ENVIRONMENTAL

Eastern Tunnelling Package Discharge Impact Assessment

John Holland CPB Ghella Joint Venture
Sydney Metro – Eastern Tunnelling Package
Sydney
SC220031.01

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EXECUTIVE SUMMARY

Sydney Metro West is a new 24-kilometre metro line that will connect Greater Parramatta with the Sydney CBD via stations at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD).

John Holland CPB Ghella Joint Venture (JCG) has been awarded the contract to design and construct Stage 2 of the development; the Sydney Metro West - Eastern Tunnelling Package (ETP). The ETP will include all major civil construction work including station excavation (at the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites) and tunnelling between The Bays and Sydney CBD. The ETP scope includes the demolition of existing structures, excavation of 2.5 km of twin metro tunnels, excavations of shafts, station caverns, a cross over cavern and adits and turnbacks.

The ETP will require discharge of process water including groundwater inflows from tunnelling activities to receiving waterbodies, following water treatment. It is proposed that water generated from tunnelling activities (including groundwater and process water) will be discharged from water treatment plants (WTP) located at The Bays Station, Pyrmont Station, and Hunter Street.

Influent to the Bays Station and Pyrmont Station will be treated prior to discharge using a multi-stage construction WTP, which will adopt the best practical technology (BPT) including:

- Primary solids removal
- Flocculation/coagulation
- Clarification
- Media filtration
- Breakpoint chlorination
- Granulated active carbon filtration
- Ion exchange
- pH correction.

The Bays Station will discharge to White Bay, while Pyrmont Station will discharge to Darling Harbour. In both cases discharge will be conveyed to the receiving waterbodies via the local council stormwater drainage network.

Influent from Hunter Street will be treated using the existing WTP that was commissioned in 2017 as part of the Sydney Metro City and Southwest Project to support tunnelling works at Martin Place. This WTP was upgraded in 2020 to include carbon filters and for utilisation by the Martin Place Station contractor to complete station excavation. The existing Hunter Street WTP is currently active and is used to treat groundwater dewatered from the existing underground structures, which is then released to Sydney Harbour (adjacent to the Man O'War Steps) via the local council stormwater drainage network. The existing Hunter Street WTP does not include breakpoint chlorination or ion exchange processes and a range of contaminants are observed at concentrations exceeding the ANZECC 2000 default guideline values (DGVs) for physical and chemical stressors in estuaries, and ANZG 2018 DGVs for chemical toxicants at 95% and 99% species protection in marine water.

The Hunter Street East worksite will be handed over to JCG on 17 March 2023 and the existing WTP is a handover item along with the existing acoustic shed and offices. The existing Hunter Street decline will also be handed over at this time which connects the acoustic shed underground to the Martin Place metro station. The worksite has already been excavated down to approximately 8 metres below road level while its access decline to the underground station is approximately 24 m below road level at its lowest level. Groundwater being processed at the WTP is collected at the low point of this access decline at the interface point with the underground Martin Place Station.

JCG are proposing to upgrade the existing Hunter Street WTP to include breakpoint chlorination and ion exchange for the purpose of improving water quality and undertake a proof performance monitoring program for the Hunter Street WTP to inform achievable discharge targets. However, to meet Sydney Metro's construction program, JCG are scheduled to commence excavation at the Hunter Street East worksite from April 2023. This will necessitate the use of the existing WTP, which JCG will refurbish on site handover, for initial excavation works in parallel with procurement of the upgraded treatment processes which are scheduled for installation and commissioning from approximately July 2023. In this initial period of approximately four months the low point intake for this WTP will remain unchanged, being the base of the handed-over Bligh Street decline. The groundwater level in the area of the Hunter Street site has been drawn down significantly due to dewatering associated with adjacent building basements and was recorded at between -3.25m and -4.7m AHD in September 2022. The existing Bligh Street decline has a maximum depth of approximately -5.5m AHD. Existing ground level in the area is 18.4m AHD.

The excavation works being carried out at the Hunter Street East Worksite from approximately April 2023 to July 2023 will be relatively shallow in comparison to the Hunter Street station and turnbacks, comprising only the upper level of the Hunter Street access decline. During this period, this decline will be excavated southwards from the worksite below Bligh Street before advancing westwards beneath Hunter Street. For the most part of this timeframe the level of this excavation is not expected to exceed the depth of the existing Bligh Street decline. As a result, it is not expected to incur significant increases in groundwater flows, if any, in comparison to the existing state.

Despite the robust water treatment processes that will be adopted at all ETP tunnelling worksites, it is anticipated that direct compliance with ANZECC / ANZG DGVs will not be achieved or consistently achieved for a number of contaminants that are present in groundwater despite adoption of best practicable technology (BPT) for water treatment. Additionally, the Hunter Street WTP (currently operational) which will be handed over to JCG and current discharge water quality is not consistent with the ANZECC / ANZG DGVs. This Discharge Impact Assessment (DIA) has therefore been prepared to confirm reasonable and feasible interim discharge criteria for inclusion in the initial Environment Protection Licence (EPL) for the ETP Works considering potential impacts to receiving waters and practicable treatment technologies in accordance with Section 45 of the Protection of Environment Operations Act 1997 (POEO Act). Interim discharge criteria proposed as part of this assessment to facilitate early construction stage water discharges, including handover of the existing Hunter Street WTP, and optimisation of water treatment processes at The Bays Station and Pyrmont Station WTPs.

This DIA has determined the effects of effluent discharge at the proposed interim limits on the water quality of receiving waterbodies (including White Bay, Darling Harbour, and Sydney Harbour). This discharge impact assessment has found that the significant storage volumes and tidal exchange rates through the receiving waterbodies will act to effectively attenuate contaminant impacts, with near ambient conditions achieved within 10 to 20m of the discharge points.

The proposed interim discharge criteria are for inclusion in the initial EPL conditions and will be reviewed following completion of a proof of performance monitoring program from which practical and sustainable water quality outcomes can be determined to inform the final EPL discharge conditions. As the ETP Works is adopting the BPT for water treatment, the proof of performance program will principally involve optimisation of treatment processes including but not limited to dosage rates, and contact times. The proof of performance program will involve:

- Fortnightly monitoring of influent and effluent water quality for all interim EPL criteria
- Fortnightly monitoring of surface water
- Monitoring and reporting of WTP operating parameters and dosing rates

The outcomes of the performance program will be incorporated into a technical report for submission to the EPA.

JCG will work collaboratively with the EPA to agree specific discharge criteria to be included in the initial EPL.

1 INTRODUCTION

1.1 Purpose

Sydney Metro West is a new 24-kilometre metro line that will connect Greater Parramatta with the Sydney CBD via stations at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD).

Tunnelling work along the line is to be delivered under three packages:

- Western Tunnelling Package (Westmead to Sydney Olympic Park)
- Central Tunnelling Package (Sydney Olympic Park to The Bays Precinct)
- Eastern Tunnelling Package (The Bays Precinct to Sydney CBD)

John Holland CPB Ghella Joint Venture (JCG) has been awarded the contract to design and construct the Eastern Tunnelling Package (ETP).

This Discharge Impact Assessment (DIA) has been prepared to address condition D97 of the Conditions of Approval (CoA) for the project, which states that a Water Pollution Impact Assessment must be prepared in consultation with the NSW EPA in the event that discharges from wastewater treatment plants will exceed:

a. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018 (ANZG (2018)) default guideline values for toxicants at the 95 per cent species protection level;
b. for physical and chemical stressors, the guideline values set out in Tables 3.3.2 and 3.3.3 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC/ARMCANZ)
c. For bioaccumulative and persistent toxicants, the ANZG (2018) guidelines values at a minimum of 99 per cent species protection level; and
d. The draft Australian and New Zealand Guidelines default guideline values for iron (marine).

As such, this DIA has been prepared to provide relevant information on potential discharge impacts, and confirm reasonable and feasible interim discharge criteria for inclusion in the initial Environment Protection Licence (EPL) for the ETP Works. The DIA accounts for groundwater conditions and expected outcomes from best practicable treatment technologies in considering potential impacts to receiving waters, and in general accordance with Section 45 of the Protection of Environment Operations Act 1997 (POEO Act).

1.2 Project Description

The scope of the EPT Works comprise:

- Demolition of existing buildings at Pyrmont East and West shaft sites and at Hunter Street East and West shaft sites
- Tunnel Boring Machine (TBM) assembly, launch, tunnelling support from an existing shaft at The Bays
- Approximately 2.5 km twin underground eastbound and westbound bored railway tunnels between The Bays and Hunter Street and six cross passages spaced up to 500 metres apart
- Pyrmont Station excavation, including two shaft excavations, associated access adits and nozzle enlargements, including temporary ground support and cast in situ cavern linings.
- Excavation and lining of a mined crossover cavern to allow trains to cross from one track to the other
- Hunter Street Station mined cavern excavation, including two shaft excavations, associated access adits, nozzle enlargements and conversion of an existing temporary connection adit at Bligh Street linking Hunter Street Station to Martin Place Station into a permanent pedestrian connection linking the stations, including temporary ground support and cast in situ linings.
- A turnback extension tunnel, of approximately 675 metres, will be constructed east of the Hunter Street Station works to enable Sydney Metro train storage and to change tracks and travel direction - eastbound to westbound
- TBM disassembly and retrieval from Hunter Street East

- Operation of the existing temporary bespoke precast facility at Eastern Creek to manufacture the TBM tunnel lining segments.

An overview of the ETP alignment is provided in Figure 1 and Table 1.

The ETP will require discharge of captured groundwater and process water from tunnelling activities to receiving waterways, following water treatment. It is proposed that water generated from tunnelling activities (including groundwater and process water) will be discharged from water treatment plants at the following locations:

- The Bays
- Pyrmont
- Hunter Street.

1.3 Construction Activities

Key sites that are relevant to this assessment and the ETP package of works are:

- The Bays tunnel launch and support site
- Pyrmont Station construction sites (west and east)
- Hunter Street Station (Sydney CBD) construction sites (west and east), including the existing Hunter Street Water Treatment Plant which will be handed over to JCG on 17 March 2023.

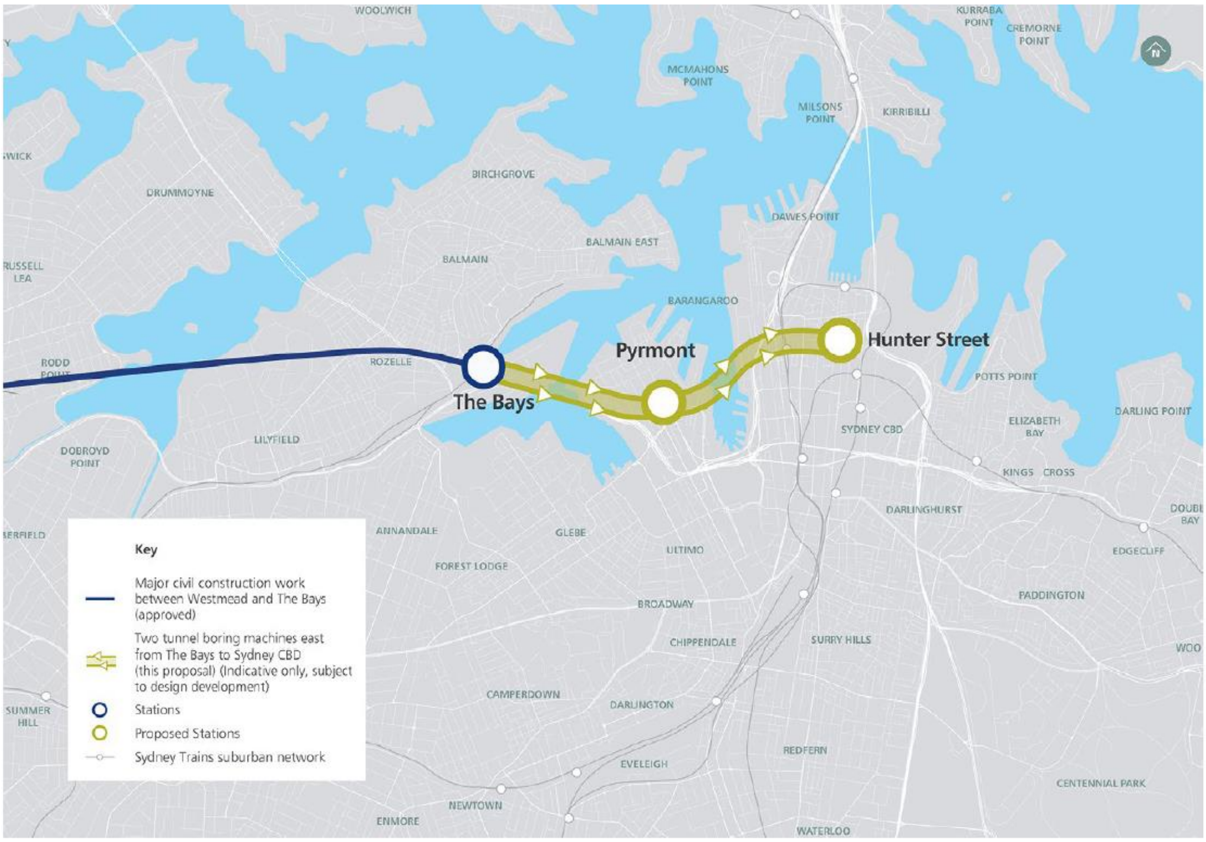

Figure 1. Overview of Sydney Metro – Eastern Tunnelling Package

Table 1 below lists the construction sites, methodologies used for construction at each site and the approximate extent of excavation and piling at each construction site. Details of how on-site water will be managed during construction activities is presented in Section 5.

Table 1. Summary of Site Works and Methods – Eastern Tunnelling Package

Worksite	Site condition at handover	Overview of ETP Works
The Bays Site area: 25,000 – 35,000m²	Existing Central Tunnelling Package Worksite • Shaft 30 metres in depth • Existing HV construction power supply conduits • Existing temporary buildings	• Protection, adjustment and decommissioning of utility services • Use of existing infrastructure for start-up • Establishment of instrumentation and monitoring • Establishment of additional temporary offices amenities and car parking • Establish high voltage construction power supply • Installation and commissioning of a new temporary Water Treatment Plant (WTP) • Nozzle enlargements and TBM launch stub tunnels • TBM assembly, launch and tunnelling support works from an existing shaft • Segment storage, and Slurry Treatment Plant (STP) to support TBM tunnelling • Cross passage construction • Principal spoil handling facility for ETP Works
Pyrmont Station West Site area: 2,600m²	Existing buildings: • 26-32 Pyrmont Bridge Road, Pyrmont – 5 Storeys Including 2 Basement Levels – Reinforced Concrete with Brick Cladding	• Protection, adjustment and decommissioning of utility services • Establish site including new construction access driveways, site hoardings, instrumentation and monitoring • Archaeological testing and salvage (if triggered) • Demolition of existing buildings • Establishment and use of temporary offices and amenities • Excavation of temporary shaft within the station shaft footprint • Installation of acoustic shed with gantry crane and steel bridging deck for excavation of station shaft, pedestrian and service adits and spoil handling for cross over cavern • Permanent concrete lining of cross over cavern and adit connections • Installation of acoustic shed will support material handling outside standard hours of work
Pyrmont Station East Site area: 1,250m²	Existing buildings • 37-69 Union St, Pyrmont – 4 Storeys with No Basements – Reinforced Concrete Structure	• Protection, adjustment and decommissioning of utility services • Establish site including new construction access driveways, site hoardings, instrumentation and monitoring • Street tree removal • Demolition of existing buildings • Detailed site investigation and contamination management • Establishment of high voltage construction power supply • Establishment and use of temporary offices and amenities • Installation and commissioning of a new temporary WTP • Excavation of temporary shaft within the station shaft footprint • Installation of acoustic shed with gantry crane and steel bridging deck for excavation of station shaft, station cavern and crossover cavern.

Worksite	Site condition at handover	Overview of ETP Works
		• Permanent concrete lining of station cavern and nozzle enlargements. • Installation of acoustic shed will support material handling outside standard hours of work
Hunter Street West Site area: 3,700m2	Existing buildings • 7-13 Hunter St (9 Hunter St), Sydney – 21 Storeys including 1 Basement level - Reinforced Concrete Structure • 5 Hunter St, Sydney (304-408 George St) - 16 Storeys including 2 Basement Levels - Reinforced Concrete Structure with Precast Panels • 298-302 George St – 16 Storeys including 1 Basement Level - Reinforced Concrete Structure with Precast Panels and Brick Cladding • 312 George St, Sydney – 1 Storey with no Basement Levels – Reinforced Concrete and Steel Frame • 314-318 George St, Sydney – 9 Storeys including 1 Basement Level – Reinforced Concrete Structure with Brick Cladding	• Protection, adjustment and decommissioning of utility services • Establish site including new construction access driveways, site hoardings, instrumentation and monitoring • Demolition of existing buildings • Archaeological testing and salvage (if triggered) • Establishment and use of temporary offices and amenities • Excavation of station access shaft

Hunter Street East
 	
Site area: 3,700m2
	• Site hoarding
	• Existing acoustic shed, spoil handling facilities and truck access
	• Excavation within acoustic shed approximately 8- metres below road level
	• Existing temporary WTP and High Voltage power supply
	• Existing temporary office and amenities
	• Existing buildings:
	    • 28-34 O'Connell St, Sydney – 19 Storeys including 3 Basement Levels – Reinforced Concrete Structure
	    • 44-48 Hunter St, Sydney – 16 Storeys including 1 Basement Level - Reinforced Concrete Structure with Concrete Encased Steel Columns and Beams
	• 37 Bligh St, Sydney – 16 Storeys including 1 Basement Level - Reinforced Concrete Structure33 Bligh St, Sydney, 20m High Steel Shed
		• Use of existing offices and amenities where practicable and establishment of additional offices and amenities
		• Tree trimming and removal
		• Use of existing acoustic shed and access driveways
		• Interim use of existing temporary Water Treatment Plant (WTP) and installation and commissioning of upgraded treatment systems
		• Protection, adjustment and decommissioning of utility services
		• Excavation of temporary decline, station cavern, nozzle enlargements, adits and turnbacks from within an existing acoustic shed
		• Establish site including new construction access driveways, site hoardings, instrumentation and monitoring
		• Demolition of existing high-rise buildings and excavation of stage 1 of station access shaft
		• Archaeological monitoring and salvage (if triggered)

Worksite	Site condition at handover	Overview of ETP Works
		• Backfill of temporary decline prior to decommissioning • Demolition of existing acoustic shed and amenities and excavation of stage 2 of station access shaft • Permanent concrete lining of station cavern and turnbacks • TBM disassembly and retrieval

As noted above, JCG are proposing to upgrade the existing Hunter Street WTP to include breakpoint chlorination and ion exchange for the purpose of improving water quality and undertake a proof performance monitoring program for the Hunter Street WTP to inform achievable discharge targets. However, to meet Sydney Metro's construction program, JCG are scheduled to commence excavation from the Hunter Street East worksite from April 2023. This will necessitate the use of the existing WTP, which JCG will refurbish on site handover, for initial excavation works in parallel with procurement of the upgraded treatment processes which are scheduled for installation and commissioning from approximately July 2023. In this period of time the low point intake for this WTP will remain unchanged, being the base of the handed-over Bligh Street decline. The groundwater level in the area of the Hunter Street site has been drawn down significantly due to dewatering associated with adjacent building basements and was recorded at between -3.25m and -4.7m AHD in September 2022. The existing Bligh Street decline has a maximum depth of approximately -5.5m AHD. Existing ground level in the area is 18.4m AHD.

The excavation works being carried out at this time will be relatively shallow in comparison to the Hunter Street station and turnbacks, comprising only the upper level of the Hunter Street access decline. During this period, this decline will be excavated northwards from the worksite below Bligh Street before advancing westwards beneath Hunter Street. For the most part of this timeframe the level of this excavation is not expected to exceed the depth of the existing Bligh Street decline. As a result, it is not expected to incur significant increases in groundwater flows, if any, in comparison to the existing state.

1.4 Conditions of Approval

The ETP is classified as Critical State Significant Infrastructure (CSSI) under the Environmental Planning & Assessment Act (1979) and is addressed under the Stage 2 Planning Approval (SSI 19238057). Conditions of Approval (CoA) include the following water quality requirements for waters generated by construction activities, including all discharges from the project and any construction WTPs.

- **D95:** The CSSI must be designed and constructed so as to maintain the NSW Water Quality Objectives (NSW WQO) where they are being achieved as at the date of this approval, and contribute towards achievement of the NSW WQO over time where they are not being achieved as at the date of this approval, unless an EPL in force in respect of the CSSI contains different requirements in relation to the NSW WQO, in which case those requirements must be complied with.
- **D96:** Unless an EPL is in force in respect to the CSSI and that licence specifies alternative criteria, discharges from wastewater treatment plants to surface waters must not exceed:
    - the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018 (ANZG (2018)) default guideline values for toxicants at the 95 per cent species protection level;
    - for physical and chemical stressors, the guideline values set out in Tables 3.3.2 and 3.3.3 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC/ARMCANZ)
    - for bio-accumulative and persistent toxicants, the ANZG (2018) guidelines values at a minimum of 99 per cent species protection level; and
    - the draft Australian and New Zealand Guidelines default guideline values for iron (marine). Where the ANZG (2018) does not provide a default guideline value for a particular pollutant,

the approaches set out in the ANZG (2018) for deriving guideline values, using interim guideline values and/or using other lines of evidence such as international scientific literature or water quality guidelines from other countries, must be used.

- **D97:** If alternative discharge criteria from the Water Treatment Plants are proposed via an EPL, a Water Pollution Impact Assessment will be required for the relevant pollutants to inform licensing consistent with section 45 of the POEO Act. Any such assessment must be prepared in consultation with the EPA and be consistent with the National Water Quality Guidelines, with a level of detail commensurate with the potential water pollution risk.
- **D98:** If construction stage stormwater discharges are proposed, a Water Pollution Impact Assessment will be required to inform licensing consistent with section 45 of the POEO Act. Any such assessment must be prepared in consultation with the EPA and be consistent with the National Water Quality Guidelines, with a level of detail commensurate with the potential water pollution risk.

1.5 Construction Water Treatment Plants

An existing WTP is currently operating at the existing Hunter Street construction compound and will continue to be used during the ETP construction works. The Hunter Street WTP is currently discharging water and will continue to discharge following handover to JCG on 17 March 2023. Additional WTPs will be commissioned and operated at Pyrmont and The Bays construction compounds.

To address relevant water quality CoAs, JCG will commission and operate the WTPs throughout the duration of tunnel and station excavation for the treatment of groundwater seepage, TBM and road header and other tunnel process water, excess rainfall into excavations, and washdown water. Treated water will then be released through discharge points included in the EPL into the stormwater system and Sydney Harbour. The existing Hunter Street WTP will be refurbished and the new WTPs at The Bays and Pyrmont will be installed and operated prior to excavation at the locations identified in Table 2.

Table 2. Construction WTPs – Summary Details

Water Treatment Plant	Proposed Capacity (L/s)	Feed Water Source	Discharge Point into Sydney Harbour
Hunter Street (Existing)	15	Tunnel and station excavation	Sydney Harbour at Opera House
Pyrmont	15	Tunnel and station excavation	Darling Harbour
The Bays	30	Tunnel and station excavation + seepage into station box	White Bay

Further detail on the construction WTPs, including treatment processes is provided in Section 5.

1.6 Construction Timeframes

Excavation is anticipated to commence in April 2023 at Hunter Street Station (east), with the remaining sites commencing construction activities the following quarter. WTPs at The Bays and Pyrmont and the upgrades to the existing Hunter Street WTP will be commissioned from approximately July 2023.

The ETP major civil works are expected to proceed through to Quarter 4 (2025), whereby construction works, and station fit out associated with the Project will be undertaken by follow on contractors.

1.7 New South Wales Environment Protection Agency Advice

EPA's policy on water management requires that wastewater DIAs are completed ideally as part of the Environmental Impact Statement (EIS), not deferred to project delivery.

In mid-2018 the EPA wrote to proponents including TfNSW (EPA reference DOC18/636188) setting out requirements for DIA to be included in EIS. Construction companies were notified of EPA's requirement to prepare DIAs in an industry forum on 21 June 2019, a year later.

Sydney Metro conducted some water quality monitoring for the ETP EIS but did not continue water quality monitoring. The EPA's Submission on the Project EIS dated 1 December 2021 (ref DOC21/1057302) identifies that the EIS does not provide enough information to determine how, or whether, water quality objectives will be met. This submission concludes by stating that:

"water pollution impact assessment should be conducted commensurate with the residual risks and consistent with the national Water Quality Guidelines to inform licensing considerations consistent with Section 45 of the Protection of Environment Operations Act 1997."

The EPA's recommendations in regard to relevant objectives for water quality discharge impact assessments from recent projects are summarised in Table 3, and have been addressed as part of this DIA.

Table 3. NSW EPA Advice Regarding the Preparation of Discharge Impact Assessments

Management Framework	Objectives	Relevant Section of Report
Water Quality Management Framework	A clear statement(s) on the adopted protection levels for each affected waterway	Section 3
	Information on existing water quality characterising each waterway, including categories for pollutants	Section 4.5
	Assessment of whether water quality objectives are currently being met in each waterway	Section 4.5
Construction Stage Wastewater Management Framework	Wastewater Pollution Impact Assessment is provided for wastewater treatment plants	This Report
	Characterise the groundwater / water quality at each site to inform the selection of appropriate water treatment processes	Section 4.6
	Detail proposed wastewater treatment processes including the treatment technology/units and the pollutants being treated	Section 5
	Detail expected plant discharge water quality under typical and worst-case conditions	Section 5
	Identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle at each discharge point	Section 5
	Assess the potential impact of discharges on the environmental values of the receiving waterway, including typical through to worst-case scenarios, with reference to the relevant guideline values consistent with the National Water Quality Guideline	Section 6
	Where a mixing zone is required, demonstrate how the National Water Quality Guideline criteria for relevant chemical and non-chemical parameters are met at the edge of the initial mixing zone of the discharge	Section 6
	Demonstrate how the proposal will be designed and operated to protect the Water Quality Objectives for receiving waters where they are currently being achieved	Section 5, Section 8
	Demonstrate how the proposal will be designed and operated to contribute towards achievement of the Water Quality Objectives over time where they are not currently being achieved	Section 5, Section 8
	Demonstrate that all practical and reasonable measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented	Section 5, Section 8

1.8 Objectives

This report provides a combined Water Pollution DIA for discharges associated with the WTPs located at Hunter Street, Pyrmont and The Bays to address the CoAs, specifically condition D97. In accordance with general EPA guidance, this DIA provides the following information:

- A review of existing (baseline) information on groundwater quality along the tunnel alignments and station excavations
- A review of existing (baseline) information on surface water quality in waterways which may be affected by construction stage discharges
- A summary of the sources, chemistry, and inflow rates of waters that will be managed by each construction WTP
- Identification of pollutants that are present at elevated concentrations in groundwater including pollutants which may present a risk of exceeding the water quality objectives (WQOs) in receiving waterways
- A summary of the proposed treatment processes at each construction WTP, including the proposed treatment technologies and expected outcomes against the desired WQOs under typical and reasonable worst-case conditions
- Demonstration of how the proposed WTPs will be designed and operated to:
  - Protect the Water Quality Objectives for receiving waters where they are currently being achieved
  - Contribute towards achievement of the Water Quality Objectives over time where they are not currently being achieved
  - Demonstrate that all practical and reasonable measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented
- Assess the potential impact of discharges on the environmental values of the receiving waterway, including typical through to worst-case scenarios, with reference to the relevant guideline values consistent with the National Water Quality Management Strategy.
- Where a mixing zone is required, demonstration of how the National Water Quality Guideline criteria for relevant chemical and non-chemical parameters are met at the edge of the initial mixing zone of the discharge

1.9 Methodology

The following scope of works has been completed to address the objectives of the DIA in assessing the water quality impacts resulting from WTP effluent discharges.

- Identification of the regulatory framework and guidelines governing the assessment and management of discharges to water, including:
  - Protection of the Environment Operations Act (1997)
  - Environmental Protection Licence (EPL 21600)
  - New South Wales (NSW) Water Quality Objectives (WQOs)
  - ANZECC (2000) and ANZG (2018) Guidelines
- Review and summary of the catchment environment conditions in waterways that will receive discharge from the project construction WTPs, including:
  - Hydrological and hydro-ecological conditions
  - Baseline water quality, including concentrations of toxicants and physical / chemical stressors in groundwater and surface water
- Review of assigned environmental values for the catchment and associated waterways with reference to the NSW Water Quality Objectives
- Identification of the project conceptual model for water treatment, including:
  - Proposed locations of the construction WTPs
  - Sources of influent to the construction WTPs and anticipated influent water quality
  - Proposed WTP design and water quality treatment processes

  - Anticipated effects of WTP processes on water quality
  - Expected compliance against NSW Water Quality Objectives under typical and worst-case conditions
  - Proposed discharge regime from construction WTPs to receiving waterways
- Assessment of anticipated impacts from discharge on receiving environments using an analytical modelling approach incorporating dilution-dispersion
- Proposed WTP discharge criteria for all relevant analytes including a justification for proposed discharge criteria
- Proposed adaptive management measures and contingency options for water treatment and discharge.

2 REGULATORY FRAMEWORK AND GUIDELINES

Table 4. NSW Regulatory and Guidance Framework for Discharges to Water

Document	Description
Protection of the Environment Operations Act 1997 (POEO Act)	The Protection of the Environment Operations Act 1997 (POEO Act) is the key piece of environment protection legislation administered by the EPA. The EPA is the appropriate regulatory authority and licencing body for the activities specified in Schedule 1 of the POEO Act (scheduled activities), which includes rail activities (Clause 33) and the ETP Works require an EPL. Under Section 120 of the POEO Act "A person who pollutes any waters is guilty of an offence". The definition of waters includes: 1. Any river, stream, lake, lagoon, swamp, wetlands, unconfined surface water, natural or artificial watercourse, dam or tidal waters (including the sea), or 2. Any water stored in artificial works, any water in water mains, water pipes or water channels, or any underground or artesian water. In granting an EPL the EPA must consider matters listed in Section 45 of the POEO Act including: " the practical measures that could be taken— (i) to prevent, control, abate or mitigate that pollution, and (ii) to protect the environment from harm as a result of that pollution."
Environmental Planning & Assessment Act (1979)	The ETP is classified as Critical State Significant Infrastructure (CSSI) under the Environmental Planning & Assessment Act (1979) and is addressed under the Stage 2 Planning Approval (SSI 19238057). Relevant Conditions of the CSSI Approval are listed in Section 1.4. In accordance with Section 5.24 of the EP&A Act the EPL must be substantially consistent with the CSSI Approval. Conditions D95 to D98 permit the EPA to confirm alternative discharge criteria through consideration of this DIA.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018 and ANZECC, 2000)	The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Water Quality Guidelines) provide authoritative guidance on the management of water quality for natural and semi-natural water resources in Australia and New Zealand. The ANZG (2018) guidelines include default guideline values (DGVs) that are used as a generic starting point for assessing water quality. The DGVs are not mandatory and have no legal status, however, are commonly incorporated into water quality protection policy and regulatory tools for state, territory and local jurisdictions (including the NSW Water Quality Objectives). DGVs have been developed for guidance with aquatic ecosystems, primary industries, drinking water, recreation, and aesthetics. The NWQMS advocates use of weight-of-evidence process above rigid application of guideline values to determine if water quality represents a risk to a particular community value. The Water Quality Management Framework can be used to assess compliance or any current or potential impacts of a waste discharge on water/sediment quality. Assessing a waste discharge in this way aims to ensure that it complies with the conditions of approval and is not causing environmental harm. Consideration of whether water/ sediment quality objectives are achievable is a key step in the management framework for assessing waste discharges.
New South Wales Water Quality and River Flow Objectives	Water quality represents the physical, chemical, and biological characteristics of water and measures the ability of a waterbody to support beneficial uses including uses for people and the environment. The NSW Water Quality Objectives are the agreed environmental values and long-term goals for water quality in surface waters of New South Wales. They set out: 1. The community's agreed values and uses for our rivers, creeks, estuaries and lakes (i.e., healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water) 2. A range of water quality indicators to help us assess whether the current condition of our waterways supports those values and uses The River Flow Objectives are the agreed high-level goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses. The water quality objectives and environmental values for the waterways that will be affected by the project are discussed further in Section 8.

3 ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES

3.1 Overview of the NSW Water Quality Objectives

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

- the community's values and uses for our rivers, creeks, estuaries, and lakes (i.e., healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water)
- a range of water quality indicators to help us assess whether the current condition of our waterways supports those values and uses

Water Quality Objectives have been agreed for fresh and estuarine surface waters and for marine water quality.

The Objectives are consistent with the agreed national framework for assessing water quality set out in the ANZECC 2000 Guidelines. These guidelines provide an agreed framework to assess water quality in terms of whether the water is suitable for a range of environmental values (including human uses). The Water Quality Objectives provide environmental values for NSW waters and the ANZECC 2000 Guidelines provide the technical guidance to assess the water quality needed to protect those values.

3.2 Relevant NSW Water Quality Objectives

The project corridor is located within the Sydney Metropolitan catchment (Port Jackson) which includes Sydney Harbour. In the context of the NSW WQOs the project is located within the Sydney Harbour and Parramatta River Catchment, which includes WQOs for "*upper estuary*", "*lower estuary*", and "*waterways affected by urban development*".

As the project is located in the mapped extent of the "*lower estuary*" for Sydney Harbour and Parramatta River Catchment (and all discharges will be directly into the lower estuary), the specific NSW WQOs that are relevant for the project include:

- Aquatic Ecosystems
- Visual Amenity
- Secondary Contact Recreation
- Primary Contact Recreation
- Aquatic Foods.

Further detail on these water quality objectives is provided in the following sections.

3.2.1 Aquatic ecosystems

The specific WQO for projection of aquatic ecosystems in Sydney Harbour relevant to the project include trigger values for both "water quality indicators" and for chemical contaminants or "toxicants". Details in water quality indicators are addressed in the ANZECC 2000 Guidelines and include direct effect non-toxic physical/chemical stressors, indirect stressors, and effect indicators. Chemical contaminants of concern are addressed in the ANZG 2018 guidelines.

Trigger values are the numeric criteria that if exceeded indicate potential for harmful environmental effects to occur. The default trigger values provided in ANZECC 2000, and AZNG 2018 Guidelines are essentially conservative and precautionary. If they are not exceeded, a very low risk of environmental damage can be assumed. If they are exceeded, further investigation is "triggered" for the pollutant concerned. Assessing whether the exceedance means a risk of impact to the Water Quality Objective requires site-specific investigation, using decision trees provided in the Guidelines.

Key water quality indicators and default trigger values for Sydney Harbour are outlined in Table 5 and are consistent with the default guideline values as identified in Tables 3.3.2 and 3.3.3 of the ANZECC (2000) guidelines.

Table 5. Assigned environmental values for watercourses relevant to Eastern Tunnelling Package

Indicator	Trigger Values
Total phosphorus	30 µg/L
Total nitrogen	300 µg/L
Chlorophyll-a	4 µg/L
Turbidity	0.5 – 10 NTU
Salinity/Electrical conductivity	-
Dissolved oxygen	80 – 110%
pH	7.0 – 8.5 pH units
Temperature	See ANZECC 2000 Guidelines, Table 3.3.1
Chemical contaminants or toxicants	See ANZECC 2000 Guidelines, Chapter 3.4, and Table 3.4.1

Trigger values for physical / chemical stressors and chemical toxicants that are directly toxic to biota are defined by the relevant environment and species protection trigger values specified in the ANZG, (2018) guidelines.

For slightly to moderately disturbed ecosystems (including those affected by urban development) the 95% species protection, and 99% species protection for (bioaccumulating contaminants) are typically applied for permanent discharges, whilst lower levels of protection may be applied for temporary discharges.

The water quality criteria for chemical contaminants and toxicants that have been adopted as general screening criteria for this project are consistent with ANZECC 2000 default guideline values (DGVs) for physical and chemical stressors (Table 3.3.2 and 3.3.2) and 95% species protection for chemical toxicants, and 99% species protection for (bioaccumulating chemical toxicants) in marine environments (ANZG, 2018).

Recommended discharge limits are included in Section 7, which are generally consistent with the ANZECC and ANZG guidelines, except for those contaminants that cannot be treated to the DGVs due to limitations in available treatment technology. For these contaminants alternative limits are proposed that are consistent either with lower limits of species protection or as site specific or interim criteria until performance outcomes can be determined.

It should be noted that the ANZECC/ARMCANZ (2000) default guideline value for nitrate toxicity was erroneous (ANZG, 2018). In the absence of a default guideline value, ANZG recommends referring to the "Grading" guideline values published in the Updating nitrate toxicity effects on freshwater aquatic species report - which were used to inform the current New Zealand nitrate toxicity attribute. As the ANZG reference does not include a nitrate toxicity reference value for marine waters, the CCME guideline (45,000 µg/L) has been included alongside the recommended freshwater DGV (2,400 µg/L) as a recommended toxicity screening value for marine waters.

3.2.2 Visual amenity

This objective applies to all waters, particularly those used for aquatic recreation and where aesthetic qualities are important. Indicators used to assess and monitor visual amenity in Sydney Harbour and associated waterbodies affected by the project are summarised in Table 6.

Table 6. Visual amenity in Sydney Harbour catchment

Indicator	Criteria
Visual Clarity and Colour	Natural visual clarity should not be reduced by more than 20%.
	Natural hue of the water should not be changed by more than 10 points on the Munsell Scale.
	The natural reflectance of the water should not be changed by more than 50%.
Indirect Stressors	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour.
	Waters should be free from floating debris and litter.
Effect Indicator	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.

3.2.3 Secondary contact recreation

This objective applies to all waters but may not be achievable for some time in some areas (e.g. heavily degraded catchments). Secondary contact recreation applies in waterways where communities do not require water quality of a level suited to primary contact recreation, or where primary contact recreation will be possible only in the future.

Indicators used to assess and monitor water for secondary contact recreation in the Parramatta River / Sydney Harbour Catchment are summarised in Table 7.

Table 7. Sydney Harbour catchment secondary contact recreation indicators

Indicator	Criteria
Faecal Coliforms	Median bacterial content in fresh and marine waters of < 1000 faecal coliforms per 100 mL, with 4 out of 5 samples < 4000/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).
Enterococci	Median bacterial content in fresh and marine waters of < 230 enterococci per 100 mL (maximum number in any one sample: 450-700 organisms/100 mL).
Algae & Blue-Green Algae	< 15 000 cells/mL
Nuisance Organisms	Use visual amenity guidelines.
	Large numbers of midges and aquatic worms are undesirable.
Chemical Contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation.
	Toxic substances should not exceed values in tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines.
Visual Clarity and Colour	Use visual amenity guidelines.
Surface Films	Use visual amenity guidelines.

3.2.4 Primary contact recreation

This objective applies in the immediate future to waters within and immediately upstream of recognised recreation sites. For many other waters, this is a long-term objective. Secondary contact recreation levels should apply in areas where primary contact recreation, such as swimming, is unlikely to be achieved in the immediate future, owing to pollution.

Indicators used to assess and monitor water for primary contact recreation in the Parramatta River Catchment are summarised in Table 8.

Table 8. Sydney Harbour catchment secondary contact recreation indicators

Indicator	Criteria
Turbidity	A 200 mm diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 m (approximately 6 NTU).
Faecal coliforms	Beachwatch considers waters are unsuitable for swimming if: The median faecal coliform density exceeds 150 colony forming units per 100 millilitres (cfu/100mL) for five samples taken at regular intervals not exceeding one month, or
	Beachwatch considers waters are unsuitable for swimming if: The second highest sample contains equal to or greater than 600 cfu/100mL (faecal coliforms) for five samples taken at regular intervals not exceeding one month.
	ANZECC 2000 Guidelines recommend: Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).
Enterococci	Beachwatch considers waters are unsuitable for swimming if: the median enterococci density exceeds 35 cfu/100mL for five samples taken at regular intervals not exceeding one month, or; the second highest sample contains equal to or greater than 100 cfu/100mL (enterococci) for five samples taken at regular intervals not exceeding one month.

Indicator	Criteria
	ANZECC 2000 Guidelines recommend: Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60-100 organisms/100 mL).
Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water. (Note, it is not necessary to analyse water for these pathogens unless temperature is greater than 24 degrees Celsius).
Algae & blue-green algae	< 15 000 cells/mL
Nuisance organisms	Use visual amenity guidelines.
	Large numbers of midges and aquatic worms are undesirable.
pH	5.0-9.0
Temperature	15°-35°C for prolonged exposure.
Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation.
	Toxic substances should not exceed the concentrations provided in tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines 2000.
Visual Clarity and Colour	Use visual amenity guidelines.
Surface Films	Use visual amenity guidelines.

3.2.5 Aquatic Foods

Refers to protecting water quality so that it is suitable to produce aquatic foods for human consumption and aquaculture activities. The ANZECC 2000 Guidelines lists this environmental value as Aquaculture and human consumption of aquatic foods (Table 9).

Table 9. Sydney Harbour catchment aquatic foods indicators

Indicator	Criteria
Algae & blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulate in other aquatic organisms
Faecal coliforms	Guideline in water for shellfish: The median faecal coliform concentration should not exceed 14 MPN/100mL; with no more than 10 % of the samples exceeding 43 MPN/100 mL
	Standard in edible tissue: Fish destined for human consumption should not exceed a limit of 2.3 MPN E Coli /g of flesh with a standard plate count of 100,000 organisms /g
Toxicants (as applied to aquaculture activities)	Metals: Copper: less than 5 µgm/L
	Metals: Mercury: less than 1 µgm/L
	Metals: Zinc: less than 5 µgm/L
	Organochlorines: Chlordane: less than 0.004 µgm/L (saltwater production)
	Organochlorines: PCBs: less than 2 µgm/L
Physio-chemical indicators (as applied to aquaculture activities)	Suspended solids: less than 40 micrograms per litre (freshwater)
	Temperature: less than 2 degrees Celsius change over one hour

3.3 River Flow Objectives

The NSW River Flow objectives are the agreed high-level goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses. The river flow objectives for the Sections of the Parramatta River / Sydney Harbour relevant to this project are provided in Table 10.

In all three WTPs, the treated effluent will be discharged to the local bays in Sydney Harbour catchment. The river flow objectives relevant to Sydney Harbour are summarised in Table 10 to provide a clear framework for assessing potential flow impacts resulting from discharges from construction water treatment plant.

A discussion of potential water flow impacts as a result of discharge from the WTPs is provided in Section 6.3.

Table 10. Sydney Harbour catchment river flow objectives

Objective	Measures to Achieve Objective
Maintain wetland and floodplain inundation	• Management plans and actions for waterways need to include strategies to maintain, restore or mimic natural patterns of inundation, water movement and drying in natural and semi-natural wetlands, and remaining native floodplain ecosystems. • Ensure adequate access for native fish to and from floodplain wetlands. • Flooding patterns should not be altered without proper environmental assessment.
Minimise effects of weirs and other structures	• Implement the NSW Weirs Policy (DLWC 1997b). • Identify, and take action to minimise, the impact on native fauna of other structures that impede movement of water-e.g., floodgates, tidal barriers, culverts.
Maintain or rehabilitate estuarine processes and habitats	• Dredging beyond minimal maintenance dredging for navigation requires environmental assessment. • Draining or disturbance of areas of potential acid sulfate soils must be minimised. • Water-based activities should be controlled to minimise impact on fish habitat. • Other processes affecting or potentially affecting estuary health need to be addressed-e.g., the impact of increasing urbanisation.

4 BASELINE ENVIRONMENTAL CONDITIONS

4.1 Catchment Context

The ETP Works between the Bays and Sydney CBD area pass underneath urban areas, which comprises a variety of land uses including commercial, residential, recreational and mixed uses.

The ETP Works corridor is located within the Sydney Metropolitan catchment (Port Jackson) which includes Sydney Harbour. The catchment is highly urbanised and altered from its natural state. Port Jackson is 11 Km long and the largest part of Sydney Harbour in terms of estuary area (29.1 Km^2) and volume (376,400 ML).

The waterways and associated catchments affected by the ETP Works include:

- **White Bay:** water treatment plant discharge and drainage lines from the Bays Station construction support site drain towards White Bay (Port Jackson)
- **Darling Harbour:** water treatment plant discharge and drainage lines from Pyrmont Station construction support site drain towards Darling Harbour (Port Jackson)
- **Sydney Harbour**: water treatment plant discharge and drainage lines from Hunter Street Station construction support site drain into Sydney Harbour near Man O'War Steps.

4.2 Geology

4.2.1 Soil and topography

The Soil Landscapes of Sydney 1:100,000 Sheet (Chapman G.A., 2009) and Penrith 1:100,000 Sheet (Bannerman S.M., 2011) identifies this footprint within the Gymea and Disturbed Terrain soil landscape. The description of topography is summarised Table 11.

Table 11. Summary of local topography

Soil Landscape	Topography
Gymea	Undulating to rolling low hills with local relief 20 – 80 metres and slopes of 10 – 25 per cent. Side slopes with narrow to wide outcropping sandstone rock benches (10 – 100 metres), often forming broken scarps of < 5 metres.
Disturbed Terrain	Terrain disturbed by human activity. Local relief is usually < 2 metres, but occasionally up to 10 metres. Most areas of disturbed ground have been levelled to slopes of < 3 per cent. In terraced cut and fill areas short rises may be steeper than 30 per cent. Microtopography may be hummocky due to truck dumping of fill material. Disturbed areas are often landscaped and artificially drained. Landform elements include berms, cut faces, embankments, mounds, pits, and trenches.

The elevation varies across the study area. Based on the use of Google Earth, the gradient of land is characterised by generally gentle undulating to flat topography, between about five to 20 metres Australian Height Datum (AHD).

The Bays Station is located at the downstream end of a sub-catchment within the Inner West Council Local Government Area, comprising of mostly urban residential lots with limited infiltration. The station will be situated on a low-lying former dockland site. There is a section of lower land immediately to the west (the former White Bay Power Station site) which forms part of a major overland flow path that drains an area stretching north-west towards Rozelle. The site is generally flat land with little to no slope around White Bay. The existing pre-development site has an elevation typically around 3 - 4 metres AHD with some low-lying sections along White Bay and a small section of higher land associated with the Victoria Road embankment to the south-east of the site.

Pyrmont Station is situated in an urban area occupied by commercial properties within the City of Sydney Local Government Area. The area generally slopes east to west eventually draining to Pyrmont Bay and is characterised by undulating to rolling low hills with local relief (20-80 metres) and slopes of 10-25 per cent. Side slopes with narrow to wide outcropping sandstone rock benches (10-100 metres) are present and often form broken scarps of less than five metres. From inspection of LiDAR survey existing pre-development elevations on Pyrmont Bridge Road and Edward Street appear to be approximately 14-15 metres AHD whereas Union Street is approximately 10 metres AHD.

Hunter Street Station (Sydney CBD) is situated in an urban area, heavily disturbed by human activity and falls towards Pitt Street from south to north. The disturbed areas are often landscaped and artificially drained. The landform elements present in the area include berms, cut faces, embankments, mounds, pits and trenches. Local relief is generally usually less than two metres, but up to 10 metres at some locations. The urban areas surrounding Hunter Street Station (Sydney CBD) have slopes of less than three per cent. In terraced cut and fill areas short rises may be steeper than 30 per cent and the microtopography may be hummocky due to truck dumping of fill material.

The general topography and depth of the tunnel alignment is provided in Figure 2 and Figure 3.

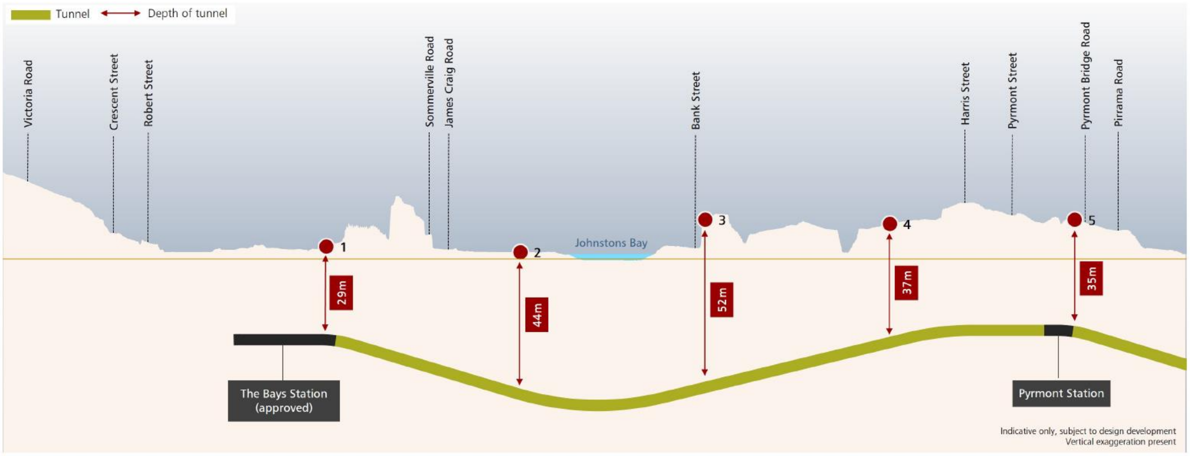

Figure 2. Indicative tunnel alignment plan and topography from The Bays to Pyrmont Station

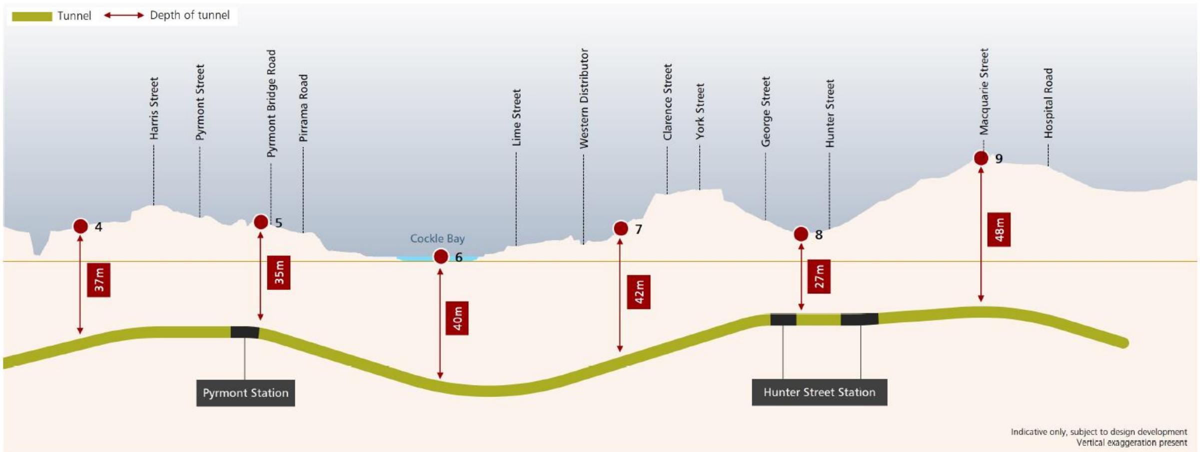

Figure 3. Indicative tunnel alignment plan and topography from Pyrmont to Hunter Street Station

Further discussions can be found in EIS Chapters and supporting technical working papers.

4.2.2 Geology

The geology of the area of the ETP Works is discussed in detail in the EIS and supporting technical working papers (Chapter 15 and Hydrogeology Report).

The Sydney 1:100,000 Geological Series Sheet 9130 (Herbert C., 1983) indicates that the geology of the alignment is dominated by Hawkesbury Sandstone bedrock. Hawkesbury Sandstone is medium to coarse grained quartz sandstone with very minor shale and laminate lenses.

Surficial soils comprising of existing fill and residual materials can also be expected to be found on top of the sandstone bedrock with variable thicknesses. Existing fill material of notable thickness can be found at The Bays tunnel launch and support site. Deep alluvial and marine soil deposits are encountered on the western side of The Bays tunnel launch and support, within Sydney Harbour.

There is the likelihood that the eastern end of The Bays tunnel launch and support site will encounter the Great Sydney Dyke. The Great Sydney Dyke has been identified as being an igneous intrusion comprising typically dolerite material with varying weathering and strength properties.

Also, possible fault zones and a dyke may be encountered about 150 metres to the west of Pyrmont Station, however there is limited geotechnical information along the tunnel alignment through here. Additional geotechnical investigations have been proposed to investigate this area.

Several fault zones have been inferred and identified within the Sydney CBD, at the Hunter Street Station (Sydney CBD) and along the turnback tunnels to the east of this station.

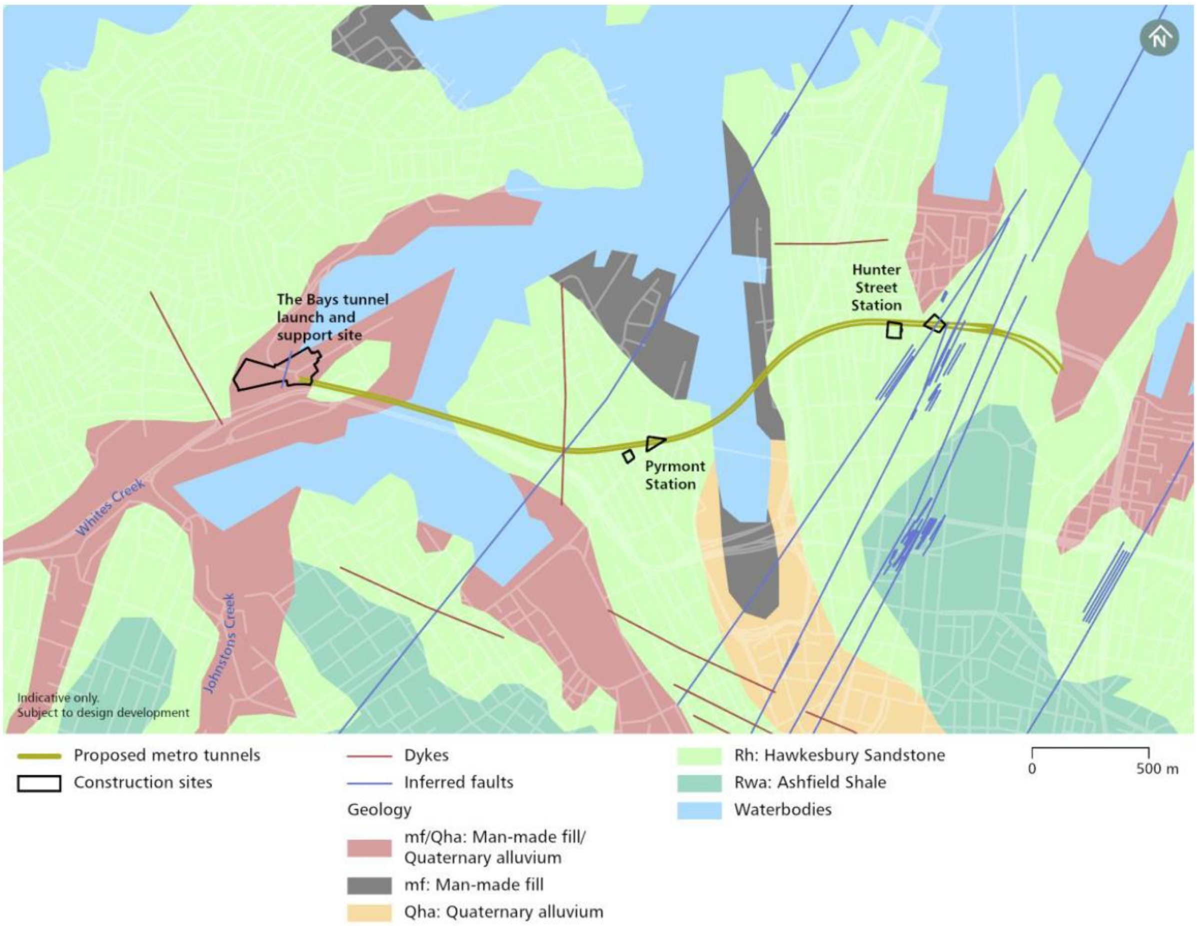

Figure 4. Local geological units

4.2.3 Acid sulfate soils

Review of the Department of Planning and Environment acid sulfate soil risk data indicates the following:

- The Bays tunnel and launch support site – entire site area is classified as disturbed terrain. Naturally occurring acid sulfate soil is likely
- Pyrmont Station – land east of the eastern construction site is classified as disturbed terrain and land to the west has not been assessed. Acid sulfate soils are likely to occur below natural ground surface in the north-east portion of the Pyrmont Station eastern construction site
- Hunter Street Station (Sydney CBD) – acid sulfate soils are not likely to occur within the site area.

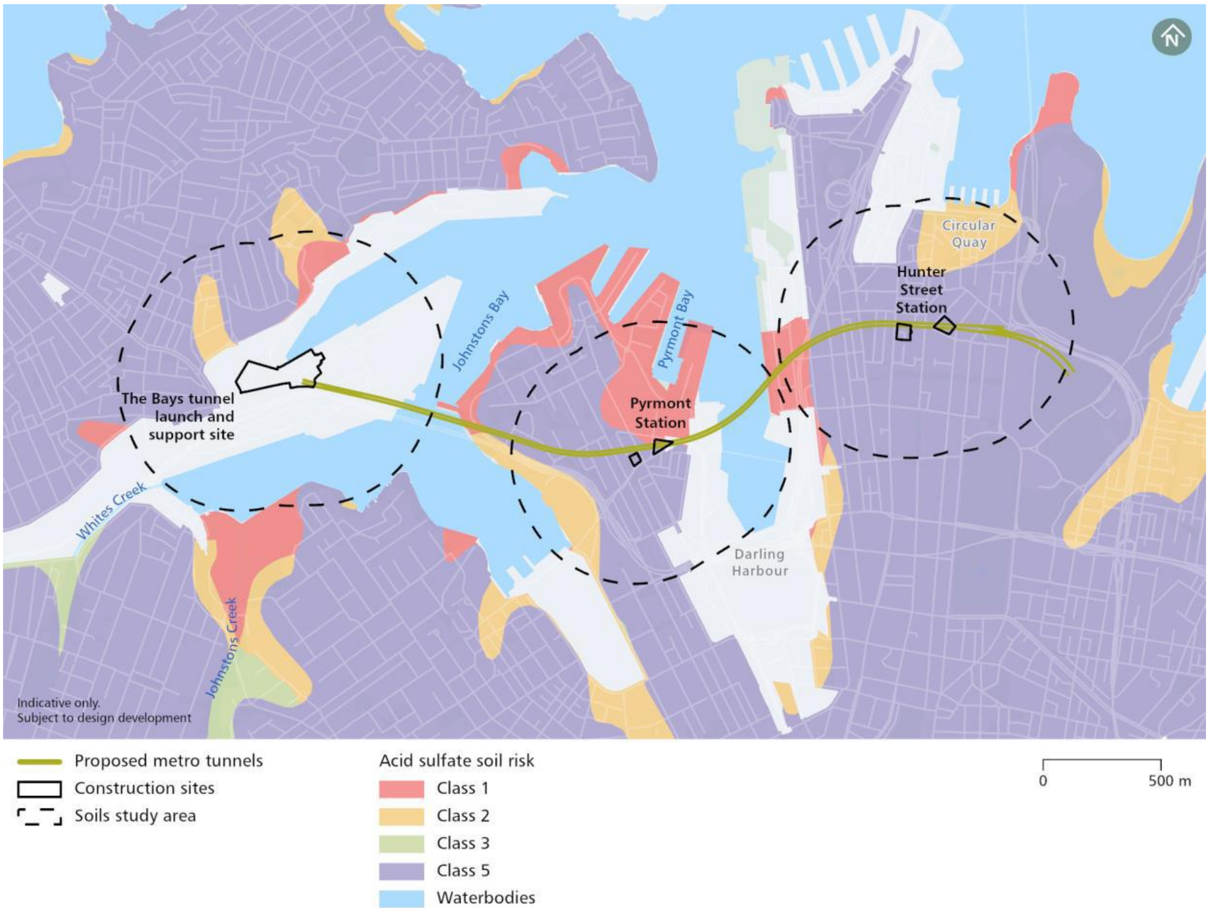

Figure 5. Acid sulfate soils risk map

4.3 Hydrogeology

4.3.1 Hydrogeologic units

A desktop review of public resources (Herbert C., 1983) and relevant reports (EIS chapters and technical reports) show three major hydrogeologic units in the immediate vicinity of the project as shown in Figure 4 and include:

- Anthropogenic (man-made) fill
- Quaternary unconsolidated sediments
- Hawkesbury Sandstone.

Ashfield shales and Quaternary marine sands are located to the south and east of the alignment. Jurassic age dolerite dykes are also known to intrude the Hawkesbury Sandstone, with the Great Sydney Dyke (not shown) crossing the alignment just east of The Bays tunnel launch and support site.

Groundwater is present within the following hydrogeological units as summarized in Table 12**.**

Table 12. Summary hydrogeological units

Hydrogeological units	Description
Quaternary alluvium	Alluvial deposits tend to occur along creeks and floodplains in the Project area. The alluvial deposits are usually observed to be coarse clean sands and gravels. These materials can form shallow localised unconfined aquifers that are typically responsive to rainfall, streamflow, and tides. The alluvium records hydraulic conductivity ranges from 0.1 metres per day to 1 metre per day in literature

Hydrogeological units	Description
Jurassic intrusions	The Jurassic age sedimentary sequences of the Sydney basin are intruded by Triassic age dolerite dykes. These dykes can act as barriers to lateral groundwater movement or conduits that enhanced pathways for groundwater. Most groundwater is encountered along the margin of the dykes and although permeability may be enhanced inflows are generally in the order of 1 to 2 litres per second when intersected in tunnels. (Dale, 1997)
Triassic Ashfield Shale	This Triassic Ashfield Shale has a thickness ranging from 45 – 60 metres. Unlike the previous layers, this layer is considered to be an aquitard due to its poor ability to transmit water through its fine-grained sequence and tight bedding planes. Groundwater flow within this layer usually occur through fractures and joints although the bulk hydraulic conductivity is typically low, in the order of 1 x 10^{-5} m/day to 1 x 10^{-2} m/day (AECOM, 2017).
Triassic Hawkesbury Sandstone	This unit is part of an aquifer system that runs across the whole Sydney Basin which covers an area of approximately 20,000 km² (Lee RJ, 2009). Groundwater flow in this layer is dominated by secondary porosity and fracture flow along joints and shear zones (Herron NF, 2018). This unit is considered a semi-confined aquifer. The hydraulic conductivity from site specific testing ranges from 1 x 10^{-6} to 1 x 10^{-3} m/day in the project and is typically in the order of 1 x 10^{-3} m/day to 1 x 10^{-1} m/day (AECOM, 2017).

4.4 Catchment and waterbodies

4.4.1 Catchment conditions and key features

The ETP Works are located entirely within the Port Jackson (Sydney Harbour) catchment of the Parramatta River Estuary. Discharges from all construction sites will drain to Sydney Harbour and various bays that belong to Sydney Harbour via a network of underground stormwater channels, pipes, and drainage systems.

The Sydney Harbour catchment is highly urbanised and altered from its natural state. The catchment includes a mixture of low, medium, and high density residential, commercial and industrial land uses, with some parklands and open spaces. The ETP Works mostly intersects commercial and industrial land uses, including the areas around Sydney CBD, Pyrmont and Rozelle. These land uses influence the water quality, quantity, and speed of flows within the catchment.

The waterbodies, waterways and catchments for each construction site are shown in Figure 6 and summarized in Table 13. There are no identified natural or modified freshwater drainage channels in proximity to the stations, and all stormwater drainage is conveyed through the built network of stormwater pipes and culverts.

Table 13. Relevant waterbodies and catchment

Waterbody	Description of the surface water features	Condition	Sensitive receiving environment rating	Location
Sydney Harbour	• Numerous SEPP Coastal Management • Potential habitat for threatened aquatic species and protected aquatic vegetation • Type 1 Key Fish Habitat • Fourth order waterway • Permanently flowing	Moderately disturbed	High	• Receiving waters 5 km north of tunnel alignment and Hunter Street Station at nearest point
White Bay	• Concrete-lined, enclosed embayment • SEPP Coastal Management within 0.5 Km	Highly disturbed	Low	• Adjacent north of The Bays tunnel launch and support site • About one kilometre north of the tunnel at the western end
Darling Harbour	• SEPP Coastal Management within 0.5 Km • Key Fish Habitat	Moderately disturbed	Moderate	• About 250 metres east of Pyrmont Station construction sites

Waterbody	Description of the surface water features	Condition	Sensitive receiving environment rating	Location
				• Above tunnel alignment between Pyrmont and Sydney CBD
Blackwattle Bay	• Key Fish Habitat • Partially concrete-lined, enclosed embayment	Highly disturbed	Low	• About 500 metres west of Pyrmont Station construction sties • Above alignment of tunnel between The Bays and Pyrmont
Johnstons Bay	• Key Fish Habitat • Partially concrete-lined, enclosed embayment	Highly disturbed	Low	• About 250 m south of The Bays tunnel launch and support site • Above alignment of tunnel between The Bays and Pyrmont

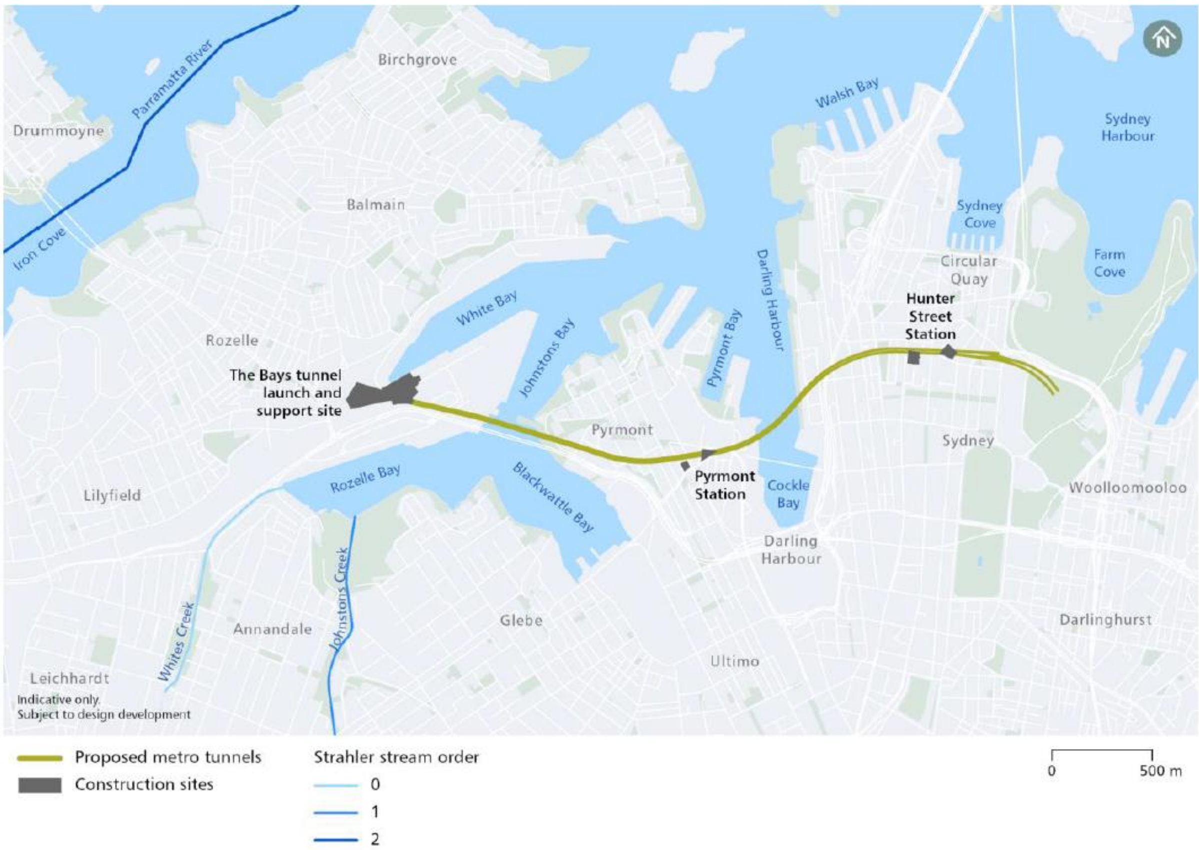

Figure 6. Receiving waterbodies and waterways for the ETP Works

4.4.2 Estuary morphology and processes

The Parramatta River (Sydney Harbour) estuary is a drowned river valley, characterized by steep sided banks carved into Sydney sandstone between 25 and 29 million ago. The Port Jackson (Sydney Harbour) catchment included a number of embayments that receive freshwater flows from local streams and stormwater drainage networks.

Local bathymetric mapping for the sub-catchments of Sydney Harbour that bisect the project are presented in Figure 7. Detailed sounding data is available for shallow water areas through Sydney Port Authority. Average water column depths within bays connecting to the main harbour (including Darling Harbour and White Bay) are typically shallower and more uniform than in the main body of Sydney Harbour, which exceeds depths of over 40m in central portions of the estuary.

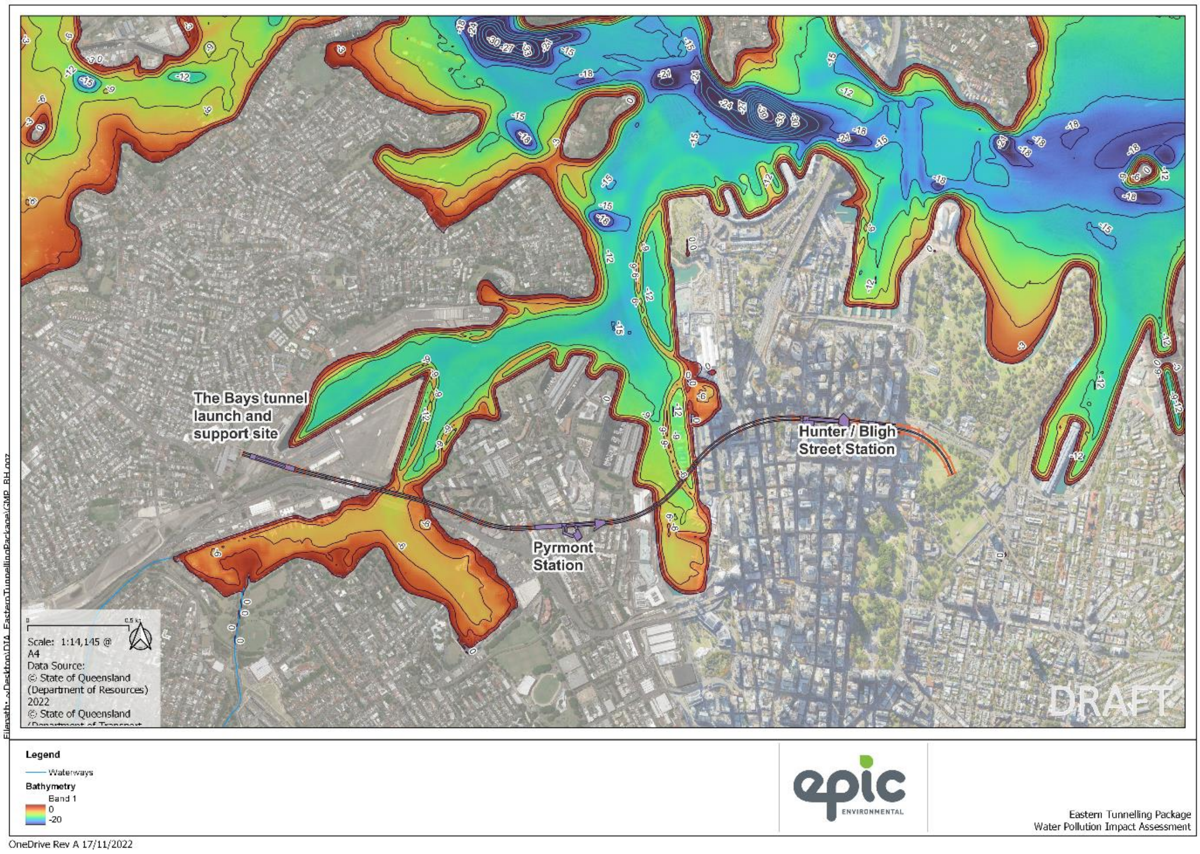

Figure 7. Local bathymetry - Sydney Harbour (Wilson & Hannah, 2018)

Evaporation, precipitation and freshwater inflow control salinity within the estuary. The estuary is generally well mixed and oceanic (30–35 parts per trillion) during dry or 'base-flow' conditions (<5mm precipitation per day). During periods of high precipitation, freshwater inflow is rapid due to large amounts of impervious surfaces in the surrounding catchment (Beck and Birch 2012 a,b). During these events a buoyant fresh layer forms on the surface of the waterbody that can be up to two metres thick (Hedge et al., 2014a).

Tidal patterns generally determine circulation in the Sydney estuary. The tide is diurnal and reverses every six hours (Das et. al., 2000). Spring tides in the harbour can have a tidal range of up to 1.6 m, and tidal forcing is strongest towards the Sydney Harbour heads (Middleton et. al., 1996). Tidal planes data adapted from the 2015 Australian National Tide Table (ANTT, 2014) are presented in Table 14.

Table 14. Tidal Planes for Sydney (Source: ANTT, 2014)

Tidal Plane	m LAT	m AHD
Highest Astronomical Tide (HAT)	2.1	1.1
Mean High Water Springs (MHWS)	1.6	0.6
Mean High Water Neaps (MHWN)	1.4	0.4
Mean Sea Level (MSL)	1.0	0.0
Mean Low Water Neaps (MLWN)	0.6	-0.4
Mean Low Water Springs (MLWS)	0.4	-0.6
Lowest Astronomical Tide (LAT)	0.0	-1.0

Tidal velocities vary considerably in magnitude both spatially and over a tidal period. Typically, towards the mouth of the harbour, depth averaged tidal velocities range from 0.1 to 0.25 m/s over the spring neap cycle (in 15 m of water) (Hedge et al., 2014a). Ebb flow from the harbour during spring tides can be up to 0.5 m/s (Hedge, et al., 2014b).

Water age in the upper Parramatta is approximately 130 days. Water within most of the bays of Sydney Harbour is nearly completely exchanged with water from the main body of the bay over a 24-hour period. Water age in the main body of the harbour varies between 18-42 days depending on wind directions. An easterly, 'up estuary' wind increases water mixing and consequently reduces water age in the main section of the estuary (Hedge et al., 2014a). Das et al. (2000) estimated discharge volumes to be up to 6000 m^3/s across the heads, at the peak of the ebb tide.

A conceptual schematic showing the typical hydrology processes associated with a drowned river valley type estuary is presented in Figure 8.

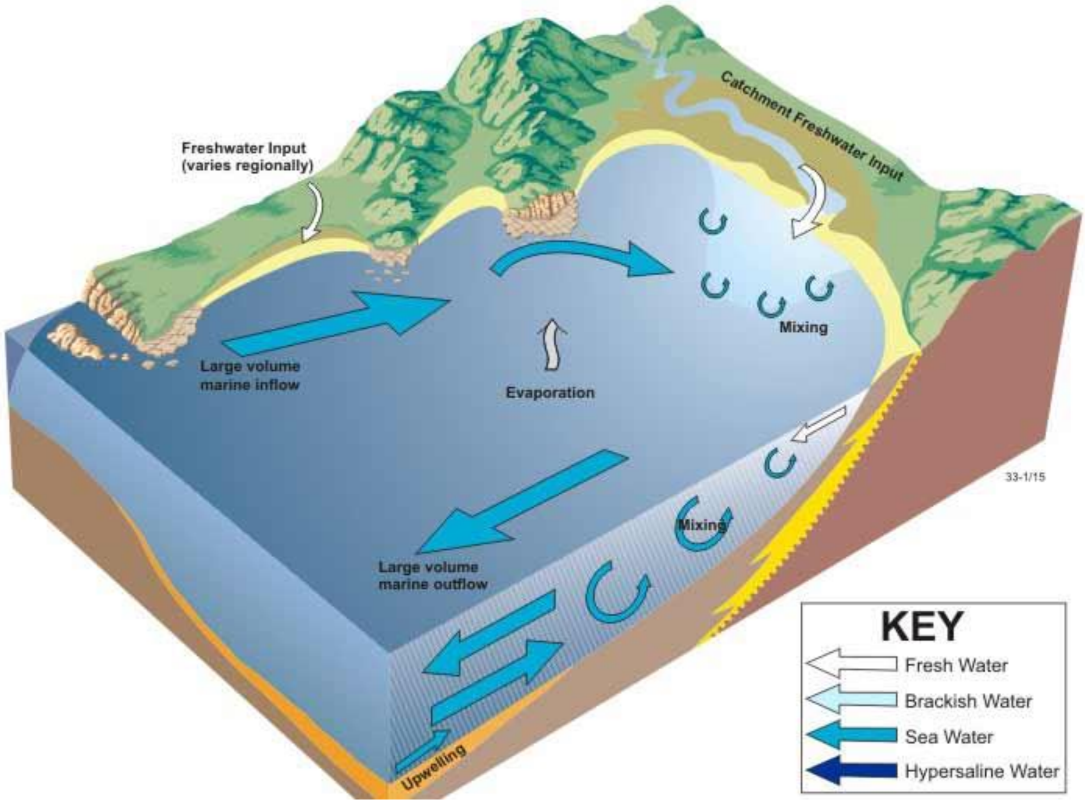

Figure 8. Hydrology processes in embayments and drowned river valleys (OzCoasts)

4.5 Sydney Harbour surface water quality

4.5.1 Overview

The quality of the waters within the Sydney Harbour estuary reflects the balance between the upstream catchment loads of varying quality (depending on the land use and practices within the catchment), the downstream ocean inputs and the tidal flushing that mixes the different water masses. Tidal flushing intensity diminishes from the ocean entrance at the Heads to the upstream reaches, with flushing rates typically increasing from 1 day up to 130 days near the headwaters of the estuary.

During rainfall events, stormwater discharges, and river flows carry dissolved contaminants, and suspended particles into the estuary causing impaired water quality. The effect of freshwater flows on water quality is dependent upon the properties of the inflowing and receiving waters and the magnitude of the flows. Freshwater flows affect a range of water quality properties of the receiving coastal waters, including temperature, salinity, turbidity, total and dissolved nutrients, suspended solids, organic matter content, dissolved oxygen, and presence of chemical pollutants (Gillanders et al. 2011, Lewis et al. 2009).

In urban environments such as the Sydney Metropolitan Region, contaminants from diffuse and point source origins (e.g., urban runoff, industrial discharges, and sewer overflows) contribute towards increased contaminant concentrations and loads through waterways. Contaminant concentration, flow rate, and duration of flow all affect the total load entering waterways from point source and diffuse sources of contamination.

First-flush events have the highest concentrations of sediment and nutrients (Butler & Burrows 2006, Furnas et al. 1997) and are associated with transport of pollutants including heavy metals, pesticides and herbicides, which can occur at their highest concentrations at the plume front (Lewis et al. 2009).

Conversely, reduced freshwater inflows and reduced tidal flushing rates can also affect water quality through increased salinity, up-channel migration of the saline interface, nutrient depletion, reduced dilution of pollutants, accumulation of sediment, and reduced dissolved oxygen levels.

The existing impacts and key threats to water quality in Sydney Harbour are discussed in detail in the Sydney Harbour Water Quality Improvement Plan (LLS, 2015), and include:

- stormwater runoff (including nutrients and sediments)
- sewerage overflows (including nutrients and pathogens)
- vessel waste discharge (including hydrocarbons and volatile / semi-volatile organic compounds)
- domestic Industrial discharges (including inorganics, nutrients, pesticides, herbicides)
- commercial and industrial discharges (including a range of toxicants and nutrients)
- litter (windblown or water based)
- urban / foreshore development.

Further detail on the relationship between water quantity and water quality is discussed further in Water Quality Australia publication "*Characterising the Relationship Between Water Quality and Water Quantity*" (Sinclair Knight Merz 2013).

4.5.2 Local conditions and Default Guideline Values

Water quality monitoring has been undertaken by JCG to provide greater resolution on local water quality conditions within the waterbodies around the proposed discharge points for the project construction water treatment plants. One (1x) round of monitoring was completed in November 2022 to provide an initial assessment of water quality under dry conditions. The results from monitoring are summarised in Table 15.

The results from the recent monitoring event show that water quality is generally good, with the ambient concentrations of most toxicants and stressors at levels below the ANZECC / ANZG DGVs, except for oxidised nitrogen, copper and zinc, which show variable exceedance of the ANZECC / ANZG DGVs. Marine DGVs have been adopted for toxicants and estuarine DGVs have been adopted for physical and chemical stressors in accordance with ANZECC classifications (Page 4.4-9, and Figure 3.1.3). Both toxicant and stressor value DGVs are provided for ammonia and nitrate as these contaminants can be toxic to aquatic and marine organisms at high concentrations.

Table 15. Surface water quality at receiving waterways

Parameter	Unit	DGV	Sydney Harbour	Darling Harbour	Johnstons Bay (White Bay)
Electrical Conductivity @ 25°C	µS/cm	-	50,000	48,000	49,000
pH (Lab)	pH unit	7.0-8.5	7.9	7.9	7.8
Dissolved Oxygen	mg/L	6.6-9.1	-	-	-
Nitrogen (Total) [b]	µg/L	300	100	100	200
Nitrate (as N)	µg/L	2,400 / 45,000	10	20	<5
Total Oxidised Nitrogen	µg/L	15	15	25	20
Ammonia (as N)	µg/L	15 / 910	7	8	45
Total Phosphorus (as P)	µg/L	30	<5	<5	<50
Arsenic	µg/L	2.3	2	1	1

Parameter	Unit	DGV	Sydney Harbour	Darling Harbour	Johnstons Bay (White Bay)
Cadmium **(B)**	µg/L	0.7	<0.1	<0.1	0.1
Chromium	µg/L	20	1	1	<1
Cobalt	µg/L	1	<1	<1	<1
Copper	µg/L	1.3	<1	2	3
Iron	µg/L	700	<10	10	<10
Lead	µg/L	4.4	<1	<1	<1
Manganese	µg/L	1900	<5	6	7
Mercury **(B)**	µg/L	0.1	<0.05	<0.05	<0.05
Nickel	µg/L	70	<1	<1	<1
Zinc	µg/L	8	5	9	140
TRH+C10 - C40 (Sum of total)	µg/L	100	<50	<50	<50

N.D. – No data available

Red – Value exceeds CoA Default Guideline Value (DGV)

(B) – Chemicals that are bioaccumulation consider the 95 % level of protection

a – Criteria adopted from the Australian interim marine guideline

b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

The results show that water quality is generally good in the Port Jackson sub-catchment of Sydney Harbour, with occasional exceedances of the ANZG (2018) / ANZECC (2000) DGVs for dissolved zinc.

4.6 Groundwater

4.6.1 Project monitoring bores

A total of thirty-seven (37) groundwater monitoring wells make up the project groundwater monitoring network for the ETP project. The locations of the ETP monitoring wells are shown in Figure 9. The ETP groundwater monitoring network includes monitoring locations along and adjacent to the alignment of the mainline tunnels and around station excavations at Pyrmont and Hunter Street.

A number of additional groundwater monitoring wells around The Bays station have been included in the assessment to provide information on local groundwater conditions around The Bays Station excavation, which will be handed over to JCG from the Central Tunnelling Package (CTP). Information for groundwater quality around The Bays Station has been derived from the groundwater monitoring program for CTP (AFJV, 2021).

Field investigations have been undertaken on the available monitoring wells and VWPs to determine groundwater levels and provide information on groundwater quality across the project area.

Groundwater samples were collected from thirty-two (32) of the 37 monitoring wells as part of a contamination assessment for the ETP Works (Golder – Douglas Partners 2022) and submitted to a NATA accredited testing laboratory for chemical analysis.

The results from groundwater level monitoring and laboratory testing of groundwater quality samples have been incorporated into this report in conjunction with engineering and design information to inform the quantity and quality of groundwater inflows to tunnels, excavations and subsequent feedwater to the construction WTP.

Figure 9. Location of project groundwater monitoring bores within the project alignment

4.6.2 Groundwater level

Groundwater is known to occur in the soil profile and within the fractured/porous rock along the alignment. The 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). (Golder & Douglas Partners, 2020) (Golder & Douglas Partners, 2021), (Golder & Douglas Partners, 2022).

Perched groundwater may be present at shallow depths across the ETP alignment with groundwater levels that are typically higher in elevation than groundwater levels in the underlying Hawkesbury Sandstone. Within the shallow sediments groundwater may be encountered at depths between one (1) and five (5) metres below ground level (mbgl).

Groundwater in the Hawkesbury Sandstone is variable in response to both topography and other natural and anthropogenic forcing. Groundwater levels in the Hawkesbury Sandstone can locally range between one (1) and twenty (20) mbgl. Available data is limited at many locations, and the approximate typical levels listed may not represent groundwater levels in the immediate vicinity of the construction sites. Based on groundwater level monitoring results from Golder & Douglas Partners, the groundwater levels around the construction sites are summarised in Table 16.

Table 16. Approximate groundwater levels near construction sites

Construction site	Approximate typical groundwater level in the vicinity of the construction site (mAHD)	Approximate typical depth to groundwater in the vicinity of the construction site in metres below ground level (mbgl)
The Bays (Cross over cavern)	0.8	4.5
Pyrmont Station	-2.4 (Likely impacted by nearby construction activities)	17.4 (Likely impacted by nearby construction activities)
Hunter Street Station	2.97 (range likely represents highly disturbed groundwater system)	12 (range likely represents highly disturbed groundwater system)

Drawdown associated with excavations are likely to lower groundwater levels in the Hawkesbury sandstone resulting in radial drawdown of up to 30 mbgl. Groundwater drawdown around excavations and during tunnelling is expected to result in migration of groundwater towards tunnels and excavations along both vertical and horizontal vectors.

4.6.3 Registered groundwater bores

A review of registered boreholes with DPI-Water identified the locations of groundwater bores within the ETP Works area, as shown in Figure 10. Exact values of the water extraction were not recorded within the source. Rates of 10 metres cubed per day for stock and domestic usages, and 50 metres cubed per day for irrigation and industrial usages may be assumed.

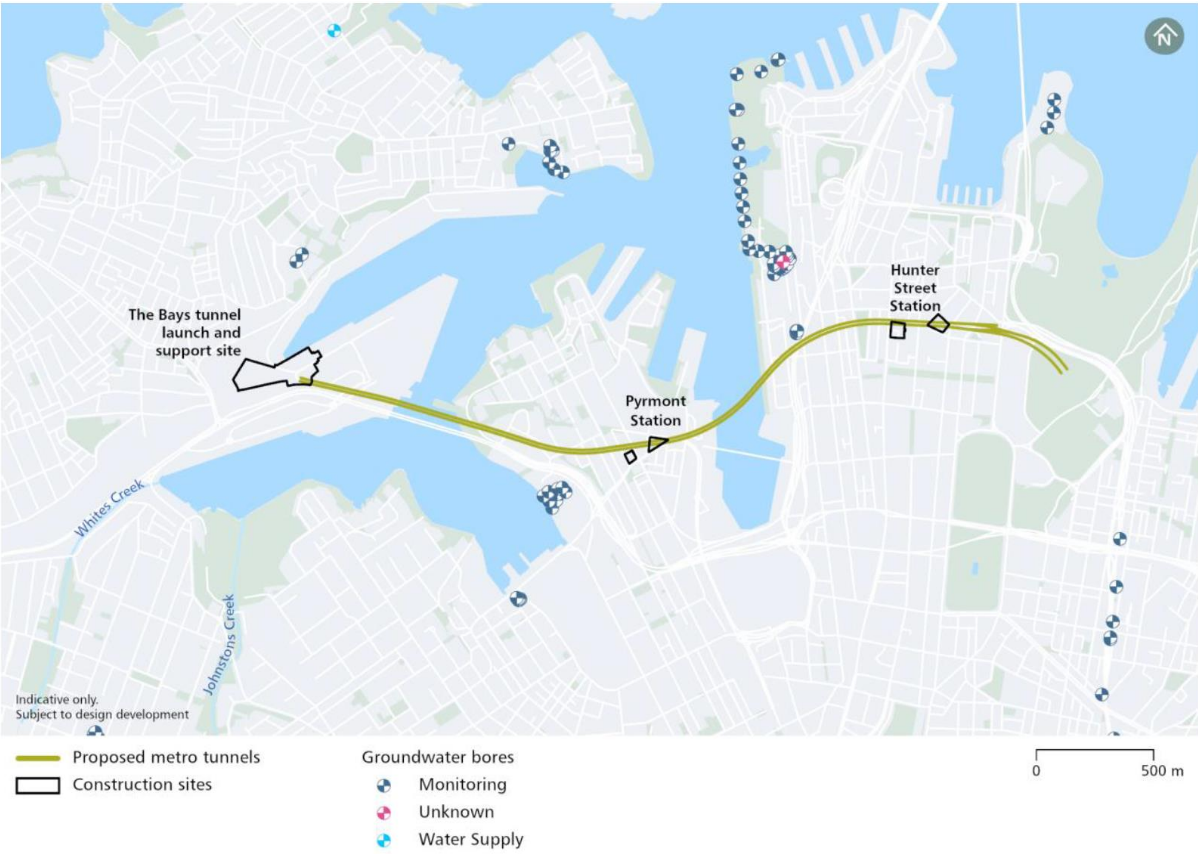

Figure 10. Location of registered groundwater bores within the project alignment

4.6.4 Surface water-groundwater interaction

Interactions between surface water and groundwater in the vicinity of the ETP alignment is expected to be minimal due to:

- The area being highly urbanised with predominantly impervious surfaces across the catchments, which reduces possible surface water infiltration into soils and underlying groundwater
- A lack of surface water courses within close proximity to the alignment. Surface water courses are generally located south of the alignment outside the area of groundwater drawdown impact
- Water courses in the vicinity are generally lined (they have a concrete base) and therefore are assumed have limited interaction with groundwater
- The dominant groundwater discharge mechanism is drainage towards the harbour
- The running tunnels and cross passage will be watertight and are required to meet strict inflow criteria limiting groundwater inflow
- The station caverns and adits and will be drained during the construction stages, but the station caverns will subsequently be permanently waterproofed and lined.
- The shafts will be drained at handover and the permanent lining installed by follow on contractors.

Therefore, drawdown of the groundwater table due to the construction sites is not anticipated to have a noticeable impact on surface water resources (flow) or access (levels).

4.6.5 Groundwater dependent ecosystems

The Bureau of Meteorology Groundwater Dependent Ecosystems Atlas (http://www.bom.gov.au/water/groundwater/gde/) identifies the potential groundwater dependent ecosystems (aquatic, terrestrial and subterranean ecosystems) located in New South Wales.

No potential groundwater dependent ecosystems were identified in proximity to the ETP alignment.

4.6.6 Groundwater quality

Groundwater monitoring data made available from recent groundwater monitoring ((Golder & Douglas Partners, 2022).Laboratory testing results from groundwater monitoring have been screened against default water quality guidelines for surface waters as groundwater inflows to tunnels and excavations will be discharged to local waterbodies following treatment.

- ANZG (2018) 95% species protection criteria for marine water, with criteria for toxicants known to bioaccumulate assessed based on the 99% species protection criteria.
- ANZECC/ARMCANZ 2000 relevant physical and chemical stressors.
- PFAS NEMP 2.0 (2020) Freshwater 95% Level of Protection (in the absence of marine criteria) for perfluorooctane sulfonate (PFOS) criteria of 0.13 µg/L, and perfluorooctanoic acid (PFOA) criteria of 220 µg/L.
- Canadian Environmental Quality Guidelines of iron for the protection of aquatic life (long term).

The laboratory testing results for groundwater monitoring wells located within and around each construction area are discussed in the following sections. The screening assessments have been used to inform potential water quality issues and associated treatment requirements.

4.6.6.1 The Bays

Groundwater from the mainline tunnels and tunnel-to-tunnel connections will be pumped to the WTP at The Bays Station for the necessary water quality improvements prior to discharge into White Bay (Sydney Harbour/Port Jackson).

The average and maximum of analyte concentrations reported in groundwater from baseline groundwater sampling (Golder & Douglas Partners, 2022), (Golder & Douglas Partners, 2021) are summarised in Table 17, noting that data is available from thirteen (13) samples out of thirteen (13) wells located to the east of the alignment.

Exceedances include the following pollutants / physical parameters:

- pH (lab)
- Nitrogen (Total), oxidised nitrogen, and ammonia
- Total phosphate and reactive phosphate
- Dissolved metals: cadmium (max), cobalt, iron, manganese (max), nickel (max) and zinc
- Sum of total TRH

Table 17. Groundwater quality summary – The Bays

Analyte	Unit	DGV	Average	Median	Range
Electrical Conductivity @ 25°C	µS/cm	-	12,206	6,315	796 – 49,600
pH (Lab)	pH unit	7.0-8.5	7.0	7.2	5.72 – 8.06
Dissolved Oxygen	mg/L	6.6-9.1	8.5	8.5	6.8 – 10.5
Nitrogen (Total) [b]	µg/L	300	3,069	700.0	300 – 14,100
Nitrate (as N)	µg/L	2,400 – 45,000	27	20	10 – 60
Nitrate + Nitrite (as N)	µg/L	15	28	20	10 – 60
Ammonia (as N)	µg/L	15 / 910	2,445	480	<10 – 12,200
Total Phosphorus (as P)	µg/L	30	235	120	<10 – 890

Analyte	Unit	DGV	Average	Median	Range
Reactive Phosphorus (as P)	µg/L	5	40.0	10	<10 – 330
Arsenic	µg/L	2.3	14.2	<1	<1 – 55
Cadmium **(B)**	µg/L	0.7	0.24	<0.1	<0.1 – 1
Chromium	µg/L	20	1.3	<1	<1 – 5
Cobalt	µg/L	1	4	<1	<1 – 23
Copper	µg/L	1.3	7	<1	<1 – 78
Iron[a]	µg/L	700	17,809	1,980	<50 – 122,000
Lead	µg/L	4.4	<1	<1	<1
Manganese	µg/L	1,900	807	298	6 – 4,390
Mercury **(B)**	µg/L	0.1	<0.1	<0.1	<0.1
Nickel	µg/L	70	9.4	<1.0	<1 – 82
Zinc	µg/L	8	56.3	6.0	<5 – 326
TRH+C10 - C40 (Sum of total)	µg/L	100	148.5	100.0	50 – 1,030

Red – Exceeding the DGV level
(B) – Chemicals that are bioaccumulation consider the 99 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

An analysis of key statistical measures indicates that exceedances of DGV's can largely be attributed to discrete locations (localized areas) around The Bays Station and the relevant tunnel sections. Contaminant distribution is also highly variable contamination issues in different locations. Inflows into Station excavations is expected to cause radial drawdown from groundwater affecting both shallow sediments and deeper strata (up to the base of excavations). The results are also affected by spatial bias in groundwater sampling locations.

Accounting for radial drawdown, the average concentrations are expected to represent the likely groundwater influent water quality to water treatment plants. Despite this, there is potential for significant variations in groundwater quality (within the identified ranges) accounting for variable permeability and anisotropy of the sandstone aquifer.

4.6.6.2 Pyrmont Station

Groundwater inflow into the excavation zone on Pyrmont will be received into the WTP at Pyrmont Station prior to discharge into Darling Harbour via local stormwater systems.

The ranges of analytes concentrations reported in groundwater from baseline groundwater sampling (Golder & Douglas Partners, 2022) are summarised in Table 18, noting that data is available from eleven (11) monitoring wells and twelve (12) samples around Pyrmont Station.

Exceedances include the following pollutants / physical parameters:

- pH and dissolved oxygen (max)
- Nitrogen (Total), total oxidised nitrogen, and ammonia (max)
- Total phosphorus (max) and reactive phosphorus
- Dissolved metals: arsenic (max), cobalt, copper, iron, lead (max) manganese, nickel (max) and zinc.

Table 18. Groundwater quality summary – Pyrmont Station

Analyte	Unit	DGV	Average	Median	Range
Electrical Conductivity @ 25°C	µS/cm	-	4,329	847	431 – 35,400
pH (Lab)	pH unit	7.0-8.5	6	6.3	4.31 – 7.16
Dissolved Oxygen	mg/L	6.6-9.1	8.6	9.1	6.6 – 10.5
Nitrogen (Total) [b]	µg/L	300	555	200	100 – 2,100
Nitrate (as N)	µg/L	2,400 – 45,000	21.7	<10	<10 – 80
Nitrate + Nitrite (as N)	µg/L	15	22.5	<10	<10 – 80
Ammonia (as N)	µg/L	15 / 910	723	35	<10 – 7,060
Total Phosphorus (as P)	µg/L	30	37.5	20	<10 – 180
Reactive Phosphorus (as P)	µg/L	5	<10/<50	<10	<10/<50*
Arsenic	µg/L	2.3	1.9	<1	<1 – 10
Cadmium **(B)**	µg/L	0.7	0.1	<0.1	<0.1 – 0.2

Analyte	Unit	DGV	Average	Median	Range
Chromium	µg/L	20	2	<1	<1 – 10
Cobalt	µg/L	1	17.5	11	<1 – 74
Copper	µg/L	1.3	2.1	<1	<1 – 13
Iron[a]	µg/L	700	77,985	23,950	<50 – 682,000
Lead	µg/L	4.4	2.3	<1	<1 – 16
Manganese	µg/L	1,900	3,286	1,165	19 – 27,000
Mercury **(B)**	µg/L	0.1	<0.1	<0.1	<0.1
Nickel	µg/L	70	26	11.5	<1 – 123
Zinc	µg/L	8	36	9	<5 – 141
TRH+C10 - C40 (Sum of total)	µg/L	100	<50	<50	<50

Red – Exceeding the DGV level
(B) – Chemicals that are bioaccumulation consider the 99 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.
* – Two results had high Limits of Report resulting in data skew (<50 µg/L)

An analysis of key statistical measures indicates that exceedances of DGV's can largely be attributed to discrete locations (localized areas) along / adjacent to Pyrmont Station and the relevant tunnel sections. Inflows into Station excavations is expected to cause radial drawdown from groundwater affecting both shallow sediments and deeper strata (up to the base of excavations). The results are also affected by spatial bias in groundwater sampling locations.

Accounting for radial drawdown, the average concentrations are expected to represent the likely groundwater influent water quality to water treatment plants. Despite this, there is potential for significant variations in groundwater quality (within the identified ranges) accounting for variable permeability and anisotropy of the sandstone aquifer.

4.6.6.3 Hunter Street

Groundwater inflow into the excavation zone will be received into the WTP at Hunter Street Station East prior to discharge into Sydney Harbour (Man O'War) via local stormwater systems.

The ranges of analytes concentrations reported in groundwater from baseline groundwater sampling (Golder & Douglas Partners, 2022) are summarised in Table 19, noting that data is available from fifteen (15) monitoring wells and sixteen (16) samples around Hunter Street.

Exceedances of the potential construction discharge criteria (ANZECC 2000 / ANZG 2018 95% and 99% species protection) include the following pollutants / physical parameters:

- pH (lab) and dissolved oxygen
- Nitrogen (Total), nitrate (max), and total oxidised nitrogen
- Total phosphorus and reactive phosphorus
- Dissolved metals: arsenic (max), cobalt, copper, iron, mercury, and zinc.

Table 19. Groundwater quality summary – Hunter Street

Analyte	Unit	DGV	Average	Median	Range
Electrical Conductivity @ 25°C	µS/cm	-	710	543	206 – 2,120
pH (Lab)	pH unit	7.0-8.5	6.7	6.5	2.5 – 11.2
Dissolved Oxygen	mg/L	6.6-9.1	7.9	8.6	4.1 – 10.1
Nitrogen (Total) [b]	µg/L	300	1,750	800	100 – 6,400
Nitrate (as N)	µg/L	2,400 – 45,000	886	15	<10 – 4,980
Nitrate + Nitrite (as N)	µg/L	15	911	25	<10 – 4,980
Ammonia (as N)	µg/L	15 / 910	92	40	<10 – 310
Total Phosphorus (as P)	µg/L	30	579	50	<10 – 7,400
Reactive Phosphorus (as P)	µg/L	5	10	<10	≤10
Arsenic	µg/L	2.3	1.6	<1	<1 – 6
Cadmium **(B)**	µg/L	0.7	0.13	<0.1	<0.1 – 0.4

Analyte	Unit	DGV	Average	Median	Range
Chromium	µg/L	20	2.6	<1	<1 – 20
Cobalt	µg/L	1	6.3	3.5	<1 – 32
Copper	µg/L	1.3	6.6	2	<1 – 39
Iron[a]	µg/L	700	3,288	475	<50 – 15,100
Lead	µg/L	4.4	1.3	<1	<1 – 2
Manganese	µg/L	1,900	286	207	<1 – 878
Mercury **(B)**	µg/L	0.1	0.6	<0.1	<0.1 – 7.8
Nickel	µg/L	70	9	4	<1 – 64
Zinc	µg/L	8	60	16	<5 – 260
TRH+C10 - C40 (Sum of total)	µg/L	100	<50	<50	<50

Red – Exceeding the DGV level

(B) – Chemicals that are bioaccumulation consider the 99 % level of protection

a – Criteria adopted from the Australian interim marine guideline

b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

An analysis of key statistical measures indicates that exceedances of DGVs can largely be attributed to discrete locations (localized areas) along / adjacent to Pyrmont Station and the relevant tunnel sections. Inflows into Station excavations is expected to cause radial drawdown from groundwater affecting both shallow sediments and deeper strata (up to the base of excavations). The results are also affected by spatial bias in groundwater sampling locations.

Accounting for radial drawdown, the average concentrations are expected to represent the likely groundwater influent water quality to water treatment plants. Despite this, there is potential for significant variations in groundwater quality (within the identified ranges) accounting for variable permeability and anisotropy of the sandstone aquifer.

As noted in Section 1, an existing WTP is to be handed over to JCG on 17 March 2023 at Hunter Street East. The existing Hunter Street East WTP has been operational as a water treatment plant since 2017 treating groundwater inflows. The water treatment plant was originally commissioned to service the Sydney Metro City and Southwest Project to support tunnelling works at around Martin Place. Details of the feedwater quality (principally derived from groundwater) are provided in 5.4.3.

4.7 Aquatic ecology

Sydney Harbour is of high aesthetic, ecological and socio-economic importance to the most populated city in Australia. The foreshores of the estuary are highly urbanised and the harbour itself conducts a large volume of commercial and private boating activities. The estuary is the final destination for runoff from about 50,000 hectares of the catchment of which at least 86 per cent is urbanised and/or industrialised through a long history since the 1800s (Birch G., 2006). The total natural area of the estuary has been reduced by 23 per cent over 220 years through extensive reclamation in areas such as Homebush Bay, Rhodes Peninsula, Blackwattle Bay, Darling Harbour and Woolloomooloo. Bays were enclosed by sandstone seawalls and the intertidal areas were reclaimed by infilling with garbage, industrial wastes and sediments removed from the floor of the adjacent estuary. These changes within the estuary have resulted in major alterations to ecological function, hydrology and physio-chemical attributes (Birch G., 2006). Despite these changes the estuary has exhibited signs of recovery (Johnston E. et al., 2015).

The Sydney Harbour estuary has a wide range of marine habitats which support one of the most biodiverse estuarine ecosystems in Australia, and potentially the world (Johnston E. et al., 2015). For example, 2473 species of polychaetes, crustaceans, echinoderms and molluscs have been recorded in the harbour as opposed to 1636 in Botany Bay and 981 in Port Hacking (Hutchings P. et al., 2013). Sydney Harbour also has a high diversity of marine fish with 574 recorded species some of which are iconic species including syngnathids (family Syngnathidae), tropical vagrants and elasmobranchs (sharks and rays). The harbour's location is unique as it acts as an ecotone, providing refuge for a number of tropical fish species at the limit of their southern distribution (Booth D., 2010). Species richness appears to follow the salinity gradient along drowned valley estuaries (Roy P. et al, 2001). The open, deep and saline mouths of drowned valley estuaries attract a higher abundance and diversity of marine fauna due to its suitability for transient and migratory species (Roy P. et al, 2001).

The estuary has five broad marine habitat areas (SIMS, 2018) (Johnston E. et al., 2015):

- Intertidal rocky shores
- Shallow soft sediments that include seagrass, saltmarsh, mangroves and intertidal sand and mudflats
- Subtidal rocky reefs
- Deep soft sediments
- Open water

These five habitats span the supralittoral, intertidal, subtidal, and deep-water areas throughout the estuary and are described in the sections below and in relation to their sensitivity 'Type' and waterway 'Class' as given in the Policy and Guidelines for Fish Habitat Conservation and Management, 2013 update (NSW DPI, 2013).

Critical habitat is listed under the FM Act and the EPBC Act. Critical habitat declared under Division 3 of the FM Act refers to the whole, or part of, the habitat of an endangered population or threatened species or ecological community that is critical to the survival of the population, species, or ecological community.

A review of the NSW DPI and the Australian Government's Register of Critical Habitat revealed no declared critical habitat to occur within the study locality.

Further detail on aquatic ecology is available in the project EIS Chapter 18 Biodiversity.

5 CONSTRUCTION WATER MANAGEMENT

5.1 Overview

As set out in Section 1.3, two TBMs will be launched from the existing construction site at The Bays to excavate the majority of the twin underground tunnels towards Sydney CBD, predominantly through Hawkesbury Sandstone.

Groundwater inflow will be collected and treated during construction via temporary WTPs, then released through discharge points to be included in the EPL via the stormwater system into Sydney Harbour. Generally, The Bays WTP will receive process water including groundwater inflow from the TBM and cross passages along with groundwater seepage into a portion of the station box at handover (approximately 445 KL/day) and rainwater into the excavation. Pyrmont Station and Hunter Street will collect all water inflow (groundwater, stormwater runoff, and process water) for the construction works in each respective area. Process water including groundwater from Pyrmont West will be transferred to the WTP at Pyrmont East. Process water including groundwater from Hunter Street West will be transferred and treated through the existing Hunter Street East WTP.

5.2 Construction water balance

The water coming from the tunnel/excavated shafts will flow directly to the WTPs, no settlement in ponds or tanks before entering the WTPs are envisaged. Particular attention is to be given to the high solids load in the incoming water and the means of removing these solids and the fact that the flow rate is changing constantly.

The flow rate for each construction WTP has been specified in Table 20. The change of incoming flow rate can vary from 0 – 100 % (or 100 % – 0) within 30 s.

Table 20. Water balance for project construction sites

<table>
<tr><th>Site location</th><th colspan="2">Estimated long term GW inflow (L/s)*</th><th>Process Water (L/s)</th><th>Total inflow** (L/s)</th><th>Min WTP capacity (L/s)</th></tr>
<tr><td>The Bays</td><td>Total Cavern</td><td>5.15</td><td>5</td><td>10.15</td><td>30</td></tr>
<tr><td rowspan="3">Pyrmont Station</td><td>West Shaft</td><td>0.05 – 0.6</td><td rowspan="3">0.5</td><td rowspan="3">1.2 – 6.6</td><td rowspan="3">15</td></tr>
<tr><td>East Shaft</td><td>0.05 – 0.8</td></tr>
<tr><td>Cavern (during excavation)</td><td>0.6 – 4.7</td></tr>
<tr><td rowspan="3">Hunter Street</td><td>West Shaft</td><td>0.05 – 1</td><td rowspan="3">0.5</td><td rowspan="3">0.9 – 4.2</td><td rowspan="3">15</td></tr>
<tr><td>East Shaft</td><td>0.05 – 1</td></tr>
<tr><td>Cavern (during excavation)</td><td>0.3 – 1.7</td></tr>
</table>

***** Estimated values by JHCPBG-JV to be updated following further groundwater modelling
****** Consider dry weather

As tunnelling progresses the volume of process water to maintain tunnelling is projected to increase significantly resulting in dilution of groundwater inflows with additional tunnel process water and improved water quality of influent (feed water) to the WTPs.

Based on the construction water balance, the raw water intake will be made up of construction process water generated from drilling and excavation activities in Shale and Sydney Sandstone as well as shotcrete and grout residue, which will be mixed in varying ratios with groundwater and in some cases, surface inflows over construction areas.

5.3 Water treatment plant discharge points and receiving waterways

The ETP construction WTPs and corresponding discharge points / receiving waterways are identified in Table 21. All construction water treatment plants will discharge treated effluent to the local stormwater network, which subsequently discharge into Sydney Harbour / Port Jackson. The embayments of Sydney Harbour / Port Jackson that will receive treated effluent include White Bay, Darling Harbour, and Sydney Harbour.

Table 21. WTP location and receiving waterways

Site Location	Discharge Point	Receiving Waterway
The Bays	Stormwater Network	White Bay
Pyrmont Station	Stormwater Network	Darling Harbour
Hunter Street Station	Stormwater Network	Sydney Harbour (Man O' War Steps)

5.4 Water treatment processes and anticipated water quality outcomes

5.4.1 The Bays & Pyrmont Station (Proposed WTPs)

New construction WTPs will be commissioned at The Bays and Pyrmont Station to facilitate the treatment of groundwater inflows to excavations and tunnels prior to discharge into Port Jackson / Sydney Harbour.

The construction WTPs at the Bays and Pyrmont Station will be designed to treat a mixture of groundwater and process water prior to on-site beneficial re-use, and discharge into various bays of Sydney Harbour / Port Jackson. The WTPs will be designed to target compliance with environmental performance requirements for discharges into estuarine and marine water type ecosystems.

For the ETP Works the environmental performance targets for The Bays and Pyrmont Station Construction WTPs comprise the default ANZG (2018) 95% species protection criteria for chemical toxicants, 99% species protection criteria for bio-accumulating chemical toxicants, and the ANZECC (2000) default guideline values for physical and chemical stressors.

The proposed treatment processes that will be adopted at The Bays and Pyrmont Station construction WTPs along with their anticipated water quality improvements are summarized in Table 22.

Table 22. The Bays and Pyrmont Station Water Treatment Plant – processes and anticipated outcomes

Process	Water Quality Outcome
Raw Water Screening and Storage (Balance tank)	Reduced turbidity; rubbish; coarse / heavy suspended solids; oxidises heavy metals such as iron and manganese for downstream processing;
In-line pH correction	Enhance removal of contaminants through conversion of dissolved solids to suspended solids and settling of suspended solids.
Coagulant / polymer flocculant dosing	Enhance removal of contaminants through settling of solids.
Clarification (lamella plate clarifier)	Reduce turbidity; suspended solids; oil and grease; heavy metals (Cr III, Cr VI, Cu, Fe, Pb, Mn, Ni, Zn); VOCs/ SVOCs; C6 – C36 petroleum hydrocarbons.
Solids removal	Removal of settled sediment.
Media filtration	Reduce turbidity; residual solids; and concentrations of heavy metals (As, Cd, Cu, Fe, Pb, Ni, Mn, Hg); oil and grease.
Breakpoint chlorination	Reduce concentrations of ammonia; range of heavy metals. Biproducts include chloramines, nitrate, nitrite.
Dechlorination	Reduce concentrations of free chlorine (including chloramines).
Carbon filtration / adsorption	Reduce residual concentrations of free chlorine (including chloramines); C6 – C36 petroleum hydrocarbons; BTEX; chlorinated solvents; VOCs / SVOCs; PAH; residual metals (Zn, Pb, Cu, Cd, Ni; Cr VI); PFAS; oil and grease.
Nitrate Ion exchange	Reduce concentrations of nitrate and PFAS.
Phosphorous adsorption	Reduce concentrations of total phosphorous.
Balancing of outgoing flows and final pH Correction (Outflow balance tank)	Flow balancing, pH correction and discharge from water treatment plant / recirculation to inflow balance tank.

The anticipated effluent water quality profile for The Bays Station WTP is outlined in Table 23 and for Pyrmont Station is outlined in Table 24. Ranges are provided for effluent water quality to account for the spatial variations observed in groundwater quality, and unknown efficacy & efficiency of treatment processes that will be subject to proof of performance testing.

It should be noted that the adopted water treatment processes include chemical oxidation of ammonia to nitrate, and nitrate removal through ion exchange. Breakpoint chlorination will convert ammonia to nitrate, following which nitrate will be removed through ion exchange. As a result, the predicted effluent concentrations for ammonia and nitrate vary between influent and effluent water quality.

Despite the proposed multi-stage treatment processes, several contaminants have potential to continue exceeding the ANZG / ANZECC DGVs following the adopted BPT treatment processes, including:

- Nutrients and inorganics: total nitrogen, oxidised nitrogen, ammonia, and total phosphorous
- Trace metals: arsenic, chromium, cobalt, copper, and zinc.

Table 23. Anticipated effluent water quality – The Bays WTP

Analyte	Unit	DGV	Anticipated Influent	Anticipated Effluent	Treatment Method
pH (Lab)	units	7.0 – 8.5	5.72 – 8.06	7.0 – 8.5	pH Correction
Nitrogen (Total)[b]	µg/L	300	152 – 7,154	<1,720	BPC, GAC, IX
Nitrate (as N)	µg/L	2,400 – 45,000	<10 – 30	<10 – <660	Ion Exchange
Nitrate + Nitrite (as N)	µg/L	15	<10 – 30	<10 – <660	Ion Exchange
Ammonia (as N)	µg/L	15 / 910	<10 – 6,190	<10 – <1,500	Breakpoint Chlorination
Total Phosphorus (as P)	µg/L	30	<10 – 452	<10 – <140	GAC, Adsorption
Arsenic	µg/L	4.5	<1 – 28	<1 – <13	Clarification, GAC
Cadmium **(B)**	µg/L	0.7	<0.1 – 0.5	<0.2	Clarification, GAC
Chromium	µg/L	4.4	<1 – 2.5	<1 – <6	Clarification, GAC
Cobalt	µg/L	1	<1 – 12	<1 – <1.4	Clarification, GAC
Copper	µg/L	1.3	<1 – 40	<1 – <2	Clarification, GAC
Iron[a]	µg/L	700	<50 – 61,901	<700	Clarification, GAC
Lead	µg/L	4.4	<1	<3.4	Clarification, GAC
Manganese	µg/L	1,900	3 – 2,227	<1,900	Clarification, GAC
Mercury **(B)**	µg/L	0.1	<0.1	<0.06	Clarification, GAC
Nickel	µg/L	70	<1 – 42	<11	Clarification, GAC
Zinc	µg/L	8	<5 – 165	<5 – <15	Clarification, GAC
TRH+C10 – C40 (Sum of total)	µg/L	100	<50 – 523	<100	Clarification, GAC

N.D. – No data available
Red – Value exceeds CoA Default Guideline Value (DGV)
(B) – Chemicals that are bioaccumulation consider the 95 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

Table 24. Anticipated effluent water quality – Pyrmont Station WTP

Analyte	Unit	DGV	Anticipated Influent	Anticipated Effluent	Treatment Method
pH (Lab)	pH unit	7.0 – 8.5	4.31 – 7.16	7.0 – 8.5	pH Correction
Nitrogen (Total)[b]	µg/L	300	92– 1,941	<1,720	BPC, GAC, IX
Nitrate (as N)	µg/L	2,400 – 45,000	<10 – 74	<10 – <660	Ion Exchange
Nitrate + Nitrite (as N)	µg/L	15	<10 – 74	<10 – <660	Ion Exchange
Ammonia (as N)	µg/L	15 / 910	<10 – 6,525	<10 – <1,500	Breakpoint Chlorination
Total Phosphorus (as P)	µg/L	30	<10 – 166	<10 – <140	GAC, Adsorption
Arsenic	µg/L	4.5	<1 – 9	<1 – <13	Clarification, GAC
Cadmium **(B)**	µg/L	0.7	<0.1 – 0.2	<0.2	Clarification, GAC
Chromium	µg/L	4.4	<1 – 9	<1 – <6	Clarification, GAC
Cobalt	µg/L	1	<1 – 68	<1 – <1.4	Clarification, GAC
Copper	µg/L	1.3	<1 – 12	<1 – <2	Clarification, GAC

Analyte	Unit	DGV	Anticipated Influent	Anticipated Effluent	Treatment Method
Iron[a]	µg/L	700	<50 – 630,333	<700	Clarification, GAC
Lead	µg/L	4.4	<1 – 15	<3.4	Clarification, GAC
Manganese	µg/L	1,900	18 – 24,955	<1,900	Clarification, GAC
Mercury **(B)**	µg/L	0.1	<0.1	<0.06	Clarification, GAC
Nickel	µg/L	70	<1 – 114	<11	Clarification, GAC
Zinc	µg/L	8	<5 – 130	<5 – <15	Clarification, GAC
TRH+C10 - C40 (Sum of total)	µg/L	100	<50	<100	Clarification, GAC

N.D. – No data available
Red – Value exceeds CoA Default Guideline Value (DGV)
(B) – Chemicals that are bioaccumulation consider the 95 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

Outcomes from the proposed water treatment processes at the Hunter Street will be limited by the influent (feedwater) chemistry and overall efficacy & efficiency of treatment processes following refurbishment and upgrades. The anticipated effluent water quality ranges presented in Table 23 represent the anticipated reasonable best case and reasonable worst case scenario outcomes accounting for these factors.

A performance monitoring program is proposed (Section 8) as a means to empirically measure feedwater quality and the performance of WTPs and determine practical and sustainable discharge limits for the ETP WTPs. Proposed interim limits are recommended (Section 7) until proof of performance results can be used to determine final discharge limits.

5.4.2 Hunter Street WTP (existing WTP)

The existing Hunter Street WTP has been operational as a water treatment plant since 2017. The water treatment plant was originally commissioned to service the Sydney Metro City and Southwest Project to support tunnelling works at around Martin Place. Water treatment processes currently operational at the existing water treatment plant are listed in Table 25. Carbon adsorption media was added to the water treatment plant in 2020 as part of planned upgrades.

The water treatment plant has a capacity of 15L/s and discharges into Sydney Harbour via the local stormwater system.

Table 25. Hunter Street Water Treatment Plant – existing processes and outcomes

Process	Water Quality Outcome
	Existing Treatment Processes
Raw Water Screening and Storage (inflow balance tank)	Reduced turbidity; coarse / heavy suspended solids; oxidises heavy metals such as iron and manganese for downstream processing;
In-line pH correction	Enhance removal of contaminants through conversion of dissolved solids to suspended solids and settling of suspended solids.
Coagulant / polymer flocculant dosing	Enhance removal of contaminants through settling of solids.
Clarification (lamella plate clarifier)	Reduce turbidity; suspended solids; oil and grease; heavy metals (Cr III, Cr VI, Cu, Fe, Pb, Mn, Ni, Zn); VOCs/ SVOCs; C6 – C36 petroleum hydrocarbons.
Solids removal	Removal of settled sediment.
Media filtration	Reduce turbidity; residual solids; and concentrations of heavy metals (As, Cd, Cu, Fe, Pb, Ni, Mn, Hg); oil and grease.
Carbon filtration / adsorption	Reduce residual concentrations of contaminants, including: C6 – C36 petroleum hydrocarbons; BTEX; chlorinated solvents; VOCs / SVOCs; PAH; residual metals (Zn, Pb, Cu, Cd, Ni; Cr VI); PFAS; oil and grease.
Balancing of outgoing flows and final pH Correction (Outflow balance tank)	Flow balancing, pH correction and discharge from water treatment plant / recirculation to inflow balance tank.

Water quality monitoring of influent and treated effluent has been undertaken throughout the operational period of the existing Hunter Street WTP. A summary of the laboratory testing results from recent water quality monitoring of influent and treated effluent at the existing Hunter Street WTP is provided in Table 26.

Table 26. Effluent water quality from the existing WTP at Hunter Street

Pollutant	DGV	Influent		Discharge				Treatment Method
		Hunter St Avg (μg/L) H1 2021	Hunter St Max (μg/L) H1 2021	HunterSt Avg (μg/L) H1 2021	Hunter St Max (μg/L) H1 2021	Hunter St Avg (μg/L) H2 2021	Hunter St Max (μg/L) H2 2021	
pH	7.0 – 8.5	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	pH Correction
Turbidity	50	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Clarification, MMF
Nitrogen (Total)[b]	300	2,100	5,270	1,500	3,900	2,400	5,400	BPC, GAC, IX
Total Phosphorous	30	190	1400	64	450	120	570	GAC, IX
Oxidised Nitrogen	15	550	1,380	440	1,400	1,200	1,900	GAC, IX
Ammonia	15 / 910	550	1,300	700	1,900	230	790	BPC, GAC, IX
Aluminium	55	3,800	11,000	240	410	1,400	9,000	Clarification, GAC
Arsenic	4.5	3.8	11	1.7	8	1.2	3	Clarification, GAC
Cadmium **(B)**	0.7	0.1	0.2	0.087	-	0.11	0.3	Clarification, GAC
Chromium	4.4	18	110	5.8	26	10	24	Clarification, GAC
Cobalt	1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Clarification, GAC
Copper	1.3	11	45	2.4	19	3.4	16	Clarification, GAC
Iron	700	2,000	6,900	96	740	94	360	Clarification, GAC
Lead	4.4	4.8	24	0.6	2	0.56	1	Clarification, GAC
Manganese	1,900	75	190	19	78	7.5	30	Clarification, GAC
Mercury **(B)**	0.1	0.065	0.2	0.056	0.2	0.053	0.1	Clarification, GAC
Nickel	70	6.4	16	3.9	24	1.9	5	Clarification, GAC
Zinc	8	140	706	34	160	56	220	Clarification, GAC

N.D. – No data available
Red – Value exceeds CoA Default Guideline Value (DGV)
(B) – Chemicals that are bioaccumulation consider the 95 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

Results from water quality monitoring at the existing Hunter Street WTP show that influent is characterised by significant concentrations of a range of toxicants and physical / chemical stressors, including the following at levels exceeding the ANZG / ANZECC DGVs:

- nutrients and inorganics: nitrogen, oxidised nitrogen, phosphorous, filterable reactive phosphorous, ammonia
- trace metals: aluminium, arsenic, chromium, copper, iron, lead, mercury, zinc

Effluent water quality monitoring shows that water treatment processes are generally effective at reducing concentrations of contaminants, however the processes are not currently achieving the necessary water quality improvements for compliance with ANZG / ANZECC DGVs. Contaminants currently exceeding the ANZG / ANZECC DGVs following treatment include:

- nutrients and inorganics: nitrogen, oxidised nitrogen, phosphorous, filterable reactive phosphorous, ammonia
- trace metals: aluminium, arsenic, chromium, copper, iron, mercury, zinc

Exceedances of DGVs for arsenic, copper, iron, and mercury are infrequent in treated effluent and typically only observed as maximum concentrations reflecting transient conditions. Exceedances of DGVs for nitrogen, oxidised nitrogen, phosphorous, aluminium, chromium and zinc are frequent, reflecting both the significant concentrations of these contaminants in influent, and limitations in the adopted treatment technology and/or maintenance of the existing WTP.

The average and maximum contaminant concentrations in effluent from the existing WTP at Hunter Street will closely reflect the effluent water quality conditions when the existing WTP is handed over to JCG for the ETP Works on 17 March 2023. As such the ranges shown in Table 26 reflect the anticipated water quality prior to proposed upgrades (discussed below). It should be noted that the existing Hunter Street WTP will continue to operate and discharge water prior to the proposed refurbishments and upgrades and as such will require an interim discharge licence.

5.4.3 Hunter Street Construction WTP (proposed additional treatment processes)

JCG are proposing to refurbish the Hunter Street WTP at handover and install necessary upgrades to facilitate improved discharge water quality during construction activities. JCG are proposing to undertake a proof performance monitoring program for the Hunter Street WTP to inform achievable discharge targets.

To meet Sydney Metro's construction program, JCG are scheduled to commence excavation at the Hunter Street East worksite from April 2023. This will necessitate the use of the existing WTP, which JCG will refurbish on site handover, for initial excavation works in parallel with procurement of the upgraded treatment processes which are scheduled for installation and commissioning from approximately July 2023. In this period of time, the low point intake for this WTP will remain unchanged, being the base of the handed over Bligh Street decline. The groundwater level in the area of the Hunter Street site has been drawn down significantly due to dewatering associated with adjacent building basements and was recorded at between -3.25m and -4.7m AHD in September 2022. The existing Bligh Street decline has a maximum depth of approximately -5.5m AHD. Existing ground level in the area is 18.4m AHD.

The excavation works being carried out at this time will be relatively shallow in comparison to the Hunter Street station and turnbacks, comprising only the upper level of the Hunter Street access decline. During this period, this decline will be excavated northwards from the worksite below Bligh Street before advancing westwards beneath Hunter Street. For the most part of this timeframe the level of this excavation is not expected to exceed the depth of the existing Bligh Street decline. As a result, it is not expected to incur significant increases in groundwater flows, if any, in comparison to the existing state.

Subject to the results of a proof of performance program, the following upgrades are proposed:

- Breakpoint chlorination (ammonia removal)
- Ion exchange (nutrient removal).

The proposed upgrades and anticipated water quality outcomes are summarised in Table 27, with the specific objective of reducing total ammonia and total nitrogen / total oxidised nitrogen in effluent discharge. The proposed upgrades represent the best practical technology (BPT) for the removal of ammonia and forms of nitrogen associated construction related projects.

Refurbishment and maintenance of existing treatment processes are expected to improve water quality outcomes for other contaminants, including the trace metals currently identified as exceeding the DGVs at the Hunter Street WTP.

Table 27. Hunter Street construction WTP – proposed additional processes and anticipated outcomes

Process	Water Quality Outcome
Breakpoint chlorination	Reduce concentrations of ammonia; range of heavy metals. Biproducts include chloramines, nitrate, nitrite.
Dechlorination	Reduce concentrations of free chlorine (including chloramines).
Phosphorous adsorption	Reduce concentrations of total phosphorous.
Nitrate Ion exchange	Reduce concentrations of nitrate and PFAS.

The anticipated effluent water quality profile for Hunter Street WTP following the proposed upgrades are outlined in Table 28. Despite the proposed upgrades, several contaminants are expected to continue exceeding the ANZG / ANZECC DGVs, including:

- Nutrients and inorganics: total nitrogen, oxidised nitrogen, ammonia, and total phosphorous
- Trace metals: arsenic, chromium, cobalt, copper, and zinc.

Table 28. Anticipated effluent water quality – upgraded Hunter Street construction WTP

Analyte	Unit	DGV	Anticipated Influent	Anticipated Effluent	Treatment Method
pH (Lab)	pH unit	7.0-8.5	N.D.	7.0 – 8.5	pH Correction
Nitrogen (Total)[b]	µg/L	300	2,100 – 5,270	<1,720	BPC, GAC, IX
Nitrate (as N)	µg/L	2,400 – 45,000	N.D.	<15 - <660	Ion Exchange
Oxidised Nitrogen	µg/L	15	550 – 1,380	<15 - <660	Ion Exchange
Ammonia (as N)	µg/L	15 / 910	550 – 1,300	<15 – <1,500	Breakpoint Chlorination
Total Phosphorus (as P)	µg/L	30	190 – 1,400	<30 – <140	GAC, Adsorption
Arsenic	µg/L	2.3	3.8 – 11	<2.3 – <13	Clarification, GAC
Cadmium **(B)**	µg/L	0.7	0.1 – 0.2	<0.1 – <0.2	Clarification, GAC
Chromium	µg/L	4.4	18 – 110	<4.4 – <6.0	Clarification, GAC
Cobalt	µg/L	1	N.D.	<1 – <1.4	Clarification, GAC
Copper	µg/L	1.3	11 – 45	<1.3 – <2.0	Clarification, GAC
Iron[a]	µg/L	700	2,000 – 6,900	<700	Clarification, GAC
Lead	µg/L	4.4	4.8 – 24	<4.4	Clarification, GAC
Manganese	µg/L	1,900	75 – 190	<1,900	Clarification, GAC
Mercury **(B)**	µg/L	0.1	0.065 – 0.2	<0.06	Clarification, GAC
Nickel	µg/L	70	6.4 – 16	<11	Clarification, GAC
Zinc	µg/L	8	140 – 706	<15	Clarification, GAC
TRH+C10 - C40 (Sum of total)	µg/L	100	N.D.	<100	Clarification, GAC

N.D. – No data available
Red – Value exceeds CoA Default Guideline Value (DGV)
(B) – Chemicals that are bioaccumulation consider the 95 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

Due to constraints with construction timeframes and materials, it is anticipated that upgrades are likely to commence approximately four months following handover of the Hunter Street WTP to CPB. Further details on timing of upgrades for the Hunter WTP are provided in Section 8.

Outcomes from the proposed water treatment processes at the Hunter Street will be limited by the influent (feedwater) chemistry and overall efficacy & efficiency of treatment processes following refurbishment and upgrades. The anticipated effluent water quality ranges presented in Table 28 represent the anticipated reasonable best case and reasonable worst case scenario outcomes accounting for these factors.

A performance monitoring program is proposed (Section 8) as a means to empirically measure feedwater quality and the performance of WTPs and determine practical and sustainable discharge limits for the project WTPs. Proposed interim limits are recommended (Section 7) until proof of performance results can be used to determine final discharge limits.

5.5 Summary

JCG are proposing to install two (2x) new construction WTPs at The Bays and Pyrmont, and upgrade the existing construction WTP located at Hunter Street, for the purpose of treating groundwater inflows to excavations and tunnels prior to discharge into receiving waterbodies around Sydney Harbour, Darling Harbour and White Bay. The WTPs will operate continuously during the construction stages of the ETP Works, treating groundwater inflows, process water, and any incident rainfall into excavations (Pyrmont Station will include sheds to prevent rainfall inflows).

The construction WTPs are being designed to include the best practicable technology (BPT) treatment solutions for removal of the contaminants of potential concern (CoPC) that have been identified through groundwater monitoring along the ETP alignment.

Due to the significant variability of contaminant concentrations in groundwater, mixing with process water and varying efficiency of treatment processes in response to feedwater chemistry, it is not possible to accurately predict effluent water quality. As such, ranges are provided for effluent water quality that account for reasonable best-case and reasonable worst-case scenarios.

A performance monitoring program is proposed (Section 8) as a means to empirically measure feedwater quality and the performance of WTPs and determine practical and sustainable discharge limits for the ETP WTPs. Proposed interim limits are recommended (Section 7) until proof of performance results can be determined for the proposed new water treatment plants, and upgrades are completed and pilot tested for the Hunter Street upgraded WTP. Interim limits are proposed for each of the WTPs to account for potential variability in feedwater quality that can affect treatment results. It should be noted that upgrades to the existing Hunter Street WTP are likely to take at least 4 months to procure before proof of performance testing for the upgraded WTP can commence. To meet Sydney Metro's construction program, JCG are scheduled to commence excavation at the Hunter Street East worksite from April 2023. This will necessitate the use of the existing WTP, which JCG will refurbish on site handover, for initial excavation works in parallel with procurement of the upgraded treatment processes which are scheduled for installation and commissioning from approximately July 2023.

6 IMPACT ASSESSMENT

6.1 Overview

With the implementation of management measures, pollutant loading to the receiving waterbodies will be minimised and the existing water quality maintained. Therefore, the ETP Works would not impact aquatic ecosystems of the receiving waterbodies. In summary, the ETP Works would not impact any water quality objectives.

6.2 Methodology

A hydrodynamic mixing zone assessment has been undertaken to assess potential water quality impacts from effluent discharges associated with the ETP Works. A spreadsheet based box-model approach was adopted to simulate the effects of radial dilution-dispersion from the point of discharge into receiving waterbodies. Key inputs to the model included:

- Local bathymetry (water depth) - derived from the seamless bathymetry and topography dataset for Sydney Harbour (Wilson and Hannah (2018).
- Ambient water quality of receiving waterbodies around the proposed discharge points - derived from recent sampling undertaken by JCG
- Predicted effluent water quality – derived from anticipated worst case scenario outcomes for discharge from the project WTPs

Two-dimensional analysis of potential effluent impacts to water quality were assessed through interpolation of results from a series of one-dimensional points representing various distances from the discharge point, including 10 m, 20 m, 50 m, 100 m, 200 m, and 300 m. The assessment of dilution-dispersion accounted for all relevant inputs including average depth of water, ambient water quality and anticipated reasonable worst-case effluent water quality.

The results of the analysis have been summarised in a series of Tables in Section 6.4. The predicted outcomes represent the anticipated steady state conditions in response to continuous effluent discharge and responses of waterbodies to tidal exchange. The accuracy of model predicted will be validated by environmental monitoring during commissioning and a proposed proof of performance period for the ETP WTPs.

Assessment of impacts from effluent discharge on River Flow Objectives has also been undertaken (Section 6.3). Assessment of flow impacts accounts for the average daily discharge volumes anticipated from the project WTPs compared against available storage and ebb / flood tidal discharge volumes. These results provide a framework for determining whether there is a risk of impacts to the NSW River Flow Objectives for the Sydney Harbour Lower Estuary from the project.

6.3 Flows

The NSW River Flow Objectives for the Sydney Harbour Lower Estuary are discussed in Section 3.3 and include the following:

- Maintain wetland and floodplain inundation
- Minimise effects of weirs and other structures, and
- Maintain or rehabilitate estuarine processes and habitats.

Discharges from the ETP construction WTPs will be released into receiving waterbodies of Sydney Harbour including:

- Sydney Harbour at the Man O' War Steps
- Darling Harbour, and
- White Bay.

The ETP construction WTPs are designed to a treatment capacity of up to between 15L/s (Hunter Street/ Pyrmont) and 30L/s (The Bays), however it is anticipated that discharges will typically remain below approximately 10 L/s. A summary account of the anticipated inflow rates (corresponding with effluent flow rates) is described in Section 5.2.

Discharges from the ETP Works are unlikely to result in any significant impact to the NSW River Flow Objectives in the receiving waterbodies because of the following factors:

- Discharge sites are not located at or within close proximity to wetlands or floodplains, and are not anticipated to affect wetlands or floodplains within the catchment
- The ETP Works will not utilise any weirs or flow modifying structures. All discharges will be pumped into the local council stormwater network, which discharge directly into the receiving waterbodies
- Discharges from the ETP Works are anticipated to be typically less than 10L/s (refer to Table 20), and as such are not anticipated to affect estuarine processes or habitats given the significant storage volumes and tidal exchange rates within the receiving waterbodies.

Overall, the instantaneous and anticipated average daily discharge volumes associated with effluent releases from the construction WTPs are insignificant (up to approximately 864 m^3/day) when compared to available storages and tidal flow rates in receiving waterbodies. A comparison of the daily discharge volumes against the estimated daily tidal discharge volumes from receiving waterbodies is provided in Table 29.

Table 29. Daily construction WTP discharge volumes vs daily tidal storage and discharge volumes for receiving waterbodies

WTP	Waterbody	WTP Average Daily Discharge Volume (m^3)	Approximate Downstream Tidal Storage Volume (m^3)	Approximate Average Ebb Tidal Discharge Volume (m^3)
Hunter Street	Sydney Harbour	484 – 838	2.6×10^8	7,440,000
Pyrmont Station	Darling Harbour	69 – 251	4.6×10^6	180,000
The Bays	White Bay	78 – 363	8.7×10^6	310,000

6.4 Water Quality

To assess the potential effects on the receiving environments of the discharges, the outlet concentrations into the catchments have been predicted through the development of a dilution assessment model.

Predictions from the dilution assessment model incorporate seamless bathymetry and topography dataset for Sydney Harbour to estimate concentrations of key contaminants of potential concern (CoPC) from effluent discharge into receiving waterbodies.

The dilution assessment model provides an estimate of the concentrations of contaminants associated with effluent discharge at various distances from the proposed discharge point into the receiving waterbody, (including 10m, 20m, 50m, 100m, 200m, and 300m ranges). A complete tidal exchange of water for each bay (i.e., Darling Harbour, and White Bay) can be expected over a 24-hour period, (in accordance with findings from Cardno, 2020 on the hydrodynamics of the adjacent Rozelle Bay).

Tidal exchange is therefore anticipated to limit any potential cumulative increase in concentrations of contaminants in receiving waterbodies resulting from discharge as a result of the periodic refreshing from both tidal exchange and rainfall-runoff events.

The location of discharge points and mapped bathymetry data for receiving waterbodies is presented in Figure 11 alongside the ETP alignment.

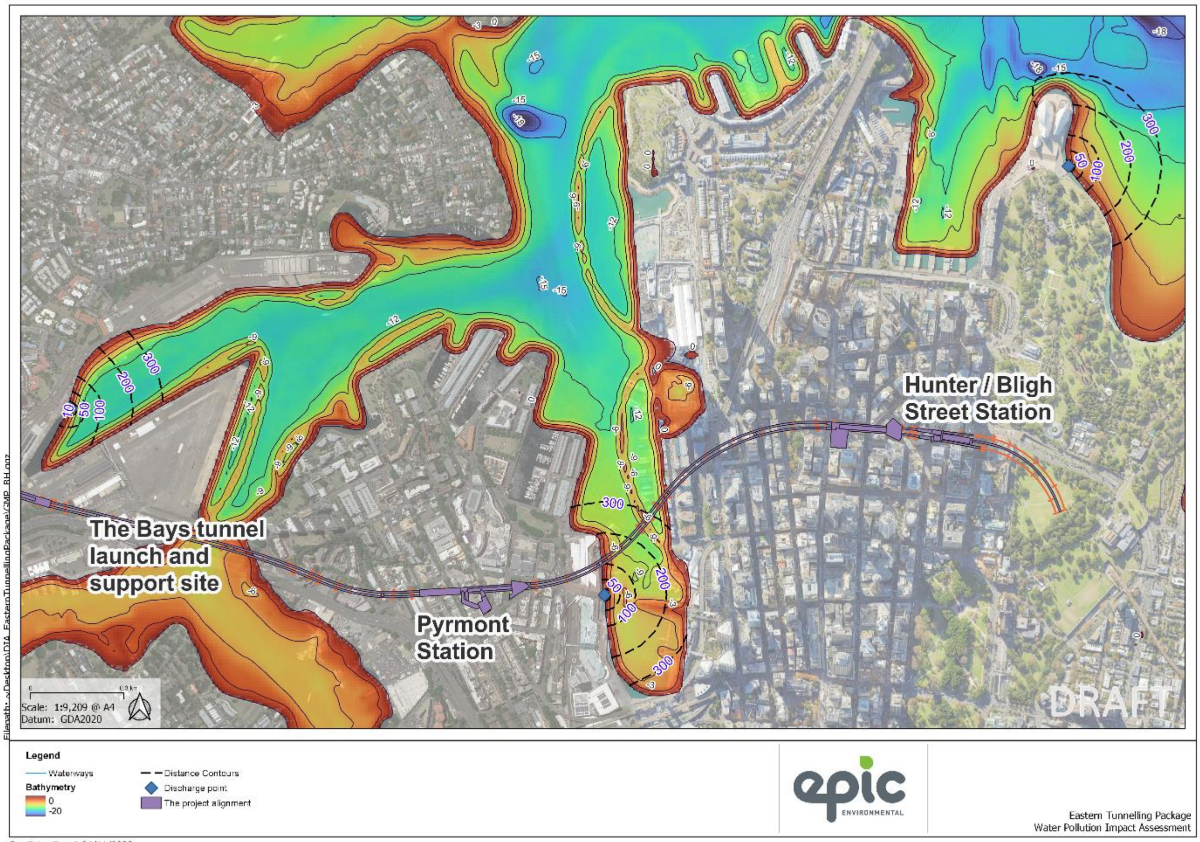

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Figure 11. Discharge points and mapped bathymetry of receiving waterbodies

Model input parameters for the dilution model (including average waterbody depth, distance from source, total area, and waterbody volume) are provided in Table 30. The available dilution factor for discharges based on ambient storage volumes within receiving waterbodies at various distances is also presented in Table 30.

Table 30. Model input parameters

Catchment	Average Depth / m	Measure	10m	20m	50m	100m	200m	300m
White Bay	17.5	area / m^2	43	128	893	3,189	12,952	19,544
		V / m^3	744	2,232	15,624	55,799	226,657	342,012
Darling Harbour	7.5	area / m^2	123	369	2,583	9,226	24,268	25,242
		V / m^3	923	2,768	19,374	69,192	182,013	189,312
Sydney Harbour (Man O' War Steps)	3.5	area / m^2	131	394	2,759	9,852	38,503	65,413
		V / m^3	459	1,379	9,657	34,482	134,761	228,946

6.4.1 White Bay (The Bays Station)

Effluent discharges from the construction WTP located at The Bays worksite will discharge to White Bay via the local council stormwater drainage network. Dilution model predictions for effluent discharges from The Bays worksite are presented in Table 31. Predictions are based on the maximum expected ranges for effluent discharge from The Bays worksite under dry conditions.

The results from dilution modelling for discharges from The Bays worksite show that effluent discharge will have limited impact on water quality beyond a 10m – 20m mixing dilution zone. Dilution from available storage is expected to attenuate the potentially elevated concentrations of nitrogen, oxidised nitrogen, phosphorous, chromium, and cobalt, and mitigate potential risks associated with these stressors / toxicants.

Ambient water quality with respect to copper and zinc is notably elevated within White Bay (under baseline conditions) at levels greater than predicted concentrations for effluent. As such, water quality improvements for copper and zinc are anticipated from effluent discharge within the mixing zone. Concentrations of oxidised nitrogen, copper, and zinc are elevated above the ANZECC / ANZG DGVs in White Bay and therefore concentrations remain above the DGVs beyond the zone of initial dilution.

Table 31. Estimated outlet concentrations at White Bay from The Bays WTP

Parameter*	DGV	Effluent	Ambient	10m	20m	50m	100m	200m	300m
Nitrogen (Total)[b]	300	1,720	200	365.20	206.45	200.04	200.00	200.00	200.00
Nitrate (as N)	1,200 – 45,000	660	5	76.19	7.78	5.02	5.00	5.00	5.00
Total Ox. Nitrogen (as N)	15	660	20	89.56	22.72	20.02	20.00	20.00	20.00
Ammonia (as N)	15 / 910	1,500	45	203.14	51.18	45.04	45.00	45.00	45.00
Total Phosphorus (as P)	30	140	5	19.67	5.57	5.00	5.00	5.00	5.00
Arsenic	2.3	4.5	1	1.38	1.01	1.00	1.00	1.00	1.00
Cadmium **(B)**	0.7	0.2	0.1	0.11	0.10	0.10	0.10	0.10	0.10
Chromium	4.4	6	1	1.54	1.02	1.00	1.00	1.00	1.00
Cobalt	1	1.4	1	1.04	1.00	1.00	1.00	1.00	1.00
Copper	1.3	2	3	2.89	3.00	3.00	3.00	3.00	3.00
Iron	700	700	10	84.99	12.93	10.02	10.00	10.00	10.00
Lead	4.4	3.4	1	1.26	1.01	1.00	1.00	1.00	1.00
Manganese	1,900	1,900	7	212.74	15.04	7.05	7.00	7.00	7.00
Mercury **(B)**	0.1	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nickel	70	11	1	2.09	1.04	1.00	1.00	1.00	1.00
Zinc	8	15	140	126.41	139.47	140.00	140.00	140.00	140.00

*Concentration unit in µg/L unless otherwise noted

Red – Value exceeds CoA Default Guideline Value (DGV)

(B) – Chemicals that are bioaccumulation consider the 95 % level of protection

a – Criteria adopted from the Australian interim marine guideline

b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

6.4.2 Pyrmont Station

Effluent discharge from the construction WTP located at Pyrmont Station will discharge to Darling Harbour via the local council stormwater drainage network. Dilution model predictions from Pyrmont Station are provided in Table 32. Predictions are based on the maximum expected ranges for effluent discharge from Pyrmont Station under dry conditions.

The results from dilution modelling for discharges from Pyrmont Station show that effluent discharge will have limited impact on water quality beyond a 10m – 20m mixing dilution zone. Dilution from available storage is expected to attenuate the potentially elevated concentrations of nitrogen, oxidised nitrogen, phosphorous and cobalt, and mitigate potential risks associated with these stressors / toxicants.

Ambient water quality with respect to copper and zinc is notably elevated within White Bay (under baseline conditions) at levels greater than predicted concentrations for effluent. As such, neutral and/or beneficial effects are anticipated for copper and zinc from effluent discharge within the mixing zone. Concentrations of oxidised nitrogen, copper, and zinc are elevated above the ANZECC / ANZG DGVs in Darling Harbour and therefore concentrations remain above the DGVs beyond the zone of initial dilution.

Table 32. Estimated outlet concentrations at Darling Harbour from Pyrmont Station WTP

Parameter*	DGV	Effluent	Ambient	10m	20m	50m	100m	200m	300m
Nitrogen (Total) [a]	300	1720	100	245.04	104.60	100.02	100.00	100.00	100.00
Nitrate (as N)	2,400 – 45,000	660	20	77.30	21.82	20.01	20.00	20.00	20.00

Parameter*	DGV	Effluent	Ambient	10m	20m	50m	100m	200m	300m
Total Ox. Nitrogen (as N)	15	660	25	81.85	26.80	25.01	25.00	25.00	25.00
Ammonia (as N)	15 / 910	1500	8	141.58	12.24	8.02	8.00	8.00	8.00
Total Phosphorus (as P)	30	140	5	17.09	5.38	5.00	5.00	5.00	5.00
Arsenic	2.3	4.5	1	1.31	1.01	1.00	1.00	1.00	1.00
Cadmium **(B)**	0.7	0.7	0.1	0.15	0.10	0.10	0.10	0.10	0.10
Chromium	4.4	6	1	1.45	1.01	1.00	1.00	1.00	1.00
Cobalt	1	1.4	1	1.04	1.00	1.00	1.00	1.00	1.00
Copper	1.3	2	2	2.00	2.00	2.00	2.00	2.00	2.00
Iron	700	700	10	71.78	11.96	10.01	10.00	10.00	10.00
Lead	4.4	4.4	1	1.30	1.01	1.00	1.00	1.00	1.00
Manganese	1,900	1900	6	175.57	11.38	6.03	6.00	6.00	6.00
Mercury **(B)**	0.1	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nickel	70	70	1	7.18	1.20	1.00	1.00	1.00	1.00
Zinc	8	15	9	9.54	9.02	9.00	9.00	9.00	9.00

*Concentration unit in µg/L unless otherwise noted
Red – Value exceeds CoA Default Guideline Value (DGV)
(B) – Chemicals that are bioaccumulation consider the 95 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

6.4.3 Hunter Street – existing WTP

Effluent discharge from the existing construction WTP located at Hunter Street will discharge to Sydney Harbour via the local council stormwater drainage network. Dilution model predictions from Hunter Street are provided in Table 33. Predictions are based on the maximum expected ranges for effluent discharge from the existing Hunter Street WTP under dry conditions.

The results from dilution modelling for discharges from the existing Hunter Street WTP show that effluent discharge has / will have limited impact beyond a 10 – 20m mixing dilution zone. Dilution from available storage currently attenuates and is expected to attenuate the impacts from elevated concentrations of nitrogen, oxidised nitrogen, phosphorous, arsenic, chromium, copper, and zinc in treated effluent, and will mitigate potential risks associated with these stressors and toxicants.

Table 33. Estimated outlet concentrations at Sydney Harbour from Hunter Street – Existing WTP

Parameter*	DGV	Effluent	Ambient	10m	20m	50m	100m	200m	300m
Nitrogen (Total)[b]	300	5,400	100	975.45	154.04	100.50	100.00	100.00	100.00
Nitrate (as N)	2,400 – 45,000	N.D.	10	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total Ox. Nitrogen (as N)	15	1,900	15	326.36	34.22	15.18	15.00	15.00	15.00
Ammonia (as N)	15 / 910	790	7	136.34	14.98	7.07	7.00	7.00	7.00
Total Phosphorus (as P)	30	570	5	98.33	10.76	5.05	5.00	5.00	5.00
Arsenic	2.3	3	2	2.17	2.01	2.00	2.00	2.00	2.00
Cadmium **(B)**	0.7	0.3	0.1	0.13	0.10	0.10	0.10	0.10	0.10
Chromium	4.4	24	1	4.80	1.23	1.00	1.00	1.00	1.00
Cobalt	1	N.D.	1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Copper	1.3	16	1	3.48	1.15	1.00	1.00	1.00	1.00
Iron [a]	700	360	10	67.81	13.57	10.03	10.00	10.00	10.00
Lead	4.4	1	1	1.00	1.00	1.00	1.00	1.00	1.00
Manganese	1,900	30	5	9.13	5.25	5.00	5.00	5.00	5.00
Mercury **(B)**	0.1	0.1	0.05	0.06	0.05	0.05	0.05	0.05	0.05
Nickel	70	5	1	1.66	1.04	1.00	1.00	1.00	1.00
Zinc	8	220	5	40.51	7.19	5.02	5.00	5.00	5.00

*Concentration unit in µg/L unless otherwise noted

N.D. – No data available
Red – Value exceeds CoA Default Guideline Value (DGV)
(B) – Chemicals that are bioaccumulation consider the 95 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

6.4.4 Hunter Street – upgraded WTP

Effluent discharge from the upgraded construction WTP located at Hunter Street will discharge to Sydney Harbour via the local council stormwater drainage network. Dilution model predictions from Hunter Street are provided in Table 34. Predictions are based on the maximum expected ranges for effluent discharge from Hunter Street under dry conditions.

The results from dilution modelling for discharges from the upgraded Hunter Street WTP show that effluent discharge will have limited impact on water quality beyond a 10m – 20m mixing dilution zone. Dilution from available storage is expected to attenuate the potentially elevated concentrations of nitrogen, oxidised nitrogen, phosphorous, arsenic, chromium, cobalt, and zinc, and will mitigate potential risks associated with these stressors / toxicants.

Table 34. Estimated outlet concentrations at Sydney Harbour from Hunter Street – Upgraded WTP

Parameter*	DGV	Effluent	Ambient	10m	20m	50m	100m	200m	300m
Nitrogen (Total)	300	1,720	100	367.59	116.52	100.15	100.00	100.00	100.00
Nitrate (as N)	2,400 – 45,000	660	10	117.37	16.63	10.06	10.00	10.00	10.00
Total Ox. Nitrogen (as N)	15	660	15	121.54	21.58	15.06	15.00	15.00	15.00
Ammonia (as N)	15 / 910	1,500	7	253.61	22.22	7.14	7.00	7.00	7.00
Total Phosphorus (as P)	30	140	5	27.30	6.38	5.01	5.00	5.00	5.00
Arsenic	2.3	13	2	3.82	2.11	2.00	2.00	2.00	2.00
Cadmium **(B)**	0.7	0.7	0.1	0.20	0.11	0.10	0.10	0.10	0.10
Chromium	4.4	6	1	1.83	1.05	1.00	1.00	1.00	1.00
Cobalt	1	1.4	1	1.07	1.00	1.00	1.00	1.00	1.00
Copper	1.3	2	1	1.17	1.01	1.00	1.00	1.00	1.00
Iron	700	700	10	123.97	17.04	10.07	10.00	10.00	10.00
Lead	4.4	4.4	1	1.56	1.03	1.00	1.00	1.00	1.00
Manganese	1,900	1,900	5	318.02	24.32	5.18	5.00	5.00	5.00
Mercury **(B)**	0.1	0.1	0.05	0.06	0.05	0.05	0.05	0.05	0.05
Nickel	70	70	1	12.40	1.70	1.01	1.00	1.00	1.00
Zinc	8	15	5	6.65	5.10	5.00	5.00	5.00	5.00

*Concentration unit in µg/L unless otherwise noted
Red – Value exceeds CoA Default Guideline Value (DGV)
(B) – Chemicals that are bioaccumulation consider the 95 % level of protection
a – Criteria adopted from the Australian interim marine guideline
b – Total nitrogen includes organic and inorganic (nitrate, nitrite, ammonia, ammonium) nitrogen.

6.5 Summary

The potential impacts from effluent discharges on receiving waterbodies have been assessed with consideration of dilution effects from mixing and dispersion. The results from water quality modelling have found that, under predicted worst-case conditions, the effluent from construction WTP discharges are attenuated within approximately 20m due to dilution effects from available storage in waterbodies.

The large storage volumes in receiving waterways, coupled with regular tidal mixing between Sydney Harbour and the Tasman Sea provide capacity to both attenuate contaminants by dilution and refresh waters with marine inflows. Rainfall events will periodically provide freshwater flows that will further modify and “refresh” water quality in the receiving waterbodies.

Toxicants with the potential to exceed their corresponding DGVs at the point of discharge include ammonia, arsenic, chromium, cobalt, copper and zinc. All potential exceedances are marginal and can be managed through the use of a mixing zone approach.

Physical and chemical stressors including nitrogen, oxidised nitrogen and ammonia may also exceed their corresponding DGVs at the point of discharge. Although the use of mixing zones is not appropriate for managing nutrients, it is evident through modelling that concentrations will return to ambient within approximately 20m from the point of discharge. As such, the potential for nutrient related stressor risks (e.g. nuisance growth of aquatic plants and algae) is low.

While varying exceedances of threshold values are anticipated under reasonable worst-case scenario conditions for WTPs, the concentrations of contaminants beyond the immediate point of discharge are sufficiently low that there is considered to be a low risk of ecological damage. The WTPs adopt the BPT technologies and as such, any improvement in water quality can only be achieved through optimising performance during the ETP excavation works.

7 PROPOSED ENVIRONMENT PROTECTION LICENCE POLLUTANT CONCENTRATION LIMITS

The construction WTPs will discharge treated effluent to the receiving waterways identified in Table 21. The construction WTPs have been designed with the objective of treated groundwater and construction process water to the following criteria:

- NSW Water Quality Objectives for Sydney Harbour and Parramatta River
- NSW River Flow Objectives for Sydney Harbour and Parramatta River
- ANZG (2018) default guideline values for 95% species protection for general toxicants, and 99% species protection for bio-accumulating toxicants
- ANZECC (2000) default guideline values for physical and chemical stressors (Table 3.3.2 and 3.3.3 of ANZECC 2000 guidelines).

The Hunter Street East worksite will be handed over to JCG on 17 March 2023 and the existing WTP is a handover item. JCG are proposing to upgrade the existing Hunter Street WTP to include breakpoint chlorination and ion exchange for the purpose of improving water quality and undertake a proof performance monitoring program for the Hunter Street WTP to inform achievable discharge targets. However, to meet Sydney Metro's construction program, JCG are scheduled to commence excavation at the Hunter Street East worksite from April 2023. This will necessitate the use of the existing WTP, which JCG will refurbish on site handover, for initial excavation works in parallel with procurement of the upgraded treatment processes which are scheduled for installation and commissioning from approximately July 2023.

Proposed interim discharge criteria / assessment criteria for the commissioning period of the construction water treatment plants are provided in the following tables:

- Table 35 – Proposed interim discharge criteria for the WTP located at The Bays Station, to be adopted during the proof of performance program as assessment criteria.
- Table 36 – Proposed interim discharge criteria for the WTP located at Pyrmont Station to be adopted during the proof of performance program as assessment criteria.
- Table 37 – Proposed interim discharge criteria for the existing WTP located at Hunter Street, prior to installation of planned refurbishment and upgrades.

The proposed interim criteria are based on a combination of known and anticipated outcomes for effluent water quality associated with the ETP Works during initial stages of WTP commissioning and upgrades. For the existing Hunter Street WTP the proposed discharge criteria are based on current discharge water quality for the existing WTP. The proposed refurbishment and upgrades are anticipated to improve water quality outcomes when completed with achievable discharge criteria identified through a proof of performance program. For Pyrmont Station and The Bays Station, the proposed interim discharge criteria are based on predicted reasonable worst-case scenario outcomes, and are unlikely to be reflective of the average conditions.

It is recommended that the proposed interim criteria are adopted until such time that the proposed proof of performance program (Section 8) can be completed, and final discharge limits based on practical and sustainable treatment outcomes can be determined. As the ETP Works is adopting the best practicable technology (BPT) for water treatment, the proof of performance program will principally involve optimisation of treatment processes including but not limited to dosage rates, and contact times.

It is further recommended that discharge criteria for total nitrogen apply only to inorganic forms of nitrogen, or, are not included in the interim discharge limits. This recommendation accounts for the potentially large fractions of organic nitrogen that may be present in groundwater, which cannot be treated by any available treatment technologies outside of biological treatment processes that are not practical for the ETP Works.

Table 35. Proposed Interim Discharge Criteria – ETP Wastewater Discharge: The Bays

Analyte	Unit	Proposed Interim Discharge Limit	Reference
pH (Lab)	pH unit	7.0 – 8.5	ANZECC 2000 Estuarine limits
Nitrogen (Total inorganic)	µg/L	1,720	Reasonable Worst Case BPT Outcome

Analyte	Unit	Proposed Interim Discharge Limit	Reference
Oxidised Nitrogen ($NO_3 + NO_2$)	µg/L	660	Reasonable Worst Case BPT Outcome
Ammonia (as N)	µg/L	1,500	Reasonable Worst Case BPT Outcome
Total Phosphorus (as P)	µg/L	140	Reasonable Worst Case BPT Outcome
Arsenic	µg/L	4.5	ANZG 2018 95% Species Protection Marine
Cadmium **(B)**	µg/L	0.7	ANZG 2018 99% Species Protection Marine
Chromium	µg/L	4.4	ANZG 2018 95% Species Protection Marine
Cobalt	µg/L	1.4	Reasonable Worst Case BPT Outcome
Copper	µg/L	2	Reasonable Worst Case BPT Outcome
Iron[a]	µg/L	700	Draft ANZG 2018 95% Species Protection Marine
Lead	µg/L	4.4	ANZG 2018 95% Species Protection Marine
Manganese	µg/L	1,900	ANZG 2018 95% Species Protection Marine
Mercury **(B)**	µg/L	0.1	ANZG 2018 99% Species Protection Marine
Nickel	µg/L	70	ANZG 2018 95% Species Protection Marine
Zinc	µg/L	15	Reasonable Worst Case BPT Outcome
TRH+C10 - C40 (Sum of total)	µg/L	100	Laboratory Practical Limit of Reporting

Table 36. Proposed Interim Discharge Criteria – ETP Wastewater Discharge: Pyrmont Station

Analyte	Unit	Proposed Interim Discharge Limit	Reference
pH (Lab)	pH unit	7.0 – 8.5	ANZECC 2000 Estuarine limits
Nitrogen (Total inorganic)	µg/L	1,720	Reasonable Worst Case BPT Outcome
Oxidised Nitrogen ($NO_3 + NO_2$)	µg/L	660	Reasonable Worst Case BPT Outcome
Ammonia (as N)	µg/L	1,500	Reasonable Worst Case BPT Outcome
Total Phosphorus (as P)	µg/L	140	Reasonable Worst Case BPT Outcome
Arsenic	µg/L	4.5	ANZG 2018 95% Species Protection Marine
Cadmium **(B)**	µg/L	0.7	ANZG 2018 99% Species Protection Marine
Chromium	µg/L	4.4	ANZG 2018 95% Species Protection Marine
Cobalt	µg/L	1.4	Reasonable Worst Case BPT Outcome
Copper	µg/L	2	Reasonable Worst Case BPT Outcome
Iron[a]	µg/L	700	Draft ANZG 2018 95% Species Protection Marine
Lead	µg/L	4.4	ANZG 2018 95% Species Protection Marine
Manganese	µg/L	1,900	ANZG 2018 95% Species Protection Marine
Mercury **(B)**	µg/L	0.1	ANZG 2018 99% Species Protection Marine
Nickel	µg/L	70	ANZG 2018 95% Species Protection Marine
Zinc	µg/L	15	Reasonable Worst Case BPT Outcome
TRH+C10 - C40 (Sum of total)	µg/L	100	Laboratory Practical Limit of Reporting

Table 37. Proposed Interim Discharge Criteria – ETP Wastewater Discharge: Hunter Street (Existing)

Analyte	Unit	Proposed Interim Discharge Limit	Reference
pH (Lab)	pH unit	7.0 – 8.5	ANZECC 2000
Nitrogen (Total inorganic)	µg/L	5,400	Hunter Street WTP Existing Performance
Oxidised Nitrogen ($NO_3 + NO_2$)	µg/L	1,900	Hunter Street WTP Existing Performance
Ammonia (as N)	µg/L	1,900	Hunter Street WTP Existing Performance
Total Phosphorus (as P)	µg/L	570	Hunter Street WTP Existing Performance
Arsenic	µg/L	13	ANZG 2018 95% Species Protection Marine
Cadmium **(B)**	µg/L	0.7	ANZG 2018 99% Species Protection Marine
Chromium	µg/L	26	Hunter Street WTP Existing Performance
Cobalt	µg/L	1	ANZG 2018 95% Species Protection Marine
Copper	µg/L	19	Hunter Street WTP Existing Performance
Iron[a]	µg/L	700	Draft ANZG Marine Guideline Value

Analyte	Unit	Proposed Interim Discharge Limit	Reference
Lead	µg/L	4.4	ANZG 2018
Manganese	µg/L	1,900	ANZG 2018
Mercury **(B)**	µg/L	0.1	ANZG 2018
Nickel	µg/L	70	ANZG 2018
Zinc	µg/L	220	Hunter Street WTP Existing Performance
TRH+C10 - C40 (Sum of total)	µg/L	<100	Practical Limit of Reporting

It is recommended that the proposed discharge limits provided in in Table 37 are adopted as interim criteria until completion of the proof of performance programmes for the Hunter Street WTP. Proof of performance programmes are also proposed for the new construction WTPs at The Bays and Pyrmont Station. Information from upgrades of the Hunter Street WTP and performance testing of WTPs at the Bays and Pyrmont Station will subsequently be used to evaluate optimal performance outcomes and identify potential discharge limits. Final EPL discharge limits should also account for mitigating potential impacts to receiving waterways in keeping with the NSW Water Quality Objectives.

It should be noted that the proposed interim discharge criteria are largely reflective of the anticipated reasonable worst-case scenario conditions for Hunter Street, so that the WTP can continue to operate under existing conditions until completion of the proof of performance program and upgrades if required. Water quality data from commissioning and initial operation of the Bays and Pyrmont Station WTPs may likely show better initial water quality outcomes, significantly below the proposed interim discharge limits.

The proposed proof of performance program will assist in providing verifiable information on attainable and sustainable discharge limits for the ETP Works. Further detail on a proposed performance monitoring program is provided in Section 8.

8 PROOF OF PERFORMANCE MONITORING PROGRAM

JCG are proposing to undertake a proof of performance (PoP) monitoring program to support the proposed refurbishment and upgrades of the existing Hunter Street WTP and installation of new construction WTPs at the Bays and Pyrmont.

Installation and upgrades of the construction water treatment plants is expected to occur at different dates, which relate to the construction program of works. The anticipated program of works including installations, upgrades, commencement of discharge and recommended performance monitoring periods are provided in Table 38

Table 38. Proposed Construction Schedule and Proof of Performance Monitoring Programs

Site	Activity	2023												2024		
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Hunter Street	Refurb			■												
	Upgrades							■								
	Discharge			■	■	■	■	■	■	■	■	■	■	■	■	■
	PoP			■	■	■	■	■	■	■	■	■	■			
Pyrmont	Install							■								
	Discharge								■	■	■	■	■	■	■	■
	PoP								■	■	■	■	■			
The Bays	Install							■								
	Discharge								■	■	■	■	■	■	■	■
	PoP								■	■	■	■	■			

JCG intend to undertake the following activities as part of the proof of performance program for each water treatment plant:

- Fortnightly monitoring of influent water quality and treated effluent water quality, including all parameters listed in the proposed EPL Licence Criteria and those identified in groundwater at concentrations exceeding the Default Guideline Values
- Fortnightly monitoring of receiving surface waters at locations upstream, downstream, and adjacent to the effluent discharge point
- Screening of all water quality data against EPL Licence Criteria, and ANZG / ANZECC DGVs
- Monitoring and reporting of chemicals, dosing rates, contact times, filters, and approaches taken to optimise and maintain optimised performance of the water treatment plants in removing contaminants from feed water.

During the commissioning monitoring period JCPG will ensure that impacts from treated effluent on the receiving environment are minimised through:

- Regular maintenance of WTP plant, machinery, dosing rates, and filters to ensure optimal efficiency of WTPs is maintained.
- Use of contingency measures where there is a risk of effluent exceeding discharge criteria, including (where suitable):
  - Beneficial reuse on-site (e.g., dust suppression, recycling of process water)
  - Recirculation through the WTP.

The outcomes from performance monitoring will be incorporated into a technical report, which will include:

- Results from fortnightly monitoring of influent (feed water) and effluent water quality, screened against the proposed EPL licence criteria, and ANZG / ANZECC DGVs
- Results from fortnightly monitoring of receiving surface waters at upstream, downstream and discharge point monitoring sites, screened against the proposed EPL licence criteria, and ANZG / ANZECC DGVs
- Summary of the treatment processes, including chemicals, dosing rates, and approaches taken to optimise and maintain performance over the commissioning period

- Recommendations for any further monitoring and/or assessment to further assess potential environmental impact
- Recommendations for any additional water treatment processes to further minimize potential environmental impacts.

It is recommended to adopt Chelex testing methods for laboratory testing of water quality samples to assess the bioavailable concentrations of metals in both effluent and receiving waters. The Chelex method (NATA accredited) is preferred over standard ICP/MS methods as a more accurate means to assess potential risks to aquatic ecosystems with respect to ANZG standards.

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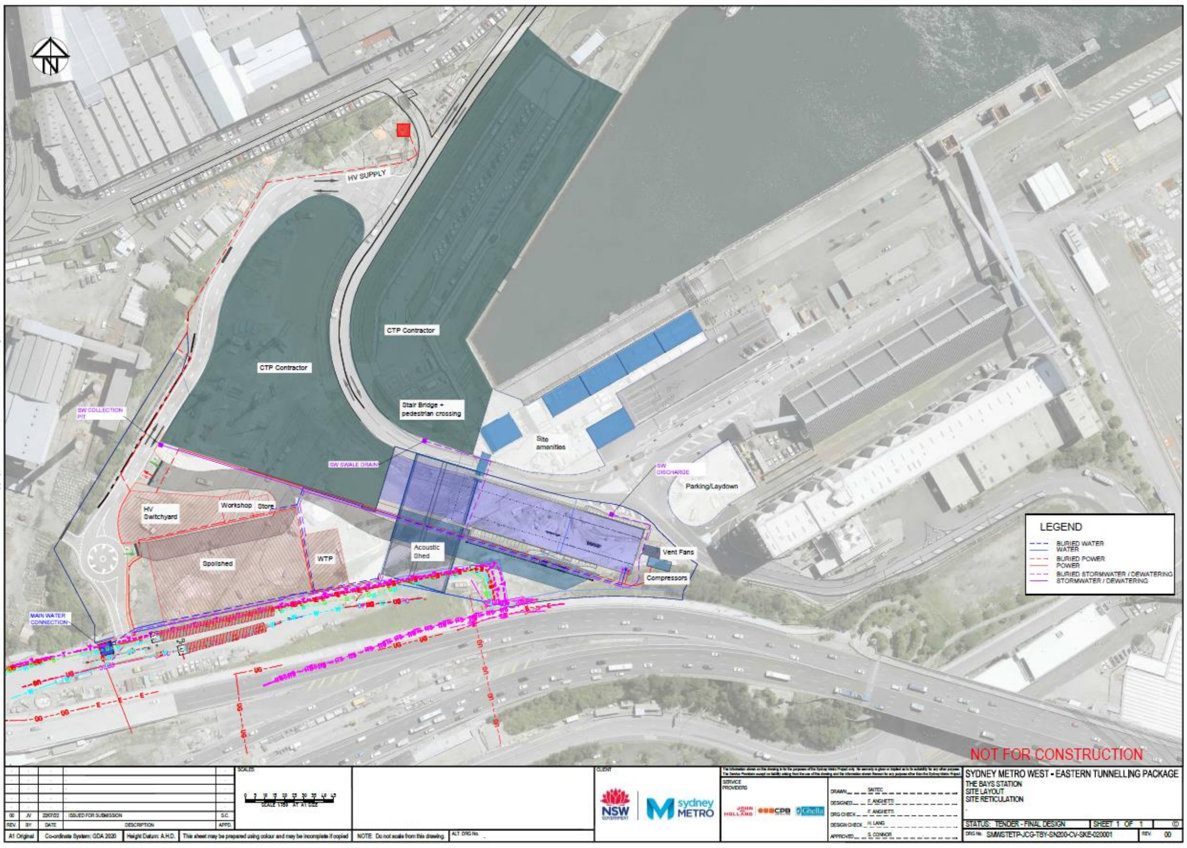
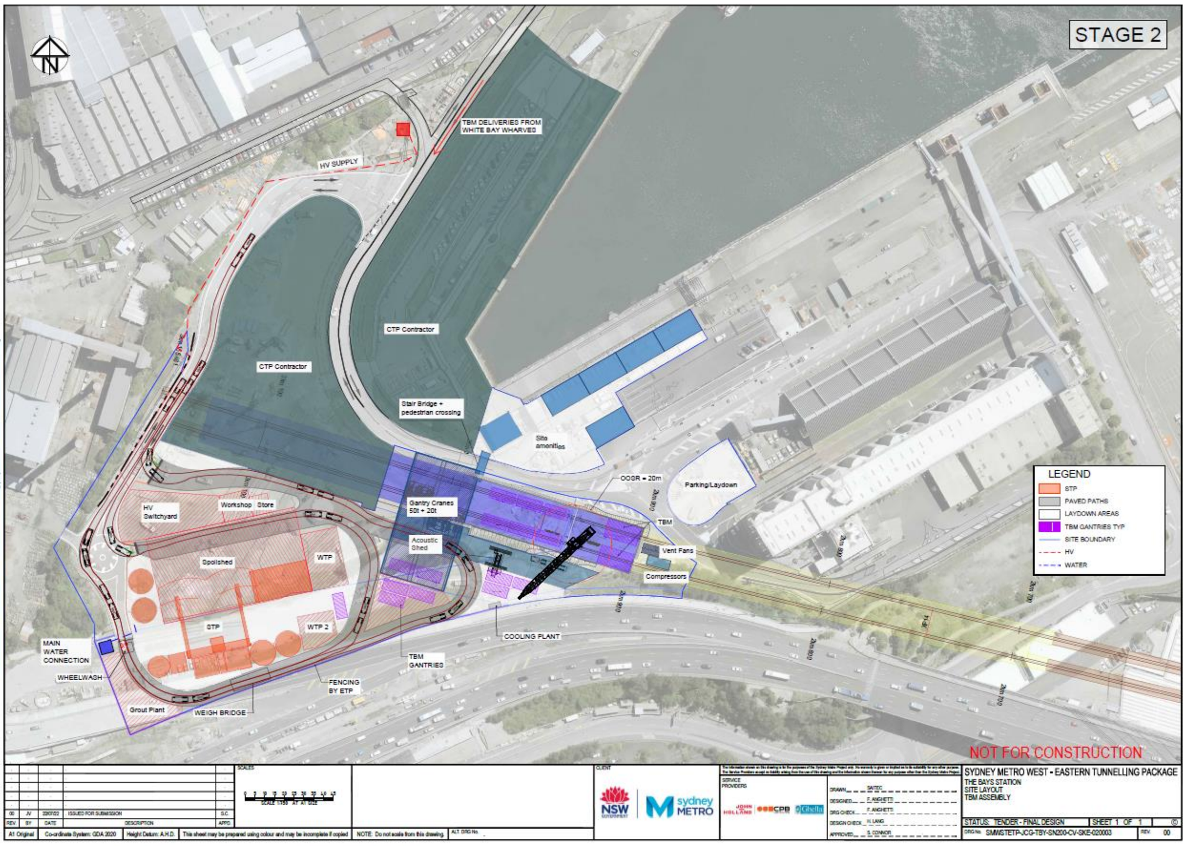
APPENDIX A INDICATIVE CONSTRUCTION LAYOUT PLANS

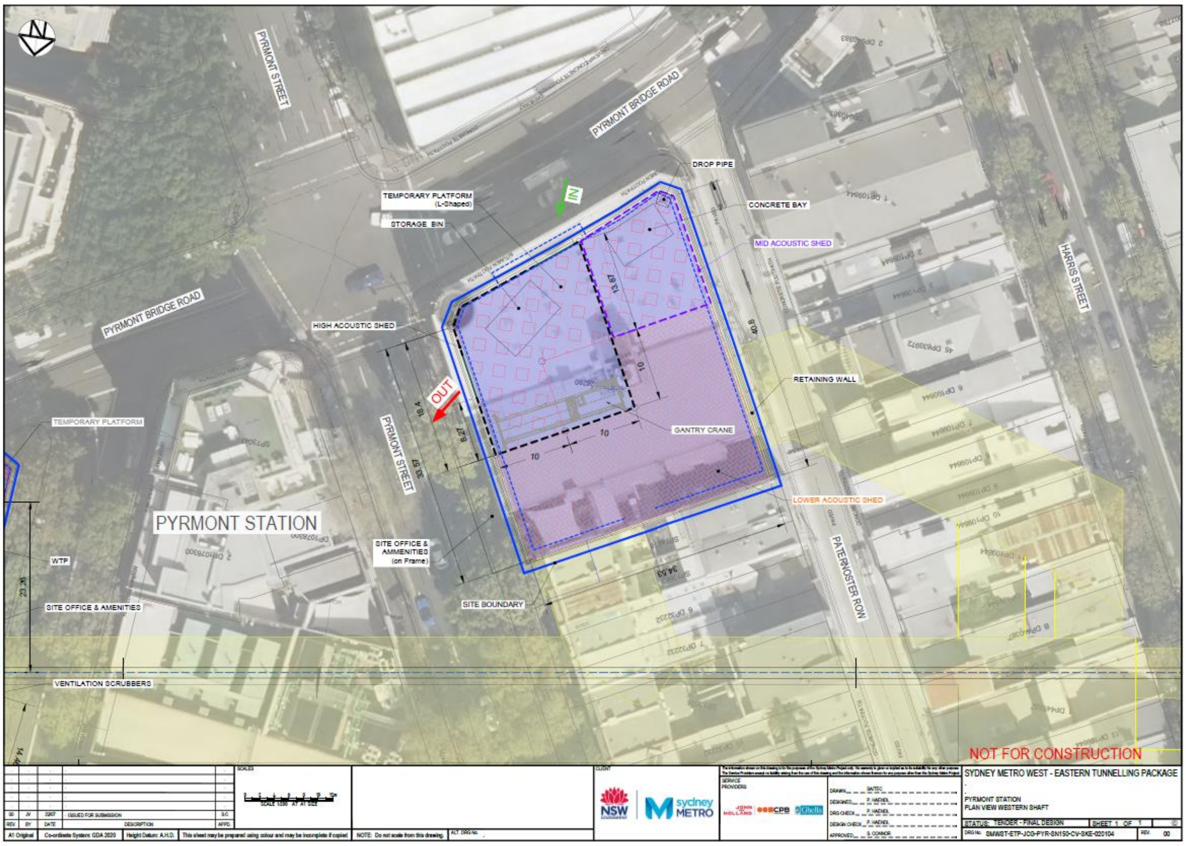
The Bays Station site reticulation



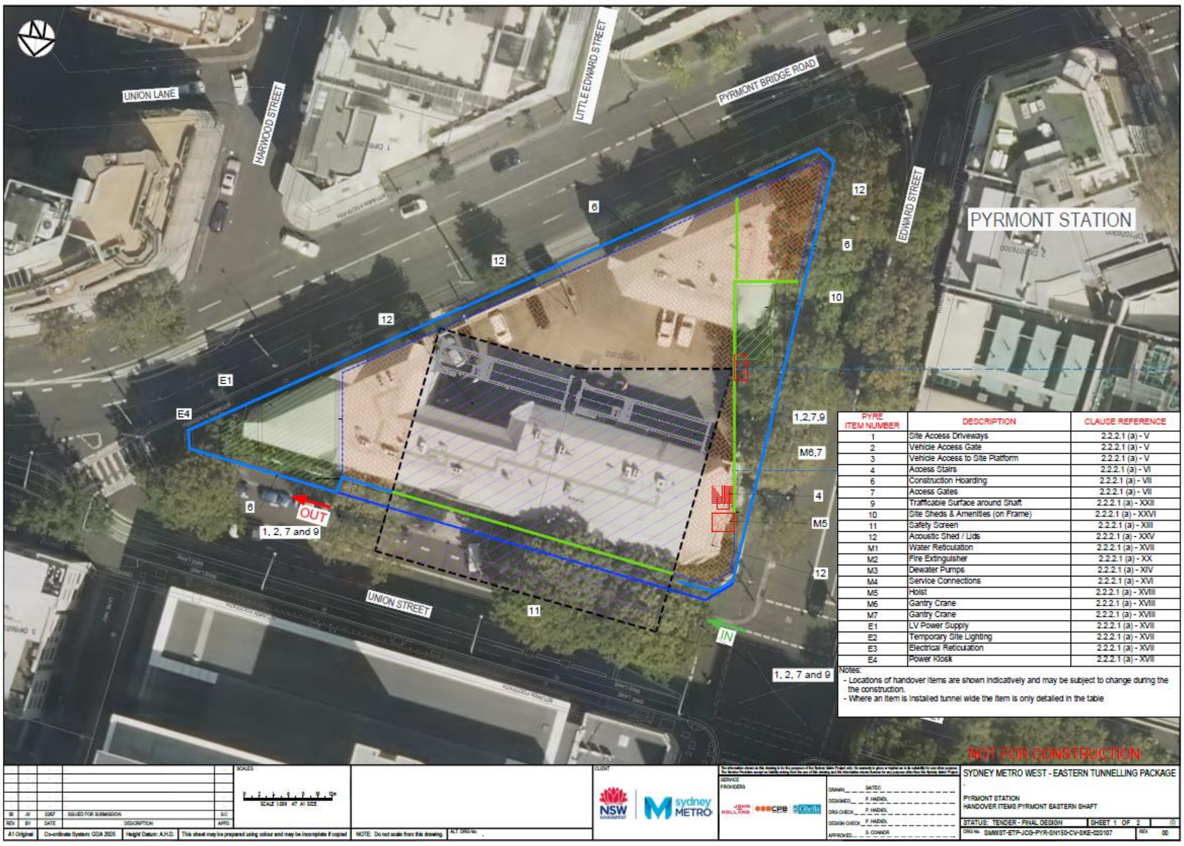
The Bays Station site layout – TBM assembly



Pyrmont Station plan view western shaft



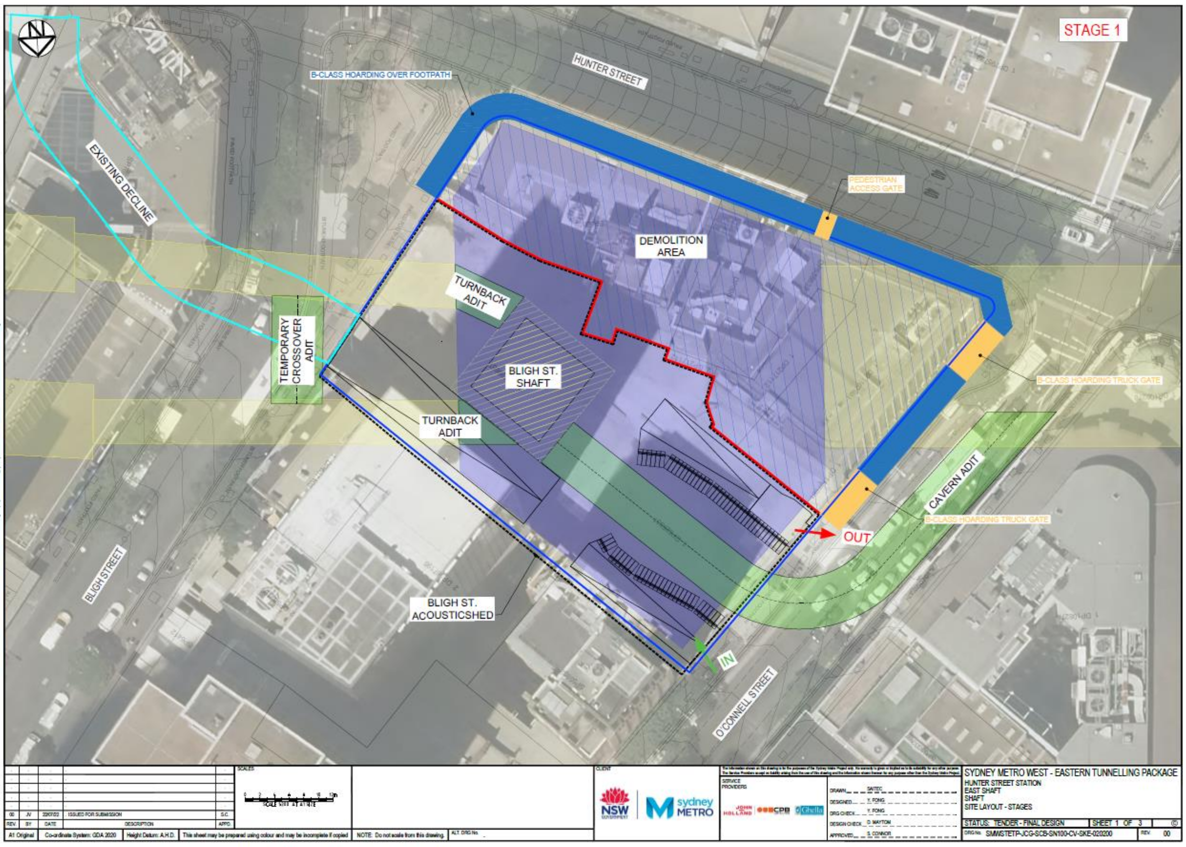
Pyrmont Station handover items Pyrmont eastern shaft



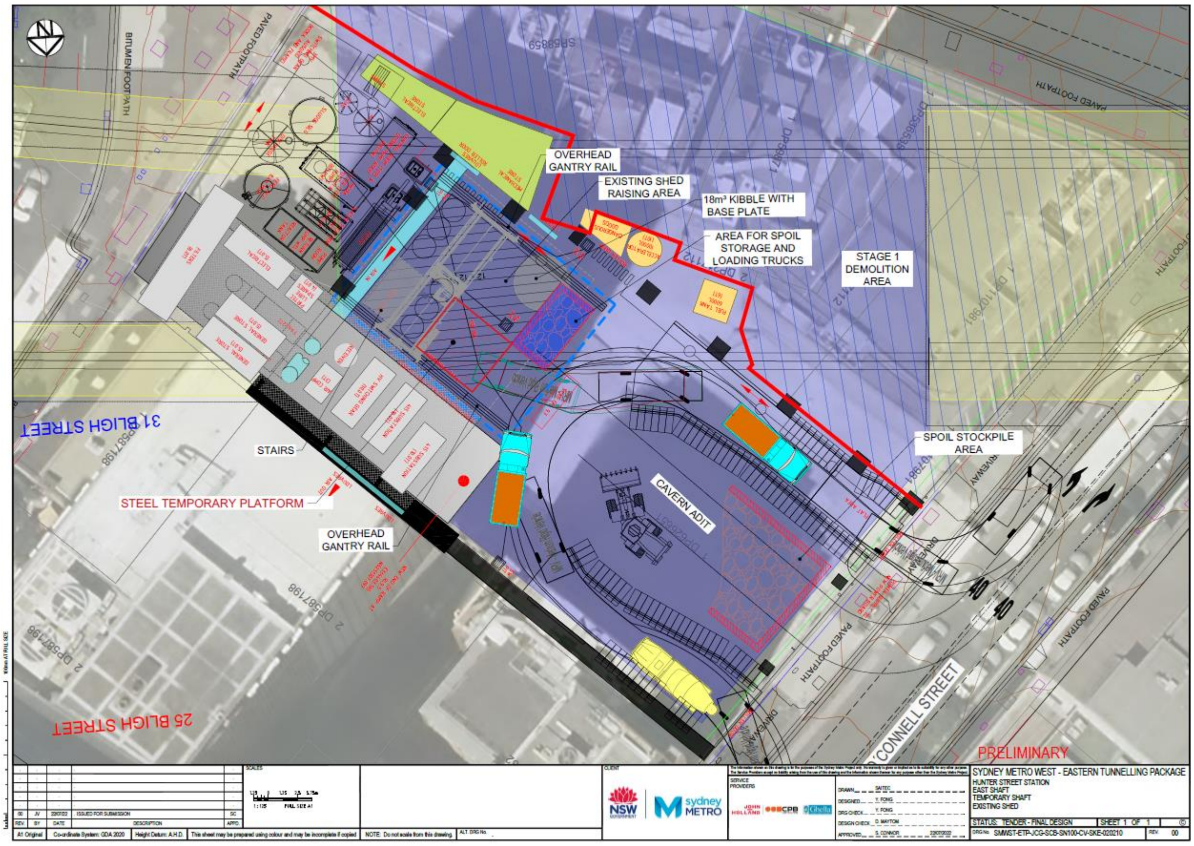
PYRE ITEM NUMBER	DESCRIPTION	CLAUSE REFERENCE
1	Site Access Driveways	2.2.2.1 (a) - V
2	Vehicle Access Gate	2.2.2.1 (a) - V
3	Vehicle Access to Site Platform	2.2.2.1 (a) - V
4	Access Stairs	2.2.2.1 (a) - VI
6	Construction Hoarding	2.2.2.1 (a) - VII
7	Access Gates	2.2.2.1 (a) - VII
9	Trafficable Surface around Shaft	2.2.2.1 (a) - XXII
10	Site Sheds & Amenities (on Frame)	2.2.2.1 (a) - XXVI
11	Safety Screen	2.2.2.1 (a) - XIII
12	Acoustic Shed / Lids	2.2.2.1 (a) - XXV
M1	Water Reticulation	2.2.2.1 (a) - XVII
M2	Fire Extinguisher	2.2.2.1 (a) - XX
M3	Dewater Pumps	2.2.2.1 (a) - XIV
M4	Service Connections	2.2.2.1 (a) - XVI
M5	Hoist	2.2.2.1 (a) - XVIII
M6	Gantry Crane	2.2.2.1 (a) - XVIII
M7	Gantry Crane	2.2.2.1 (a) - XVIII
E1	LV Power Supply	2.2.2.1 (a) - XVII
E2	Temporary Site Lighting	2.2.2.1 (a) - XVII
E3	Electrical Reticulation	2.2.2.1 (a) - XVII
E4	Power Kiosk	2.2.2.1 (a) - XVII

Notes:
- Locations of handover items are shown indicatively and may be subject to change during the the construction.
- Where an item is installed tunnel wide the item is only detailed in the table

Hunter Street Station east shaft site layout – stages



Hunter Street Station east shaft temporary shaft – existing shed



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