundwater).

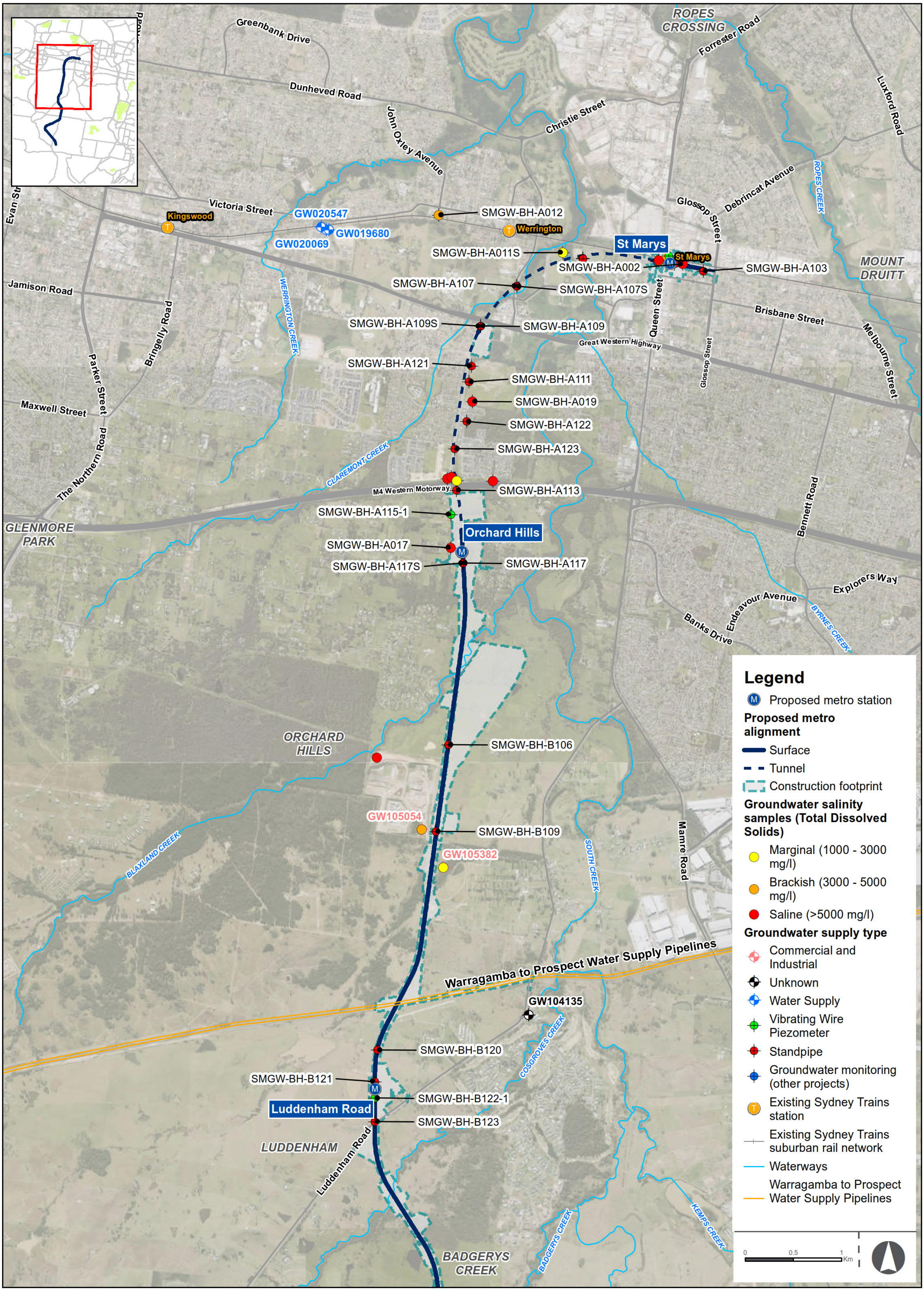
The results of groundwater quality testing indicate that groundwater across the project may be expected to have elevated salinity (electrical conductivity) and contain elevated concentrations of heavy metals and nutrient load. The pH of the groundwater in the region is observed to be generally acidic to neutral. The pH of groundwater samples ranged from 4.2 to 9.2 however most samples collected had a pH in the range of 5 to 7.5.

Elevated ammonia and phosphorous was observed in most samples and is likely due to the semi-rural setting of the study area. Farming practices introduce fertilisers and other organic material to the soils over a wide area, which can migrate into underlying groundwater. A range of elevated heavy metals were detected in the groundwater. Given the wide distribution of groundwater samples, it is unlikely that heavy metals within the groundwater are from a point source and could be naturally elevated.

Groundwater salinity as measured from groundwater samples shows a range from fresh (less than 1,000 milligrams per litre (mg/l)) to saline (greater than 5,000 mg/l). The maximum observed salinity was in alluvial deposits along Badgerys Creek south of Western Sydney International. This location corresponds to known locations of soil salinity.

Figure 15-2 shows the distribution of groundwater salinity across the project based on existing available information and geotechnical investigations carried out for the project.

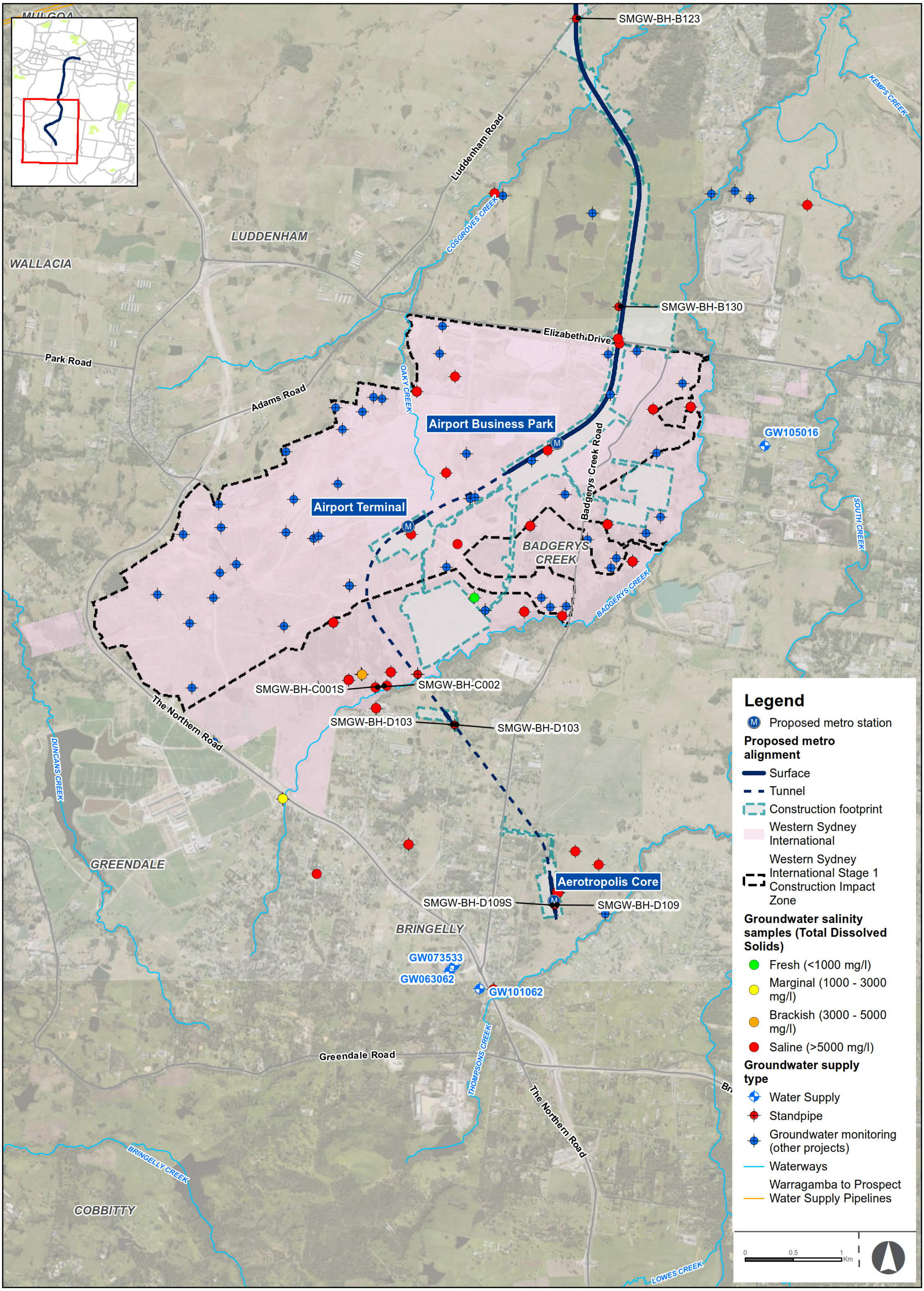
Most of the groundwater samples (85 per cent) are considered saline (greater than 5,000 mg/l). In about 50 per cent of the samples, the salinity is greater than the maximum that can be used for watering of livestock (about 13,000 mg/l).



Groundwater salinity and supply wells within the study area

Figure 15-2a

Indicative only, subject to design development



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Groundwater salinity and supply wells within the study area

Figure 15-2b

Indicative only, subject to design development

Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are defined as 'ecosystems that require access to groundwater to meet all or some of their water requirements to maintain their communities of plants and animals, ecological processes and ecosystem services' (Department of Planning, Industry and Environment, 2020).

Ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater may include native plant communities. GDEs which are reliant on the surface expressions of groundwater within the locality of the off-airport construction footprint (<10 km) include the South Creek and associated tributaries as well as other GDEs which are reliant on subsurface groundwater.

Further discussion on GDEs is provided in Chapter 11 (Biodiversity).

Groundwater users

There are 10 groundwater supply wells within the study area listed on the *National Groundwater Information System* (NGIS) (BoM, 2019). The majority of the bores are drilled very deep into the Hawksbury Sandstone unit to access the more readily available fresher water. The locations of the groundwater supply wells within the study area are shown in Figure 15-2.

15.4.3 On-airport

Groundwater level

A summary of the groundwater monitoring data within Western Sydney International is presented in Table 15-3.

Table 15-3 Summary groundwater level information – on-airport

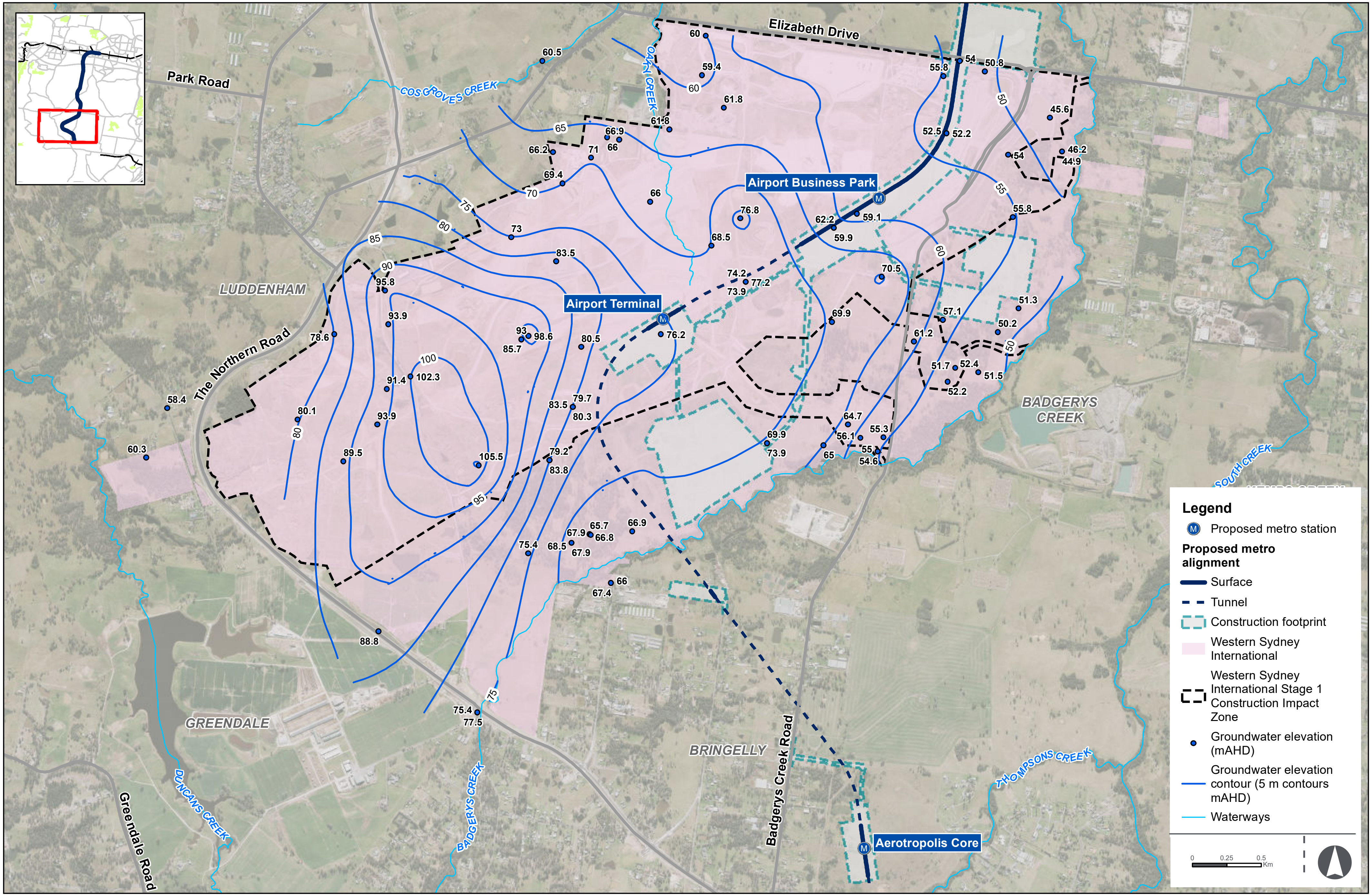
Location	Groundwater level (metres below existing ground level)	Groundwater level (relative to final surface level)	Groundwater elevation (mAHD)
Western Sydney International to Bringelly tunnel (within Western Sydney International)	2 to 9	2m to 11m below	67 to 80
Western Sydney International tunnel portal	0.5 to 3	3m below to 2m above[1]	57 to 67
Airport Terminal Station	0.5 to 3.5	8m to 9m below	74 to 76

Note: Areas of cut at Western Sydney International mean that existing groundwater levels are above the final surface level

Groundwater monitoring bores were installed during the groundwater assessment undertaken for the Western Sydney Airport – Environmental Impact Statement. The bores show that the groundwater gradients (i.e. the slope of the water table within the rock layers) within the Bringelly Shale appear to be relatively shallow, at around one per cent gradient. Flow directions are generally in a northerly and easterly direction towards Cosgroves Creek, and in a southerly and easterly direction towards Badgerys Creek and South Creek. To the west groundwater appears to flow westwards towards Duncans Creek.

Groundwater flow within the Bringelly Shale is anticipated to be slow and total flow rates are likely to be small due to the low hydraulic conductivity of the residual soils and Bringelly Shale bedrock.

Figure 15-3 shows relative groundwater levels at Western Sydney International. The contours indicate that groundwater broadly follows the existing topography of the site.



Western Sydney International Bringelly Shale groundwater contour plot

Figure 15-3

Groundwater quality

Contaminant testing of groundwater quality was undertaken at 15 sampling locations across Western Sydney International between April 2018 and April 2019. While none of the groundwater samples collected were located directly within the project alignment, it is reasonable to infer a consistency of conditions across the site, so that groundwater quality at the sampling locations is likely to be consistent with groundwater that would be encountered during construction and operation of the project. The groundwater quality test results are detailed in Section 4.3.2 and 4.4.2 of Technical Paper 7 (Groundwater).

The testing identified trace metals, nutrient parameters organic hydrocarbons and pesticides; however, these were not consistently detected across the monitoring period. In addition, the results showed that the groundwater has background concentrations of copper, lead, nickel and zinc above the 95 per cent ANZECC freshwater criteria.

Similar to the off-airport environment, the elevated levels of heavy metals, ammonia and nitrogen are likely attributable to historic agricultural land use or natural background concentrations rather than a specific point source of contamination.

Groundwater salinity as measured by the electrical conductivity for the on-airport site varied between 600 and 41,000 µS/cm, mostly well above the criteria for lowland rivers. Around half of the samples tested for ammonia exceeded the 95 per cent guideline value for freshwater ecosystems. Around half the samples also had concentrations of nitrogen in excess of the threshold for lowland rivers.

Groundwater dependent ecosystems

Vegetation mapping indicates that the predominant vegetation communities on Western Sydney International are Cumberland Plain Woodland and Cumberland River Flat Forest (both of which are identified as potential GDEs). The River Flat Forest is located adjacent to the main drainage channels of Badgerys Creek as well as other minor creek lines within Western Sydney International. Reliance on groundwater in these areas is likely to be from alluvial groundwater, connected to creek flow. A small area of Shale Gravel Transition Forest is located to the far east of the airport site.
Native vegetation would be cleared from areas within the Western Sydney International Stage 1 Construction Impact Zone.

No other GDEs (including Ramsar wetlands or aquatic, subterranean or wetland GDEs) were identified within the on-airport site. Further discussion on GDEs is provided in Chapter 11 (Biodiversity).

Groundwater users

No existing registered groundwater users were identified within Western Sydney International.

15.5 Potential impacts – construction

This section presents the potential impacts of the project on the groundwater and geological environment that may occur during construction. The impact of groundwater drawdown on the potential migration of contamination is considered in Chapter 16 (Soils and contamination).

Potential impacts on the groundwater environment during the construction phase include:

- impacts on GDEs, water supply wells, creeks or other environmental receptors resulting from changes to groundwater level or flow. Further discussion on GDEs is provided in Chapter 11 (Biodiversity)
- impacts on groundwater quality due to contamination from release of chemicals used during construction activity and potential impacts on other connected environmental receptors
- impacts on groundwater quality due to exposure, storage and leaching of saline soils along the alignment
- impacts on buildings and infrastructure from ground movement related to groundwater drawdown and excavation during construction.

15.5.1 Off-airport

Hydrogeological conditions at each of the main project elements off-airport that are likely to interact with the groundwater environment are presented in Table 15-4 and provided in detail in Appendix A of Technical Paper 7 (Groundwater).

Table 15-4 Hydrogeological conditions at project elements – off-airport

Location / structure	Hydrogeological units	Anticipated groundwater level (metres below ground level)	Approximate maximum depth below groundwater level (m)
St Marys Station and crossover	Residual soil Bringelly Shale	2 to 7	About 15
St Marys to Orchard Hills tunnel	Bringelly Shale	0 to 6 (assumed)[1]	Up to about 25
Claremont Meadows service facility	Alluvium Residual soil Bringelly Shale	1 to 2	Up to 15
Orchard Hills tunnel portal and station	Residual soil Bringelly Shale	3 to 5	6 to 8
Cutting south of Orchard Hills Station	Residual soil Bringelly Shale	5 to 6	5 to 6
Western Sydney International to Bringelly tunnel (off-airport)	Bringelly Shale	0 to 6 (assumed)[1]	Up to about 25
Bringelly service facility	Residual soil Bringelly Shale	3 to 4 (assumed)[1]	About 20
Aerotropolis Core Station	Residual soil Bringelly Shale	4 to 5	About 15

Note 1: No data currently available for this site.

Changes to groundwater level

The assessment focuses on sources/areas where it has been identified that there would likely be a higher potential for groundwater impact, such as where tunnel and station box excavations are proposed. Areas where limited impacts on groundwater were anticipated, such as sections of viaduct and surface track infrastructure, were not considered in detail.

Rail tunnels

Changes to groundwater levels due to construction of the tunnels and associated cross-passages would be minor and associated with short-term groundwater inflows during tunnel excavation.

Groundwater inflow may occur during construction in the short period between excavation at the tunnel face and installation of the tunnel lining. Once the lining is in place, the tunnel would be effectively waterproofed and groundwater inflow would cease.

Groundwater inflow to cross passage excavations could occur since they are constructed using traditional mining excavation methods. However, efforts to minimise groundwater inflow such as ground improvement are usually undertaken prior to excavation, to minimise the volume of groundwater entering the tunnel cross passages.

The magnitude of groundwater level change during excavation is expected to be small given that inflows would be localised and of short duration, and excavation would be within the Bringelly Shale, which has a low hydraulic conductivity.

St Marys Station and crossover

St Marys Station would consist of an underground cut-and-cover station which would require excavation to around 15 metres below the existing surface level. The station and crossover would be drained (un-tanked) during construction and undrained (tanked) in operation.

Changes to groundwater levels would occur during the construction of the cut and cover structure at St Marys Station. These changes would occur for the duration of the excavation period (up to about 18 to 24 months) until the permanent watertight station structure is in place.

The predicted changes to groundwater level during the construction of the station and crossover structure at St Marys is shown on Figure 15-4. Groundwater within the residual soils (if saturated) and the Bringelly Shale would be lowered surrounding the excavation. The point at which drawdown is expected to occur would be close to the base of the excavation.

The assessment indicates that a one metre drawdown (change in groundwater levels of one metre compared with baseline levels) would extend out from the excavation for about 340 metres. Although the contours are shown to extend out uniformly from the excavation, it is likely that there would be variation in the drawdown owing to changes in the hydrogeological conditions.

Claremont Meadows services facility

Construction of the Claremont Meadows services facility at the corner of Gipps Street and Great Western Highway is not anticipated to result in large volumes of groundwater inflow since the facility would be undrained (tanked) during construction and in operation. There may be some minor seepage into the base of the excavation which could lead to some depressurisation outside the waterproof retaining wall. However, this would only occur temporarily during excavation until the internal concrete structures are installed and waterproofed.

Due to its relatively small footprint, the magnitude of impact is likely to be minor and changes in groundwater levels are unlikely to occur outside of the excavation during the construction period.

Orchard Hills Station, tunnel portal and cutting

Orchard Hills Station would consist of a station in a cutting up to a maximum of 15 metres below the existing surface level. The tunnel portal and station would be undrained (tanked) during construction and in operation. The cutting south of the station would be drained (un-tanked) during construction and operation.

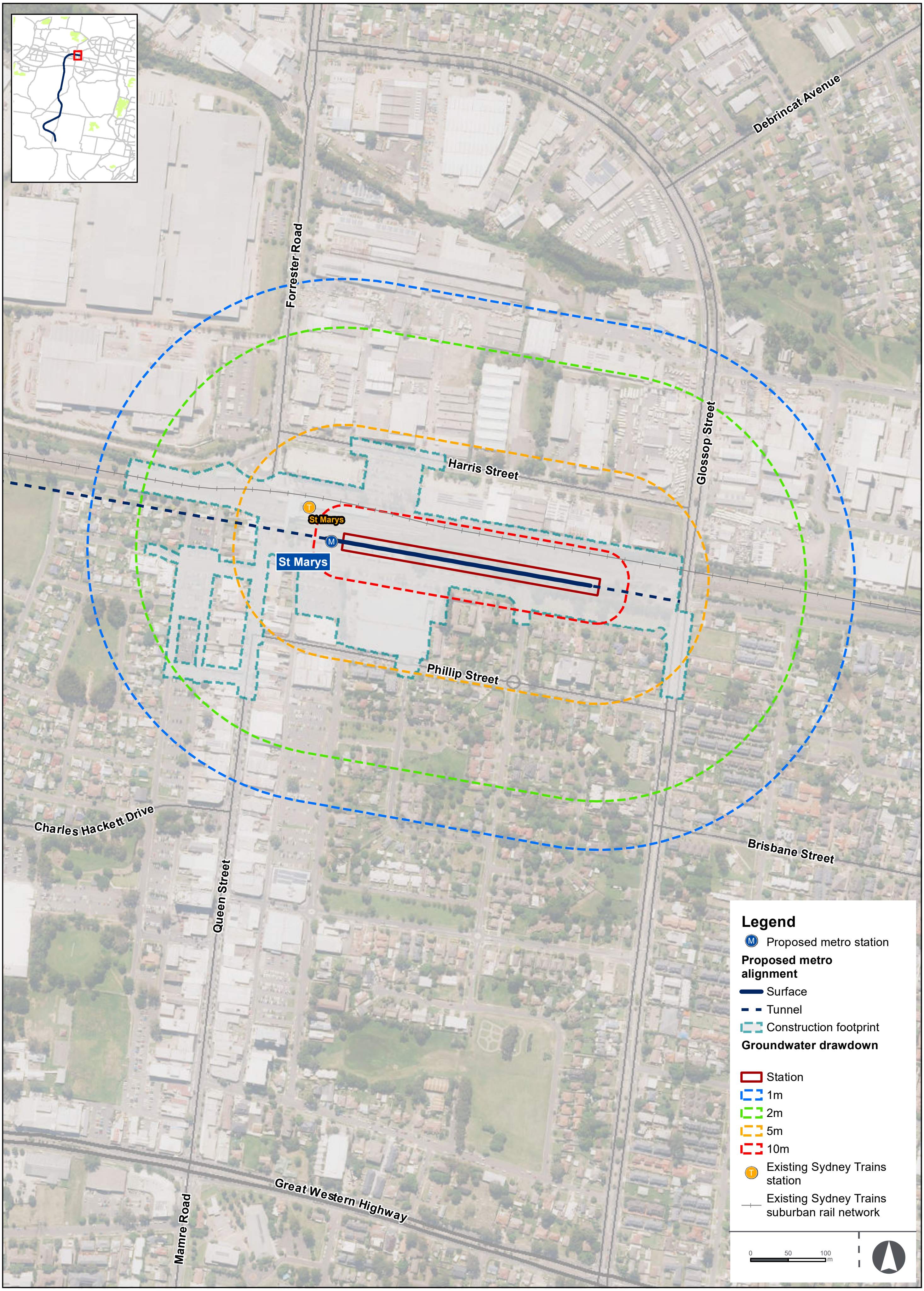
Groundwater inflows during construction of Orchard Hills Station and the tunnel portal are expected to be minor since the structure would be undrained. There may be some minor seepage into the base of the excavation which could lead to some depressurisation outside the waterproof retaining wall. However, this would only occur temporarily during excavation until the internal concrete structures are installed and waterproofed.

Groundwater inflow into the drained cutting south of the station would occur, causing a lowering of adjacent groundwater levels and progressive ingress of water into the surrounding shale. Changes to the groundwater level would develop during construction (as excavation takes place) but may continue to occur into the operational phase of the project.

The predicted changes to groundwater level from the undrained station box, dive structure and drained cutting south of Orchard Hills Station are presented in Figure 15-5.

The modelling at Orchard Hills Station predicts groundwater drawdown of up to two metres would extend to a distance of around 230 metres to the east of the proposed cutting and drawdown of up to one metre would likely extend to a distance of around 440 metres to the east of the station.

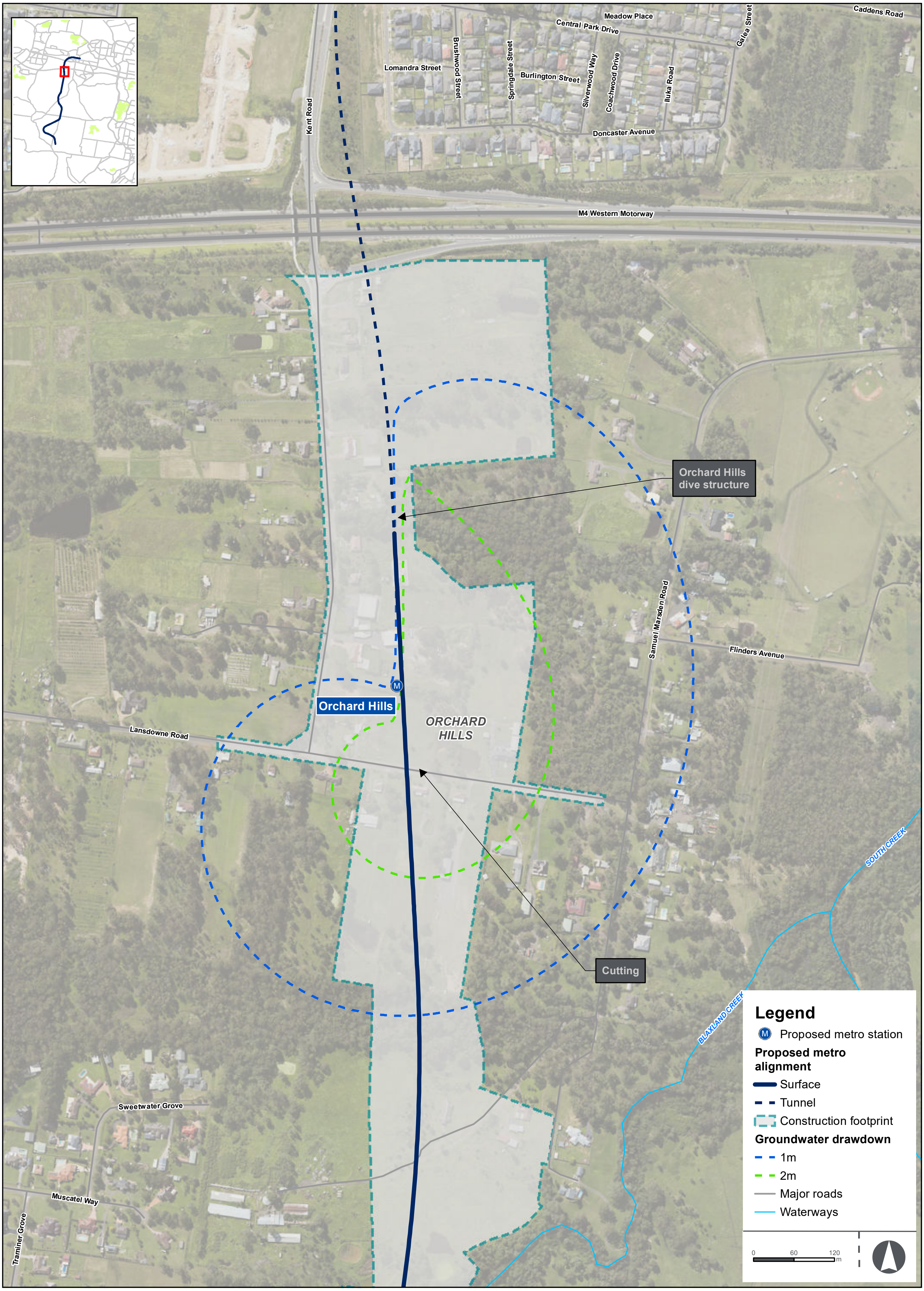
Groundwater levels observed in the underlying shale indicate that water levels within the residual soil, if present are likely to be relatively deep. Drawdown in the Bringelly Shale may lead to increased vertical head gradients (pressure) between the residual soil and deeper groundwater. However, due to the predominantly clay soils present in the area, any impacts are likely to be limited. The potential impact on very shallow soil water is unlikely due to its intermittent and localised nature.



Predicted changes to groundwater levels at St Marys Station during construction

Figure 15-4

Indicative only, subject to design development



Sydney Metro – Western Sydney Airport

Predicted changes to groundwater water levels at Orchard Hills during construction

Figure 15-5

Indicative only, subject to design development

Bringelly services facility

Bringelly services facility would be drained (un-tanked) during construction and undrained (tanked) in operation. Groundwater inflows at Bringelly services facility would occur during excavation and construction leading to changes to groundwater levels in the surrounding shale and residual soil. The changes to groundwater level would occur until the permanent watertight structure is in place.

The predicted changes to groundwater level during the construction phase are presented in Figure 15-6. The assessment indicated that up to two metres of groundwater drawdown would extend to a distance of around 220 metres away from the excavation during construction and one metre of drawdown would extend to a distance of around 315 metres from the excavation.

Aerotropolis Core Station

Aerotropolis Core Station would consist of an underground cut-and-cover station which would require excavation to a maximum depth of around 15 metres below the existing surface level. Aerotropolis Core Station would be drained (un-tanked) during construction and undrained (tanked) in operation. Groundwater inflows would occur during excavation and construction leading to changes to groundwater levels in the surrounding shale and residual soil. The changes to groundwater level would occur over the course of the construction period until the permanent watertight structure is in place.

The predicted changes to groundwater level during the construction phase is presented in Figure 15-6. Drawdown at the excavation is expected to be close to the base of the excavation. The assessment indicated that one metre of groundwater drawdown would extend to a distance of around 270 metres from the excavation.

Changes to groundwater recharge

Groundwater recharge is the proportion of rainfall that makes its way into an aquifer system, as a result of infiltration through unsaturated soils. The principal mode of recharge to groundwater systems is through rainfall. Changes to recharge from the surface can cause changes in groundwater level in the underlying system.

Changes to recharge during construction are likely to occur principally because of:

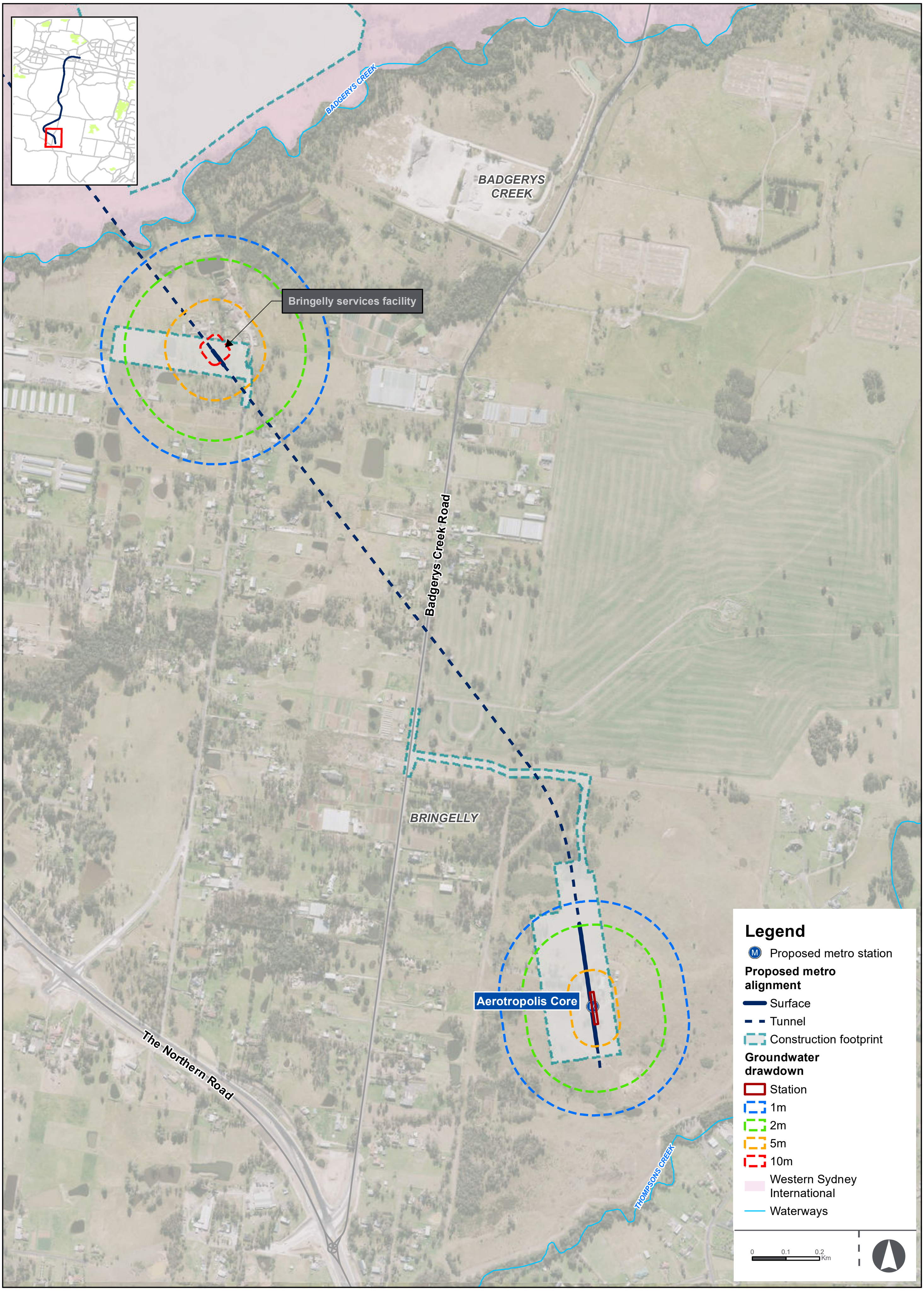
- introduction and construction of engineered fill, paved surfaces and site facilities preventing rainfall from infiltrating the ground, leading to a reduction in groundwater recharge
- surface runoff on construction areas being captured by drainage systems, as opposed to infiltrating the ground, leading to a reduction in recharge
- sedimentation basins used during construction acting as local points of increased recharge.

The effect of the reduction in direct recharge to groundwater levels across this footprint is anticipated to be minor due to the limited scale of the project and its footprint (compared to the size of the catchment) and the existing low recharge within the study area due to the low hydraulic conductivity of the residual clay soils and Bringelly Shale bedrock.

Potential impact to groundwater dependent ecosystems

Potential impacts on GDEs include changes to groundwater level and flow resulting from groundwater drawdown during excavation works. The biodiversity assessment contained in Chapter 11 (Biodiversity) and Technical Paper 3 (Biodiversity Development Assessment Report) considers areas of greater than or equal to two metres groundwater drawdown have the potential to result in impacts on GDEs.

The potential impact on native vegetation communities as a result of groundwater drawdown is discussed further in Chapter 11 (Biodiversity) and Technical Paper 3 (Biodiversity Development Assessment Report).



Predicted changes to groundwater water levels at Bringelly services facility and Aerotropolis Core during construction

Figure 15-6

Indicative only, subject to design development

Potential impacts to groundwater users

There are no groundwater supply wells (bores) located within the study area at locations where groundwater levels are affected by the project. No registered supply bores would therefore be impacted by the project.

There are two supply wells located within 150 metres of the project alignment between Patons Lane, and Luddenham Road Station. The alignment adjacent to these bore locations would be on viaduct and construction activity would principally involve construction of foundations for the viaduct piers and abutments, with minimal impact on the groundwater environment. These bores are drilled to depths of around 250 metres and 360 metres respectively, and the project would not have any impact on these supply wells.

Although there is a potential for unregistered supply wells to be present in the study area, it is considered unlikely due to the high salinity of the shale groundwater, which makes it of limited value as a groundwater supply.

Potential impacts from ground movement

A preliminary assessment of potential ground movement as a result of construction of the project has been carried out.

The surface environment above the St Marys to Orchard Hills tunnel is predominantly urbanised (residential and commercial development) but transitioning to a more rural residential character to the south of the M4 Western Motorway around Orchard Hills. In contrast, the surface environment above the Western Sydney International to Bringelly tunnel (south of Badgerys Creek) is typically rural and rural residential land with only a limited number of dispersed structures.

Tunnel construction ground movement

For the St Marys to Orchard Hills tunnel, the maximum predicted ground movement associated with construction of the twin tunnels was five millimetres or less for the majority of the tunnel lengths. Where the tunnels interface with the two stations at St Marys and Orchard Hills the ground movement at the surface is expected to be higher.

For the Western Sydney International to Bringelly tunnel, the maximum predicted ground movement from construction of the twin tunnels south of Badgerys Creek is expected to be in the range 5-10 millimetres. Where the tunnels interface with the Aerotropolis Core Station and the Bringelly services facility ground movement at the surface is expected to be higher.

The maximum predicted ground surface movements from the excavation of mined tunnels (stub tunnels and cross passages) for both sections of tunnel is less than five millimetres.

Combined ground movements

Table 15-5 summarises the predicted combined ground movements from tunnel excavation, excavation of cut and cover stations and services facility shafts inclusive of groundwater drawdown arising from the preliminary assessment. It should be noted that the combined ground movements would not be uniform across the excavation.

Further assessment of ground movement would be carried out during design development based on the results of detailed geotechnical investigations and refinement of the project design and construction methodology.

The western end of St Marys Station would have the maximum movement and slope, due to the combination of tunnelling and station excavation. The northern end of Orchard Hills Station would experience the maximum movement and slope as predicted ground movement from the tunnel is combined with the excavation of the cut and cover structure. For the Claremont Meadows and Bringelly services facilities, the maximum movement and slope is uniform across the shaft and the area of excavation is more limited by comparison to the cut and cover stations.

Table 15-5 Summary of predicted combined ground movement – off-airport

Location	Indicative maximum excavation depth (m)	Indicative total predicted ground movement (mm)	Predicted range of ground surface slope (V:H)
St Marys Station (immediately west of new station box)	About 15	40 to 50	1:200 to 1:1,000
St Marys Station (other areas - south, east and north of new station box)	About 15	20 to 30	1:500 to 1:2,000
St Marys Station (west side of Queen Street to the north of Nariel Street)	About 15	30 to 40	1:200 to 1:1,000
Claremont Meadows services facility	About 25	40 to 50	1:200 to 1:500
Orchard Hills Station (northern end)	About 15	15 to 40	1:200 to 1:500
Orchard Hills Station (other areas)	About 10 to 15	5 to 15	1:500 to 1:2,000
Bringelly services facility	About 30	40 to 50	Not available
Aerotropolis Core Station	About 20	20 to 30	Not available

Note: St Marys Station is drained during construction and undrained (tanked) in the long term. Orchard Hills dive structure is drained during construction and in the long term. Only the groundwater drawdown effects during construction are included in the predicted ground movement predictions.

Building impacts

A preliminary assessment of the potential impact to existing buildings and structures as a result of ground movement arising from the construction of the project has been carried using the Rankin (1988) risk classification. For the construction of the St Marys to Orchard Hills tunnels and the Western Sydney International to Bringelly tunnels the assessment identified that:

- the vast majority of building lots were expected to experience a negligible degree of risk (slopes shallower than 1:2,000 and/or settlement of less than 10 millimetres)
- a small number of building lots were expected to experience a slight degree of risk (slopes of between 1:200 to 1:500 and/or settlement of between 10 and 50 millimetres). Some of these lots are located within the construction footprint where buildings and structures are likely to be removed
- a small number of building lots were expected to experience a moderate degree of risk (slopes of between 1:50 to 1:200 and/or settlement of between 50 and 75 millimetres). Many of these lots are located within the construction footprint where buildings and structures are likely to be removed
- no building lots were expected to experience a high degree of risk (slopes of greater than 1:50 and/or settlement of greater than 75 millimetres).

Almost all building lots are assessed as being within either the ‘negligible’ or ‘slight’ risk categories based on Rankin (1988). Further assessment of any building lots identified within the slight, moderate or high risk categories would be undertaken as part of future design development including consideration of information about the type and condition of the potentially impacted building structures.

Heritage listed items

St Marys Station is a heritage listed item of State significance. A number of heritage assets associated with the station (including the Goods Shed, jib crane, signal box and the station building on platform 3/4) are located in the vicinity of the tunnelling and cut and cover station excavation proposed to the south of the existing station. The preliminary assessment has identified that without mitigation the Goods Shed may be subject to ground movement impacts that could result in slight damage to this structure. The predicted impacts on the signal box and station building on platform 3/4 are negligible.

Construction activities would be required in the area of the jib crane and it would be temporarily relocated during construction. This would avoid any potential ground movement impacts to this structure. The following actions are proposed to manage the potential impacts to the Goods Shed during construction:

- detailed assessment of potential ground movement impacts on this structure including a building condition survey would be carried out and, if required, feasible measures to reduce or mitigate the effects of ground movement on this structure would be implemented
- ground movement in the vicinity of the Goods Shed and the condition of the Goods Shed building would be monitored
- a dilapidation survey of the Goods Shed would be undertaken and, if required, damage to the building as a result of the project would be repaired.

Road and rail infrastructure and utility assets

Road and rail infrastructure has the potential to be temporarily impacted by ground movement associated with tunnelling or excavations for cut and cover station boxes and service facility vent shafts. This infrastructure includes:

- the T1 Western line at St Marys including associated infrastructure within the rail corridor such as signal boxes and overhead wiring
- Station Street, Queen Street and the Glossop Street bridge at St Marys
- Great Western Highway and Gipps Street at Claremont Meadows
- M4 Western Motorway at Orchard Hills including the bridge over the motorway at Kent Road
- Derwent Road and Badgerys Creek Road at Bringelly.

In addition, there are a number of major utilities including gas, water, sewer and drainage assets which also have the potential to be temporarily impacted by ground movement during construction.

Further assessment of potential ground movement impacts on the road and rail infrastructure and utility assets would be undertaken during design development. Consultation would be undertaken with the infrastructure and asset owners in each case to determine appropriate ground movement criteria for the assessment and, if required, to agree management measures to manage potential impacts.

Potential ground movement associated with viaduct and bridge structures

Groundwater impacts and related ground movement impacts due to the construction of viaduct and bridge piers, are anticipated to be small. The excavation depths for these structures are relatively shallow compared to the main station excavations, reducing the magnitude and extent of any drawdown should groundwater ingress occur. A shorter construction period for these structures would also serve to limit any groundwater drawdown and subsequent ground movement occurring away from the excavation.

At critical infrastructure, such as the Warragamba to Prospect Water Supply Pipelines, groundwater drawdown is not expected to occur, based on the nearest groundwater level monitoring information. However, further assessment would be undertaken during design development to confirm this, once site specific data becomes available. Consultation with WaterNSW would be ongoing to develop appropriate ground movement criteria, monitoring regimes and mitigation measures, if required during construction to limit groundwater drawdown related ground movement.

Options to mitigate ground movement impacts

During detailed assessment, if ground movement impacts are predicted to exceed acceptable criteria for buildings, heritage assets, road and rail infrastructure or utilities then a range of potential options are available to reduce impacts to acceptable levels including:

- changes to elements of the construction methodology
- consideration of ground improvement options
- provision of structural support to the tunnels/excavations and/or to the structures potentially impacted
- ground movement monitoring for identified sensitive areas of the project.

These options have been successfully implemented to manage ground movement impacts on a number of other rail and road tunnelling projects in NSW.

Potential impacts on groundwater quality

Groundwater in the study area has limited environmental value due to the high salinity of the water in the area. As a result, the main potential risks to groundwater quality during construction include:

- hydrocarbon (or other chemical) contamination from potential fuel and chemical spills during construction, leading to contamination of groundwater
- infiltration of contaminated surface water runoff at discharge basins
- release of saline groundwater seepage from excavations during construction into the environment (including impacting on shallow, better quality soil groundwater)
- mobilisation of existing groundwater contamination due to dewatering, groundwater ingress to excavations or because of altered groundwater flow directions due to construction activity
- leaching of saline, acidic or contaminated water from permanent soil stockpiles into the groundwater environment.

Groundwater ingress into excavations for stations or other cuttings would be captured, treated and then reused for construction activity where possible. Where reuse of the groundwater is not possible, the water would be discharged from the sites via construction water quality treatment plants. Water captured during tunnelling would be treated and recirculated to the cutting face or used for dust suppression purposes. Further information, including the proposed location of water discharge points and mitigation measures relating to the monitoring of surface water quality during construction are provided in Chapter 14 (Flooding, hydrology and water quality).

Assessment of contaminated soil is further described in Chapter 16 (Soils and contamination) and Technical Paper 8 (Contamination). This assessment identifies a potential medium to high risk of a pollutant linkage due to potentially contaminated groundwater being present in certain parts of the study area. These include potentially contaminated groundwater from Gipps Street landfill and off-site sources up-gradient of St Marys. There is also a potential medium risk of groundwater contamination due to the construction of the rail tunnels between St Marys and Orchard Hills.

The risk of cross contamination between aquifers as a result of saline groundwater migration or intrusion is low. The underlying Hawkesbury Sandstone aquifer in this region is expected to be in excess of 100 metre depth across the study area and beyond the zone of impact from construction activity or resulting changes in groundwater levels.

Apart from these existing sources of groundwater contamination, the potential risk of impacting groundwater quality is anticipated to be low, for the following reasons:

- the infiltration of saline or contaminated water from stockpiles or at discharge basins would be limited by the low permeability of clay soils present in the study area
- groundwater that is captured in excavations for stations, cuttings and cut-and-cover tunnels would be collected, separated and pumped to construction water quality treatment plants for treatment in line with any requirements of an Environment Protection Licence before either being reused or discharged

- mobilisation of large quantities of existing contamination is unlikely, due to the low permeability groundwater environment in the study area and the design of the main project elements, which would limit groundwater inflow and drawdown during construction.

The project would include the provision of water treatment plants for the off-airport section of the project to treat any contaminated groundwater intercepted during construction before discharge. The final location and design of the water treatment system for the project would be confirmed during design development.

Potential impacts to creeks and wetlands

Creeks

Due to the low hydraulic conductivity of the Bringelly Shale and overlying soils, the amount of interflow between the creeks and the groundwater is likely to be small, with creeks being principally surface water run-off fed or supported by baseflow from alluvial deposits. As a result, the potential impact of groundwater drawdown at creek lines is anticipated to be minor.

Direct impacts on alluvial groundwater are unlikely since construction activity would principally occur within residual soil and Bringelly Shale. Alluvial soils are expected to be encountered at each of the main creek crossings where the alignment would either be in viaduct or tunnel well below the alluvial deposits. Excavation of the Claremont Meadows services facility may be partly located within alluvial soils, although this would likely to be close to the edge of the mapped deposits. Excavation of the shaft could locally affect groundwater levels within the alluvial deposits however due to its relatively small footprint, the magnitude of potential impact is likely to be minor.

Tunnelling below South Creek, Badgerys Creek and other minor creek lines would be within Bringelly Shale bedrock at around 10 metres below ground level (on average) from the tunnel crown. There is a potential for higher hydraulic conductivity within the Bringelly Shale below the creeks which could increase the connection between the shale and alluvial deposits. However, since the period over which groundwater inflow would occur during tunnelling is short, any impact is anticipated to be temporary. Construction of the tunnels is also considered unlikely to impact on flow within the creeks.

Wetlands

The potential impact to artificial wetlands (stock and farm dams) from the project is likely to be negligible since these features are expected to be largely disconnected from the underlying Bringelly Shale groundwater, where changes in groundwater level would predominantly occur.

Estimated construction groundwater take

Estimated groundwater inflows for the off-airport environment are provided in Table 15-6. The total estimated construction inflow rate is likely to be a conservative estimate and may be substantially lower in practice.

Measures to limit groundwater ingress during construction may be implemented where excessive or greater than predicted inflows are encountered, in order to reduce the potential impact on the surrounding environment. As most structures are designed to be undrained (tanked) in the long term, groundwater ingress will be temporary, occurring during the construction phase only.

Table 15-6 Estimated maximum construction groundwater inflows – off-airport

Project element	Predicted average groundwater inflow (kL/d)	Predicted maximum groundwater inflow (kL/d)
St Marys to Orchard Hills tunnels	5	75
St Marys Station and crossover	69	153
Claremont Meadows services facility	5	15
Orchard Hills tunnel portal	2	6
Orchard Hills Station	6	9
Orchard Hills cutting	13	62

Project element	Predicted average groundwater inflow (kL/d)	Predicted maximum groundwater inflow (kL/d)
Bringelly services facility	9	18
Western Sydney International to Bringelly tunnel (outside Western Sydney International)	4	71
Aerotropolis Core Station	54	117
Off-airport total	**166**	**527**

Notes:
1. The combined predicted inflow may not occur due to staged construction.
2. The maximum inflow is likely to be of short duration and unlikely to occur concurrently across the project

15.5.2 On-airport

Hydrogeological conditions at each of the main project elements for on-airport which are likely to interact with the groundwater environment are presented in Table 15-7.

Table 15-7 Hydrogeological conditions at project elements – on-airport site

Location/structure	Hydrogeological units	Approximate groundwater level (metres below existing ground level)[1]	Approximate depth of structure below existing groundwater level (m)
Western Sydney International tunnel portal	Residual soil Bringelly Shale	0.5 to 3	0 to 20
Airport Terminal Station	Residual soil Bringelly Shale	0.5 to 3.5	15 to 19
Western Sydney International to Bringelly tunnel (within Western Sydney International)	Bringelly Shale	1 to 9	Up to 28

Note 1: Groundwater depths based on existing ground levels.

Changes to groundwater level

Rail tunnels

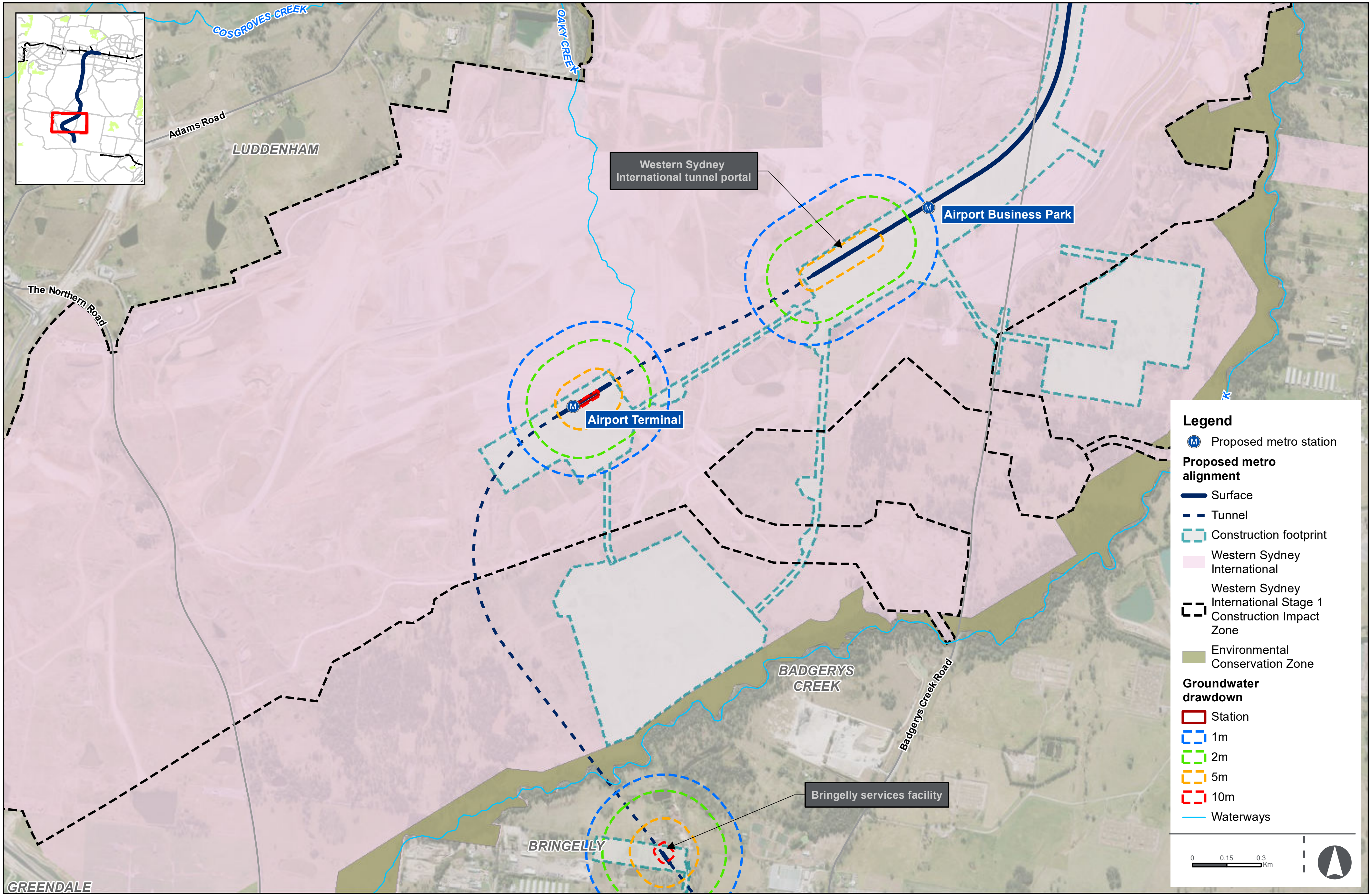
As described in Section 15.5.1, changes in groundwater level as a result of tunnel and cross passage excavation during construction are likely to be of short duration and unlikely to lead to a material change in groundwater levels.

Similar impacts to those previously described are anticipated to occur for the on-airport component of the project.

Western Sydney International tunnel portal

Groundwater inflows at the Western Sydney International tunnel portal would occur during construction as the excavation would take place within a drained (un-tanked) retaining wall. This would lead to potential changes to groundwater levels in the surrounding shale and residual soil. The temporary changes to groundwater level would occur over the course of construction until the permanent watertight portal structure is in place.

The predicted changes to groundwater level during the construction phase is presented in Figure 15-7. Drawdown at the excavation is expected to be close to the base of the excavation. However, since the excavation is deeper to the west, greater drawdown and inflow would be expected in that area. The assessment indicates that the one metre drawdown contour would extend to about 285 metres from the excavation. This extent is unlikely to occur across the entire length of the tunnel portal since there would be less drawdown in shallower areas. However, for this assessment, it is assumed that this drawdown occurs uniformly across the length of the structure.



Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Predicted changes to groundwater levels on-airport during construction

Figure 15-7

Airport Terminal Station

Groundwater inflows at Airport Terminal Station would occur during construction as the excavation would take place within a drained (un-tanked) retaining wall. This would lead to potential changes to groundwater levels in the surrounding shale and residual soil. The temporary changes to groundwater level would occur over the course of construction until the permanent watertight station structure is in place.

At the Airport Terminal Station, modelling results indicate that that the one metre drawdown contour would extend to around 270 metres from the excavation face (see Figure 15-7).

Changes to groundwater recharge

The same mechanisms as those described in Section 15.5.1 are expected to result in changes to recharge during construction of the project at Western Sydney International. In addition, a large permanent spoil placement area for excavated spoil material would be located within Western Sydney International (see Figure 15-3) which could reduce groundwater recharge into the underlying ground. Further details on the permanent spoil placement area are provided in Chapter 8 (Project description – construction).

As this spoil placement area would be permanent, its effect on groundwater recharge would continue into the operational phases of the project. However, given the existing low permeability residual soils and low recharge rates present across the majority of Western Sydney International, it is unlikely that this would have a significant impact on recharge rates and underlying groundwater levels.

Potential impact on groundwater dependent ecosystems

The Western Sydney International Stage 1 Construction Impact Zone would be cleared before or during construction of the project, removing the potential for occurrence of GDEs. Groundwater drawdown outside the Western Sydney International Stage 1 Construction Impact Zone is considered unlikely due to the undrained tunnel design and construction method and given that proposed excavation areas (Western Sydney International tunnel portal and Airport Terminal Station) are over 400 metres away from any potential GDEs.

Condition 8.4 of the Airport Plan states that groundwater monitoring would be undertaken for the *Soil and Water Construction Environmental Management Plan* (Western Sydney Airport, 2019g) which must include monitoring points adjacent to woodlands in areas outside of the Western Sydney International Stage 1 Construction Impact Zone (but within the airport). This measure is intended to monitor changes at groundwater dependent vegetation as a result of construction of the airport site.

Potential impact on groundwater users

No groundwater supply wells have been identified within Western Sydney International and therefore existing groundwater users would not be affected by the project. No impacts to existing groundwater supply wells off-airport are predicted as a result of changes to groundwater levels or flows at the airport site.

Potential impacts from ground movement

A preliminary assessment of potential ground movement impacts due to construction of Western Sydney International to Bringelly tunnel within the airport site has been carried out. This assessment considered ground movements resulting from tunnelling works, excavation for cut and cover stations including retention systems and temporary groundwater drawdown. In contrast to the off-airport environment, the surface environment within the airport site is assumed to have been cleared and not contain any remaining buildings or structures.

The preliminary assessment assumes that ground movements arising from the proposed action would occur prior to construction of the Airport Terminal building and associated civil works at the airport. Consultation with Western Sydney Airport will be ongoing in respect to the construction programs for both projects to understand the potential for ground movement impacts to proposed buildings and structures.

Tunnel construction movement

For the Western Sydney International to Bringelly tunnel, the maximum predicted ground movement associated with construction of the twin tunnels within the airport site is expected to be in the range between 10 and 15 millimetres at the Western Sydney International tunnel portal and the Airport Terminal Station.

Combined ground movements

Table 15-8 summarises the predicted combined ground movements from tunnel excavation and excavation of cut and cover stations, inclusive of groundwater drawdown. It should be noted that the combined ground movements would not be uniform across the excavation.

Table 15-8 Summary of predicted combined ground movement – on-airport

Location	Indicative maximum excavation depth (m)	Maximum combined settlement (mm)
Western Sydney International tunnel portal	About 10 to 20	30 to 40
Airport Terminal Station	About 25	20 to 30

Note: Predicted settlement does not include any ground movements from Western Sydney International construction works. No information is available at this stage about predicted range of ground surface slope.

Building, road infrastructure and utility impacts

The airport site is under construction and has been cleared of all buildings or structures. There are no existing roads or utility assets within the airport site that would be potentially be impacted by ground movement impacts associated with the project.

Consultation with Western Sydney Airport will be on-going in respect to the construction programs for both projects to understand the potential for ground movement impacts to proposed buildings and structures.

Potential impacts on groundwater quality

The potential impacts on groundwater quality within the airport site are likely to be similar to those identified for the off-airport environment in Section 15.5.1. The potential permanent spoil placement area at Western Sydney International may potentially lead to an increased risk of generating saline or contaminated runoff and leachate with resultant impacts on groundwater.

The overall potential risk of impacts on groundwater quality remain low due to:

- the low permeability soil cover, limiting the risk of infiltration of water into the ground
- the limited environmental value of the groundwater at the site
- the low likelihood of existing chemical contamination at Western Sydney International (see Chapter 16 (Soils and contamination) and Technical Paper 8 (Contamination)).

The project would include the provision of water treatment plants on-airport to treat any contaminated groundwater intercepted during construction before discharge to ensure that works meet the requirements under Schedule 2 of the Airports Regulations.

Potential impacts to creeks and wetlands

Groundwater drawdown at creek lines is not expected to occur during the construction phase of the project for the on-airport site. Due to the significant earthworks being undertaken at the Western Sydney International site, there are not anticipated to be any impacts on artificial wetlands, since the Stage 1 site would be fully redeveloped.

Estimated construction groundwater take

Predicted groundwater inflows for the on-airport environment are provided in Table 15-9. The total estimated construction inflow rate is likely to be a conservative estimate and may be substantially lower in practice.

Table 15-9 Estimated maximum construction groundwater inflows on-airport

Project element	Predicted average groundwater inflow (kL/d)	Predicted maximum groundwater inflow (kL/d)
Western Sydney International tunnel portal	30	53
Airport Terminal Station	44	88
Western Sydney International to Bringelly tunnel (within Western Sydney International)	4	62
On-airport total	**78**	**203**

Notes:
1. The combined predicted inflow may not occur due to staged construction.
2. The maximum inflow is likely to be of short duration and unlikely to occur concurrently across the project

15.5.3 Total project groundwater take – construction

The total estimated water take for the project (combining off-airport and on-airport components) during construction is about 240 mega litres per year, compared to the long-term average annual extraction limit of 45,915 mega litres per year in the water sharing plan for the *Sydney Basin Metropolitan Region Groundwater Sources* (NSW, 2015).

The results indicate that there is sufficient groundwater available from a licensing perspective for the maximum estimated construction inflow. This water take represents less than one per cent of the extraction limit for the Sydney Basin.

The Sustainability Plan for the project includes the objective of maximising opportunities for the re-use of non-potable water sources during construction including water from groundwater inflows during tunnelling and excavations. Further information on the potential re-use of non-potable water sources during construction is provided in Chapter 17 (Sustainability, climate change and greenhouse gas).

15.6 Potential impacts – operation

15.6.1 Off-airport

Changes to groundwater level

Rail tunnels

Once the permanent waterproofing and lining is installed, the rail tunnels and cross passages would become undrained, and groundwater inflows would be incidental and maintained to below the waterproofing requirements. In this respect, the design of the rail tunnels has sought to mitigate against long term drawdown of groundwater levels in the Bringelly Shale that would be caused if the tunnels were drained.

The undrained tunnels and cross passages would lead to a reduction in the available aquifer transmissivity (the rate at which groundwater flows horizontally through an aquifer) causing a potential increase in water levels upgradient and a decrease in levels downgradient. The size of the tunnels and cross passages compared to the overall thickness of the Bringelly Shale is small and changes in water levels during the operational phase are expected to be localised around the tunnel structures. These changes in groundwater level are likely to be small and would be unlikely to have a substantial impact on long term hydrogeology for the area.

Stations, tunnel portals and services facilities

In the operational phase of the project, all stations, services facilities and tunnel portal structures would be undrained. Groundwater inflow to these structures would be prevented due to waterproofing. Any groundwater levels that were temporarily lowered during construction would recover slowly.

In the longer term, these undrained structures would present a barrier to the natural groundwater flow, since the shale and residual soils would have been removed and replaced with a largely impermeable barrier. This would potentially lead to an increase in groundwater levels upgradient of any structure and a lowering of levels downgradient.

The predicted changes in groundwater level as a result of these undrained structures is relatively small, and likely to be within the range of seasonal and long-term groundwater fluctuation. The potential changes in groundwater level would also be predominantly localised around the structures.

The services facilities shafts at Claremont Meadows and Bringelly are unlikely to cause substantial changes in water levels during the operational phase due to their relatively small size. Changes to groundwater levels at Orchard Hills Station would be dominated by the drained cutting to the south.

Minor changes in groundwater levels and flow may also potentially occur at surface water detention and treatment basins where there is increased infiltration to the ground. However, given the low permeability of the soils at these locations, potential changes to infiltration are expected to be small with only minor and localised changes in water level occurring beneath the basins.

Potential impacts on land salinity

Potential salinity risks from the project may occur due to increases in groundwater levels, which could lead to an increase in salt loading of shallow soils. This is most likely to occur at locations where project elements impede water movement (i.e. undrained elements) causing groundwater to rise. The risk of potential impacts occurring is relatively low due to:

- overall changes to groundwater level are expected to be relatively minor meaning the risk of salinity developing is likely to be low
- groundwater levels are generally anticipated to be well below the surface suggesting that any increased water level would be unlikely to impact on shallow soils.

Potential impacts on groundwater quality

Groundwater inflow rates to the operational tunnels are expected to be variable over the operational phase and are likely to be responsive to seasonal and climatic variation in precipitation and recharge. Any water accumulating in the open trench and tunnel sections of the project would be pumped to permanent water quality treatment plants at St Marys Station and Bringelly services facility where the water would be treated in accordance with criteria established in consultation with the NSW Environmental Protection Authority and the Department of Planning, Industry and Environment prior to discharge.

Impacts on groundwater quality as a result of operation are expected to be minimal. There is potential for hydrocarbon spills at the stabling and maintenance yard, which could impact on groundwater; however, given the low porosity of the soil and the low connectivity of the soil to the groundwater systems, the potential for impact is low. Site drainage would also be designed appropriately to capture chemical spills to reduce the risk of environmental release.

Surface water drainage systems would be installed along the rail alignment which include water quality treatment/stormwater detention basins. These systems are unlikely to present a risk to the underlying groundwater quality although differences in the chemistry between the runoff and groundwater may locally alter the groundwater salinity. The underlying groundwater is generally brackish to saline and surface runoff would be fresh; therefore, any additional recharge in these areas is unlikely to detrimentally impact on water quality. Surface water runoff is unlikely to contain contaminants in sufficient concentrations to impact the groundwater.

Estimated operational groundwater take

Table 15-10 provides a summary of estimated groundwater take in the off-airport areas as a result of operation of the project.

Table 15-10 Estimated maximum operational groundwater inflows off-airport

Project element	Estimated inflow drained structures (kL/d)	Estimated inflow undrained structures [1] (kL/d)
St Marys Station and crossover	-	1.1
St Marys to Orchard Hills tunnel	-	8.3
Claremont Meadows services facility	-	0.2
Orchard Hills tunnel portal	-	0.2
Orchard Hills Station	-	0.9
Orchard Hills cutting	4	-
Bringelly services facility	-	0.2
Aerotropolis Core Station	-	1.2
Off-airport total	**4 kL/d**	**12.3 kL/d**

Note 1: Based on waterproofing criteria of 2.0 ml per hour per m2 of concrete lining surfaces

15.6.2 On-airport

Changes to groundwater level and flow

All tunnels, structures and stations at Western Sydney International are designed as undrained. Groundwater inflow to these structures would be prevented due to waterproofing and groundwater levels that were lowered during construction would recover slowly. In the longer term, these undrained structures would present a barrier to the natural groundwater flow.

Over the longer term, minor increases in groundwater level upgradient and minor decreases downgradient of these structures can be expected. However, changes in groundwater level are anticipated to be relatively small and within the range of seasonal and long-term groundwater fluctuation. The extent of changes to groundwater level are expected to be localised around the structures.

Changes to recharge may also lead to a change in groundwater level at Western Sydney International. This may occur:

- below detention and treatment basins where there is increased infiltration to the ground
- below the permanent spoil placement area where decreased groundwater recharge may occur.

Given the existing low permeability at the site, changes to infiltration are expected to be small with only minor changes in groundwater level occurring as a result.

Land salinity impacts

Potential salinity risks from the on-airport component of the project may occur due to increases in groundwater levels, which could lead to an increase in salt loading of shallow soils. This is most likely to occur at locations where project elements impede water movement (i.e. undrained structures) causing groundwater to rise. The risk of potential salinity impacts occurring is considered to be relatively low as:

- changes to groundwater level are expected to be relatively small as a result of impedance to groundwater flow
- groundwater levels are generally anticipated to be well below the surface suggesting that any increased water level would be unlikely to impact on shallow soils
- in locations where shallow groundwater is currently near the surface such as the Western Sydney International tunnel portal, substantial re-profiling of the surface is being undertaken so that in the long term, groundwater levels are likely to be well below the final ground surface.

Potential impacts on groundwater quality

During operation, any minor groundwater ingress which may be collected at within rail tunnels on Western Sydney International would be directed to Bringelly services facility where it would be treated at the water quality treatment plant. Ongoing seepage is likely to be of relatively small quantity and would be treated in accordance with criteria established in consultation with the Environmental Protection Authority and DPIE (Water).

Impacts on groundwater quality during the operation phase of the project are not expected on the airport site. It is unlikely that groundwater would be impacted from contamination from unintended release of chemicals or fuels used by the project. As all stations, tunnel portals and rail tunnels at the airport site are undrained during the operational phase, the risk of capturing groundwater contaminated by the airport site is considered negligible.

The proposed water treatment plants (as discussed in Chapter 14 (Flooding, hydrology and water quality) would treat wastewater and groundwater ingress pumped from the stations, tunnels and other below ground facilities. The water treatment plant building would include chemical treatment tanks, water storage tanks, and filters which would collect treated collected water to a standard in line with the performance outcomes prior to discharge from the site (refer to the performance outcomes in Chapter 14 (Hydrology, flooding and water quality)).

The interaction between Western Sydney International and the project would continue to be considered in the operational phase of the project. Stormwater treatment systems and the use of other chemicals at Western Sydney International could infiltrate into the groundwater environment and eventually be captured by the rail cutting. The proposed management and mitigation measures implemented by Western Sydney International would mean that the risk of this occurring is likely to be low. The Airport Plan provides the overall master plan for the airport and includes specific conditions on elements such as groundwater monitoring (conditions 8(4) to 8(6) of the Airport Plan).

Estimated operational groundwater take

The estimated operational groundwater inflows for the project on-airport are presented in Table 15-11.

Table 15-11 Estimated maximum operational groundwater inflows on-airport

Project element	Estimated inflow drained structures (kL/d)	Estimated inflow undrained structures[1] (kL/d)
Western Sydney International tunnel portal	-	0.8
Airport Terminal Station	-	0.9
Western Sydney International to Bringelly tunnel (within Western Sydney International)	-	10.1
On-airport total	**0 kL/d**	**11.7 kL/d**

Note 1: Based on waterproofing criteria of 2.0 ml per hour per m^2 of concrete lining surfaces

15.6.3 Total project groundwater take – operation

The total estimated water take for the project (including off-airport and on-airport) during operation is about 9 mega litres per year, compared to the long-term average annual extraction limit of 45,915 mega litres per year in the water sharing plan for the Sydney Basin Metropolitan Region Groundwater Sources.

The results indicate that there is sufficient groundwater available from a licensing perspective for the estimated long-term steady state operational inflow.

The Sustainability Plan for the project includes the objective of maximising opportunities for the re-use of non-potable water sources during operation including the harvest and reuse of groundwater at permanent water treatment facilities where feasible. Further information on the potential re-use of non-potable water sources during operation is provided in Chapter 17 (Sustainability, climate change and greenhouse gas).

15.6.4 Aquifer Interference Policy

As discussed in Section 15.3.1, the AIP provides a useful basis for determining whether a groundwater source should be considered productive or less productive. The definition for a less productive source is:

- a groundwater source having total dissolved solids greater than 1,500 mg/l
- a groundwater source that does not contain water supply works that can yield water at a rate greater than five litres per second.

On this basis, the Bringelly Shale is a less productive source since the groundwater contains total dissolved solids generally in excess of 1,500 mg/l and low permeability such that yields are likely to be well below five litres per second.

The AIP requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against the minimal impact considerations. If the predicted impacts are less than the Level 1 minimal considerations, then the impacts of the project are acceptable. As noted above, the AIP provides appropriate criteria against which the impacts of the project on groundwater can be assessed.

Consideration of the potential impacts on the hydrogeological environment are compared to the criteria/requirements of the AIP in Section 6.6 of Technical Paper 7 (Groundwater). This assessment is summarised below:

- water table – no water supply work is expected to be affected by a decline in water table and therefore the project meets the requirements of Level 1. Some high priority terrestrial GDEs are likely to be within the zone of predicted groundwater change adjacent to the Orchard Hills Station and Bringelly services facility. Based on the relatively conservative estimates of drawdown, it is possible that groundwater changes in these areas may be in excess of Level 1
- water pressure - no water supply work is anticipated to be affected by a decline in pressure head of more than two metres and therefore the project meets the requirements of Level 1
- water quality - groundwater in the study area has limited beneficial use owing to its high background salinity. Groundwater quality is unlikely to be impacted because of the project and there would be no change to the beneficial use category. The impacts associated with the project are therefore expected to meet the requirements of Level 1.

Further geotechnical investigations and ongoing groundwater data collection has been undertaken during the preparation of this Environmental Impact Statement. The additional information would be used in future revisions of any hydrogeological assessment during design development in order to verify or update the conclusions of the assessment.

15.7 Proposed management and mitigation measures

Environmental management for the project would be undertaken through an environmental management approach as detailed in Chapter 25 (Environmental management and mitigation). The construction and operational environmental management frameworks are discussed in Section 25.2 and 25.3 respectively.

Under these broad frameworks, a series of performance outcomes have been developed to define the minimum environmental standards that would be achieved during construction and operation (detailed in Section 15.7.1), and mitigation measures that would be applied during construction and operation to manage potential identified impacts.

15.7.1 Performance outcomes

Performance outcomes have been developed consistent with the requirements of the SEARs for the project. Performance outcomes for groundwater and geology for the project are listed in Table 15-12 and identify measurable, performance-based standards for environmental management.

Table 15-12 Performance outcomes – groundwater and geology

SEARs desired performance outcome	Project performance outcome	Timing
Groundwater and geology		
Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised	Groundwater availability and quality for water supply and environmental benefit (e.g. groundwater dependent ecosystems) is not affected beyond the requirements outlined in the NSW Aquifer Interference Policy	Construction and operation
	Structural damage to buildings, heritage items and public utilities and infrastructure, including the Warragamba to Prospect Water Supply Pipelines, from ground movement to be avoided	Construction

15.7.2 Mitigation measures

A Construction Environmental Management Framework (CEMF) (Appendix F) describes the approach to environmental management, monitoring and reporting during construction. Specifically, it lists the requirements to be addressed in developing the Construction Environmental Management Plans (CEMP), sub-plans, and other supporting documentation for each specific environmental aspect.

The Soil and Water CEMP for the on-airport works would be developed in consultation with Western Sydney Airport and would be consistent with the existing Soil and Water Construction Environmental Management Plan and the *Western Sydney Airport Remediation Action Plan* (Department of Infrastructure and Regional Development, 2019).

Mitigation measures that would be implemented to address potential groundwater and geological impacts are listed in Table 15-13.

Table 15-13 Groundwater and geology mitigation measures

Ref	Mitigation measures	Applicable location(s)
Construction		
GW1	Further assessment would be undertaken during design development, and prior to construction commencing, to ensure that damage to buildings and structures at risk of ground movement impacts around St Marys, Claremont Meadows, Orchard Hills and Bringelly are avoided or managed Where building damage risk is rated as slight, moderate or high (as per Rankin 1988), a structural assessment of the affected buildings/structures would be carried out and specific measures implemented to address the risk of damage	St Marys construction site Claremont Meadows services facility construction site Orchard Hills construction site Bringelly services facility construction site

Ref	Mitigation measures	Applicable location(s)
GW2	Further assessment of road and rail infrastructure and utility assets (including the Warragamba to Prospect Water Supply Pipelines) considered to be at risk from ground movement would be undertaken during design development. Consultation would be undertaken with the infrastructure and asset owners in each case to determine appropriate ground movement criteria for the assessment and, if required, to agree management measures to manage potential impacts	St Marys construction site Claremont Meadows services facility construction site Orchard Hills construction site Off-airport construction corridor Bringelly services facility construction site
GW3	Further assessment of potential ground movement impacts on the Goods Shed building at St Marys Station, including a building condition survey, would be carried out during design development and prior to the commencement of construction. The assessment would be carried out in consultation with a suitably qualified heritage architect and would identify acceptable ground movement criteria and, if required, feasible measures to reduce or mitigate the effects of ground movement on this structure Ground movement in the vicinity of the Goods Shed and the condition of the Goods Shed building would be monitored during construction A dilapidation survey of the Goods Shed would be carried out prior to work commencing in the vicinity of the building. At the completion of construction, should there be any damage to the building which is determined to be as a result of the project construction works, the building would be repaired in consultation with a suitably qualified heritage architect.	St Marys construction site
GW4	Consultation with Western Sydney Airport will be on-going in respect to the construction programs for both projects to understand the potential for ground movement impacts to proposed buildings and structures	On-airport

Ref	Mitigation measures	Applicable location(s)
GW5	Detailed hydrogeological and geotechnical models for the project would be developed and progressively updated during design and construction These models would: • be informed by the results of groundwater monitoring undertaken before and during construction • identify predicted changes to groundwater levels, including at nearby water supply works and at groundwater dependent ecosystems or other sensitive groundwater receptors Where changes to groundwater levels are predicted at nearby water supply works, groundwater dependent ecosystems or other sensitive groundwater receivers, an appropriate groundwater monitoring program would be developed and implemented Where changes to groundwater level are close to the ground surface, dryland salinity monitoring would be implemented to allow for management of any identified impacts The groundwater monitoring program would aim to confirm no adverse impacts on the receiver during construction or to effectively manage any impacts with the implementation of appropriate mitigation measures. Monitoring at any specific location would be subject to the status of the water supply work and agreement with the landowner	All

Ref	Mitigation measures	Applicable location(s)
GW6	A Groundwater Management Plan would be prepared and implemented. The plan must include the following trigger-action-response measures in relation to groundwater levels in areas identified as subject to potential drawdown (at groundwater dependent ecosystems or other sensitive receivers) but outside the construction footprint and Western Sydney International Stage 1 Construction Impact Zone: a. target criteria, set with reference to relevant standards and site specific parameters; b. trigger values and corresponding corrective actions to prevent recurring or long-term exceedance of the target criteria described in (a); and c. corrective actions to compensate for any recurring or long-term exceedance of the target criteria described in (a) Response measures may include: • targeted ground improvement and grouting to limit groundwater inflows into station excavations, tunnels and cross-passage to reduce groundwater drawdown • design of undrained temporary retention systems to minimise groundwater inflow into station excavations and reduce groundwater drawdown • supplementing groundwater supply at affected groundwater dependent ecosystems or watercourses • make good provisions for groundwater supply wells impacted by changes in groundwater level or quality	All
Operation		
GW7	Ongoing groundwater inflows from drained project elements (or incidental flows) would be treated and tested before discharge to comply with any relevant Environmental Protection Licence or agreed discharge criteria	St Marys Station Bringelly services facility

15.7.3 Consideration of the interaction between measures

Mitigation measures in other chapters that are relevant to the management of potential groundwater and geology impacts include

- Chapter 11 (Biodiversity), specifically measures which address potential impacts to groundwater dependant ecosystems
- Chapter 14 (Flooding, hydrology and water quality), specifically measures which address the management of potential surface water flows which may affect groundwater inflows
- Chapter 16 (Contamination and soils), specifically measures which address the management of potential contaminant run-off during construction and operation that may affect groundwater
- Chapter 17 (Sustainability, climate change and greenhouse gas), specifically measures which address the reuse of captured groundwater.