West

Westmead to The Bays and Sydney CBD

Environmental Impact Statement

Concept and Stage 1

Technical Paper 7
Hydrogeology

Sydney Metro West
Technical Paper 7: Hydrogeology

Final

Prepared for Sydney Metro

Sydney Metro West – Stage 1

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Executive Summary

Sydney Metro (as 'the proponent') is seeking approval for the Sydney Metro West Concept and for construction of the first stage (Stage 1). Planning approvals for Sydney Metro West are expected to be staged as follows:

- Stage 1 would involve the major civil construction works between Westmead and The Bays (further described in Chapter 9 (Stage 1 description) of the Environmental Impact Statement) and is being assessed concurrently with the Concept
- Future stage(s) would include the remaining major civil construction works from The Bays to Sydney CBD, rail systems fit-out, station fit-out and aboveground building construction, and operation of the metro line.

Sydney Metro is seeking a specific declaration for Sydney Metro West to be declared as State significant infrastructure and critical State significant infrastructure under sections 5.12(4) and 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), respectively.

This technical paper has been prepared for Stage 1 of Sydney Metro West to support the Environmental Impact Statement and to identify and assess the potential impacts of Stage 1 during construction, in relation to groundwater. In doing so, this technical paper responds directly to the Secretary's Environmental Assessment Requirements.

Groundwater impact assessment

A groundwater impact assessment was carried out through the review of background information and site data, and a subsequent groundwater modelling exercise. The modelling comprised water level drawdown assessment and water inflow/take prediction using two-dimensional models of each of the proposed construction sites using the software package SEEP/W (GeoSlope International Ltd).

The models were developed based on the definition design, regional hydrogeological data, and local geotechnical and hydrogeological data recorded as part of the Sydney Metro West site investigations. Groundwater level drawdown contours were developed based on the results of multiple model cross sections (i.e. cross sections and long sections through the station box, cavern and shaft excavations). A sensitivity analysis was carried out on the model parameters to assess the model's sensitivity to variation in the model parameter values. The sensitivity of these parameters was explored through increasing and decreasing the various parameter values and examining the effect these have on the results. Saline migration modelling was undertaken at locations where the potential risk of saline waters intruding into groundwater was identified.

Potential impacts were assessed by reviewing the predicted groundwater level drawdown due to Stage 1 against the locations and conditions of existing supply bores; groundwater dependent ecosystems; acid sulfate soils; and interpreted existing groundwater recharge, flow and surface water-groundwater behaviour.

The minimal harm criteria presented in the Aquifer Interference Policy (NSW Office of Water, 2012) is addressed with respect to each of these aspects. The two-metre drawdown contour was used to identify the limit of the minimal impact consideration (for groundwater level drawdown) of the *NSW Aquifer Interference Policy* (DPI Water, 2012).

A preliminary water balance assessment was also carried out for the construction period to assess water demand and rates of consumption.

Results

Groundwater impacts to water quality, groundwater level, inflows, acid sulfate soils, groundwater dependent ecosystems, groundwater users and groundwater-surface water interaction were reviewed and ranked from low to very high. The station box or shaft excavations at the Westmead, Parramatta, Clyde, Silverwater, Sydney Olympic Park, North Strathfield, Burwood North and The Bays station/services facilities construction sites were found to have a moderate or greater groundwater impact risk. This was assessed on the potential impact to environmental assets due to Stage 1 induced groundwater drawdown.

The model sensitivity analysis was carried out on the simulated drawdown and inflows relative to the station excavation at Burwood North Station construction site. The sensitivity analysis showed that the model is most sensitive to variation of hydraulic conductivity and only moderately sensitive to changes in specific yield/storage and rainfall infiltration.

The water balance assessment was carried out on a project-wide basis. The results of the assessment show that there is likely to be a demand for 369 ML per year, a supply of 940 ML per year (including groundwater inflow) and a likely discharge volume of 551 ML per year.

Licensing and compliance

Groundwater take as inflow was predicted using the model. The total inflow during Stage 1 is predicted to be up to 1,204 megalitres in the first year and up to 1,164 megalitres in the second year (total of 2,350 megalitres over both years). The inflows generated by Stage 1 would need to be assigned through an annual allocation of unassigned water under the Water Sharing Plan, or by purchasing an existing entitlement if there is insufficient unassigned water. There is currently about 43,353 megalitres per year that is unassigned under the long-term average annual extraction limit. Annual inflows for Stage 1 would be less than 5.4 per cent of the unassigned water.

Mitigation and management

Once all practicable steps to avoid or minimise impacts have been implemented at the detailed design phase (such as lining of excavations and tunnels), management measures would be implemented to monitor for potential impacts outside of those predicted.

The main risks due to potential groundwater impacts include: exposure of site users/workers to contaminated groundwater and potential reduction of the beneficial use of the aquifer, potential impact to groundwater dependent ecosystems, potential reduction in groundwater baseflow to waterways and potential impact to domestic supply (bores).

A monitoring program would be developed to assess the potential risks before, during and after the construction of Stage 1. As per the recommendations in this report, where possible, groundwater quality assessment would be undertaken in conjunction with any contamination site assessment.

Glossary of terms and abbreviations

Abbreviation / Acronym	Meaning
AEI	Area of Environmental Interest
AIP	NSW Aquifer Interference Policy
ASS	Acid sulfate soils
BOM	Bureau of Meteorology
BTEX	Benzene, toluene, ethylbenzene, xylenes
DPI	Department of Primary Industries
EC	Electrical conductivity
GDE	Groundwater dependent ecosystem
LTAAEL	Long-term average annual (groundwater) extraction limit
NEPM	National Environment Protection (Assessment of Site Contamination) Measure 1999
NWQMS	National Water Quality Management Strategy
OCP	Organochlorine pesticides
OPP	Organophosphate pesticides
PAH	Polycyclic aromatic hydrocarbons
PASS	Potential acid sulfate soils
PCB	Polychlorinated biphenyls
PFOS	Per- and poly-fluoroalkyl substances
SEARs	Secretary’s environmental assessment requirements
TRH	Total recoverable hydrocarbons
VWP	Vibrating Wire Piezometers
VOC	Volatile Organic Compounds

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1 Introduction

1.1 Sydney Metro West

Sydney Metro West is a critical step in the delivery of Future Transport Strategy 2056. It would provide fast, reliable and frequent rail service between Greater Parramatta and the Sydney CBD.

Sydney Metro (as 'the proponent') is seeking planning approvals as follows:

- Approval for the whole Sydney Metro West (at concept level) concurrent with Stage 1. Stage 1 involves the major civil construction works between Westmead and The Bays (and is the subject of this technical paper)
- Future stage(s) would include the remaining major civil construction works from The Bays to the Sydney CBD, rail systems fit-out, station fit-out and aboveground building construction, and operation of the metro line (future application(s)).

Sydney Metro is seeking a specific declaration for Sydney Metro West to be declared as State significant infrastructure and critical State significant infrastructure under sections 5.12(4) and 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), respectively.

1.1.1 Location

Sydney Metro West would mainly be located underground in twin tunnels. Stage 1, which is subject of this assessment, extends from Westmead to The Bays (refer to Figure 1-1).

1.1.2 Overview of Stage 1

The Stage 1 would involve the major civil construction work from Westmead to The Bays, including:

- Enabling works such as demolition, utility supply to construction sites, utility adjustments and modifications to the existing transport network
- Tunnel excavation including tunnel support activities
- Station excavation for new metro stations at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays
- Shaft excavation for services facilities at Rosehill (within the Clyde stabling and maintenance facility construction site), Silverwater and between Five Dock Station and The Bays Station construction sites
- Civil work for the stabling and maintenance facility at Clyde including earthworks and structures for crossings of A'Becketts Creek and Duck Creek
- A concrete segment facility for use during construction located at the Clyde stabling and maintenance facility construction site
- Excavation of a tunnel dive structure and associated tunnels at Rosehill to support a connection between the Clyde stabling and maintenance facility and the mainline metro tunnels.

Stage 1 is further described in Chapter 9 (Stage 1 description) of the Environmental Impact Statement.

The location of the services facility between Five Dock Station and The Bays Station is currently being investigated, and is not assessed within this technical paper. Further detail on the locational and design criteria that would be used as part of determining the preferred location is detailed in Chapter 9 (Stage 1 description) of the Environmental Impact Statement.

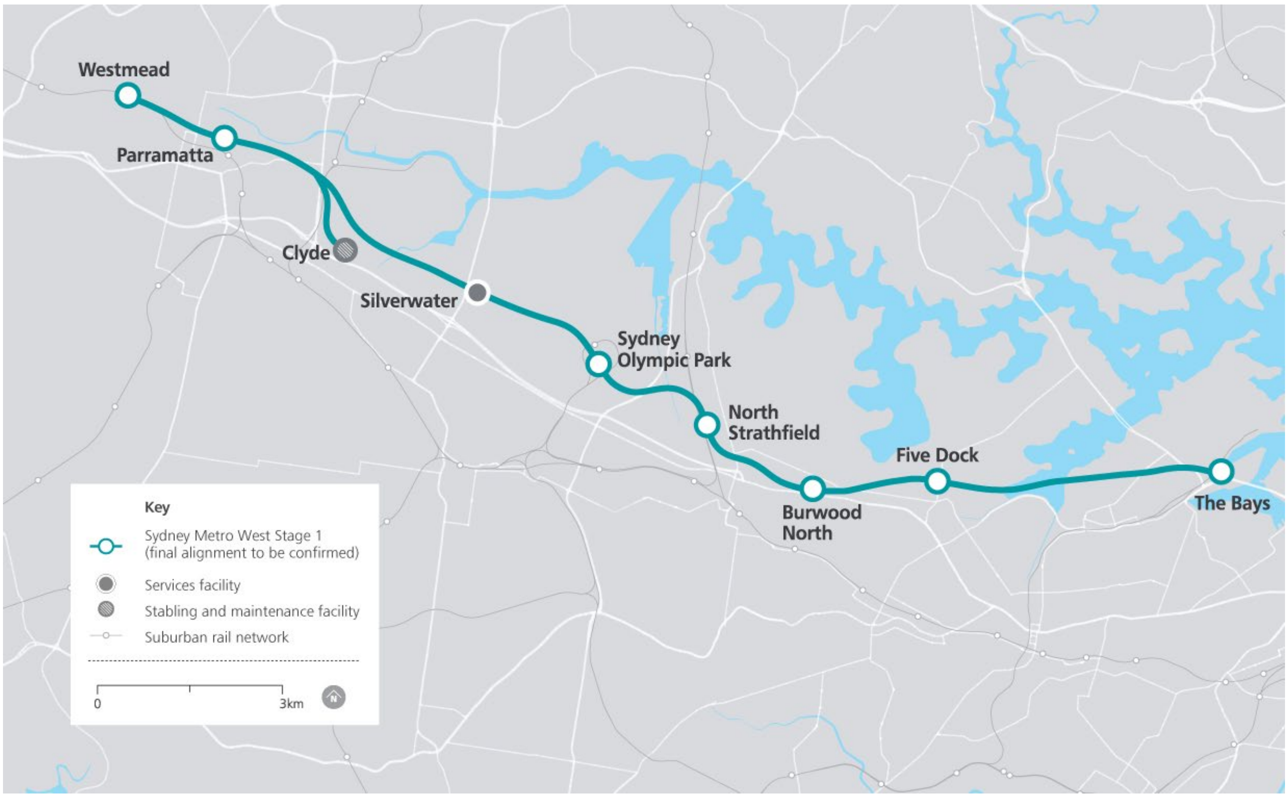

Figure 1-1: Sydney Metro West – Stage 1 overview

1.2 Purpose and scope of this report

This technical paper is one of a number of technical papers that form part of the Environmental Impact Statement for Stage 1. The purpose of this technical paper is to identify and assess the potential impacts of Stage 1 during construction, in relation to groundwater. In doing so, this technical paper responds directly to the Secretary's Environmental Assessment Requirements outlined in Section 1.3.

1.3 Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements where issued for Stage 1 on 11 December 2019. The requirements specific to groundwater and where these requirements are addressed in this technical paper are outlined in Table 1-1. Further, the Secretary's Environmental Assessment Requirements reference the investigations and assessments identified in the Sydney Metro West Scoping Report – Westmead to The Bays and Sydney CBD (Sydney Metro, 2019). Table 1-2 outlines where these requirements have been addressed.

Table 1-1: Secretary's Environmental Assessment Requirements – Water

Secretary's environmental assessment requirements	Where addressed
Water – Hydrology (including groundwater)	
1. The existing hydrological regime for any surface and groundwater resource (including mapping, the reliance by users, and for ecological purposes) likely to be impacted, including stream orders.	Section 4 Also refer to Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement
2. A water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration.	Section 5.13.4 Also refer to Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement
3. Requirements for baseline monitoring of hydrological attributes.	Section 7
4. The impact on surface and groundwater hydrology in accordance with the current guidelines, including: a. natural processes within rivers, wetlands, estuaries, marine waters and floodplains; b. impacts from any permanent and temporary interruption of groundwater flow; c. stormwater and wastewater management on natural hydrological attributes and the conveyance capacity of existing stormwater systems where discharges are proposed through such systems or details of alternative disposal options; and d. water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction.	Section 5 Also refer to Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement
5. Flood behaviour for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including: a. potential flood affectation of other properties, assets and infrastructure; b. consistency (or inconsistency) with applicable Council floodplain risk management plans; c. compatibility with the flood hazard of the land; and d. compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land.	Refer to Chapter 21 (Hydrology and flooding – Stage 1) of the Environmental Impact Statement

Secretary's environmental assessment requirements	Where addressed
Water – quality	
1. Surface and groundwater quality impacts including: a. identifying and estimating the discharge water quality and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment; b. identifying the rainfall event that the water quality protection measures will be designed to cope with; and c. assessing the significance of any identified impacts including consideration of the relevant ambient water quality outcomes.	Section 5 Also refer to Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement
2. Demonstrating how Stage 1 will, to the extent that the project can influence, ensure that: a. where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and b. where the NSW WQOs are not currently being met, activities will work toward their achievement over time; and c. justify, if required, why the WQOs cannot be maintained or achieved over time.	Refer to Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement

Table 1-2: Proposed investigations and assessments for groundwater, as identified in Sydney Metro West Scoping Report – Westmead to The Bays and Sydney CBD

Proposed investigations and assessment	Where addressed
Describe the aquifer system(s) traversed by Stage 1	Section 4
Identify existing groundwater levels along the alignment and near the stations and portals	Section 4.6.1
Identify sensitive groundwater receivers (registered groundwater bores)	Sections 4.6.2 and 4.8
Discuss the nature and extent of potential impacts on groundwater associated with construction and the ongoing presence of infrastructure including tunnels and station excavations. This would take into account existing groundwater levels, the geological context, the extent to which the infrastructure is 'tanked' (designed to inhibit the inflow of groundwater) and experience on other projects (including groundwater inflow rates)	Section 5
Identify potential impacts on groundwater quality	Section 5
Propose monitoring/management measures to address identified impacts	Section 7

2 Legislative and policy context

This chapter presents relevant regulation, legislation and policy governing management of groundwater and groundwater quality as it pertains to Stage 1.

2.1 Commonwealth Legislation

2.1.1 Commonwealth Environment Protection and Biodiversity Conservation Act

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prescribes the Commonwealth Government's role in environmental assessment, biodiversity conservation and the management of protected areas and species, population and communities and heritage items.

Approval from the Commonwealth Minister for the Environment is required for:

- An action which has, would have, or is likely to have a significant impact on 'matters of National Environmental Significance' (NES matters). The NES matter of most relevance to the groundwater assessment are the Ramsar wetlands of international importance
- An action by the Commonwealth or a Commonwealth agency which has, would have, or is likely to have a significant impact on the environment
- An action on Commonwealth land which has, would have, or is likely to have a significant impact on the environment
- An action which has, would have, or is likely to have a significant impact on the environment of Commonwealth land, no matter where it is to be carried out.

Impacts on groundwater due to Stage 1 may be relevant under the EPBC Act where groundwater is shown to support NES matters, such as wetlands or ecological communities.

2.1.2 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is the adopted national approach to protecting and improving water quality in Australia. It consists of a number of guideline documents, with specific documents relating to the protection of surface water and groundwater resources.

The primary document relevant to the assessment of groundwater risks for Stage 1 is the Guidelines for Groundwater Quality Protection in Australia (Australian Government, 2013). This document sets out a high-level risk-based approach to protecting or improving groundwater quality for a range of groundwater beneficial uses (called 'environmental values'). The beneficial uses are as follows:

- Aquatic ecosystems, comprising the animals, plants and micro-organisms that live in water, and the physical and chemical environment and climatic conditions with which they interact
- Primary industries, including irrigation and general water users, stock drinking water, aquaculture and human consumption of aquatic foods
- Recreation and aesthetic values, including recreational activities such as swimming and boating, and the aesthetic appeal of water bodies
- Drinking water, which is required to be safe to use and aesthetically pleasing

- Industrial water, such as water used for industrial processes including cooling towers, process water or wash water
- Cultural and spiritual values, which may relate to a range of uses and issues of a water source, particularly for indigenous people, including spiritual relationships, sacred sites, customary use, the plants and animals associated with water, drinking water or recreational activities.

Each beneficial use has a unique set of water quality criteria designed to protect the environmental value of the groundwater resource.

For the purposes of this assessment, 'environmental values' pertaining to aquatic ecosystems, primary industries, industrial water, and cultural values are considered potentially applicable. 'Environmental values' pertaining to drinking water are not applicable as the groundwater quality is generally not suitable for drinking water due to poor groundwater quality (see Section 4.7). The majority of creeks that Stage 1 passes beneath at depth, which may be fed by groundwater baseflow at times, have been identified as having visual amenity values. A few have also been identified as having primary or secondary contact recreation (e.g. Parramatta River).

Cultural values are not considered applicable as groundwater-related Aboriginal cultural heritage sites have not been identified in the vicinity of Stage 1. There are no high priority culturally significant sites listed in the schedule of the Water Sharing Plan.

The Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ, 2000) and Australian and New Zealand Governments and Australian state and territory governments (ANZG, 2018) are part of the NWQMS. Refer to Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement for more information.

2.2 NSW Legislation

2.2.1 Water Act 1912, Water Management Act 2000 and Water Management Regulation 2018

Water resources in NSW are administered under the *Water Act 1912* and the *Water Management Act 2000* by the NSW Department of Planning, Industry and Environment. The *Water Management Act* governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in NSW where Water Sharing Plans have commenced. The Water Sharing Plan for the Stage 1 area has commenced, and the area is therefore governed under the *Water Management Act 2000*.

In accordance with Section 5.23(1) of the EP&A Act, the following approvals, which may have otherwise been required to undertake Stage 1, would not be required for approved State significant infrastructure:

- Water use approval under Section 89 of the *Water Management Act 2000*
- Water management work approval (including a water supply works approval) under section 90 of the *Water Management Act*
- Activity approval under Section 91 of the *Water Management Act 2000*.

2.2.2 Water Sharing Plans

Water sharing plans, following the introduction of the *Water Management Act 2000*, provide the basis for equitable sharing of surface water and groundwater between water users, including the environment.

The majority of NSW is now covered by Water Sharing Plans. If an activity leads to a take from a groundwater or surface water source covered by a Water Sharing Plan, then an approval and / or licence is required. In general, the *Water Management Act 2000* requires:

- A water access licence to take water
- A water supply works approval to construct a work
- A water use approval to use the water.

Stage 1 lies within the Sydney Basin Central Groundwater Source. The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (the Water Sharing Plan) applies to the Sydney Basin Central Groundwater Source.

The Water Sharing Plan contains provisions for allocation of water to construction projects through a volume of 'unassigned water' or through the ability to purchase an entitlement where groundwater is available under the long-term average annual extraction limit (LTAAEL).

The LTAAEL for the Sydney Basin Central is 45,915 megalitres per year, which is 25 per cent of the estimated annual recharge for the area. Under the Water Sharing Plan, there are currently 120 groundwater access licences, with a total licensed volume of 2,592 megalitres per year. As such there is up to 43,323 megalitres per year of water available under the LTAAEL.

The Sydney Basin Central Groundwater Source is declared a Less Productive Groundwater Source by the NSW Office of Water (now WaterNSW). Therefore, Less Productive Minimal Impact Considerations of the NSW Aquifer Interference Policy apply with respect to Porous and Fractured Rock Water Sources. These are discussed in Section 6.2.

2.3 NSW Policy

2.3.1 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (AIP) (Office of Water, 2012) is a component of the NSW Strategic Regional Land Use Policy and was introduced in September 2012. The AIP defines the regime for protecting and managing impacts of aquifer interference activities on NSW's water resources and strikes a balance between the water needs of towns, farmers, industry and the environment. It clarifies the requirements for obtaining groundwater extraction licences and the assessment process under the *Water Management Act 2000*.

The *Water Management Act 2000* defines a number of aquifer interference activities including penetration of, interference with, and obstruction of water flow within, an aquifer. Taking and disposing of groundwater from an aquifer are also defined as being aquifer interference activities.

The AIP refers to the beneficial use of an aquifer, which is outlined in the National Water Quality Management Strategy (NWQMS, 2013). Within the management strategy the term beneficial use is replaced with environmental value (as discussed in 2.1.2). The AIP also requires that for an aquifer interference activity to meet the minimal impact considerations, any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.

Groundwater along the alignment is likely to be used by aquatic ecosystems, and primary industries to account for small-scale domestic use of groundwater. However, this varies locally depending on ambient groundwater conditions.

The AIP also provides a framework for assessing the impacts of aquifer interference activities on water resources. To assess potential impacts, groundwater sources are categorised as either highly productive or less productive, with sub-categories for alluvial, coastal sands, porous rock, and fractured rock aquifers. For each category, there are a number of prescribed minimal impact considerations relating to watertable and groundwater pressure drawdown, and changes to groundwater and surface water quality. These are discussed in Section 6.2 for the relevant groundwater sources potentially impacted by Stage 1.

2.3.2 NSW Water Quality Objectives

The NSW Government has developed Water Quality Objectives that are consistent with the National Water Quality Management Strategy, and in particular, with the ANZECC (2019) guidelines for fresh and marine water quality. The water quality objectives relate to fresh and estuarine surface waters. Groundwater quality must therefore be maintained to a level that does not degrade any receiving surface water environments. Further discussion of these guidelines is included in Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement.

2.3.3 NSW Groundwater Dependent Ecosystems Policy

Stage 1 has the potential to impact Groundwater Dependent Ecosystems by reducing the potential groundwater that is accessible to those ecosystems.

The NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation, 2002) implements the *Water Management Act 2000* by providing guidance on the protection and management of Groundwater Dependent Ecosystems. It sets out management objectives and principles to:

- Ensure that the most vulnerable and valuable ecosystems are protected
- Manage groundwater extraction within defined limits thereby providing groundwater flow sufficient to sustain ecological processes and maintain biodiversity
- Ensure that sufficient groundwater of suitable quality is available to ecosystems when needed
- Ensure that the precautionary principle is applied to protect groundwater dependent ecosystems, particularly the dynamics of flow and availability and the species reliant on these attributes
- Ensure that land use activities aim to minimise adverse impacts on groundwater dependent ecosystems.

3 Assessment methodology

3.1 General

The Stage 1 components that would interface specifically with groundwater include:

- Tunnel excavation between Westmead and The Bays
- Station excavation for new metro stations at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays
- Shaft excavation for services facilities at Rosehill and Silverwater
- Excavation of a tunnel dive structure and associated tunnels at Rosehill to support a connection between the stabling and maintenance facility and the mainline metro tunnels

Stage 1 excavations would cause groundwater inflows to the excavations, and associated groundwater level drawdown. This has the potential to cause the oxidation of acid sulfate soils (if present) and ground movement, as well as impacts to groundwater quality, groundwater dependent ecosystems, groundwater users and surface water-groundwater interaction.

Minor short-term dewatering may be required for the construction of power supply routes. It is anticipated that the groundwater inflow to excavations for power supply routes would generally be relatively minor (if at all) compared to those experienced by the station or shaft excavations. Dewatering for power supply routes is therefore not likely to cause impacts to groundwater beyond those impacts discussed above relating to station/service facility excavations.

The assessment of potential groundwater-related impacts arising from Stage 1 has been carried out as follows:

- Characterisation of the existing environment including climate; topography; geology; groundwater occurrence, quality and use; existing groundwater users and groundwater dependent ecosystems
- Groundwater modelling to assess the potential groundwater inflows to excavations and associated groundwater level drawdown
- Assessment of the potential groundwater-related impacts listed above based on the modelling results, to satisfy the minimal impact considerations of the Aquifer Interference Policy, and address groundwater related issues raised in the Secretary's Environmental Assessment Requirements
- Recommendations for monitoring and management of identified impacts and risks, including management and mitigation measures as appropriate.

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

A preliminary water balance assessment was also carried out. The assessment considers water demand and rates of consumption for Stage 1.

3.2 Desktop assessment

The desktop assessment involved a review of the existing groundwater environment in proximity to the Stage 1 alignment and construction sites, to assess the potential impacts of Stage 1 on groundwater during construction.

The following data were collected to inform existing groundwater conditions across Stage 1 area:

- WaterNSW's groundwater bore database (https://realtimedata.waternsw.com.au/) (accessed March 2019)
- The Water Register (http://www.water.nsw.gov.au/water-licensing/registers) for data on existing groundwater users, including Water Access Licence (WAL) holders and stock and domestic users (accessed June 2019)
- The Bureau of Meteorology (BOM) Groundwater Dependent Ecosystems Atlas (http://www.bom.gov.au/water/groundwater/gde/) to identify the location of groundwater-dependent surface water systems and vegetation (accessed November 2018)

Publicly available maps were also used, including geological maps, topography and drainage maps, and soil maps.

3.3 Site investigation information

Site investigations for Sydney Metro West included construction of 55 monitoring piezometers. Vibrating Wire Piezometers (VWP) were installed in 12 boreholes.

Continuous groundwater monitoring is reported for 59 piezometers and VWP for variable lengths of time (depending on location) between June 2018 and January 2019.

3.4 Groundwater modelling

Groundwater modelling has been carried out to support the Environmental Impact Statement.

Models were developed for each Stage 1 construction site in the software package SEEP/W developed by GeoSlope International Ltd. The models considered the following sites:

- Westmead metro station
- Parramatta metro station
- Clyde stabling and maintenance facility construction site, which contains the Rosehill dive structure and services facility shaft (separate models/sites for the dive and shaft)
- Silverwater services facility
- Sydney Olympic Park metro station
- North Strathfield metro station
- Burwood North Station
- Five Dock Station
- The Bays Station.

The models were developed based on the definition design, regional hydrogeological data, and local geotechnical and hydrogeological data recorded as part of the Sydney Metro West site investigations. Modelling assumptions are discussed in Section 5.2.1.

Groundwater level drawdown contours were developed based on the results of multiple model cross sections (i.e. cross sections and long sections through station box, cavern and shaft excavations).

The two-metre drawdown contour represents the minimal impact consideration (for groundwater level drawdown) of the NSW Aquifer Interference Policy (DPI Water, 2012).

3.5 Impact assessment

The modelling results, combined with hydrogeological interpretation, have been applied to assess potential groundwater impacts relating to Stage 1.

The models were used to estimate:

- Groundwater inflows to excavations and station/services facility excavations
- Groundwater level drawdown associated with construction

Potential impacts are assessed by reviewing the predicted groundwater level drawdown due to Stage 1 against the locations and conditions of existing supply bores; groundwater dependent ecosystems; acid sulfate soils; and interpreted existing groundwater recharge, flow and surface water-groundwater behaviour.

The minimal harm criteria presented in the Aquifer Interference Policy (NSW Office of Water, 2012) is addressed with respect to each of these aspects.

4 Existing environment

The existing environment has been characterised based on a desktop review of publicly available information, as well as the results of field investigations specifically completed for Sydney Metro West.

The conceptualisation of the existing geology and hydrogeology relates to the geological setting and groundwater systems that Stage 1 is situated within, the boundaries of which extend beyond the Stage 1 footprint.

The purpose of this information is to:

- Understand the existing groundwater regime within which Stage 1 would be implemented
- Understand the physical controls on groundwater flow
- Identify potential receptors that may be impacted by changed groundwater conditions.

4.1 Topography

Stage 1 falls within the catchment of the Parramatta River and Sydney Harbour. The catchment lies in the Cumberland Plain and is relatively flat, with elevations ranging from 140 metres AHD in the north-west of the catchment to sea level in the east. Most of the waterways are urbanised coastal areas. Some waterways have tidal sections.

4.2 Climate

Review of the Bureau of Meteorology (BOM) rainfall and temperature data for the Parramatta River and Sydney Olympic Park weather stations indicates that the mean monthly rainfall within the study area ranges between 51 millimetres in September and 110 millimetres in February, with mean annual rainfall of about 914 millimetres. Mean monthly maximum temperatures range from 17.6°C in July to 28.4°C in January, and mean minimum monthly temperatures range from 7.8°C in July to 19.4°C in February.

Rainfall that infiltrates into the ground contributes to groundwater.

4.3 Geology

Information obtained as part of site investigations for Sydney Metro West, and desktop review of the Department of Mineral Resources 1:100,000 Geological Sheet 9030 for Parramatta (Herbet and Smith, 1991) and the 1:100,000 Geological Sheet 9130 for Sydney (Herbet, 1983), indicate that the geological units in the region of the Stage 1 include, in order of youngest to oldest:

- Fill
- Quaternary deposits
- Ashfield Shale
- Mittagong Formation
- Hawkesbury Sandstone

Details of these units are summarised in the following sections. Figure 4-1 presents the distribution of geological units along the alignment of Stage 1.

The geological long section is presented in Appendix A.

The geology of the alignment is dominated by Triassic-Age Ashfield Shale of the Wianamatta Group. The alignment is crossed by Triassic-Age Hawkesbury Sandstone of the Wianamatta Group; Quaternary Age alluvial/fluvial sediments comprising sand, silt and clay; and fill.

A number of structural features, including faults, dykes and joint swarms, have been identified and inferred.

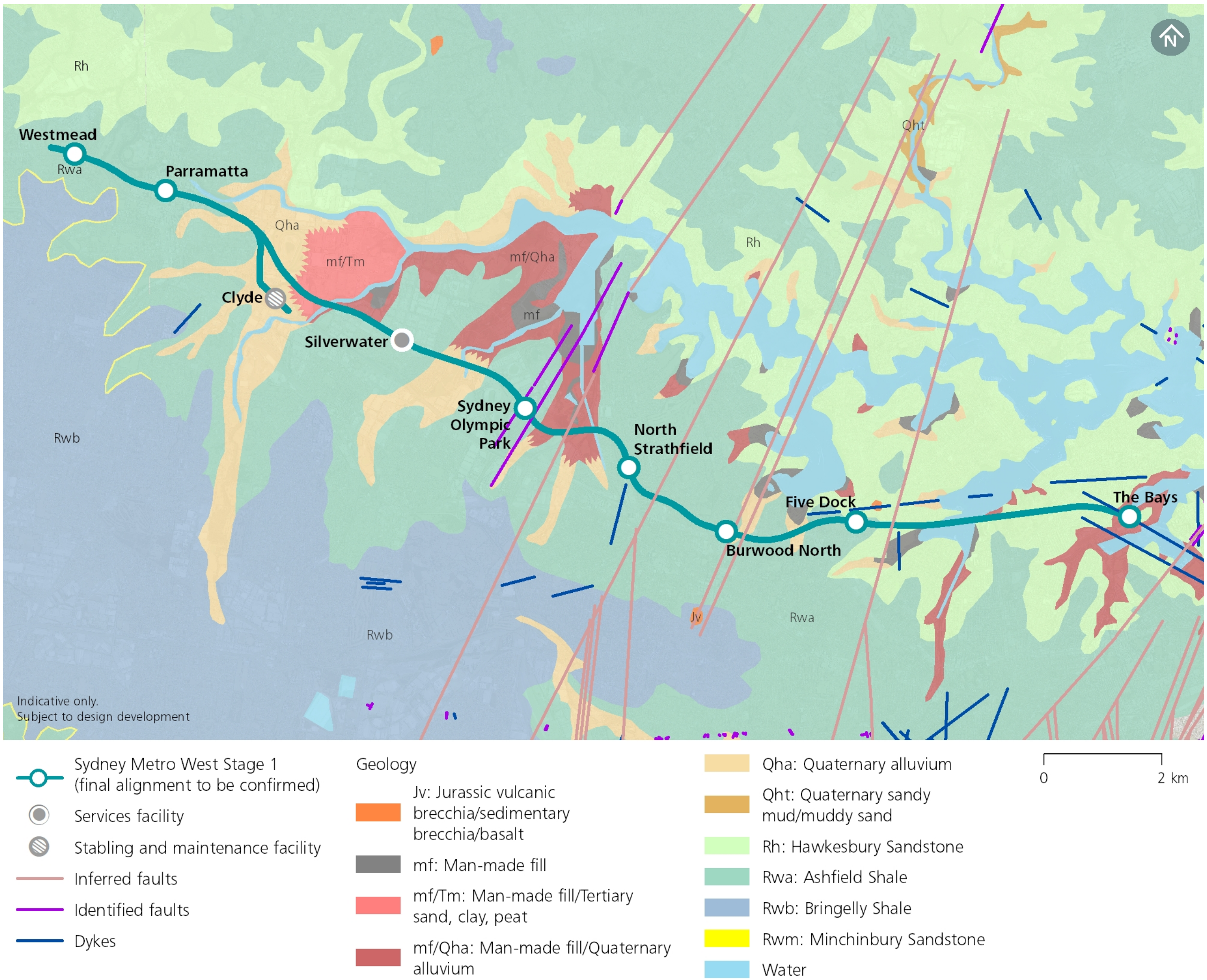

Figure 4-1: Geology along Stage 1 alignment

4.3.1 Fill

In general, a thin layer of fill (less than one metre thick) is commonly encountered in urban areas and is associated with minor modifications to the topography, landscaping and pavement construction. Such fill can be highly variable in composition and consistency.

Reclaimed land areas are generally located next to the harbour and include parkland, residential, industrial, and open space areas.

Thicker deposits of fill are expected towards the mouths of the infilled channels, associated with land reclamation, back-filled quarries, landfills, stream capture and urban development in these areas.

Significant infilled areas are present at Rosehill, Silverwater, Sydney Olympic Park and The Bays.

4.3.2 Quaternary deposits

Undifferentiated, Holocene- and Pleistocene-age alluvial, estuarine and marine sediments have been deposited in gullies, valleys, and former drainage channels. These sediments comprise interbedded sands and clays with discontinuous “inter-fingered” lenses of the same material. Pleistocene-age, marine sediments comprise typically clayey sediments with intermittent sand lenses.

The occurrence of infilled palaeochannels or palaeovalleys is generally limited to harbour areas and drainage channels in their vicinity. Experience from previous tunnel projects in Sydney indicates that identification of palaeovalleys is critical to tunnel design, because the rock mass beneath palaeovalleys is often more structurally complex, and rock permeability may be locally high due to valley stress relief and/or the presence of faults and dykes. Palaeovalley geometry along the Stage 1 alignment is variable and generally increases in width and depth towards the palaeovalley axes.

4.3.3 Ashfield Shale

The Middle-Triassic Ashfield Shale comprises black to dark grey shale and laminate of four variably thick sub-units. The thickness of the unit ranges between less than one metre and 50 metres. At some locations, the shale may become carbonaceous, with variable silt and clay particles present. The unit is laminated, although it retains bedding planes at some locations.

4.3.4 Mittagong Formation

The Middle-Triassic Mittagong Formation consists of alternating siltstone and sandstone laminae. The shale beds are very similar to the Ashfield Shale; however, the unit is typically no more than 0.5 metres thick while the sandstone beds are up to five metres thick and are fine to medium grained.

The Mittagong Formation consists of alternating siltstone and sandstone laminae. The shale beds are very similar to the Ashfield Shale, though it is typically no more than 0.5 metres thick while the sandstone beds are up to five metres thick and are fine to medium grained.

4.3.5 Hawkesbury Sandstone

The Middle-Triassic Hawkesbury Sandstone was deposited in a fluvial paleo-environment, likely to have been a braided river setting, and as such it is highly stratified. It is ubiquitous across the Sydney Basin and is up to some 300 metres thick.

Hawkesbury Sandstone is often described as a medium to coarse grained and consists of three main depositional environments: massive sandstone facies, cross-bedded or sheet facies, and shale/siltstone interbedded facies.

4.3.6 Structural geology

The rock structures or discontinuities in the Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone typically include:

- Sub-horizontal bedding, with typical bedding partings that are either tight and sub-horizontal with dips of between zero degrees and 10 degrees, or parallel to cross bedded with dips of between 15 degrees and 40 degrees. Bedding partings in the shale are typically planar and have extremely weathered seams with clay veneers, and open bedding partings in the sandstone have a variety of infills including clay seams, crushed seams, silty interbeds or coatings
- Sub-vertical jointing or joint swarms. Two dominant orthogonal joint sets exist, with north northeast and east southeast strikes. Joint spacing varies depending on topography, proximity to weathered zones and major geological structures, but is typically greater than six metres in the Ashfield Shale and Mittagong Formation, with localised moderately spaced (0.06 metres to 0.2 metres) joints grading to into fractured rock zones. Joint spacing is typically between two metres and six metres in the Hawkesbury Sandstone, but can be up to 25 metre spacing, with closer spacing of 0.1 metres to 0.5 metres associated with local joint swarms
- Decomposed zones/seams
- Crushed zones/seams and shear zones
- Sub-vertical igneous intrusions (dykes) and associated jointing
- Buried valleys (palaeovalleys).

Both identified and inferred major sub-vertical faults, and identified dykes, are shown in Figure 4-1. Rock permeability may be higher in the vicinity of faults and therefore result in potentially higher groundwater inflows to Stage 1 excavations in their vicinity. Fault zones generally present as joint swarms or brecciated zones. These structural features have been recorded at numerous locations within the Sydney Basin and are generally continuous, mappable and relatively predictable, although not always uniformly linear across the Sydney region.

Faults and joints can act as conduits to groundwater flow; however, faults may also act as barriers to groundwater flow. Increased groundwater inflows may be experienced during excavation where faults act as conduits to flow, with consequent depressurisation of the unit in the vicinity of the excavation. Excavation itself can enhance the inherent permeability of joints or brecciated zones through stress relief and dilation.

Identified and inferred faults cross the tunnel alignment to the south and east, respectively, of Sydney Olympic Park metro station construction site. Inferred faults cross the tunnel alignment to the south of North Strathfield metro station and Burwood North Station construction sites. It is possible that unidentified fault and joint swarms could be encountered during excavation. It is also possible that rock permeability in the vicinity of these (potential) faults and joints could be higher than elsewhere.

4.3.7 Dykes

Dykes crossing the Stage 1 alignment and in proximity to the Stage 1 construction sites are typically doleritic intrusions through the shale and sandstone formations. The dyke orientations are generally consistent with the dominant structural orientations, and typically strike in two dominant directions: either between azimuth 090 and 120 (north-northeast) or between azimuth 005 degrees and 035 degrees north (east-southeast).

The dykes are of variable dimensions, and typically range from less than three metres to over ten metres wide. The dyke rock type is susceptible to weathering and the dykes often possess a sub-vertical weathered zone, where the rock has degraded to soft clay (as well as exhibiting complete weathering to a white and green kaolinite clay near ground surface). Partly for this reason, these dykes typically act as a hydraulic barrier perpendicular to their orientation, potentially acting as a groundwater flow divide.

Dykes can also have elevated permeability parallel to strike, resulting from jointing and alteration related to the original intrusion and subsequent weathering. As such, they can present a risk to tunnelling. If unmanaged, tunnelling through a dyke can result in significant groundwater flow and depressurisation of the surrounding groundwater system. Dykes may also provide a conduit for higher groundwater inflows, especially when in proximity to open water bodies.

The intrusion of dykes can cause metamorphism of the host rock due to the high temperature of the intruding material. This can cause the host rock immediately adjacent the intrusion to increase in strength, or it can result in increased fracturing at the contact zone.

An observed fault is interpreted to intersect the station box for the Sydney Olympic Park metro station, and an inferred fault is interpreted to intersect Burwood North Station construction site. Inferred dykes may intersect North Strathfield metro station and The Bays Station construction sites.

An inferred dyke comes in close proximity to the tunnel alignment to the east of Five Dock Station construction site.

It is possible that unidentified dykes/dyke, fault and joint swarms could be encountered during excavation. It is also possible that rock permeability in the vicinity of these (potential) faults and dykes/dyke swarms could be higher than elsewhere.

4.3.8 Geology in the vicinity of construction sites and the alignment

Table 4-1 summarises the geological conditions at each of the Stage 1 construction sites and along the alignment.

Table 4-1: Geological conditions at construction sites

Construction site	Geological conditions (in order of depth from surface metres Below Ground Level (BGL))
Westmead metro station	Alluvial/residual clay (0 to 2 m BGL) Ashfield Shale (2 to 45 m BGL) Hawkesbury Sandstone (+45 m BGL)
Parramatta metro station	Alluvial/residual clay and fluvial sand (0 to 16 m BGL) Ashfield Shale (16 to 19 m BGL) Hawkesbury Sandstone (+19 m BGL)

Construction site	Geological conditions (in order of depth from surface metres Below Ground Level (BGL))
Silverwater services facility	Fill (0 to 1 m BGL) Alluvial/fluvial sand, clay, peat (1 to 5 m BGL) Ashfield Shale (5 to 30 m BGL) Hawkesbury Sandstone (+30 m BGL)
Clyde stabling and maintenance facility (shaft)	Fill (0 to 1 m BGL) Alluvial/residual clay and fluvial sand (1 to 13 m BGL) Ashfield Shale (13 to 28 m BGL) Hawkesbury Sandstone (+28 m BGL)
Sydney Olympic Park metro station	Fill/alluvial/residual clay (0 to 2 m BGL) Ashfield Shale (2 to 45 m BGL) Hawkesbury Sandstone (+45 m BGL) Inferred fault
North Strathfield metro station	Alluvial/residual clay (0 to 2 m BGL) Ashfield Shale (2 to 34 m BGL) Hawkesbury Sandstone (+34 m BGL) Possible dyke
Burwood North Station	Alluvial/residual clay (0 to 2 m BGL) Ashfield Shale (2 to 22 m BGL) Hawkesbury Sandstone (+22 m BGL) Inferred fault
Five Dock Station	Alluvial/residual clay (0 to 4 m BGL) Ashfield Shale (4 to 13 m BGL) Hawkesbury Sandstone (+13 m BGL)
The Bays Station	Fill (0 to 4 m BGL) Alluvial/fluvial sand and clay (4 to 16 m BGL) Hawkesbury Sandstone (+16 m BGL) Dyke, inferred fault

4.4 Acid sulfate soils

Acid sulfate soils (ASS) are naturally occurring soils, commonly associated with low lying areas of fine grained sediments and typically occurring in lacustrine, estuarine, or swamp environments. Sediment accumulations within the harbours would also have an elevated risk of ASS. For acid sulfate soils to exist, the soils need to be saturated (anoxic) and contain sulfide minerals, the most common of which is pyrite. Potential acid sulfate soils (PASS) are water-saturated soils, rich in iron sulphide minerals, that have not yet been oxidised.

Groundwater level drawdown associated with construction excavation has the potential to de-saturate acid sulfate soils. Disturbance of (P)ASS and exposure of the sulphide minerals to oxygen through de-saturation of the soils, results in sulfide oxidation and subsequent acidification of the soil and potentially groundwater that can cause environmental impact. Acidification of groundwater can result in the mobilisation of heavy metals previously bound in the formation. Potential impacts of acidification and mobilisation of heavy metals include:

- Increased toxicity and loss of biodiversity in wetlands and waterways
- Groundwater contamination
- Reduced agricultural productivity
- Corrosion of concrete and steel infrastructure
- Discoloration of soil and groundwater seepage.

Management of ASS and PASS involves preventing the minerals from oxidising, or neutralising the acid released from oxidised soils by mixing those soils with a neutralising agent (generally lime).

Acid drainage can also occur from rock formations that contain sulfide minerals, such as are likely to be present in the black shale units of the Ashfield Shale, and possibly in some finer grained units of the Hawkesbury Sandstone.

(P)ASS risk maps from the former Office of Environment and Heritage (now part of NSW Department of Planning, Industry and Environment [DPIE]) were reviewed to assess the probability of ASS being present in proximity to the Stage 1 alignment and construction sites. The ASS risk maps classify the risk of encountering ASS. (P)ASS risks along the Stage 1 alignment are presented in Figure 4-2.

Figure 4-2 shows that a large part of the Stage 1 alignment passes through areas where ASS is unlikely to occur. These areas are typically on elevated ground at distance from shorelines and drainage lines. In areas around the Parramatta River, Rosehill, Silverwater, Sydney Olympic Park and White Bay are identified as “disturbed terrain” or Quaternary sediments which comprises areas of reclaimed land or dredged/mined areas, with the potential presence of acid sulfate soils. These areas are associated with fill and/or alluvium that extends from harbour shores up local drainage lines and may be at risk of impacts from ASS due to potential dewatering/depressurisation associated with the excavation.

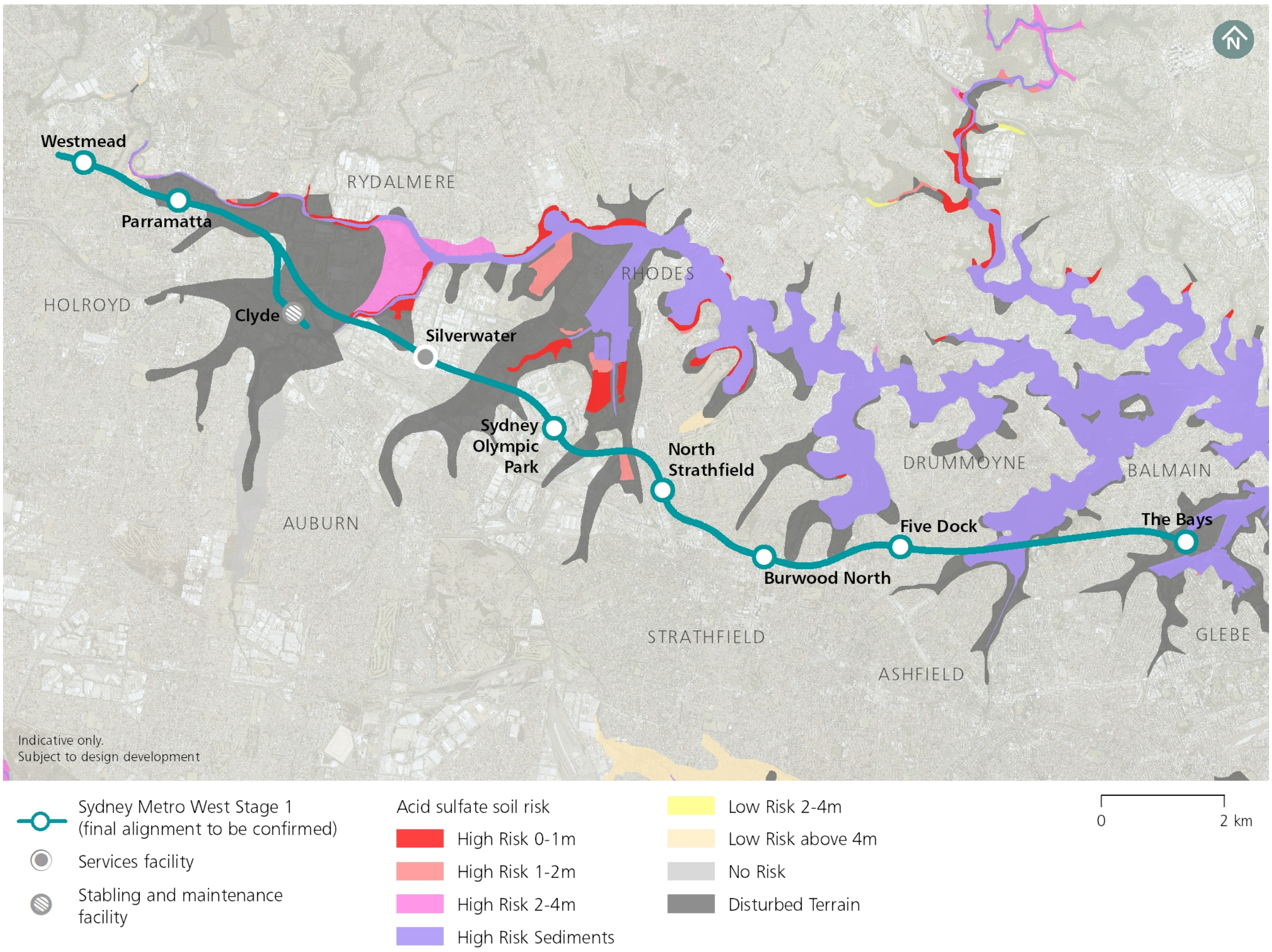

Figure 4-2: Acid sulfate soils risk along the Stage 1 alignment

4.5 Salinity

Changes that occur to the groundwater system due to the construction of the tunnel and station excavations may cause salinity impacts. Salinity impacts may include locally severe salt scalding across landscape elements, damage to buildings and infrastructure, fluvial and sheet erosion, high in-stream salinity, localised water-logging, flood hazard, and a potential decline in water quality.

Public salinity risk information is limited for the Stage 1 area. The spatial information system, eSPADE, managed by the former NSW Office of Environment and Heritage (2019b) presents public soil and land information in the NSW Soil and Land Information System (SALIS). The SALIS hydrogeology landscapes / salinity data is limited to west of Sydney Olympic Park. Areas to the west of Sydney Olympic Park metro station construction site is mapped as being high; specifically, the overall salinity hazard is reported as high between Westmead and Parramatta, and very high between Parramatta and Sydney Olympic Park.

The NSW Department of Primary Industries (Winkler et al, 2012) reports very high salinity hazard west of Burwood North Station construction site. Whereas, high to very high salinity hazard is reported for elevated areas east of Burwood North Station construction site and very low risk is reported for areas at lower elevation.

4.6 Groundwater

4.6.1 Groundwater levels

Groundwater is known to occur in the soil profile and within the fractured/porous rock along the alignment. Available data from site investigations for Sydney Metro West indicate that groundwater levels in the soils along the alignment are generally shallow (typically between one metre and five metres below ground surface).

Where adjacent piezometers are screened separately in soil and rock horizons, the data indicates that there is generally hydraulic connection between the soil and rock aquifers. At some locations a perched watertable may be present within the soils, due to a separation caused by the low conductivity of the soil profile.

Table 4-2 presents typical groundwater levels in metres Australian Height Datum (AHD) in the vicinity of the alignment based on site investigation data obtained for Sydney Metro West. Data are limited at many locations, and the typical levels listed may not represent groundwater levels in the immediate vicinity of the station/facility structure.

Table 4-2: Groundwater levels in the vicinity of construction sites

Construction site	Typical groundwater level in the vicinity of the construction site (m AHD)	Typical groundwater level in the vicinity of the construction site* (metres below ground surface)
Westmead metro station	33	3
Parramatta metro station	4	6
Clyde stabling and maintenance facility	3 (assumed at the shaft) 7 (assumed at the dive portal)	3 5
Silverwater services facility	5	1
Sydney Olympic Park metro station	12	12
North Strathfield metro station	15	5
Burwood North Station	4	12
Five Dock Station	16 to 18	2
The Bays Station	2	2

*Average/typical values based on available data and average ground surface elevation. Depth to groundwater will vary depending on topography.

4.6.2 Groundwater extraction

Groundwater bores recorded in WaterNSW's groundwater bore database were reviewed (March 2019). Details of the registered bores are shown in Figure 4-3.

Details of bores located within the predicted groundwater level drawdown zone of influence during construction (see Section 5) are summarised in Table 4-3, along with their licence number.

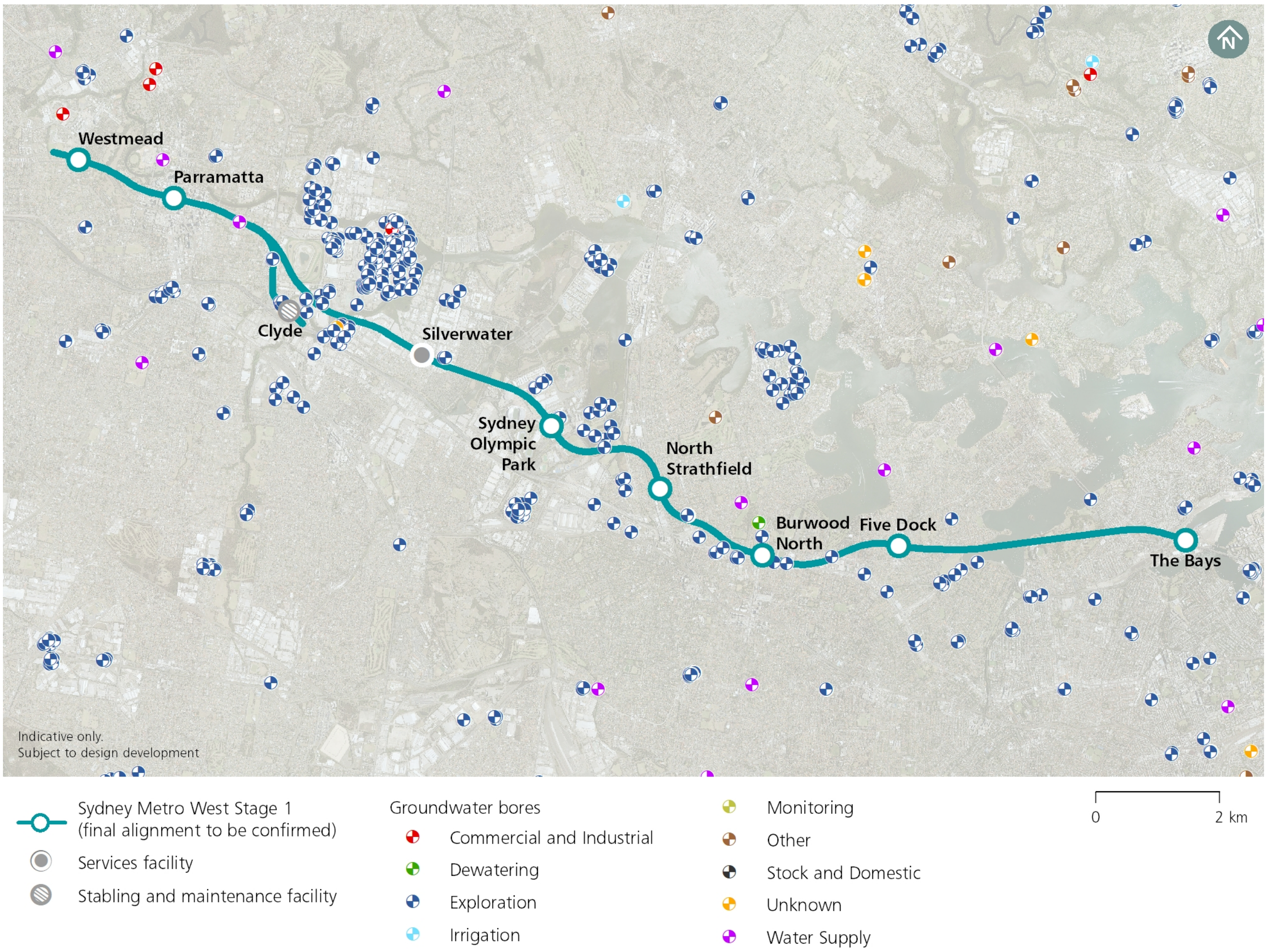

Figure 4-3: WaterNSW-registered groundwater bores along the Stage 1 alignment

Table 4-3: Status of water works approvals within the groundwater level drawdown zone of influence

Construction site	Bore ID	Bore purpose	Bore installation year	MGA Easting	MGA Northing	*Water Act 1912* licence number
Westmead metro station	GW108378	Industrial	2006	313516	6257945	10BL165559, 10BL602047, 10WA109505
Clyde stabling and maintenance facility	GW104256	Monitoring	1995	317813	6255054	10BL160114
	GW104257	Monitoring	1995	317819	6255068	10BL160114
	GW104258	Monitoring	1995	317823	6255093	10BL160114
	GW104951	Monitoring	2002	317712	6254884	10BL160497
	GW104952	Monitoring	2002	317682	6255018	10BL160497
	GW107978	Monitoring	2005	316898	6255613	10BL162924, 10BL601779
	GW107979	Monitoring	2005	316897	6255605	10BL162924, 10BL601779
	GW107980	Monitoring	2005	316904	6255603	10BL162924, 10BL601779
	GW107981	Monitoring	2005	316900	6255599	10BL162924, 10BL601779
	GW107982	Monitoring	2005	316903	6255596	10BL162924, 10BL601779
	GW107983	Monitoring	2005	316893	6255589	10BL162924, 10BL601779
Sydney Olympic Park metro station	GW111341	Monitoring	2010	321544	6253031	10BL604349
	GW111342	Monitoring	2010	321547	6253037	10BL604349
	GW111343	Monitoring	2010	321540	6253040	10BL604349

Construction site	Bore ID	Bore purpose	Bore installation year	MGA Easting	MGA Northing	*Water Act 1912* licence number
Burwood North Station	GW102215	Dewatering	1999	324765	6251338	10BL157754
	GW105170	Monitoring	2002	324089	6250844	10BL161851
	GW105171	Monitoring	2002	324092	6250853	10BL161851
	GW105172	Monitoring	2002	324082	6250860	10BL161851
	GW105173	Monitoring	2002	324056	6250851	10BL161851
	GW112138	Monitoring	2003	323806	6251098	10BL160939
	GW112139	Monitoring	2002	324194	6250925	10BL160939
	GW112140	Monitoring	2003	324820	6251116	10BL160939
	GW112141	Monitoring	2002	325215	6250679	10BL160939
	GW112142	Monitoring	2002	325949	6250783	10BL160939
	GW112634	Monitoring	2009	324436	6250769	10BL603209
	GW112635	Monitoring	2009	324408	6250763	10BL603209
	GW112636	Monitoring	2009	324405	6250783	10BL603209
	GW114577	Monitoring	2011	325013	6250693	10BL604460
	GW305646	Water Supply	2003	324481	6251658	30BL181321
Five Dock Station	GW112143	Monitoring	2002	326478	6250502	10BL160939

4.6.3 Surface water-groundwater interaction

Interaction between groundwater and surface water along the alignment is generally expected to be limited to:

- Likely surface water infiltration that contributes to groundwater
- Discharge from groundwater to surface watercourses and waterbodies, especially in low lying areas or deeply incised channels
- Leakage from surface watercourses to groundwater.

There is potential for groundwater to contribute to streamflow (baseflow) and surface water bodies in low lying areas or deeply incised channels.

Table 4-4 lists the watercourses and water bodies identified in proximity to Stage 1 construction sites which have the potential for groundwater to contribute to baseflow. However, where the portions of these watercourses are lined, they would be unlikely to have a connection with the groundwater system.

Table 4-4: Drainage lines and water bodies within approximately 1.5 kilometres of station and services facility construction sites

Construction site	Drainage line / Waterbody	Approximate distance from site (metres)
Westmead metro station	Parramatta River Toongabbie Creek Domain Creek Finlaysons Creek	250 1,250 250 1,000
Parramatta metro station	Parramatta River Clay Cliff Creek	250 1500
Clyde stabling and maintenance facility	Duck River	Less than 100
Silverwater services facility	Duck River	1,000
Sydney Olympic Park metro station	Haslams Creek Powells Creek Saleyards Creek Associated water bodies (Lake Belvedere, Bennelong Pond) Bicentennial Park Wetlands Newington Wetlands	900 1,000 350 350 500 1,500
North Strathfield metro station	Powells Creek Saltwater Creek	400 600
Burwood North Station	St Lukes Park Canal Saltwater Creek	500 1,400
Five Dock Station	Iron Cove Creek Parramatta River / neighbouring bays	600 600
The Bays Station	Whites Creek Parramatta River /White Bay	550 50

4.7 Groundwater quality

4.7.1 Typical quality

The quality of groundwater within the Ashfield Shale is typically brackish to saline, and acidic to near-neutral. The salinity typically ranges between about 2,000 milligrams per litre and 20,000 milligrams per litre as total dissolved solids, and pH ranges between about 4 and 8.

The quality of groundwater within the Mittagong Formation and Hawkesbury Sandstone is typically fresh to brackish with near-neutral pH and elevated metals concentrations, particularly for iron and manganese.

The salinity of the Mittagong Formation regionally is typically between about 250 milligrams per litre and 350 milligrams per litre as total dissolved solids, and pH ranges between about 4.5 and 8. Generally, groundwater from this unit is sodium-chloride or sodium-chloride-sulfate type water.

The quality of groundwater within the Hawkesbury Sandstone regionally is typically of low to moderate salinity, with electrical conductivity ranging between 500 microSiemens per centimetre and 2,000 microSiemens per centimetre (about 300 milligrams per litre to 1,400 milligrams per litre as total dissolved solids), and pH values generally between 4.5 and 8. Generally, groundwater from this unit is a sodium-chloride type water, and high in iron.

Where Ashfield Shale overlies Hawkesbury Sandstone, the quality of groundwater within the Hawkesbury Sandstone is often influenced by the overlying unit and the groundwater is generally of a higher salinity leading to elevated salinity within the groundwater in the Hawkesbury Sandstone.

Organic compounds are not naturally associated with Ashfield Shale, Mittagong Formation or Hawkesbury Sandstone.

The quality of groundwater within the residual and alluvial soils that overlie the Ashfield Shale and Hawkesbury Sandstone is typically fresh to brackish, and may be saline in close proximity to salt water bodies. It typically has near-neutral to slightly acidic pH and metals concentrations generally lower than those in the underlying bedrock.

4.7.2 Project specific quality

4.7.2.1 Sydney Metro West data

Groundwater samples were collected and analysed from the 50 monitoring bores installed along the alignment.

Laboratory analyses were carried out for various combinations of test parameters (depending on sample) for major ions, heavy metals, total recoverable hydrocarbons (TRH), benzene, toluene, ethyl benzene and xylene (BTEX), polycyclic aromatic hydrocarbons (PAH), nutrients, hexavalent chromium, total and speciated phenols, per- and polyfluoroalkyl substances, volatile organic compounds (VOC), organochlorine (OCP) and organophosphate pesticides (OPP), and tributyltins.

The pH reported from these monitoring bores is consistent with the typical ranges noted in Section 4.7.1 above. The electrical conductivity (EC) is also generally consistent with the typical ranges encountered in similar geological settings in Sydney, with higher EC values recorded in piezometers that are in closer proximity to salt water bodies.

Data show that groundwater along the alignment exceeds the ANZECC (2019) trigger levels for 95 percent protection of freshwater aquatic ecosystems at numerous locations for ammonia and heavy metals. In particular, concentrations of ammonia, cobalt and manganese were above the trigger in 50 percent or more of the samples tested. Concentrations also exceeded the trigger levels for arsenic, copper, lead, nickel and zinc at some locations.

The freshwater aquatic ecosystems trigger levels are lower than those for marine waters, and therefore represent a more conservative metric for impact assessment.

ANZECC (2019) does not provide a 95 per cent protection of freshwater aquatic ecosystems trigger level for iron, but iron concentrations along the alignment are relatively high, ranging from less than 50 per litre to 556 milligrams per litre, and with a mean concentration of about 19 milligrams per litre.

Groundwater in the Sydney region that has not been impacted by anthropogenic activity can contain heavy metals concentrations above the ANZECC trigger levels, and elevated concentrations for some metals (e.g. iron and manganese) may be due to the leaching of natural metals from the host rock/soil.

TRH, BTEX, PAH, hexavalent chromium, total and speciated phenols, per- and polyfluoroalkyl substances, VOC, OCP, OPP, and tributyltins in groundwater samples along the alignment were below the trigger levels provided by ANZECC (2019) for 95 per cent protection of freshwater aquatic ecosystem.

A review of the analytical results from the groundwater investigation data (September 2018) has been undertaken in the context of bio-accumulative contaminants and guidelines for 99 per cent protection of aquatic ecosystems. Groundwater from selected monitoring locations reported nickel and PFAS concentrations above the guidelines for 99 per cent protection of aquatic ecosystems. It was also noted that the Limit of Reporting was above the guidelines for the 99 per cent protection of aquatic ecosystems for a number of contaminants (e.g. mercury, phenols, VOC, pesticides, PFAS). The risk to receiving aquatic ecosystems from bio-accumulative contaminants is not fully understood as sampling and analysis has not been undertaken from the receiving surface waters to establish background conditions.

Electrical conductivity values ranged between 20 microSiemens per centimetre and 20,500 microSiemens per centimetre (salinity of up to about 11,300 milligrams per litre as total dissolved solids), with the Ashfield Shale showing higher values than the Hawkesbury Sandstone.

Cobalt, manganese and zinc concentrations were above the ANZECC (2019) trigger for 95 per cent protection of freshwater aquatic ecosystems in 50 per cent or more of the samples tested. Groundwater quality also exceeded the freshwater trigger values for arsenic, copper, lead and nickel at some locations. Iron concentrations were relatively high, ranging from 50 micrograms per litre to 45 milligrams per litre, and with a mean concentration of about eight grams per litre.

4.7.2.2 Other project data

Data was also reviewed for groundwater samples collected from 40 piezometers along the M4 East alignment as part of the WestConnex M4 East monitoring programme (CPB-Samsung-JH JV, 2017). This alignment runs approximately parallel to the Stage 1 alignment between Sydney Olympic Park and Five Dock.

The pH measured in the alluvium, Ashfield Shale and Hawkesbury Sandstone units ranged from about 3.8 to 8.5 (higher values were observed in one piezometer screened in the Hawkesbury Sandstone but were likely associated with piezometer construction).

The WestConnex M4 East monitoring results are generally consistent with those for the Stage 1 groundwater monitoring.

4.7.3 Potential contamination

It is possible that groundwater quality measured as part of the Sydney Metro West field investigations is not fully representative of all the groundwater quality in the vicinity of the Stage 1 construction sites, particularly if localised contamination is present at distance from the Stage 1 groundwater monitoring piezometers.

Groundwater quality may also be impacted by potential contamination. The Technical Paper 8 (Contamination) (Jacobs, 2020a) identifies the potential for contaminated groundwater to be present at the following Stage 1 sites:

- Westmead metro station
- Parramatta metro station
- Clyde stabling and maintenance facility
- Silverwater services facility
- Sydney Olympic Park metro station
- Burwood North Station
- The Bays Station.

For information on potential groundwater contamination, refer to the Technical Paper 8.

Section 5 discusses the potential groundwater contamination for each construction site (for very low to very high contamination impact potential sites listed in Technical Paper 8).

4.8 Sensitive receiving environments

4.8.1 Groundwater Dependent Ecosystems

The Technical Paper 10 (Biodiversity Development Assessment Report) (Jacobs, 2020b) identifies the potential groundwater dependent ecosystems (terrestrial vegetation) located in the vicinity of Stage 1.

Potential groundwater dependent ecosystems (terrestrial vegetation) in proximity to (about one kilometre of) the Stage 1 construction sites and tunnel (the likelihood of being a groundwater dependent ecosystem is noted after each ecosystem) are as follows:

- In the vicinity of Westmead metro station construction site:
  - Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley (moderate to high likelihood) to the north and north-west of the construction site
  - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain (moderate to high likelihood) along Domain Creek to the east of the construction site and along Toongabbie Creek to the north-west of the construction site
  - Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain (high likelihood) within the construction site footprint (these are not mapped) and to the east of the construction site

- In the vicinity of Parramatta metro station construction site:
  - Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley (moderate to high likelihood) to the north-west along Parramatta River
  - Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain (moderate to high likelihood) to the north-west of the construction site along the Parramatta River
  - Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain (high likelihood) to the north-west of the construction site along the Parramatta River
  - Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion (high likelihood) to the north-east along the Parramatta River
- In the vicinity of the Clyde stabling and maintenance facility construction site:
  - Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion (high likelihood) along Duck Creek
  - Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion (moderate to high likelihood) along Duck Creek
  - Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion (low likelihood) along Duck Creek
- In the vicinity of the Silverwater services facility construction site:
  - Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion (high likelihood) along Duck River
- In the vicinity of Sydney Olympic Park metro station construction site, associated with the Bicentennial Park wetlands to the east and north-east:
  - Common Reed on the margins of estuaries and brackish lagoons (moderate to high likelihood) to the east and north-east
  - Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion (moderate to high likelihood) to the east
  - Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion (high likelihood) to the east
  - Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion (low likelihood) to the east
- In the vicinity of North Strathfield metro station construction site:
  - Turpentine -– Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion (moderate to high likelihood) at Concord Golf Club to the north-east
  - Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion (low likelihood) associated with the Bicentennial Park wetlands to the north-west

- Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley to the west (moderate to high likelihood) associated with the Bicentennial Park wetlands to the north-west

- In the vicinity of Burwood North Station construction site:
  - Turpentine -– Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion (moderate to high likelihood) at Queen Elizabeth Park to the north
- In the vicinity of Five Dock Station construction site:
  - Turpentine -– Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion (moderate to high likelihood) at Five Dock Park to the east.

These groundwater dependent ecosystems (terrestrial vegetation) are shown in Figure 4-4.

High priority groundwater dependent ecosystems are listed in Schedule 4 of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources (Department of Industry, 2011). The plan lists Cumberland Plain Woodland and Coastal Saltmarsh in the Sydney Basin Bioregion as high priority groundwater dependent ecosystems. Therefore, Grey Box - Forest Red Gum woodland on the flats of the Cumberland Plain in the vicinity of Westmead metro station and Parramatta metro station construction sites, and the Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion in the vicinity of Sydney Olympic Park metro station and North Strathfield metro station construction sites are classified as high priority groundwater dependent ecosystems.

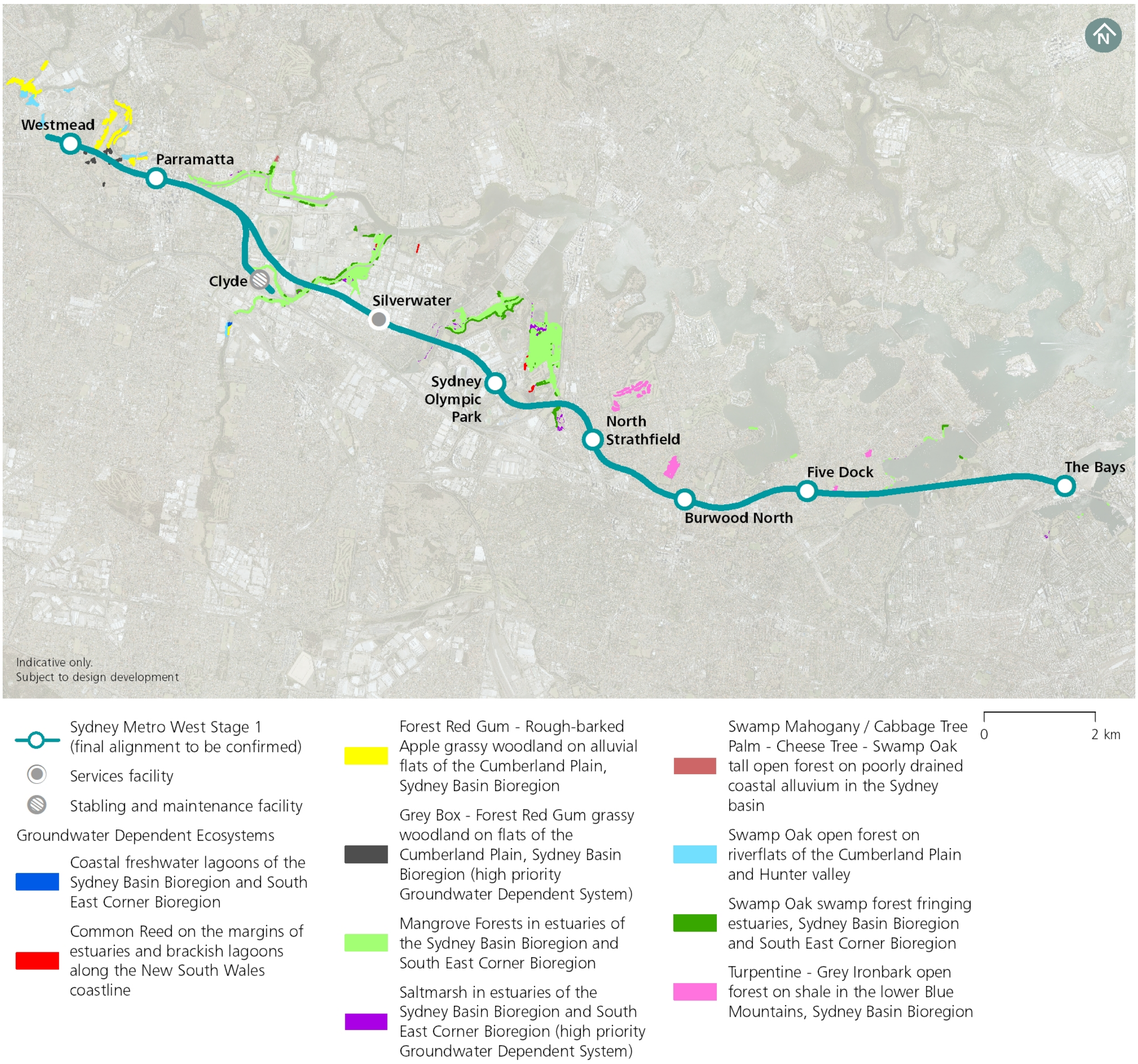

Figure 4-4: Potential groundwater dependent ecosystems (terrestrial vegetation) along the Stage 1 alignment

4.8.2 Surface waterways and wetlands

Six waterways (Parramatta River, Sydney Harbour, Duck River, Haslams Creek, Powells Creek and Iron Cove Creek) have been identified as receiving environments of high sensitivity predominantly due to the key fish habitat classifications (including those downstream) and/or proximity to coastal wetlands as defined by the Coastal Management SEPP. These watercourses have a high conservation or community value or supports ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

These waterways have the potential to be impacted by Stage 1 due to groundwater drawdown.

The Department of the Environment and Energy Protected Matters Search Tool (http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf) identifies the Bicentennial Park Wetlands and the Newington Wetlands, both at Sydney Olympic Park, as the only Nationally Important Wetlands in the vicinity of Stage 1.

The Protected Matters Search Tool does not identify any Ramsar Wetlands in the vicinity of Stage 1.

Table 4-5 lists the waterways/wetlands, their condition, and their sensitivity to potential impact.

Table 4-5: Sensitive nearby surface water environments

Watercourse	Waterway order	Type	SEPP Wetland	Habitat type	Condition	Sensitive receiving environment rating
Finlaysons Creek	First order waterway	Concrete-lined channel	Nil	-	Highly disturbed	Low
Toongabbie Creek	Third order waterway	Unlined	Nil	Type 2 Key Fish Habitat Some aquatic habitat present	Moderately disturbed	Moderate
Domain Creek	First order waterway	-	Modified channel, with no SEPP Coastal Wetlands within 0.5 kilometres	-	Highly disturbed	Low
Parramatta River	Fourth order waterway	Permanently flowing	Numerous SEPP Coastal Wetlands	Potential habitat for threatened aquatic species and protected aquatic vegetation Type 1 Key Fish Habitat	Moderately disturbed	High
Clay Cliff Creek	Second order waterway	Highly modified channel with limited aquatic habitat. Concrete-lined with no instream habitat	SEPP Coastal Wetlands within 0.5 kilometres	-	Highly disturbed	Moderate
Duck River	Third order estuarine waterway	Concrete-lined in upper reaches	SEPP Coastal Wetlands within 0.5 kilometres	Type 1 Key Fish Habitat	Moderately disturbed	High
Duck Creek	Second order waterway	Unlined	-	Type 1 Key Fish Habitat	Highly disturbed	Low
A'Becketts Creek	First order waterway	Concrete-lined channels along long sections	-	Type 1 Key Fish Habitat	Highly disturbed	Low

Watercourse	Waterway order	Type	SEPP Wetland	Habitat type	Condition	Sensitive receiving environment rating
Haslams Creek	Third order waterway	-	SEPP Coastal Wetlands within 0.5 kilometres	Type 1 Key Fish Habitat	Moderately disturbed	High
Newington Wetlands	-	Rehabilitated wetland/Nature Reserve	SEPP Coastal Wetlands within 0.5 kilometres	-	Moderately disturbed	High
Bicentennial Park Wetlands	-	Rehabilitated wetland/Nature Reserve	SEPP Coastal Wetlands within 0.5 kilometres	-	Moderately disturbed	High
Saleyards Creek	First order waterway	Concrete-lined channel	SEPP Coastal Wetlands within 0.5 kilometres	Type 1 Key Fish Habitat	Highly disturbed	Moderate
Powells Creek Mason Park Wetland	First order waterway	Highly modified channel with limited aquatic habitat Permanently flowing Estuarine with tidal limit 0.1 kilometres upstream of Allen Street Bridge, Homebush)	SEPP Coastal wetlands within 0.5 kilometres	-	Moderately disturbed	High
St Lukes Park Canal	First order waterway	Estuarine Predominantly concrete-lined No instream aquatic habitat	SEPP Coastal Wetlands within 0.5 kilometres	Type 1 Key Fish Habitat	Highly disturbed	Moderate
Sydney Harbour	Fourth order waterway	Permanent water body	Numerous SEPP Coastal Wetlands	Potential habitat for threatened aquatic species and protected aquatic vegetation Type 1 Key Fish Habitat	Moderately disturbed	High

Watercourse	Waterway order	Type	SEPP Wetland	Habitat type	Condition	Sensitive receiving environment rating
Barnwell Park Canal	-	Highly modified channel with limited aquatic habitat Concrete lined channel No instream aquatic habitat	SEPP Coastal Wetlands greater than 0.5 kilometres downstream	-	Highly disturbed	Moderate
Dobroyd Canal/Iron Cove Creek	-	Highly modified channel with limited aquatic habitat Concrete-lined channel	SEPP Coastal Wetlands greater than 0.5 kilometres downstream	-	Moderately disturbed	High
Iron Cove	Fourth order waterway	Permanent water body	Numerous SEPP Coastal Wetlands	Potential habitat for threatened aquatic species and protected aquatic vegetation Type 1 Key Fish Habitat	Moderately disturbed	High
White Bay	-	Concrete-lined, enclosed embayment	SEPP Coastal Wetlands within 0.5 kilometres	-	Highly disturbed	Low

4.9 Conceptual hydrogeological model

The geological long section in Appendix A presents the conceptual model, diagrammatically, with respect to the various components of Stage 1.

Stage 1, including the stations, tunnels, tunnel dive and services facility shafts, intersect alluvial/fluvial/residual soils as well as Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone.

Where groundwater is present in the soils, it is generally encountered at relatively shallow depth (one metre to five metres below ground surface). In general, there appears to be hydraulic connection between the soils and underlying rock at many locations along the alignment. However, it is possible that a perched watertable lies within the soils at some locations, with an unsaturated zone within the underlying rock. It is expected that the watertable within the soils, where present, and rock units would be unconfined.

Soils are recharged by rainfall and localised irrigation, as well as incidental runoff from impervious surfaces. When exposed at surface, it is anticipated that there is direct recharge of the rock aquifers, with transmission primarily through rock joints. Recharge to the rock aquifers elsewhere is by downward percolation through soils.

Groundwater discharge is expected to occur to drainage lines and water bodies.

Groundwater quality in the area of the alignment is typically fresh to brackish, with pH being near-neutral. Groundwater along the alignment shows concentrations of numerous heavy metals above the ANZECC trigger levels for 95% protection of freshwater aquatic ecosystems. This is typical of natural groundwater in Sydney.

Groundwater yield in both rock aquifers and soils is anticipated to be low to very low. Typical yields for bores screened in the Mittagong Formation and Hawkesbury Sandstone identified in the region are less than three litres per second. The anticipated groundwater yield in Ashfield Shale is very low to negligible, and likely to be typically less than 0.1 litres per second.

5 Stage 1 – Hydrogeological impact assessment

5.1 Excavation and groundwater management strategy

Stage 1 would involve excavation of the tunnels, stations and ancillary infrastructure for Sydney Metro West between Westmead and The Bays, as well as civil construction works for the Clyde stabling and maintenance facility.

Station excavations would be cut-and-cover, with the exception of Five Dock Station which would be a mined cavern excavation. In addition, at the cut-and-cover excavations at Westmead metro station and Burwood North Station, crossover caverns would be mined at these station locations.

Some excavations would be fully drained (i.e. the entry of groundwater to the excavation would occur across both soil and rock horizons). Other excavations would be undrained across the soils during construction (i.e. groundwater would be prevented from flowing into the excavation from the soil). The modelling has assumed that all crossover caverns are drained during construction. This reflects the fact that the caverns would be drained during the construction excavation period, and provides a conservative estimate of groundwater level drawdown/inflow. Following excavation, caverns would be undrained.

For the running tunnels, the tunnel boring machines would construct a pre-cast segmental tunnel lining as excavation progresses. The tunnels would therefore be undrained almost immediately following their excavation.

Due to the excavation intersecting the water table, the excavations are expected to dewater the immediate area adjacent to the site and depressurise the soils and/or rock beyond the immediate area. The following hydrogeological impact assessment is a review of the predicted impacts to the groundwater system.

5.2 Modelling

The existing modelling was reviewed and modelling parameters updated as part of the assessment. The site geological profile was divided into four main geological layers to represent the hydrogeological system, including surface clay/soil, fractured rock weathering profile, shale (to represent the Ashfield Shale) and sandstone (to represent the Hawkesbury Sandstone). The assumed hydrogeological parameters for the modelling are summarised in Table 5-1. Rainfall recharge equal to approximately five per cent of the long-term mean annual rainfall recorded at the Bureau of Meteorology Station nearest to each site was adopted.

Saline intrusion modelling was undertaken using the software package C/TRAN (developed by Geoslope International Ltd).

Table 5-1: Modelling parameters

Geological unit	Hydraulic conductivity - horizontal (k_x) (m/day)	Horizontal-vertical conductivity ratio (k_y/k_x) ratio	Specific yield (dimensionless)	Approximate Specific storage (m^{-1})
Clay	0.01	0.1	0.1	1×10^{-3}
Fractured rock	1	0.1	0.1	6×10^{-5}
Shale	0.018	0.1	0.03	1×10^{-5}
Sandstone	0.12	0.1	0.03	5×10^{-6}

5.2.1 Assumptions

The groundwater management approach for each excavation site is listed in Table 5-2.

In addition, the following assumptions have been made:

- Excavations would be open for up to two years during construction
- Tunnel excavation occurs over about a 26 month period
- Inflows to station entry adits would be minor relative to the inflows to the station cut and cover excavations and caverns, due to their relatively small size
- The influence of climate change on long-term rainfall recharge is not expected to cause significantly greater impacts than those predicted in the model. The former NSW Office of Environment and Heritage (2019c) NSW Climate Change projections for 2060 to 2079 predict increased rainfall in the region of Stage 1. Increased rainfall would increase the infiltration to the aquifer, potentially resulting in increased groundwater recharge, which would result in reduced groundwater drawdown. The groundwater drawdowns predicted here are therefore considered reasonable under these predicted climate change (rainfall) scenarios
- Rock in the vicinity of water-bearing geological features such as faults, dykes and joint swarms has the potential to have relatively high hydraulic conductivity. Identification of such features would be carried out, and significant water-bearing features would be grouted prior to excavation, to reduce the potential for relatively high groundwater inflows to the excavations
- Two-dimensional groundwater flow models were used to estimate groundwater inflows to excavations and resultant groundwater level drawdown. Numerous assumptions are relevant to the groundwater modelling. The approach and assumptions adopted are considered reasonable given the limited hydrogeological data available at each station/services site. The following assumptions apply:
    - The modelling is based on limited geotechnical and hydrogeological data. Where data are not available at sites, assumptions regarding ground conditions have been made. Groundwater modelling should be validated at later stages of the project, once additional data are available
    - The excavations are “wished-in-place” (i.e. progressive excavation over time is not considered). This assumption results in potentially higher inflows to the excavations than

would be experienced with progressive excavation, and therefore provides a conservative estimate of groundwater inflow

- Groundwater level drawdown contours were developed based on the results of multiple model cross sections (i.e. cross sections and long sections through station box, cavern and shaft excavations) and are subject to assumptions regarding groundwater recharge and no-flow boundaries. There is some uncertainty regarding these boundaries and therefore uncertainty in the estimated drawdown levels and extents
- Ground conditions at distance from the station box / service facility excavation are generally consistent with those at the station box / service facility excavation, and hydrogeological units are homogeneous
- Adopted hydrogeological property values are based on water pressure (packer) tests and values reported in the literature for the hydrogeological units along the alignment
- The modelling has assumed that all crossover caverns are drained during construction. This reflects that caverns would be drained during the construction excavation period for a period of time, prior to being lined and provides a conservative estimate of groundwater level drawdown/inflow
- Saline intrusion modelling assumed:
  - Modelling of a cross section in the CTRAN/W software package (GeoSlope International Ltd) through the station excavation, extending to the nearest saltwater body
  - Flow model based on the existing transient SEEP/W model parameter values
  - Steady state modelling of saline intrusion in the absence of the station excavation to establish the existing saline groundwater distribution before transient modelling of saline intrusion for Stage 1 (in the presence of the station excavation)
  - For saltwater, a constant relative concentration boundary condition of 1 mg/L at the saltwater body, and an initial relative concentration boundary condition of 0 mg/L
  - Saltwater has a density typical of seawater (fluid density of 1025 kg/m^3)
  - For advection-dispersion solute transport, a longitudinal and vertical transverse dispersivity of 100 metres and 20 metres, respectively
  - A diffusion coefficient value equal to 1.6×10-4 m^2/day.

Table 5-2: Groundwater management approach and assumptions for Stage 1 components

Construction site	Excavation type	Construction
Westmead metro station	Cut and cover box Crossover cavern to east of box	Drained box Drained crossover cavern during construction[a] excavation for Stage 1
Paramatta metro station	Cut and cover box	Undrained (soil) Drained (rock)
Clyde stabling and maintenance facility – tunnel portal at Rosehill	Tunnel portal and dive structure	Undrained (soil) Drained (rock)
Clyde stabling and maintenance facility – Rosehill services facility	Shaft	Undrained (soil) Drained (rock)
Silverwater services facility	Shaft	Drained
Sydney Olympic Park metro station	Cut and cover box with northern entry adit	Drained
North Strathfield metro station	Cut and cover box	Drained
Burwood North Station	Cut and cover box with entry adit Shaft (southern entry) Crossover cavern to west of box	Drained Drained crossover cavern during construction[a] excavation for Stage 1
Five Dock Station	Mined cavern Access shafts (west and east)	Drained
The Bays Station	Cut and cover box	Undrained (soil) Drained (rock)

[a]Caverns would be lined (undrained) following excavation but are assumed to be drained throughout the Stage 1 excavation period (period of two years assumed). This is a conservative assumption for the purposes of impact assessment.

5.2.2 Limitations

Information on ground and hydrogeological conditions is limited along the alignment and at station, services facilities and dive construction sites. The level of characterisation of hydrogeological conditions and potential impacts are limited to the data available and the preliminary nature of the project design. Reasonable assumptions have been made where conditions are limited or unknown, based on known conditions in similar hydrogeological environments, with model parameter values adopted based on those reported in the literature.

Impact assessment conclusions may differ from those presented in this technical paper if conditions differ from those modelled and assumed.

This impact assessment is adequate to assess general environmental impacts and provide recommendations for monitoring and mitigation. These would require refinement as Stage 1 passes through the detailed design stage, and validation is undertaken through the construction stage.

There is uncertainty regarding the potential baseflow loss to waterways due to Stage 1 station and services facility excavations, since data on the ground conditions (stratigraphy), groundwater levels and steam flows at the locations of waterways are not available. It is therefore not possible to assess existing groundwater baseflow with confidence, and by extension, quantification of the impact of the Stage 1 station and services facility excavations on baseflow cannot be assessed with confidence.

Further review of the potential change in baseflow due to Stage 1 station and services facility excavations would be completed based on the findings of additional site investigation that would be carried out during detailed design.

These additional site investigations would be undertaken to assess the existing baseflow contribution to the waterways potentially impacted by Stage 1. This would firstly comprise measurements of streamflows during dry periods, which would allow the assessment of existing groundwater baseflow contributions to the waterways. Based on the outcome of these initial investigations, additional site investigations may be required to further reduce uncertainty, including borehole drilling to assess ground conditions in the vicinity of the waterways, and the installation of groundwater monitoring piezometers in the vicinity of waterways to measure groundwater levels. Groundwater flow modelling would then be undertaken, considering the findings of the site investigations, to assess the potential change in baseflow due to the Stage 1 station and services facilities excavations. If unacceptable changes in baseflow are predicted at potentially impacted waterways, additional design measures would be implemented at station and services facility excavations to reduce groundwater inflow to those excavations, thereby reducing the potential baseflow loss to waterways.

5.2.3 Groundwater modelling results summary

The Stage 1 excavation program indicates that each Stage 1 station or shaft excavation would be carried out over a period of less than two years. The volumetric groundwater take for each excavation is therefore presented for the first and second year of excavation to address the requirements of the NSW Aquifer Interference Policy and the Water Sharing Plan.

The groundwater inflows to Stage 1 excavations would decrease with time until a steady state is reached. The groundwater level drawdown induced by the Stage 1 excavations would increase over time, also until a steady state is reached. Inflows (and annual volumetric take) have been predicted for Construction Years 1 and 2. Beyond that (in Year 3) the water inflow would not be considered as Stage 1 water take. The take for Year 3 and beyond is likely to be at a similar rate and volume as predicted for the end of Year 2, providing steady state has been reached. In the case that steady state has not been reached, the take would likely be lower in magnitude than for Years 1 and 2.

Given that Stage 1 excavations would be carried out over a period of less than two years, and the groundwater modelling assumes the excavations are wished-in-place, the predicted groundwater level drawdown at two years after excavation therefore represents a conservative (greater) estimate of the likely groundwater level drawdown due to Stage 1.

Details of the modelling of individual sites are included in the following sections.

5.3 Westmead metro station construction site

The Westmead metro station construction site would require the excavation of a cut-and-cover station adjacent to the existing rail line, and a turnback cavern located immediately east of the station box.

5.3.1 Groundwater levels

Figure 5-1 shows the estimated groundwater level drawdown from the current (recorded in 2018) average water level at the end of two years of excavation.

5.3.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the excavation is up to 1.5 litres per second at both one and two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 54 megalitres in the first year and 46 megalitres in the second year.

The groundwater flow regime in the vicinity of the construction site is expected to change due to excavation. Without Stage 1, groundwater was interpreted to flow away from the Stage 1 construction site in southerly, westerly and easterly directions. With Stage 1, the station excavation would act as a groundwater sink, causing groundwater to flow towards the excavation.

5.3.3 Groundwater recharge

Changing the natural land surface from being pervious (that is, water can infiltrate through), to an impervious area has the potential to reduce infiltration of rainfall or surface water to the aquifer below, which would recharge the groundwater system.

About half of the surface within the proposed construction site area is currently impervious. Stage 1 would increase the proportion of impervious areas through the site establishment and excavation which could reduce recharge rates within the footprint of the construction site. However, this area is small relative to the local catchment area, and the net impact on regional recharge due to Stage 1 is not likely to be significant.

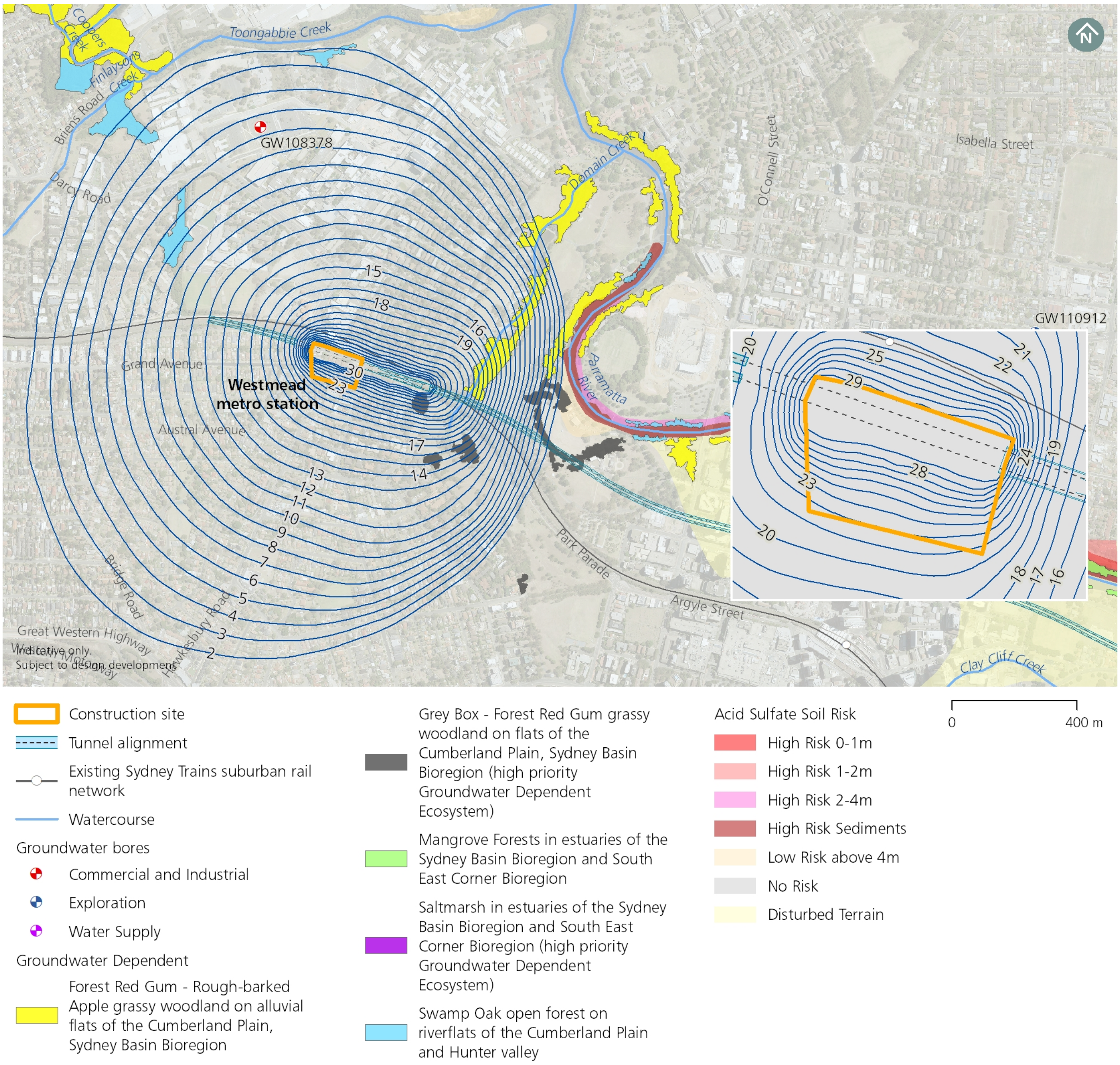

Figure 5-1: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation – Westmead metro station construction site

5.3.4 Groundwater quality

The station box is expected to act as a groundwater sink, causing surrounding groundwater in the Ashfield Shale and Hawkesbury Sandstone to flow towards the excavation. This groundwater movement has the potential to cause groundwater to flow towards the excavation that is of a different quality than existing background conditions.

The Technical Paper 8 identifies the potential for groundwater both within, and adjacent to, the construction site footprint to be impacted by hydrocarbons (TRH, BTEX, PAH) and VOC at area of environmental interest (AEI) 2). This AEI lies within the predicted extent of groundwater level drawdown. The potential contamination impact was assessed to be moderate for groundwater associated with this AEI.

There is potential for groundwater impact associated with the ingress of contaminated groundwater into excavations and the management of dewatering during the construction of the station box.

Any potentially contaminated groundwater within the extent of groundwater level drawdown would migrate towards the station excavation. Contaminated groundwater seeping into the excavation could pose a potential exposure risk to site users/workers and adjacent site users and could reduce the beneficial use of the aquifer. Groundwater inflow would be collected and treated during construction.

The Westmead metro station construction site lies upgradient of the Charles Street and Marsden Street weirs on the Parramatta River, therefore the waters of Parramatta River in the vicinity of the station are not expected to be saline, and groundwater in the vicinity of the Westmead metro station construction site is therefore not likely to be impacted by saline water intrusion.

5.3.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater level drawdown. Impact to acid sulfate soils due to excavation of the station is therefore not expected.

5.3.6 Groundwater Dependent Ecosystems

Potential groundwater dependent ecosystems (terrestrial vegetation) are identified within the predicted extent of groundwater level drawdown, including:

- Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley located between about 500 metres and one kilometre to the north and north-west (moderate to high likelihood)
- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain located between about 350 and 650 metres to the east (moderate to high likelihood)
- Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain located within the construction site footprint and also between about 200 and 650 metres to the east (high likelihood).

The Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain (which is commonly referred to as Cumberland Plain Woodland) is listed as a high priority groundwater dependent ecosystem in Schedule 4 of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011.

The following groundwater drawdown is predicted at the locations of the following groundwater dependent ecosystems (terrestrial vegetation) at two years after excavation:

- Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley of up to nine metres
- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain to the east of up to 23 metres
- Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain within the construction site footprint and to the east of up to 30 metres.

The Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley and the Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain both grow in clay alluvium and the Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain grows in Wianamatta Shale. These geological units are likely to be of relatively low permeability, with a potential perched watertable present (which may be temporary) upon which these groundwater dependent ecosystems may intermittently rely. The predicted groundwater level drawdown in the deeper sandstone unit is unlikely to cause direct groundwater level drawdown within a perched aquifer that lies in clay alluvium or Wianamatta Shale. In addition, since a conservative approach has been adopted for the groundwater modelling, the magnitude of potential drawdown is considered to be a conservative estimate. Therefore, the likelihood of these ecosystems being impacted by the groundwater level drawdown associated with Stage 1 is low.

See Section 5.3.8 for further discussion in relation to the potential impacts of surface water-groundwater interaction on groundwater dependent ecosystems.

5.3.7 Groundwater users

One WaterNSW-registered bore (GW108378) was identified within the predicted extent of groundwater level drawdown (see Table 4-3). WaterNSW reports the purpose of this bore as commercial/industrial, and its depth is around 280 metres below ground surface.

The estimated groundwater level drawdown at this bore due to Stage 1 excavation is four metres at two years after excavation. This does not satisfy the minimal impact considerations of the NSW Aquifer Interference Policy.

However, given the depth of the bore, and an assumed groundwater table of about 20 metres below ground surface, the available water column in the bore would be reduced by Stage 1 by about two per cent. Based on this, groundwater supply is not likely to be affected at this bore due to Stage 1.

5.3.8 Surface water-groundwater interaction

Groundwater level drawdown due to station excavation is expected in the vicinity of Domain Creek and Toongabbie Creek, and some 150 metres to 200 metres from Finlaysons Creek and the Parramatta River. Finlaysons Creek is a concrete lined channel and is not likely to receive groundwater baseflow. Groundwater baseflow contribution to Parramatta River would likely be negligible relative to the river water flows/volumes.

It is not known whether groundwater contributes baseflow to Domain Creek or Toongabbie Creek. Groundwater level drawdown at distance from that creek could result in reduced groundwater flow towards the creek, and if so, ultimately reduced baseflow to the creek. If there is existing groundwater baseflow contribution to Domain Creek and/or Toongabbie Creek, then Stage 1 has the potential to reduce that baseflow contribution and reduce stream flows. These stream flows are likely to support the Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain and Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley groundwater dependent ecosystems, which would have roots within the clay alluvium, and the water available within this alluvium would be impacted if baseflows are reduced due to groundwater drawdown from Stage 1. Other aquatic ecosystems could also be impacted if baseflows are reduced. As baseflows are likely to be a minor component of streamflow, the significance of this impact is likely to be low.

As discussed in Section 5.2.2, to confirm the existing baseflow contribution to Domain Creek and Toongabbie Creek, additional site investigations would be carried out during detailed design to confirm potential impacts to baseflow. Where significant reduction in baseflow is confirmed, measures would be implemented at the station box to reduce the potential for baseflow loss.

5.4 Parramatta metro station construction site

The Parramatta metro station construction site would require the excavation of a cut-and-cover station box.

5.4.1 Groundwater levels

Figure 5-2 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

5.4.2 Groundwater inflows and local flow regime

The estimated groundwater inflow towards the excavation is up to 2.7 litres per second at both one year and two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 89 megalitres in the first year and 85 megalitres in the second year.

The groundwater flow regime in the vicinity of the station box is expected to change due to excavation. Without Stage 1, groundwater was interpreted to flow in a generally northerly direction, towards the Parramatta River. With Stage 1, the excavation is assessed to act as a groundwater sink, causing groundwater to flow towards the excavation.

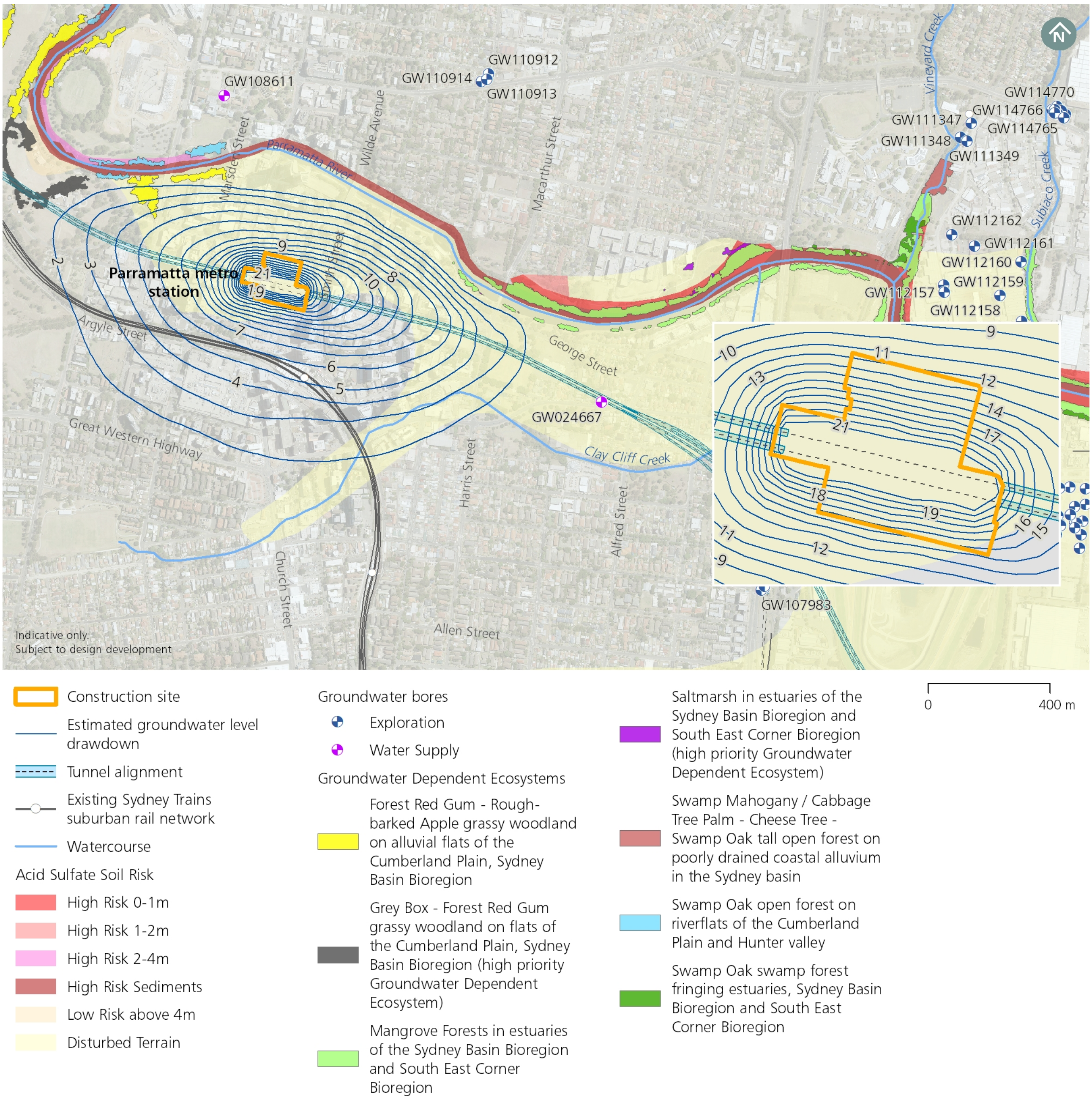

Figure 5-2: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at Parramatta metro station construction site

5.4.3 Groundwater recharge

Almost all ground over the proposed construction site is currently impervious. Stage 1 would therefore not reduce recharge rates in the vicinity of the site.

5.4.4 Groundwater quality

The station excavation is expected to act as a groundwater sink causing groundwater to flow towards the excavation.

The Technical Paper 8 identifies the potential for groundwater within the construction site footprint and nearby alignment to be impacted by heavy metals, hydrocarbons (TRH, BTEX, PAH), chlorinated hydrocarbons, VOC and phenol (at AEI 7, 8, 9). AEI 7 lies within the predicted zone of groundwater level drawdown. AEI 8 and 9 relate to non-location-specific historical commercial/industrial site use, which may lie within the predicted zone of groundwater level drawdown.

The potential contamination impact was assessed to be moderate for groundwater associated with AEI 7 to 9.

There is an increased risk of likely impact associated with the ingress of contaminated groundwater into excavation voids and the management of dewatering during the construction of the station box.

Any potentially contaminated groundwater within the extent of groundwater level drawdown would migrate towards the station excavation, posing a potential exposure risk to site users/workers and adjacent site users, and could reduce the beneficial use of the aquifer.

As the station excavation is undrained across the soil horizon during construction, there is potential for contaminated groundwater within the soils to be drawn downwards into the rock. Contaminated groundwater seeping into the excavation would be collected and treated during construction.

It is possible that saline water within the Parramatta River east of the Charles Street weir could be drawn into the fresher groundwater adjacent to the river. Groundwater supply for primary industries/ industrial/drinking water and sites with groundwater-dependent cultural or spiritual values were not identified in the area where this potential impact could occur. The groundwater dependent ecosystems (terrestrial vegetation) identified in the area where this potential impact could occur comprise Estuarine Mangrove Forest, which are tolerant of saline groundwater. Based on this, potential saline water intrusion in this area is not likely to impact the environmental value of the aquifer.

5.4.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater level drawdown. However, disturbed soils have been identified within this area. Up to 23 metres of groundwater level drawdown is estimated in the area where disturbed soils have been identified at two years after excavation. It is possible that excavation of the station box would cause oxidation of potential acid sulfate soils in the area, if they are present. The risk of this is considered to be low. Site investigation would be required to confirm the presence of potential acid sulfate soils in the vicinity of the construction site.

5.4.6 Groundwater Dependent Ecosystems

Up to four metres of groundwater level drawdown is predicted at the Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain located along the Parramatta River to the north-west of the station excavation at two years after excavation.

However, this ecosystem grows in clay alluvium, which is likely to be of relatively low permeability, with a potential perched watertable present (which may be temporary) upon which this groundwater dependent ecosystems may intermittently rely. The groundwater level drawdown in the sandstone geological unit induced by station excavation is not likely to cause direct groundwater level drawdown within the clay alluvium. In addition, since a conservative approach has been adopted for the groundwater modelling, the magnitude of potential drawdown is considered to be a conservative estimate. The likelihood of this ecosystem being impacted by the groundwater level drawdown associated with Stage 1 is therefore low.

See Section 5.4.4 for further discussion in relation to the potential impacts of saline water intrusion, and Section 5.4.8 for further discussion in relation to the potential impacts of surface water-groundwater interaction, on groundwater dependent ecosystems.

5.4.7 Groundwater users

WaterNSW-registered bores were not identified within the predicted extent of groundwater drawdown.

5.4.8 Surface water-groundwater interaction

Groundwater drawdown due to station excavation is expected in the vicinity of Clay Cliff Creek, and at distance from the Parramatta River. Clay Cliff Creek is a concrete lined channel and is not likely to receive groundwater baseflow. Groundwater baseflow contribution to Parramatta River would likely be negligible relative to the river water flows/volumes. Stage 1 excavation at Parramatta metro station construction site is therefore not likely to reduce baseflow contributions to streams.

5.5 Clyde stabling and maintenance facility construction site

The Clyde stabling and maintenance facility construction site would support the excavation of a dive structure and tunnel portal, as well as the excavation of a services facility shaft at Rosehill.

5.5.1 Groundwater levels

Figure 5-3 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

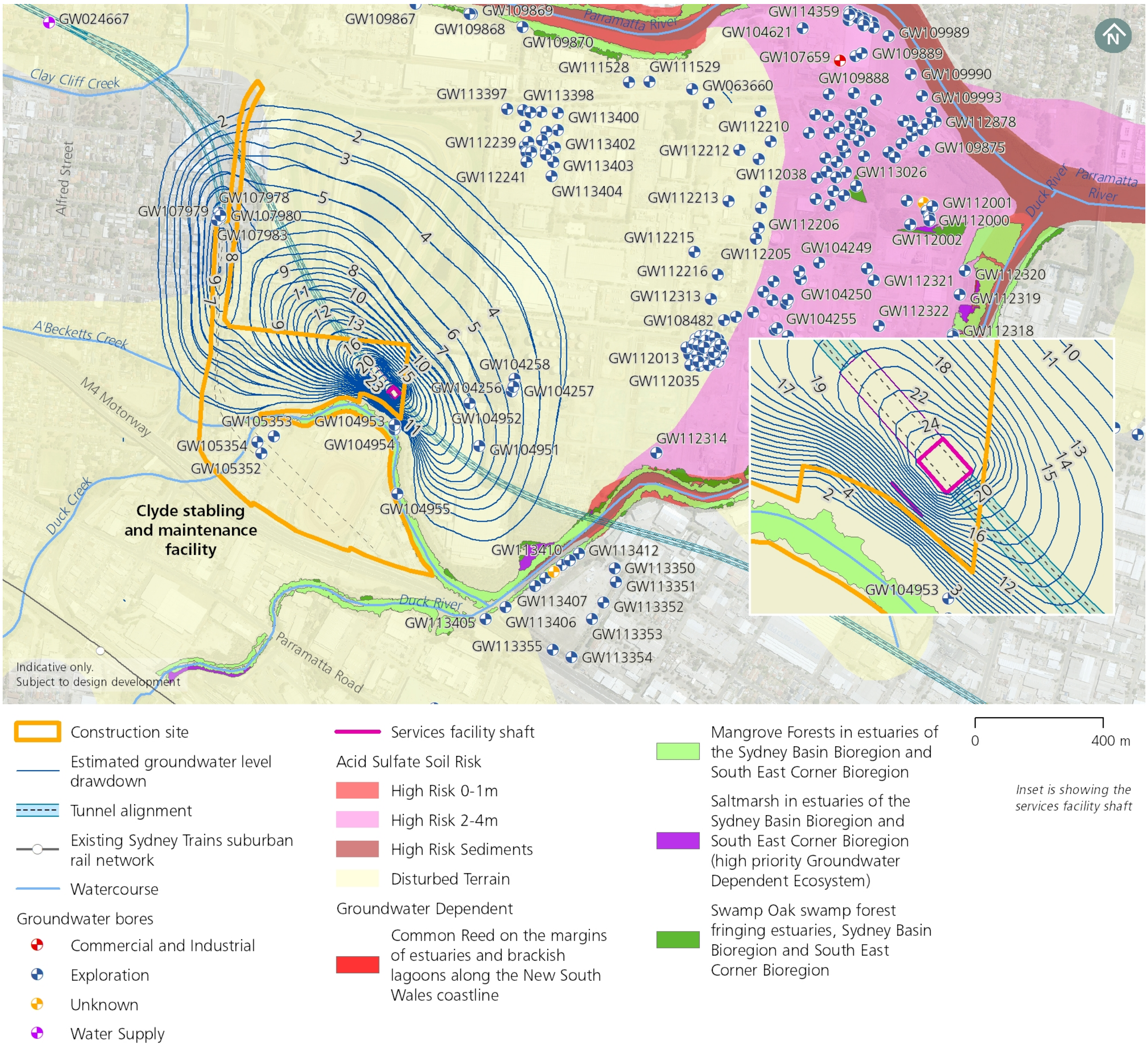

Figure 5-3: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at Clyde stabling and maintenance facility construction site

5.5.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the dive and shaft excavations is up to 0.5 litres per second and 0.8 litres per second, respectively, at both one and two years after excavation.

The groundwater inflow (at both the dive structure and the shaft) is sourced (taken) from the rock aquifer and is estimated to be up to 38 megalitres in the first year and up to 40 megalitres in the second year.

The groundwater flow regime in the vicinity of the construction site is expected to change as a result of Stage 1. Under existing conditions, groundwater was likely to flow away from the dive structure and shaft in southerly and easterly directions. With Stage 1, the excavations would act as groundwater sinks, causing groundwater to flow towards the excavations.

5.5.3 Groundwater recharge

Prior to Stage 1, approximately 30 per cent of the site footprint is pervious. This is largely due to the pervious ground at the Sydney Speedway (location on NSW Government owned land). Stage 1 is therefore likely to reduce the groundwater recharge rate in the vicinity of the construction site. This would potentially reduce the groundwater baseflow to Duck Creek and A'Becketts Creek.

5.5.4 Groundwater quality

The shaft and dive excavations are expected to act as groundwater sinks, causing groundwater to flow towards the excavations.

The Technical Paper 8 identifies the potential for groundwater at the following sites to be contaminated:

- 1 Grand Avenue, Camellia, located about 500 metres north-east of the construction site, potentially contaminated with zinc, phenol and polycyclic aromatic hydrocarbons (AEI 10)
- The former Shell Clyde Refinery, located about 200 metres east of the construction site, potentially contaminated with light non-aqueous phase liquid, hydrocarbons, lead, chromium, perfluoroctane sulfonate (AEI 14)
- The construction site and the current commercial/industrial sites adjacent to it, potentially contaminated with heavy metals, hydrocarbons and volatile organic compounds (AEI 15 and 16)
- The Rosehill Helipad site, potentially contaminated with hydrocarbons, volatile organic compounds and perfluorooctanesulfonic acid (AEI 18)
- The Rapid Oil Distributors site at Deniehy Street, Rosehill, potentially contaminated with hydrocarbons (AEI 19)
- The landfill located at Carnavon Road, Silverwater, potentially contaminated with perfluorooctanesulfonic acid (AEI 20).

Of these potentially groundwater-contaminated sites, AEI 14, 15, 18 and 19 lie within the estimated extent of groundwater level drawdown. The potential contamination impact was assessed to range from low to moderate for groundwater associated with these AEI.

Any potentially contaminated groundwater within the extent of groundwater drawdown would migrate towards the excavation. As the shaft and dive excavations are undrained across the soil horizon, there is potential for contaminated groundwater within the soils to be drawn downwards into the rock. Contaminated groundwater seeping into the excavation would be collected and treated during construction.

It is possible that construction workers and adjacent site users could be exposed to contaminated groundwater and vapours. Migration of contamination could also reduce the beneficial use of the aquifer.

Additional desktop review and field investigation is required to confirm the presence of groundwater contamination at the site and at adjacent sites.

Groundwater level drawdown in the vicinity of saltwater bodies has the potential to cause saltwater to intrude into freshwater groundwater systems. Saline water can reduce the beneficial uses of the groundwater system, impact in-ground structures (durability), and potentially impact existing groundwater users and groundwater dependent ecosystems.

It is possible that saline water within the Duck Creek could be drawn into fresh groundwater adjacent to the river. Groundwater supply for primary industries/drinking water and sites with groundwater-dependent cultural or spiritual values were not identified in the area where this potential impact could occur. The groundwater dependent ecosystems (terrestrial vegetation) identified in the area where this potential impact could occur comprise Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, and Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion, which are tolerant of saline groundwater. Furthermore, groundwater supply bores and in-ground structures (such as deep foundations) were not identified in this area. Based on this, increased salinity in the groundwater in this area is not likely to impact these groundwater dependent ecosystems or the environmental value of the aquifer.

5.5.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater drawdown. However, disturbed soils have been identified within this area. Up to 25 metres of groundwater level drawdown is estimated in the area where disturbed soils have been identified at two years after excavation (the anticipated end of Stage 1). It is possible that excavation of the dive and shaft would cause oxidation of potential acid sulfate soils in the area, if they are present. Site investigation is required to confirm the presence of potential acid sulfate soils in the vicinity of the dive and shaft.

The groundwater modelling undertaken has adopted a conservative approach and the magnitude of potential drawdown is therefore a conservative estimate. The likelihood of Stage 1 excavations at this construction site impacting acid sulfate soils is therefore considered to be low.

5.5.6 Groundwater Dependent Ecosystems

Potential groundwater dependent ecosystems (terrestrial vegetation) were identified to the immediate south and east of the shaft along Duck Creek (Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion, and Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion). Groundwater level drawdown is not predicted in the vicinity of these ecosystems at two years after excavation. Therefore, these ecosystems are not expected to be impacted by groundwater level drawdown associated with Stage 1.

See Section 5.5.4 for further discussion in relation to the potential impacts of saline water intrusion, and Section 5.5.8 for further discussion in relation to the potential impacts of surface water-groundwater interaction, on groundwater dependent ecosystems.

5.5.7 Groundwater users

Eleven WaterNSW-registered bores were identified within the predicted extent of groundwater drawdown (see Table 4-3). WaterNSW reports the purpose of these bores are monitoring.

WaterNSW-registered water supply bores are therefore not likely to be impacted by the dive and shaft excavation.

5.5.8 Surface water-groundwater interaction

Groundwater level drawdown due to excavation of the shaft and dive is predicted in the vicinity of A'Becketts Creek and Duck Creek. It is not known whether groundwater contributes baseflow to these surface water features.

If there is existing groundwater baseflow contribution to A'Becketts Creek and Duck Creek, then Stage 1 has the potential to reduce that baseflow contribution and reduce stream flows. Stage 1 could potentially cause reduced baseflow to A'Becketts Creek and Duck Creek due to groundwater level drawdown within the vicinity of and at distance of the creeks, and the reduced groundwater recharge caused by converting pervious ground to impervious ground at the Sydney Speedway.

The Technical Paper 10 notes that estuarine and near-shore marine systems, such as coastal mangroves are known to somewhat rely on the submarine discharge of groundwater, but that the extent of groundwater dependence is not well known. The groundwater baseflow to Duck Creek is likely to support the Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion, and Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion along Duck Creek, which could be impacted if baseflows are reduced. Other aquatic ecosystems are also likely to be impacted if baseflows are reduced. However, as baseflows are likely to be a minor component of streamflow, the significance of this impact is likely to be low.

As discussed in Section 5.2.2, to confirm the existing baseflow contribution to A'Becketts Creek and Duck Creek, additional site investigations would be carried out during detailed design to confirm potential impacts to baseflow. Where significant reduction in baseflow is confirmed, measures would be implemented at the dive structure and services shaft excavations to reduce the potential for baseflow loss.

A proportion of the groundwater inflows to the shaft may be indirectly sourced from the waters of Duck Creek, with waters from Duck Creek leaking into the underlying and adjacent ground, and this water migrating towards the shaft excavation. As groundwater level drawdown at the creek is likely to be negligible, the significance of this impact is likely to be low.

5.6 Silverwater services facility construction site

The Silverwater services facility construction site would support the excavation of the shaft for the future services facility.

5.6.1 Groundwater levels

Figure 5-4 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

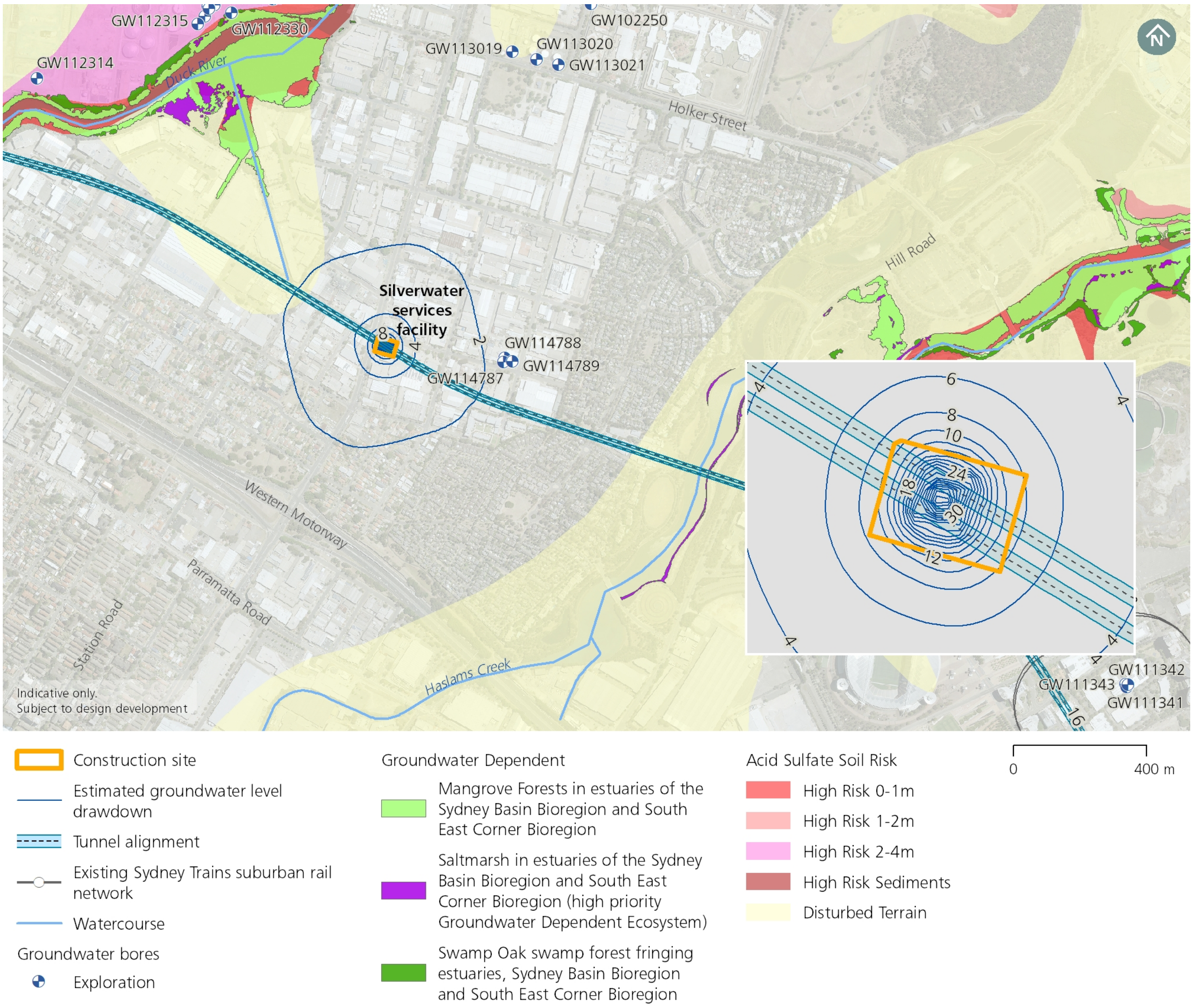

Figure 5-4: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at Silverwater services facility construction site

5.6.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the shaft excavation is up to 0.3 litres per second at both one and two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 11 megalitres in the first year and 10 megalitres in the second year.

The groundwater flow regime in the vicinity of the shaft is expected to change due to excavation. Without Stage 1, groundwater was likely to flow away from the construction site in an approximately westerly direction. With Stage 1, the excavation is assessed to act as a groundwater sink, causing groundwater to flow towards the shaft.

5.6.3 Groundwater recharge

The conversion of pervious areas to impervious areas has the potential to reduce infiltration of rainfall or surface water that recharges the groundwater system.

Ground over the proposed construction site area appears to be mostly pervious. Stage 1 may therefore reduce recharge rates within the footprint of the construction site. However, this area is small relative to the local catchment area, and the net impact on regional recharge due to Stage 1 is not likely to be significant.

5.6.4 Groundwater quality

The shaft excavation is expected to act as a groundwater sink, causing groundwater to flow towards the shaft.

The Technical Paper 8 identifies the potential for groundwater within the construction site footprint and nearby alignment to be impacted by heavy metals, hydrocarbons and VOC (at AEI 22, 24 and 25). AEI 22 lies within the predicted zone of groundwater level drawdown. AEI 24 and 25 relate to non-location-specific historical commercial/industrial sites that may lie within the predicted zone of groundwater level drawdown. The potential contamination impact was assessed to be moderate to high for groundwater associated with these AEI.

There is an increased risk of likely impact associated with the ingress of contaminated groundwater into excavation voids and the management of dewatering during the construction of the station box.

It is possible that contaminated groundwater from this site would migrate towards, and seep into, the excavation. There is a risk that construction workers and adjacent site users could be exposed to contaminated groundwater at this construction site, and that migration of contamination could reduce the beneficial use of the aquifer.

Contaminated groundwater seeping into the excavation would be collected and treated during construction.

Additional desktop review and field investigation is required to confirm the presence of groundwater contamination at the adjacent site and quantify this risk.

The estimated zone of groundwater level drawdown influence does not extend to any saline water bodies. Groundwater in the vicinity of the station is therefore not likely to be impacted by saline water intrusion due to Stage 1.

5.6.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater level drawdown. However, disturbed soils have been identified in this area. Up to two metres of groundwater level drawdown is estimated at two years after excavation in the area where disturbed soils have been identified, to the northwest of the shaft. It is possible that excavation of the shaft would cause oxidation of potential acid sulfate soils in the area, if they are present. Site investigation is required to confirm the presence of potential acid sulfate soils in the vicinity of the shaft.

The groundwater modelling undertaken has adopted a conservative approach and the magnitude of potential drawdown is therefore a conservative estimate. The likelihood of the services facility excavation impacting acid sulfate soils is therefore considered to be low.

5.6.6 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems were not identified within the predicted extent of groundwater level drawdown of the shaft.

5.6.7 Groundwater users

WaterNSW-registered bores were not identified within the predicted extent of groundwater drawdown (drawdown greater than two metres). The two-metre drawdown contour represents the minimal impact consideration (for groundwater level drawdown) of the NSW Aquifer Interference Policy.

5.6.8 Surface water-groundwater interaction

Groundwater level drawdown due to shaft excavation is not likely to affect groundwater interaction with surface waters.

5.7 Sydney Olympic Park metro station

The Sydney Olympic Park Station construction site would support the excavation of a cut-and-cover station box with a northern entry adit.

5.7.1 Groundwater levels

Figure 5-5 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

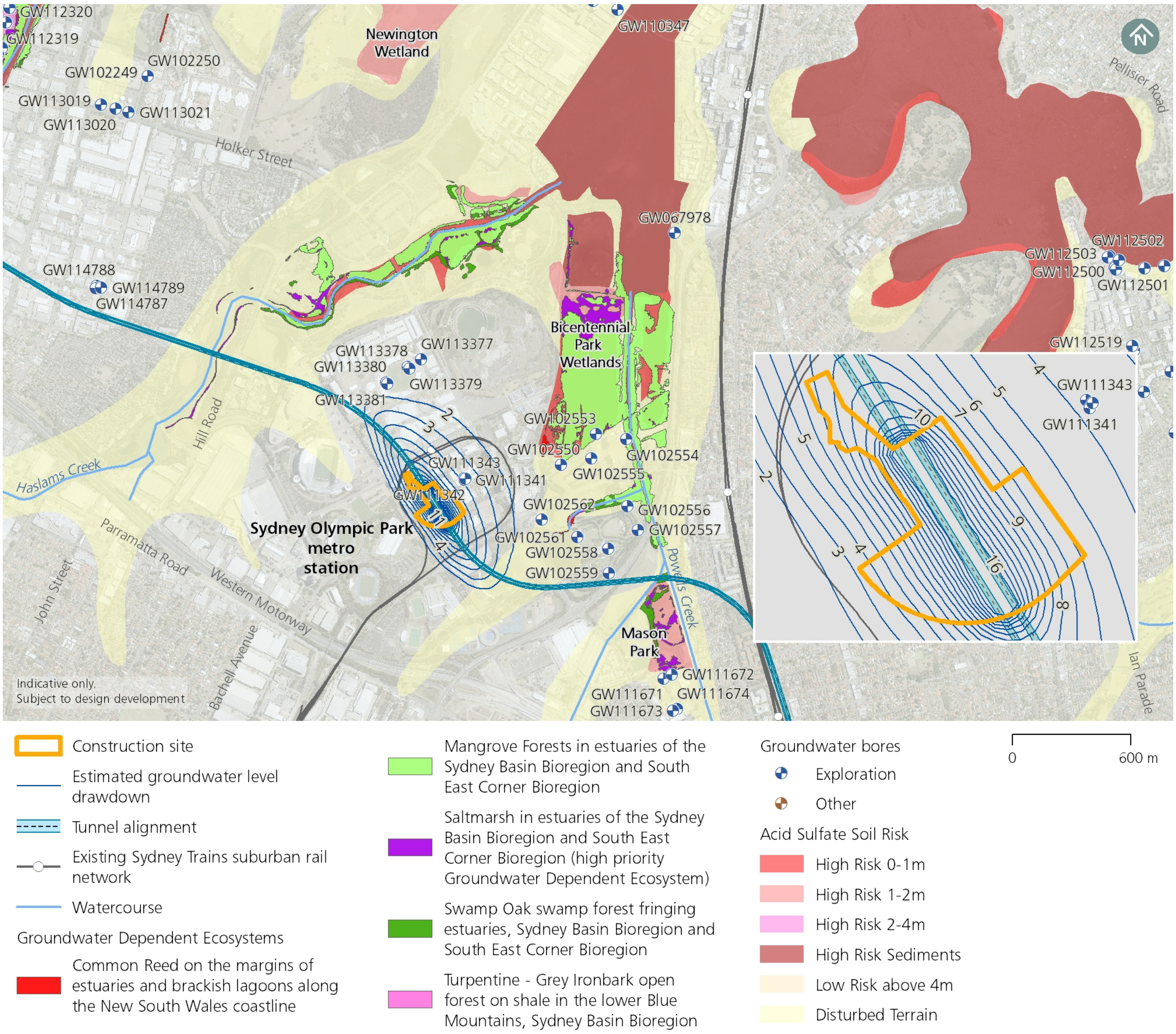

Figure 5-5: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at Sydney Olympic Park metro station construction site

5.7.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the excavation is up to 0.4 litres per second at both one and two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 13 megalitres in the first year and 12 megalitres in the second year.

The groundwater flow regime in the vicinity of the construction site is expected to change due to excavation. Without Stage 1, groundwater was interpreted to flow away from the construction site in southerly and easterly directions. With Stage 1, the excavation is assessed to act as a groundwater sink, causing groundwater to flow towards the excavation.

5.7.3 Groundwater recharge

The conversion of pervious areas to impervious areas has the potential to reduce infiltration of rainfall or surface water that recharges the groundwater system.

The majority of the existing ground over the proposed construction site is impervious. Stage 1 therefore would not reduce recharge rates in the vicinity of the site.

5.7.4 Groundwater quality

The station excavation is expected to act as a groundwater sink, causing groundwater to flow towards the excavations.

The Technical Paper 8 identifies the potential for groundwater at numerous former landfill sites in the region. One of these, the former Golf Driving Range Landfill, located at Sarah Durack Avenue, Sydney Olympic Park (AEI 30), lies within the estimated extent of groundwater level drawdown, and could be contaminated with nutrients, metals, hydrocarbons, volatile organic compounds, perfluorooctanesulfonic acid, asbestos and landfill gas. The potential contamination impact was assessed to be moderate to high for groundwater associated with this AEI.

Any potentially contaminated groundwater migrating from this site could seep into the excavation. There is a potential risk that construction workers and adjacent site users could be exposed to contamination via contact with contaminated groundwater and/or vapour released from contaminated groundwater. There is a further risk that migration of contamination could reduce the beneficial use of the aquifer.

Additional desktop review and field investigation is required to confirm the presence of groundwater contamination at this site.

It is possible that saline water within Powells Creek and the Bicentennial Park Wetlands could be drawn into the fresh groundwater between the station excavation and these waterways/water bodies. Groundwater supply for primary industries/drinking water and sites with groundwater-dependent cultural or spiritual values were not identified in the area where this potential impact could occur. The groundwater dependent ecosystems (terrestrial vegetation) identified in the area where this potential impact could occur comprise:

- Common Reed on the margins of estuaries and brackish lagoons
- Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion
- Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion
- Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion.

These ecosystems are tolerant of saline groundwater. Based on this, potential saline water intrusion in this area is not likely to impact the environmental value of the aquifer.

5.7.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater level drawdown. However, disturbed soils have been identified within the estimated extent of groundwater level drawdown, to the south of the station excavation. Up to four metres of groundwater level drawdown is estimated in the area where disturbed soils have been identified at two years after excavation. It is possible that excavation of the station box would cause oxidation of potential acid sulfate soils in this area, if they are present. Site investigation is required to confirm the presence of potential acid sulfate soils in this area.

The groundwater modelling undertaken has adopted a conservative approach and the magnitude of potential drawdown is therefore a conservative estimate. The likelihood of the station excavation impacting acid sulfate soils is therefore considered to be low.

5.7.6 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems were not identified within the predicted extent of groundwater level drawdown of the station excavation.

See Section 5.7.4 for further discussion in relation to the potential impacts of saline water intrusion, and Section 5.7.8 for further discussion in relation to the potential impacts of surface water-groundwater interaction, on groundwater dependent ecosystems.

5.7.7 Groundwater users

Three WaterNSW-registered bores were identified within the predicted extent of groundwater level drawdown (see Table 4-3). WaterNSW reports the purpose of these bores as monitoring. Water supply at WaterNSW-registered bores are therefore not likely to be impacted by the station excavation.

5.7.8 Surface water-groundwater interaction

Groundwater level drawdown due to station excavation is predicted at distance from Haslams Creek, the Mason Park wetlands, Bicentennial Park wetlands, and the Brickpit at Sydney Olympic Park. It is not known whether groundwater contributes baseflow to these surface water features.

If there is existing groundwater baseflow contribution to the surface waters, then Stage 1 has the potential to reduce that baseflow contribution to these surface waters. Groundwater level drawdown from Stage 1 at distance from these surface water features could result in reduced groundwater flow towards these surface waters, which could potentially cause reduced baseflow contribution to streamflow.

The baseflows would be likely to support the following groundwater dependent ecosystems (terrestrial vegetation) located along Haslams Creek, and in the Bicentennial Park wetlands and the Mason Park wetlands:

- Common Reed on the margins of estuaries and brackish lagoons
- Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion
- Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion
- Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion.

These groundwater dependent ecosystems could be impacted if baseflows are reduced. Other aquatic ecosystems could also be impacted if baseflows are reduced.

However, as baseflows are likely to be a minor component of creek streamflow, and the groundwater modelling undertaken is conservative, the significance of this impact on Haslams Creek is likely to be low.

For the Bicentennial and Mason Park wetlands, rainfall and tidal flows from the Parramatta River are likely to be the dominant source of water for the wetland systems. As groundwater baseflows are likely to be a minor component of water contributing to the wetland systems, the significance of this impact is likely to be low.

As discussed in Section 5.2.2, to confirm the existing baseflow contribution to Haslams Creek, additional site investigations would be carried out during detailed design to confirm potential impacts to baseflow. Where significant reduction in baseflow is confirmed, measures would be implemented at the dive structure and services shaft excavations to reduce the potential for baseflow loss.

5.8 North Strathfield metro station construction site

The North Strathfield metro station construction site would support the excavation of a cut-and-cover station box.

5.8.1 Groundwater levels

Figure 5-6 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

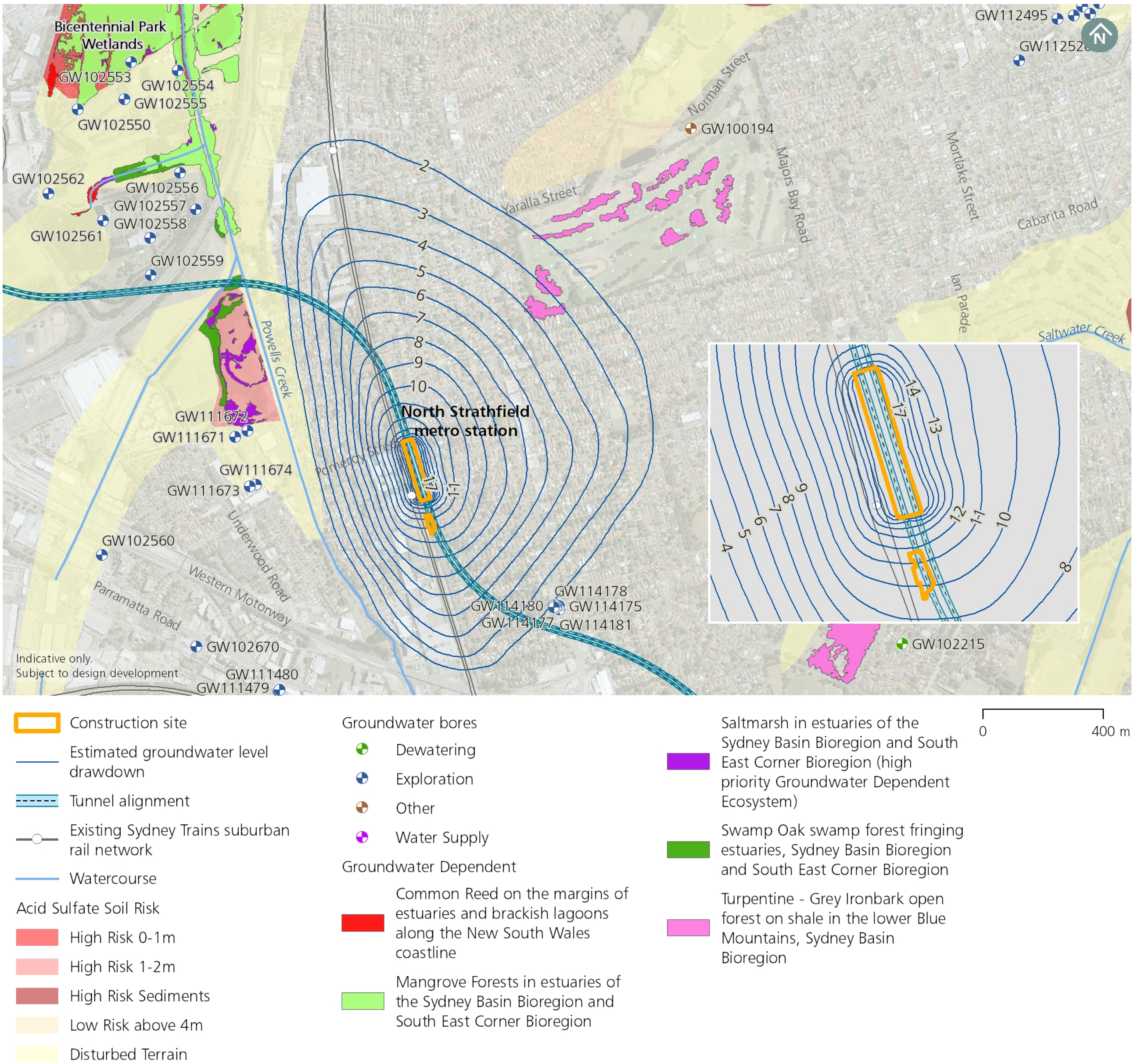

Figure 5-6: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at North Strathfield metro station construction site

5.8.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the excavation is up to 0.4 litres per second at both one and two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 22 megalitres in the first year and 12 megalitres in the second year.

The groundwater flow regime in the vicinity of the construction site is expected to change due to excavation. Where formerly groundwater was interpreted to flow away from the construction site in a westerly direction, the excavation is assessed to act as a groundwater sink, causing groundwater to flow towards the excavation.

5.8.3 Groundwater recharge

The conversion of pervious areas to impervious areas has the potential to reduce infiltration of rainfall or surface water that recharges the groundwater system.

Ground within the proposed station construction site is expected to be pervious. However, at a regional scale, the contribution of potential recharge over this area is likely to be minor, and changes to groundwater recharge from the conversion of the site to an impervious area are therefore likely to be minor to negligible.

5.8.4 Groundwater quality

The station excavation is expected to act as a groundwater sink, causing groundwater to flow towards the excavations.

The Technical Paper 8 identifies the potential for groundwater at commercial/industrial/retail sites adjacent to the construction site footprint and within the estimated extent of groundwater level drawdown to be potentially contaminated with heavy metals, hydrocarbons, solvents (namely formaldehyde), chlorinated hydrocarbons, and volatile organic compounds (AEI 36, 37,39 and 40). AEI 36, 37 and 39 lie within the predicted zone of groundwater level drawdown. The potential contamination impact was assessed to be moderate for groundwater associated with these AEI.

Any potentially contaminated groundwater migrating from nearby sites with contamination potential could seep into the excavation. There is a potential risk that construction workers and adjacent site users could be exposed to contamination via contact with contaminated groundwater and/or vapour released from contaminated groundwater. There is a further risk that migration of contamination could reduce the beneficial use of the aquifer.

It is possible that saline water within Powells Creek could be drawn into the fresh groundwater adjacent to the creek. The groundwater dependent ecosystems (terrestrial vegetation) identified between the station excavation and the Powells Creek comprise:

- Common Reed on the margins of estuaries and brackish lagoons
- Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion
- Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion
- Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion

These ecosystems are tolerant of saline groundwater. Furthermore, groundwater supply for primary industries/drinking water and groundwater-dependent cultural/spiritual sites were not identified in the area where this potential impact could occur. Based on this, potential saline water intrusion in this area is not likely to impact these ecosystems or the environmental value of the aquifer.

5.8.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the modelled extent of groundwater level drawdown. However, disturbed soils have been identified to the west of the construction site where up to two metres of groundwater level drawdown is predicted at two years after excavation, and it is possible that construction excavation would impact potential acid sulfate soils in that area, if present. Site investigation would be required to confirm the presence of potential acid sulfate soils to the west of the construction site.

The groundwater modelling undertaken has adopted a conservative approach and the magnitude of potential drawdown is therefore a conservative estimate. The likelihood of the station excavation impacting acid sulfate soils is therefore considered to be low.

5.8.6 Groundwater Dependent Ecosystems

Groundwater level drawdown of up to four metres is predicted at two years after excavation in the vicinity of the Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion potential groundwater dependent ecosystems. This ecosystem is located 650 metres to the north east of North Strathfield metro station at the Concord Golf Club. There is potential for Stage 1 to impact this groundwater dependent ecosystem.

This ecosystem grows on Wianamatta Shale and the rootzone is likely to lie within residual clay soils of the shale and/or the shale itself (where shallow). These geological units are likely to be of relatively low permeability, with a potential perched watertable present (which may be temporary) upon which these groundwater dependent ecosystems may intermittently rely. The groundwater level drawdown in the sandstone induced by station excavation is not likely to cause direct groundwater level drawdown in a perched aquifer that lies within the shallow clay or shale. Based on this, and the modelling approach being conservative, the likelihood of this ecosystem being impacted by the groundwater level drawdown associated with Stage 1 is therefore low.

See Section 5.8.4 for further discussion in relation to the potential impacts of saline water intrusion, and Section 5.8.8 for further discussion in relation to the potential impacts of surface water-groundwater interaction, on groundwater dependent ecosystems.

5.8.7 Groundwater users

Seven WaterNSW-registered bore were identified within the predicted extent of groundwater level drawdown (see Table 4-3). WaterNSW reports the purpose of these bores are monitoring. WaterNSW-registered water supply bores are therefore not likely to be impacted by station excavation.

5.8.8 Surface water-groundwater interaction

Groundwater level drawdown due to station excavation is predicted at distance from Powells Creek and the wetlands at Mason Park, Powells Creek Reserve and Bicentennial Park.

Groundwater level drawdown at distance from the creek and wetlands could result in reduced groundwater flow towards the creeks/wetlands, and ultimately reduced baseflow to the creeks/wetlands. It is not known whether groundwater currently contributes baseflow to these surface water features. If there is existing groundwater baseflow contribution to these surface water features, then Stage 1 has the potential to reduce that baseflow contribution and reduce stream flows.

These stream flows are likely to support the following groundwater dependent ecosystems (terrestrial vegetation) located along Powells Creek:

- Common Reed on the margins of estuaries and brackish lagoons
- Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion
- Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion

- Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion.

These groundwater dependent ecosystems could be impacted if baseflows are reduced. Other aquatic ecosystems are also likely to be impacted if baseflows are reduced. As baseflows are likely to be a minor component of streamflow, the significance of this impact is likely to be low.

As discussed in Section 5.2.2, to confirm the existing baseflow contribution to Powells Creek, additional site investigations would be carried out during detailed design to confirm potential impacts to baseflow. Where significant reduction in baseflow is confirmed, measures would be implemented at the station excavation to reduce the potential for baseflow loss.

5.9 Burwood North Station construction site

The Burwood North Station would support the excavation of a cut-and-cover station box with a southern entry adit, and a mined crossover cavern.

5.9.1 Groundwater levels

Figure 5-7 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

5.9.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the excavation is up to 3.1 litres per second at one year after excavation, and up to 2.8 litres per second at two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 117 megalitres in the first year and 91 megalitres in the second year.

The groundwater flow regime in the vicinity of the construction site is expected to change due to excavation. Without Stage 1, groundwater was interpreted to flow eastwards across the construction site. With Stage 1, the excavation is assessed to act as a groundwater sink, causing groundwater to flow towards the excavation.

5.9.3 Groundwater recharge

The conversion of pervious areas to impervious areas has the potential to reduce infiltration of rainfall or surface water that recharges the groundwater system.

Almost all ground over the proposed construction site is impervious. Stage 1 would not reduce recharge rates in the vicinity of the construction site.

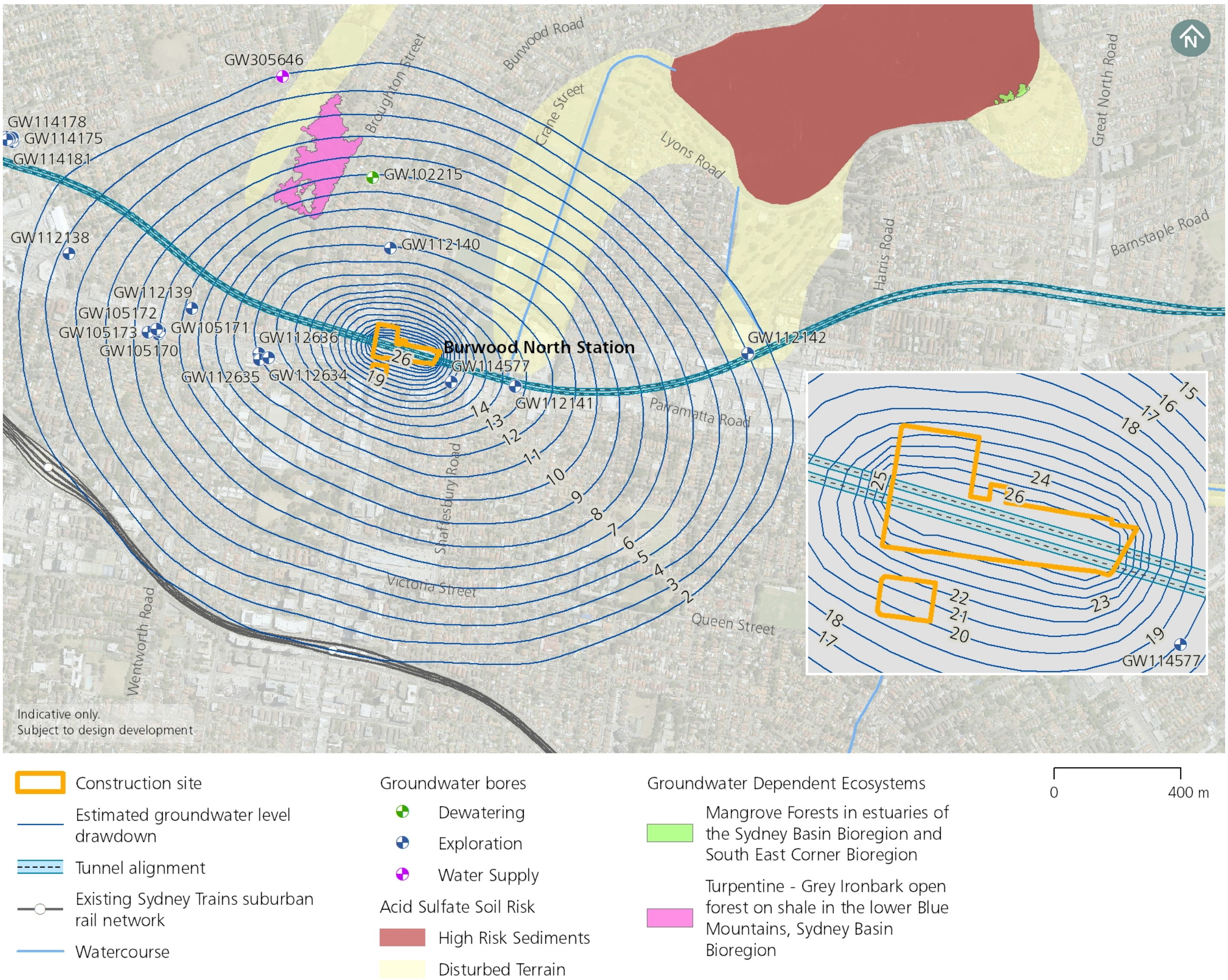

Figure 5-7: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at Burwood North Station construction site

5.9.4 Groundwater quality

The station excavations are expected to act as a groundwater sink, causing groundwater to flow towards the excavations.

The Technical Paper 8 identifies the potential for groundwater within and adjacent to the construction site to be contaminated with heavy metals, hydrocarbons, and volatile organic compounds; and sites adjacent to the construction site to be contaminated with heavy metals, hydrocarbons, solvents (VOC), volatile organic compounds, surfactants, and perfluorooctanesulfonic acid (AEI 41, 42 and 45). AEI 41 and 42 lie within the predicted zone of groundwater level drawdown. AEI 45 relates to non-location-specific historical commercial/industrial sites that may lie within the predicted zone of groundwater level drawdown. The potential contamination impact was assessed to be moderate for groundwater associated with these AEI.

Any potentially contaminated groundwater migrating from these sites could seep into the excavation. There is a potential risk that construction workers and adjacent site users could be exposed to contamination via contact with contaminated groundwater and/or vapour released from contaminated groundwater. There is a further risk that migration of contamination could reduce the beneficial use of the aquifer.

The results of the saline intrusion modelling show that the freshwater-saltwater interface could advance inland by less than 50 metres at depths of less than ten metres below ground level at the end of two years of excavation. The migration of saline water into the freshwater aquifer is therefore considered to be negligible. Further, groundwater supply bores and groundwater dependent ecosystems were not identified in this area. The likelihood of environmental impact due to saline intrusion in the groundwater is therefore considered to be low.

5.9.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater level drawdown. However, disturbed soils have been identified within this area, to the north-west and north-east of the station excavation. Up to 14 metres of groundwater level drawdown is estimated in the area where disturbed soils have been identified at two years after excavation. It is possible that excavation of the station box would cause oxidation of potential acid sulfate soils in the area, if they are present. Site investigation is required to confirm the presence of potential acid sulfate soils in the vicinity of the construction site.

The groundwater modelling undertaken has adopted a conservative approach and the magnitude of potential drawdown is therefore a conservative estimate. The likelihood of the station excavation impacting acid sulfate soils is therefore considered to be low.

5.9.6 Groundwater Dependent Ecosystems

A potential groundwater dependent ecosystem (terrestrial vegetation) was identified about 450 metres north-west of Burwood North metro station (Turpentine -– Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion at Queen Elizabeth Park). Groundwater level drawdown of up to 11 metres is predicted in the vicinity of this ecosystem at two years after excavation.

This ecosystem grows on Wianamatta Shale and the rootzone is likely to lie within residual clay soils of the shale and/or the shale itself (where shallow). These geological units are likely to be of relatively low permeability, with a potential perched watertable present (which may be temporary) upon which these groundwater dependent ecosystems may intermittently rely. The groundwater level drawdown in the sandstone induced by the station excavation is not likely to cause direct groundwater level drawdown in a perched aquifer that potentially lies within the shallow clay or shale. Based on this, and the conservative modelling approach adopted, the likelihood of this ecosystem being impacted by the groundwater level drawdown associated with Stage 1 is therefore low.

See Section 5.9.8 for further discussion in relation to the potential impacts of surface water-groundwater interaction, on groundwater dependent ecosystems.

5.9.7 Groundwater users

Fifteen WaterNSW-registered bore were identified within the predicted extent of groundwater level drawdown (see Table 4-3). WaterNSW reports the purpose of these bores as monitoring, with the exception of bore GW305646, which is reported as a domestic water supply bore, and bore

GW102215, which is reported as a dewatering bore. As GW102215 is not a groundwater supply bore, it is not likely to be adversely impacted by Stage 1.

Water supply bore GW305646 is recorded as six metres deep. The estimated groundwater drawdown at its location is two metres at two years after excavation. Two metres is at the limit of minimal impact considerations as per the NSW Aquifer Interference Policy (NSW Office of Water, 2012), and considering that the modelling is conservative, it is unlikely that this bore would be impacted by excavation for Burwood North Station. This bore is not listed as active in the NSW Water Register. Site inspection is recommended to confirm the viability of this bore. If viable, the bore would be monitored throughout construction. Make good measures would be implemented if a loss of yield were to occur.

5.9.8 Surface water-groundwater interaction

Groundwater level drawdown due to station excavation is expected in the vicinity of St Lukes Park Canal and Barnwell Park Canal. Groundwater is not likely to contribute to these waters as they are concrete-lined channels. The potential naturalisation of these channels by Sydney Water would modify the banks of the channels, but would retain the concrete-lining at the base and centre-line of the channels. Connection between surrounding groundwater and the concrete-lined channel is not likely, and groundwater level drawdown due to station excavation is not likely to affect groundwater interaction with these surface waterways. Therefore, surface water-groundwater interaction is not likely to be affected by Stage 1 excavation.

5.10 Five Dock Station construction site

The Five Dock Station construction site would support the excavation of a mined cavern with access shafts at the western and eastern construction sites.

5.10.1 Groundwater levels

Figure 5-8 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

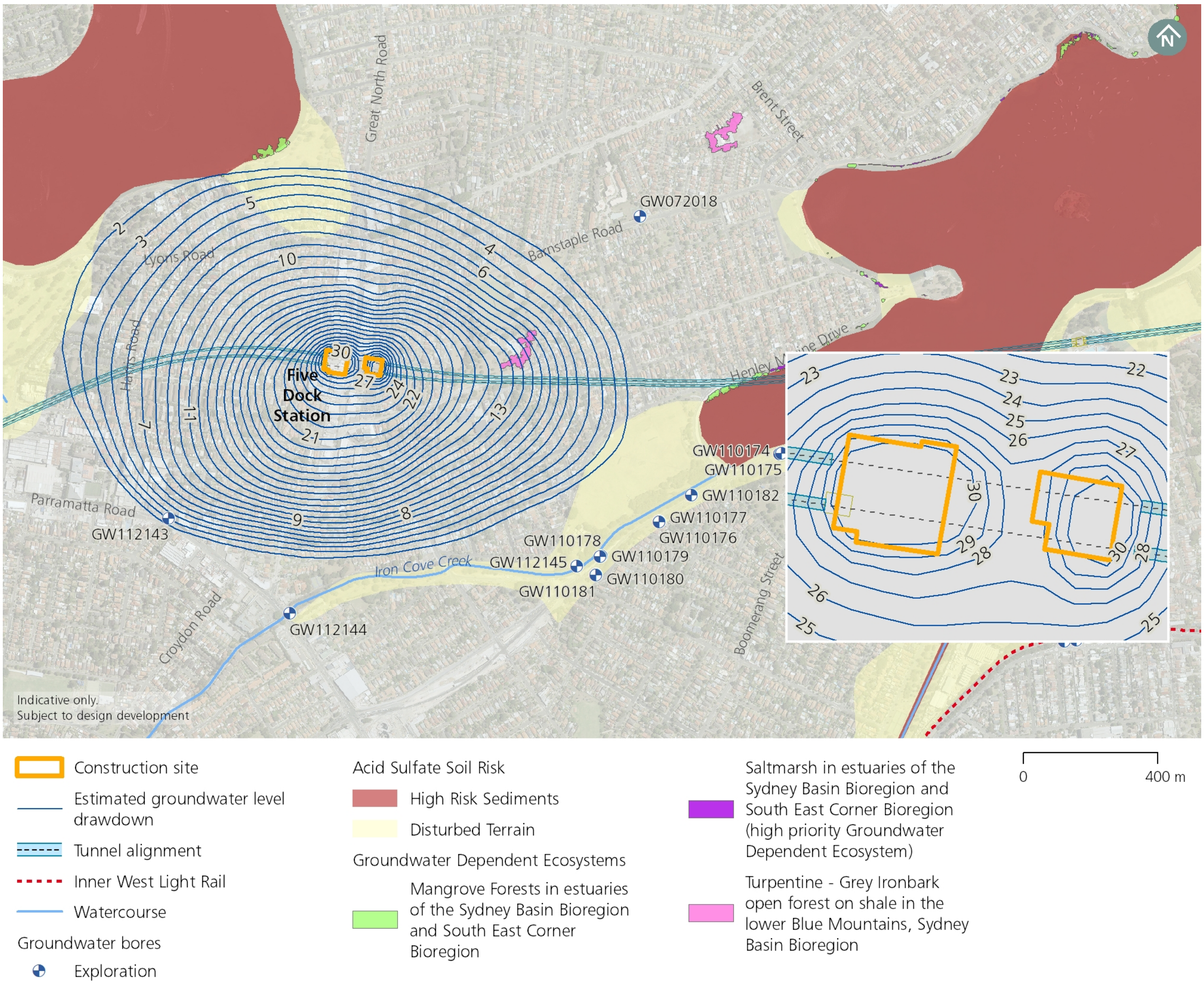

Figure 5-8: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at Five Dock Station

5.10.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the excavations (shafts and cavern) is up to 1.7 litres per second at both one and two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 64 megalitres in the first year and 53 megalitres in the second year.

The groundwater flow regime in the vicinity of the construction site is expected to change due to excavation. Where formerly groundwater was interpreted to flow away from the site, the shafts and cavern excavations are assessed to act as a groundwater sink, causing groundwater to flow towards the excavation.

5.10.3 Groundwater recharge

The conversion of pervious areas to impervious areas has the potential to reduce infiltration of rainfall or surface water that recharges the groundwater system.

Almost all ground over the proposed construction site is currently impervious. Stage 1 is therefore unlikely to reduce recharge rates in the vicinity of the construction site.

5.10.4 Groundwater quality

The station excavation is expected to act as a groundwater sink, causing groundwater to flow towards the excavations.

The Technical Paper 8 identifies the potential for groundwater adjacent to the construction site to be contaminated with heavy metals, hydrocarbons, solvents (namely formaldehyde) and volatile organic compounds (AEI 46, 49 and 50). AEI 46 lies within the predicted zone of groundwater level drawdown. AEI 49 and 50 relate to non-location-specific historical commercial/industrial sites that may lie within the predicted zone of groundwater level drawdown. The potential contamination impact was assessed to be low to moderate for groundwater associated with these AEI.

Any potentially contaminated groundwater migrating from this site could seep into the excavation. There is a potential risk that construction workers and adjacent site users could be exposed to contamination via contact with contaminated groundwater and/or vapour released from contaminated groundwater. There is a further risk that migration of contamination could reduce the beneficial use of the aquifer.

Groundwater level drawdown in the vicinity of saltwater bodies has the potential to cause saltwater to intrude into freshwater groundwater systems. Saline water can reduce the beneficial uses of the groundwater system, impact in-ground structures (durability), and potentially impact existing groundwater users and groundwater dependent ecosystems.

The results of the saline intrusion modelling predict that the freshwater-saltwater interface could advance inland by 100 metres at depths of less than five metres below ground level at the end of two years of excavation. The migration of saline water into the freshwater aquifer is therefore considered to be negligible. Further, groundwater supply bores and groundwater dependent ecosystems were not identified in this area. The likelihood of environmental impact due to saline intrusion in the groundwater is therefore considered to be low.

5.10.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater level drawdown. However, disturbed soils have been identified within this area, to the north-west of the construction site. Up to nine metres of groundwater level drawdown is estimated in the area where disturbed soils have been identified at two years after excavation. It is possible that excavation of the construction site would cause oxidation of potential acid sulfate soils in the area, if they are present. Site investigation is required to confirm the presence of potential acid sulfate soils in the vicinity of the construction site.

Groundwater level drawdown induced by the excavation is not likely to impact potential acid sulfate soils associated with Kings Bay, as these sediments would remain saturated with the waters of the bay.

The groundwater modelling undertaken has adopted a conservative approach and the magnitude of potential drawdown is therefore a conservative estimate. The likelihood of the station excavations impacting acid sulfate soils is therefore considered to be low.

5.10.6 Groundwater Dependent Ecosystems

A potential groundwater dependent ecosystem (terrestrial vegetation) was identified about 350 metres to the east of Five Dock Station construction site (Turpentine -– Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion at Five Dock Park). Groundwater level drawdown of up to 15 metres is predicted in the vicinity of this ecosystem at two years after excavation.

This ecosystem grows on Wianamatta Shale and the rootzone is likely to lie within residual clay soils of the shale and/or the shale itself (where shallow). These geological units are likely to be of relatively low permeability, with a potential perched watertable present (which may be temporary) upon which these groundwater dependent ecosystems may intermittently rely. The groundwater level drawdown in the sandstone induced by station excavation is not likely to cause direct groundwater level drawdown a perched aquifer that lies within the clay or shale. Based on this, and the conservative approach adopted for the modelling, the likelihood of this ecosystem being impacted by the groundwater level drawdown associated with Stage 1 is therefore low.

5.10.7 Groundwater users

One WaterNSW-registered bore was identified within the predicted extent of groundwater level drawdown (see Table 4-3). WaterNSW identifies this bore as a monitoring bore. WaterNSW-registered water supply bores are therefore not likely to be impacted by station excavation.

5.10.8 Surface water-groundwater interaction

Groundwater level drawdown due to station excavation is expected in the vicinity of Barnwell Park Canal and Iron Cove Creek. Groundwater is not likely to contribute to these waterways as they are concrete-lined channels. The naturalisation of these channels by Sydney Water would modify the banks of the channels, but would retain the concrete-lining at the base and centre-line of the channels. Connection between surrounding groundwater and the concrete-lined channel is not likely, and groundwater level drawdown due to station excavation is not likely to affect groundwater interaction with these surface waterways.

Water from Kings Bay may also be indirectly drawn into the groundwater to the south of the bay, as noted in Section 5.10.4.

5.11 The Bays Station construction site

The Bays Station construction site would support the excavation of a cut-and-cover station box.

5.11.1 Groundwater levels

Figure 5-9 shows the estimated groundwater drawdown from the current average water level at the end of two years of excavation.

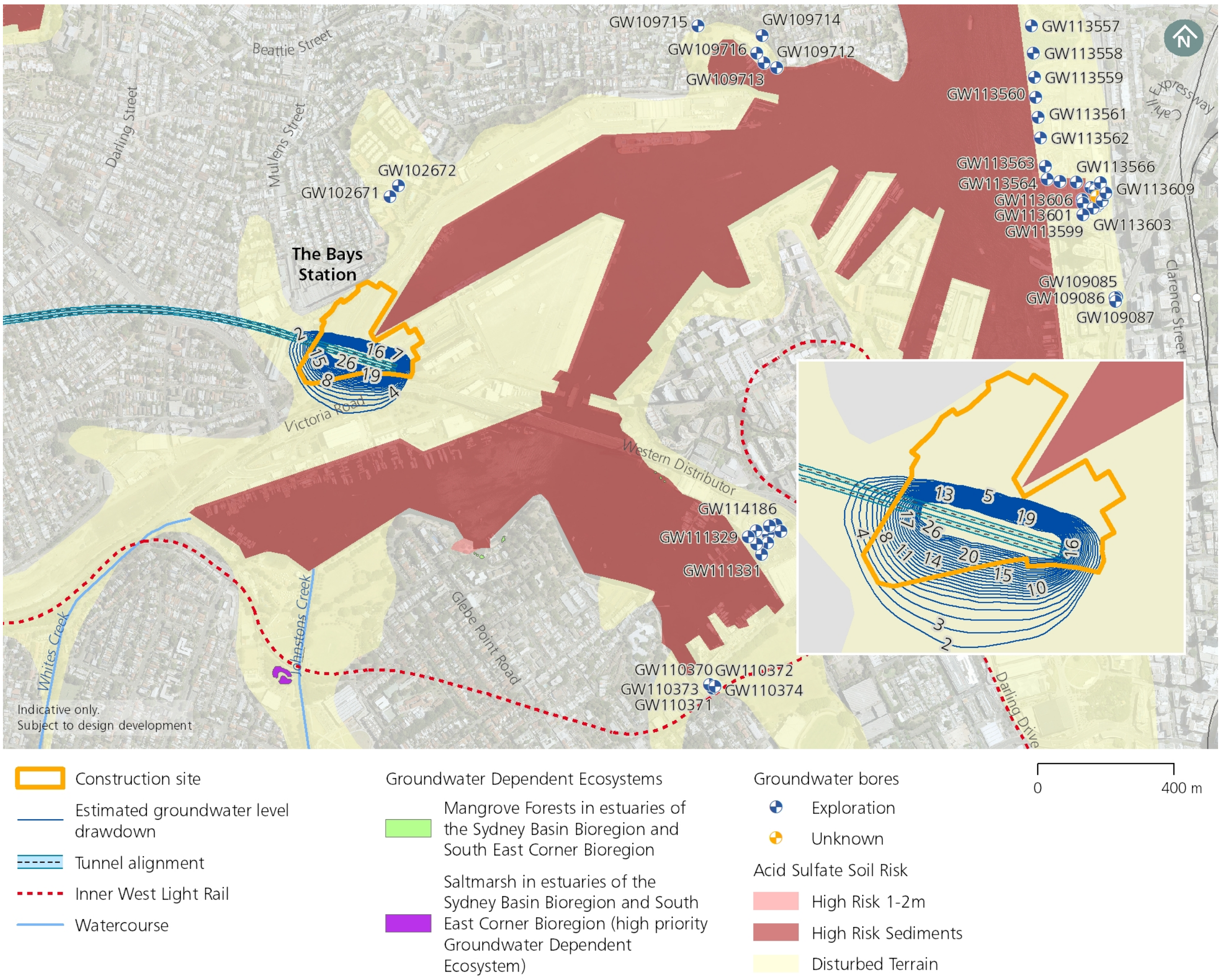

Figure 5-9: Estimated groundwater level drawdown from the current water level after two years due to Stage 1 excavation at The Bays Station construction site

5.11.2 Groundwater inflows and local flow regime

The estimated groundwater inflow to the excavation is up to 10.1 litres per second at both one and two years after excavation.

The groundwater inflow is sourced (taken) from the rock aquifer and is estimated to be up to 319 megalitres in the first and 320 megalitres in the second year. A proportion of this flow is likely to be indirectly sourced from the White Bay.

The station structure would be designed prevent the ingress of groundwater through the soils, and is drained across the rock. As such, groundwater levels (pressures) in the rock would reduce and the soils would partially underdrain, causing a potential fall in the groundwater table in the vicinity of the excavation.

Where formerly groundwater was interpreted to flow across the site towards White Bay and Rozelle Bay, the excavation is assessed to act as a groundwater sink, causing groundwater to flow towards the excavation instead.

5.11.3 Groundwater recharge

The conversion of pervious areas to impervious areas has the potential to reduce infiltration of rainfall or surface water that recharges the groundwater system.

Almost all ground over the proposed construction site is impervious. Stage 1 would therefore not reduce recharge rates in the vicinity of the site.

5.11.4 Groundwater quality

The station excavation is expected to act as a groundwater sink, with groundwater flow towards the station construction site.

The Technical Paper 8 identifies the potential for groundwater within the construction site footprint to be contaminated with heavy metals, hydrocarbons, polychlorinated biphenyls, asbestos and perfluorooctanesulfonic acid; and groundwater adjacent to the construction footprint to be contaminated with heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos and perfluorooctanesulfonic acid (AEI 54 to 58). AEI 55 and 56 lie within the predicted zone of groundwater level drawdown. AEI 54 and 57 relate to non-location-specific historical commercial/industrial sites that may lie within the predicted zone of groundwater level drawdown. The potential contamination impact was assessed to be moderate for groundwater associated with these AEI.

As the station excavation is undrained across the soil horizon during construction, there is potential for contaminated groundwater within the soils to be drawn downwards into the rock. Any potentially contaminated groundwater within the groundwater level drawdown zone of influence could seep into the excavation. There is a potential risk that construction workers and adjacent site users could be exposed to contamination via contact with contaminated groundwater and/or vapour released from contaminated groundwater. There is a further risk that migration of contamination could reduce the beneficial use of the aquifer.

Additional investigation is required to confirm the presence of groundwater contamination at the construction site and adjacent sites.

Groundwater level drawdown in the vicinity of saltwater bodies has the potential to cause saltwater to intrude into freshwater groundwater systems. Saline water can reduce the beneficial uses of the groundwater system, impact in-ground structures (durability), and potentially impact existing groundwater users and groundwater dependent ecosystems.

Project groundwater quality monitoring data for the site indicates that groundwater at the site is brackish and likely to be influenced by intrusion of saline waters from White Bay/Rozelle Bay.

Stage 1 excavation is likely to cause groundwater between the station excavation and White Bay/Rozelle Bay to increase in salinity. Groundwater supply bores and groundwater dependent ecosystems were not identified in this area, and existing in-ground structures in the area are expected to be designed for saline groundwater conditions. Based on this, increased salinity in the groundwater in these areas is not likely to cause environmental impact.

5.11.5 Acid sulfate soils

Potential acid sulfate soils were not identified within the estimated extent of groundwater level drawdown. However, disturbed soils have been identified within this area. Up to 28 metres of groundwater level drawdown is estimated in the area where disturbed soils have been identified at two years after excavation. It is possible that excavation of the station box would cause oxidation of potential acid sulfate soils in the area, if they are present. Site investigation is required to confirm the presence of potential acid sulfate soils in the vicinity of the construction site.

5.11.6 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems were not identified within the predicted extent of groundwater level drawdown of the station excavation.

5.11.7 Groundwater users

WaterNSW-registered bores were not identified within the predicted extent of groundwater level drawdown.

5.11.8 Surface water-groundwater interaction

A proportion of inflow to the station excavation is likely to be indirectly sourced from White Bay, as bay waters would be drawn into the groundwater system.

5.12 Tunnels

5.12.1 Groundwater level drawdown

The mainline tunnels would be constructed by tunnel boring machines through Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone. The tunnel boring machines would construct a pre-cast segmental tunnel lining as excavation progresses.

Given the relatively low hydraulic conductivity and storativity of the rock and the short timeframe over which an open (unlined) excavation would be open in the tunnels, groundwater level drawdown due to the tunnels is not likely to be significant.

Tunnel cross passages may be open for a short period of time prior to being waterproofed. Given the relatively small footprint anticipated for the cross passages, the impacts of cross passage construction on groundwater are not likely to be significant.

5.12.2 Groundwater quality

Ground impacted by drilling/cutting fluids used by tunnel boring machines is expected to be removed as spoil. Tunnel mining is therefore not likely to impact the groundwater quality of the surrounding aquifer.

If contaminants are expected to be mobilised towards the tunnel during construction, there would be controls in place at the face of the tunnel boring machine to prevent the exposure of tunnel construction workers to contaminated groundwater (e.g. isolation of spoil with enclosed conveyors). Groundwater collected by the tunnel boring machine would be treated prior to release to the environment.

The Technical Paper 8 identifies the potential for groundwater in the vicinity of the tunnel to be contaminated:

- With perfluorooctanesulfonic acid within the suburbs of Clyde, Silverwater, Sydney Olympic Park, North Strathfield and Rozelle

- With heavy metals (including chromium), phenol, light non-aqueous phase liquid and hydrocarbons in the suburb of Clyde
- With nutrients, heavy metals, hydrocarbons, and volatile organic compounds in the suburb of Sydney Olympic Park.

5.12.3 Groundwater Dependent Ecosystems

The tunnel alignment passes in proximity (within 500 metres) to groundwater dependent ecosystems (terrestrial vegetation) in the suburbs of Westmead, Parramatta, Clyde, Silverwater, and Sydney Olympic Park.

Given that groundwater level drawdown is not likely to be significant due to tunnel excavation, impacts to groundwater dependent ecosystems due to tunnel excavation are not expected.

5.13 Stage 1 wide considerations

5.13.1 Ground movement

Stage 1 would cause ground movement, which has the potential to cause damage to infrastructure. Ground movement includes ground settlement and lateral movement. Total ground settlement would occur as a combination of groundwater level drawdown-induced settlement and excavation-induced settlement.

Additional information on ground movement can be found in Chapter 18 (Groundwater and ground movement – Stage 1) of the Environmental Impact Statement with respect to management of potential ground movement.

5.13.2 Groundwater quality and discharge

Groundwater collected within site excavations and within the tunnels during construction would be treated by temporary water treatment plants so that discharged water quality into the local stormwater system meets the requirements of any relevant environment protection licence for Stage 1.

For further discussion on discharges, see Chapter 19 (Soils and surface water quality – Stage 1) of the Environmental Impact Statement.

5.13.3 Culturally sensitive sites

Culturally sensitive groundwater-dependent sites have not been identified in the vicinity of Stage 1.

5.13.4 Stage 1 water balance

A preliminary water balance assessment was carried out for the construction period.

Water demand and rates of consumption would be based on the final construction methodology. At this stage of construction planning, the following methodology and assumptions were considered for the Stage 1 water balance:

- The water balance is project-wide, as there are insufficient site-specific data on water demand/supply to provide an individual water balance for each site

- Estimated water consumption for Stage 1 was based on consumption records for the construction of Sydney Metro Northwest, with consumption approximately scaled to the Sydney Metro West tunnel length and number of stations/facilities sites
- Potable water demand would be sourced from Sydney Water (mains supply)
- Non-potable water uses would include activities such as dust suppression, plant wash-down and concrete batching
- There is potential for some of the non-potable demand during construction to be met by supply from groundwater inflows to excavations. Groundwater inflows to station excavations would reduce with time. Evaporative losses are also assumed. The proportion of this groundwater that can be used in construction is 50 per cent
- Of the potable water used, 30 per cent would be recycled to meet non-potable water demand
- The remaining water would be discharged to the stormwater network, watercourses or potentially to the sewerage network (under a trade waste agreement)

There may be an opportunity for rainwater harvesting at some construction sites. This opportunity would be explored during detailed construction planning.

The water balance for Stage 1 is shown in Table 5-3.

Based on this water balance, water supply would exceed water demand, with losses via consumption comprising a relatively minor quantum, and discharge volumes being a significant proportion of total supply.

Table 5-3: Stage 1 water balance

Source / activity	Type	ML per year
Demand		
Construction activities associated with the stabling and maintenance facility	Non-potable	40
	Potable	35
Construction activities associated with station and tunnel excavation	Non-potable	43
	Potable	251
	Demand (total)	369
Supply		
Recycled potable water to meet non-potable demand	Non-potable	256
Groundwater inflow (station excavations) to meet non-potable demand	Non-potable	568
Sydney Water (mains supply)	Potable	286
	Supply (total)	1,110

Source / activity	Type	ML per year
Losses via consumption		
Consumed by construction activities (eg dust suppression, plant wash-down and concrete batching)	Non-potable	83
Discharge (total)	Non-potable	515

5.13.5 Utility adjustments

Minor short-term dewatering may be required to undertake adjustments for utilities in the immediate vicinity of construction sites.

It is anticipated that the groundwater inflow to excavations for utility adjustments would generally be relatively minor compared to those experienced by the station or shaft excavations. Dewatering for utility adjustments is therefore not likely to cause impacts to groundwater beyond those impacts discussed above relating to station/service facility excavations.

5.14 Sensitivity analysis

5.14.1 Methodology

A sensitivity analysis was carried out on the model parameters to assess sensitivity of the model results to variation in model parameter values. The sensitivity of these parameters is explored through increasing and decreasing the various parameter values and examining the effect these have on the results.

The sensitivity simulations were carried out where the parameter value of interest was run with either an increase or a decrease as per the scenario summary in Table 5-4. Both an increase and decrease were investigated as the relationship is not linear.

Table 5-4: Sensitivity scenarios

Scenario	Hydraulic conductivity - horizontal	Specific yield	Specific storage	Rainfall recharge
Initial model	Refer to Table 5-1			
1	×2	as per initial model	as per initial model	as per initial model
2	×0.5	as per initial model	as per initial model	as per initial model
3	as per initial model	×2	×10	as per initial model
4	as per initial model	×0.5	×0.1	as per initial model
5	as per initial model	as per initial model	as per initial model	×2
6	as per initial model	as per initial model	as per initial model	×0.5

5.14.2 Results

The results of the sensitivity analysis are shown graphically in Figure 5-10 to Figure 5-13. The curves shown on the graphs are the simulated drawdown relative to the Burwood North box and maximum drawdown is at the edge of the box excavation. The results have been shown (for ease of comparison) together with the + and – of one standard deviation curve (grey line) of the initial model results for Burwood North Station construction site.

The sensitivity analysis on the drawdown result shows that the model is most sensitive to variation of hydraulic conductivity (k). In the south section, the change (doubling/halving) to the conductivity value caused a difference of 21 metres in the drawdown at 266 metres from the excavation (refer to Figure 5-10). The drawdown simulation is only moderately sensitive to changes in specific yield/storage and rainfall infiltration, with the majority of results ranging within the one standard deviation range of the initial modelling results, with the exception of high rainfall infiltration scenario south of the excavation (Figure 5-11).

Inflows expressed as litres/second (Figure 5-12) and cumulative inflow (Figure 5-13) show a similar sensitivity to drawdown. Inflow simulation results are most sensitive to changes in hydraulic conductivity and only moderately sensitive to changes in specific yield/storage and rainfall infiltration, with the majority of results ranging within the one standard deviation range of the initial modelling results.

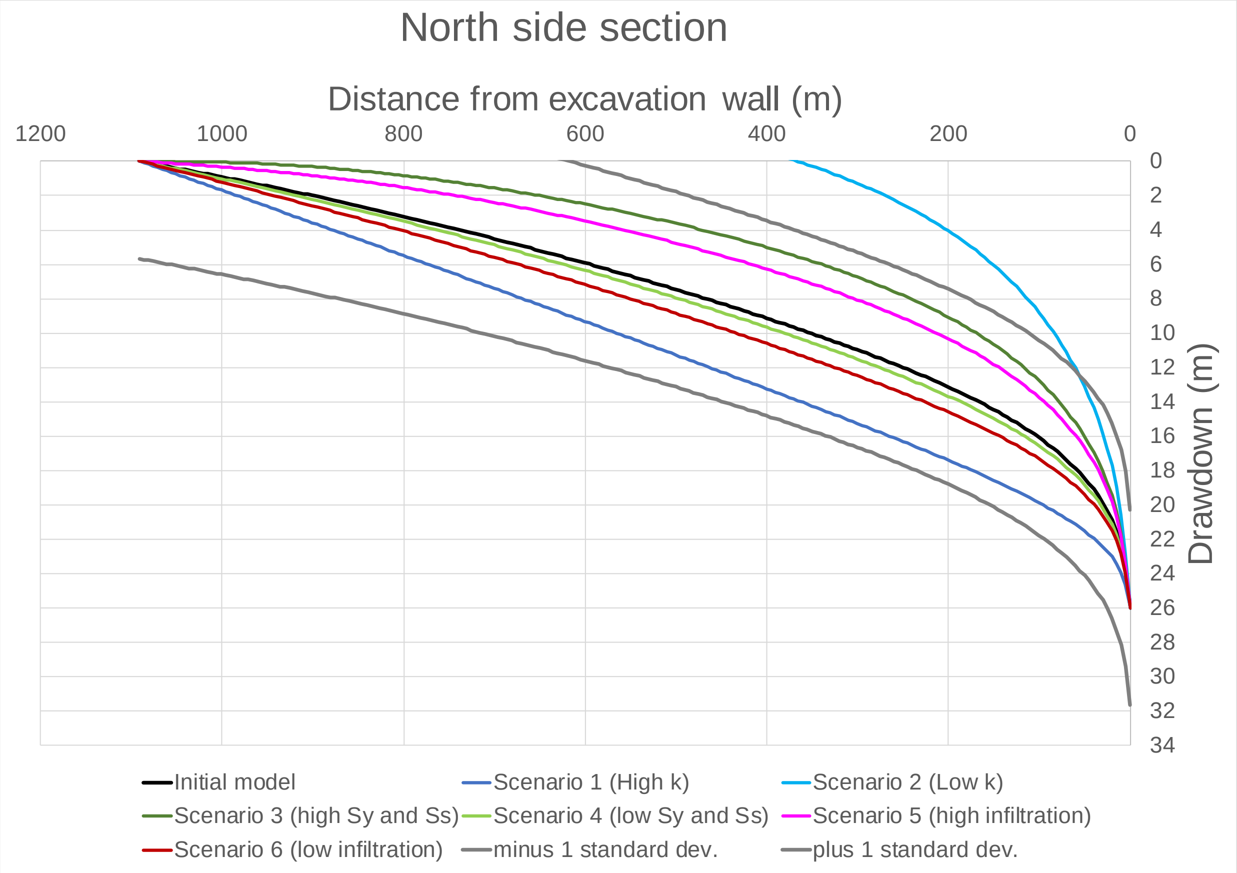

Figure 5-10: Sensitivity analysis results – Drawdown – North of Burwood North Station box

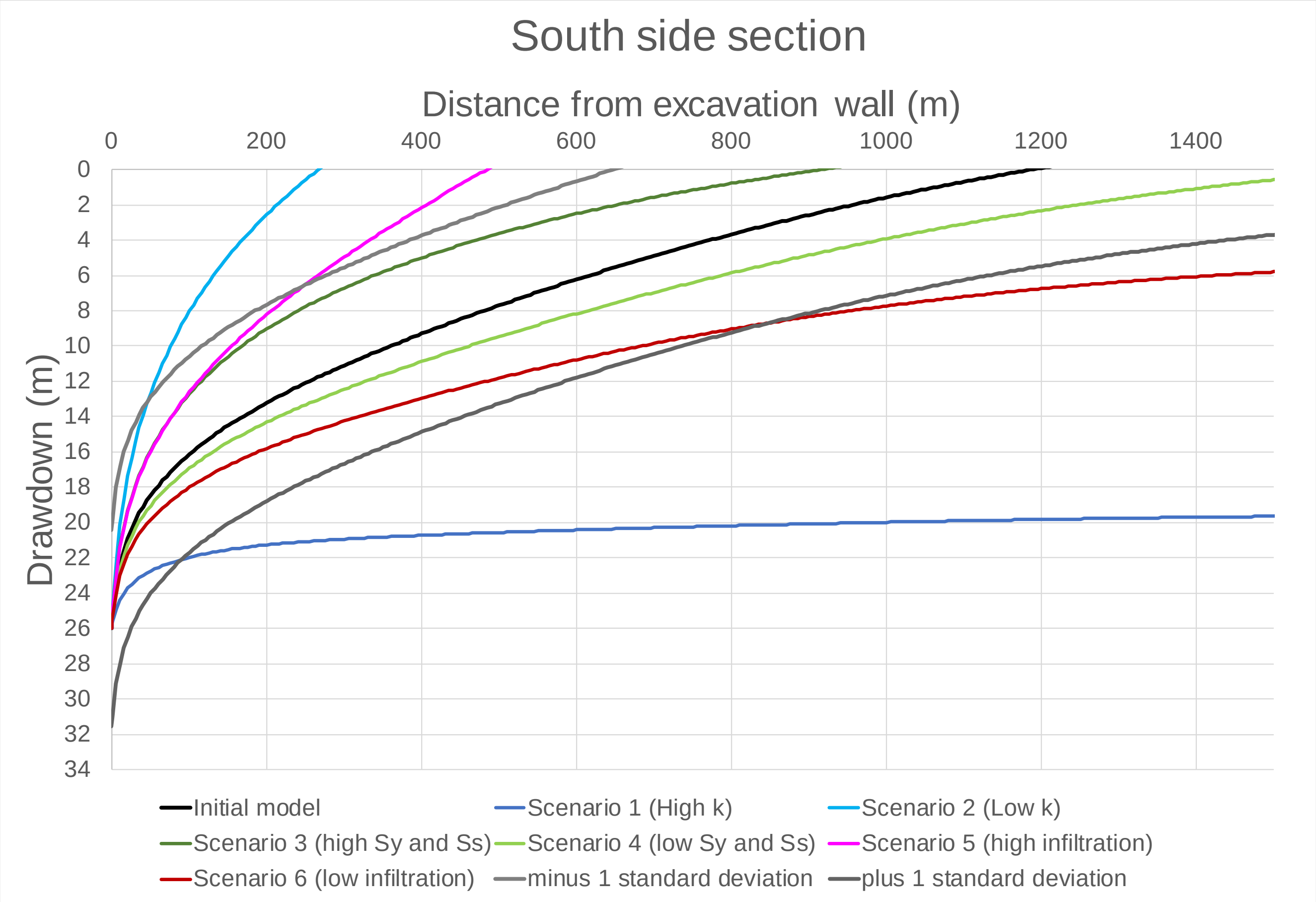

Figure 5-11: Sensitivity analysis results – Drawdown – South of Burwood North Station box

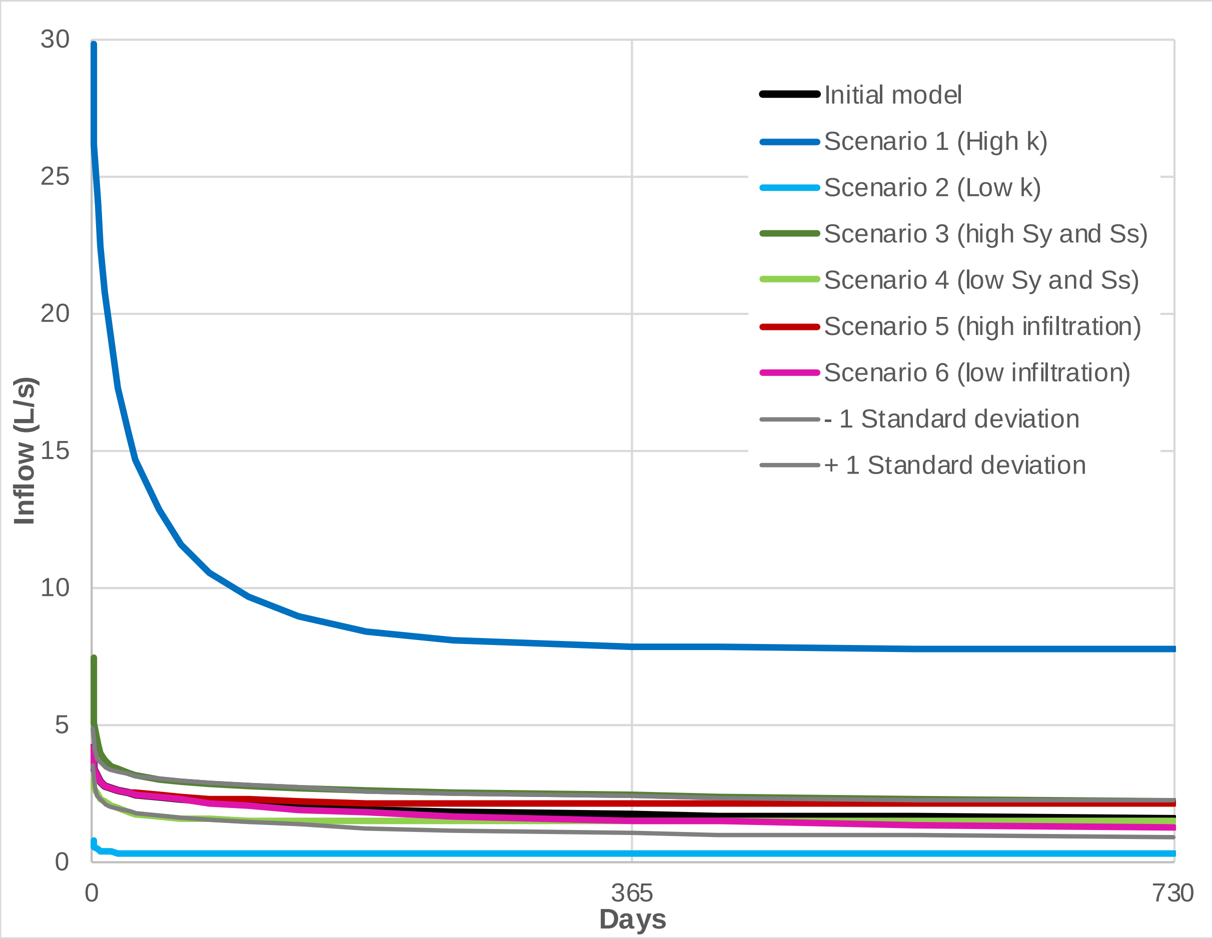

Figure 5-12: Sensitivity analysis results – Inflow rate (L/s) – South of Burwood North Station box

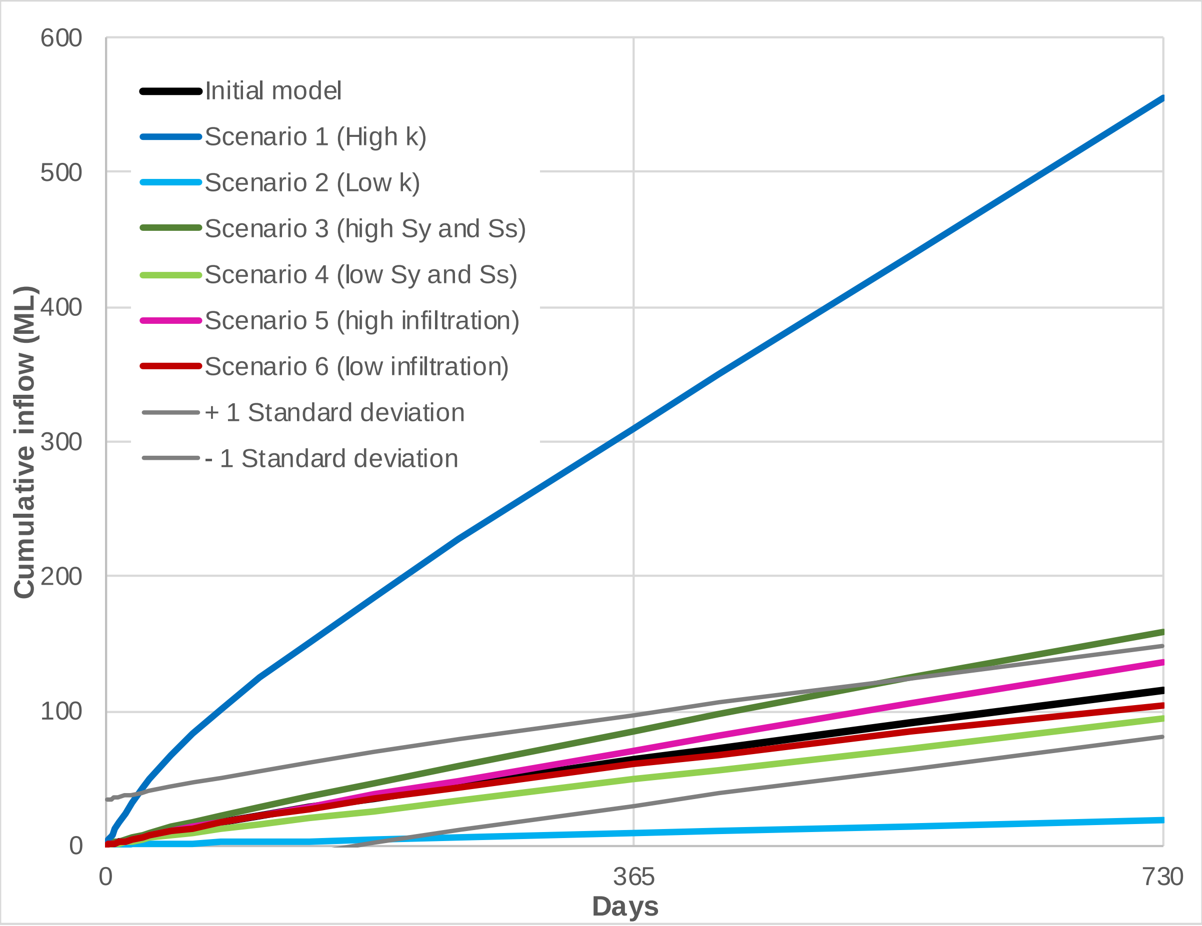

Figure 5-13: Sensitive analysis results – Cumulative inflow (ML) – South of Burwood North Station box

5.15 Cumulative impacts

Overlapping of drawdown associated with the excavation of individual Stage 1 stations and shafts has the potential to cause a cumulative impact. This is most likely to occur in areas where the drawdown extends to the adjacent excavation impact; for example, at North Strathfield, Burwood North and Five Dock. This is likely to cause additional drawdown than that predicted. The modelling carried out is considered to be conservative and potential cumulative impact is generally likely to be included in the predicted drawdown.

The presence of other drained tunnels and/or excavations within the vicinity of the Stage 1 sites has the potential to induce significantly greater groundwater level drawdown than the Stage 1 works alone. Groundwater level drawdown in such areas would be the cumulative product of drawdown due to Stage 1 and the other drained excavations/structures. The following infrastructure has been identified as having potential to cause additional groundwater level drawdown to that assessed for Stage 1 alone:

- M4 East (in the vicinity of North Strathfield metro station construction site, Burwood North Station construction site and Five Dock Station construction site)
- The proposed Western Harbour Tunnel
- Existing and proposed drained basements in close proximity to any of the Stage 1 excavations.

Based on the groundwater assessment provided in the Environmental Impact Assessment for the M4 East project (WestConnex Delivery Authority, 2015), the M4 East tunnels are predicted to induce groundwater level drawdown in the vicinity of North Strathfield metro station, Burwood North Station and Five Dock Station construction sites. The Environmental Impact Assessment for the M4 East project predicted long term (steady state) drawdown only and does not present predicted drawdowns during M4 East construction or in the early years of operation. The predicted drawdown indicates that there may be cumulative drawdown in some areas in the vicinity of North Strathfield metro station and Five Dock Station construction sites due to M4 East and Stage 1, and that this cumulative drawdown could be some metres greater than that predicted for Stage 1 alone. The drawdown predicted in the vicinity of Burwood North Station construction site due to M4 East is significantly greater than the drawdown predicted due to Stage 1.

Based on the predicted groundwater level drawdown due to the M4 East tunnels, the potential impacts to potential acid sulfate soils, groundwater dependent ecosystems, groundwater users (domestic supply bores) and contaminant migration that have been identified due to the Stage 1 excavations for North Strathfield metro station, Burwood North Station and Five Dock Station construction sites are likely to have been previously (at least partially) induced by excavation of the M4 East Tunnels, and may have already occurred.

The groundwater assessment provided in the Environmental Impact Assessment for the M4-M5 Link project (WestConnex Delivery Authority, 2017), which includes the Rozelle Interchange, does not predict long term (steady state) groundwater level drawdown for the M4-M5 Link that lies within the predicted zones of groundwater level drawdown due to Stage 1. Based on this, the M4-M5 Link tunnels are not expected to contribute cumulative impacts to Stage 1.

The Environmental Impact Statement for the Western Harbour Tunnel and Warringah Freeway Upgrade (Roads and Maritime Services, 2019) shows that the tunnels associated with this project lie to the west of The Bays Station construction site. Groundwater modelling results reported for this project indicate that it is likely to cause groundwater level drawdown in the vicinity of The Bays

Station construction site. Based on the predicted groundwater level drawdown at the end of tunnel construction for the project, an additional groundwater level drawdown of up to three metres would be expected at The Bays Station construction site. This drawdown would be additive to the drawdown induced by Stage 1. The potential impacts of this cumulative drawdown and their significance are not expected to differ from those predicted for Stage 1 alone.

5.16 Summary of potential impacts

The potential impacts discussed above are summarised in Table 5-5.

Table 5-5: Summary of potential impacts due to Stage 1

Construction site	Summary of potential impacts due to Stage 1	Significance of potential impact[a]
Westmead metro station	Contamination could be present in groundwater at concentrations above the relevant assessment criteria and is likely to be limited in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Moderate
	Potential impact to potential groundwater dependent ecosystems (terrestrial vegetation) due to groundwater level drawdown: • Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley located between about 500 metres and one kilometre to the west • Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain located about 350 and 650 metres to the east • Pockets of Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain between 200 and 650 metres to the east. There is a moderate to high likelihood of these ecosystems being dependent on groundwater. However, these potential groundwater dependent ecosystems are likely to rely temporarily on perched groundwater within the soils and are therefore not likely to be impacted by the groundwater level drawdown in the sandstone that is induced by Stage 1	Low
	Potential reduction in groundwater baseflow to Domain Creek and Toongabbie Creek with potential impact to ecosystems in/along the creek	Low

Construction site	Summary of potential impacts due to Stage 1	Significance of potential impact[a]
Parramatta metro station	Contamination could be present in groundwater at concentrations above the relevant assessment criteria and is likely to be limited in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Moderate
	Potential impact to potential groundwater dependent ecosystem (terrestrial vegetation) (Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, located along the Parramatta River to the northwest) due to groundwater level drawdown. There is a moderate to high likelihood of this ecosystem being dependent on groundwater	Low
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
Clyde stabling and maintenance facility	Some groundwater contamination sources could be the vicinity of Stage 1 at concentrations above the relevant assessment criteria and is likely to be limited in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Low to moderate
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
	Potential reduction in groundwater baseflow to A'Becketts Creek and Duck Creek due to groundwater level drawdown at distance from the creeks and conversion of pervious ground to impervious ground at the Sydney Speedway site, with potential impact to ecosystems in/along these creeks	Low
	Potential increase in groundwater salinity to impact the beneficial uses of the aquifer and groundwater dependent ecosystems	Low

Construction site	Summary of potential impacts due to Stage 1	Significance of potential impact[a]
Silverwater services facility	Contamination (possible and known) could be / is present in groundwater at concentrations above the relevant assessment criteria and could range from limited to widespread in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Moderate to high
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
Sydney Olympic Park metro station	Contamination (possible and known) could be / is present in groundwater at concentrations above the relevant assessment criteria and could range from limited to widespread in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and complete during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	High
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
	Potential reduction in groundwater baseflow to Haslams Creek, the tributaries of Powells Creek, the Mason Park wetlands, Bicentennial Park wetlands, and the Brickpit at Sydney Olympic Park, with potential impact to ecosystems in/along these creeks (Common Reed on the margins of estuaries and brackish lagoons, Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion, Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, and Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion). There is a low to high likelihood of these ecosystems being dependent on groundwater	Low
	Potential increase in groundwater salinity to impact the beneficial uses of the aquifer and groundwater dependent ecosystems	Low

Construction site	Summary of potential impacts due to Stage 1	Significance of potential impact[a]
North Strathfield metro station	Contamination could be present in groundwater at concentrations above the relevant assessment criteria and is likely to be limited in extent. Contaminated groundwater may intersect Stage 1 and exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Moderate
	Groundwater level drawdown at potential groundwater dependent ecosystem (terrestrial vegetation): Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion located 650 metres to the north east, at Concord Golf Club. There is a moderate to high likelihood of this ecosystem being dependent on groundwater	Low
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
	Potential reduction in groundwater baseflow to Powells Creek and the wetlands at Mason Park, Powells Creek Reserve and Bicentennial Park, with potential impact to ecosystems in/along the creeks and the wetlands	Low
	Potential increase in groundwater salinity to impact the beneficial uses of the aquifer and groundwater dependent ecosystems	Low
Burwood North Station	Contamination could be present in groundwater at concentrations above the relevant assessment criteria and is likely to be limited in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Moderate
	Groundwater level drawdown at potential groundwater dependent ecosystem (terrestrial vegetation): Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion at Queen Elizabeth Park, located about 450 metres northwest of the station box excavation. There is a moderate to high likelihood of this ecosystem being dependent on groundwater	Low

Construction site	Summary of potential impacts due to Stage 1	Significance of potential impact[a]
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
	Potential impact to domestic supply bore GW305646	Moderate
	Potential increase in groundwater salinity to impact the beneficial uses of the aquifer	Low
Five Dock Station	Some groundwater contamination sources could be in the vicinity of Stage 1 but are unlikely to significantly impact upon construction. Contamination (from other sources in the vicinity of Stage 1) could be present in groundwater at concentrations above the relevant assessment criteria and is likely to be limited in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Low to moderate
	Groundwater level drawdown at potential groundwater dependent ecosystem (terrestrial vegetation): Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion located about 350 metres to the east of the station box excavation at the Five Dock Park. There is a moderate to high likelihood of this ecosystem being dependent on groundwater	Low
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
	Potential for increased groundwater salinity to the south of Kings Bay, with potential for groundwater of increased salinity to affect ecosystems, the durability of in-ground structures, and the beneficial uses of the aquifer	Low

Construction site	Summary of potential impacts due to Stage 1	Significance of potential impact[a]
The Bays Station	Contamination could be present in groundwater at concentrations above the relevant assessment criteria and is likely to be limited in extent. Contaminated groundwater may intersect Stage 1, and the exposure pathways for human or ecological receptors could be present and fully reached during construction. Potential migration of contaminated groundwater towards, and into, station excavation, poses a potential exposure risk to site users/workers and adjacent site users, and could potentially reduce the beneficial use of the aquifer	Moderate
	Potential impact to acid sulfate soils, if present within disturbed soils in the vicinity of the station	Low
	Potential for increased groundwater salinity in the vicinity of the shaft, with potential for groundwater of increased salinity to affect ecosystems, the durability of in-ground structures, and the beneficial uses of the aquifer	Low
Tunnels	If contaminants were expected to migrate towards the tunnel during construction, the tunnel boring machine would provide controls to prevent the exposure of construction workers to contaminated groundwater. Groundwater collected by the tunnel boring machine would be treated prior to release to the environment.	Low
	Migration of contaminants in groundwater could reduce the beneficial use of the aquifer	Low
Stage 1 wide	Ground movement and settlement, which has the potential to cause damage to infrastructure	Moderate
	Cumulative impacts: the presence of other drained tunnels and/or excavations within the vicinity of the Stage 1 construction sites has the potential to induce greater groundwater level drawdown than the Stage 1 works alone	High

[a] Rating based on the contamination severity and extent, and the potential pathways and receptors, as discussed in the Technical Paper 8 (Contamination), for contamination identified within the predicted groundwater level drawdown zone of influence (and/or potential contamination associated with non-location-specific historical site use in the vicinity of the Stage 1 construction sites)

6 Compliance

6.1 Licencing

All groundwater and surface water in the vicinity of Stage 1 is managed through the *Greater Metropolitan Region Water Sharing Plan*, which provides rules to manage and allocate the groundwater resources. The Water Sharing Plan including specific rules on taking groundwater near high priority groundwater dependent ecosystems, groundwater dependent culturally significant sites, sensitive environmental areas (first/second order streams), and near other licenced bores. The groundwater source relevant to Stage 1 is the Sydney Central Basin Groundwater Source.

The NSW Aquifer Interference Policy states the licensing requirements for any activities that interfere with, or take water from, an aquifer. Stage 1 components constitute aquifer interference activities as the Stage 1 excavations would allow groundwater ingress which includes the collection and disposal of groundwater. These groundwater inflows remove water from the aquifer and must be accounted for within the extraction limits of the Water Sharing Plan.

In general, a water licence is required for the removal of water from an aquifer. Transport authorities are exempt from the requirement to hold a licence for the take of water under Clause 22 and Schedule 4, Part 3 of the Water Management (General) Regulation 2018. Sydney Metro must still satisfy the requirements of licensing set out in the Greater Metropolitan Region Water Sharing Plan and satisfy the approval requirements of the NSW Aquifer Interference Policy.

The NSW Aquifer Interference Policy specifies that the application for the take of water must be supported by robust predictions of the volumetric take from the aquifer(s) to ensure compliance with licenced volumes, and with the established limits for the aquifer as stated in the Water Sharing Plan. Inflow volumes and the methods used to predict them have been outlined in Section 5.

The total inflow across all of the Stage 1 components is predicted to be up to 1,204 megalitres in the first year and up to 1,164 megalitres in the second year (total of 2,350 megalitres over both years).

The inflows generated by Stage 1 would need to be assigned through an annual allocation of unassigned water under the Water Sharing Plan, or by purchasing an existing entitlement if there is insufficient unassigned water.

There is currently about 43,353 megalitres per year that is unassigned under the long-term average annual extraction limit. Annual inflows for Stage 1 would be less than six per cent of the unassigned water. Stage 1 is therefore not likely to impact the unassigned water available under the Water Sharing Plan.

Section 5.23 of the EP&A Act, states that a water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the *Water Management Act 2000*, is not required for approved State Significant Infrastructure. As such, water supply works approvals and water use approvals would not be required for Stage 1. However, an aquifer interference approval is required.

6.2 Aquifer Interference Policy

The NSW Aquifer Interference Policy is the NSW Government policy that details the licensing and assessment requirements for aquifer interference activities under the *Water Management Act 2000*. It sets out the information that would be required by the Minister to assess Stage 1 and provide advice under the *Environmental Planning and Assessment Act 1979*. Compliance with the policy forms the basis of this impact assessment and the development of mitigation measures for Stage 1.

The NSW Aquifer Interference Policy supports the requirements of the *Water Management Act 2000* to ensure that the granting of water licences and approvals result in 'no more than minimal harm' to any water source or dependent ecosystem. It also provides guidance on the predicted level of impact associated with an interference activity that would be considered acceptable by the Department of Planning, Industry and Environment. Approval is based on the proponent's ability to account for the take of water, prevent the take of water as far as possible, meet the minimal impact considerations, and employ remedial actions for unacceptable impacts.

The NSW Aquifer Interference Policy sets out minimal impact considerations that aim to maintain water levels, water pressure and water quality of aquifers in order to protect the groundwater resource, as well as connected water sources, groundwater users, culturally significant sites and the environment.

Stage 1 excavations would be predominantly located within the Hawkesbury Sandstone, which is classified as:

- A 'less productive aquifer' because yields are generally less than five litres per second. Of the over 600 WaterNSW-registered bores in the region, the average reported yield is about 2.7 litres per second
- A porous rock aquifer.

The minimal impact considerations for this aquifer type are summarised in Table 6-1, together with the response developed in this impact assessment.

Table 6-1: Minimal impact consideration for a 'Less productive porous rock aquifer'

Minimal impact considerations	Response
<u>Water table</u> 1. Less than or equal to ten percent cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 metres from any: a. High priority groundwater dependent ecosystem; or b. High priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a two-metre decline cumulatively at any water supply work.	High priority groundwater dependent ecosystems (terrestrial vegetation) include: • Grey Box - Forest Red Gum woodland on the flats of the Cumberland Plain in the vicinity of Westmead metro station and Parramatta metro station construction sites • Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion in the vicinity of Sydney Olympic Park metro station and North Strathfield metro station construction sites. Groundwater level drawdown is not predicted at the location of these ecosystems, with the exception of the Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain to the east of Westmead metro station construction site. However, this ecosystem grows in clay alluvium and this geological unit is likely to be of relatively low permeability, with a potential perched watertable present (which may be temporary) upon which these groundwater dependent ecosystems may intermittently rely. The groundwater level drawdown in the sandstone induced by station excavation is not likely to cause direct groundwater level drawdown within a potential perched aquifer in the clay alluvium. The likelihood of this ecosystem being impacted by the groundwater level drawdown associated with Stage 1 is therefore low. The Greater Metropolitan Regional Groundwater Sources Water Sharing Plan does not list any high priority culturally significant in the vicinity of Stage 1. Groundwater modelling has estimated a groundwater level drawdown of two metres at two years after excavation at water supply bore GW305646, and four metres at two years after excavation at water supply bore GW108378. This does not satisfy the minimal impact considerations of the NSW Aquifer Interference Policy. However, the available water column in bore GW108378 would be reduced by Stage 1 by about two per cent. Based on this, groundwater supply is not likely to be affected at this bore due to Stage 1. At bore GW305646, site inspection would be carried out to confirm the current viability of this bore. If viable, the bore would be monitored throughout construction. Make good measures would be implemented if a loss of yield were to occur.

Minimal impact considerations	Response
2. If more than ten percent cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: a. High priority groundwater dependent ecosystem; or b. High priority culturally significant site; listed in the schedule of the relevant water sharing plan if appropriate studies demonstrate to the Minister's satisfaction that the variation would not prevent the long-term viability of the dependent ecosystem or significant site. If more than a two-metre decline cumulatively at any water supply work, then make good provisions should apply.	Item (1) responses apply. Mitigation measures to address potential impacts at bore GW305646 have been identified. See Section 7 for mitigation measures.
Water pressure 1. A cumulative pressure head decline of not more than a two-metre decline, at any water supply work.	Management and mitigation measures to address potential impacts at bore GW305646 have been identified. See Section 7 for mitigation measures.
2. If the predicted pressure head decline is greater than consideration (1) above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline would not prevent the long-term viability of the affected water supply works unless make good provisions apply.	Management and mitigation measures to address potential impacts at bore GW305646 have been identified. See Section 7 for mitigation measures.

Minimal impact considerations	Response
<u>Water quality</u> 1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	Where contaminated groundwater, saline groundwater, or acid sulfate soils are present within the groundwater level drawdown zone of influence, Stage 1 has the potential to alter the groundwater quality between the excavations and the contaminant/saline water sources. These processes mean that this requirement of the Aquifer Interference Policy may not be satisfied. See Section 7 for mitigation measures.
2. If consideration (1) is not met then appropriate studies would need to demonstrate to the Minister's satisfaction that the change in groundwater quality would not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.	Water supply works (WaterNSW-registered groundwater bores) are not expected to be impacted by groundwater quality changes induced by Stage 1. Changes to groundwater quality in the vicinity of potential groundwater dependent ecosystems are not expected due to Stage 1. Changes to groundwater quality that would impact groundwater dependent ecosystems are not expected due to Stage 1.
<u>Additional Considerations</u> … any advice provided to a gateway panel, the Planning and Assessment Commission or the Minister for Planning on a State significant development or State significant infrastructure would also consider the potential for: • Acidity issues to arise, for example exposure of acid sulfate soils • Water logging or water table rise to occur, which could potentially affect land use, groundwater dependent ecosystems and other aquifer interference activities. Specific limits would be determined on a case-by-case basis, depending on the sensitivity of the surrounding land and groundwater dependent ecosystems to waterlogging and other aquifer interference activities to water intrusion.	Where the presence of acid sulfate soils and potential groundwater level drawdown within those soils is confirmed, an acid sulfate soils management plan would be developed for Stage 1 to reduce the risks associated with oxidation/activation of acid sulfate soils. The risk of water logging or watertable rise is assessed to be negligible due to Stage 1 excavation works.

6.3 Water Sharing Plan

Rules for granting access licences, managing access licences, water supply works approvals and access licence dealings are provided in the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011. Details of mandatory conditions are provided in the Water Sharing Plan with respect to access licences and water supply works approvals.

Table 6-2 presents a summary of the rules of the Water Sharing Plan in relation to Stage 1.

Table 6-2: Project Compliance with Water Sharing Plan Rules

Rule	Assessment Requirements
Part 7 – Rules for granting access licences	Sydney Metro is a transport authority and is therefore exempt of requiring a groundwater access licence for Stage 1. The *Water Management Act 2000* requires that a water supply work approval is obtained for groundwater ingress to tunnels, stations and services facilities.
Part 8 – Rules for managing access licences	As per response to Part 7 response.
Part 9 – Rules for water supply work approvals	The approval process would determine distance restrictions to minimise interference between water supply works. In the case of the Stage 1, the water supply works include the excavations and permanently drained structures, including the station boxes, shafts, dives and services facilities.
Part 9 – 39 Distance restrictions to minimise interference between water supply works	While some of the distance restrictions identified in Part 9 – 39 are not satisfied, water supply bores (approved water supply works that are reported to supply water) would not be adversely impacted.
• Distance restriction from an approved water supply work nominated by another access licence is 400 metres	Stage 1 sites lie within 400 metres of approved water supply works under other access licences. Impacts to water supply works are noted in Table 6-1.
• Distance restriction from an approved water supply work for basic landholder rights only is 100 metres	Stage 1 sites lie within 100 metres of approved water supply works for basic landholder rights. Impacts to water supply works are noted in Table 6-1.
• Distance restriction from the property boundary is 50 metres	Stage 1 sites lie within 50 metres of property boundaries. Impacts to water supply works are noted in Table 6-1.
• Distance restriction from an approved water supply work nominated by a local water utility or major utility access licence is 1000 metres	Water supply works nominated by a local water utility or major utility access licence were not identified within 1000 metres of the Stage 1 sites.
• Distance restriction from a Department observation bore is 200 metres	WaterNSW (Department) observation bores/monitoring piezometers were not identified within 200 metres of the Stage 1 sites.

Rule	Assessment Requirements
Part 9 – 40 Rules for water supply works located near contamination sources	Restrictions on water supply works approvals would apply to Stage 1 where construction dewatering and permanent drainage infrastructure for Stage 1 are located in the vicinity of ground contamination. Refer to Chapter 20 (Contamination – Stage 1) for information on contamination.
Part 9 – 41 Rules for water supply works located near sensitive environmental areas	Stage 1 sites with the potential to induce groundwater level drawdown are not located within 100 metres of a high priority groundwater dependent ecosystem listed in Schedule 4 of the relevant Water Sharing Plan, or within 40 metres of the top of the high bank of a lagoon or any third order or higher order stream, or within 100 metres of the top of an escarpment. The Stage 1 excavations lie greater than 40 metres from first or second order streams.
Part 9 – 42 Rules for water supply works located near groundwater dependent culturally significant sites	Groundwater-dependent culturally sensitive sites have not been identified within 100 metres of the Stage 1 sites.
Part 9 – 44 Rules for water supply works located within distance restrictions	Stage 1 sites that do not comply with the above distance restrictions could have limitations on groundwater take under the Water Sharing Plan. However, with implementation of the mitigation measures, it is expected that such limitations would not be imposed.
Part 10 – Access licence dealing rules	As per response to Part 7

7 Mitigation and management

Detailed design phase would provide an opportunity for review and updated of predicted potential impacts. Once all practicable steps to avoid or minimise impacts have been implemented at the detailed design phase (such as lining of excavations and tunnels), management measures would be implemented to monitor for potential impacts outside of those predicted.

Mitigation and management measures that are recommended to be implemented to monitor for potential groundwater impacts considered moderate risk or greater are listed in Table 7-1. The measures would be incorporated into a groundwater management plan as detailed in the Construction Environmental Management Framework (Appendix D of the Environmental Impact Statement),

Mitigation and management measures identified in other technical papers and other chapters of the Environmental Impact Statement that are relevant to the management of potential impacts include:

- Chapter 18 (Groundwater and ground movement – Stage 1) with respect to management of potential ground movement
- Chapter 20 (Contamination – Stage 1) with respect to management of potential contamination, and Technical Paper 8
- Chapter 22 (Biodiversity – Stage 1) with respect to management of potential impacts on groundwater dependent ecosystems, and Technical Paper 10.

Table 7-1: Summary of potential groundwater impacts and management measures

Reference	Impact	Mitigation measure	Applicable location(s)[1]
GW1	Loss of groundwater available to existing groundwater (bore supply) users	Site inspection would be carried out on private domestic supply bore GW305646 to confirm the current viability of that bore. If found to be viable, the bore would be monitored throughout construction. Make good measures would be implemented if a loss of yield were to occur.	BNS

Reference	Impact	Mitigation measure	Applicable location(s)[1]
GW2	Potential reduced baseflow to Toongabbie Creek, Domain Creek, A'Becketts Creek, Duck Creek, Haslams Creek, Powells Creek and the Mason Park wetlands, Bicentennial Park wetlands, Brickpit and Powells Creek Reserve.	A review of additional geotechnical and hydrogeology data would be undertaken to confirm the geological and groundwater conditions and determine, based on these local conditions, whether predicted groundwater drawdown from Stage 1 is likely to occur in the vicinity of these creeks. Where the additional data review shows local conditions and predicted groundwater drawdown are likely to cause surface water-groundwater interaction, then additional site investigations (in accordance with GW3) would be undertaken for those creeks or surface water bodies.	WMS, CSMF, SOPMS, NSMS
GW3	Potential reduced baseflow to Toongabbie Creek, Domain Creek, A'Becketts Creek, Duck Creek, Haslams Creek, Powells Creek and the Mason Park wetlands, Bicentennial Park wetlands, Brickpit and Powells Creek Reserve. Requirements for baseline monitoring of hydrological attributes	Additional site investigations would be carried out at creeks or surface water bodies where the additional data review in GW2 shows there is a likely surface water / groundwater interaction. This would involve baseline monitoring of creek flows (streamflow gauging) prior to construction, and baseflow streamflow analysis to confirm the existing groundwater baseflow contribution to streamflow for each creek. Where a significant reduction in baseflow is predicted due to Stage 1, design responses would be implemented at station and shaft excavations to reduce potential baseflow loss.	WMS, CSMF, SOPMS, NSMS
GW4	Requirements for baseline monitoring of hydrological attributes Migration of contaminants in groundwater and reduction in beneficial uses of aquifers	Monitoring of groundwater levels and quality of the site area would occur before, during and after construction. This would also include monitoring of potential contaminants of concern. Groundwater level data would be regularly reviewed during and after construction by a qualified hydrogeologist.	WMS, PMS, CSMF, SSF, SOPMS, NSMS, BNS, FDS, TBS

1WMS: Westmead metro station; PMS: Parramatta metro station; CSMF: Clyde stabling and maintenance facility; SSF: Silverwater services facility; SOPMS: Sydney Olympic Park metro station; NSMS: North Strathfield metro station; BNS: Burwood North Station; FDS: Five Dock Station; TBS: The Bays Station; Metro rail tunnels: Metro rail tunnels not related to other sites (eg tunnel boring machine works); PSR: Power supply routes

8 References

ANZECC/ARMCANZ (2019), Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, accessed 27 March 2019.

Australian Government (2013), Guidelines for groundwater quality protection in Australia: National Water Quality Management Strategy, Department of Agriculture and Water Resources, Canberra, March.

Birch, G.F., and S.E. Taylor (2004), Sydney Harbour and Catchment Contaminant Status of Sydney Harbour Sediments: A Handbook for the Public and Professionals, Geological Society of Australia, Environmental, Engineering and Hydrogeology Specialist Group: Canberra, ACT. ISBN 0-9752486-0-1 accessed at https://www.researchgate.net/publication/289871817_Sydney_Harbour_and_Catchment_Contaminant_Status_of_Sydney_Harbour_Sediments_A_Handbook_for_the_Public_and_Professionals/download, 5 June 2019.

CPB-Samsung-JH JV (2017), WestConnex M4 East Water Quality Monitoring Program, Document Number M4E-ES-PRG-PWD-00839, Prepared by CPB Contractors - Samsung - John Holland JV, 6 November 2017.

Dafforn, K.A., S.L. Simpson, B.P. Kelaher, G. Clark, V. Komyakova, C.K.C. Wong, and E.L. Johnston (2012), The challenge of choosing environmental indicators of anthropogenic impacts in estuaries, Environmental Pollution, 163, 207–217.

DPI (2007), Key Fish Habitat LGAs in Sydney Area, Fisheries Ecosystems Branch, Division of Fisheries Compliance and Regional Relations, NSW Department of Primary Industries, https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/634354/Sydney_updated.pdf

Cardno Lawson Treloar (2008), Parramatta River Estuary Data Compilation and Review Study. Prepared for the Parramatta City Council, Department of Environment and Climate Change & Sydney Metropolitan Catchment Management Authority on behalf of the Parramatta River Estuary Management Committee.

Department of Industry (2019), Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011, https://www.industry.nsw.gov.au/water/plans-programs/water-sharing-plans/status, accessed 1 February 2019.

Department of Land and Water Conservation (1998), NSW Groundwater Quality Protection Policy, ISBN 0-7313-0379-2, dated December 1998.

Department of Land and Water Conservation (2002), The NSW State Groundwater Dependent Ecosystems Policy, ISBN 0-7347-5225-3, dated April 2002.

Ghyben, B.W. (1889), Nota in verband met de voorgenomen put boring nabij, Amsterdam Kononkl. Inst. Ing. Tijdschr., 1888–1889, 8–22.

Hazelton, P., S. Bannerman, and P. Tille (2010), Soil Landscapes of the Penrith 1:100,000 Sheet, NSW Department of Environment, Climate Change and Water.

Herbet, C. (1983), Geology of the Sydney 1:100,000 Sheet 9130, Department of Mineral Resources, Sydney.

Herbet, C., and V. Smith (1991), Geology of the Penrith 1:100,000 Sheet 9030, Department of Mineral Resources, Sydney.

Herzberg, B. (1901), Die Wasserversorgung einiger Nordseebäder, Jour. Gasbeleuchtung Wasserversorg, 44, 815–844.

Jacobs (2020a), Sydney Metro West, Technical Paper 8: Contamination, Document reference report prepared for Sydney Metro Authority.

Jacobs (2020b), Sydney Metro West, Technical Paper 10: Biodiversity Development Assessment Report, report prepared for Sydney Metro Authority.

Mayer-Pinto, M., E.L. Johnson, P.A. Hutchings, E.M. Marzinelli, S.T. Ahyong, G. Birch, D.J. Booth, R.G. Creese, M.A. Doblin, W. Figueira, P.E. Gribben, T. Pritchard, M. Roughan, P.D. Steinberg, and L.H. Hedge (2015), Sydney Harbour: a review of anthropogenic impacts on the biodiversity and ecosystem function of one of the world's largest natural harbours, Marine and Freshwater Research, 66, 1088–1105.

NSW Department of Primary Industries (2013), Industries Policy and Guidelines for Fish Habitat Conservation and Management, NSW Department of Primary Industries, June 2013.

NSW Government (2019), Sydney Metro West, Scoping Report, Westmead to The Bays and Sydney CBD, Request for Secretary's Environmental Assessment Requirements, available at https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=PDA-700%2120191021T010350.047%20GMT, accessed 27 November 2019.

NSW Government (2012), Sydney Local Environmental Plan 2012, New South Wales Government, NSW legislation, available at www.legislation.nsw.gov.au, 8 March 2019.

NSW Office of Environment and Heritage (2019a), Acid Sulfate Soils Risk Maps, available at https://www.environment.nsw.gov.au/topics/land-and-soil/soil-degradation/acid-sulfate-soils, accessed 25 March 2019.

NSW Office of Environment and Heritage (2019b), Hydrogeological Landscapes of New South Wales and the Australian Capital Territory, available at https://datasets.seed.nsw.gov.au/dataset/hydrogeological-landscapes-nsw-act, accessed 11 February 2019

NSW Office of Environment and Heritage (2019c), NSW Climate Change projections for 2060 to 2079, https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/NSW-Climate-Change-Downloads, accessed 2 September 2019.

NSW Office of Water (2012), NSW Aquifer Interference Policy: NSW Government policy for the licensing an assessment of aquifer interference activities, ISBN 978-1-74256-338-1, dated September 2012.

Roads and Maritime Services (2019), Western Harbour Tunnel and Warringah Freeway Upgrade Environmental Impact Statement, Appendix N, Technical working paper: Groundwater, December 2019, Prepared for Roads and Maritime by Jacobs Group (Australia) Pty Limited

Stone, Y., C.R. Ahern, and B. Blunden (1998), Acid Sulfate Soils Manual 1998, Acid Sulfate Soils Management Advisory Committee, available at https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/epa/Acid-sulfate-Manual-1998.ashx

Tille, P.J., G. Atkinson, and R.J. Morse (2009), Soil Landscapes of the Sydney 1:100,000 Sheet, NSW Department of Environment, Climate Change and Water.

WaterNSW (2019), NSW Water Register, https://waterregister.waternsw.com.au, accessed 25 March 2019.

WestConnex Delivery Authority (2017), M4-M5 Link Environmental Impact Statement, August 2017, prepared by AECOM Australia Pty Ltd, available at http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=7485

WestConnex Delivery Authority (2015), WestConnex M4 East Environmental Impact Statement, September 2015, prepared by AECOM Australia Pty Ltd and GHD Pty Ltd, available at http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=6307

Winkler, M.A., A. Nicholson, B.R. Jenkins, R. Muller, W. Cook, C.L. Moore, and A. Wooldridge (2012), Salinity hazard report for Catchment Action Plan upgrade - Sydney Metropolitan CMA, NSW Department of Primary Industries, Sydney.

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Appendix A Geological long sections

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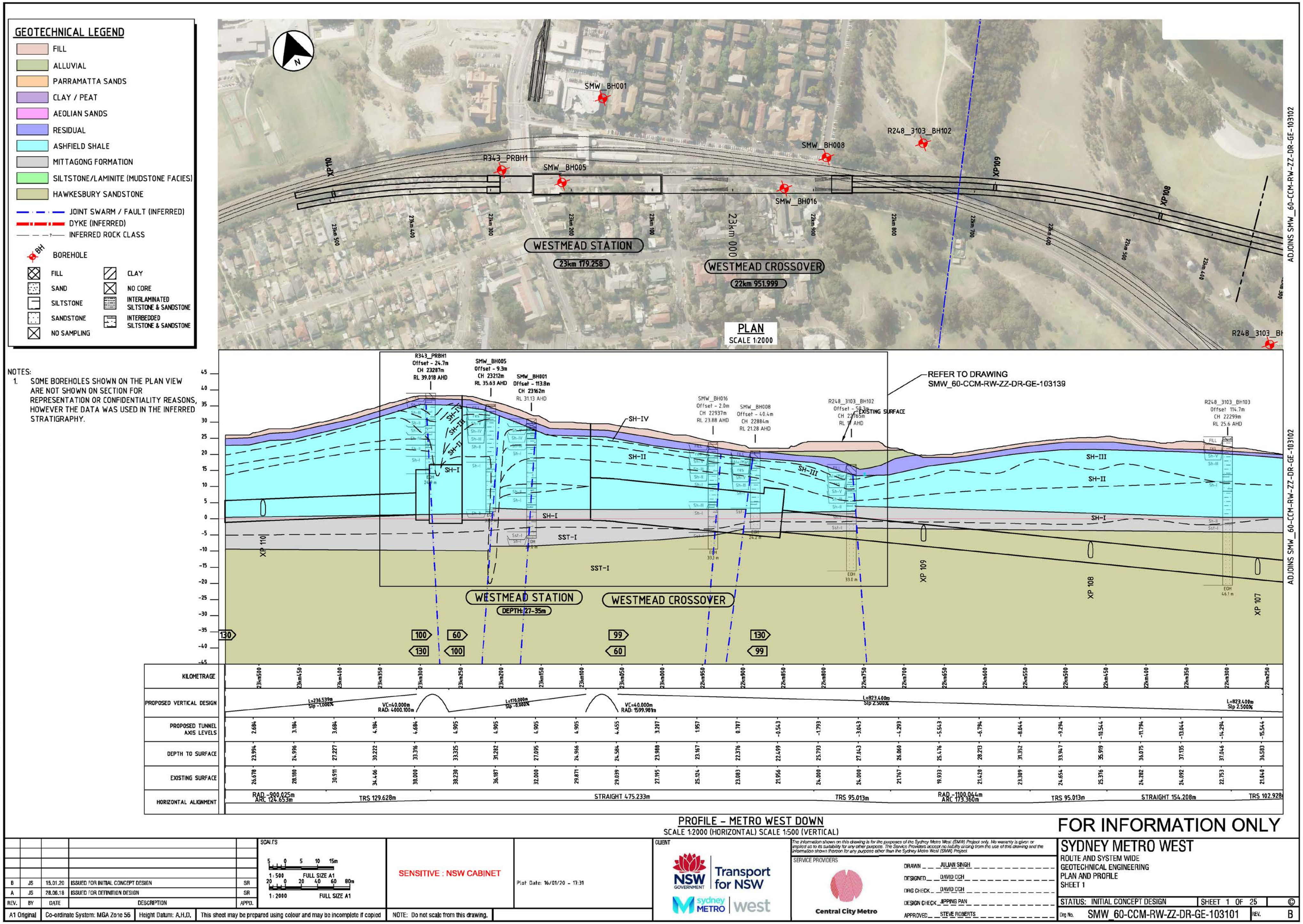
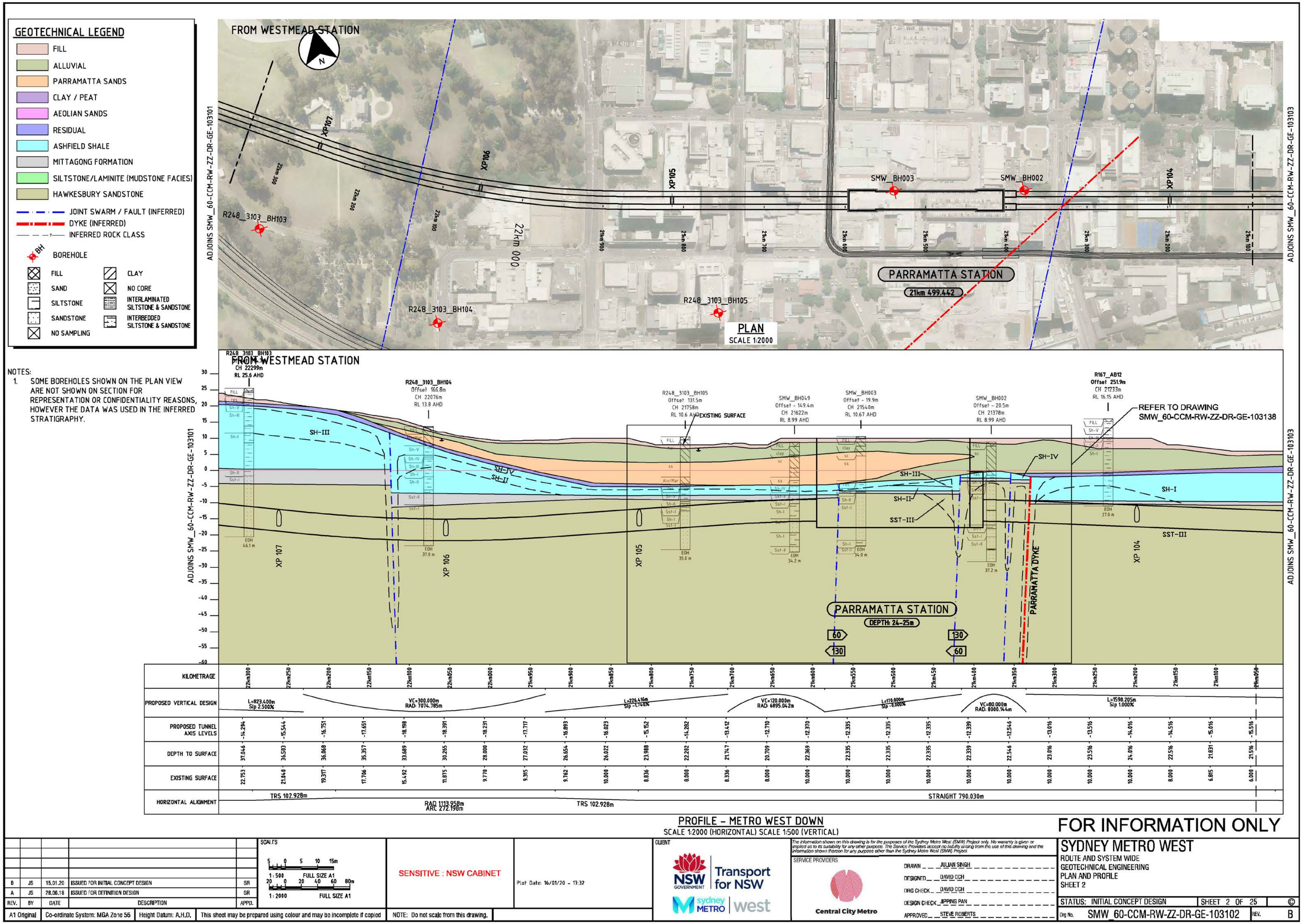
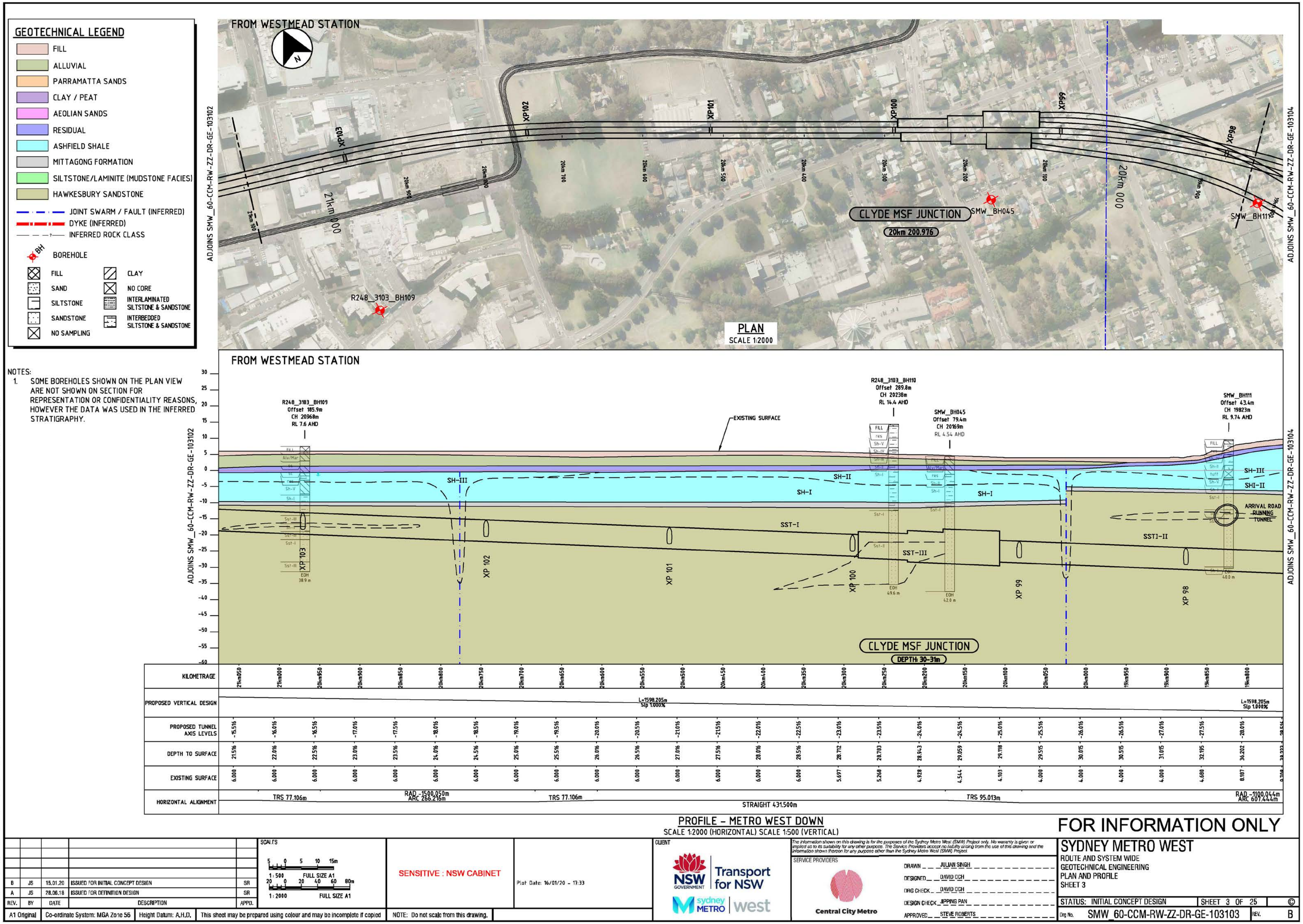
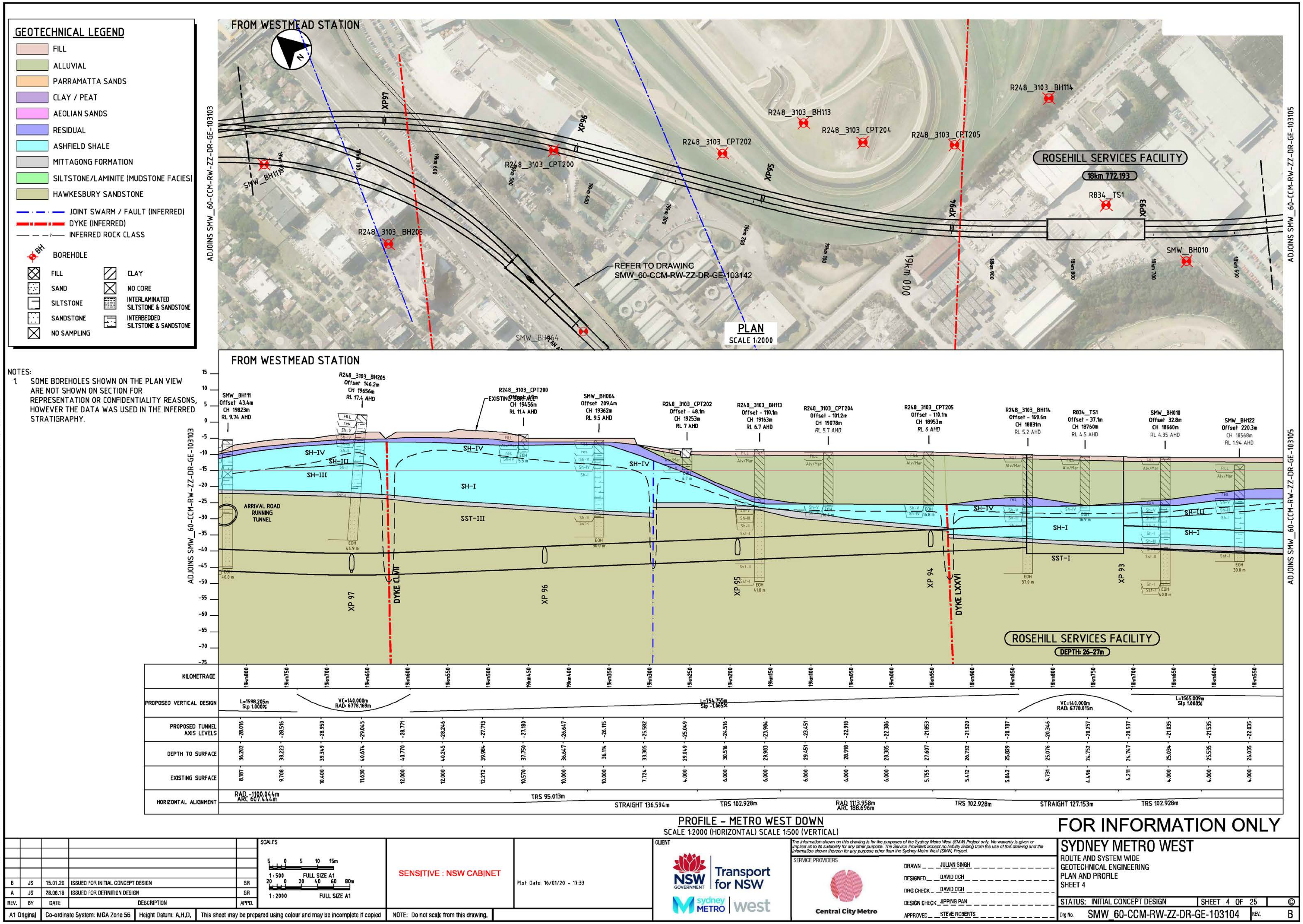
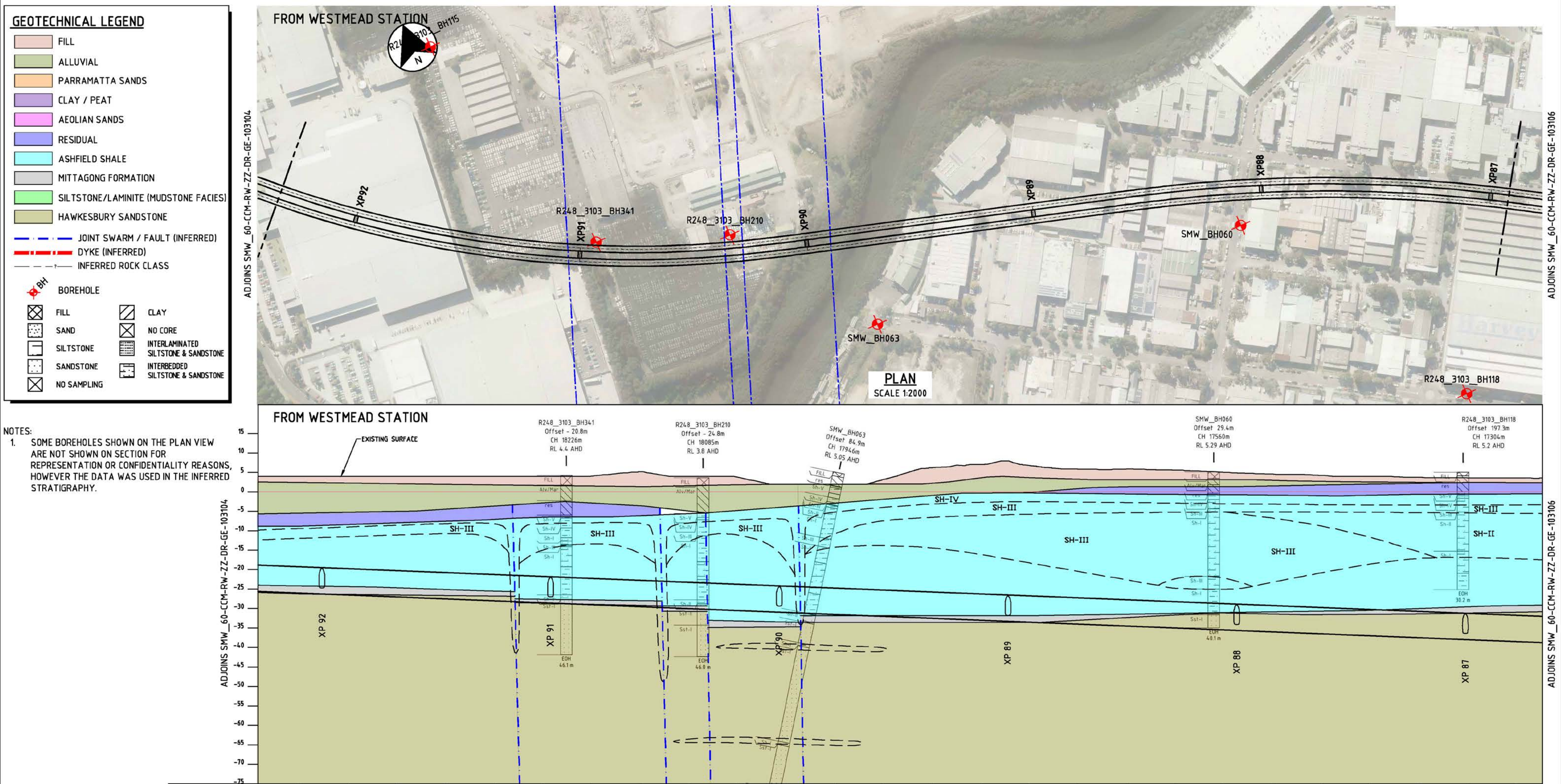

GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
SMW_BH001
R343_PRBH1
SMW_BH005
SMW_BH008
SMW_BH016
R248_3103_BH102
WESTMEAD STATION
23km 179.258
WESTMEAD CROSSOVER
22km 951.999
PLAN
SCALE 1:2000
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103102
REFER TO DRAWING SMW_60-CCM-RW-ZZ-DR-GE-103139
EXISTING SURFACE
SH-IV
SH-III
SH-II
SH-I
SST-I
XP 110
XP 109
XP 108
XP 107
WESTMEAD STATION
DEPTH: 27-35m
WESTMEAD CROSSOVER
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
STRAIGHT 475.233m
STRAIGHT 154.208m
PROFILE - METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
REV. BY DATE DESCRIPTION APPD.
A1 Original
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.
SENSITIVE : NSW CABINET
Plot Date: 16/01/20 - 17:31
Transport for NSW
Sydney Metro West
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OOH
DRG CHECK DAVID OOH
DESIGN CHECK SIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 1
STATUS: INITIAL CONCEPT DESIGN
SHEET 1 OF 25
SMW_60-CCM-RW-ZZ-DR-GE-103101
B


GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
PARRAMATTA STATION
21km 499.442
PLAN
SCALE 1:2000
SMW_BH003
SMW_BH002
R248_3103_BH103
R248_3103_BH104
R248_3103_BH105
XP107
XP106
XP105
XP104
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103101
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103103
REFER TO DRAWING SMW_60-CCM-RW-ZZ-DR-GE-103138
EXISTING SURFACE
SH-I
SH-II
SH-III
SH-IV
SST-III
PARRAMATTA DYKE
PARRAMATTA STATION
DEPTH: 24-25m
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
TRS 102.928m
RAD 1113.958m
ARC 272.198m
STRAIGHT 790.030m
PROFILE – METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
SENSITIVE : NSW CABINET
Plot Date: 16/01/20 - 17:32
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
REV. BY DATE DESCRIPTION APPD.
A1 Original
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.
CLIENT
Transport for NSW
Sydney Metro West
SERVICE PROVIDERS
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OCH
DRG CHECK DAVID OCH
DESIGN CHECK JIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 2
STATUS: INITIAL CONCEPT DESIGN
SHEET 2 OF 25
Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103102
REV. B


GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103102
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103104
XP103
XP102
XP101
XP100
XP99
XP98
21km 000
20km 000
CLYDE MSF JUNCTION
20km 200.976
SMW_BH045
SMW_BH111
R248_3103_BH109
PLAN
SCALE 1:2000
R248_3103_BH109 Offset 185.9m CH 20968m RL 7.6 AHD
R248_3103_BH110 Offset 289.8m CH 20238m RL 14.4 AHD
SMW_BH045 Offset 79.4m CH 20169m RL 4.54 AHD
SMW_BH111 Offset 43.4m CH 19823m RL 9.74 AHD
EXISTING SURFACE
SH-III
SH-II
SH-I
SST-I
SST-III
SSTI-II
ARRIVAL ROAD RUNNING TUNNEL
CLYDE MSF JUNCTION
DEPTH: 30-31m
KILOMETRAGE
PROPOSED VERTICAL DESIGN
L=1598.205m Slp 1.000%
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
TRS 77.106m
RAD -1500.050m ARC 266.216m
TRS 77.106m
STRAIGHT 431.500m
TRS 95.013m
RAD -1100.044m ARC 607.444m
PROFILE – METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
REV. BY DATE DESCRIPTION APPD.
SCALES
1:500 FULL SIZE A1
1:2000 FULL SIZE A1
SENSITIVE : NSW CABINET
Plot Date: 16/01/20 - 17:33
CLIENT
Transport for NSW
Sydney Metro West
SERVICE PROVIDERS
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OCH
DRG CHECK DAVID OCH
DESIGN CHECK JIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 3
STATUS: INITIAL CONCEPT DESIGN
SHEET 3 OF 25
Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103103
REV. B
A1 Original
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.



GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
ROSEHILL SERVICES FACILITY
18km 772.193
REFER TO DRAWING SMW_60-CCM-RW-ZZ-DR-GE-103142
PLAN
SCALE 1:2000
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103103
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103105
ARRIVAL ROAD RUNNING TUNNEL
DYKE CLVII
DYKE LXXVI
ROSEHILL SERVICES FACILITY
DEPTH: 26-27m
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
PROFILE – METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
SENSITIVE : NSW CABINET
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 4
STATUS: INITIAL CONCEPT DESIGN
SHEET 4 OF 25
SMW_60-CCM-RW-ZZ-DR-GE-103104
B
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.
Plot Date: 16/01/20 - 17:33
Transport for NSW
Sydney Metro West
Central City Metro



NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.

KILOMETRAGE	18km500	18km450	18km400	18km350	18km300	18km250	18km200	18km150	18km100	18km050	18km000	17km950	17km900	17km850	17km800	17km750	17km700	17km650	17km600	17km550	17km500	17km450	17km400	17km350	17km300	17km250
PROPOSED VERTICAL DESIGN	L=1565.009m Slp 1.000%																									
PROPOSED TUNNEL AXIS LEVELS	-22.535	-23.035	-23.535	-24.035	-24.535	-25.035	-25.535	-26.035	-26.535	-27.035	-27.535	-28.035	-28.535	-29.035	-29.535	-30.035	-30.535	-31.035	-31.535	-32.035	-32.535	-33.035	-33.535	-34.035	-34.535	-35.035
DEPTH TO SURFACE	26.535	27.035	27.535	28.035	28.535	29.035	29.535	31.130	30.535	31.035	29.535	30.035	31.253	35.102	36.583	37.034	36.463	36.903	37.206	37.193	37.158	37.398	37.535	37.761	38.167	38.597
EXISTING SURFACE	4.000	4.000	4.000	4.000	4.000	4.000	4.000	5.095	4.000	4.000	2.000	2.000	2.718	6.067	7.048	6.999	5.928	5.868	5.671	5.158	4.623	4.363	4.000	3.726	3.632	3.562
HORIZONTAL ALIGNMENT	RAD 1113.958m ARC 527.081m									TRS 102.928m				STRAIGHT 279.579m				TRS 77.106m			RAD -1500.050m ARC 327.066m				TRS 77.106m	

PROFILE – METRO WEST DOWN

SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

SCALES: 1:500 FULL SIZE A1; 1:2000 FULL SIZE A1

SENSITIVE : NSW CABINET

Plot Date: 16/01/20 - 17:34

CLIENT: NSW Government Transport for NSW; Sydney Metro west

The information shown on this drawing is for the purposes of the Sydney Metro West (SMW) Project only. No warranty is given or implied as to its suitability for any other purpose. The Service Providers accept no liability arising from the use of this drawing and the information shown thereon for any purpose other than the Sydney Metro West (SMW) Project.

SERVICE PROVIDERS: Central City Metro

DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

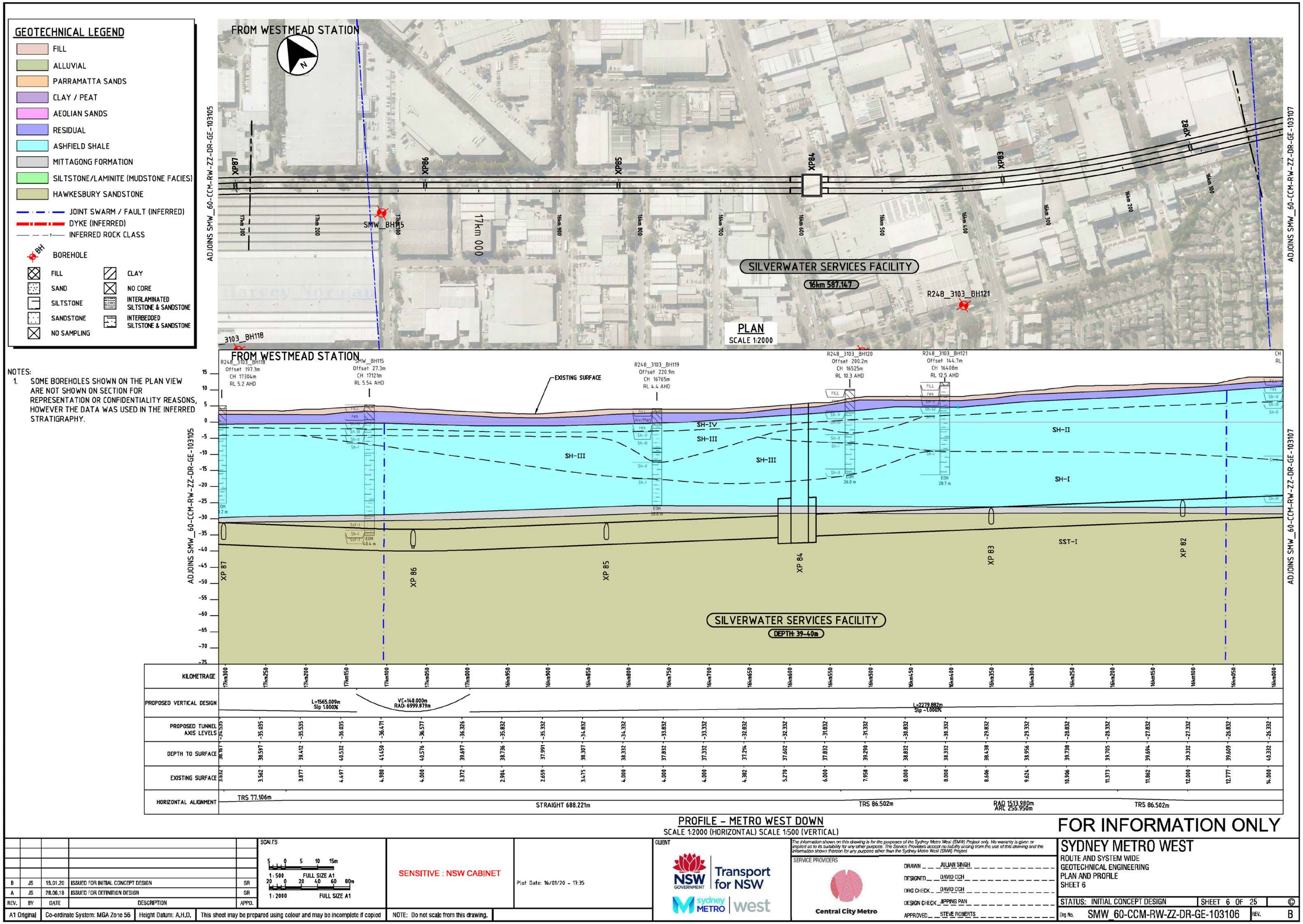
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 5

STATUS: INITIAL CONCEPT DESIGN | SHEET 5 OF 25

Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103105 | REV. B

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

Cad File: C:_Process\PW Export\SMW_60-CCM-RW-ZZ-DR-GE-103105.dwg Plot Date: 16/01/20 - 17:34 100mm AT FULL SIZE

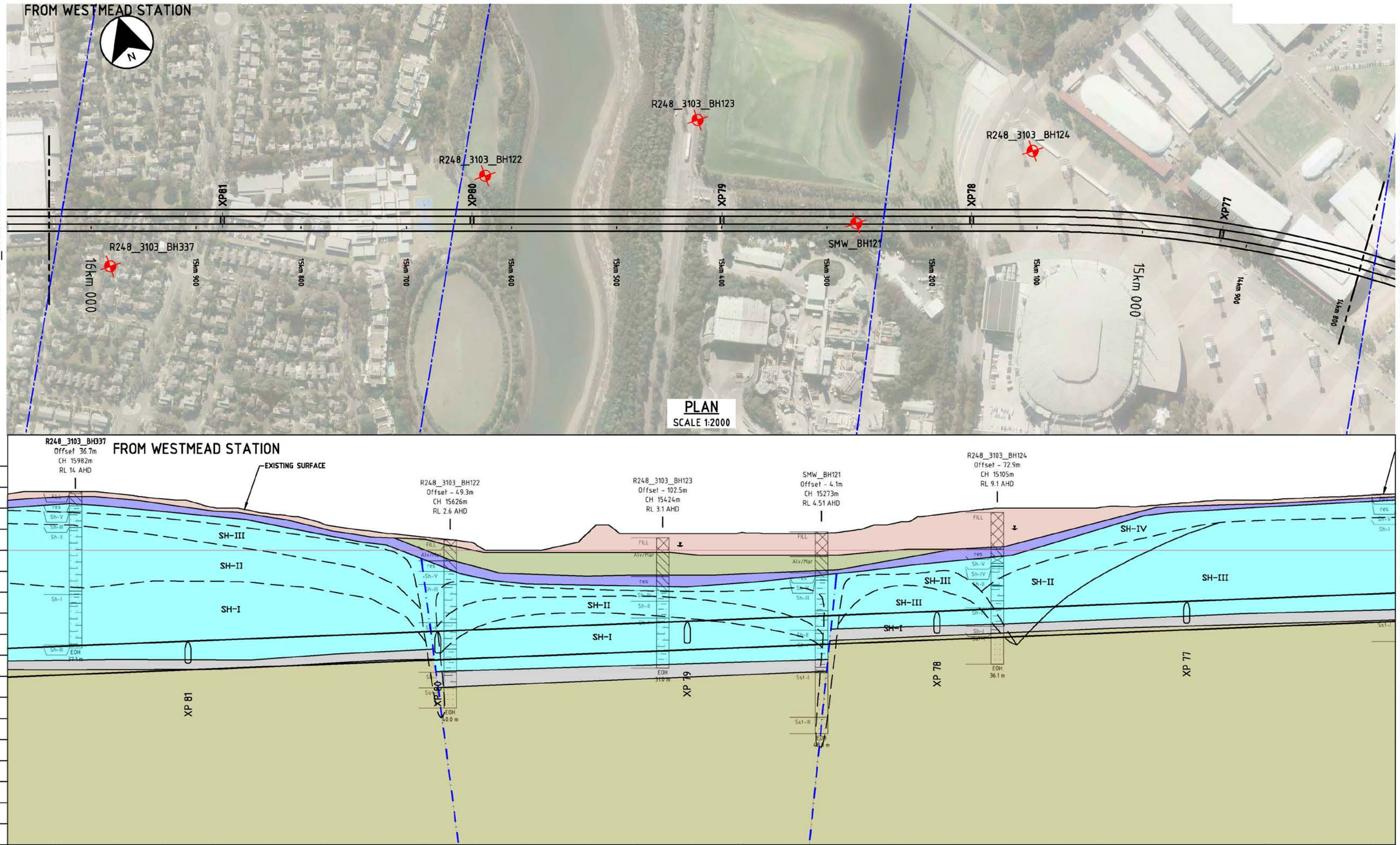

GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103105
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103107
XP87
XP86
XP85
XP84
XP83
XP82
SMW_BH115
SILVERWATER SERVICES FACILITY
16km 587.147
R248_3103_BH121
PLAN
SCALE 1:2000
3103_BH118
EXISTING SURFACE
SH-IV
SH-III
SH-II
SH-I
SST-I
SILVERWATER SERVICES FACILITY
DEPTH: 39-40m
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
TRS 77.106m
STRAIGHT 688.221m
TRS 86.502m
TRS 86.502m
PROFILE - METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
SENSITIVE : NSW CABINET
Plot Date: 16/01/20 - 17:35
Transport for NSW
Sydney Metro West
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OCH
DRG CHECK DAVID OCH
DESIGN CHECK JIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 6
STATUS: INITIAL CONCEPT DESIGN
SHEET 6 OF 25
SMW_60-CCM-RW-ZZ-DR-GE-103106
B
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
A1 Original
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.

GEOTECHNICAL LEGEND

- FILL
- ALLUVIAL
- PARRAMATTA SANDS
- CLAY / PEAT
- AEOLIAN SANDS
- RESIDUAL
- ASHFIELD SHALE
- MITTAGONG FORMATION
- SILTSTONE/LAMINITE (MUDSTONE FACIES)
- HAWKESBURY SANDSTONE
- JOINT SWARM / FAULT (INFERRED)
- DYKE (INFERRED)
- INFERRED ROCK CLASS
- BOREHOLE
- FILL
- CLAY
- SAND
- NO CORE
- SILTSTONE
- INTERLAMINATED SILTSTONE & SANDSTONE
- SANDSTONE
- INTERBEDDED SILTSTONE & SANDSTONE
- NO SAMPLING

NOTES:

1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.



KILOMETRAGE	16km000	15km950	15km900	15km850	15km800	15km750	15km700	15km650	15km600	15km550	15km500	15km450	15km400
PROPOSED TUNNEL AXIS LEVELS	-26.332	-25.832	-25.332	-24.832	-24.332	-23.832	-23.332	-22.832	-22.332	-21.832	-21.332	-20.832	-20.332
DEPTH TO SURFACE	40.332	39.660	37.755	35.349	33.281	30.947	28.055	26.167	24.332	21.832	23.157	24.832	24.332
EXISTING SURFACE	14.000	13.828	12.423	10.517	8.949	7.115	4.723	3.335	2.000	0.000	1.825	4.000	4.000

KILOMETRAGE	15km350	15km300	15km250	15km200	15km150	15km100	15km050	15km000	14km950	14km900	14km850	14km800	14km750
PROPOSED TUNNEL AXIS LEVELS	-19.832	-19.332	-18.832	-18.332	-17.832	-17.332	-16.832	-16.332	-15.832	-15.332	-14.832	-14.332	-13.832
DEPTH TO SURFACE	23.832	23.332	23.077	24.552	26.499	27.332	26.832	26.547	26.527	27.049	26.832	26.837	26.868
EXISTING SURFACE	4.000	4.000	4.245	6.220	8.667	10.000	10.000	10.215	10.695	11.717	12.000	12.505	13.036

PROPOSED VERTICAL DESIGN: L=2279.882m Slp -1.000%

HORIZONTAL ALIGNMENT: STRAIGHT 963.491m; TRS 95.013m; RAD ARC

PROFILE – METRO WEST DOWN

SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

SCALES: 1:500 FULL SIZE A1; 1:2000 FULL SIZE A1

SENSITIVE : NSW CABINET

Plot Date: 16/01/20 - 17:36

CLIENT: NSW Government Transport for NSW; Sydney Metro West

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SERVICE PROVIDERS: Central City Metro

DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

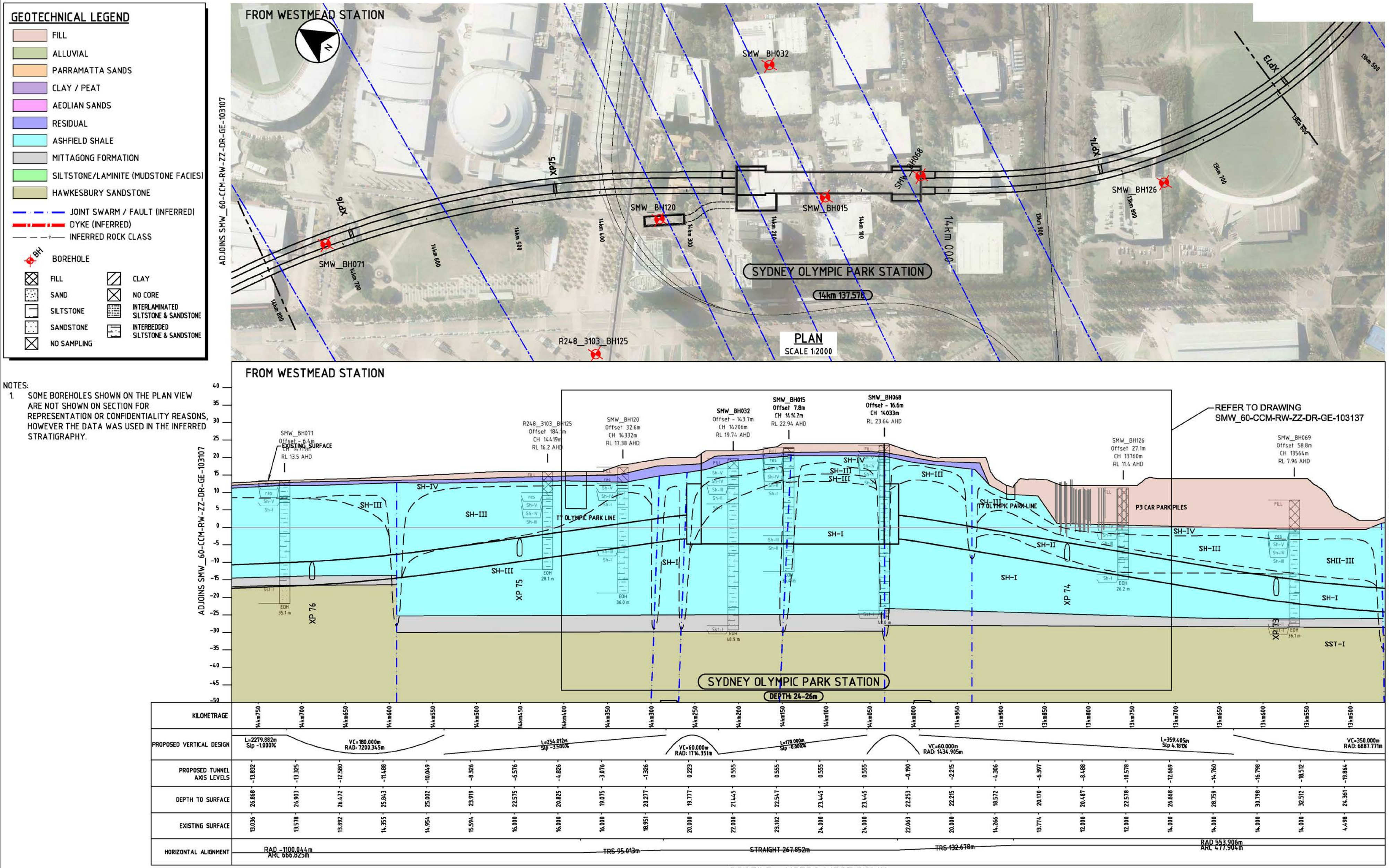
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 7

STATUS: INITIAL CONCEPT DESIGN | SHEET 7 OF 25

Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103107 | REV. B

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

Cad File: C:_Process\PW Export\SMW_60-CCM-RW-ZZ-DR-GE-103107.dwg Plot Date: 16/01/20 - 17:36 100mm AT FULL SIZE



PROFILE – METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied

SCALES 1:500 FULL SIZE A1; 1:2000 FULL SIZE A1

SENSITIVE : NSW CABINET

NOTE: Do not scale from this drawing.

Plot Date: 16/01/20 - 17:37

CLIENT: NSW Government Transport for NSW; Sydney Metro West

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SERVICE PROVIDERS: Central City Metro

DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 8

STATUS: INITIAL CONCEPT DESIGN | SHEET 8 OF 25

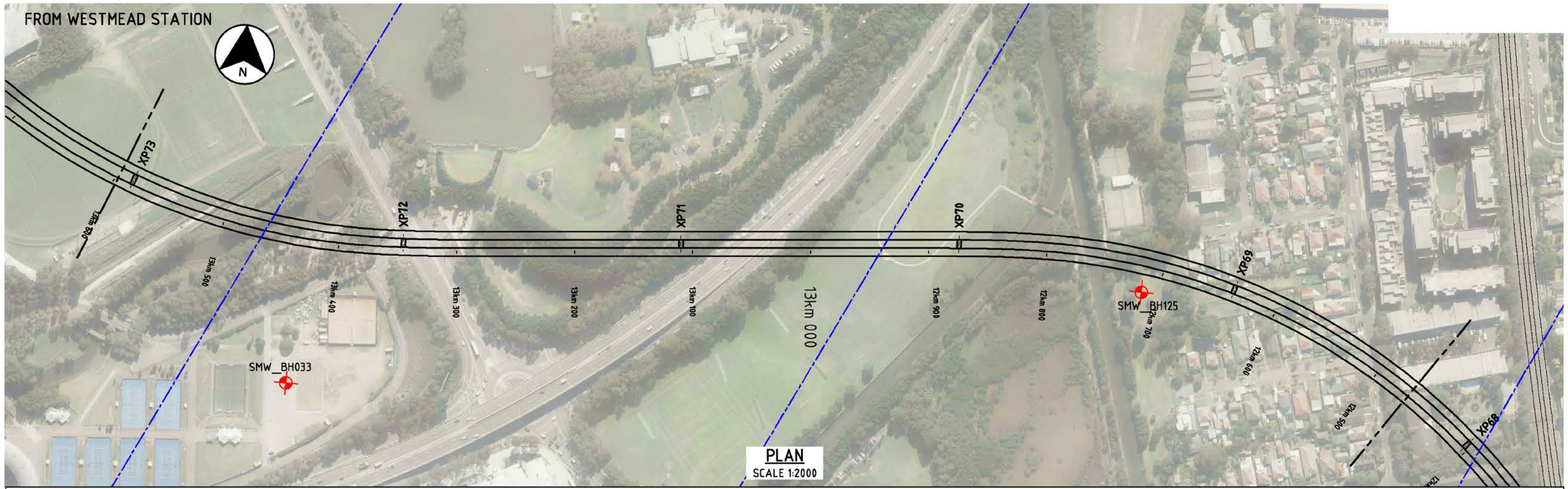
Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103108 | REV. B

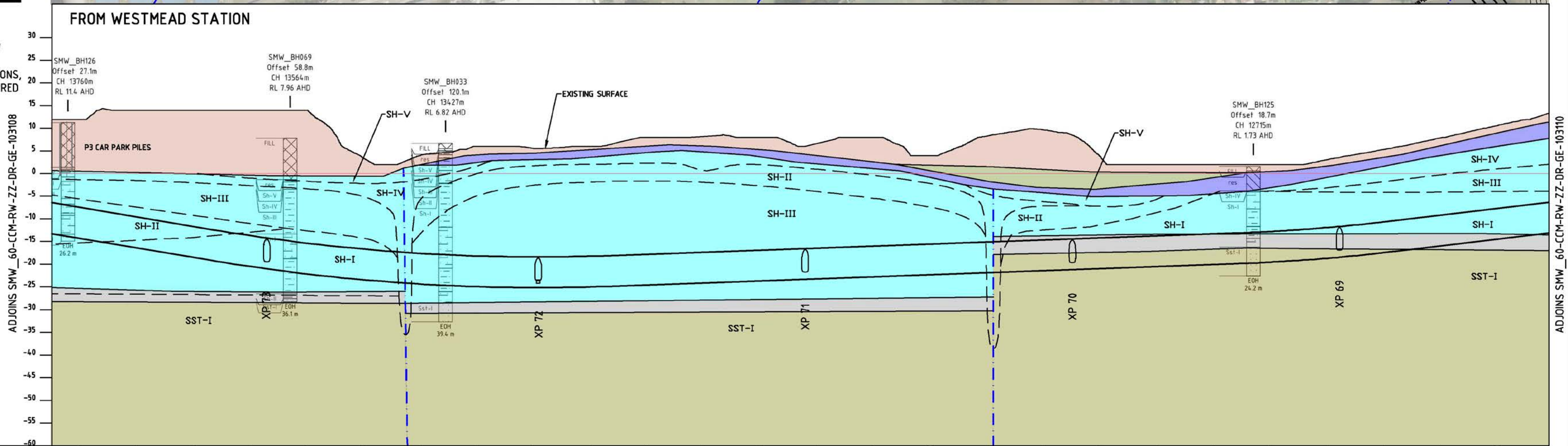
100mm AT FULL SIZE | Plot Date: 16/01/20 - 17:37 | Cad File: C:_Process\PW Export\SMW_60-CCM-RW-ZZ-DR-GE-103108.dwg

GEOTECHNICAL LEGEND

- FILL
- ALLUVIAL
- PARRAMATTA SANDS
- CLAY / PEAT
- AEOLIAN SANDS
- RESIDUAL
- ASHFIELD SHALE
- MITTAGONG FORMATION
- SILTSTONE/LAMINITE (MUDSTONE FACIES)
- HAWKESBURY SANDSTONE
- JOINT SWARM / FAULT (INFERRED)
- DYKE (INFERRED)
- INFERRED ROCK CLASS
- BOREHOLE
- FILL
- CLAY
- SAND
- NO CORE
- SILTSTONE
- INTERLAMINATED SILTSTONE & SANDSTONE
- SANDSTONE
- INTERBEDDED SILTSTONE & SANDSTONE
- NO SAMPLING

NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.





KILOMETRAGE: 13km750, 13km700, 13km650, 13km600, 13km550, 13km500, 13km450, 13km400, 13km350, 13km300, 13km250, 13km200, 13km150, 13km100, 13km050, 13km000, 12km950, 12km900, 12km850, 12km800, 12km750, 12km700, 12km650, 12km600, 12km550, 12km500

PROPOSED VERTICAL DESIGN: L=359.405m Slp 4.181% · VC=350.000m RAD: 6887.771m · L=553.862m Slp -0.900% · VC=140.000m RAD: 6667.533m · L=447.045m Slp -3.000%

PROPOSED TUNNEL AXIS LEVELS	DEPTH TO SURFACE	EXISTING SURFACE
-10.578	22.578	12.000
-12.669	26.668	14.000
-14.760	28.759	14.000
-16.798	30.798	14.000
-18.512	32.512	14.000
-19.864	24.361	4.498
-20.852	24.192	3.340
-21.478	27.045	5.568
-21.740	27.569	5.829
-21.640	27.639	6.000
-21.229	29.129	7.901
-20.779	28.876	8.098
-20.328	28.328	8.000
-19.878	26.122	6.244
-19.428	27.428	8.000
-18.978	22.978	4.000
-18.528	26.554	8.026
-18.078	27.920	9.842
-17.628	22.989	5.361
-17.178	19.178	2.000
-16.728	18.728	2.000
-16.239	18.238	2.000
-15.429	18.155	2.727
-14.244	19.254	5.010
-12.766	20.287	7.522
-11.266	21.486	10.221
-9.766	22.913	13.147

HORIZONTAL ALIGNMENT: RAD 553.906m ARC 477.904m · TRS 132.678m · STRAIGHT 372.207m · TRS 126.439m · RAD -540.052 ARC 606.182

PROFILE - METRO WEST DOWN

SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

SCALES: 1:500 FULL SIZE A1; 1:2000 FULL SIZE A1

SENSITIVE : NSW CABINET

Plot Date: 16/01/20 - 17:37

CLIENT: NSW Government Transport for NSW · Sydney Metro West

The information shown on this drawing is for the purposes of the Sydney Metro West (SMW) Project only. No warranty is given or implied as to its suitability for any other purpose. The Service Providers accept no liability arising from the use of this drawing and the information shown thereon for any purpose other than the Sydney Metro West (SMW) Project.

SERVICE PROVIDERS: Central City Metro

DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

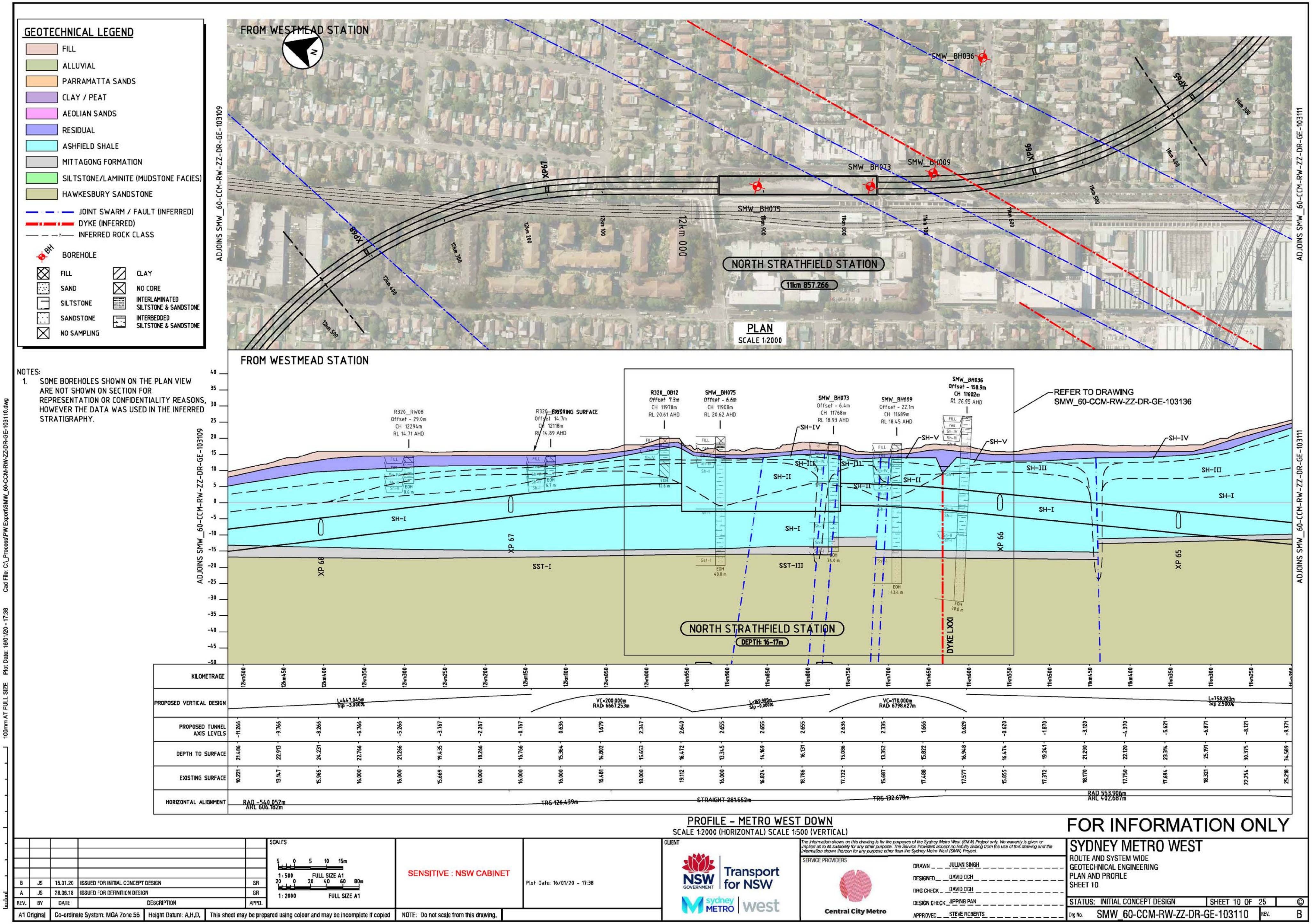
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 9

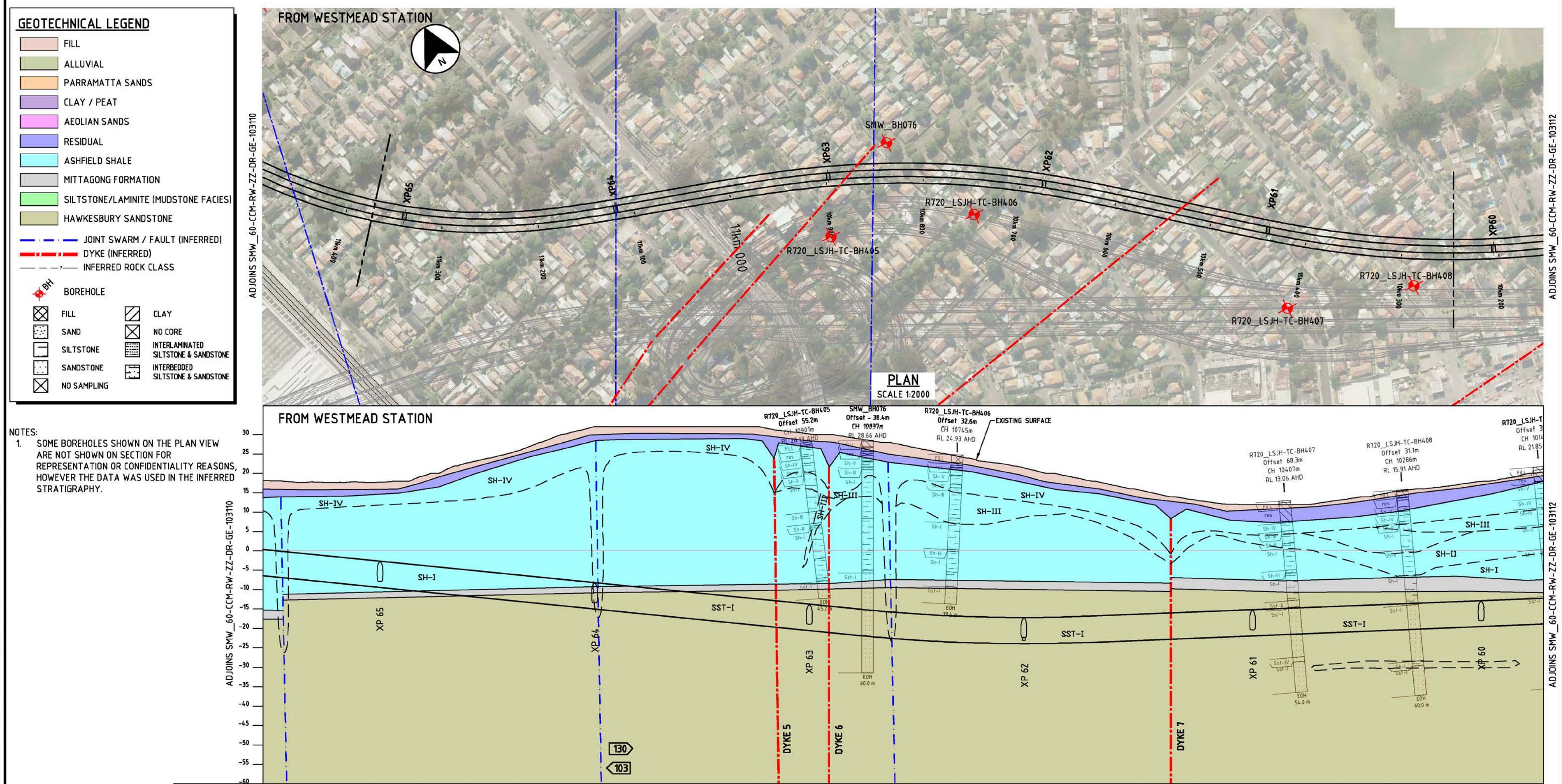
STATUS: INITIAL CONCEPT DESIGN · SHEET 9 OF 25

Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103109 · REV. B

A1 Original · Co-ordinate System: MGA Zone 56 · Height Datum: A.H.D. · This sheet may be prepared using colour and may be incomplete if copied · NOTE: Do not scale from this drawing.

Cad File: C:_Process\PW Export\SMW_60-CCM-RW-ZZ-DR-GE-103109.dwg · Plot Date: 16/01/20 - 17:37 · 100mm AT FULL SIZE


GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
SMW_BH036
SMW_BH073
SMW_BH009
SMW_BH075
NORTH STRATHFIELD STATION
11km 857.266
PLAN
SCALE 1:2000
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103109
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103111
REFER TO DRAWING SMW_60-CCM-RW-ZZ-DR-GE-103136
EXISTING SURFACE
SH-I
SH-II
SH-III
SH-IV
SH-V
SST-I
SST-III
XP 68
XP 67
XP 66
XP 65
DYKE LXXI
NORTH STRATHFIELD STATION
DEPTH: 16-17m
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
PROFILE - METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
REV. BY DATE DESCRIPTION APPD.
SENSITIVE : NSW CABINET
Plot Date: 16/01/20 - 17:38
CLIENT
Transport for NSW
Sydney Metro West
SERVICE PROVIDERS
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OCH
DRG CHECK DAVID OCH
DESIGN CHECK JIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 10
STATUS: INITIAL CONCEPT DESIGN
SHEET 10 OF 25
SMW_60-CCM-RW-ZZ-DR-GE-103110
B
A1 Original
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.



KILOMETRAGE	11km450	11km400	11km350	11km300	11km250	11km200	11km150	11km100	11km050	11km000	10km950	10km900	10km850
PROPOSED VERTICAL DESIGN	L=758.203m Slp 2.500%												
PROPOSED TUNNEL AXIS LEVELS	-3.120	-4.370	-5.621	-6.871	-8.121	-9.371	-10.622	-11.872	-13.122	-14.372	-15.623	-16.873	-18.123
DEPTH TO SURFACE	21.290	22.120	23.314	25.191	30.375	34.589	40.337	43.871	45.122	46.372	47.622	47.329	47.456
EXISTING SURFACE	18.170	17.750	17.694	18.321	22.254	25.218	29.716	32.000	32.000	32.000	32.000	30.457	29.333
HORIZONTAL ALIGNMENT	RAD 553.906m ARC 402.687m					TRS 132.678m		STRAIGHT 54.069m		TRS 129.628m			

KILOMETRAGE	10km800	10km750	10km700	10km650	10km600	10km550	10km500	10km450	10km400	10km350	10km300	10km250	10km200	10km150
PROPOSED VERTICAL DESIGN		VC=235.000m RAD: 6713.117m											L=522.171m Slp -1.000%	
PROPOSED TUNNEL AXIS LEVELS	-19.267	-20.050	-20.461	-20.499	-20.165	-19.665	-19.165	-18.665	-18.165	-17.665	-17.165	-16.665	-16.164	-15.664
DEPTH TO SURFACE	46.850	45.106	43.223	40.735	38.164	35.350	32.561	30.684	30.164	30.589	31.901	32.893	34.040	35.595
EXISTING SURFACE	27.583	25.056	22.763	20.237	18.000	15.686	13.397	12.020	12.000	12.925	14.737	16.229	17.876	19.931
HORIZONTAL ALIGNMENT	RAD -900.025m ARC 217.444m			TRS 129.628m		STRAIGHT 53.015m	TRS 135.533m				RAD 913.927m ARC 227.043m			

PROFILE – METRO WEST DOWN

SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

SCALES: 1:500 FULL SIZE A1 (5 0 5 10 15m); 1:2000 FULL SIZE A1 (20 0 20 40 60 80m)

SENSITIVE : NSW CABINET

Plot Date: 16/01/20 - 17:39

CLIENT: Transport for NSW; Sydney Metro West

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SERVICE PROVIDERS: Central City Metro

DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

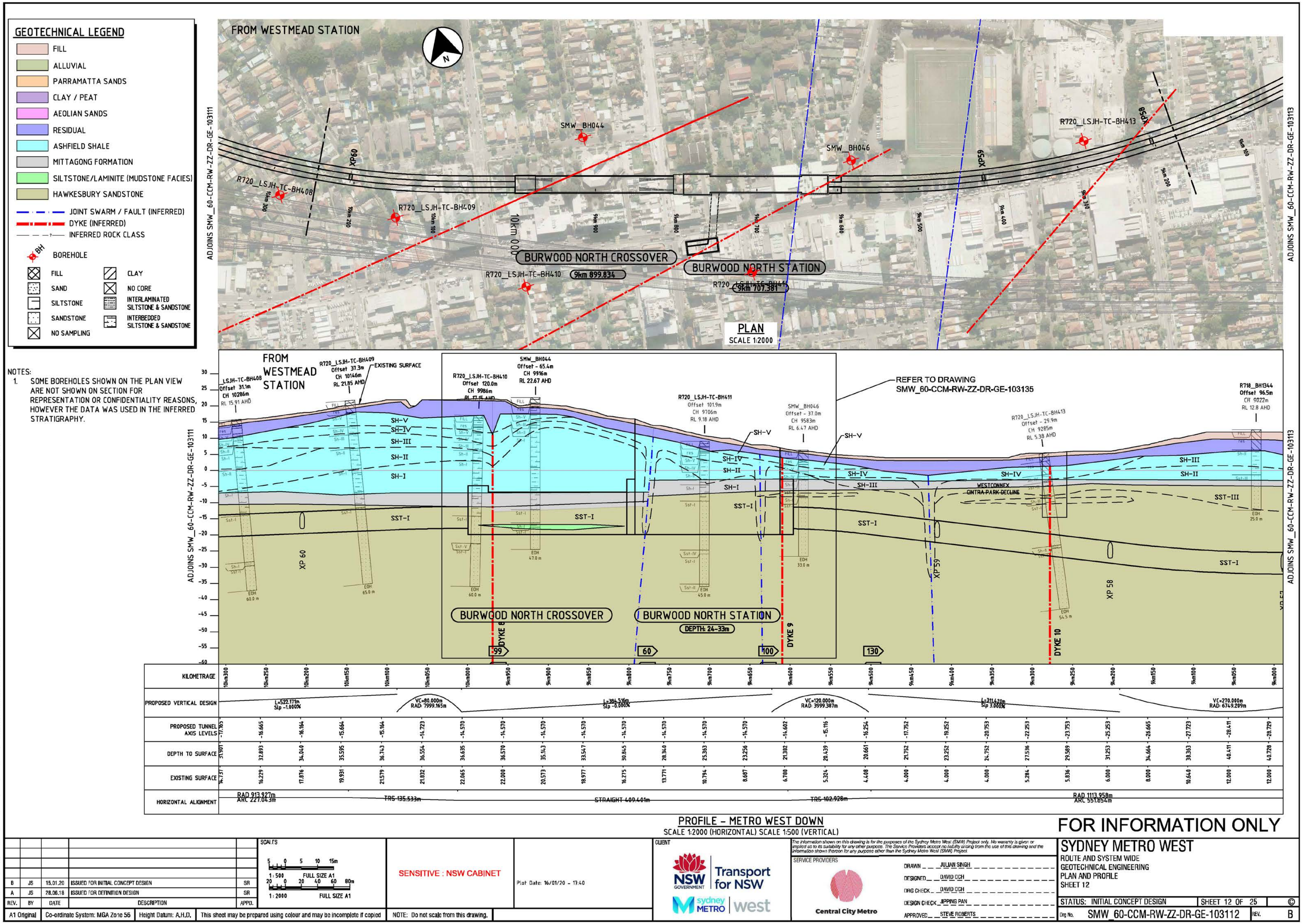
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 11

STATUS: INITIAL CONCEPT DESIGN | SHEET 11 OF 25

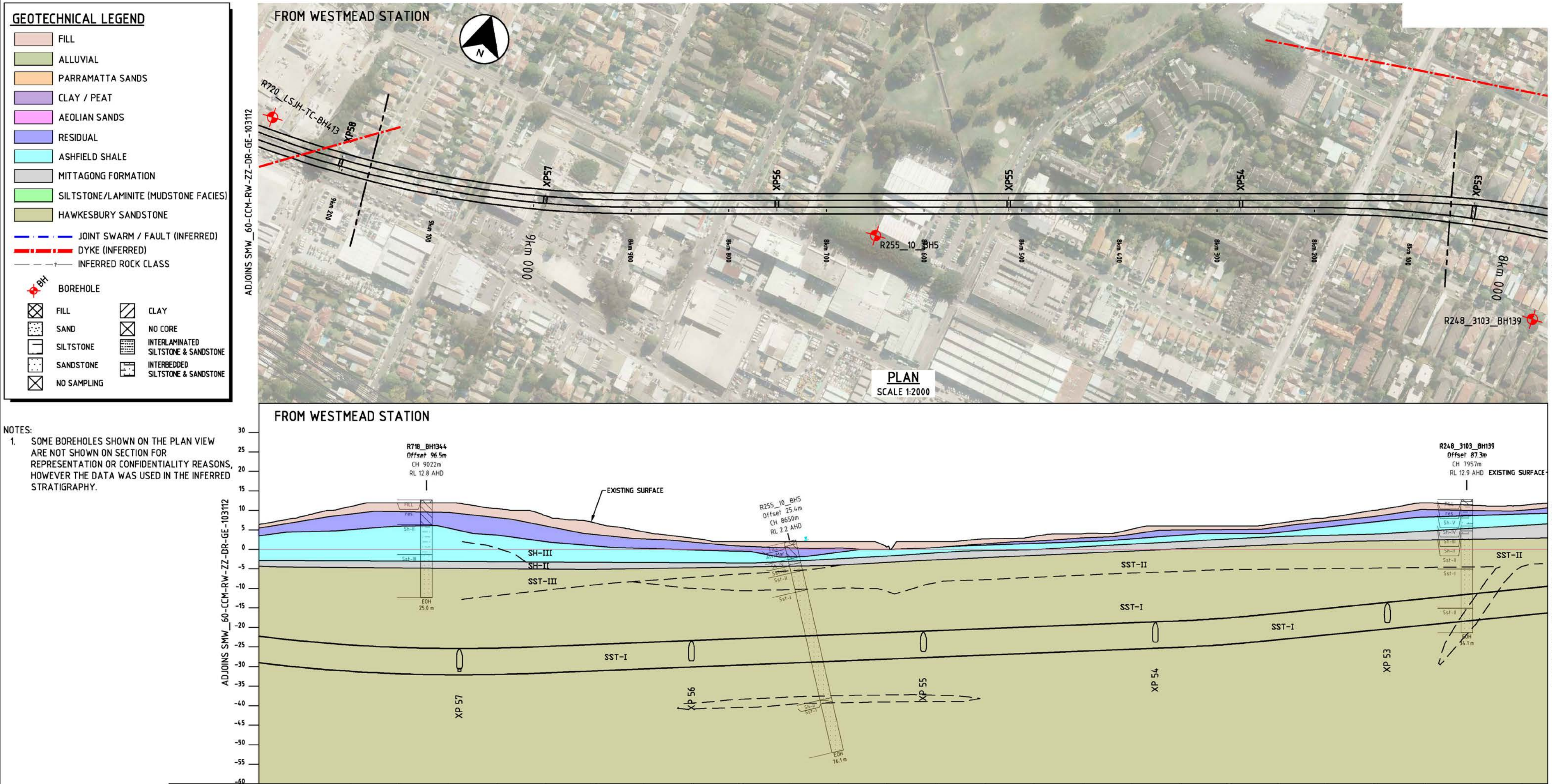
Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103111 | REV. B

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

Cad File: C:_Process\PW Export\SMW_60-CCM-RW-ZZ-DR-GE-103111.dwg   Plot Date: 16/01/20 - 17:39   100mm AT FULL SIZE



GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
SMW_BH044
SMW_BH046
R720_LSJH-TC-BH408
R720_LSJH-TC-BH409
R720_LSJH-TC-BH410
R720_LSJH-TC-BH413
BURWOOD NORTH CROSSOVER
BURWOOD NORTH STATION
9km 899.834
9km 707.381
PLAN
SCALE 1:2000
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103111
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103113
REFER TO DRAWING SMW_60-CCM-RW-ZZ-DR-GE-103135
EXISTING SURFACE
WESTCONNEX CINTRA PARK DECLINE
DEPTH: 24-33m
DYKE 8
DYKE 9
DYKE 10
XP 60
XP 59
XP 58
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
PROFILE - METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
REV. BY DATE DESCRIPTION APPD.
A1 Original
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.
SENSITIVE : NSW CABINET
Plot Date: 16/01/20 - 17:40
Transport for NSW
Sydney Metro West
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OCH
DRG CHECK DAVID OCH
DESIGN CHECK JIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 12
STATUS: INITIAL CONCEPT DESIGN
SHEET 12 OF 25
SMW_60-CCM-RW-ZZ-DR-GE-103112
REV. B



NOTES:

1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.

KILOMETRAGE	9km150	9km100	9km050	9km000	8km950	8km900	8km850	8km800	8km750	8km700	8km650	8km600	8km550
PROPOSED VERTICAL DESIGN	VC=270.000m RAD: 6749.209m											L=657.005m Slp -1.000%	
PROPOSED TUNNEL AXIS LEVELS	-26.665	-27.723	-28.411	-28.729	-28.676	-28.268	-27.768	-27.268	-26.768	-26.268	-25.768	-25.268	-24.768
DEPTH TO SURFACE	34.664	38.363	40.411	40.728	39.313	37.525	35.007	32.141	29.895	28.268	27.768	27.268	26.141
EXISTING SURFACE	8.000	10.640	12.000	12.000	10.638	9.257	7.239	4.873	3.127	2.000	2.000	2.000	1.373
HORIZONTAL ALIGNMENT						TRS 102.928m							STRAIGHT 603.307m

KILOMETRAGE	8km500	8km450	8km400	8km350	8km300	8km250	8km200	8km150	8km100	8km050	8km000	7km950	7km900
PROPOSED VERTICAL DESIGN							VC=100.000m RAD: 6667.211m					L=421.003m Slp -2.500%	
PROPOSED TUNNEL AXIS LEVELS	-24.268	-23.768	-23.268	-22.768	-22.268	-21.764	-21.019	-19.904	-18.654	-17.404	-16.154	-14.904	-13.654
DEPTH TO SURFACE	26.268	26.397	26.316	26.768	27.056	27.763	27.019	26.399	26.653	27.258	28.047	26.279	24.841
EXISTING SURFACE	2.000	2.629	3.048	4.000	4.788	6.000	6.000	6.496	8.000	9.855	11.894	11.376	11.188
HORIZONTAL ALIGNMENT							TRS 95.013m					RAD -1100.044m ARC 425.722m	

PROFILE – METRO WEST DOWN

SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

SCALES: 1:500 FULL SIZE A1; 1:2000 FULL SIZE A1

SENSITIVE : NSW CABINET

Plot Date: 16/01/20 - 17:40

CLIENT: NSW GOVERNMENT Transport for NSW; Sydney Metro West

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SERVICE PROVIDERS: Central City Metro

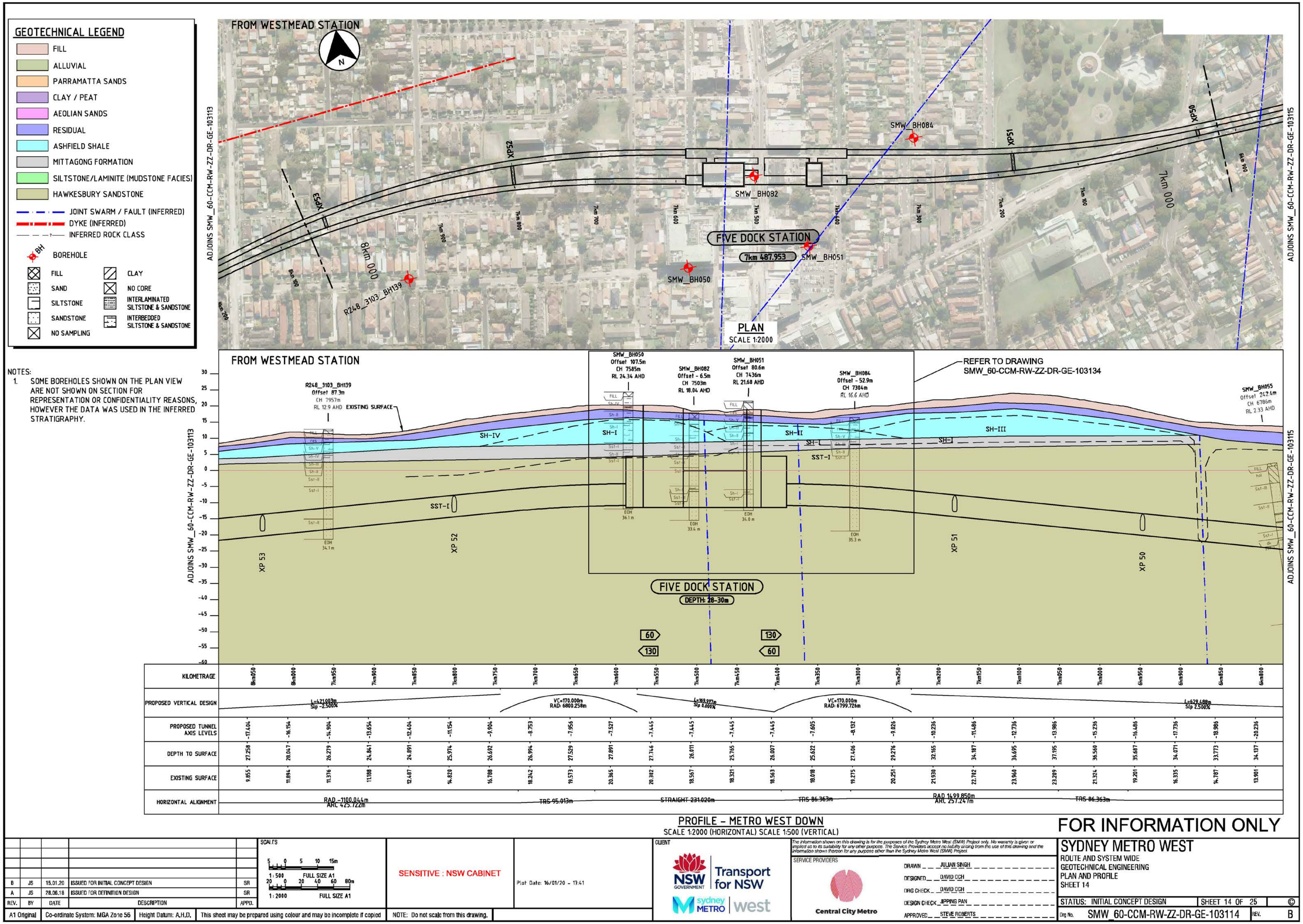
DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

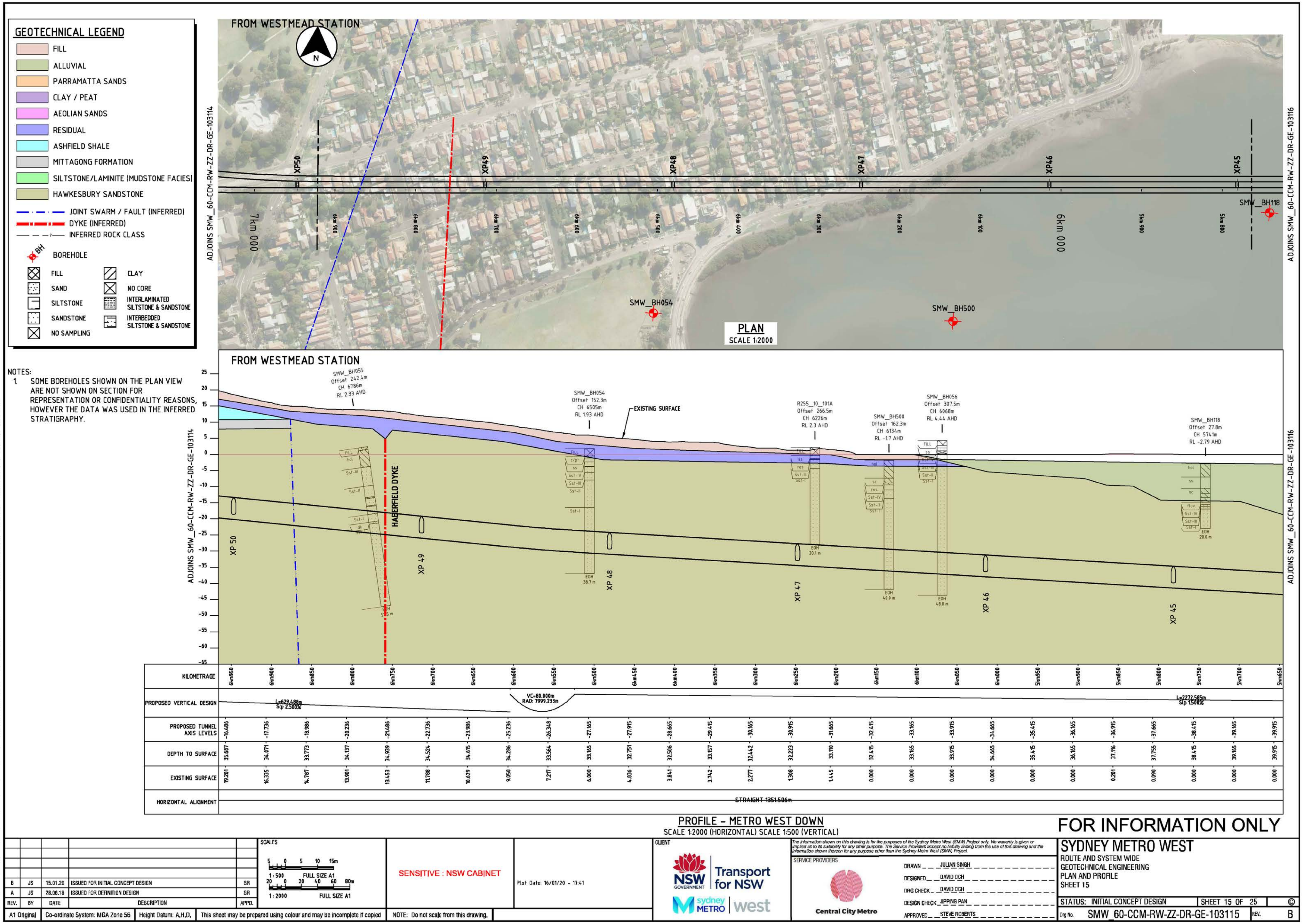
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 13

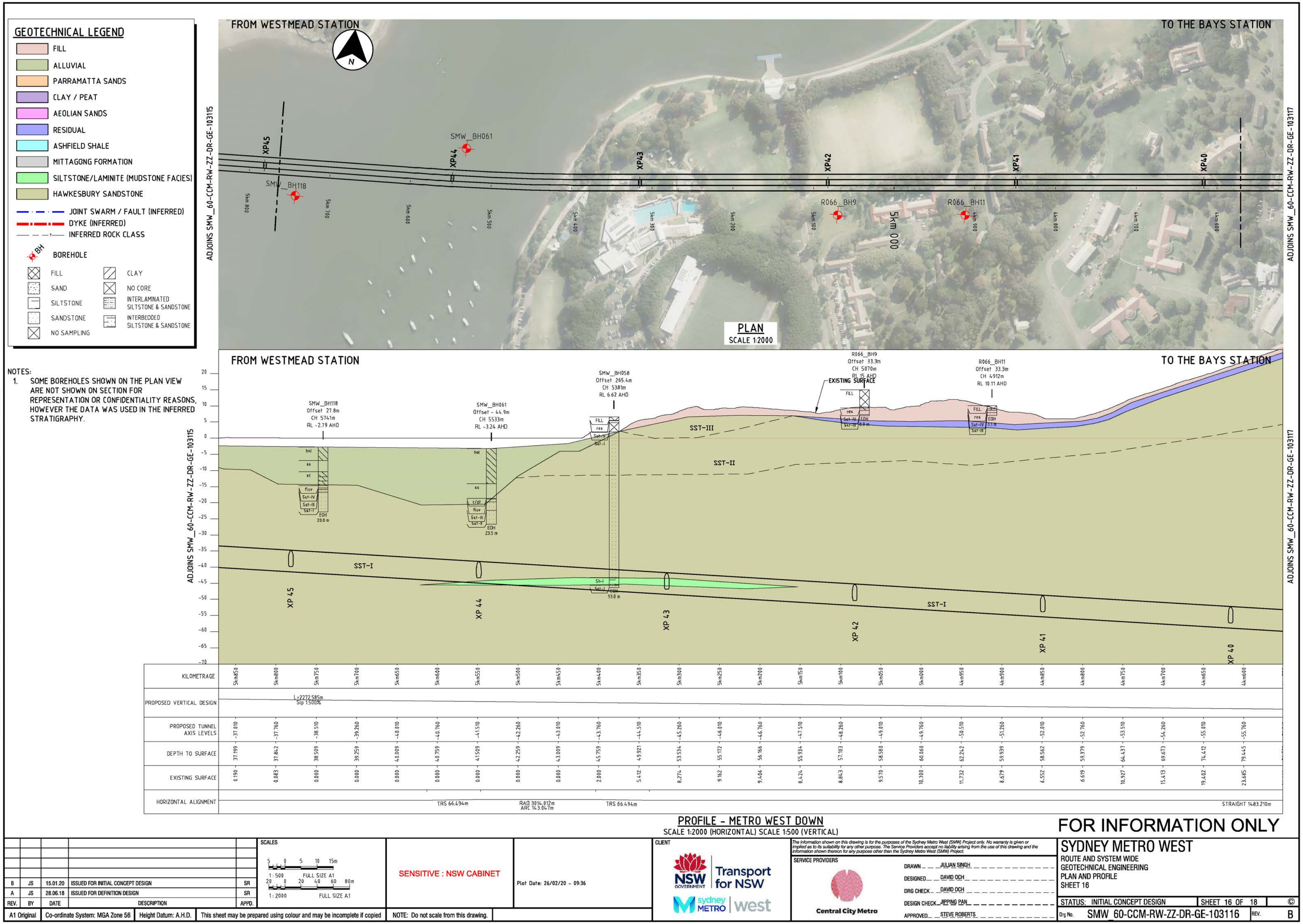
STATUS: INITIAL CONCEPT DESIGN | SHEET 13 OF 25
Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103113 | REV. B

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

Cad File: C:_Process\PW Export\SMW_60-CCM-RW-ZZ-DR-GE-103113.dwg Plot Date: 16/01/20 - 17:40 100mm AT FULL SIZE


GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
CLAY
SAND
NO CORE
SILTSTONE
INTERLAMINATED SILTSTONE & SANDSTONE
SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NO SAMPLING
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103113
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103115
SMW_BH084
SMW_BH082
SMW_BH051
SMW_BH050
R248_3103_BH139
FIVE DOCK STATION
7km 487.953
PLAN
SCALE 1:2000
REFER TO DRAWING SMW_60-CCM-RW-ZZ-DR-GE-103134
EXISTING SURFACE
FIVE DOCK STATION
DEPTH: 28-30m
PROFILE - METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
FOR INFORMATION ONLY
SENSITIVE : NSW CABINET
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
REV. BY DATE DESCRIPTION APPD.
A1 Original Co-ordinate System: MGA Zone 56 Height Datum: A.H.D. This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.
Plot Date: 16/01/20 - 17:41
CLIENT
Transport for NSW
Sydney Metro West
SERVICE PROVIDERS
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OCH
DRG CHECK DAVID OCH
DESIGN CHECK JIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 14
STATUS: INITIAL CONCEPT DESIGN
SHEET 14 OF 25
Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103114
REV. B


GEOTECHNICAL LEGEND
FILL
ALLUVIAL
PARRAMATTA SANDS
CLAY / PEAT
AEOLIAN SANDS
RESIDUAL
ASHFIELD SHALE
MITTAGONG FORMATION
SILTSTONE/LAMINITE (MUDSTONE FACIES)
HAWKESBURY SANDSTONE
JOINT SWARM / FAULT (INFERRED)
DYKE (INFERRED)
INFERRED ROCK CLASS
BOREHOLE
FILL
SAND
SILTSTONE
SANDSTONE
NO SAMPLING
CLAY
NO CORE
INTERLAMINATED SILTSTONE & SANDSTONE
INTERBEDDED SILTSTONE & SANDSTONE
NOTES:
1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.
FROM WESTMEAD STATION
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103114
ADJOINS SMW_60-CCM-RW-ZZ-DR-GE-103116
XP50
XP49
XP48
XP47
XP46
XP45
7km 000
6km 000
SMW_BH054
SMW_BH500
SMW_BH118
PLAN
SCALE 1:2000
FROM WESTMEAD STATION
SMW_BH055
SMW_BH054
R255_10_101A
SMW_BH500
SMW_BH056
SMW_BH118
EXISTING SURFACE
HABERFIELD DYKE
XP 50
XP 49
XP 48
XP 47
XP 46
XP 45
KILOMETRAGE
PROPOSED VERTICAL DESIGN
PROPOSED TUNNEL AXIS LEVELS
DEPTH TO SURFACE
EXISTING SURFACE
HORIZONTAL ALIGNMENT
STRAIGHT 1351.506m
PROFILE - METRO WEST DOWN
SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)
FOR INFORMATION ONLY
B JS 15.01.20 ISSUED FOR INITIAL CONCEPT DESIGN SR
A JS 28.06.18 ISSUED FOR DEFINITION DESIGN SR
REV. BY DATE DESCRIPTION APPD.
A1 Original
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
This sheet may be prepared using colour and may be incomplete if copied
NOTE: Do not scale from this drawing.
SENSITIVE : NSW CABINET
Plot Date: 16/01/20 - 17:41
CLIENT
Transport for NSW
Sydney Metro west
SERVICE PROVIDERS
Central City Metro
DRAWN JULIAN SINGH
DESIGNED DAVID OCH
DRG CHECK DAVID OCH
DESIGN CHECK JIPPING PAN
APPROVED STEVE ROBERTS
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 15
STATUS: INITIAL CONCEPT DESIGN
SHEET 15 OF 25
SMW_60-CCM-RW-ZZ-DR-GE-103115
B



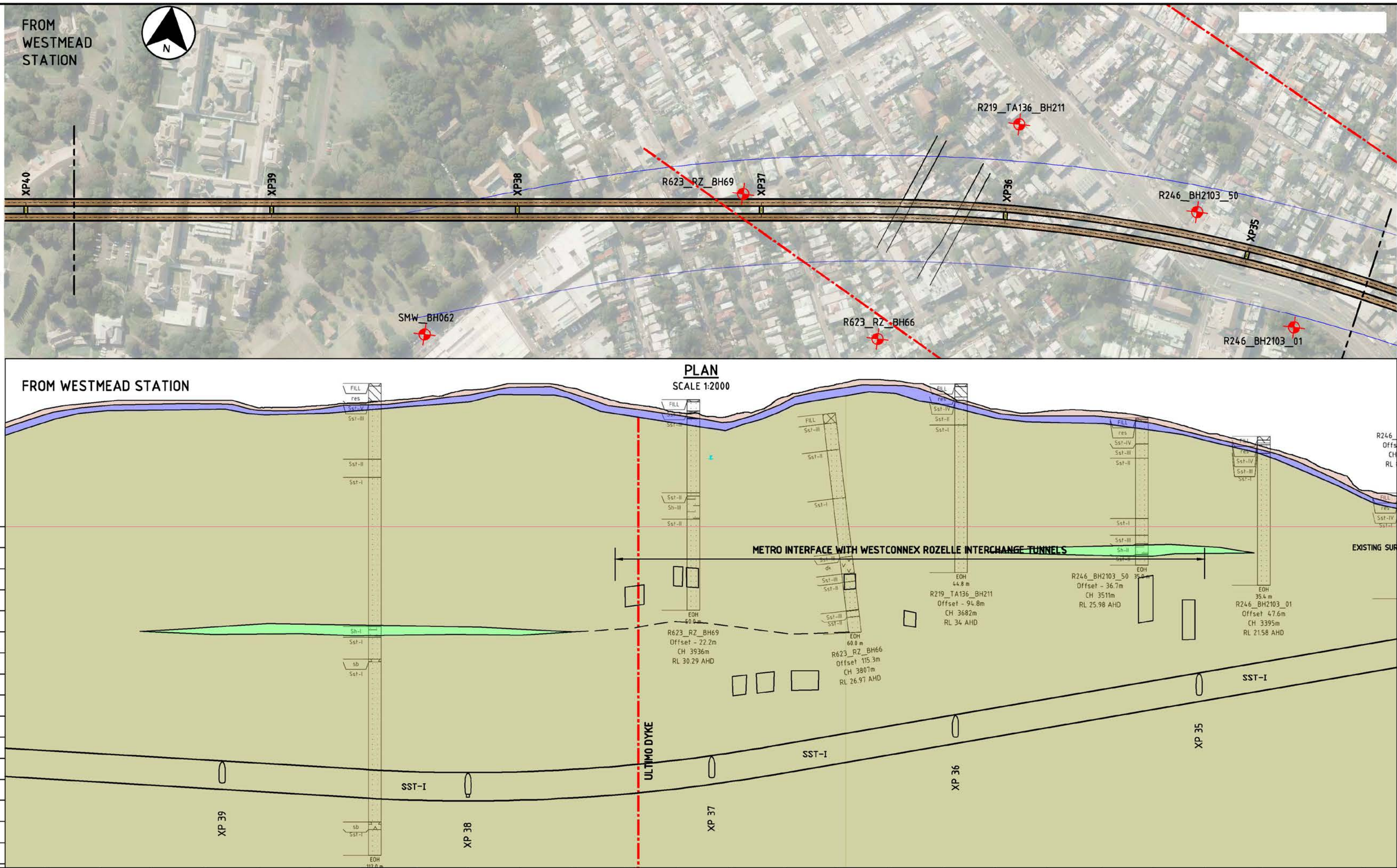
KILOMETRAGE	PROPOSED TUNNEL AXIS LEVELS	DEPTH TO SURFACE	EXISTING SURFACE
5km850	-37.010	37.199	0.190
5km800	-37.760	37.842	0.083
5km750	-38.510	38.509	0.000
5km700	-39.260	39.259	0.000
5km650	-40.010	40.009	0.000
5km600	-40.760	40.759	0.000
5km550	-41.510	41.509	0.000
5km500	-42.260	42.259	0.000
5km450	-43.010	43.009	0.000
5km400	-43.760	45.759	2.000
5km350	-44.510	49.921	5.412
5km300	-45.260	53.534	8.274
5km250	-46.010	55.172	9.162
5km200	-46.760	56.166	9.406
5km150	-47.510	55.934	8.424
5km100	-48.260	57.103	8.843
5km050	-49.010	58.580	9.570
5km000	-49.760	60.060	10.300
4km950	-50.510	62.242	11.732
4km900	-51.260	59.939	8.679
4km850	-52.010	58.562	6.552
4km800	-52.760	59.379	6.619
4km750	-53.510	64.437	10.927
4km700	-54.260	69.673	15.413
4km650	-55.010	74.412	19.402
4km600	-55.760	79.445	23.685

GEOTECHNICAL LEGEND

- FILL
- ALLUVIAL
- PARRAMATTA SANDS
- CLAY / PEAT
- AEOLIAN SANDS
- RESIDUAL
- ASHFIELD SHALE
- MITTAGONG FORMATION
- SILTSTONE/LAMINITE (MUDSTONE FACIES)
- HAWKESBURY SANDSTONE
- JOINT SWARM / FAULT (INFERRED)
- DYKE (INFERRED)
- INFERRED ROCK CLASS
- BOREHOLE
- FILL
- CLAY
- SAND
- NO CORE
- SILTSTONE
- INTERLAMINATED SILTSTONE & SANDSTONE
- SANDSTONE
- INTERBEDDED SILTSTONE & SANDSTONE
- NO SAMPLING

NOTES:

1. SOME BOREHOLES SHOWN ON THE PLAN VIEW ARE NOT SHOWN ON SECTION FOR REPRESENTATION OR CONFIDENTIALITY REASONS, HOWEVER THE DATA WAS USED IN THE INFERRED STRATIGRAPHY.



KILOMETRAGE	4km550	4km500	4km450	4km400	4km350	4km300	4km250	4km200	4km150	4km100	4km050	4km000	3km950
PROPOSED VERTICAL DESIGN	L=2272.585m Slp 1.500%							VC=390.000m RAD: 6724.245m					
PROPOSED TUNNEL AXIS LEVELS	-56.415	-57.165	-57.915	-58.665	-59.415	-60.165	-60.915	-61.518	-61.750	-61.611	-61.101	-60.218	-58.964
DEPTH TO SURFACE	83.866	86.573	87.915	88.665	88.211	88.614	90.199	91.814	93.994	95.611	94.255	89.762	86.236
EXISTING SURFACE	27.451	29.408	30.000	30.000	28.796	28.449	29.284	30.297	32.244	34.000	33.155	29.545	27.273
HORIZONTAL ALIGNMENT	83.210m												

KILOMETRAGE	3km900	3km850	3km800	3km750	3km700	3km650	3km600	3km550	3km500	3km450	3km400	3km350	3km300
PROPOSED VERTICAL DESIGN		L=666.459m Slp -4.300%											
PROPOSED TUNNEL AXIS LEVELS	-57.337	-55.341	-53.191	-51.041	-48.891	-46.741	-44.591	-42.441	-40.291	-38.141	-35.991	-33.841	-31.691
DEPTH TO SURFACE	83.342	85.509	86.579	85.884	81.567	74.960	71.833	69.896	66.305	60.971	55.827	49.945	40.927
EXISTING SURFACE	26.005	30.169	33.389	34.843	32.676	28.219	27.242	27.455	26.014	22.830	19.836	16.104	9.236
HORIZONTAL ALIGNMENT		TRS 77.106m						RAD -1500.050m ARC 558.146m					

PROFILE - METRO WEST DOWN

SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

SCALES 1:500 FULL SIZE A1; 1:2000 FULL SIZE A1

SENSITIVE : NSW CABINET

Plot Date: 16/01/20 - 17:42

CLIENT: NSW GOVERNMENT Transport for NSW; Sydney Metro west

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SERVICE PROVIDERS: Central City Metro

DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

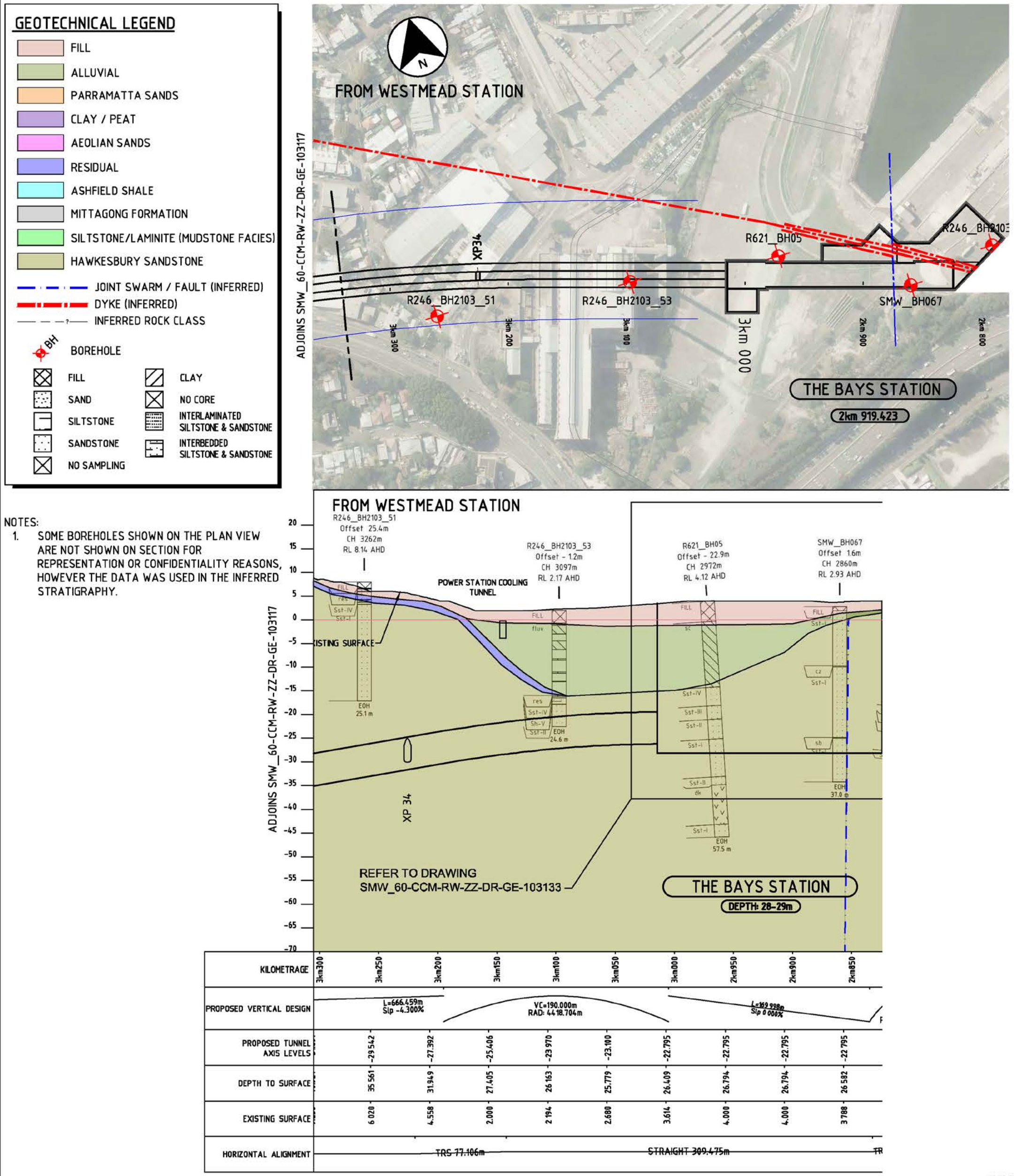
SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 17

STATUS: INITIAL CONCEPT DESIGN | SHEET 17 OF 25

Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103117 | REV. B

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

100mm AT FULL SIZE   Plot Date: 16/01/20 - 17:42   Cad File: C:_Process\PW Export\SMW_60-CCM-RW-ZZ-DR-GE-103117.dwg



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PROFILE – METRO WEST DOWN

SCALE 1:2000 (HORIZONTAL) SCALE 1:500 (VERTICAL)

FOR INFORMATION ONLY

REV.	BY	DATE	DESCRIPTION	APPD.
B	JS	15.01.20	ISSUED FOR INITIAL CONCEPT DESIGN	SR
A	JS	28.06.18	ISSUED FOR DEFINITION DESIGN	SR

SCALES 1:500 FULL SIZE A1; 1:2000 FULL SIZE A1

SENSITIVE : NSW CABINET

Plot Date: 16/01/20 - 17:43

CLIENT: Transport for NSW; Sydney Metro West

SERVICE PROVIDERS: Central City Metro

DRAWN: JULIAN SINGH
DESIGNED: DAVID OCH
DRG CHECK: DAVID OCH
DESIGN CHECK: JIPPING PAN
APPROVED: STEVE ROBERTS

SYDNEY METRO WEST
ROUTE AND SYSTEM WIDE
GEOTECHNICAL ENGINEERING
PLAN AND PROFILE
SHEET 18

STATUS: INITIAL CONCEPT DESIGN — SHEET 18 OF 25

Drg No. SMW_60-CCM-RW-ZZ-DR-GE-103118 REV. B

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.