Review of Environmental Factors

JOYNTON AVENUE, ZETLAND – STORMWATER DRAINAGE UPGRADE

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ACRONYMS AND ABBREVIATIONS

AHIMS	Aboriginal heritage information management system
BC Act	*Biodiversity Conservation Act 2016*
CEMP	Construction environmental management plan
Cwth	Commonwealth
DECCW	Refer to OEH
DP&I	(NSW) Department of Planning and Infrastructure
EEC	Endangered ecological community – as defined under relevant law applying to the proposal
EIA	Environmental impact assessment
EKI	Extended Kerb Inlet
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwth)
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
ESD	Ecologically Sustainable Development
FM Act	*Fisheries Management Act 1994* (NSW)
GPT	Gross Pollutant Traps
ha	hectares
Heritage Act	*Heritage Act 1977* (NSW)
ISEPP	*State Environmental Planning Policy (Infrastructure) 2007* (NSW)
IL	Invert Level
KFH	Key Fish Habitat
km	kilometres
LALC	Local Aboriginal Land Council
LEP	Local Environment Plan
m	Metres
NES	Matters of National environmental significance under the EPBC Act (*c.f.*)
Noxious Weeds Act	*Noxious Weeds Act 1993* (NSW)
NPW Act	*National Parks And Wildlife Act 1974* (NSW)
NSW	New South Wales
NV Act	*Native Vegetation Act 2003* (NSW)
OEH	(NSW) Office of Environment and Heritage, formerly Department of Environment, Climate Change and Wate
RC	Reinforced Concrete
RCBC	Reinforced Concrete Box Culvert

RCP	Reinforced Concrete Pipe
REF	Review of Environmental Factors
REP	Regional Environmental Plan
SEPP	State Environmental Planning Policy (NSW)
SEWPAC	(Cwth) Department of Sustainability, Environment, Water, Population and Communities
SIS	Species Impact Statement
sp/spp	Species/multiple species

1 INTRODUCTION

The City of Sydney Council (the City) proposes to construct a stormwater trunk drain in Joynton Avenue, Zetland, between O'Dea Avenue and Elizabeth Street (the proposal site; Figure 1-1). The trunk drain is required to provide stormwater relief as well as linking the new upstream O'Dea Avenue trunk drain with the new Green Square trunk drain discharging to Alexandra Canal. The proposal is located in the Green Square Urban Renewal Area and the area has experienced substantial development in recent years requiring increased stormwater capacity. The proposal is required to reduce flooding on Joynton Avenue for events up to and including the 1 in 20 year rainfall events.

The proposal involves construction of a stormwater main along the eastern side of Joynton Avenue. Microtunnelling would be used to construct the pipeline and open trenching undertaken for local stormwater connections. Microtunnelling is a process where a pipe is tunnelled between a launch pit and receiving pit, minimising above ground impacts. The proposal would involve:

- Constructing stormwater mains
- Connecting new main to existing stormwater infrastructure
- Constructing new junction chambers
- Constructing new stormwater pits along Joynton Avenue
- Constructing Gross Pollutant Traps (GPT)
- Decommissioning of redundant stormwater infrastructure
- Management of Woolwash Pond, including all approvals and permits
- Relocation of Post Box at the corner of Gadigal Avenue & Joynton Avenue
- Settlement monitoring during construction along the alignment and nearby buildings and roads.
- Management of existing groundwater system during construction (may include dewatering)

1.1 SITE DESCRIPTION

Green Square Urban Renewal Area

The Green Square Urban Renewal Area is located in an important economic corridor between Sydney's City Centre and Kingsford Smith International Airport. It incorporates the suburbs of Zetland and Beaconsfield and parts of Roseberry, Alexandria and Waterloo and covers an area of 278 hectares. Four major new precincts are planned for the area:

- Green Square Town Centre: 2014-2024
- Lachlan: 2014-2019
- Epsom Park: 2014-2024
- North Rosebery: 2014-2019.

The Lachlan precinct is located within the north-east of the Green Square Urban Renewal Area, in the suburb of Waterloo and is positioned four kilometres south of the Sydney Central Business District. The close proximity of major roads including the Eastern Distributor and Bourke Street, which run north-south along each side of the site, ensure good access and connectivity to Sydney's metropolitan region. The precinct has a total site area of about 17.5 hectares. It is highly urbanised, with industrial development being the dominant land use. Since the 1990's, much of the neighbouring urban renewal areas of Crown Square, Victoria Park and Mary O'Brien have transitioned from older industrial buildings to residential and mixed use developments. The proposed land use objectives for Lachlan is to provide a predominantly residential precinct within a mix of open spaces, ground floor retail, offices, shops and generally compatible commercial development.

Joynton Avenue

Joynton Avenue is a two-lane, sub-arterial road connecting O'Dea Avenue to the north and Epsom Drive to the south. The City is the roads authority for this road. The dominant features in the street are the residential units, lines of mature fig trees of heritage significance on both sides of the road and by Mary O'Brien Reserve. The Green Square Library is located at 100 Joynton Avenue in heritage listed building. The library will close and relocate from the 1st of June 2018, however the heritage building will remain. The street has a number of bus stops and forms part of a key bus corridor linking the Sydney CBD to Mascot, Botany, Kingsford and Rosebery. There are a number of businesses around O'Dea Avenue, Gadigal Avenue and Elizabeth Street, and the southern extent of the proposal is at an AusGrid depot.

Proposal Site

The alignment of the proposed underbore extends over about 470 m and is located along the eastern side of Joynton Avenue, Zetland, between O'Dea Avenue and Elizabeth Street ('the site'). In general, the ground surface levels along the proposed pipe alignment fall gently to the south-south-west at less than 1 degree.

The public roads along the proposed pipe alignment are generally paved with asphaltic concrete (AC) and there are various buildings located close to the route. There are also a number of large fig trees in the area. A preliminary design for the proposed works is provided in Appendix A.

1.2 ENVIRONMENTAL ASSESSMENT AND APPROVALS PROCESS

This Review of Environmental Factors (REF) has been prepared by NGH Environmental on behalf of the City. For the purposes of these works, the City is the proponent and the determining authority under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The purpose of the REF is to describe the proposal, to document the likely impacts of the proposal on the environment, and to detail protective measures to be implemented to avoid, minimise and/or mitigate those impacts.

The description of the proposed works and associated environmental impacts have been undertaken in context of clause 228 of the *Environmental Planning and Assessment Regulation 2000*, the *Biodiversity Conservation Act 2016* (BC Act) and the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In doing so, the REF helps to fulfil the requirements of section 5.5 of the EP&A Act, that the City examines and takes into account to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the activity.

The findings of the REF would be considered when assessing:

- Whether the proposal is likely to have a significant impact on the environment and therefore the necessity for an environmental impact statement to be prepared and approval to be sought from the Minister for Planning under Division 5.2 of the EP&A Act
- The significance of any impact on threatened species as defined by the BC Act and Section 1.7 of the EP&A Act and therefore the requirement for a Species Impact Statement or a Biodiversity Development Assessment Report
- The potential for the proposal to significantly impact a Matter of National Environmental Significance or Commonwealth land and the need to make a referral to the Australian Government Department of the Environment for a decision by the Commonwealth Minister for the Environment on whether assessment and approval is required under the EPBC Act.

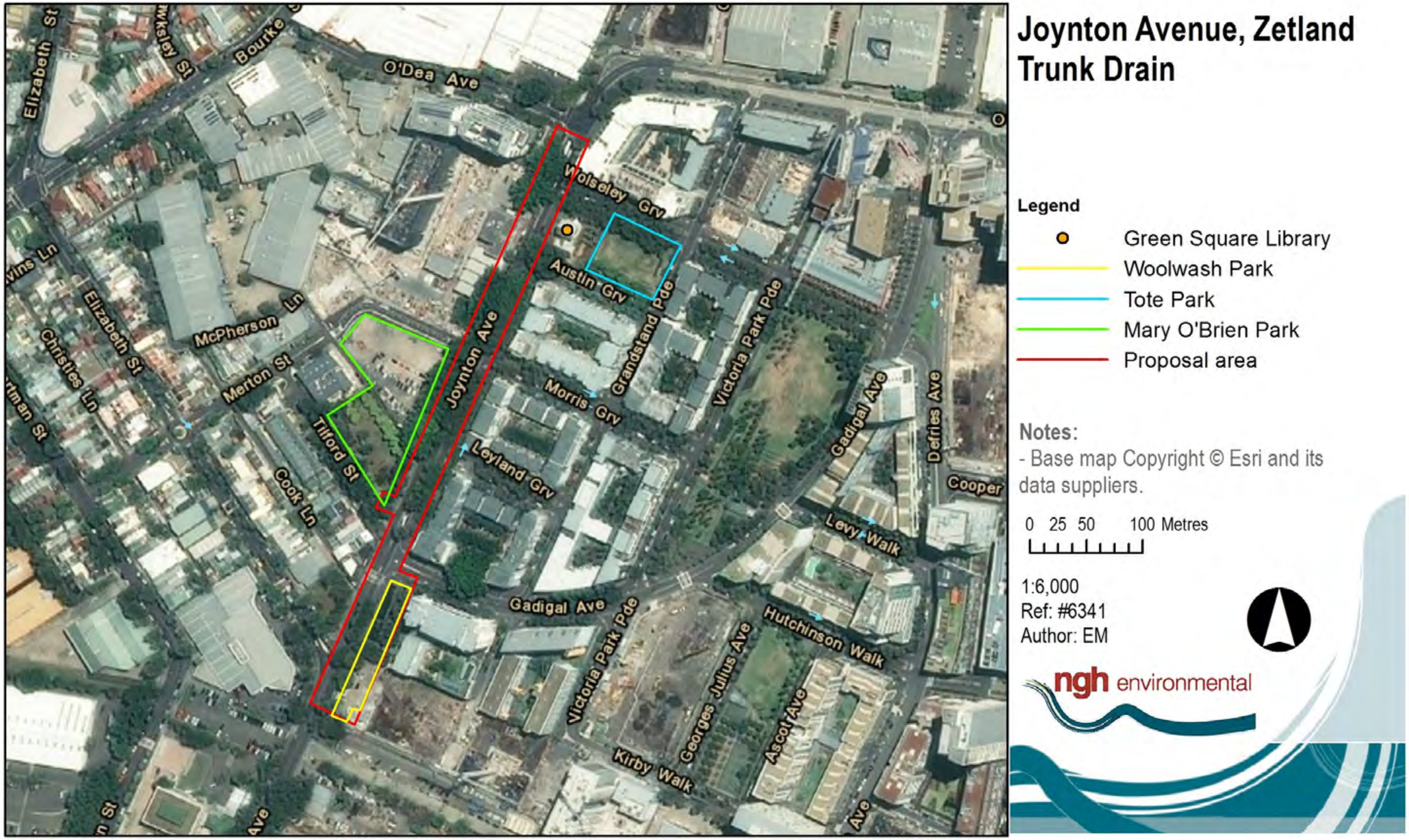


Figure 1-1 Proposal site

1.3 BACKGROUND

Flooding and existing stormwater infrastructure

Joynton Avenue is located in the Green Square and West Kensington catchment. Urbanisation has dramatically altered the nature of available drainage within the catchment. The current alignment of Joynton Avenue is adjacent to the former boundary of the Waterloo Swamp, and towards the southern extent of the site, at approximately the junction of Joynton Avenue and Elizabeth Street, Joynton Avenue crosses what was once Big Waterloo Dam. Flood problems typically result from insufficient capacity in the formal drainage system and ponding in trapped low-points such as those found in Joynton Avenue, Lachlan Street, South Dowling Street and Botany Road. A number of these locations are known to have experienced severe flooding in the past.

The existing stormwater infrastructure in the area does not have the capacity to carry the volumes of stormwater generated during heavy rainfall. The existing infrastructure includes:

- 3.0 metre x 1.5 metre and 600 millimetre mains on the western side of Joynton Avenue;
- 1.3 metre x 1 metre main on the eastern side of Joynton Avenue;
- Two parallel 1350 millimetre diameter mains on Gadigal Avenue;
- Existing GPTs at the intersection of Gadigal Avenue and Joynton Avenue; and
- Two parallel 1500 millimetre diameter mains at the northern end of the Joynton Avenue.

1.4 SURROUNDING DEVELOPMENT

Three adjacent major stormwater upgrade projects are currently in various stages and will be completed in 2019 and 2020:

- O’Dea Avenue Crossing on the western side of Joynton Avenue
- Green Square Stormwater Drain
- Joynton Avenue, Stage 4A

The upgrade work on O’Dea Avenue would connect to the upstream of the 3.0 metre x 1.5 metre main on the western side of the Joynton Avenue at the junction of O’Dea Avenue. This will be carried out by Private Developer under a VPA Agreement.

The Joynton Avenue proposal would then connect to the Green Square Stormwater Drain near Elizabeth Street outside the Ausgrid Site at 130 Joynton Avenue. This project provides increased capacity to carry stormwater to Alexandra Canal.

The Joynton Avenue and Zetland Avenue Infrastructure Proposal is located within the Green Square Town Centre which is a new retail/commercial and residential precinct in Zetland. The Proposal is for infrastructure works centred upon the creation of Zetland Avenue and upgrade of the existing Joynton Avenue as well as the associated utilities and public domain including:

- Creation of Zetland Avenue Mid (between Portman Street and Joynton Avenue) including a cyclepath and associated public domain works
- Creation of Zetland Avenue East (between Joynton Avenue and the future Victoria Park Parade) including a cyclepath and associated public domain works
- Upgrade of the existing Joynton Avenue
- A new intersection between Joynton Avenue and the proposed Zetland Avenue;
- Internal utilities reticulation and lead-ins

- Reinstatement of pavements outside the new roads where excavation is required for services works

2 NEED AND OPTIONS CONSIDERED

2.1 REASONS FOR THE ACTIVITY

Need for the proposal

A Flood Risk Management Study for the Green Square-West Kensington catchment was completed in 2013 (WMA Water, 2013). The study found that flood problems typically result from ponding in trapped low-points such as those found in Lachlan Street, South Dowling Street, Botany Road and Joynton Avenue. Table 2-1 provides predicted flood depths on Joynton Avenue for floods of different Annual Exceedance Probabilities (AEP).

Table 2-1 Flood depths (m) on Joynton Avenue for various AEPs

50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP	PMF
1.6	1.9	2	2.1	2.2	2.3	2.4	3

The study assessed a variety of flood management measures. Pit/pipe and trunk system upgrade was identified as a management measure of high priority. Upgrades to the O'Dea Avenue and Joynton Avenue trunk system forms part of this management measure.

Proposal objectives

The objectives of the proposal are:

- Provide increased stormwater capacity for existing and future development
- Reduce the risk of flood events
- Minimise impacts on services
- Retain fig trees on Joynton Avenue
- Minimise environmental impacts
- Improve water quality

2.2 CONSIDERATION OF OPTIONS

Option 1 - Do nothing

This option would maintain the existing condition. It would not provide any stormwater relief and localised flooding on Joynton Avenue would be likely to continue. There would be no construction impacts associated with this option.

Option 2 – Open trench in middle of Joynton Avenue

Construct the trunk main in the middle of Joynton Avenue using open trenching. This option would not align with the O'Dea Avenue trunk main. It would require the relocation of services in particular an 840 millimetre diameter Sydney Water main, and would have substantial noise, traffic and potentially dust impacts on local residents.

Option 3 – Open trench in Joynton Avenue footpath

Construct the trunk main using open trenching on the footpath of Joynton Avenue. This option would not align with the O'Dea Avenue trunk main but would minimise impacting services as well as traffic compared to Option 2. It would however impact the heritage fig trees with a high number needing to be removed and would also have more air quality and noise impacts compared to Option 4.

Option 4 – Microtunneling beneath Joynton Avenue Footpath

Construct the trunk main under the fig trees in the footpath of Joynton Avenue using microtunnelling. This option would align the main with the O'Dea Avenue trunk main, with minimal head loss. This option would minimise the number of heritage fig trees lost, with no high retention value trees lost if tunnelling goes as planned.

2.3 SELECTION OF THE PREFERRED OPTION

Option 4 would provide increased stormwater capacity and reduce the risk of flooding on Joynton Avenue. The use of microtunnelling to construct the pipe would minimise the impact on services. Tunnelling would be at a depth of about four metres to the top of the pipe and would not impact the fig trees. Excavations would only be required for the launch/receiving pits for the tunnelling, minimising dust impacts. Noise impacts on residents around the launch pits are likely to be substantial. The City determined that Option 4 provides the most feasible solution to comply with the project objectives.

Table 2-2 Analysis of options

Option	Increase stormwater capacity	Reduce the risk of flood events	Minimise impacts on services	Retain fig trees	Minimise environmental impacts	Water quality
Option 1	No	No	Yes	Yes	Yes	No
Option 2	Yes	Yes	No	Yes	No	Yes
Option 3	Yes	Yes	No	No	No	Yes
Option 4	Yes	Yes	Yes	Yes	Yes	Yes

3 PROJECT DESCRIPTION

The City proposes to construct a stormwater trunk main from O'Dea Avenue to Elizabeth Street in Zetland (refer to Figure 3-1). The main elements of the proposal are:

- Installation of trunk mains (1800 millimetres diameter reinforced concrete pipe) from O'Dea Avenue to Elizabeth Street
- Connections to existing stormwater infrastructure
- Connections to future stormwater connections
- Decommissioning of redundant stormwater infrastructure
- Construction of a Gross Pollutant Trap (GPT) on Joynton Avenue to improve water quality

The preliminary design is attached as Appendix A and includes:

Joynton Avenue near Wolseley Grove

- Install new 1800 mm trunk drain along the eastern side of Joynton Avenue

- Remove existing pits and realign 2 x 1500mm reinforced concrete pipes (RCP) to new diversion chamber
- Diversion chamber away from the existing building line
- Install new GPT Reinforced Concrete (RC) pit
- Realign existing 1.3m x 1.0m Reinforced Concrete Box Culvert (RCBC) to avoid GPT

Joynton Avenue near Morris Grove

- Install new 1800 mm trunk drain along the eastern side of Joynton Avenue
- Install two new extended kerb inlet (EKI) pit, 375mm RCP and junction pit over existing RCB
- Install pipe launch/receive pit, as required.

Joynton Avenue near Gadigal Avenue and Leyland Grove

- Install new 1800 mm trunk drain along the eastern side of Joynton Avenue
- Install new 1800 mm trunk drain from the corner of Joynton Avenue and Tilford Street to the new junction chamber near Joynton Avenue and Gadigal Avenue
- Construct new pit at existing invert level (IL)
- Construct new RC pit
- Install three EKI pits over existing RCBC
- Demolish existing EKI pit and pipe
- Install two new junction chambers and receiving/launching pits, as required
- Reconnect existing GPTs and reconfigure to suit new arrangement
- Decommissioning of redundant stormwater infrastructure
- Install new 1350mm RCP

Joynton Avenue near Elizabeth Street

- Install two new 1800 mm trunk drain along the eastern side of Joynton Avenue
- Install EKI pit cover over existing RCP
- Install new 450mm and 900mm RCP
- Install pipe launch/recovery pit, as required
- Decommission existing redundant stormwater infrastructure
- Connection of two new 1800 mm RCP to existing pit near Ausgrid entrance
- Removal of temporary retrofitting works at existing manhole EX5

Drainage of Woolwash Pond

- Woolwash Pond, which is located to the south west of the junction of Joynton Avenue and Gadigal Avenue, may have to be managed/drained during the course of the works to reduce flooding risk of excavations during construction.

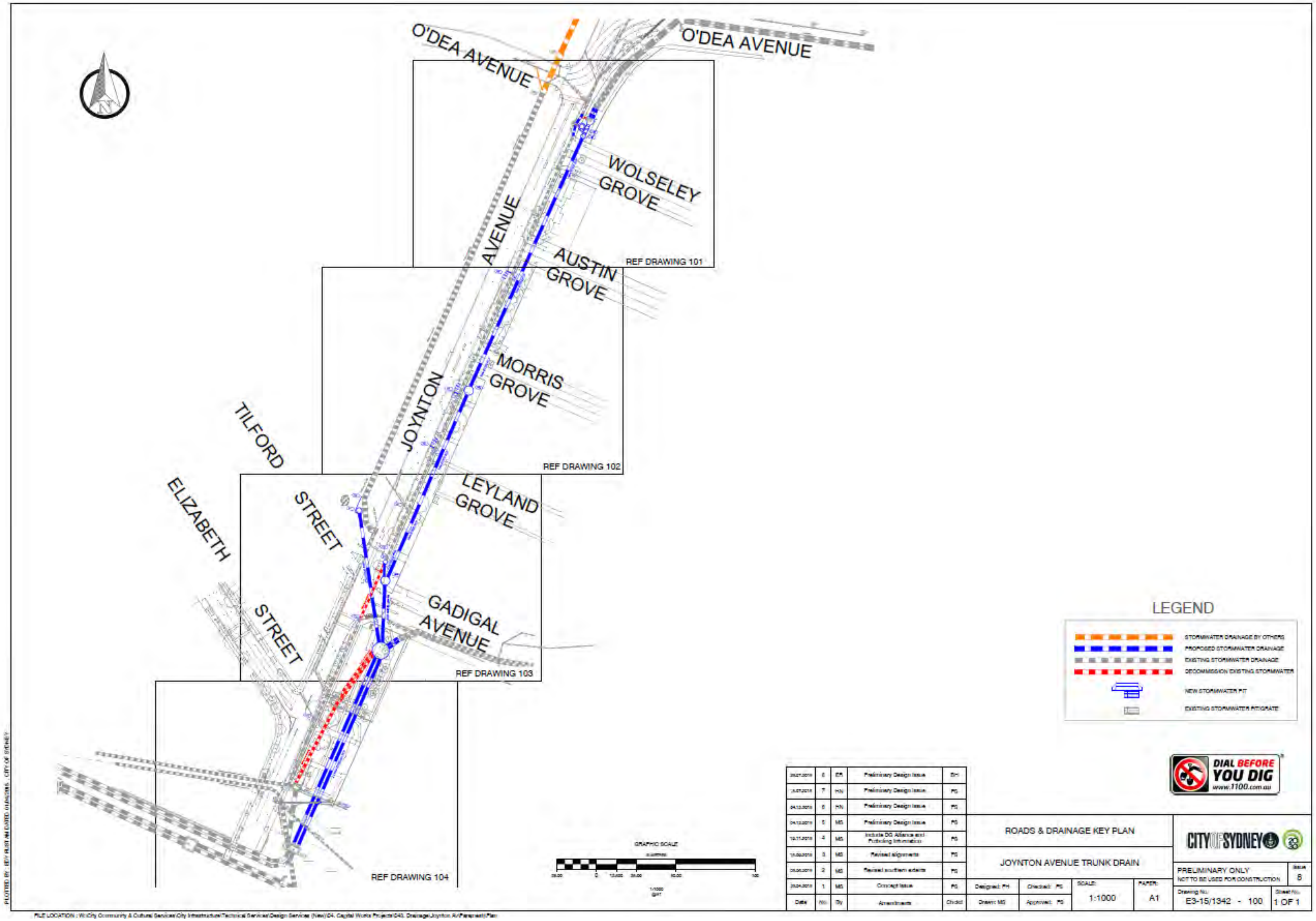


Figure 3-1 The proposal

3.1 CONSTRUCTION METHODOLOGY

Summary of construction

Site set up

- Set up site compound, as required
- Remove nine trees (considered to be of low to moderate retention value) trees within the proposal corridor (refer to Arboricultural Impact Assessment report attached as Appendix B).
- Install erosion and sediment control measures as per Landcom's "Managing urban stormwater soil and construction" (Blue Book)
- Install traffic and pedestrian detours

Section between O'Dea Avenue and Morris Grove

- Deliver plant and ancillary tunnelling equipment to the launch pit location
- Remove existing temporary pits at O'Dea Avenue
- Excavate pit (refer to pit 1/27 in preliminary drawings) at Wolseley Grove and Joynton Avenue intersection for GPT and microtunnelling works
- Realign existing box culvert main to avoid new GPT
- Install caisson and dewatering equipment
- Excavate pit if required (refer to pit 1/28 in preliminary drawings) on the southern side of Morris Grove
- Dewater pit 1/28 and 1/27 if required(this would continue throughout the tunnelling)
- Ensure groundwater drawdown will not cause settlement of adjacent structures or infrastructure. If required, clean water or captured groundwater (depending on groundwater contamination) would be injected into the ground (this would continue throughout the tunnelling)
- Install microtunnelling machine
- Tunnel between O'Dea/Joynton Avenue intersection (pit 1/27) and Morris Grove and Joynton Avenue intersection (pit 1/28)
- Backfill pit
- Restore footpath at O'Dea/Joynton Avenue intersection (location of pit 1/27)
- Landscape disturbed areas
- Install 1800 mm diameter RCP from 1/27 to 1/28 and 1/28 to 1/29

Section between Morris Grove and north side of Gadigal Avenue

- Deliver plant and ancillary tunnelling equipment to the launch pit location
- Excavate pit (refer to pit 1/29 in preliminary drawings) at Gadigal Avenue and Joynton Avenue intersection
- Install caisson and dewatering equipment
- Dewater pits if required(this would continue throughout the tunnelling)
- Ensure groundwater drawdown will not cause settlement of adjacent structures or infrastructure. If required, clean water or captured groundwater (depending on groundwater contamination) would be injected into the ground (this would continue throughout the tunnelling)
- Install microtunnelling machine
- Tunnel between Morris Grove and Joynton Avenue intersection (pit 1/28) and Gadigal Avenue and Joynton Avenue intersection (pit 1/29)
- Backfill pit
- Construct reinforced concrete pit in place of pit 1/28 on the southern side of Morris Grove
- Restore footpath at Morris Grove
- Landscape disturbed areas
- Install 1350mm diameter RCP from 2/1 to 1/29

Section between north of Gadigal Avenue and Woolwash Park

- Remove vegetation from Woolwash Park as per Arboriculture Impact Assessment Report Appendix B.
- Manage/Drain Woolwash Pond (depending on contractor requirement) to stormwater
- Excavate pit (refer to pit 1/30 in concept drawings) at south side of Gadigal Avenue and Joynton Avenue
- Install caisson and dewatering equipment
- Dewater pits if required(this would continue throughout the tunnelling)
- Ensure groundwater drawdown will not cause settlement of adjacent structures or infrastructure. If required, clean water or captured groundwater (depending on groundwater contamination) would be injected into the ground (this would continue throughout the tunnelling)
- Install microtunnelling machine
- Tunnel between north side of Gadigal Avenue (pit 1/29) and south side of Gadigal Avenue (pit 1/30)
- Connect existing GPTs at Woolwash Pond to new infrastructure
- Backfill pit
- Restore footpath at Gadigal Avenue
- Landscape disturbed areas

Section between Woolwash Park and Mary O’Brien Reserve

- Deliver plant and ancillary tunnelling equipment to the launch pit location
- Remove timber structure and a section of the boardwalk at the southern end of Mary O’Brien Reserve
- Excavate pit (refer to pit 3/1 and 3/2 in preliminarydrawings) on the north side of the Tilford Street and Joynton Avenue intersection within Mary O’Brian Reserve
- Install caisson and dewatering equipment
- Dewater pits if required(this would continue throughout the tunnelling)
- Ensure groundwater drawdown will not cause settlement of adjacent structures or infrastructure. If required, clean water or captured groundwater (depending on groundwater contamination) would be injected into the ground (this would continue throughout the tunnelling)
- Install microtunnelling machine
- Tunnel between pit 1/30 in Woolwash Park and pit 3/1 in Mary O’Brien Reserve
- Restore disturbed area in Mary O’Brien Reserve, reinstate the boardwalk and the timber structure
- Landscape disturbed areas

Section between Woolwash Park and Elizabeth Street

- Deliver plant and ancillary tunnelling equipment to the launch pit location
- Excavate a pit approximately 50 metres south of the Elizabeth Street and Joynton Avenue intersection, on the east side of Joynton Avenue
- Install caisson and dewatering equipment
- Dewater launch pit (this would continue throughout the tunnelling)
- Ensure groundwater drawdown will not cause settlement of adjacent structures or infrastructure. If required, clean water or captured groundwater (depending on groundwater contamination) would be injected into the ground (this would continue throughout the tunnelling)
- Tunnel (two 1800mm diameter pipes) between pit 1/30 at Woolwash Park and the location of EX-5 south of Elizabeth Street
- Construct twin parallel 1800 millimetre diameter pipes from Woolwash Pond to the southern extent of the proposal outside the Ausgrid site at 130 Joynton Avenue. These pipes will connect to existing manhole EX5 and removal of temporary retrofitting works at existing manhole EX5
- Connect 450 mm RCP to 1800 mm pipe

- Install new stormwater junction pit
- Decommission existing 1.7m X 1.0m RCBC.
- Restore the disturbed area at Woolwash Park and Elizabeth Street
- Landscape disturbed areas

Open trenching

- Open trenching to construct connections to the new trunk main. The methodology for open trenching to make connection will be:
    - Saw cut road/footpath
    - Excavate trench
    - Lay pipes and pipe bedding
    - Backfill and compact using excavated material
    - Remediate disturbed area using asphalt/concrete
    - Landscaping disturbed areas

3.2 GENERAL METHODOLOGY

Pre-construction set up

Site compound – 67 Bourke Road, Zetland

A site compound could be established at 67 Bourke Road, located approximately 2.5 kilometres by road from the proposal site. 67 Bourke Road currently City of Sydney Operational Land. The site is contaminated with asbestos, which has been remediated using a capping layer, and is subject to an Environmental Management Plan prepared by Douglas Partners (refer to *Report on Long Term Environmental Management Plan 67 & 67A Bourke Road and Part 6A Huntley Street Alexandria* dated February 2009). The City of Sydney Property Strategy and Development Team would need to endorse the use of this site as a site compound. The construction contractor would be responsible for seeking the relevant consent for use of this site. The Construction Environmental Management Plan (CEMP) would need to be complied with including an additional layer installed at the site prior to storage (specifications of which to be provided by City of Sydney). The compound would be secured with perimeter fencing and would contain a site office, toilets, lunch room, plant storage and material storage.

It should be noted the contractor would be responsible for providing the permitting process for access to the site. Should this site be deemed unsuitable, or if other sites are required by the contractor, the contractor is to seek the relevant approvals.

Tunnelling pit set up

Launch/receiving pits are required for microtunnelling. Each pit location identified in the preliminary design (Appendix A) will be assessed as both a launch and receiving pit site. The launch and receiving pits would be excavated to a depth of more than five metres (to the top of the tunnel) and would be approximately 6 to 9 metres in diameter. Temporary caisson would be installed to maintain the pit structure during the work. The tunnelling machine would be lowered into the pit with a crane and would remain in place while the pit is in use. The pit would be below the water table and pumps would be installed to dewater the pit. Equipment would be delivered during low traffic times to minimise traffic impacts. This would be the typical procedure for all launch pits

A receiving pit would be required for the tunnelled pipe and retrieval of the tunnelling machine. All receiving pits would consist of a water tight supported excavation whereby the tunnelling machine could be craned out of the hole.

A Tunnel Boring Machine (TBM) (or similar) may be used for drilling operations, the TBM will be jacked along (using a hydraulic jack) by pipes installed at the rear of the TBM. An excavator or mobile crane will be required to lift the pipes into the launch pit. Around the launch pit there is substantial plant and equipment consisting of pumps, generators for the slurry line returns and equipment for the hydraulics for the jack.

Construction activities

Microtunnelling

Microtunelling would be used to install the stormwater main. This would avoid open trenching and reduce environmental impacts including tree removal, impacts to pedestrian and residential access, traffic impact and dust generation. The tunnel is bored from a launch pit to a receiving pit and the sections of pipe are pushed through as the tunnel is bored. The pipe is fed into the tunnel until the microtunnelling machine reaches the receiving pit. A jacking frame is set up in the launch pit to feed pipe sections into the tunnel. The speed of the tunnelling is controlled by the hydraulic rams of the jacking frame that push the pipe sections. A microtunnelling system is shown in Figure 3-2.

The tunnelling would be below the water table and groundwater would infiltrate the pits. Pumps would be used to dewater the pits. The water would be captured in a storage tank. Depending on the quality of the captured groundwater, it may be re-injected into the ground or disposed of to a licenced waste facility. Groundwater may be treated on site prior to reinjection or disposal, depending on the levels of contamination.

Microtunnelling would be at a depth to pipe invert of five metres to avoid services and avoid impact on the trees which line Joynton Avenue. Sections of pipe would be fed into the tunnel at a rate of about 10 metres per day. Tunnelling would mainly be carried out during standard hours to avoid night noise impacts on nearby residents. However, some night work may be required, subject to strict conditions. A stringent community liaison process would be implemented to ensure residents are well informed in advance of proposed changes to normal working hours.

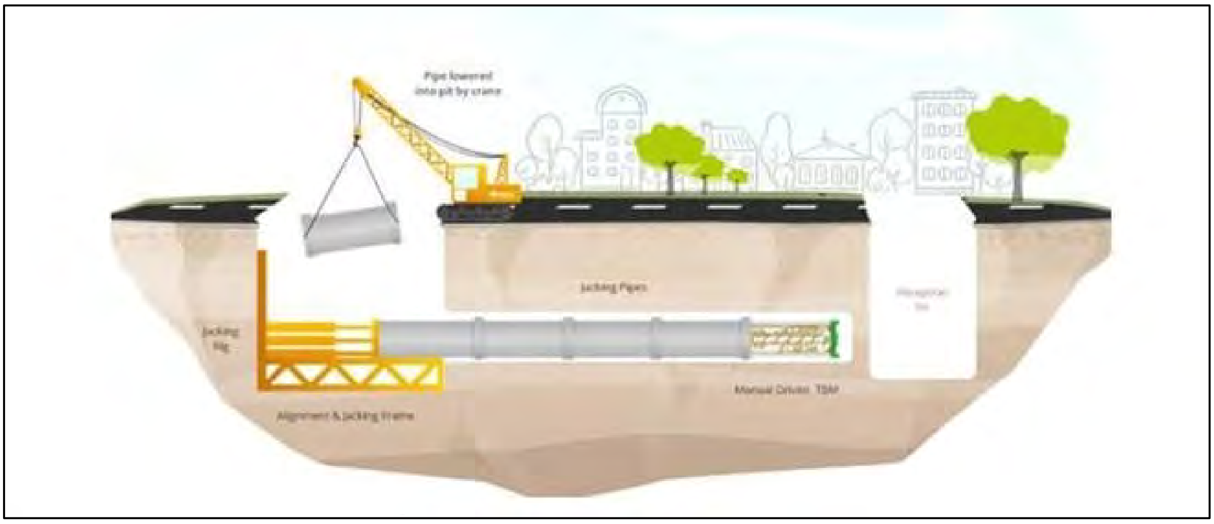


Figure 3-2 Microtunnelling showing launch pit, receiving pit and pipe jacking

Open trenching

Open trenching would be used to lay local stormwater connections. A 12-20 tonne excavator, and a truck and dog would be used. The 12-20 tonne excavator would be used to excavate the trench and to lift the pipes into the trench with a lifting attachment. Reinforced concrete pits for junctions and connections will be constructed using standard timber formwork. A truck and dog would be used to remove excavated material from the trench and also returning material back for backfilling operations.

Open trenching may also be required if the tunnel boring machine gets stuck or there is equipment failure and the TBM needs to be retrieved. In this case, excavation above the location of the equipment failure would be undertaken including removal of any trees as required.

Construction of pits

Reinforced concrete pits for junctions and connections will be installed (prefabricated) or constructed insitu (using formwork around reinforcement steel, a concrete truck, concrete pump and a concrete vibrator).

Decommissioning of stormwater pipes

Pipes to be decommissioned would be filled with a low strength concrete mix and would remain in their existing position. Limited or no excavation would be required to decommission pipes.

Earthworks

Earthworks would be required to construct the launch and receiving pits, the junction pits and the connections to existing and future stormwater mains. Spoil would be generated during tunnelling. Excavated material would be stored at the compound site per Blue Book requirements and reused if suitable. Excess material from tunnel will be disposed off-site. Estimates of the volumes of material to be excavated are provided in Table 3-1.

Table 3-1 Estimates of earthworks volumes

Work	Volume
Six pits in total, five pits 6 metres in diameter and one pit 11 metres diameter	Approximately 2,000 m^3
Stormwater connections	Approximately 200 m^3
Tunnel bore	Approximately 7,000 m^3
Other pits	Unknown

Stormwater connections

- Mobile Crane
- Excavator
- Pump
- Diesel Generator
- Tip Truck
- Vacuum Truck
- Bobcat
- Concrete Pump
- Jack Hammer
- Compressor
- Dewatering pump

Open trenching to lay local stormwater connections – closure:

- Compactor
- Asphalt Plant
- Excavator
- Tip Truck
- Bobcat
- Concrete Pump
- Jack Hammer
- Compressor
- Dewatering Pump

3.2.2 Timing

Construction duration

Construction work would take about 12 months to complete. The work would be carried out both within and possibly outside standard working hours.

Standard working hours as defined in the City of Sydney *Sydney Streets Technical Specifications B1. Preliminaries / General* (2016) for areas outside Pyrmont and the City Centre are:

- Monday to Friday – 7:30 am to 5:30 pm
- Saturday – 7:30 am to 3:30pm
- Sunday and public holidays – no work

4 LEGAL AND POLICY REQUIREMENTS

4.1 LEGAL PERMISSIBILITY

Table 4-1 Legal requirements for the proposal

Law, Policy or Regulation	Objective	Requirement for the proposal
State Law		
Environmental Planning and Assessment Act 1979	Provides for a co-ordinated approach development ensuring the proper management, development and conservation of natural and cultural resources and promoting social and economic welfare and a better environment. Proposals which do not require development consent under a planning instrument may be approved by relevant government agencies under division 5.1 of the Act. A Review of Environmental Factors is required to assess if significant impacts are likely. If significant impacts are likely, an Environmental Impact Statement (EIS) would be required (See also EP&A Regulation below for 'designated development').	This REF has been completed under Division 5.1 of the EP&A Act, and aims to address City of Sydney Council's duty in respect to considering the environmental impact of the proposed activities under section 5.5 of the EP&A Act.
Environmental Planning and Assessment Regulation 2000 **(EP&A Regulation)**	This regulation details the assessment processes and information that must accompany development applications. Clause 228 (Part 14, environmental assessment under Part 5 of the Act) outlines the factors that must take into account concerning the impact of an activity on the environment.	A clause 228 checklist is included in this REF in Appendix G.
State Environmental Planning Policy (Infrastructure) 2007 **(Infrastructure SEPP)**	The object of the Infrastructure SEPP is to facilitate the effective and efficient delivery of infrastructure across the state. The Clause 50 (1) allows flood mitigation work may be carried out by or on behalf of a public authority without consent on any land. Flood mitigation works are works constructed for the express purpose of mitigating flood impacts	The proposal is permissible without consent under the infrastructure SEPP. Impacts resulting from these activities have been discussed in section 6 of this REF.

Law, Policy or Regulation	Objective	Requirement for the proposal
	Clause 94 (2) (d) allows environmental management works to be undertaken without consent if the works are in or adjacent to a road corridor.	
State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017	The aims of this Policy are: a) To protect the biodiversity values of trees and other vegetation in non-rural areas of the State, and b) To preserve the amenity of non-rural areas of the State through the preservation of trees and other vegetation. Clearing of vegetation may not occur without a permit to clear vegetation, provided by the relevant council. A permit to clear vegetation can not be granted if the vegetation forms part of a heritage item, unless the impact to the heritage item is considered minor.	The proposal would remove street trees identified in the LEP as heritage item. However, Clause 8 of the ISEPP serves to override the permissible development provisions of the Policy.
***Fisheries Management Act 1994* (FM Act)**	The FM Act aims to protect fishery resources and marine species, and conserver habitats and diversity. The FM Act works in conjunction with the EP&A Act. If the following activities form part of the proposal, Section 201 of this Act requires a permit from DPI prior to works commencing: • Aquaculture • Dredging or reclamation • Harm marine vegetation (mangrove, seagrass, seaweed). • Obstruct free passage of fish	The site is not classed as key fish habitat. Drainage of Woolwash Pond would not obstruct fish passage as it is mechanically filled from groundwater and drains to irrigate parks. A permit for obstruction of fish passage is not required. Fish may be present within Woolwash Pond, and may need to be taken, stored, relocated or euthanised (if a pest species). A permit for this activity should be sought under clause 37 of the Act. Refer to section 8 of this REF.
***National Parks & Wildlife Act 1974* (NPW Act)**	The NPW Act establishes the fundamental functions of the NSW National Parks and Wildlife Service. These include the conservation of nature, objects, features, places and management of land reserved under the Act.	The proposal has the potential to harm non-threatened fauna, which will be managed in accordance with Section 6.5 of this REF. There are no known Aboriginal heritage items in the proposal area, therefore, a permit would not be required.

Law, Policy or Regulation	Objective	Requirement for the proposal
	The NPW Act also sets out to protect and preserve Aboriginal Heritage values and is required to maintain a register of sites of archaeological and Aboriginal heritage significance (Schedule 14). Part 6 of this Act refers to Aboriginal objects and places and prevents persons from impacting on an Aboriginal place or relic, without consent or a permit. Office of Environment and Heritage (OEH, formerly DECCW) has released Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW that when followed meets the requirements of due diligence under the Act (DECCW 2010). If works impact on an Aboriginal object or place, an Aboriginal Heritage Impact Permit would be required.	The potential to discover previously unknown Aboriginal heritage items during construction would be managed by the implementation of safeguards identified in Section 6.11 of this REF.
***Biodiversity Conservation Act 2016* (BC Act)**	The BC Act outlines the framework for addressing impacts on biodiversity from development and clearing and sets out to: • Conserve biological diversity and promote ecologically sustainable development; • Prevent the extinction and promote the recovery of threatened species, populations and ecological communities; • Protect the critical habitat of those species, populations and ecological communities that are endangered; • Eliminate or manage certain threatening processes; • Ensure proper assessment of activities impacting threatened species, populations and ecological communities, and • Encourage the conservation of threatened species, populations and ecological communities through co-operative management.	Section 6.5 discusses the potential impacts of the proposed works on threatened species, populations or EECs in the vicinity of the proposed work areas.
Biosecurity Act 2015	The primary object of the *Biosecurity Act 2015* is to provide a framework for the prevention, elimination and minimisation of biosecurity risks posed by biosecurity matter, dealing with biosecurity matter, carriers and potential carriers, and other activities that involve biosecurity	A search of the Department of Primary Industries WeedWise database for regional priority weeds for Greater Sydney was undertaken in March 2018 (see Appendix E).

Law, Policy or Regulation	Objective	Requirement for the proposal
	matter, carriers or potential carriers. The biosecurity framework and tools safeguard our economy, environment and community and Any land managers and users of land have a responsibility for managing weed biosecurity risks that they know about or could reasonably be expected to know about.	Section 6.5 addresses impacts relating to priority weeds.
Heritage Act 1977	This Act aims to conserve heritage values. The Act defines 'environmental heritage' as those places, buildings, works, relics, moveable objects and precincts listed in the local or state heritage significance. A property is a heritage item if it is listed in the heritage schedule of the local council's Local Environmental Plan or listed on the State Heritage Register, a register of places and items of particular importance to the people of NSW.	Heritage impacts are considered in section 6.12 of this REF.
***Water Management Act 2000* (WM Act)**	Under the WM Act a controlled activity approval confers a right on its holder to carry out a specified controlled activity at a specified location in, on or under waterfront land (i.e. in or within 40 metres of a river lake or estuary). Under the WM Act a controlled activity means: (a) The erection of a building or the carrying out of a work (within the meaning of the Environmental Planning and Assessment Act 1979), or (b) The removal of material (whether or not extractive material) or vegetation from land, whether by excavation or otherwise, or (c) The deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or (d) The carrying out of any other activity that affects the quantity or flow water in a water source. It is an offence under Section 91E (1) of the WM Act to carry out controlled activity without, or otherwise than as authorised by, a controlled activity approval. However, Penrith Council is exempt from obtaining a controlled activity approval for works, pursuant to Clause 38 of the Water Management (General) Regulation 2011:	A controlled activity approval is not required as works would not be undertaken on waterfront land and under Clause 39A of the Water Management (General) Regulation 2004, all public authorities (other than Landcom) are exempt from controlled activity approvals. Impacts on broader water quality are considered in section 6.3 of this REF.

Law, Policy or Regulation	Objective	Requirement for the proposal
	A public authority is exempt from 91E (1) of the Act in relation to all controlled activities that it carries out in, on or under waterfront land.	
Protection of the Environment and Operations Act 1997 **(POEO Act)**	The objectives of this Act include protecting, restoring and enhancing the quality of the environment in NSW having regard to the need to maintain ecologically sustainable development; reducing risks to human health and preventing the degradation of the environment. Under the Act, the Environment Protection Authority (EPA) is responsible for issuing licences for specified activities. Schedule 1 lists the types of premises and non-premises based activities that require a license under the Act.	The proposal is not an activity listed under Schedule 1 of the Act. Therefore, a license would not be required.
Roads Act 1993	The objectives of this Act include, but are not limited to, the rights of persons to pass along public roads, the rights of neighbouring landowners, the responsibilities and requirements of roads authorities and the regulation of various activities on public roads. The council is the roads authority for all public roads within an LGA, other than any freeway, crown road, or road for which some other public authority is declared to be the roads authority.	Section 71 of the Act states that a roads authority may carry out road work on any public road for which it is the roads authority and on any other land under its control. The proposal would not require approval or any additional licences under this Act.

Law, Policy or Regulation	Objective	Requirement for the proposal
4.1.1 Contaminated Land Management Act 1997 (2008 amendment)	In NSW, the management of contaminated land is shared by the EPA, P&I and planning consent authorities. The general objective of the Act is to: 'establish a process for investigating and (where appropriate) remediating land that the EPA considers to be contaminated significantly enough to require regulation under Division 2 of Part 3' (Lands declared as significantly contaminated by the EPA). Sites not regulated by the EPA are managed by local councils through land-use planning processes. One particular object of the act in Section 3 (2) (d) is to 'ensure that contaminated land is managed with regard to the principles of ecologically sustainable development'.	Environmental management measures for dealing with contaminated lands are detailed in Section 6.4 of this REF.
Commonwealth Law		
***Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)**	The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) regulates the assessment and approval of activities that will have or is likely to have a significant impact on Matters of National Environmental Significance (MNES), activities by Commonwealth government agencies and activities by any person on Commonwealth land. Currently MNES include: • World Heritage properties • National Heritage places • Wetlands of international importance (listed under the Ramsar Convention) • Nationally listed threatened species and ecological communities, migratory species (protected under international agreements)	An EPBC Act protected matters search was undertaken in March 2017 (Appendix E). An assessment of the impacts of the proposal determined that the proposal does not constitute an activity which may have a significant adverse impact on any MNES. MNES relevant to the study area include: • Nationally listed threatened species and ecological communities • migratory species (protected under international agreements)

Law, Policy or Regulation	Objective	Requirement for the proposal
	- Commonwealth marine areas - Great Barrier Reef Marine Park - Nuclear actions (including uranium mines) A water resource, in relation to coal seam gas development and large coal mining development	
Local Law		
***Sydney Local Environmental Plan 2012* (LEP)**	The particular aims of this Plan thatrelate to the proposal are as follows: - To support the City of Sydney as an important location for business, educational and cultural activities and tourism, - To promote ecologically sustainable development, - To enable a range of services and infrastructure that meets the needs of residents, workers and visitors, - To enhance the amenity and quality of life of local communities, - To conserve the environmental heritage of the City of Sydney, - To protect, and to enhance the enjoyment of, the natural environment of the City of Sydney, its harbour setting and its recreation areas. In addition to the above aims, the policy has objectives for each zonation. These are as follow. RE1 Public recreation The objectives for this zone include: - To enable land to be used for public open space or recreational purposes. - To provide a range of recreational settings and activities and compatible land uses.	The proposal generally meets the objectives of this plan. With regard to the specific objectives of the various zones: Within the areas zoned RE1, the proposal would include: - Construction of launch/receiving pit - Tunnelling - Dewatering - Treatment of won water These works are prohibited works in this zone. Within the area zoned B4. The proposal would include: - Construction of launch/receiving pit - Tunnelling These works are permitted with consent in this zone. Within the area zoned R1. The proposal would include: - Construction of launch/receiving pit - Tunnelling These works are permitted with consent in this zone. In addition, Clause 8 of the ISEPP serves to override the permissible development provisions of the LEP, the development restrictions of the LEP do not apply.

Law, Policy or Regulation	Objective	Requirement for the proposal
	- To protect and enhance the natural environment for recreational purposes. - To provide links between open space areas. - To retain and promote access by members of the public to areas in the public domain including recreation facilities and waterways and other natural features. B4 Mixed use The objectives for this zone include: - To provide a mixture of compatible land uses. - To integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling. - To ensure uses support the viability of centres. R1 General residential The objectives for this zone include: - To provide for the housing needs of the community. - To provide for a variety of housing types and densities. - To enable other land uses that provide facilities or services to meet the day to day needs of residents. - To maintain the existing land use pattern of predominantly residential uses.	

5 CONSULTATION

5.1 COMMUNITY CONSULTATION

Consultation would be undertaken by City of Sydney to inform local businesses and residents of proposed works prior to commencement of construction.

A public community consultation period will run from Monday 15 October to Monday 19 November 2018.

The public exhibition of this REF report provides another opportunity for the community to learn more about the project and provide comment. A letter will be sent to businesses and residents in the shaded area on Figure 5-1 below.

In the weeks prior to the official community consultation period, key stakeholders (identified in Table 5-2) will be contacted to discuss the REF. Other stakeholders relevant to the proposal are identified in Table 5-3. The purpose of the pre-consultation period is to discuss key issues and concerns due to high impact of work on their business.

The action plan below outlines the dates and process for the community consultation is identified in Table 5-1 below.

Table 5-1 The action plan below outlines the dates and process for the community consultation period.

ACTION PLAN	Date	Stakeholder
Pre-consultation with key stakeholders	15 October to 19 October 2018	Listed in Table 5-2
Start of community consultation period	22 October 2018	Local businesses and residents receive letter in mailbox drop
End of community consultation period	19 November 2018	All submissions to be compiled for submissions report
Submission report	10 December 2018	To be completed and sent to project team

Table 5-2 Key stakeholders for pre-consultation

Key stakeholders for pre-consultation	Location
Ausgrid – 130 Joynton Avenue, Zetland	Driveway on Joynton Avenue, which currently facilitated two way traffic for heavy vehicles, to be disrupted by construction of watermain pit. Impacts are discussed in Section 6; socio-economic impacts are discussed in 6.6.
Victoria Park Café - 33/106 Joynton Ave, Zetland	Business on the corner of Joynton Avenue and Gadigal Avenue. Impacts are discussed in Section 6; socio-economic impacts are discussed in 6.6.

Little Piazza Bar and Grill - 1/30 Gadigal Ave, Zetland	Business on the corner of Joynton Avenue and Gadigal Avenue. Impacts are discussed in Section 6; socio-economic impacts are discussed in 6.6.
Transport for NSW	Bus stop on Joynton Avenue before Gadigal Avenue, southbound, will be impacted. Impacts are discussed in Section 6; socio-economic impacts are discussed in 6.6.

Table 5-3 Local stakeholders for consultation

Local stakeholders for consultation	Impacts
Residents	Impacts are discussed in Section 6; socio-economic impacts are discussed in 6.6.
Businesses of Joynton Avenue and Gadigal Avenue including: • Orthoworx - 1/98 Joynton Ave, Zetland • Chinese Restaurant - 13 Joynton Avenue, Zetland • The Rizzeria - 3 Joynton Ave, Zetland • Victoria Park Cellars - 3/30 Gadigal Ave, Zetland • S,Thada - 2/30 Gadigal Ave, Zetland • Toto - Joynton Avenue, Zetland • Neuromoves – 3 Joynton Avenue, Zetland (access from Portman Street) • NSW Health Hydrotherapy – 3 Joynton Avenue (access from Portman Street)	Impacts are discussed in Section 6; socio-economic impacts are discussed in 6.6.
City of Sydney Community Venues • Mary O'Brien Reserve • Tote Park • Portman Street south car park (access from Portman Street) • Joynton Avenue Community Centre (access from Portman Street) • Matron Ruby Grant Park (access from Portman Street)	Impacts are discussed in Section 6; socio-economic impacts are discussed in 6.6.

The map below outlines the impact zone associated with the project and the area where letters will be distributed.

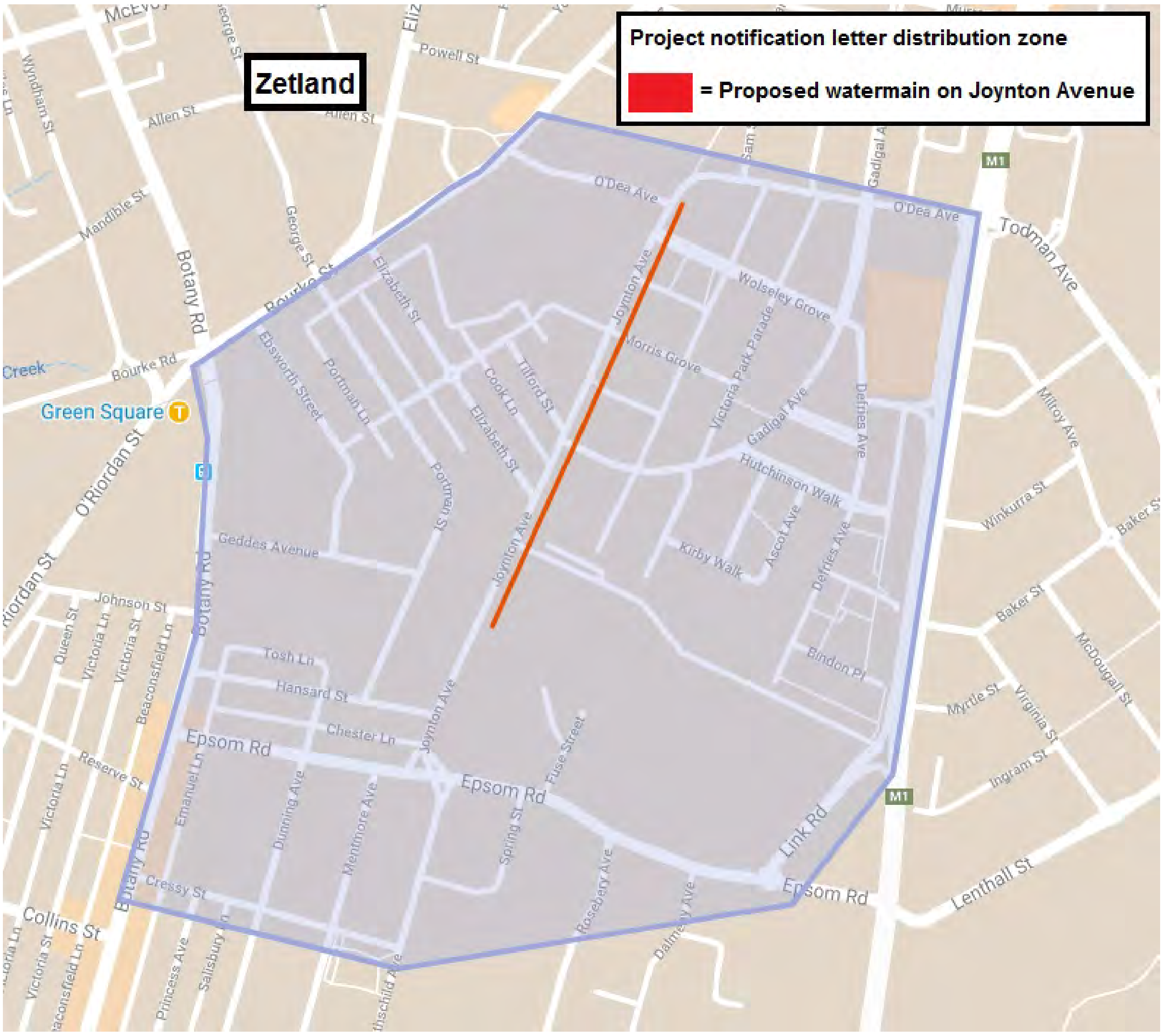


Figure 5-1 Distribution area for letters related to the proposal

All submissions received in the community consultation period will be compiled and analysed in a submissions report as with all City of Sydney projects.

5.2 ISEPP CONSULTATION

Clauses 13, 14, 15 and 16 of *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP) requires that public authorities (which includes the City of Sydney Council) undertake consultation with other public authorities when proposing to carry out development without consent. Table 5-4 lists items that may trigger consultation and assesses whether they are relevant to the proposal.

Table 5-4 ISEPP consultation requirements

Item	Response
Clause 13 Consultation with councils—development with impacts on council-related infrastructure or services	
(1) This clause applies to development carried out by or on behalf of a public authority that this Policy provides may be carried out without consent if, in the opinion of the public authority, the development: (a) A substantial impact on stormwater management services provided by a council. (b) Likely to generate traffic to an extent that will strain the capacity of the road system in a local government area. (c) Involves connection to, and a substantial impact on the capacity of, any part of a sewerage system owned by a council. (d) Involves connection to, and use of a substantial volume of water from, any part of a water supply system owned by a council. (e) Involves the installation of a temporary structure on, or the enclosing of, a public place that is under a council's management or control that is likely to cause a disruption to pedestrian or vehicular traffic that is not minor or inconsequential. (f) Involves excavation that is not minor or inconsequential of the surface of, or a footpath adjacent to, a road for which a council is the roads authority under the *Roads Act 1993* (if the public authority that is carrying out the development, or on whose behalf it is being carried out, is not responsible for the maintenance of the road or footpath).	Clause 13 are not applicable to the proposed development. City of Sydney Council is undertaking the works within their own council area. Consultation within the relevant sections of council has occurred regarding this proposal.

6 ENVIRONMENTAL ASSESSMENT

This section of the REF provides a detailed description of the potential environmental impacts associated with the construction and operation of the proposal. All aspects of the environment potentially impacted upon by the proposal are considered. This includes consideration of the factors specified in the guidelines *Is an EIS required?* (DUAP 1999) and *Roads and Related Facilities* (DUAP 1996) as required under clause 228(1)(b) of the *Environmental Planning and Assessment Regulation 2000*. The factors specified in clause 228(2) of the *Environmental Planning and Assessment Regulation 2000* are also considered. Site-specific safeguards are provided to ameliorate the identified potential impacts.

6.1 NOISE AND VIBRATION

An assessment of the potential noise and vibration impacts of the proposal was undertaken by Renzo Tonin (2016). Their report is provided in Appendix D and summarised below.

6.1.1 Receiver locations

The nearest affected receivers were identified during a site visit as follows and illustrated in Figure 6-1.

Receiver ID	Address	Description
R1	2-6 Tilford Street	Double storey residential property located approximately 73m directly west of the project area.
R2	13 Joynton Avenue	Multi-storey residential property located approximately 28m directly west of the project area.
R3	19 Joynton Avenue	Multi-storey residential property located approximately 28m directly west of the project area.
R4	5 O'Dea Avenue	Multi-storey residential property located approximately 28m directly west of the project area
R5	98 Joynton Avenue	Multi-storey residential property located approximately 5m directly east of the project area.
R6	102 Joynton Avenue	Multi-storey residential property located approximately 8m directly east of the project area.
R7	104 Joynton Avenue	Multi-storey residential property located approximately 8m directly east of the project area
R8	106 Joynton Avenue	Multi-storey residential property located approximately 6m directly east of the project area.
R9	30 Gadigal Avenue	Multi-storey residential property located approximately 16m directly east of the project area.
R10	128 Joynton Avenue	Multi-storey residential property located approximately 17m directly east of the project area.
R11	Green Square Neighbourhood Service Centre (100 Joynton Avenue)	Commercial property located approximately 5m directly east of the project area.
R12	811 Elizabeth Street	Commercial property located approximately 32m directly west of the project area.
R13	966-968 Elizabeth Street	Industrial property located approximately 37m directly west of the project area.
R14	11 Joynton Avenue	Commercial property located approximately 17m directly west of the project area.
R15	Mary O'Brien Park	Parrk located approximately 25m directly west of the project area.
R16	47 Tilford Street	Single storey residential property located approximately 20m directly west of the project area.
R17	43 Tilford Street	Single storey residential property located approximately 26m directly west of the project area.
R18	41 Tilford Street	Single storey residential property located approximately 35m directly west of the project area.
R19	39 Tilford Street	Single storey residential property located approximately 39m directly west of the project area.
R20	37 Tilford Street	Single storey residential property located approximately 45m directly west of the project area.
R21	35 Tilford Street	Double storey residential property located approximately 51m directly west of the project area.
R22	33 Tilford Street	Double storey residential property located approximately 56m directly west of the project area.
R23	31 Tilford Street	Double storey residential property located approximately 60m directly west of the project area.
R24	29 Tilford Street	Double storey residential property located approximately 64m directly west of the project area.
R25	27 Tilford Street	Double storey residential property located approximately 68m directly west of the project area.
R26	25A Tilford Street	Double storey residential property located approximately 72m directly west of the project area.
R27	25 Tilford Street	Double storey residential property located approximately 77m directly west of the project area.
R28	23 Tilford Street	Double storey residential property located approximately 81m directly west of the project area.
R29	21 Tilford Street	Double storey residential property located approximately 85m directly west of the project area.
R30	19 Tilford Street	Double storey residential property located approximately 90m directly west of the project area.
R31	17 Tilford Street	Double storey residential property located approximately 94m directly west of the project area.
R32	15 Tilford Street	Double storey residential property located approximately 98m directly west of the project area.
R33	13 Tilford Street	Double storey residential property located approximately 103m directly west of the project area.
R34	11 Tilford Street	Double storey residential property located approximately 107m directly west of the project area.
R35	9 Tilford Street	Double storey residential property located approximately 112m directly west of the project area.
R36	13 Joyton Avenue (Chinese restaurant)	Chinese restaurant located approximately 28m directly west of the project area.
R37	1/30 Gadigal Avenue (Pizza Restaurant)	Pizza restaurant located approximately 16m directly east of the project area.

R38	33/106 Joynton Avenue (Café)	Cafe located approximately 6m directly east of the project area.

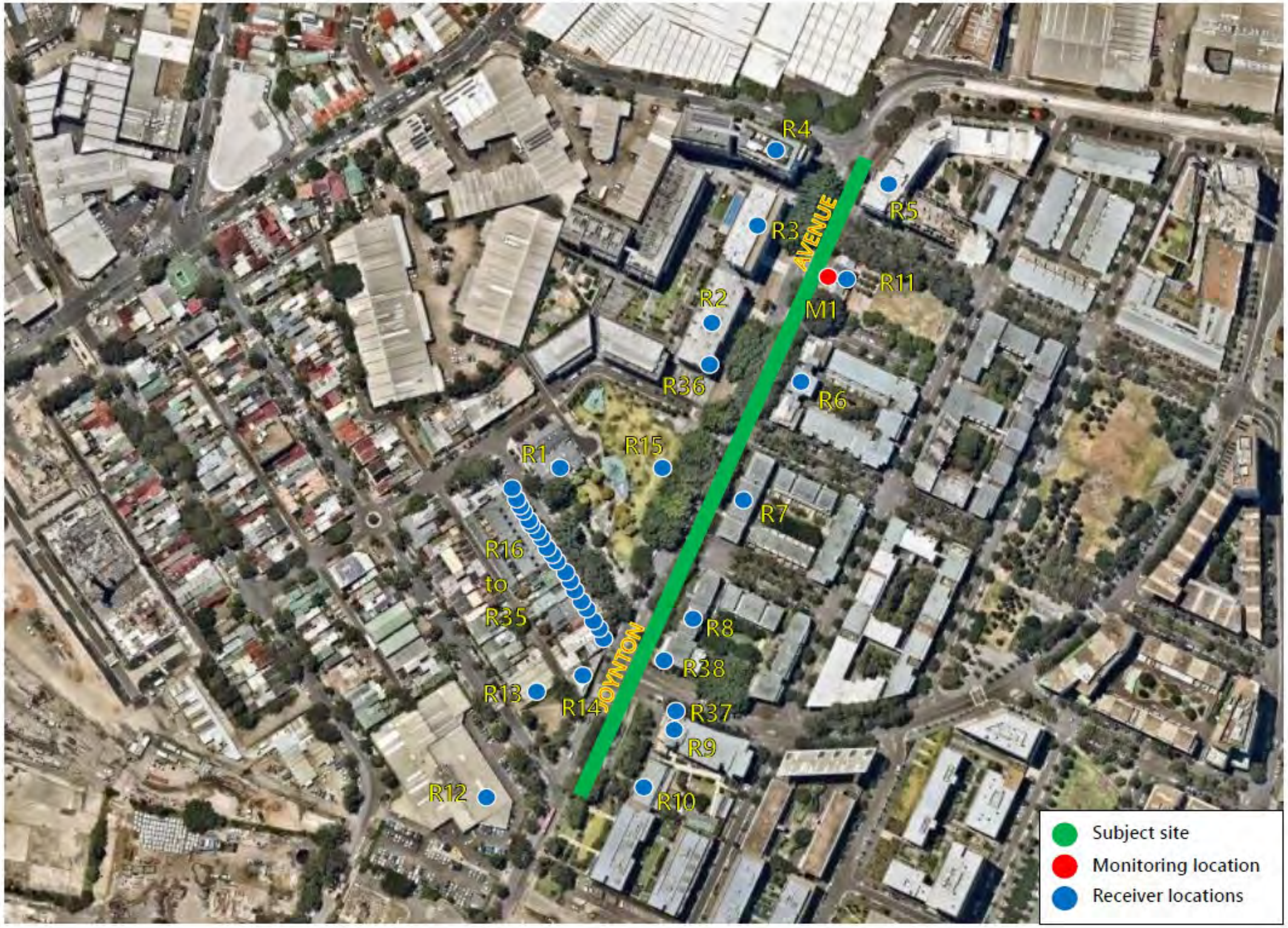


Figure 6-1 Location of receivers (Renzo Tonin 2018)

6.1.2 Criteria

Construction noise management levels

The NSW *'Interim Construction Noise Guideline'* (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments. In accordance with the ICNG, a quantitative noise assessment was undertaken considering the proposed works would take more than three weeks to complete.

Table 6-1 reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 6-1 Noise management levels at residential receivers

Time of Day	Management Level LAeq (15 min)	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Time of Day	Management Level LAeq (15 min)	How to Apply
Outside recommended standard hours	Noise affected RBL + 5dB(A)	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Based on the RBL measured above, the noise management level for residential premises is presented in Table 6-2.

Table 6-2 Construction noise management levels at residential receivers

Receiver Location		Noise Management Level LAeq(15 min)
All residential receivers (R1 to R10)	Day Standard Hours	54 + 10 = **64dB(A)**
	Day Outside Standard Hours	54 + 5 = **59dB(A)**
	Evening	50 + 5 = **55dB(A)**
	Night	40 + 5 = **45dB(A)**

In addition, Table 6-3 sets out the ICNG noise management levels for other noise sensitive receiver locations, when these are in use only. As identified for residential receivers, a ‘highly affected’ noise objective of $L_{aeq(15min)}$ 75dB(A) is adopted for all noise sensitive receivers, with exceedances addressed as described in Table 6-1.

Table 6-3 Noise management levels at other noise sensitive receivers

Land use	Where objective applies	Management Level ($L_{aeq(15min)}$)
Classrooms at schools and other educational institutions	Internal noise levels	45 db(A)
Active recreation areas	External noise levels	65 dB(A)
Commercial premises	External noise levels	70 dB(A)
Industrial premises	External noise levels	75 dB(A)

The external to internal noise level reductions have been estimated based on each receiver type’s building construction, and these reductions range from 10 to 20dB(A). For this project a conservative 10dB(A) reduction from external to internal noise levels has been adopted to allow an external assessment. Therefore, for classrooms the equivalent external noise management level would be 55dB(A).

Sleep disturbance

Given that night works may occur from Monday to Thursday, noise emanating from construction works associated with the project has been assessed for its potential to disturb sleep. As stated in the NSW Road Noise Policy (DECCW 2011) section 5.4:

> *"Further studies by the enHealth Council (2004) and the guidelines published by the World Health Organisation (1999) were reviewed and analysed in terms of the guidance on noise exposure and sleep disturbance. The enHealth report states that:*
>
> *'as a rule for planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) LA, (Max) more than 10 or 15 times per night'."*

Therefore, where the screening limit $L_{A90(15min)}$ (i.e. the background noise level) + 15 is less than 55dB(A) outside, a value of 55dB(A) would be appropriate to ensure the internal noise level does not exceed 45 dB(A), on the assumption that there is a 10dB(A) outside-to-inside noise loss through an open window (see NSW Industrial Noise Policy (EPA 2000), p17). It should be noted this policy is usually applied to operational noise assessment, but as been applied for construction traffic in this case as one measure of sleep disturbance potential. This proposal is not expected to generate operational noise.

Vibration

Construction vibration is associated with three main types of impact:

- disturbance to building occupants
- potential damage to buildings
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the DECC '*Assessing Vibration; a technical guideline*' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'.

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy. German Standard DIN 4150 –Part 3 '*Structural vibration in buildings –Effects on Structure'*(DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

6.1.3 Potential impacts

Construction noise

Construction activities will comprise of the following three (3) phases:

- Excavation of launch and retrieval pits – Construction of the pits will need to be first supported by sheet piles. Once the sheet piles are installed, typical excavation operations will be undertaken.
- Trenchless construction – A closed face shield Tunnel Boring Machine (TBM) will be used for drilling operation where the TBM will be jacked along (using a hydraulic jack) by pipes instead at the rear of the TBM. A large 20T excavator or crane will be required to lift the pipes into the launch pit. Noise from the TBM and jacking ram will be largely attenuated due to the equipment being located below ground level within the shaft.
- Open trenching to lay local stormwater connections – Initial phase of open trenching will include the excavation of trench and laying/installing pipes. Reinforced concrete pits for junctions and connections will be constructed. The second phase will conclude the open trenching activity by closure of the trench and concrete pits.

The following table lists plant and equipment likely to be used by the contractor to carry out the necessary construction works for the project.

Table 6-4 Typical construction equipment and sound power levels, dB(A) re. 1pW

Plant item	**Plant description**	**L_{Aeq} Sound power levels**	**L_{Amax} Sound power levels**
Excavation of launch and retrieval pits			
Sheet piling		111	119
Excavator		107	115
Truck and dog		105	110
Tip truck		108	117
Dewatering pump		102	109
Vacuum truck		107	117
Bobcat		107	115
Compressor		95	105
Jackhammer		110	115
Concrete truck		106	110
Trenchless construction			
Mobile crane		110	115
Excavator		107	115
Pump		102	109

Plant item	**Plant description**	**L_{Aeq} Sound power levels**	**L_{Amax} Sound power levels**
Diesel generator	100	106	
Slurry treatment plant	103	110	
Slurry shield pump	108	115	
Open trenching to lay local stormwater connections - excavation and installation			
Mobile crane	110	115	
Excavator	107	115	
Pump	102	109	
Diesel generator	100	106	
Tip Truck	108	117	
Vacuum truck	107	117	
Bob cat	107	115	
Concrete pump	102	109	
Jack hammer	110	115	
Compressor	95	105	
Dewatering pump	102	109	
Open trenching to lay local stormwater connections – closure			
Compactor	95	105	
Asphalt plant	103	116	
Excavator	107	115	
Tip truck	108	117	
Bobcat	107	115	
Concrete pump	102	109	
Jackhammer	110	115	
Compressor	95	105	

Plant item	**Plant description**	**L_{Aeq} Sound power levels**	**L_{Amax} Sound power levels**
Dewatering pump		102	109

The noise prediction models takes into account:

- Location of noise sources and receiver locations
- Height of sources and receivers
- Separation distances between sources and receivers
- Ground type between sources and receivers (soft)
- Attenuation from barriers (natural and purpose built).

Noise levels at any receptors resulting from construction would depend on the above and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary substantially over the total construction program due to the transient nature and large range of plant and equipment that could be used.

A predicted of the noise levels likely to be experienced at the nearby affected receiver locations during the construction works was undertaken based on the construction equipment proposed to be used at the site. The presented levels are a worst case maximum with all plant and equipment operating concurrently.

Based on the predicted construction noise levels, the construction management levels would be exceeded when works are conducted at the closest proximity to Receivers R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R14, R15, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37 and R38. Predicted construction noise levels at Receiver R13 would comply with the applicable construction management levels.

Furthermore, construction noise levels are predicted to exceed the highly noise affected level of 75dB(A) at Receivers R2, R4, R5, R6, R7, R8, R9, R1, R11, R14, R16, R17, R36, R37 and R38.

It should be noted that the exceedances predicted are based on all plant and equipment operating concurrently and at a location closest to the corresponding receiver location. This scenario would not typically occur on site.

Nevertheless, in light of the predicted noise exceedances, it is recommended that a feasible and reasonable approach towards noise management measures be applied to reduce noise levels as much as possible to manage the impact from construction noise.

Further details on construction noise mitigation and management measures are provided in Section 6.1.4 below.

Sleep disturbance

In accordance with the ICNG the sleep disturbance assessment is only applicable where construction works are planned to extend over more than two consecutive nights. It is noted that utility relocation works are transient in nature and would not necessarily require two consecutive nights of works at one location. The presented levels are a range of maximum noise level where the highest level in the range occurs when the works are at the closest proximity to the receiver and the lowest level in the range occurs when the works are at the furthest extent to the receiver.

For the assessment of sleep disturbance, the predicted external LAmax noise levels will generally exceed the background plus 15dB(A) criteria at all receiver locations. Therefore, in accordance with the requirements of the ICNG, construction works should not occur over more than two consecutive nights to allow respite to nearby residences.

Nevertheless, a reasonable and feasible approach towards noise management measures would be required to reduce noise levels as much as possible to manage the impact from construction noise during night time periods.

Vibration

Based on the proposed plant items presented in Table 6-4, vibration generated by construction plant was estimated and potential vibration impacts predicted (Appendix D). The assessment is relevant to the identified residential, commercial and industrial type buildings.

Based on the potential vibration impacts there is a medium risk of structural damage to buildings within 10m of the work.

The pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Site specific buffer distances should be determined once vibration emission levels are measured from each plant item prior to the commencement of their regular use on site. Where construction activity occurs in close proximity to sensitive receivers, minimum buffer distances for building damage should be determined by site measurements and maintained. If required vibration monitoring could be undertaken at locations within 10m of vibratory works.

Construction traffic

It is anticipated that up to 10 trucks will access the site per day. Based on 10 trucks per day, a total of 20 truck movements (i.e 10 truck movements in and 10 truck movements out) have been used for the traffic noise assessment.

Existing traffic noise levels along Joynton Avenue was predicted to already exceed both the day and night time RNP criteria of Laeq(15hour) 60dB(A) and Laeq (9 hour) 55dB(A), respectively (EPA 2011). The predicted day time construction traffic noise level is 27dB(A) below the existing traffic noise level and 20dB(A) below the day time RNP criterion, while the predicted night time construction traffic noise level is 21dB(A) below the existing traffic noise level and 13dB(A) below the night time RNP criterion.

Therefore, traffic associated with the construction works will not contribute to the existing daytime and night time traffic noise levels.

Operational noise

The stormwater pipes would be installed underground and potential noise source is the noise of water flow through the pipes during operation. The noise of water flow through the pipes would be significantly attenuated by both the pipes and the ground. Operational noise at the ground surface is expected to be inaudible and therefore noise to nearby receiver locations are also expected to be inaudible due to further distance separation.

6.1.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
Construction noise and vibration	• A construction noise and vibration management plan (CNVMP) would be prepared as part of the CEMP and take into account the results of the noise and vibration impact assessment Renzo Tonin 2018. The CNVMP must be reviewed and approved by the City of Sydney. The CNVMP must contain as a minimum: o A process for documenting and resolving issues and complaints. o A construction staging program incorporating a program of noise and vibration monitoring for sensitive receivers. o A process for updating the plan when activities affecting construction noise and vibration change or if additional measures need to be incorporated to resolve complaints or exceedances of the relevant guidelines. o Identify in toolbox talks where noise and vibration management is required o A process for assessing the performance of the implemented mitigation measures. o A process for staging works where exceedances cannot be avoided, to provide periods of respite to residents o A map indicating the locations of sensitive receivers including residential properties. o The results of the quantitative noise assessment completed in accordance with the EPA Interim Construction Noise Guidelines (DECCW, 2009) refer to 10Appendix D • Management measures to minimise the potential noise impacts from the quantitative noise assessment and for potential works outside of standard working hours (including implementation of EPA Interim Construction Noise Guidelines (DECCW, 2009). Management measures would include those in Renzo Tonin (2018). • A risk assessment to determine potential risk for activities likely to affect receivers (for activities undertaken during and outside of standard working hours)		

Impact	Environmental safeguards	Responsibility	Timing
	• Mitigation measures to avoid vibration impacts during construction activities. Management measures would include those in Renzo Tonin (2018).		
Construction vibration	• The proper implementation of a vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with occupants and property owners is recommended and should be aimed at providing a communication path directly to the contractor. • Carry out vibration testing of actual equipment on site prior to the construction works to determine acceptable buffer distances to the sensitive receivers. • Carry out additional vibration monitoring as specified in Renzo Tonin (2018) (refer to Appendix D) when construction activities are at the nearest point to the nominated occupancies. This monitoring may signal to the contractor by way of a buzzer or flashing light etc, when levels approach/exceed the recommended limits in nearby occupancies. • Carry out periodic vibration monitoring at all critical or sensitive areas and assess the vibration levels for compliance with the set vibration limits. This monitoring shall be undertaken in accordance with the vibration monitoring program described in Renzo Tonin (2018) (refer to Appendix D). • Where vibration is found to be excessive, management measures should be considered to ensure vibration compliance is achieved. • Before, during and after the construction works we recommend preparation of dilapidation reports on the state of the existing buildings surrounding the construction site. The condition of surrounding buildings will also be assessed with regard to settlement as described in Section 6.2.3.		
Construction noise	• Use less noisy plant and equipment, where feasible and reasonable. • Plant and equipment should be properly maintained.		

Impact	Environmental safeguards	Responsibility	Timing
	• Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended. • Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel. • Avoid any unnecessary noise when carrying out manual operations and when operating plant. • Any equipment not in use for extended periods during construction work should be switched off. • In accordance with the requirements of the ICNG, construction works should not occur over more than two consecutive nights to allow respite to nearby residences. • Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters. • Noise monitoring would be carried out when construction activities are at the nearest point to sensitive receivers and if noise complaints are received		

6.2 TOPOGRAPHY GEOLOGY AND SOILS AND CONTAMINATED LAND

6.2.1 Existing environment

Topography

Prior to extensive development in the region, the landscape was comprised of gently undulating to rolling coastal dune fields with slope gradients of 1-10% (Chapman and Murphy 1989). In general, the ground surface levels along the proposed pipe alignment fall gently to the south - south west at less than one degree (Douglas Partners 2015).

Geology and soil

The landscape and soils of this area have been extensively disturbed and modified for urban development. Remnant soils of this area are typical of the Tuggerah Soil Landscape Group (as classified in the Soil Landscapes of the Sydney 1:100,000 Sheet), consisting of deep (greater than 2000mm) *Podzols* on dunes and *Podzol/Humus Podzol* intergrades on swales. The limitations of this soil landscape group are extreme wind erosion hazard, non-cohesive, highly permeable soil, very low soil fertility, localised flooding and permanently high watertables.

The site is situated within the Botany Basin and is underlain by fine and medium grained sands of marine origin.

Douglas Partners (2018) notes the ground profile varies along the proposed route but basically comprises:

- FILLING – silty sand, sand and clayey sand with included silt, gravel and building rubble to
- depths ranging from 0.9 m to 3.5 m; overlying
- SILTY SAND – very loose to loose, between 0.7 m and 2.0 m thick in the northern part and at the southern end of the alignment only; overlying
- SAND – medium dense, dense and very dense, but mostly medium dense with some very dense layers to depths ranging from 6.7 m to 8.5 m; overlying
- CLAYEY SAND – medium dense, residual soil; overlying
- SANDSTONE – intersected in two boreholes (BH103 and BH104) below depths of 8.6 m and 7.9 m, respectively.

The ground profile differed at the northern and southern ends of the proposal site, where some peaty silty sand and peaty clay layers between 0.5 m and 1.8 m thick were encountered below the loose and very loose to loose silty sand at the northern end and below the filling at the southern end.

Acid sulfate soils

Douglas Partners (2018) have been confirmed the presence of Acid Sulphate Soils (ASS) at BH1 and BH103. ASS will need to be appropriately managed and treated during excavation of the pits. As the presence of ASS across the site has been confirmed at two sample locations, additional sampling and testing is to be carried out, either in situ or ex situ, to provide guidance on the presence of ASS and management and disposal requirements for the soils to be disturbed/generate the spoil.

Contaminated land

Potential contamination sources may be associated with both current and historical land activities adjacent to Joynton Avenue. Historically, the area was surrounded by industrial activities, including wool washing, tanning and car manufacturing. A considerable quantity of fill was imported to the area, varying between 0.5 to 1.5 m in depth across the proposal area.

During the 2018 geotechnical investigation, Douglas Partners made the following findings with regard to contaminated land:

- A number of samples were collected by Douglas Partners as part of the geotechnical investigation (refer to Figure 6-2). At borehole 105, relatively high levels of lead was detected; 4700 mg/kg at 0.4-0.5 meters below ground level (BGL), 310 mg/kg at 1.9-2 metres BGL and 6100 mg/kg 2.9-3 m BGL.
- Whilst asbestos was not detected within filling, building rubble was recorded within filling at all bores which is indicative of the potential presence of asbestos.

Douglas Partners considered the remainder of the material to meet the criteria for General Solid Waste (non-putrescible), with some opportunity for classification as Virgen Excavated Natural Material pending further analysis.

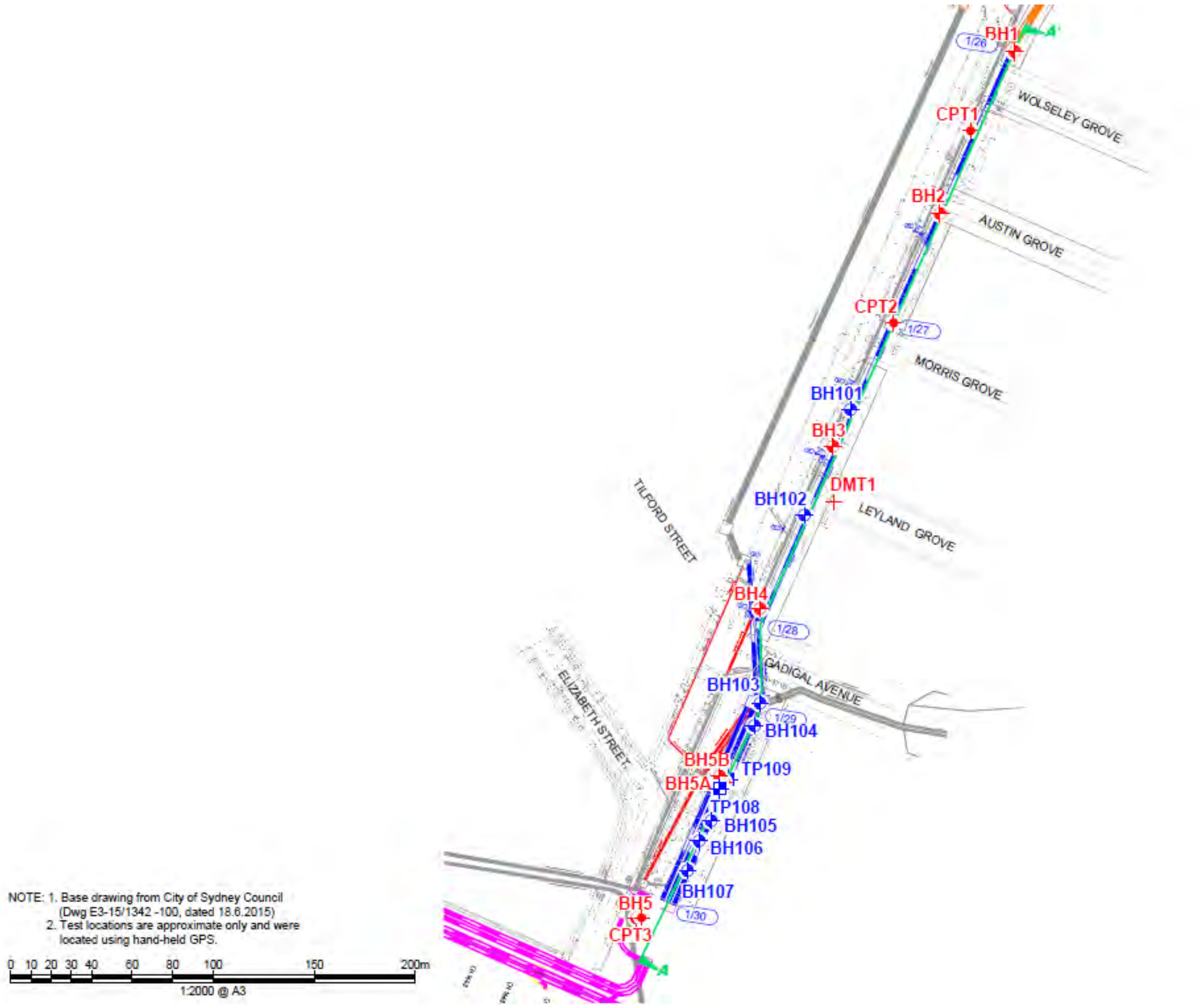


Figure 6-2 Douglas Partners borehole locations

Douglass Partners found evidence of buried concrete infrastructure near the Joynton Avenue/Elizabeth Street junction. This was Interpreted to possibly be associated with a 33 by 6 metre box culvert Identified In 1943 aerial Imagery. The depth of the buried concrete was not determined. This feature has the potential to block the tunnel boring machine. The tunnel boring machine cannot reverse, and therefore would need to be excavated, resulting in additional earthworks and a larger footprint. It Is also possible obstruction exist in other locations planned to be used by the proposal.

The site compound would be established at 67 Bourke Road, Zetland. The site is contaminated with asbestos, which has been remediated using a capping layer, and is subject to an Environmental Management Plan prepared by Douglas Partners (refer to *Report on Long Term Environmental Management Plan 67 & 67A Bourke Road and Part 6A Huntley Street Alexandria* dated February 2009).

6.2.2 Potential impacts

Construction impacts

Microtunneling would be used, with excavation required for five launch/receiving pits. The potential impacts include:

- Erosion of soils exposed during the earthwork and from stockpiling.
- Disturbance of ASS.
- Disturbance of contaminated soils. This could prevent the reuse of the excavated material and require the import of clean fill to backfill the pits.
- Surface settlement due to underbore

Construction of the proposal has the potential to impact soil quality through accidental spills from construction plant (i.e. fuels) or during specific activities such as concreting during the decommissioning of existing pipes. Poor waste stream management has the potential to result in cross contamination.

Douglas Partners (2018) found that the underbore may result in a surface settlement or other land instability, determined by a range of factors (refer to Appendix C for more information). Broadly, Douglass Partners found

- Trenchless pipe-jacking method is considered to be the most appropriate underboring method for this project
- During the construction of launch and retrieval pits, support will be required to prevent excavation collapse
- Dewatering of works area may result in damaging adjacent structures, utilities and roads, unless reinjection occurs
- The techniques used and the monitoring implemented during the operation of the tunnel boring machine

Should the buried concrete infrastructure near the Joynton Avenue/Elizabeth Street junction, or other obstructions, block the tunnel boring machine, the tunnel boring machine would have to be extracted using open excavations. This would result in a much larger excavation footprint, and higher noise, visual impact and other impacts.

Operational impacts

The operation of the proposal would be unlikely to impact soils. Exposed areas would be repaved, minimising the risk of erosion.

6.2.3 Safeguards and mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Erosion and sedimentation	• An erosion and sedimentation control plan (ESCP) must be prepared as part of the Construction Environmental Management Plan (CEMP). The ESCP must be prepared in accordance with “Managing Urban Stormwater: Soils and Construction” (4th Edition Landcom, 2004, aka the Blue Book).	Contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
Ground movements	• An Environmental Work Method Statement (EWMS) must be prepared and implemented for the microtunneling and pit excavations. The EWMS must be reviewed and approved by the City of Sydney. The EWMS must contain as a minimum: o A risk assessment detailing which activities have the potential to impact ground levels o Management measures to prevent/minimise ground level movements or subsidence. This would include but not be limited to measures from Douglas and Partners (2018) o Monitoring requirements to check for potential ground movements. o Monitoring requirements if Bentonite or other product is used to prevent subsidence, to ensure there is no leakage. o Settlement monitoring	Contractor	Pre-construction and construction
Contamination	• Material excavated from the excavation pit must be visually inspected and anthropogenic inclusions such as clinker and furnace slag noted. • Whilst asbestos was not detected within filling, building rubble was recorded within filling which is indicative of the potential presence of asbestos. Where suspicious or unknown materials are encountered during the works, an Environmental Engineer/Scientist must inspect the material and advise accordingly. • Construction personnel to receive training prior to works on site regarding the identification and work methods relating to identifying potentially asbestos containing material, and other gross contaminates such as clinker slag etc.	Contractor	Pre-construction and construction
Acid sulphate soils	• Additional sampling and testing must be carried out to provide guidance on the presence of ASS and management requirements.	Contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
	• Acid sulphate soils must be appropriately managed and treated during excavation of the pits.		
Spoil management	• A Spoil and Soil Management Plan should be developed that details: o Methods for the identification of contamination and the need for further testing to confirm contamination, so that contamination is known and can be adequately managed o Methods for the management of waste streams that prevents cross contamination of uncontaminated spoil and to maximise the opportunity for reuse. o Methods for the management contaminated material that ensure contamination does not impact the surrounding environment, especially public areas, sensitive receptors and waterways (including groundwater and stormwater) o Methods for the management and liming (were required) of acid sulphate soils to prevent impacts to the environment the especially public areas and waterways (including groundwater and stormwater) o Methods to confirm opportunities for reuse (e.g. VENM) and confirm the waste classification.	Contractor	Pre-construction and construction

6.3 WATER QUALITY

6.3.1 Existing environment

Waterways

There are no natural waterways in the vicinity of the proposal. Alexandra Canal is located about 1.5 kilometres west of the proposal site. The canal is approximately 60 metres wide, and flows to the Cooks River, eventually discharging to Botany Bay. Woolwash Park contains a 417 square metre pond, fed by stormwater and a groundwater spear located within Nutfield Park within Victoria Park Precinct.

Groundwater

Douglas Partners (2015) assessed the groundwater conditions and the potential impacts of the proposal on groundwater at the proposal site. The results have been summarised below and the detailed report is provided in Appendix C.

There are two groundwater systems operating in the region, one being a deeper confined aquifer system in the fractured triassic bedrock and a shallower unconfined to semi-confined system which is present within the unconsolidated sediments of the Botany sand beds. The saturated portion of the Botany sand beds is known as the Botany sands aquifer.

Groundwater flow directions are typically towards the main surface water systems (Botany Bay and Alexandra Canal being the closest to the proposal site). Groundwater depth in the proposal area site ranges from about 2.3 metres to about 3.2 metres. However, this could fluctuate by about 1 to 2 metres due to wet weather.

Water quality in the Botany Sand Aquifer is typically of low salinity (i.e. less than 150 µS/m) and pH varies between 4.3 and 8.9. The area of the Botany Sand Aquifer, extending from Botany Bay to Surry Hills and Centennial Park, contains 32 monitoring bores operated by DPI Water (formerly the NSW Office of Water) and approximately 500 licensed bores. Extracted groundwater was once used for industrial and irrigation purposes, and is still used for irrigation at Randwick Racecourse and the University of New South Wales. The site and surrounding area is located within Zone 2 of the Botany Groundwater Management Zone where domestic groundwater use is banned.

Water samples taken during geotechnical investigations undertaken by Douglas Partners (2015) were analysed for metals, TRH, BTEX, PAH, OCP, PCB, phenols and VOC and were below laboratory limits of reporting with the exception of zinc at BH1/MW1 (96 µg/L) which exceeded a hardness modified GIL1 of 20 µg/L. Elevated zinc concentrations are typically encountered within urbanised areas of Sydney. In particular, the underlying regional Botany Sands aquifer has been impacted by contaminants including elevated metals from past industrial activities. The elevated zinc concentration encountered is therefore unlikely to be localised and is not considered significant enough to warrant treatment.

6.3.2 Potential impacts

Construction

Fuel or chemical spills (e.g. concrete) from plant or equipment in or around the pit has the potential to impact stormwater and groundwater quality in the immediate area and potentially impact the Botany Aquifer. A reduction in aquifer water quality could affect the current industrial and irrigation uses. This could occur should any of the groundwater/stormwater become contaminated during construction and is not treated before being released/reinjected.

Erosion and sedimentation of roadside drains may occur, in particular where excavations would be required for the pits. Stockpile sites are also potential sources of turbid runoff which could impact adjacent areas including drain inlets. Erosion and related impacts are discussed in Section 6.1.

Water extraction and water reinjection has been recommended by Douglas Partners during construction. The water extraction includes the dewatering of the groundwater at the proposal site, within the excavation pits, to a depth 1 metre below the bottom of the pits. The injection of contaminated water into groundwater bodies has the potential in impact the water quality at the proposal site and surrounding the site through the contamination of groundwater.

Operation

The proposal would include the upgrade of GPTs which would improve water quality discharging into the Green Square trunk main then into Alexandria Canal. The proposal is designed to reduce flooding in the area, which in turn has the potential in improve the quality of water entering the stormwater system.

6.3.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
Water quality impacts	• Water quality control measures are to be used to prevent any materials (eg. Sediment, concrete) entering surrounding environment, in particular stormwater drains.	Contractor	Construction
Water quality impacts	• Prior to groundwater reinjection or otherwise release of water associated with the proposal, testing should be undertaken to ensure it would not adversely impact the waterbody (including groundwater, stormwater etc.) into which it would be released • If water won from dewatering or groundwater extraction is found to be contaminated or not appropriate for reinjection or release, due care should be taken to ensure spills and similar do not occur and that it is disposed of appropriately	Contractor	Construction
Chemical spills	• All fuels, chemicals and liquids are to be stored in an impervious bunded area at the compound site. • Refuelling of plant and equipment is to occur in impervious bunded area at the compound site or offsite. • An emergency spill kit is to be kept on site at all times. All staff are to be made aware of the location of the spill kit and trained in its use. • An emergency spill procedure must be prepared as part of the Construction Environmental Management Plan (CEMP) that must detail the steps to be taken in the event of a spill. The procedure must include as a minimum: o Contact details of relevant authorities to be contacted in the event of a spill	Contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
	o Location of hazardous materials stored on site o Location of spill kits o Steps to be undertaken in the event of a spill		

6.4 HYDROLOGY

WMA Water prepared a Floodplain Risk Management Plan for the Green Square-West Kensington catchment (WMA Water, 2013). Douglas Partners developed a geotechnical report pertaining to the site, including assessments related to groundwater hydrology. This section is based on these reports.

6.4.1 *Existing environment*

Flooding

The Green Square and West Kensington catchment has an area of around 2.5 square kilometres and drains predominantly from east to west. South Dowling Street runs north-south through the middle of the catchment dividing the City of Sydney and Randwick City Local Government Areas (LGAs). The City of Sydney portion of the catchment includes parts of the suburbs of Zetland, Waterloo, Alexandria and Rosebery.

Urbanisation has dramatically altered the nature of available drainage within the catchment and has led to:

- A major increase in the proportion of paved area and consequent reduction in pervious areas, resulting in corresponding increases in runoff (in terms of both peak flows and volumes)
- Development within the trapped depressions that were once swamps or dams, resulting in flood problems in these areas. Examples include Lachlan Street and Joynton Avenue. Peak flood depths within these locations are expected to exceed 1m in the 1% Annual Exceedance Probabilities (AEP) rainfall event.

Flood problems typically result from insufficient capacity in the formal drainage system and ponding in trapped low-points such as those found in Joynton Avenue, Lachlan Street, South Dowling Street and Botany Road. A number of these locations are known to have experienced severe flooding in the past. Due to the natural topography and the large area of contributing catchment upstream, the Joynton Avenue trapped low point is one of the most significant flood-affected areas within the catchment.

Drainage in the area is mainly managed by pipes or watercourses with limited capacity and constrained by large adjoining industrial developments. Flows exceeding the pipe network capacity are conveyed overland along streets and in some cases through private property. Surcharging of pits occurs at some locations. Property damage and disruption are the result of frequent inundation of private land as well as major road and rail transport links to the city. Above floor level inundation and disruption to transport occur in storms as frequent as the 2 year Average Recurrence Interval (ARI) storm.

Hydrologic and hydraulic investigations have been undertaken by WMA Water to determine the response of the catchment and drainage system to 50% AEP (1 in 2 year), 20% AEP (1 in 5 year), 5% AEP (1 in 20 year), 2% AEP (1 in 50 year), 1% AEP (1 in 100 year) and 0.2% AEP (1 in 500 year) rainfall events and the Probable Maximum Flood (PMF). This study was limited to the Green Square – West Kensington catchment. The flood depths are provided in Table 6-5. The estimated number of residential building floors which are likely to be inundated in the 20% AEP is 8 and 17 in the 1% AEP. The corresponding number of commercial properties inundated is 27 and 56 for the 20% AEP and 1% AEP events respectively. In the PMF a total of 130 building floors would be inundated.

Table 6-5 Flood depths (m) on Joynton Street for various AEPs

50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP	PMF
1.6	1.9	2	2.1	2.2	2.3	2.4	3

Groundwater

Based on groundwater measurements and comparison with the invert levels of the proposed pipeline, Douglas Partners found groundwater will be encountered within the expected depth of both the underbore and pits. Although standing groundwater was measured at depths of between 2.3 m and 3.2 m during the investigations, experience in the area suggests that groundwater level fluctuations of about 1 – 2 m could be expected due to wet weather. For permanent substructures, it is suggested that design should be based on a groundwater depth of 0 m.

6.4.2 Potential impacts

Construction

There is potential for construction plant located on Joynton Avenue to block overland flow paths during heavy rain. This has the potential to increase the risk of localised flooding, resulting in increased traffic disruptions and potentially increased impacts to properties.

Flooding in the launch/receiving pits has the potential to impact microtunnelling, resulting in delays to construction but also increasing impacts to water quality though increased erosion and sedimentation and/or contamination from construction plants and cross contamination from interactions with contaminated sediments. Douglas partners have recommended the groundwater level should be lowered to 1 meter below the bottom of the excavated areas. There is therefore a potential for the proposal to result in the lowering of the groundwater table and potentially damaging adjacent structures, utilities and roads. However, a system of recharge wells close to the pits has been recommended by Douglas Partners to reinject pumped groundwater back into the ground to maintain the groundwater level outside the pit excavations.

Operation

The proposal, in addition to other stormwater upgrade projects, would have a positive impact on flooding in the area. The proposal would increase stormwater carrying capacity on Joynton Avenue and when considered with the Sydney Water stormwater drain and the O'Dea Avenue stormwater upgrade, regional improvements to stormwater drainage and flood mitigation are expected.

6.4.3 Safeguards and mitigation measures

On this basis, it is suggested that the design of temporary shoring walls and dewatering systems be based on a groundwater depth of about 1.5 m.

Impact	Environmental safeguards	Responsibility	Timing
Lowering of groundwater level	• An Environmental Work Method Statement (EWMS) must be prepared for the construction of the pits and their management. The EWMS must be reviewed and approved by the City of Sydney. The EWMS must contain as a minimum: o Descriptions of works/activities including machinery to be used. o Lists of licences/permits that may be required under the Water Management Act and/or Water Act and related conditions. o Outline of the sequence of the works/activities. o Identification of the potential environmental impacts due to works/activities such as but not limited to potential contamination of groundwater. o An environmental risk assessment to identify potential risks to discrete work elements or activities likely to affect the environment. o Mitigation measures to reduce environmental risks. o A process for assessing the performance of the implemented mitigation measures. o A process for resolving environmental issues and conflicts. • Recharge wells close to the pits must be used to reinject pumped groundwater back into the ground to maintain the groundwater level outside the pit excavations	Contractor	Construction
Flood	• A site-specific flood evacuation plan must be prepared and implemented as required. It would include the following measures as a minimum: o Daily weather and flood monitoring o List equipment to be removed from the site. o Detail who would be responsible for monitoring the flood threat and how this is to be done. It is expected	Contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
	that flood warning information would be sourced from the BoM website. o Detail staff training requirements and roles and responsibilities for the implementation of the Plan.		
	• The groundwater level must be lowered to at least 1 m below the bulk excavation level for the pits to allow man access and machinery to operate, and to prevent flooding during heavy rainfall.	Contractor	Construction

6.5 BIODIVERSITY

6.5.1 *Approach*

Background searches

Background searches of existing information in order to identify potential biodiversity constraints at the proposal site were undertaken. This included a search of Commonwealth and State databases to determine whether any threatened flora and fauna species, populations, ecological communities, migratory species and areas of outstanding biodiversity values (AOBVs) as detailed in State and Commonwealth legislation have the potential to occur at the proposal site. Specifically, a search of the:

- Office of Environment and Heritage (OEH) Bionet database within a 10 km radius of the proposal site was undertaken on 21 August 2018.
- Department of the Environment and Energy Protected Matters Search Tool within a 1 km radius of the proposal site was undertaken on 21 August 2018.
- Department of Primary Industries priority weed declarations for the Greater Sydney region was undertaken on 25 July 2018.

Literature review

Earthscape Horticultural Services prepared the *Arboricultural Impact Assessment Report: Proposed stormwater pipeline, Joynton Avenue, Zetland* (Earthscape 2016; Appendix B). The results of this report relevant to biodiversity are summarised below.

6.5.2 *Flora*

Existing environment

The Earthscape (2016) abroricultural report found there are 46 street trees located in the vicinity of the proposed works, within a section of road reserve on the eastern side of the Joynton Avenue between the intersections of O'Dea Avenue and Gadigal Avenue and the northern section of Woolwash Park (corner Joynton and Gadigal Avenues). These include nine *Ficus rubiginosa* (Port Jackson Fig) on the eastern side of the road reserve in Joynton and nine *Ficus microcarpa var. hillii* (Hills Weeping Fig) on the western side of Joyton Avenue, which are listed on the City of Sydney Significant Tree Register. Earthscape (2016) assessed the retention value of each tree based on their estimated longevity and their landscape significance rating. The landscape significance rating was determined by a combination of their amenity, environmental and heritage values. Of the 46 trees, three have low retention value, 23 have moderate retention value and 20 have high retention value.

The OEH Bionet search identified a total of 14 threatened flora species and 26 Endangered Ecological Communities (EECs) previously recorded within a 10 km radius of the study area listed under the *Biodiversity Conservation Act 2016* (BC Act) (Appendix E). The EPBC Protected Matters database search identified 12 threatened flora species and 6 EECs previously recorded within a 1 km radius of the study area listed under the EPBC Act (Appendix E). The closest previously recorded threatened flora species to the proposal site is *Hibbertia puberula* (TSC-E1), located about 970 metres away. The OEH Bionet search and the EPBC Protected Matters database search did not identify any threatened species at the proposal site.

A weed of national significance, Salvinia (*Salvinia molesta*) is known to occur within Woolwash Pond, amongst other aquatic plants. Other species of reeds and other aquatic species grow throughout the pond.

Potential impacts

The proposed works would remove approximately nine trees of moderate retention value. The location of the trees to be retained, removed and or trimmed are illustrated in Figure 6-3, Figure 6-4 and Figure 6-5. The trees that would be removed include *Magnolia grandiflora* (Bull Bay Magnolia) (T3 & T31), *Ficus rubiginosa* (Port Jackson Fig) (T4), and *Melaleuca quinquenervia* (Broad-leaved Paperbark) (T32, T35, T56, T37, T38 & T39). With the exception of T32, all of these trees are relatively small and can be replaced in the short term with new tree planting.

The Earthscape (2016) report found the risk of mechanical damage to the root systems of trees within the proposal site is considered unlikely as the tunnelling would occur beneath the secondary root plate. Given the soil conditions in this area, mature trees may develop a secondary root crown usually just above the water table, which is located at about 2.7 metres below ground level at the proposal site. The pipeline would be located between three and four metres below the surface, and therefore would not impact on root systems.

The proposed receiving pit on the south east corner of Morris Street is located within the Tree Protection Zones (TPZs) of T15 (*Corymbia citriodora* (Lemon-scented Gum)) and T16 (*Corymbia maculata* (Spotted Gum)). The extent of encroachment to the TPZ of T15 (assuming vertical sheet piling on the around the edge of the pit) is less than 10% of the TPZ, which is considered within acceptable limits under the *Australian Standard for Protection of Trees on Development Sites* (AS 4970:2009). The encroachment to the TPZ of T16 marginally exceeds acceptable limits (13%). Excavations for the pit have the potential to result in the severance and damage to woody roots of this tree, resulting in an adverse impact.

Proposed excavations for various other pits and pipelines are located within the TPZs of T2 (*Melaleuca quinquenervia* (Broad-leaved Paperbark)), T8 & T9 (*Ficus rubiginosa* (Port Jackson Fig)), T17 & T18 (*Melaleuca quinquenervia* (Broad-leaved Paperbark)) and T16 (*Corymbia maculata* (Spotted Gum)) and T22 (*Ficus rubiginosa* (Port Jackson Fig)). In all instances the extent of the encroachment to the TPZs resulting from these excavations would be relatively minor (less than 10% of the TPZ for all except T2 (13%)). These excavations would be undertaken with care in accordance with the safeguards provided in Section 6.5.4, and are not expected to result in any adverse impact on these trees.

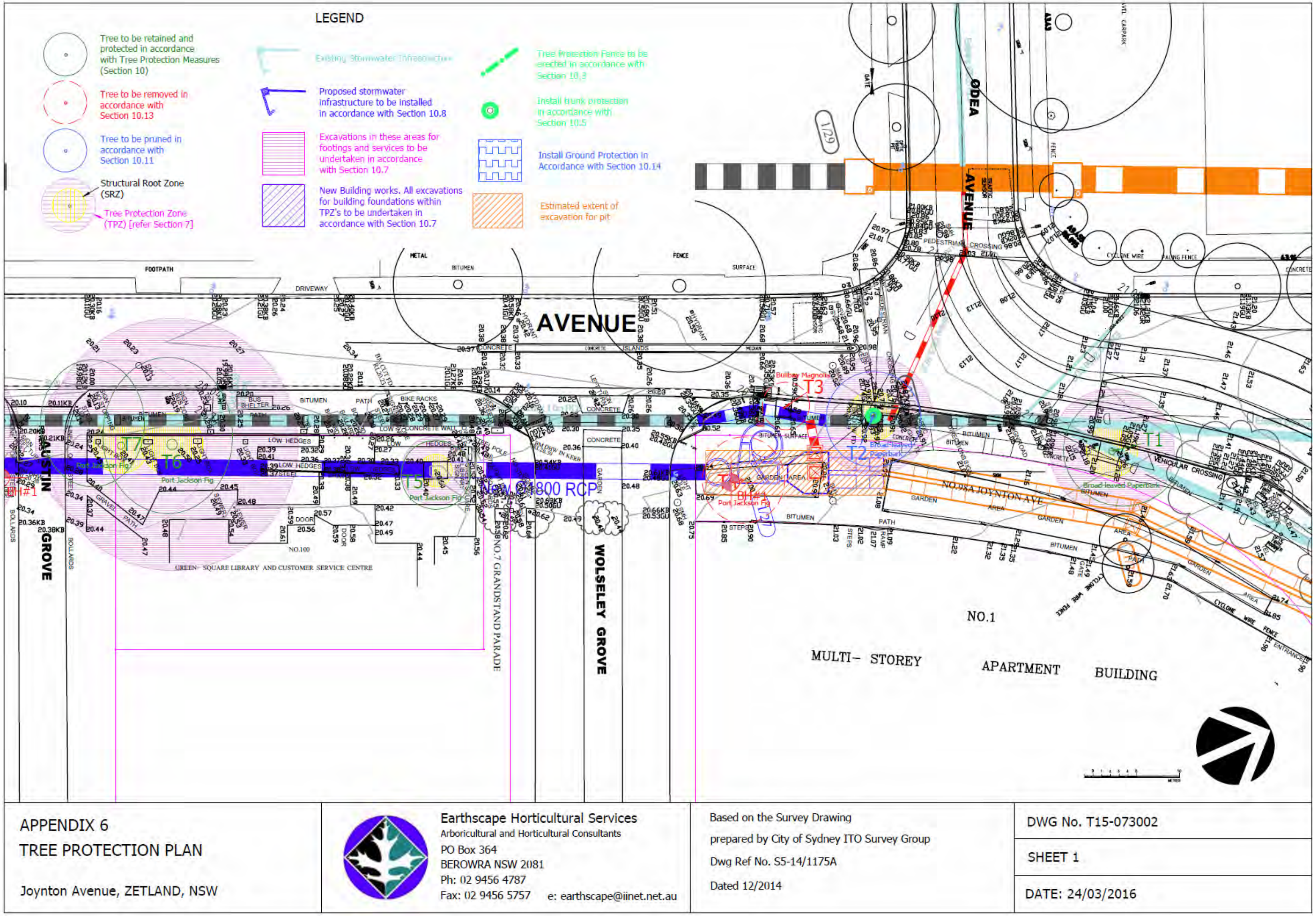


Figure 6-3 Impacts to trees along Joynton Avenue

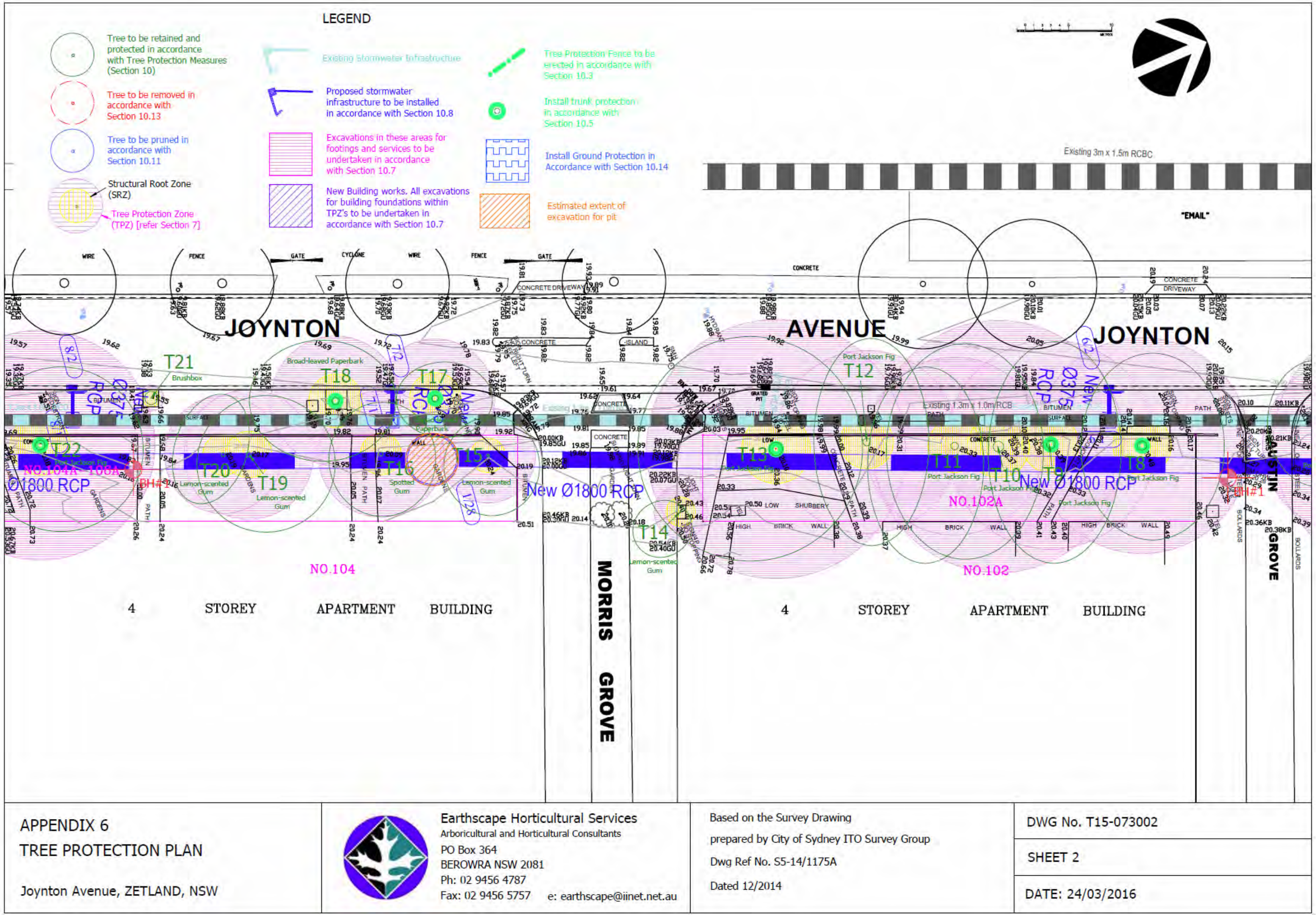


Figure 6-4 Impacts to trees along Joynton Avenue

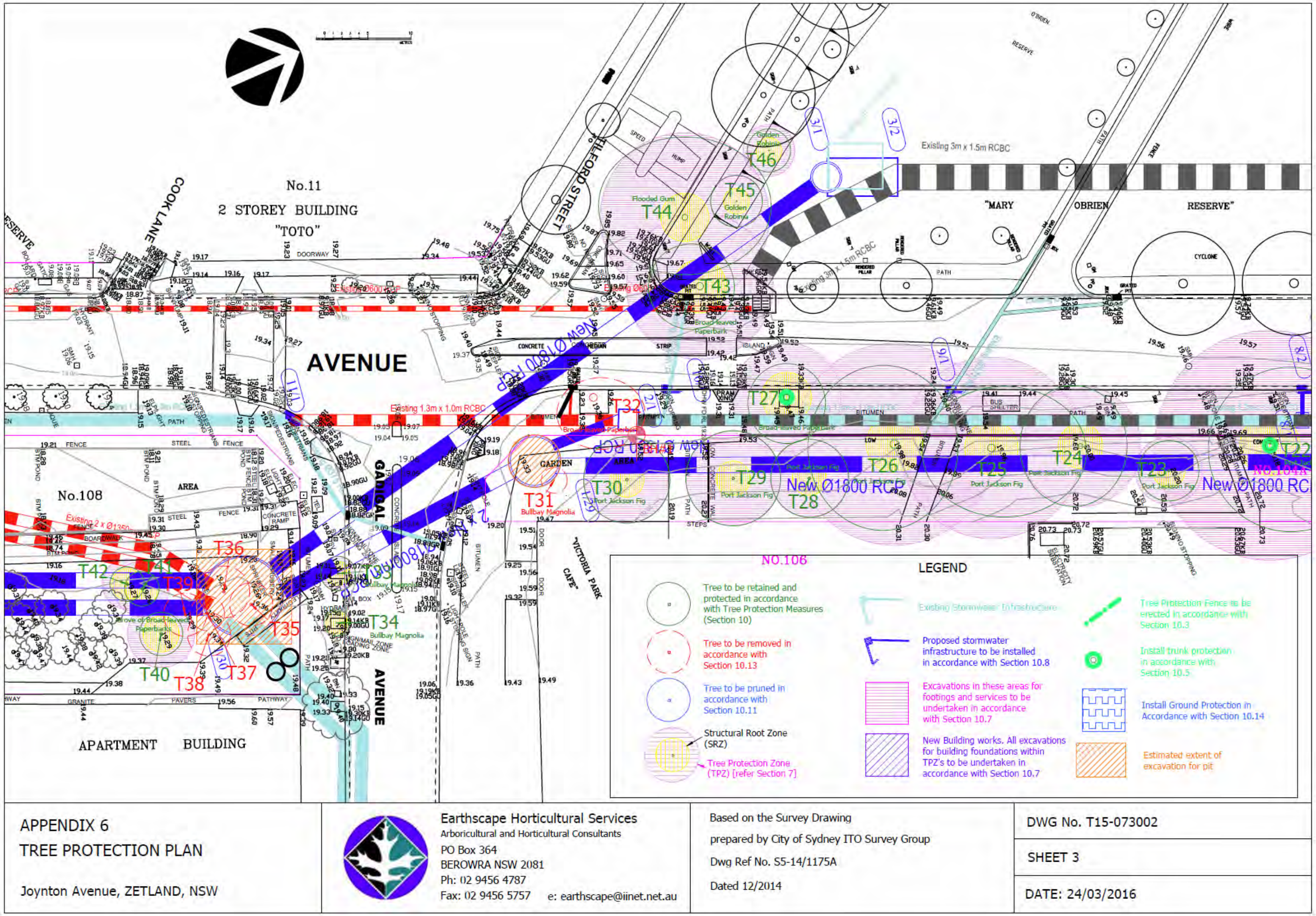


Figure 6-5 Impacts to trees along Joynton Avenue

Some minor canopy pruning of T2 (*Melaleuca quinquenervia* (Broad-leaved Paperbark)) would potentially be required to clear the entry/jacking pit. All pruning would be undertaken in accordance with the safeguards provided below, and would not be expected to result in any adverse impact.

Joints between pipe sections would be sealed with a banded steel joint to prevent water ingress and therefore long term impact on the water table, such as localised draw down of the groundwater table, would be avoided. Therefore the pipeline is unlikely to impact on the health of the trees as a result of altering the water table in the long term. Some short term draw down may occur during the construction phase.

Should the tunnel boring machine become obstructed during tunnelling works, it would have to be retrieved by open excavation at the location it was stuck at. If this was to occur, one or more trees including trees with high retention value may have to be removed.

Material from Woolwash Pond is likely to be contaminated with the weed of National Significance, Salvinia (*Salvinia molesta*). Improper management of this material may result in the spread of this weed.

6.5.3 Fauna

Existing environment

The OEH Bionet search identified a total of three amphibian, 27 bird and nine mammal species previously recorded within a 10 km radius of the study area listed under the BC Act (Appendix E). The EPBC Protected Matters database search identified 35 bird, two frog and nine mammal species previously recorded within a 1 km radius of the study area listed under the EPBC Act (Appendix E). There have been 466 records of *Myotis macropus* (Southern Myotis) (BC-V), 180 records of *Litoria aurea* (Green and Golden Bell Frog) (BC-E1, EPBC-V), 174 records of *Pteropus poliocephalus* (Grey-headed Flying-fox) (BC-V, EPBC-V), and 153 records of *Calidris ferruginea* (Curlew Sandpiper) (BC-E1, EPBC-CE) within 10 km of the study area. The closest threatened fauna species to the proposal site are *Litoria aurea* (Green and Golden Bell Frog) (BC-E1, EPBC-V) (840 metres from the proposal site), Grey-headed Flying-fox) (TSC-V, EPBC-V) (960 metres from proposal site), and *Ninox strenua* (Powerful Owl) (TSC-V) (980 metres from proposal site).

Terrestrial fauna habitat at the proposal site is highly disturbed due to its urban setting and is limited to road side trees and landscaped parks. The proposal site would provide some foraging habitat for fauna species which are highly tolerant to human disturbances. In regards to threatened species, the proposal site is only likely to provide some marginal foraging habitat for the Grey-headed Flying-fox due to the presence of fig trees. No hollow-bearing trees were recorded on site.

Woolwash Pond contains carp (*Cyprinus carpio*) a freshwater pest species in NSW. Due to the accessibility of the pond, it is possible other pet-release pest species occur at the pond. The pond potentially contains Eastern long-necked turtles (*Chelodina longicollis*) and Eels (Short and Long-finned) (*Anguilla reinhardtii*) may also occur at the site due to their ability for terrestrial travel.

Potential impacts

Melaleuca quinquenervia (Broad-leaved Paperbark) (T1, T2, T17, T18, T27, T32 & T35-T42) is a locally-indigenous species, which is representative of the original vegetation of the area and would be of benefit to native wildlife. However, none of the trees contain cavities suitable as nesting hollows for arboreal mammals or birds or other visible signs of wildlife habitation.

The proposal has the potential to disturb some of the local fauna during construction as a result of construction noise. This may include the Grey-headed Flying-fox should it use the fig trees for feeding. The impact is likely to be minor as any fauna using the proposal site for foraging purposes would be tolerant to such disturbances and the impacts would be temporary.

Draining of Woolwash Pond could result in impacts to fauna living in the swamp. Machinery used to drain the pond may harm fauna though induction into pumping equipment. The drainage of the swamp may cause fauna within the pond to become stranded without water. The waters of the pond may contain viable breeding pairs, eggs and similar, that if incorrectly managed could result in the spread of pests within NSW.

6.5.4 Safeguards and mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Damage to trees	• Management measures detailed in Section 10 and the tree protection plan (Appendix 6) of the *Arboricultural Impact Assessment Report* (Earthscape 2015) must be implemented to ensure damage to trees is avoided or minimised. These measures must be included within the Construction Environmental Management Plan (CEMP) to be prepared for the proposed works. • Should the TBM fail and require open excavation for removal; o An arborist must assess the excavation and provide management measures to avoid and mitigate impacts to trees. o If arborist classifies the unplanned excavations to likely result in the death of medium or high retention value trees (ass assessed in the EHS 2015 report) an addendum REF will be required.	Contractor	Pre-construction and Construction
Tree removal	• In order to compensate for the loss of trees, a minimum of one tree should be replanted within an appropriate area for every tree to be removed. The species should be selected in accordance with Council's Street Tree Masterplan.	Contractor	Post-construction
Aquatic vegetation removal	• Aquatic vegetation removed/killed during the drainage of Woolwash Pond should be replaced to restore the visual character and environmental quality of the pond	Contractor	Post-construction
Management of priority weeds	• All plant and equipment must be cleaned prior to entering the site to prevent the importation of priority weeds and propagules of priority weeds to the proposal area • Material from Woolwash Pond must be managed in such a way to prevent the spread of the weed of National Significance, Salvinia (*Salvinia molesta*),	Contractor	Pre-construction and Construction

	including cleaning of plant and equipment that may harbour propagules		
Draining of Woolwash pond	• Prior to drainage of Woolwash Pond, a fauna relocation plan should be developed that identifies the following for the fauna that is likely to be present: o Pre-drainage survey of the site o Appropriate capture methods and appropriately licenced personnel o Appropriate storage methods o Locations for translocation, that satisfy relevant biosecurity obligations and habitat potential o Long term housing (where applicable) • Draining must be conducted to ensure no fauna are harmed during the draining process (e.g. sucked into pumping equipment) • Suitably qualified and licenced ecologist should be present during the drainage of Woolwash Pond, to capture and safely house any native fauna stranded during the drainage process • Suitably qualified and licenced ecologist should be present during the drainage of Woolwash Pond, to capture and euthanise pest fauna stranded during the drainage process • Drainage and works within the Woolwash Pond area should be done in such a manner to prevent the spread of pests.	Contractor	Pre-construction and Construction

6.6 SOCIO-ECONOMIC IMPACTS

Potential Socio-economic impacts have been assessed in the following sections:

- Noise and vibration Section 6.1
- Traffic and access Section 6.8
- Air quality Section 6.9
- Visual amenity Section 6.10

6.6.1 Existing environment

The Green Square Urban Renewal Area is located in an important economic corridor between Sydney's City Centre and Kingsford Smith International Airport. It incorporates the suburbs of Zetland and Beaconsfield and parts of Roseberry, Alexandria and Waterloo and covers an area of 278 hectares. Four major new precincts are planned for the area:

- Green Square Town Centre: 2014-2024
- Lachlan: 2014-2019

- Epsom Park: 2014-2024
- North Rosebery: 2014-2019.

A desktop study found three hospitality venues adjacent to the proposal area:

- Little Piazza Bar and Grill (30 Gadigal Avenue)
- Victoria Park Café (33/106 Joynton Avenue)
- 周厨 – a Chinese restaurant (15 Joynton Avenue)

6.6.2 Potential impacts

The proposal has the potential to impact the local community due to noise, dust, traffic and other impacts during construction. This would include residents as well as businesses, including the various hospitality venues located within the vicinity of the proposal. While management measures detailed in the REF would help avoid, minimise or mitigate potential impacts, some impacts would be unavoidable. Impacts may also be exacerbated as a result of cumulative impacts (refer to Section 6.13). It will be important to keep the community and relevant stakeholders informed of the proposed works prior to and throughout construction.

There is a potential for a positive impact on local businesses during construction due to short-term demand for services in the area.

Impacts for specific stakeholders are discussed in Table 6-6.

Table 6-6 Impacts to stakeholders

Impacted parties	Impacts
Residents	Impacts associated with construction including noise, vibration, visual amenity and pedestrian access on Joynton Avenue, southbound.
Businesses of Joynton Avenue and Gadigal Avenue including: • Orthoworx - 1/98 Joynton Ave, Zetland • Chinese Restaurant - 13 Joynton Avenue, Zetland • The Rizzeria - 3 Joynton Ave, Zetland • Victoria Park Cellars - 3/30 Gadigal Ave, Zetland • S,Thada - 2/30 Gadigal Ave, Zetland • Toto - Joynton Avenue, Zetland • Neuromoves – 3 Joynton Avenue, Zetland (access from Portman Street) • NSW Health Hydrotherapy – 3 Joynton Avenue (access from Portman Street)	Impacts associated with disruption and construction including noise, vibration, visual amenity and pedestrian access on Joynton Avenue, southbound.
Ausgrid – 130 Joynton Avenue, Zetland	Driveway on Joynton Avenue, which currently facilitated two way traffic for heavy vehicles, to be disrupted by construction of watermain pit.

	Likely a temporary driveway will have to be installed for two way traffic on the Gunyama Park land to the right of the Ausgrid existing entrance.
Victoria Park Café - 33/106 Joynton Ave, Zetland	Business on the corner of Joynton Avenue and Gadigal Avenue. Will be obscured by hoarding and have entry to the business disrupted during construction.
Little Piazza Bar and Grill - 1/30 Gadigal Ave, Zetland	Business on the corner of Joynton Avenue and Gadigal Avenue. Will be obscured by hoarding and have entry to the business disrupted during construction.
Transport for NSW	Bus stop on Joynton Avenue before Gadigal Avenue, southbound, will be impacted. The need for signage and temporary relocation further south toward Gadigal Avenue to be discussed.
City of Sydney Community Venues • Mary O'Brien Reserve • Tote Park • Portman Street south car park (access from Portman Street) • Joynton Avenue Community Centre (access from Portman Street) • Matron Ruby Grant Park (access from Portman Street)	Impacts associated with disruption and construction including noise, vibration, visual amenity and pedestrian access on Joynton Avenue, southbound.

6.6.3 Safeguards and mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Socio-economic impacts	A Communication Plan will be prepared and included in the CEMP. The Communication Plan must include (as a minimum): • A map identifying locations of potential adjacent residences and a list of relevant stakeholders (e.g. Ausgrid, bus services). • An evaluation of the potential impacted properties/stakeholders at the different stages of the construction activities, taking into account any cumulative impact as a result of other works taking place in the locality. • Requirements to provide details and timing of proposed activities to affected residents • Procedure to notify adjacent land owners or users for changed conditions during the	Contractor	Construction

	construction period such as traffic/pedestrian access.		
Socio-economic impacts	• The Contractor must appoint a Community Liaison Officer (CLO) who will be the first point of contact for any property owner, tenant and general public enquiries and / or complaints and their satisfactory resolution. • The CLO must liaise with the Strategic Community Consultation team from the City of Sydney about their program and community relations to ensure a coordinated approach. • A complaints handling procedure and register will be included in the CEMP and maintained for the duration of the project. The complaints procedure is to include contact name and contact details for complaints.	Contractor	Construction
Hospitality premises	• Work must be staged in such a way that access to and from the various hospitality venues is maintained during construction	Contractor	Construction

6.7 WASTE MINIMISATION AND MANAGEMENT

6.7.1 Waste sources

The proposed works would generate waste from the following sources:

- Grass, shrubs and tree cuttings from vegetation clearing
- Soil from any used excavated material that is not needed/suitable for reuse on site
- Water won from the drainage of Woolwash Pond, and dewatering activities associated with groundwater drawdown
- Packaging waste from materials brought on site for installation
- General waste.

The quantities of volumes of earthworks are illustrated in Table 6-7. Some material from the pit excavations could be used reused onsite, however the remaining material would be disposed of.

Table 6-7 Estimates of earthworks volumes

Work	Volume
Six pits in total, five pits 6 metres in diameter and one pit 11 metres diameter	Approximately 2,000 m^3
Stormwater connections	Approximately 200 m^3
Tunnel bore	Approximately 7,000 m^3
Other pits	Unknown

6.7.2 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
Production of packaging materials and other construction waste	- Waste management would occur in accordance with the _Waste Avoidance and Resource Recovery Act 2001_. The resource management hierarchy will be followed at all times throughout the proposal: _avoid resource consumption → recover recyclable materials for reuse → dispose material unable to be recycled_ - Details of how the above would be met for all stages of the proposed works would be detailed in the Construction Environmental Management Plan.	Contractor	Construction
Burning of waste	- Waste will not to be burnt on site.	Contractor	Construction
Waste on site	- Waste material will not be left on site once the works have been completed. - Working areas will be maintained, kept free of rubbish and cleaned up at the end of each working day.	Contractor	Construction
Production of garden organics materials	- If feasible, the cleared vegetation must be mulched and reused on site for landscaping.	Contractor	Pre-construction and construction
Spoil from excavation	Spoil must be managed in accordance with the requirements of Section 6.2.3	Contractor	Pre-construction and construction
Wastewater	Spoil must be managed in accordance with the requirements of Section 6.3.3	Contractor	Pre-construction and construction

6.8 TRAFFIC AND ACCESS

Traffic and pedestrian conditions

Joynton Avenue is a two-lane, sub-arterial road connecting O'Dea Avenue to the north and Epsom Drive to the south. The speed limit on Joynton Avenue is 50 kilometres per hour. Details of the streets around the proposal site are provided in Table 6-8. Parking is available on both sides of Joynton Avenue, north of Gadigal Avenue.

Table 6-8 Details of streets around Joynton Avenue

Name	Location in relation to Joynton Avenue	Intersection type	General type of use
O'Dea Avenue	North	Traffic lights	Sub-arterial road
Wolseley Grove	East	No traffic lights	Local access
Austin Grove	East	No traffic lights	Local access
Morris Grove	East	No traffic lights	Local access
Leyland Grove	East	No intersection. Leyland Grove is a cul-de-sac	Local access
Gadigal Avenue	East	No traffic lights	Local road
Lamond Lane	West	No traffic lights	Local access
Tilford Street	West	No traffic lights	
Cook Lane	West	No traffic lights	
Elizabeth Street	West	No traffic lights	

There is a six to seven metre wide footpath on the eastern side of Joynton Avenue, with eight accesses to the blocks of units. The landscaped area between the path and the unit blocks contains the fig trees. A footpath runs along the western side of Joynton Avenue and a boardwalk in Mary O'Brien Reserve, parallel to the path.

Bus routes

The following bus routes travel on Joynton Avenue, through the proposal site:

- 301 – Eastgargens to Sydney CBD
- 343 - Kempsey to South Kempsey (Loop Service)
- 348 – Wolli Creek to Bondi Junction
- M20 – Artarmon to Botany.

Two routes are located close to the proposal site:

- 302 – Eastgardens to Sydney CBD. This services runs along O'Dea Avenue, immediately north of the proposal area
- 303 - Sans Souci to City Circular Quay via Mascot

All bus routes are likely to carry large number of passengers during peak periods. Route 348 is a key route linking the residential areas surrounding the proposal to the University of New South Wales.

Access

There are no vehicular accesses to residential properties from Joynton Avenue in the proposal area. At the southern extent of the proposal site, there is a driveway access to an Ausgrid depot at 130 Joynton Avenue.

6.8.2 Potential impacts

Construction

The delivery of plant and the set-up of the launch/receiving pits would be carried out at night to minimise the impact on traffic. Closure of the south bound lane on Joynton may be required at:

- O'Dea Avenue
- Morris Grove
- Gadigal Avenue.

Traffic management would be required during the lane closures and would be likely to impact traffic in both northbound and southbound traffic on Joynton Avenue. Traffic on Morris Grove and Gadigal would also be impacted with some delays likely. However, traffic volumes would be low at night and impacts are not expected to be substantial.

Sections of pipe would be delivered to the launch pit periodically. The area around the launch pit would provide some temporary storage capacity. Due to the tunnelling rate, about 10 metres per day, deliveries of pipe sections would be infrequent. Traffic management would be required during deliveries and this would have short term impacts on traffic flow.

As the kerbside lane would be temporarily closed during deliveries, this would temporarily impact roadside parking. This impact is unavoidable but would be temporary.

Pedestrian movements would be impacted while the launch/receiving pits are in place. Considering the width of the footpath, only minor detours around each works zone would be required for pedestrians. This would not be a substantial impact.

No bus stops would be impacted by the proposal and disruptions to traffic would be managed through a traffic control plan, minimising the potential for impacting bus services.

There may be some temporary impact on the driveway access to the Ausgrid depot when works are being undertaken in that area. This would need to be adequately managed in consultation with Ausgrid to ensure access to the depot is maintained.

Operation

There would be no traffic and access impacts once construction has been completed.

6.8.3 Safeguards and mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Traffic	• A Traffic Management Plan to manage road and pedestrian traffic, including bus services, would be developed for the construction work and form part of the Construction Environmental Management Plan (CEMP). • Traffic management measures must ensure that impacts on kerbside parking is minimised at all times.	Contractor	Pre-construction

Impact	Environmental safeguards	Responsibility	Timing
Traffic	• Safety barriers would be used to isolate the construction area from the existing travel lane.	Contractor	Construction
Traffic	• Temporary variable message signs (VMS) would be used to warn approaching road users of the works.	Contractor	Pre-construction and construction
Traffic	• Access to residences would be maintained during the works.	Contractor	Construction
Traffic	• Pedestrian access to the footpath on the eastern side of Joynton Avenue would be maintained through construction.	Contractor	Construction
Traffic	• No deliveries of materials would occur during peak traffic periods.	Contractor	Construction
Ausgrid driveway access	• Access to the Ausgrid depot would be maintained at all times. The City must inform Ausgrid of planned works near driveway.	Contractor	Construction

6.9 AIR QUALITY

6.9.1 Existing environment

The air quality in the area is mainly influenced by vehicle emissions and potentially construction site dust from developments taking place in the locality. There are many sensitive receivers surrounding the proposal site including:

- Residents
- Businesses, including cafes with outdoor seating
- Park users

6.9.2 Potential impacts

Air pollution can cause a wide range of health symptoms, from coughing, wheezing and shortness of breath, to more serious impacts for those with pre-existing respiratory and cardiac conditions.

During the proposed works there would be the potential for a localised deterioration in air quality due to:

- Emissions from machinery and vehicles
- Dust and particulates generated from disturbed surfaces, in particular during earthworks. Earthworks would be required to construct the launch and receiving pits. This would be at O’Dea Avenue, Morris Grove and around Gadigal Avenue.

Dust emissions have the potential to cause disturbances, affecting human health, coat windows and cars, cause disturbance at parks and outdoor eating areas. However, the use of microtunnelling would minimise the amount of disturbed areas, therefore, reducing the potential for dust generation. Uncovered loads transporting excavated material to the compound site for stockpiling as well as the stockpiles are also potential sources of dust. Any dust emissions would be short-term.

The proposal is unlikely to result in operational air quality impacts.

6.9.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
Vehicle emissions	• Plant and machinery must be maintained in accordance with manufacturer's specification.	Contractor	Construction
Vehicle emissions	• Smoky emissions must be kept within the standards and regulations under the *Protection of the Environment Operations Act 1997* that no vehicle shall have continuous smoky emissions for more than 10 seconds.	Contractor	Construction
Vehicle emissions	• Vehicles must not be left running when idle.	Contractor	Construction
Dust generation	• Any material transported in trucks must be appropriately covered to reduce dust generation.	Contractor	Construction
Dust emissions	• Measures including watering or covering exposed areas, including stockpiles sites, must be used to minimise or prevent dust generation.	Contractor	Construction
Dust emissions	• Visual surveillance for dust generation would occur at all times. Work must cease when high levels of airborne dust cannot be controlled.	Contractor	Construction
Smoke emissions	• Vegetation or other materials are not to be burnt on site.	Contractor	Construction

6.10 VISUAL AMENITY

6.10.1 Approach

The method to measure visual impact is based on the combination of the sensitivity of the existing area or view to change and the magnitude (scale, character, distance) of the proposal on that area or view. This provides the rating of the landscape character for a project or individual character zone, or visual impact for viewpoints.

Sensitivity refers to the qualities of an area, the type number and type of receivers and how sensitive the existing character of the setting is to the proposed change. Magnitude refers to the nature of the project. The combination of sensitivity and magnitude will provide the visual impact for viewpoints (refer to Table 6-9 for grading values).

Table 6-9 Impact grading matrix

Magnitude

Sensitivity	High	Moderate	Low	Negligible
High	High Impact	High-Moderate	Moderate	Negligible
Moderate	High-Moderate	Moderate	Moderate-Low	Negligible
Low	Moderate	Moderate-Low	Low	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

6.10.2 Existing environment

Landscape character

To the north of the proposal area, the character urban, with unit blocks and fig trees the dominant features. The fig trees, Mary O'Brien Reserve and landscaped areas associated with the unit blocks provide leafy character to the area. The interlocking canopies of large fig trees form a contiguous green archway over sections of Joynton Avenue creating a boulevard effect. To the south of the proposal area, commercial properties are the dominant feature. Woolwash Park provides a green area south of Gadigal Avenue.

Viewpoints

Key viewpoint were established to assess the visual impact of the proposal. The viewpoints are detailed in Table 6-10.

Table 6-10 Viewpoints

Viewpoint	Location	Existing view
1	Residents around the intersection of O'Dea Avenue and Joynton Avenue	View of the intersection and street trees
2	Residents at Morris Grove	View of the street and street trees
3	Residents at the intersection of Joynton Avenue and Gadigal Avenue and customers at outdoor seating at the café	View of the intersection and street trees
4	Pedestrians on Joynton Avenue	Views of wide footpaths and street trees

Viewpoint	Location	Existing view
5	Road users on Joynton Avenue	Views of Joynton Avenue, unit blocks and street trees
6	Users of Mary O'Brien Reserve	Views of the reserve and street trees

6.10.3 Potential impacts

Landscape character

The proposal would not have a substantial impact on landscape character. The use of microtunnelling means that the majority of street trees including the prominent fig trees would not be impacted by the construction work. The launch/receiving pits would be in place during construction but are not expected to impact the character of the area.

Table 6-11 Impact on landscape character

Sensitivity	**Magnitude**	**Impact**
High	Low	Moderate

Visual impact

The impact on viewpoints is provided in Table 6-12. The proposal has the potential to have a relatively high visual impact due to the close proximity of the works to residences and the sensitivity of the receivers. The main areas of impact would be around the pits at O'Dea Avenue and at Gadigal Avenue where streets trees would be removed.

Table 6-12 Impact on viewpoints

Viewpoint	Location	Phase	Sensitivity	Magnitude	Impact	Comment
1	Residents around the intersection of O'Dea Avenue/Worsley Grove and Joynton Avenue	Construction	Moderate	Moderate	Moderate	Residents would have views of the launch pit and vehicle movements. Impacts would be temporary
		Operation	Moderate	Low	Moderate-Low	Two trees would be removed at the intersection of Joynton Avenue and Worsley Grove including a tree which provides some visual barrier towards Joynton Avenue for residents on the first floor. Trees removed would be

Viewpoint	Location	Phase	Sensitivity	Magnitude	Impact	Comment
						replaced with advanced trees.
2	Residents at Morris Grove	Construction	Low	Low	Low	Microtunneling would be used in this area and residents would only have distant views of construction activities.
		Operation	Negligible	Negligible	Negligible	There is unlikely to be any visual impacts to these receivers.
3	Residents at the intersection of Joynton Avenue and Gadigal Avenue and customers at outdoor seating at the café	Construction	Moderate	Moderate-Low	Moderate-Low	A launch/receiving pit would be located at the intersection. The impact would be temporary.
		Operation	Moderate	Low	Moderate-Low	Street trees would be removed as part of the proposal including a clump of small trees near Woolwash Park which offer only a minimal visual barrier to residents and one large tree on the north east corner of Cadigal Avenue. This last tree offers some minor visual barrier for residents on that corner. Trees removed would be replaced with advanced trees.
4	Pedestrians on Joynton Avenue	Construction	Moderate	Low	Moderate-Low	Pedestrians would have views of the launch/receiving pits. The impact would be temporary.

Viewpoint	Location	Phase	Sensitivity	Magnitude	Impact	Comment
		Operation	Moderate	Low	Moderate-Low	Street trees would be removed as part of the proposal. However, the more significant large trees would be retained which would mitigate visual impacts. Trees removed would be replaced with advanced trees.
5	Road users on Joynton Avenue	Construction	Moderate	Low	Moderate-Low	Road users would have brief views of the construction work as they move through the proposal site. The impact would be temporary.
		Operation	Moderate	Negligible	Negligible	Street trees would be removed as part of the proposal. However, the more significant large trees would be retained and there would be no impacts on the interlocking canopies forming a contiguous green archway over the street which would mitigate visual impacts. Trees removed would be replaced with advanced trees.
6	Users of Mary O'Brien Reserve	Construction	Moderate	Moderate	Moderate	Reserve users would have views of the construction in the south

Viewpoint	Location	Phase	Sensitivity	Magnitude	Impact	Comment
						eastern corner of the park. The impact would be temporary.
		Operation	Moderate	Low	Moderate-Low	Three trees would be removed in the south eastern corner of the park. This would have some moderate-low impact on visual amenity. However, disturbed areas would be rehabilitated and landscaped which would mitigate this impacts. Trees removed would be replaced with advanced trees.

6.10.4 Safeguards and mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Rehabilitation	• A Landscape Plan would be prepared to detail the landscaping of disturbed areas including the replanting of street trees removed and any vegetation within Woolwash Pond that is harmed • Street trees to be planted must be of an appropriate height to minimise visual impact of the removal.	Contractor	Pre-construction
Visual	• Site compound would be maintained in a tidy manner.	Contractor	Construction

6.11 INDIGENOUS HERITAGE

6.11.1 Existing environment

A search of the Aboriginal Heritage Information Management System (AHIMS) was carried out on 27 July 2018. There are no registered Aboriginal heritage sites or places within a 1km buffer zone of the proposal area.

6.11.2 Potential impacts

Landforms such as creeks, hilltops, ridge lines are important when considering the potential for finding Aboriginal heritage items. However, the proposal site is highly disturbed due to the highly urbanised environment and all areas have been extensively disturbed. The potential for impacting Aboriginal heritage items is therefore low.

6.11.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
Impact on unknown heritage items	• If Aboriginal heritage items are uncovered during the works, all works in the vicinity of the find must cease and the City of Sydney environment officer contacted immediately.	Contractor	Construction

6.12 NON-INDIGENOUS HERITAGE

6.12.1 Approach

A search of Australian, State and Local heritage databases was undertaken on the 27 July 2018 to determine the heritage significance of the area surrounding Joynton Avenue.

6.12.2 Existing environment

Australian Heritage Database

The Australian Heritage Database includes items listed on the National, Commonwealth and World Heritage Lists. The database was searched on 27 July 2018 for the suburb of Zetland and no heritage items were found in the vicinity of the site.

State Heritage Register

The State Heritage Register was searched on 27 July 2018 for the suburb of Zetland and no heritage items were found in the vicinity of the proposal site. However, the trunk drain in Joynton Avenue would connect to the new Green Square trunk drain, discharging to Alexandra Canal (about 1.3 kilometres from the proposal site). Alexandra Canal is listed under the NSW Heritage Act (refer to Appendix F). The proposed works will have no determined impact upon the heritage significance of the Alexandra Canal.

Sydney Local Environmental Plan 2012

The City of Sydney LEP was searched on 27 July 2018 for the suburb of Zetland. The following items listed under the Sydney LEP were found in the vicinity of the proposal site (refer to Appendix F):

- Street Trees in Joynton Avenue Between O'Dea Avenue & Gadigal Avenue (within proposal site)
- Horse Trough, Joynton Avenue, Corner Elizabeth Street (adjacent to proposal site)
- Zetland Estate Heritage Conservation Area (adjacent to proposal site)
- Former Victoria Park Racecourse Group, 100-106A Joynton Avenue (adjacent to proposal site)
- Royal South Sydney Hospital Group (Former), Joynton Avenue (adjacent to proposal site)

- Cottage Including Interior, 37 Tilford Street (40 metres from proposal site)
- Alexandra Canal, receiving stormwater from proposed Joyton Avenue trunk drain (1.3 kilometres from proposal site)
- Zetland Estate Conservation Area (50m from proposal site)

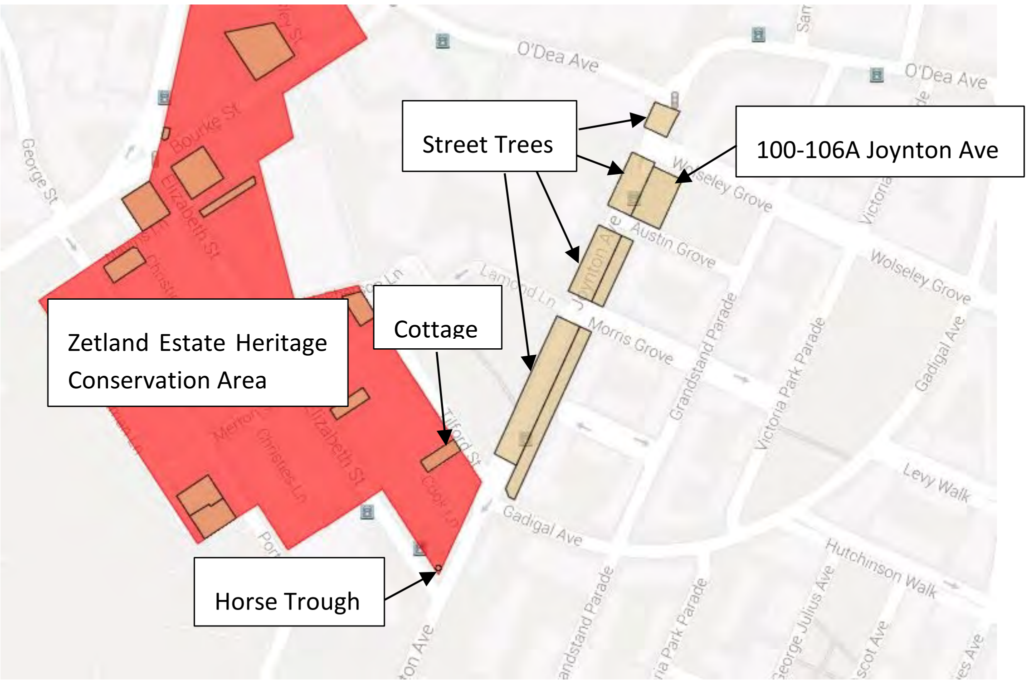


Figure 6-6 Heritage items (Source DP&I Planning Viewer, 2016)

6.12.3 Potential impacts

No direct impact to non-Indigenous heritage buildings is anticipated. However, there is potential for indirect heritage impacts through vibration or dust from plant and equipment during construction. There is also the potential of damage to significant trees.

The heritage listed buildings in closest proximity to the proposed works are the cottage at 37 Tilford Street, the horse trough near Elizabeth Street and the former Victoria Park Racecourse Group and Totaliser Building at 100 Joynton Avenue, previously adaptively re-used as the Green Square Library and Customer Service Centre. Potential damage to heritage buildings through vibration can be managed in accordance with Section 6.1. As recommended in the Noise and Vibration Assessment (refer to Section 6.1 and Appendix D) buffer distances should be determined once vibration emission levels are measured from each plant item prior to use on site.

The significant locally listed street trees along Joynton Avenue make a positive contribution to the amenity of Joynton Avenue, their interlocking canopies forming a contiguous green archway over the street. They are representative of typical plantings of this period in the Sydney area and have a landmark quality. The Broad-leaved Paperbarks and Lemon-scented Gums are also considered to be contributory items, adding to the streetscape quality.

The open excavations associated with the proposed works would necessitate the removal of nine trees of low to moderate retention value. Of the nine trees to be removed (two bull Bay Magnolias, one Port Jackson Fig, and six Broad-leaved Paperbarks), all but one are relatively small and can be replaced in the short-term with new plantings. The arborist report (Earthscape Horticultural Services 2016) noted that none of these trees to be removed are considered significant, with exception of tree T32, a broad-leaved paperbark. Whilst T32, close to the junction of Gadigal Avenue, has some value as a contributory item as noted in the Sydney LEP, the arborist assessment identified that this tree has a large wound from a previous branch failure that has resulted in loss of about 35% of the crown and its removal would not impact the heritage significance of the overall group of trees. Microtunnelling would avoid impacting the more significant heritage listed fig trees and would not impact the contiguous archway over the street.

Impacts on heritage items is considered unlikely with the implementation of safeguards and mitigation measures below and in Section 6.5.3.

6.12.4 Safeguards and mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Damage to heritage items	- If unexpected archaeological remains are uncovered during the works, all works must cease in the vicinity of the material/find and the City Project manager contacted for advice on how to proceed.	Contractor	Construction
Damage to heritage items	- If any items defined as relics under the NSW *Heritage Act 1977* are uncovered during the works, all works must cease in the vicinity of the find and the City Project manager contacted for advice on how to proceed.	Contractor	Construction
Damage to heritage items	- Construction personnel would be inducted through tool box talk prior to construction to ensure that all personnel are aware of the heritage significance of the heritage items and requirements to avoid impacts on these.	Contractor	Construction
Damage to heritage items	- Existing heritage items on site or in the near vicinity of the works are to be protected to prevent any damage or disturbance.	Contractor	Construction
Damage to heritage items	- Trees to be removed from Joynton Street during works to be replaced with trees of the species of a similar size once works are completed.	Contractor	Post-construction

6.13 CUMULATIVE IMPACTS

6.13.1 Existing environment

The trunk drain would link with the new upstream O'Dea Avenue trunk drain to the new Green Square trunk drain discharging to Alexandra Canal and would reduce flooding in the locality. The proposal, in conjunction with the other drainage works would improve flood immunity up to and including the 1 in 20 year rainfall event.

6.13.2 Potential impacts

The proposal is located in the Green Square Urban Renewal Area which is experiencing substantial development. The proposal has therefore the potential to exacerbate construction related impacts such as noise, air quality and traffic impacts. The safeguards and management measures detailed in the REF would mitigate potential cumulative impacts from other construction activities taking place in the locality. Furthermore, a construction liaison group was set up for works taking place in the north of the Green Square Town Centre precinct. This group could be contacted would be required to ensure involvement with other contractors working within the area.

6.13.3 Safeguards and mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Cumulative impacts	• Regular communication between the contractor and the construction liaison group set up for the north of the Green Square Town Centre precinct must be maintained to ensure programs of construction activities are properly scheduled to minimise potential cumulative impacts	Contractor	Construction

6.14 PRINCIPLES OF ECOLOGICALLY SUSTAINABLE DEVELOPMENT

6.14.1 The precautionary principle

The precautionary principle has been adopted during the selection of the preferred option and preparation of the REF. Safeguards would be implemented to minimise or mitigate any potential impacts and provide a high degree of certainty that no significant environmental impacts would occur as a result of the proposal.

6.14.2 Inter-generational equity

The proposal would not adversely impact on the environment such that it would compromise the health, diversity or productivity of the environment to unsustainable levels that would subsequently impact on the present and future generations. The proposed works would reduce flooding impacts for residents of the area.

6.14.3 Conservation of biological diversity and ecological integrity

The proposal would remove some street trees which have some biodiversity value. The street trees would be replaced following completion of works and the biological diversity and ecological integrity of the proposal site would not be compromised.

6.14.4 Appropriate valuation of environmental factors

The proposal would improve the drainage system along Joynton Avenue which would reduce the potential for flooding and subject damage to public and private assets. This would reduce potential repairs in the long terms. The financial, environmental and social cost of the proposed works was also considered in the selection of the preferred option.

6.15 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

6.15.1 Summary of MNES searches

No MNES related to the site were identified.

6.15.2 Potential impacts

The proposal is considered to be unlikely to impact matters of national environmental significance.

6.15.3 Safeguards and mitigation measures

No additional safeguards are required to address matters of national environmental significance.

7 SUMMARY OF SAFEGUARDS

Table 6-13 Key environmental safeguards

Issue	Key Environmental Objectives
Noise and vibration	• A construction noise and vibration management plan (CNVMP) would be prepared as part of the CEMP and take into account the results of the noise and vibration impact assessment Renzo Tonin 2018. The CNVMP must be reviewed and approved by the City of Sydney. The CNVMP must contain as a minimum: o A process for documenting and resolving issues and complaints. o A construction staging program incorporating a program of noise and vibration monitoring for sensitive receivers. o A process for updating the plan when activities affecting construction noise and vibration change or if additional measures need to be incorporated to resolve complaints or exceedances of the relevant guidelines. o Identify in toolbox talks where noise and vibration management is required o A process for assessing the performance of the implemented mitigation measures. o A process for staging works where exceedances cannot be avoided, to provide periods of respite to residents o A map indicating the locations of sensitive receivers including residential properties. o The results of the quantitative noise assessment completed in accordance with the EPA Interim Construction Noise Guidelines (DECCW, 2009) refer to Appendix D o Management measures to minimise the potential noise impacts from the quantitative noise assessment and for potential works outside of standard working hours (including implementation of EPA Interim Construction Noise Guidelines (DECCW, 2009). Management measures would include those in Renzo Tonin (2018).

  - A risk assessment to determine potential risk for activities likely to affect receivers (for activities undertaken during and outside of standard working hours)
  - Mitigation measures to avoid vibration impacts during construction activities. Management measures would include those in Renzo Tonin (2018).

- The proper implementation of a vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with occupants and property owners is recommended and should be aimed at providing a communication path directly to the contractor.
- Carry out vibration testing of actual equipment on site prior to the construction works to determine acceptable buffer distances to the sensitive receivers.
- Carry out additional vibration monitoring as specified in Renzo Tonin (2018) (refer to Appendix D) when construction activities are at the nearest point to the nominated occupancies. This monitoring may signal to the contractor by way of a buzzer or flashing light etc, when levels approach/exceed the recommended limits in nearby occupancies.
- Carry out periodic vibration monitoring at all critical or sensitive areas and assess the vibration levels for compliance with the set vibration limits. This monitoring shall be undertaken in accordance with the vibration monitoring program described in Renzo Tonin (2018) (refer to Appendix D).
- Where vibration is found to be excessive, management measures should be considered to ensure vibration compliance is achieved.
- Before, during and after the construction works we recommend preparation of dilapidation reports on the state of the existing buildings surrounding the construction site. The condition of surrounding buildings will also be assessed with regard to settlement as described in Section 6.2.3.
Use less noisy plant and equipment, where feasible and reasonable.
- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of ‘noise control’ or ‘silencing’ kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work should be switched off.
- In accordance with the requirements of the ICNG, construction works should not occur over more than two consecutive nights to allow respite to nearby residences.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters.

	• Noise monitoring would be carried out when construction activities are at the nearest point to sensitive receivers and if noise complaints are received
Topography, geology, soils and contaminated land	• An erosion and sedimentation control plan (ESCP) must be prepared as part of the Construction Environmental Management Plan (CEMP). The ESCP must be prepared in accordance with "Managing Urban Stormwater: Soils and Construction" (4th Edition Landcom, 2004, aka the Blue Book). • An Environmental Work Method Statement (EWMS) must be prepared and implemented for the microtunneling and pit excavations. The EWMS must be reviewed and approved by the City of Sydney. The EWMS must contain as a minimum: o A risk assessment detailing which activities have the potential to impact ground levels o Management measures to prevent/minimise ground level movements or subsidence. This would include but not be limited to measures from Douglas and Partners (2018) o Monitoring requirements to check for potential ground movements. o Monitoring requirements if Bentonite or other product is used to prevent subsidence, to ensure there is no leakage. o Settlement monitoring • Material excavated from the excavation pit must be visually inspected and anthropogenic inclusions such as clinker and furnace slag noted. • Whilst asbestos was not detected within filling, building rubble was recorded within filling which is indicative of the potential presence of asbestos. Where suspicious or unknown materials are encountered during the works, an Environmental Engineer/Scientist must inspect the material and advise accordingly. • Construction personnel to receive training prior to works on site regarding the identification and work methods relating to identifying potentially asbestos containing material, and other gross contaminates such as clinker slag etc. • Additional sampling and testing must be carried out to provide guidance on the presence of ASS and management requirements. • Acid sulphate soils must be appropriately managed and treated during excavation of the pits. • A Spoil and Soil Management Plan should be developed that details: o Methods for the identification of contamination and the need for further testing to confirm contamination, so that contamination is known and can be adequately managed o Methods for the management of waste streams that prevents cross contamination of uncontaminated spoil and to maximise the opportunity for reuse. o Methods for the management contaminated material that ensure contamination does not impact the surrounding environment, especially public areas, sensitive receptors and waterways (including groundwater and stormwater) o Methods for the management and liming (were required) of acid sulphate soils to prevent impacts to the environment the especially public areas and waterways (including groundwater and stormwater) o Methods to confirm opportunities for reuse (e.g. VENM) and confirm the waste classification.

Water quality	• Water quality control measures are to be used to prevent any materials (eg. Sediment, concrete) entering surrounding environment, in particular stormwater drains. • Prior to groundwater reinjection or otherwise release of water associated with the proposal, testing should be undertaken to ensure it would not adversely impact the waterbody (including groundwater, stormwater etc.) into which it would be released • If water won from dewatering or groundwater extraction is found to be contaminated or not appropriate for reinjection or release, due care should be taken to ensure spills and similar do not occur and that it is disposed of appropriately • All fuels, chemicals and liquids are to be stored in an impervious bunded area at the compound site. • Refuelling of plant and equipment is to occur in impervious bunded area at the compound site or offsite. • An emergency spill kit is to be kept on site at all times. All staff are to be made aware of the location of the spill kit and trained in its use. • An emergency spill procedure must be prepared as part of the Construction Environmental Management Plan (CEMP) that must detail the steps to be taken in the event of a spill. The procedure must include as a minimum: • Contact details of relevant authorities to be contacted in the event of a spill • Location of hazardous materials stored on site • Location of spill kits • Steps to be undertaken in the event of a spill
Hydrology	• An Environmental Work Method Statement (EWMS) must be prepared for the construction of the pits and their management. The EWMS must be reviewed and approved by the City of Sydney. The EWMS must contain as a minimum: • Descriptions of works/activities including machinery to be used. • Lists of licences/permits that may be required under the Water Management Act and/or Water Act and related conditions. • Outline of the sequence of the works/activities. • Identification of the potential environmental impacts due to works/activities such as but not limited to potential contamination of groundwater. • An environmental risk assessment to identify potential risks to discrete work elements or activities likely to affect the environment. • Mitigation measures to reduce environmental risks. • A process for assessing the performance of the implemented mitigation measures. • A process for resolving environmental issues and conflicts. • Recharge wells close to the pits must be used to reinject pumped groundwater back into the ground to maintain the groundwater level outside the pit excavations • A site specific flood evacuation plan must be prepared and implemented as required. It would include the following measures as a minimum: • Daily weather and flood monitoring • List equipment to be removed from the site. • Detail who would be responsible for monitoring the flood threat and how this is to be done. It is expected that flood warning information would be sourced from the BoM website.

	• Detail staff training requirements and roles and responsibilities for the implementation of the Plan. • The groundwater level must be lowered to at least 1 m below the bulk excavation level for the pits to allow man access and machinery to operate, and to prevent flooding during heavy rainfall.
Biodiversity	• Management measures detailed in Section 10 and the tree protection plan (Appendix 6) of the Arboricultural Impact Assessment Report (Earthscape 2015) must be implemented to ensure damage to trees is avoided or minimised. These measures must be included within the Construction Environmental Management Plan (CEMP) to be prepared for the proposed works. • Should the TBM fail and require open excavation for removal; • An arborist must assess the excavation and provide management measures to avoid and mitigate impacts to trees. • If arborist classifies the unplanned excavations to likely result in the death of medium or high retention value trees (ass assessed in the EHS 2015 report) an addendum REF will be required. • In order to compensate for the loss of trees, a minimum of one tree should be replanted within an appropriate area for every tree to be removed. The species should be selected in accordance with Council's Street Tree Masterplan. • Aquatic vegetation removed/killed during the drainage of Woolwash Pond should be replaced to restore the visual character and environmental quality of the pond • All plant and equipment must be cleaned prior to entering the site to prevent the importation of priority weeds and propagules of priority weeds to the proposal area • Material from Woolwash Pond must be managed in such a way to prevent the spread of the weed of National Significance, Salvinia (Salvinia molesta), including cleaning of plant and equipment that may harbour propagules • Draining must be conducted to ensure no fauna are harmed during the draining process (e.g. sucked into pumping equipment) • Suitably qualified and licenced ecologist should be present during the drainage of Woolwash Pond, to capture and safely house any native fauna stranded during the drainage process • Suitably qualified and licenced ecologist should be present during the drainage of Woolwash Pond, to capture and euthanise pest fauna stranded during the drainage process • Drainage and works within the Woolwash Pond area should be done in such a manner to prevent the spread of pests. • Suitably qualified and licenced ecologist should be present during tree clearing, to capture and safely house any fauna displaced during tree removal
Socio-economic impacts	• A Communication Plan will be prepared and included in the CEMP. The Communication Plan must include (as a minimum): • A map identifying locations of potential adjacent residences and a list of relevant stakeholders (e.g. Ausgrid, bus services). • An evaluation of the potential impacted properties/stakeholders at the different stages of the construction activities, taking into account any cumulative impact as a result of other works taking place in the locality. • Requirements to provide details and timing of proposed activities to affected residents • Procedure to notify adjacent land owners or users for changed conditions during the construction period such as traffic/pedestrian access.

	• The Contractor must appoint a Community Liaison Officer (CLO) who will be the first point of contact for any property owner, tenant and general public enquiries and / or complaints and their satisfactory resolution. • The CLO must liaise with the Strategic Community Consultation team from the City of Sydney about their program and community relations to ensure a coordinated approach. • A complaints handling procedure and register will be included in the CEMP and maintained for the duration of the project. The complaints procedure is to include contact name and contact details for complaints. • Work must be staged in such a way that access to and from the various hospitality venues is maintained during construction
Waste minimisation and management	• Waste management would occur in accordance with the Waste Avoidance and Resource Recovery Act 2001. The resource management hierarchy will be followed at all times throughout the proposal: • avoid resource consumption → recover recyclable materials for reuse → dispose material unable to be recycled • Details of how the above would be met for all stages of the proposed works would be detailed in the Construction Environmental Management Plan. • Waste will not to be burnt on site. • Waste material will not be left on site once the works have been completed. • Working areas will be maintained, kept free of rubbish and cleaned up at the end of each working day. • If feasible, the cleared vegetation must be mulched and reused on site for landscaping. • Spoil must be managed in accordance with the requirements of Section 5.2.3 • Spoil must be managed in accordance with the requirements of Section 5.3.3
Traffic and Access	• A Traffic Management Plan to manage road and pedestrian traffic, including bus services, would be developed for the construction work and form part of the Construction Environmental Management Plan (CEMP). • Traffic management measures must ensure that impacts on kerbside parking is minimised at all times. • Safety barriers would be used to isolate the construction area from the existing travel lane. • Temporary variable message signs (VMS) would be used to warn approaching road users of the works. • Access to residences would be maintained during the works. • Pedestrian access to the footpath on the eastern side of Joynton Avenue would be maintained through construction. • No deliveries of materials would occur during peak traffic periods. • Access to the Ausgrid depot would be maintained at all times. The City must inform Ausgrid of planned works near driveway.
Visual amenity	• A Landscape Plan would be prepared to detail the landscaping of disturbed areas including the replanting of street trees removed and any vegetation within Woolwash Pond that is harmed • Street trees to be planted must be of an appropriate height to minimise visual impact of the removal. • Site compound would be maintained in a tidy manner.

Indigenous heritage	• If Aboriginal heritage items are uncovered during the works, all works in the vicinity of the find must cease and the City of Sydney environment officer contacted immediately.
Non-indigenous heritage	• If unexpected archaeological remains are uncovered during the works, all works must cease in the vicinity of the material/find and the City Project manager contacted for advice on how to proceed. • If any items defined as relics under the NSW Heritage Act 1977 are uncovered during the works, all works must cease in the vicinity of the find and the City Project manager contacted for advice on how to proceed. • Construction personnel would be inducted through tool box talk prior to construction to ensure that all personnel are aware of the heritage significance of the heritage items and requirements to avoid impacts on these. • Existing heritage items on site or in the near vicinity of the works are to be protected to prevent any damage or disturbance. • Trees to be removed from Joynton Street during works to be replaced with trees of the species of a similar size once works are completed.
Cumulative impacts	• Regular communication between the contractor and the construction liaison group set up for the north of the Green Square Town Centre precinct must be maintained to ensure programs of construction activities are properly scheduled to minimise potential cumulative impacts
Principles of Ecologically Sustainable Development	• None required
Matters of national environmental significance	• None required

8 SUMMARY OF LICENSES AND APPROVALS

Table 6-14 Summary of licenses and approvals required

Legal Instrument	License or Approval
Roads Act 1993	• Road occupancy licence
Fisheries Management Act 1994	• Special permit under clause 37 for capture and storage of fish

9 CONCLUSION

This Review of Environmental Factors identifies the likely impacts of the proposal on the environment and details the mitigation measures to be implemented to minimise the potential impact to the environment.

The assessment has concluded that as the proposed works as described in this REF, including any proposed management measures and safeguards, will not result in a significant effect on the environment. Therefore, an Environmental Impact Statement (EIS) is not required.

The proposed works will not result in a significant impact on any declared critical habitat, threatened species, populations or ecological communities or their habitats. Therefore, a Species Impact Statement (SIS) is not required.

9.1 ECOLOGICALLY SUSTAINABLE DEVELOPMENT

This proposal is considered with the principles of ecologically sustainable development. The proposal would not have significant impact for the quality of life, either now or into the future, and the proposal would not significantly adversely impact on matters of intergenerational equity, provided the safeguards within the body of this report are wholly implemented.

9.2 JUSTIFICATION OF THE PROPOSAL

The proposal has been identified as a measure to meet the stormwater demand at the site, as part of overall stormwater infrastructure improvements in the area. Of the options considered, the proposed method best meets the proposal objectives.

10 REFERENCES

DECC (2006). Assessing Vibration; a technical guideline

DECCW (2009). NSW Interim Construction Noise Guideline

DECCW (2011). NSW Road Noise Policy

Department of Planning and Environment (2014). A Plan for Growing Sydney

Douglas Partners (2018). Factual Report on Geotechnical Investigations Joynton Avenue Stormwater Drainage Upgrade Joynton Avenue, Zetland. Prepared for City of Sydney.

Douglas Partners (2018b). Interpretive Report on Geotechnical Investigations Joynton Avenue Stormwater Drainage Upgrade Joynton Avenue, Zetland, Prepared for City of Sydney.

Earthscape Horticultural Services (2016). Arboricultural Impact Assessment Report. Proposed stormwater pipeline. Joynton Avenue, Zetland.

EPA (2000). NSW Industrial Noise Policy

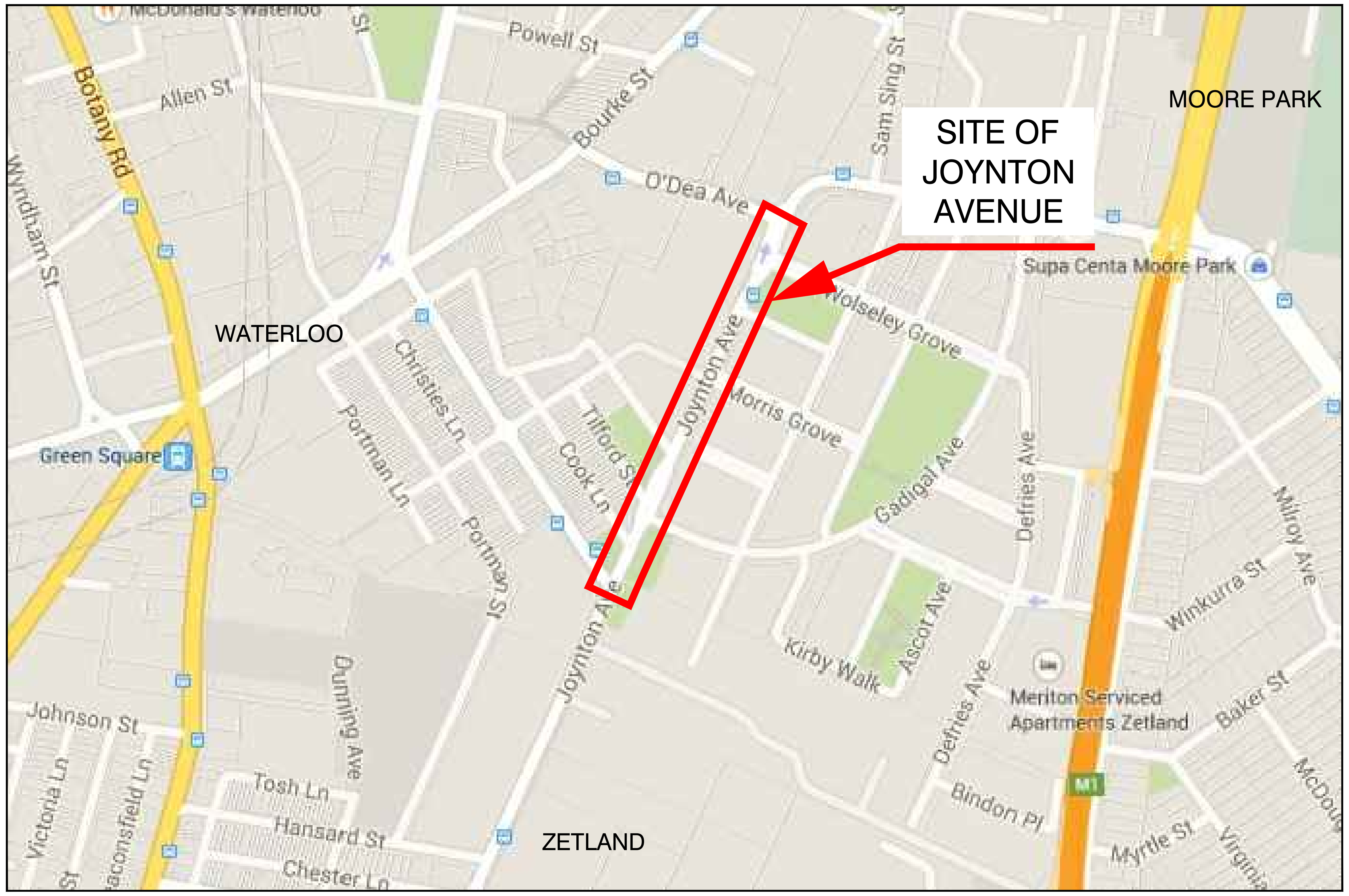
Renzo Tonin (2018). Joynton Avenue, Zetland – Stormwater drainage upgrade. REF Noise and vibration assessment

WMA Water (2013). Green Square – West Kensington floodplain risk management study. Prepared for City of Sydney

Appendix A **PLANS OF THE PROPOSAL**

JOYNTON AVENUE, ZETLAND

TRUNK DRAIN



LOCALITY PLAN

N.T.S.

DRAWING LIST

DRAWING No.	TITLE	DESCRIPTION
E3-15/1342 - 000	COVER SHEET	INDEX
E3-15/1342 - 100	ROADS & DRAINAGE KEY PLAN	WORKS KEY PLAN
E3-15/1342 - 101	WORKS PLAN	SHEET 1 OF 4
E3-15/1342 - 102	WORKS PLAN	SHEET 2 OF 4
E3-15/1342 - 103	WORKS PLAN	SHEET 3 OF 4
E3-15/1342 - 104	WORKS PLAN	SHEET 4 OF 4
E3-15/1342 - 401	DRAINAGE LONGSECTIONS	SHEET 1 OF 2
E3-15/1342 - 402	DRAINAGE LONGSECTIONS	SHEET 2 OF 2
E3-15/1342 - 500	SERVICES AND UTILITIES KEY PLAN	SERVICES KEY PLAN
E3-15/1342 - 501	SERVICE AND UTILITIES PLANS	SHEET 1 OF 4
E3-15/1342 - 502	SERVICE AND UTILITIES PLANS	SHEET 2 OF 4
E3-15/1342 - 503	SERVICE AND UTILITIES PLANS	SHEET 3 OF 4
E3-15/1342 - 504	SERVICE AND UTILITIES PLANS	SHEET 4 OF 4
E3-15/1342 - 601	PIT DETAILS	SHEET 1 OF 2
E3-15/1342 - 602	PIT DETAILS	SHEET 2 OF 2

1. SERVICE LOCATIONS ON PLANS ARE INDICATIVE ONLY. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO DETERMINE SERVICE LOCATIONS OR RELOCATION INCLUDING ALL APPROVALS PRIOR TO THE COMMENCEMENT OF ANY WORK. ANY DAMAGES REMAIN THE RESPONSIBILITY OF THE CONTRACTOR. COST FOR MAKING GOOD SHALL BE AT THE CONTRACTOR EXPENSE.

2. ALL WORK SHOULD BE CARRIED OUT IN ACCORDANCE WITH THE CITY'S "SPECIFICATIONS", OR AS DIRECTED BY THE CITY'S REPRESENTATIVE.

3. COUNCIL'S SURVEYOR TO BE NOTIFIED AT LEAST FOUR WEEKS PRIOR TO THE COMMENCEMENT OF WORKS THAT MAY RESULT IN THE DESTRUCTION OR DAMAGE TO ANY PERMANENT MARKS OR STATE SURVEY MARKS. COST FOR SURVEY AND REPLACEMENT OF THE PERMANENT SURVEY MARK SHALL BE AT THE CONTRACTOR EXPENSE.

4. PRIOR TO COMMENCEMENT OF ANY WORK CONTACT THE CITY'S TREE PRESERVATION OFFICER TO ENSURE THAT ALL WORK IN THE VICINITY OF EXISTING TREES WILL BE DONE BY APPROPRIATE METHODS TO ENSURE PROTECTION OF SPECIMENS AND ROOT ZONE.

5. ANY REMOVAL OF ROOT SYSTEMS SHALL REQUIRE APPROVAL FROM THE TREE PRESERVATION OFFICER.

6. IN LOCATIONS WHERE LESS THAN 300mm CLEARANCE IS ACHIEVED TO TREE ROOTS ALL WORK (I.E. EXCAVATION AND CONCRETE) MUST BE DONE MANUALLY TO AVOID DAMAGE.

7. TREE PROTECTION WILL BE REQUIRED TO BE INSTALLED BY AN AQF III ARBORIST PRIOR TO THE COMMENCE OF WORKS. TREE PROTECTION WILL BE REQUIRED FOR ANY TREE WITHIN 5m OF ANY EXCAVATION AND AREAS WHERE LOADING AND UNLOADING OF EQUIPMENT AND MATERIALS IS TO TAKE PLACE.

8. ACCESS IS TO BE MAINTAINED TO ALL PROPERTIES ADJACENT THE WORKS THROUGHOUT THE CONSTRUCTION DURATION

9. DO NOT SCALE FROM THE DRAWINGS. REPORT ANY DISCREPANCIES TO THE SITE CITY'S REPRESENTATIVE IMMEDIATELY.

10. ALL HOLD POINTS AND WITNESS POINTS ARE TO BE AGREED TO WITH THE CITY'S REPRESENTATIVE PRIOR TO WORKS COMMENCING ON SITE.

11. ALL UTILITY FEATURES e.g. HYDRANTS, TELECOMMUNICATION PITS, SHALL BE ADJUSTED TO SUIT FINISHED SURFACE.

12. ALL REDUNDANT LINE MARKINGS ARE TO BE REMOVED BY MECHANICAL GRINDING.

13. ALL ROAD MARKING PAINTS TO BE THERMOPLASTIC UNLESS OTHERWISE APPROVED BY THE PRINCIPAL.

14. ALL REGULATORY AND WARNING SIGNS ARE TO BE INSTALLED IN ACCORDANCE WITH THE RMS GUIDELINES AND TO THE SATISFACTION OF THE CITY'S REPRESENTATIVE

15. THE CONTRACTOR WILL PROVIDE NECESSARY MEASURES IN ACCORDANCE WITH LANDCOM'S "MANAGING URBAN STORMWATER SOILS AND CONSTRUCTION" (BLUE BOOK) AND AS DEEMED APPROPRIATE TO PREVENT SOIL EROSION OF EXPOSED AREAS DURING THE COURSE OF CONSTRUCTION, OR AS DIRECTED BY THE CITY'S REPRESENTATIVE.

16. ALL NEW WORKS WILL MAKE A SMOOTH JUNCTION WITH EXISTING CONDITIONS.

17. ALL EXISTING DRAINAGE GRATES TO BE REPLACED WITH APPROVED HEAVY DUTY, CLASS D, BIKE SAFE GRATES OR AS DIRECTED.

18. ALL NEW DRAINAGE PIPES ARE TO BE MINIMUM CLASS 4 REINFORCED CONCRETE WITH RUBBER RING JOINTS. DRAINAGE PIPES ARE TO BE A MINIMUM OF 375Ø.

19. ALL DRAINAGE PIPES ARE TO BE INSTALLED TO TYPE HS3 SUPPORT UNDER ROADS AND HS2 SUPPORT ELSEWHERE IN ACCORDANCE WITH AS3725.

20. ALL STORMWATER PITS WITHIN THE LIMIT OF THE WORKS TO BE CLEANED OF DEBRIS AT THE COMPLETION OF THE WORKS.

21. RETAIN ALL EXISTING PROPERTY STORMWATER OUTLETS.

22. ALL PITS INCLUDED IN THE SCOPE OF WORKS SHALL BE BENCHED, TO MINIMUM HALF PIPE HEIGHT.

23. THE CONTRACTOR WILL COMPLY WITH ALL CONFINED SPACE REGULATIONS WHILST WORKING WITHIN A CONFINED SPACE.

24. ALL TRAFFIC CONTROL MEASURES ARE TO BE CARRIED OUT PRIOR, DURING AND AFTER CONSTRUCTION IN ACCORDANCE WITH THE RMS "TRAFFIC CONTROL AT WORKSITES" MANUAL AND AS 1742.3.

25. ANY STONE KERB OR GUTTER NOT REUSED ON SITE IS TO BE DELIVERED TO THE CITY'S DEPOT UNDAMAGED.

26. ROAD RESTORATION ADJACENT NEW KERB AND GUTTER IS TO BE A MINIMUM150MM THICK CONCRETE.

27. THE MINIMUM RESTORATION WIDTH IS TO BE 600mm, UNLESS SHOWN OTHERWISE.

28. CERTIFICATION OF COMPLIANCE WILL BE PROVIDED, TO THE CITY'S REPRESENTATIVE, FOR ALL SOILS THAT ARE TO BE IMPORTED ON SITE PRIOR TO THE SOILS ARRIVING ON SITE.

29. PROVIDE RODDING POINTS AT THE END OF EACH SLOTTED PVC PIPE RUN - RODDING POINTS ARE TO FINISH 100mm ABOVE SURFACE AND HAVE SCREW ON CAPS

30. 100mm Ø SLOTTED PVC PIPES WILL HAVE NO SOCK OR GEO-FABRIC AND WILL BE INSTALLED AT THE BOTTOM OF THE RAINGARDEN DRAINAGE LAYER WITH MIN 50mm COVER

31. CONCRETE FOR PITS & INSITU CULVERTS WILL HAVE MINIMUM COMPRESSION STRENGTH OF F'c =50 MPa. IN ADDITION, AN 80mm TO 120mm SLUMP TEST RESULT IS REQUIRED.

32. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY ALL THE EXISTING LEVELS IN THE DRAWINGS PRIOR TO THE COMMENCEMENT OF ANY WORK.

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Date	No.	By	Amendments	Chckd
23.07.2018	8	ER	Preliminary Design Issue	BH
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18.09.2015	3	MS	Revised alignments	PS
03.06.2015	2	MS	Revised southern extents	PS
23.04.2015	1	MS	Concept Issue	PS

COVER SHEET

JOYNTON AVENUE TRUNK DRAIN

Designed: SA
Checked: PS
Drawn: MS
Approved: PS
SCALE: NTS
PAPER: A1

CITY OF SYDNEY 2030

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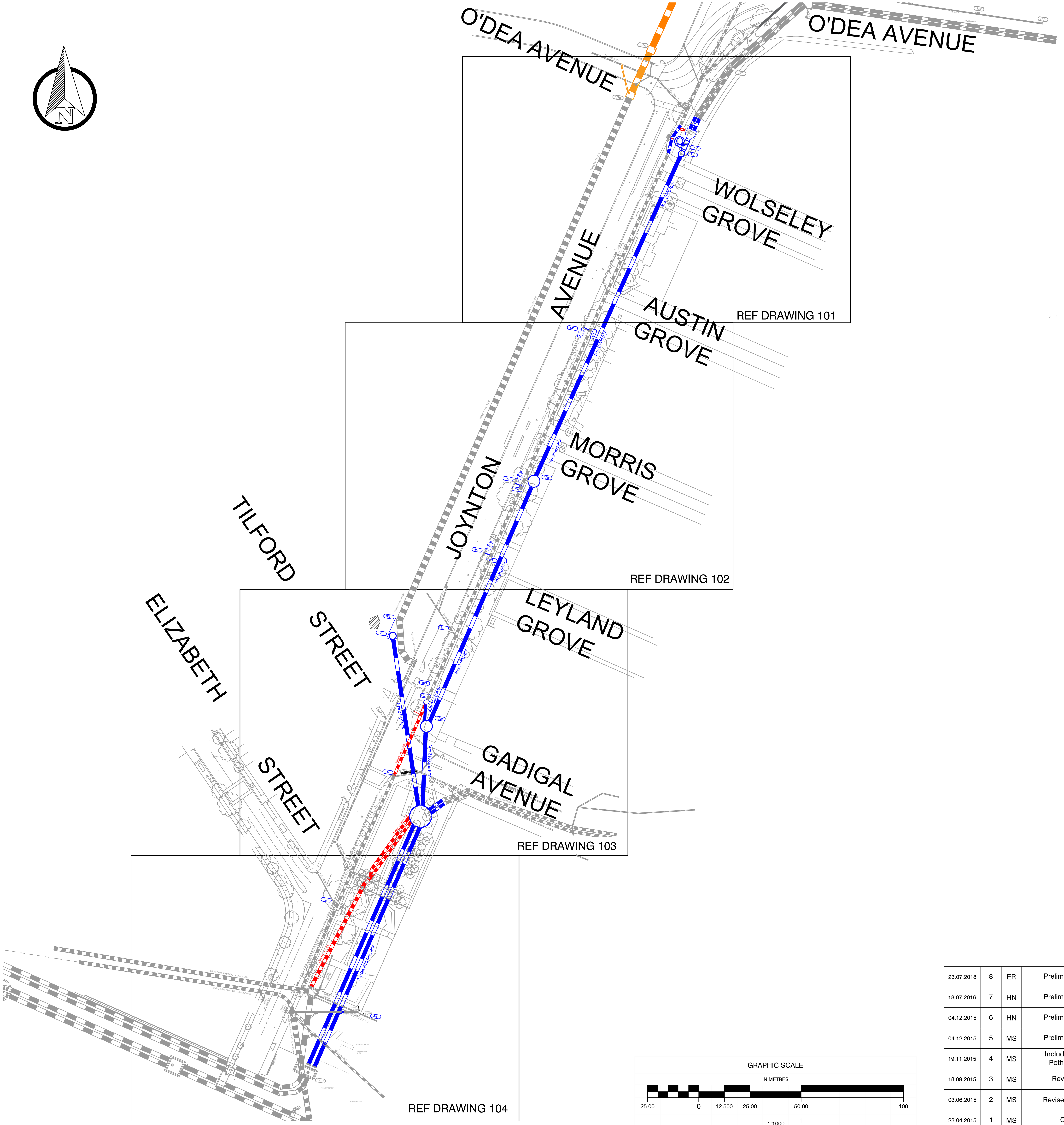
Drawing No. E3-15/1342 - 000
Sheet No. 1



LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
▨	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
▤	NEW STORMWATER PIT
▤	EXISTING STORMWATER PIT/GRATE

GRAPHIC SCALE
IN METRES
25.00 0 12.500 25.00 50.00 100
1:1000
@A1

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Date	No.	By	Amendments	Chckd
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23.04.2015	1	MS	Concept Issue	PS

ROADS & DRAINAGE KEY PLAN

JOYNTON AVENUE TRUNK DRAIN

Designed: PH
Checked: PS
Drawn: MS
Approved: PS
SCALE: 1:1000
PAPER: A1

CITY OF SYDNEY 2030

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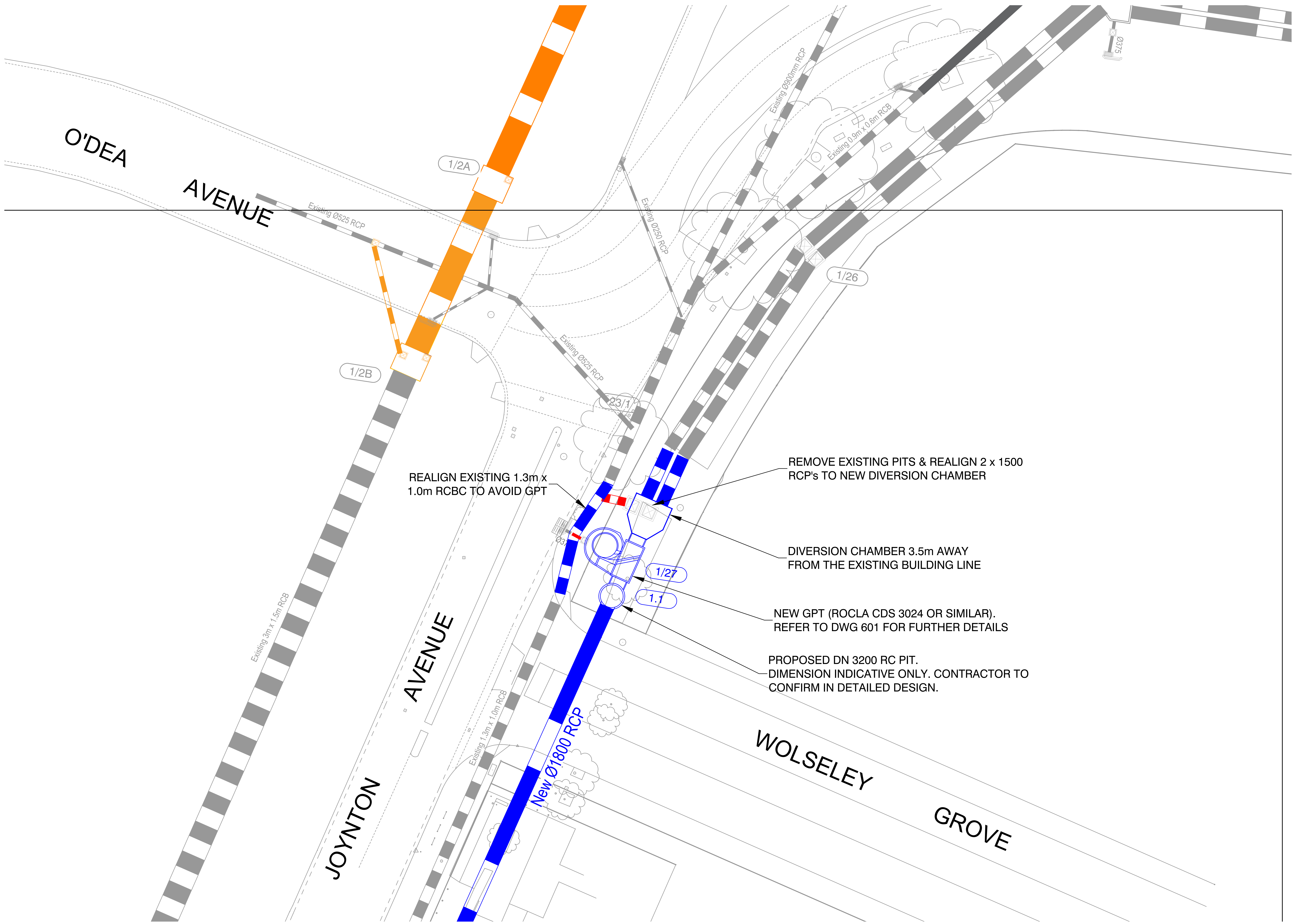
Drawing No. E3-15/1342 - 100
Sheet No. 1 OF 1

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan



REMOVE EXISTING PITS & REALIGN 2 x 1500 RCP's TO NEW DIVERSION CHAMBER

REALIGN EXISTING 1.3m x 1.0m RCBC TO AVOID GPT

DIVERSION CHAMBER 3.5m AWAY FROM THE EXISTING BUILDING LINE

NEW GPT (ROCLA CDS 3024 OR SIMILAR). REFER TO DWG 601 FOR FURTHER DETAILS

PROPOSED DN 3200 RC PIT. DIMENSION INDICATIVE ONLY. CONTRACTOR TO CONFIRM IN DETAILED DESIGN.

LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
⬜	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
▭	NEW STORMWATER PIT
▤	EXISTING STORMWATER PIT/GRATE

JOINS SHEET 102

GRAPHIC SCALE
IN METRES
6.25 0 3.125 6.25 12.50 25
1:250
@A1

Date	No.	By	Amendments	Chckd
23.07.2018	8	ER	Preliminary Design Issue	BH
18.07.2016	7	HN	Preliminary Design Issue	PS
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23.04.2015	1	MS	Concept Issue	PS

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ROADS & DRAINAGE KEY PLAN

JOYNTON AVENUE TRUNK DRAIN

CITY OF SYDNEY 2030

Designed: PH
Checked: PS
Drawn: MS
Approved: PS
SCALE: 1:250
PAPER: A1

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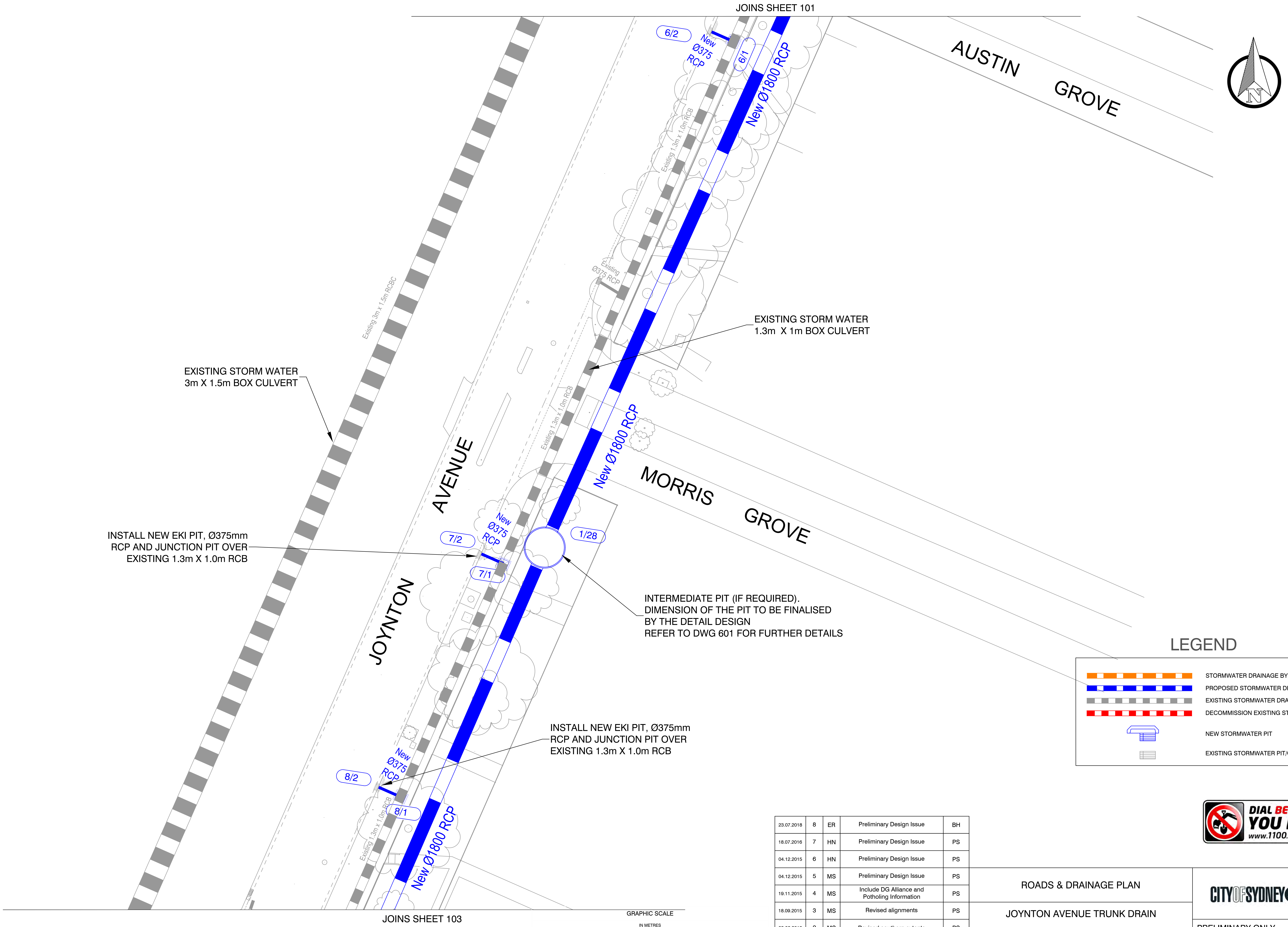
Sheet No. 1 OF 4

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 . CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan



EXISTING STORM WATER
1.3m X 1m BOX CULVERT

EXISTING STORM WATER
3m X 1.5m BOX CULVERT

INSTALL NEW EKI PIT, Ø375mm
RCP AND JUNCTION PIT OVER
EXISTING 1.3m X 1.0m RCB

INTERMEDIATE PIT (IF REQUIRED).
DIMENSION OF THE PIT TO BE FINALISED
BY THE DETAIL DESIGN
REFER TO DWG 601 FOR FURTHER DETAILS

INSTALL NEW EKI PIT, Ø375mm
RCP AND JUNCTION PIT OVER
EXISTING 1.3m X 1.0m RCB

LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
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🟥	DECOMMISSION EXISTING STORMWATER
▤	NEW STORMWATER PIT
▤	EXISTING STORMWATER PIT/GRATE

GRAPHIC SCALE
IN METRES
6.25 0 3.125 6.25 12.50 25
1:250
@A1

Date	No.	By	Amendments	Chckd
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ROADS & DRAINAGE PLAN

JOYNTON AVENUE TRUNK DRAIN

Designed: PH
Checked: PH
Drawn: MS
Approved: PS
SCALE: 1:250
PAPER: A1

CITY OF SYDNEY

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Drawing No. E3-15/1342 - 102
Sheet No. 2 OF 4

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 . CITY OF SYDNEY

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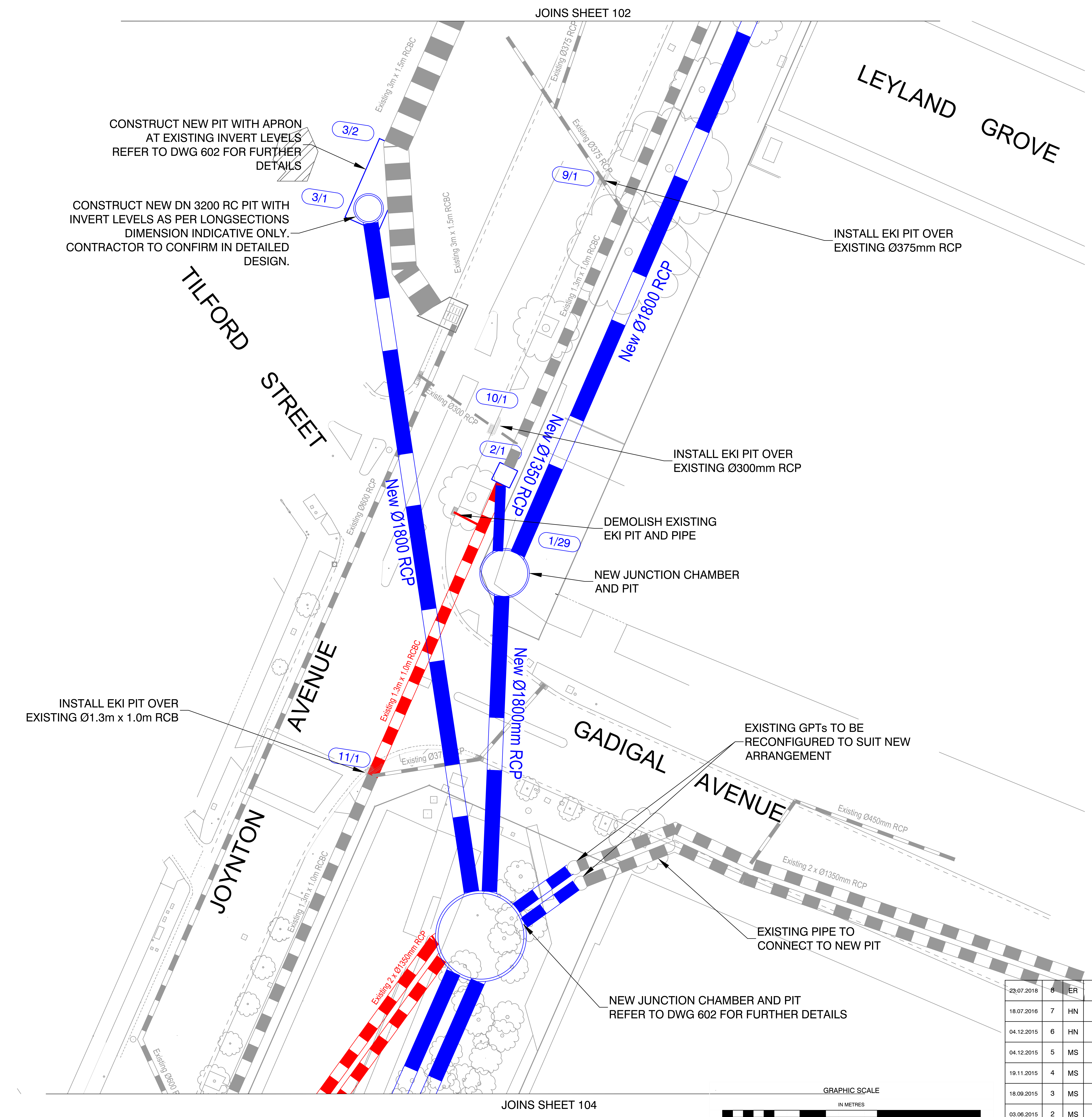

LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
⬜	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
	NEW STORMWATER PIT
	EXISTING STORMWATER PIT/GRATE

GRAPHIC SCALE
IN METRES
6.25 0 3.125 6.25 12.50 25
1:250
@A1

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ROADS & DRAINAGE PLAN

JOYNTON AVENUE TRUNK DRAIN

CITY OF SYDNEY

Designed: PH
Checked: PS
Drawn: MS
Approved: PS
SCALE: 1:250
PAPER: A1

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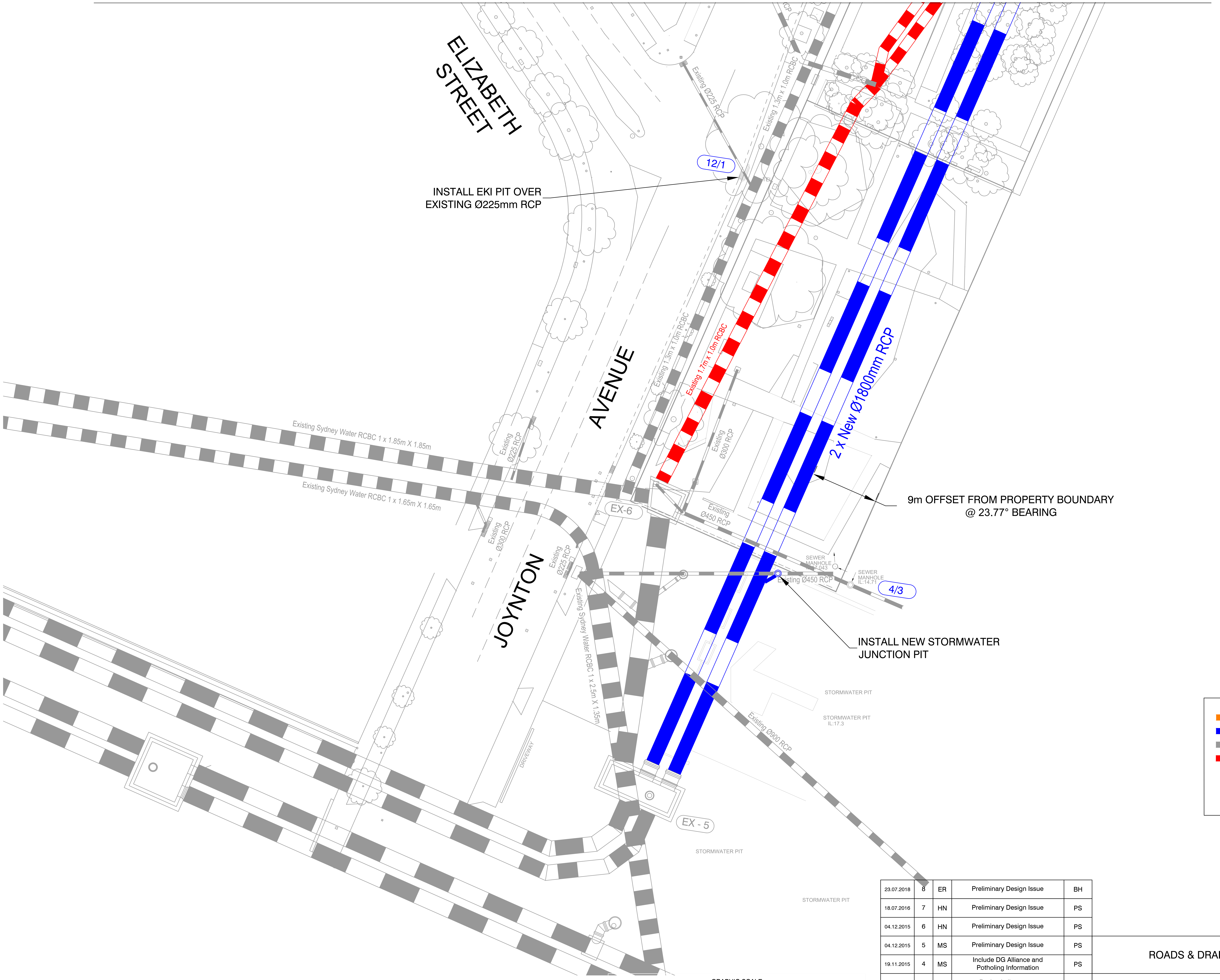
Issue 8
Drawing No. E3-15/1342 - 103
Sheet No. 3 OF 4

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan

JOINS SHEET 103



LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
▨	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
	NEW STORMWATER PIT
	EXISTING STORMWATER PIT/GRATE

GRAPHIC SCALE
IN METRES
6.25 0 3.125 6.25 12.50 25
1:250
@A1

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ROADS & DRAINAGE PLAN

JOYNTON AVENUE TRUNK DRAIN

CITY OF SYDNEY 2030

Designed: PH
Checked: PH
Drawn: MS
Approved: PS
SCALE: 1:250
PAPER: A1

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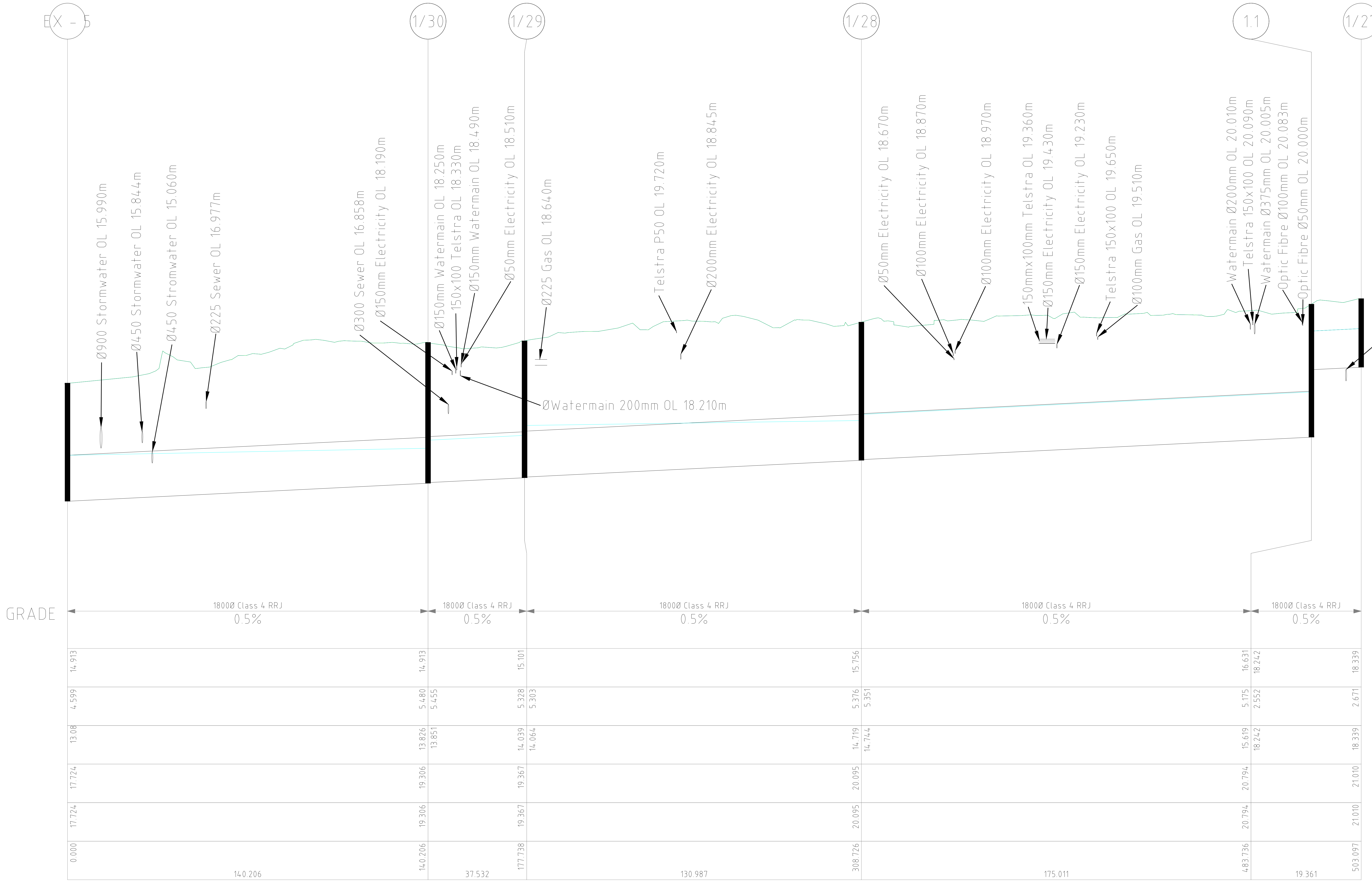
Issue 8
Drawing No. E3-15/1342 - 104
Sheet No. 4 OF 4

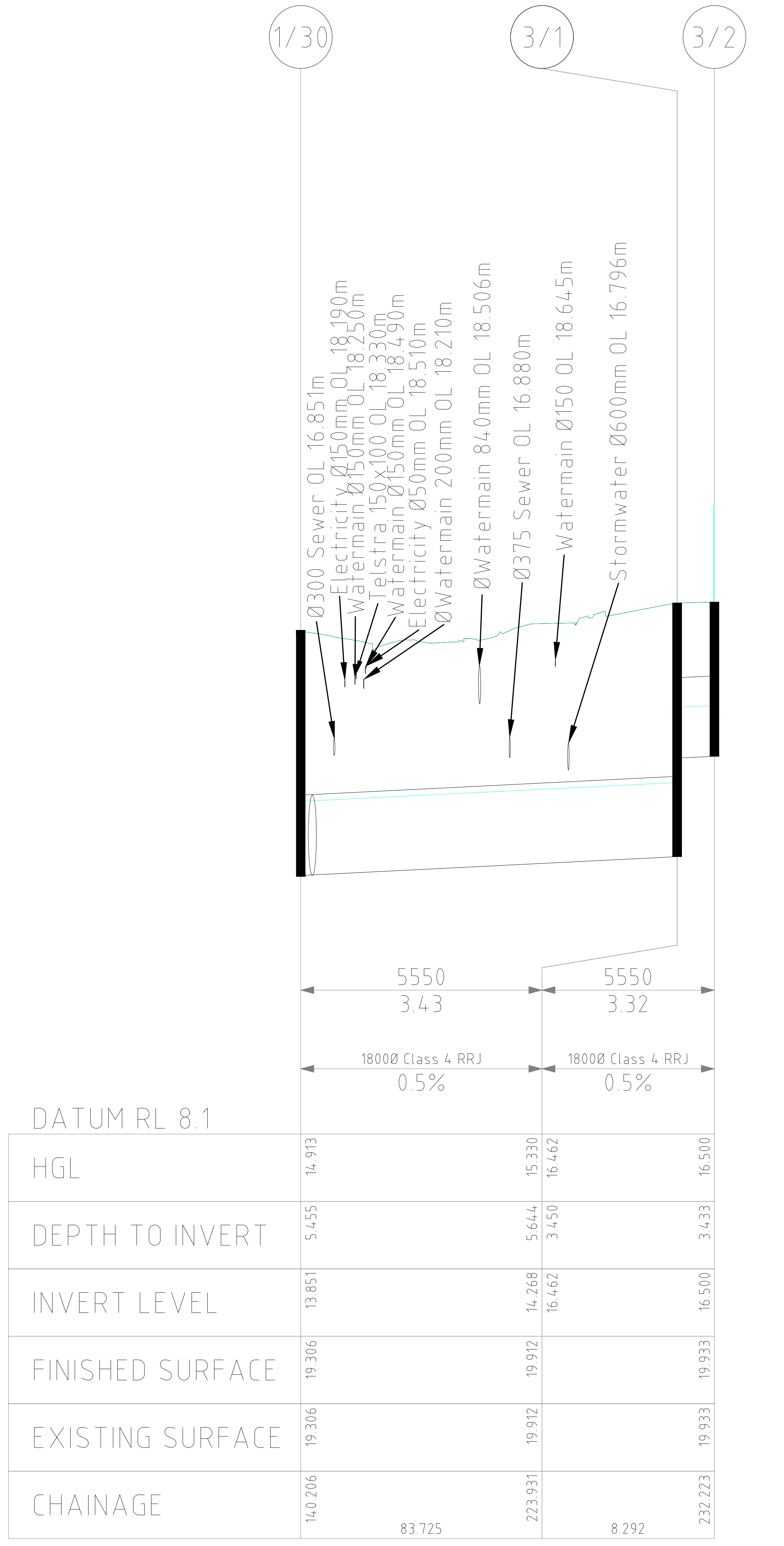
PLOTTED BY : EDY RUSTAM DATED 01/04/2015 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan



DRAINAGE LONGITUNDINAL SECTION FOR LINE 1

SCALES: HORIZONTAL 1:1000 VERTICAL 1:100



DRAINAGE LONGITUNDINAL SECTION FOR LINE 3

SCALES: HORIZONTAL 1:1000 VERTICAL 1:100

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18.07.2016	7	HN	Preliminary Design Issue	PS
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23.04.2015	1	MS	Concept Issue	PS
Date	No.	By	Amendments	Chckd

DRAINAGE LONGSECTIONS

JOYNTON AVENUE TRUNK DRAIN

Designed: PH
Checked: PH
Drawn: MS
Approved: PS
SCALE: As per longsections text
PAPER: A1

CITY OF SYDNEY 2030

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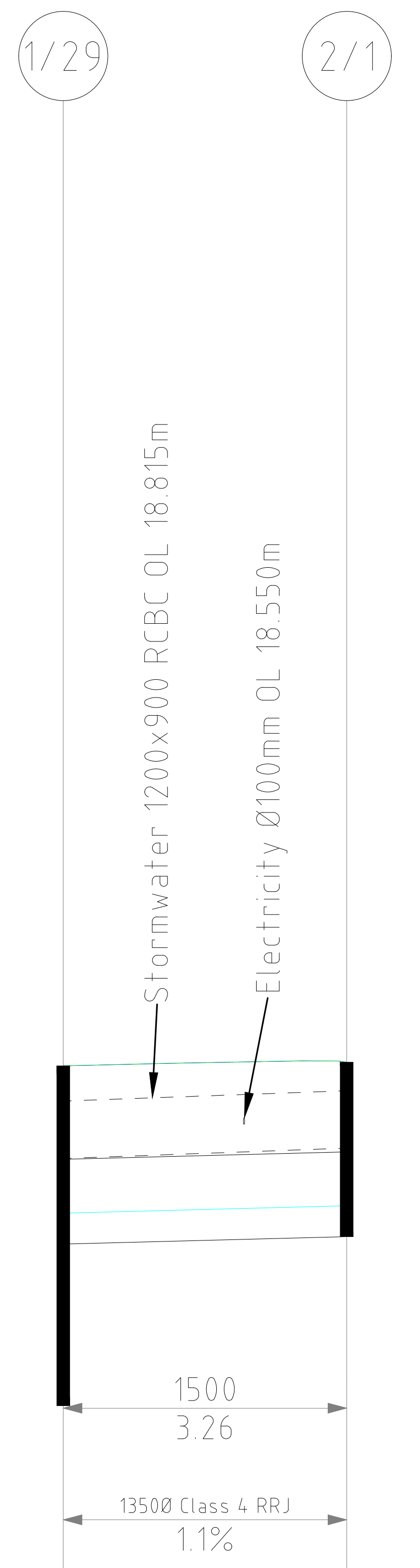
Issue 8
Drawing No. E3-15/1342 - 401
Sheet No. 1 OF 2



DATUM RL 10.8

HGL	16.572		16.689
DEPTH TO INVERT	2.795		2.736
INVERT LEVEL	16.572		16.689
FINISHED SURFACE	19.367		19.425
EXISTING SURFACE	19.367		19.425
CHAINAGE	177.738	11.118	188.857

DRAINAGE LONGITUNDINAL SECTION FOR LINE 2

SCALES: HORIZONTAL 1:250 VERTICAL 1:100

Date	No.	By	Amendments	Chckd
23.07.2018	8	ER	Preliminary Design Issue	BH
18.07.2016	7	HN	Preliminary Design Issue	PS
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23.04.2015	1	MS	Concept Issue	PS

DRAINAGE LONGSECTIONS

JOYNTON AVENUE TRUNK DRAIN

Designed: PH
Checked: PH
Drawn: MS
Approved: PS
SCALE: As per longsections text
PAPER: A1

CITY OF SYDNEY 2030

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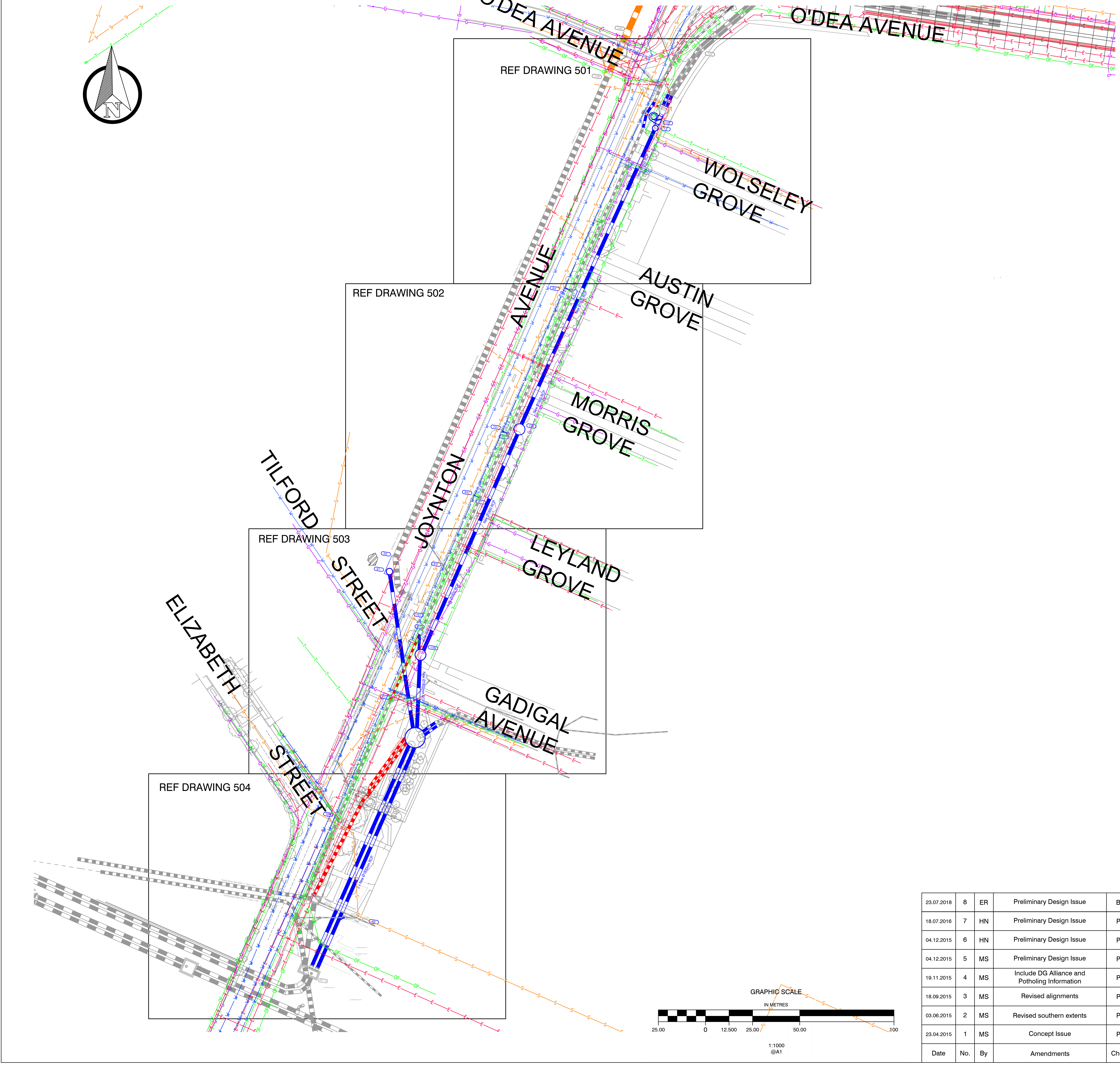
Issue 8
Drawing No. E3-15/1342 - 402
Sheet No. 2 OF 2



LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
⬜	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
▭	NEW STORMWATER PIT
▤	EXISTING STORMWATER PIT/GRATE

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SERVICES AND UTILITIES KEY PLAN

JOYNTON AVENUE TRUNK DRAIN

CITY OF SYDNEY 2030

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Issue
8

Designed: PS
Checked: PS
Drawn: MS
Approved: PS

SCALE:
1:1000

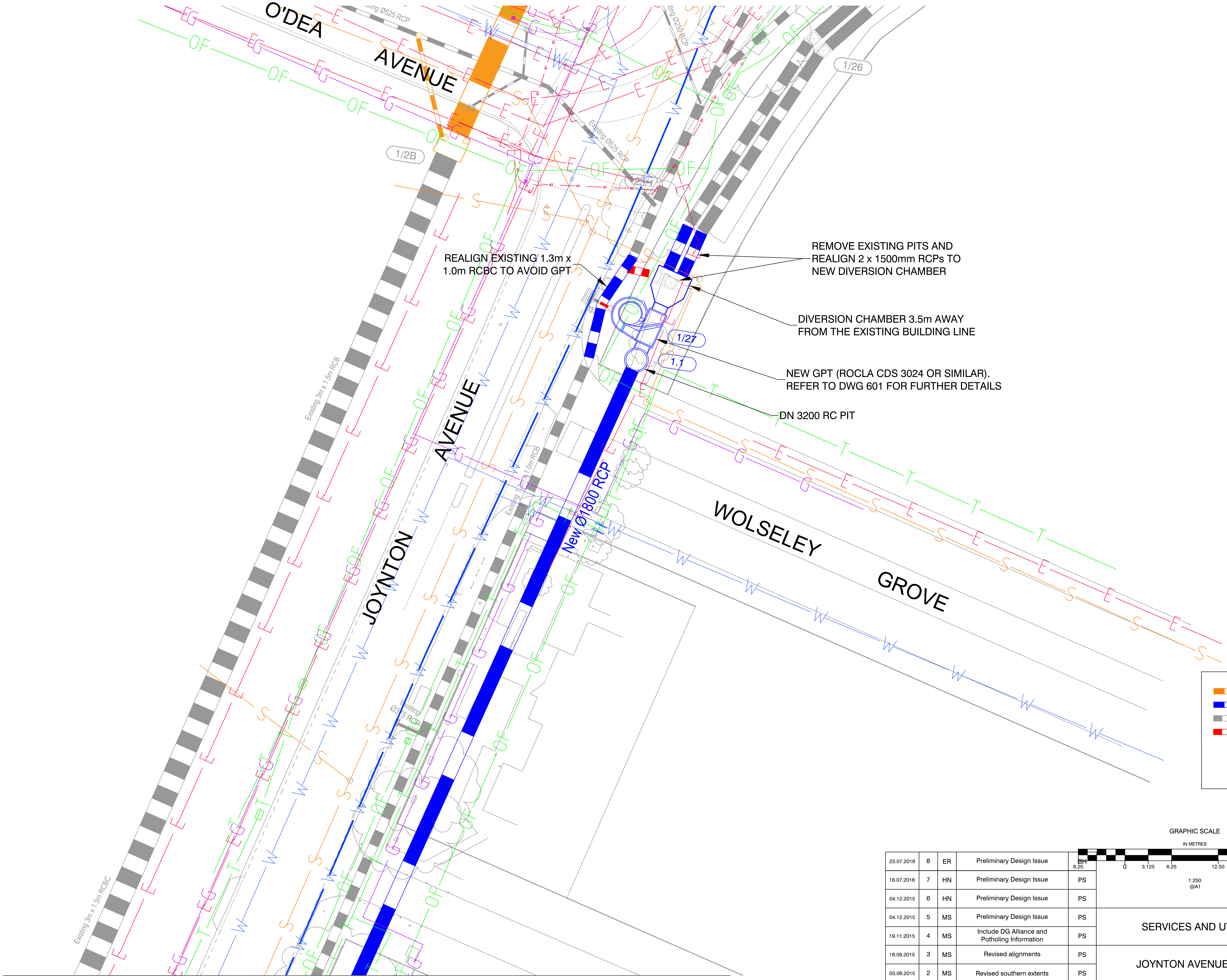
PAPER:
A1

Drawing No.
E3-15/1342 - 500

Sheet No.
1 OF 1

PLOTTED BY : Edy Rustam DATED 01/04/2015 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan



REALIGN EXISTING 1.3m x 1.0m RCBC TO AVOID GPT

REMOVE EXISTING PITS AND REALIGN 2 x 1500mm RCPs TO NEW DIVERSION CHAMBER

DIVERSION CHAMBER 3.5m AWAY FROM THE EXISTING BUILDING LINE

NEW GPT (ROCLA CDS 3024 OR SIMILAR). REFER TO DWG 601 FOR FURTHER DETAILS

DN 3200 RC PIT

JOINS SHEET 502

LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
⬜	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
▭	NEW STORMWATER PIT
▤	EXISTING STORMWATER PIT/GRATE

GRAPHIC SCALE
IN METRES
6.25 0 3.125 6.25 12.50 25
1:250
@A1

Date	No.	By	Amendments	Chckd
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SERVICES AND UTILITIES PLAN

JOYNTON AVENUE TRUNK DRAIN

CITY OF SYDNEY 2030

Designed: PH
Drawn: MS
Checked: PS
Approved: PS
SCALE: 1:250
PAPER: A1

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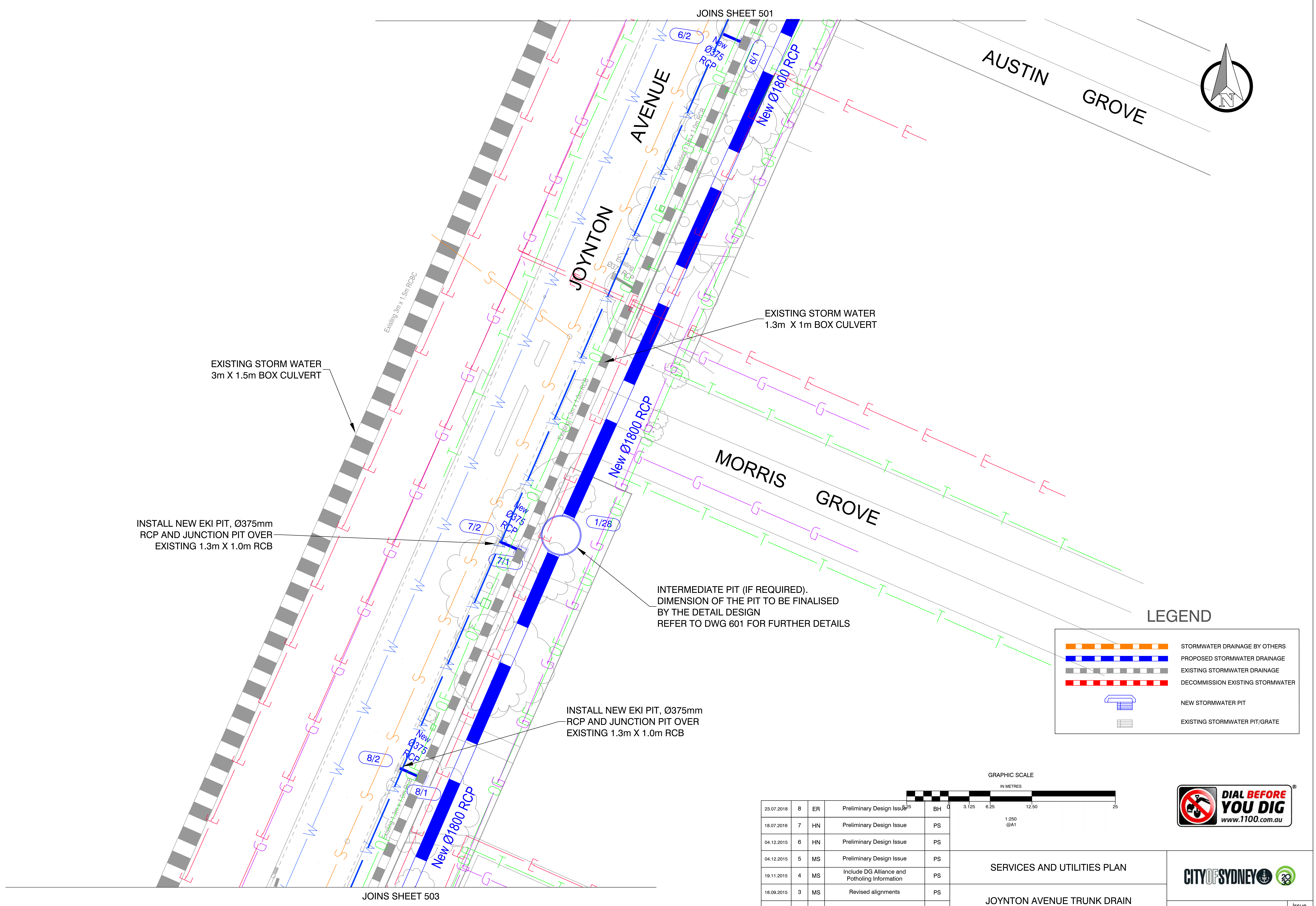
Drawing No. E3-15/1342 - 501
Sheet No. 1 OF 4

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan



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SERVICES AND UTILITIES PLAN

JOYNTON AVENUE TRUNK DRAIN

Designed: PH
Checked: PS
Drawn: MS
Approved: PS
SCALE: 1:250
PAPER: A1

CITY OF SYDNEY 2030

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Issue 8
Drawing No. E3-15/1342 - 502
Sheet No. 2 OF 4

PLOTTED BY : EDY RUSTAM DATED 27/09/2018 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan

JOINS SHEET 502

LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
▨	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
▭	NEW STORMWATER PIT
▤	EXISTING STORMWATER PIT/GRATE

JOINS SHEET 504

Date	No.	By	Amendments	Chckd
23.07.2018	8	ER	Preliminary Design Issue	BH
18.07.2016	7	HN	Preliminary Design Issue	PS
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23.04.2015	1	MS	Concept Issue	PS

SERVICES AND UTILITIES PLAN

JOYNTON AVENUE TRUNK DRAIN

Designed: PH
Drawn: MS
Checked: PS
Approved: PS
SCALE: 1:250
PAPER: A1

CITY OF SYDNEY

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Issue 8

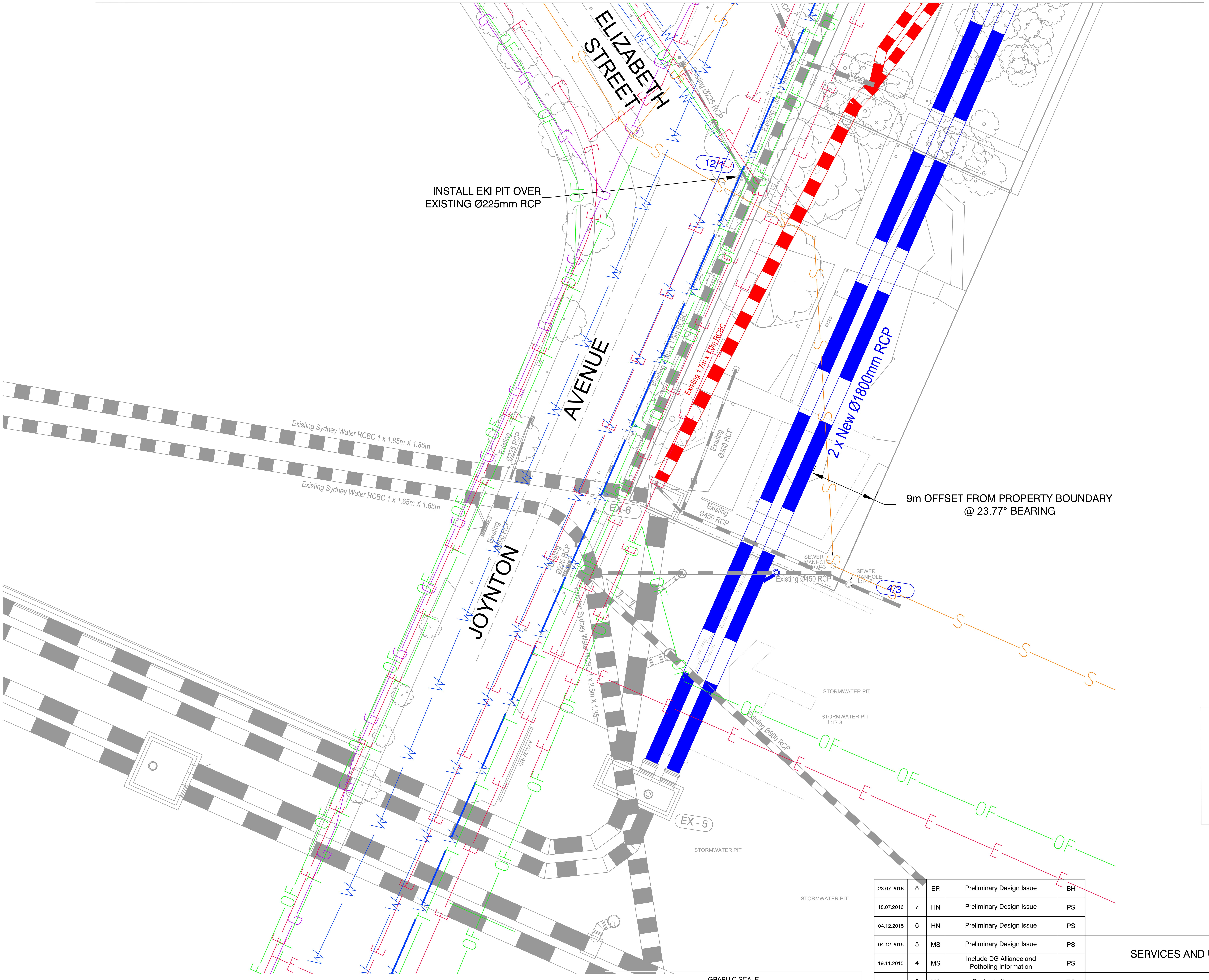
Drawing No. E3-15/1342 - 503

Sheet No. 3 OF 4

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan

JOINS SHEET 503



LEGEND

🟧	STORMWATER DRAINAGE BY OTHERS
🟦	PROPOSED STORMWATER DRAINAGE
⬜	EXISTING STORMWATER DRAINAGE
🟥	DECOMMISSION EXISTING STORMWATER
▭	NEW STORMWATER PIT
▤	EXISTING STORMWATER PIT/GRATE

GRAPHIC SCALE
IN METRES
6.25 0 3.125 6.25 12.50 25
1:250
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Date	No.	By	Amendments	Chckd
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18.07.2016	7	HN	Preliminary Design Issue	PS
04.12.2015	6	HN	Preliminary Design Issue	PS
04.12.2015	5	MS	Preliminary Design Issue	PS
19.11.2015	4	MS	Include DG Alliance and Potholing Information	PS
18.09.2015	3	MS	Revised alignments	PS
03.06.2015	2	MS	Revised southern extents	PS
23.04.2015	1	MS	Concept Issue	PS

SERVICES AND UTILITIES PLAN

JOYNTON AVENUE TRUNK DRAIN

Designed: PH
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Approved: PS
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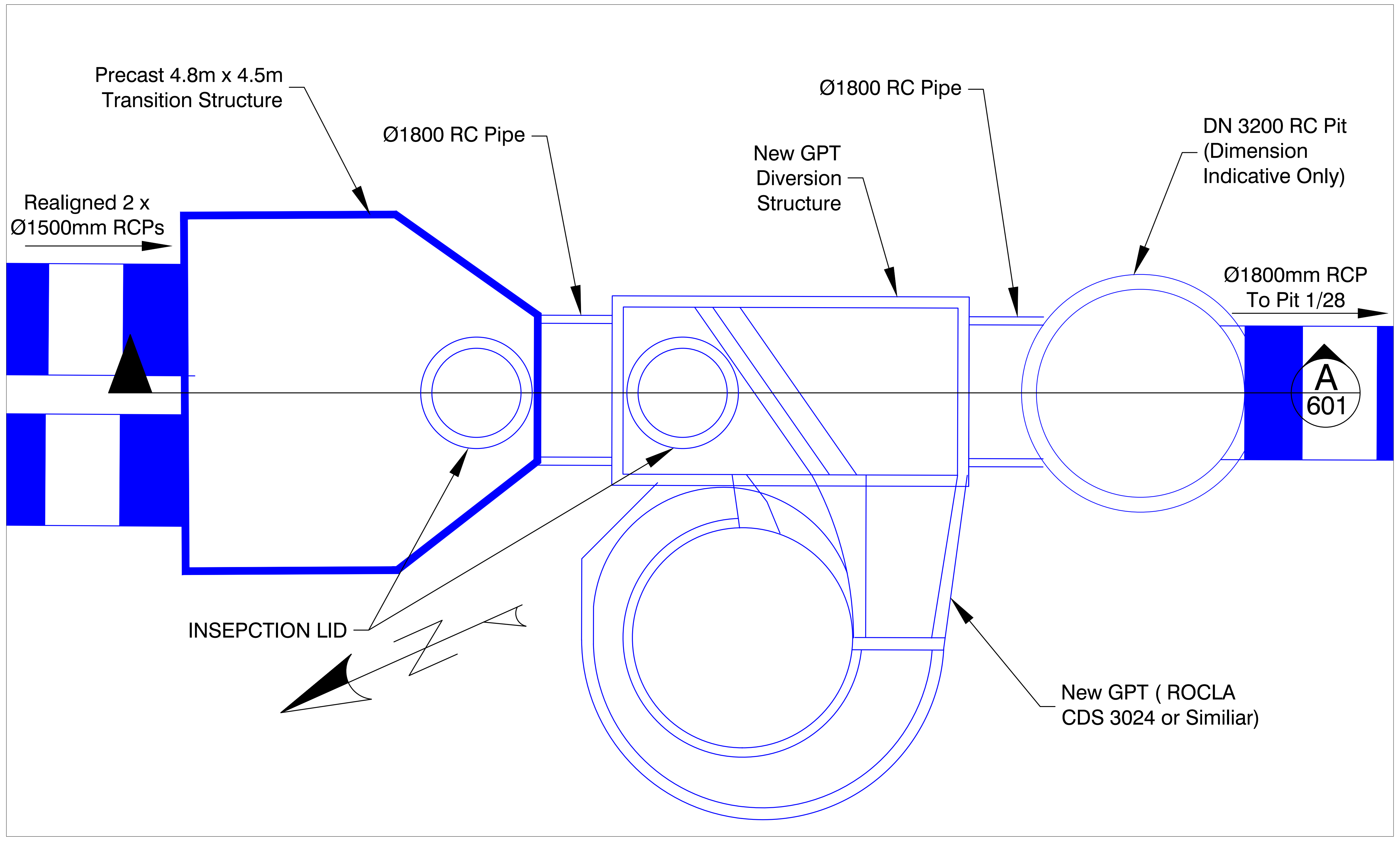
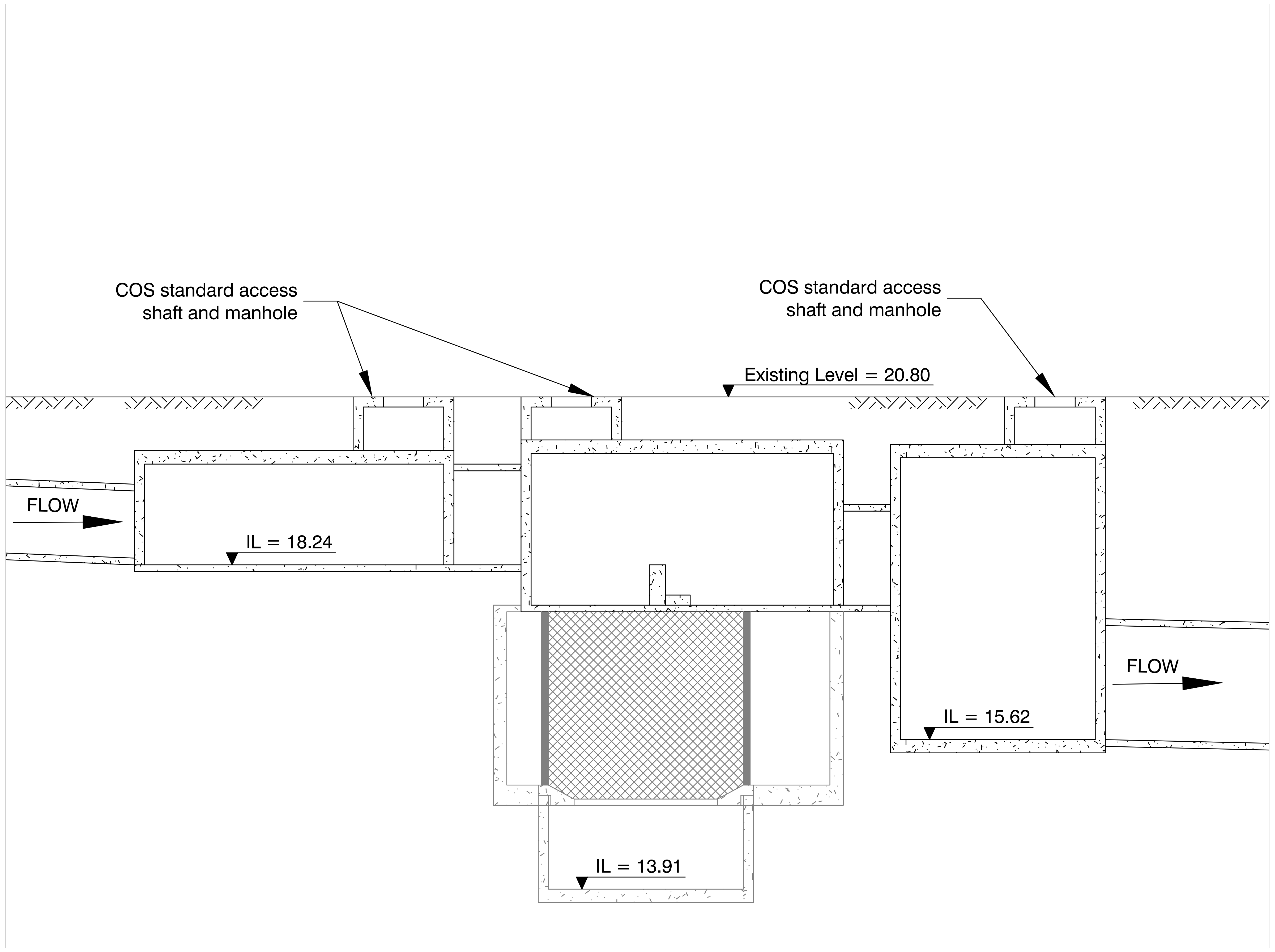
Drawing No. E3-15/1342 - 504
Sheet No. 4 OF 4

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 , CITY OF SYDNEY

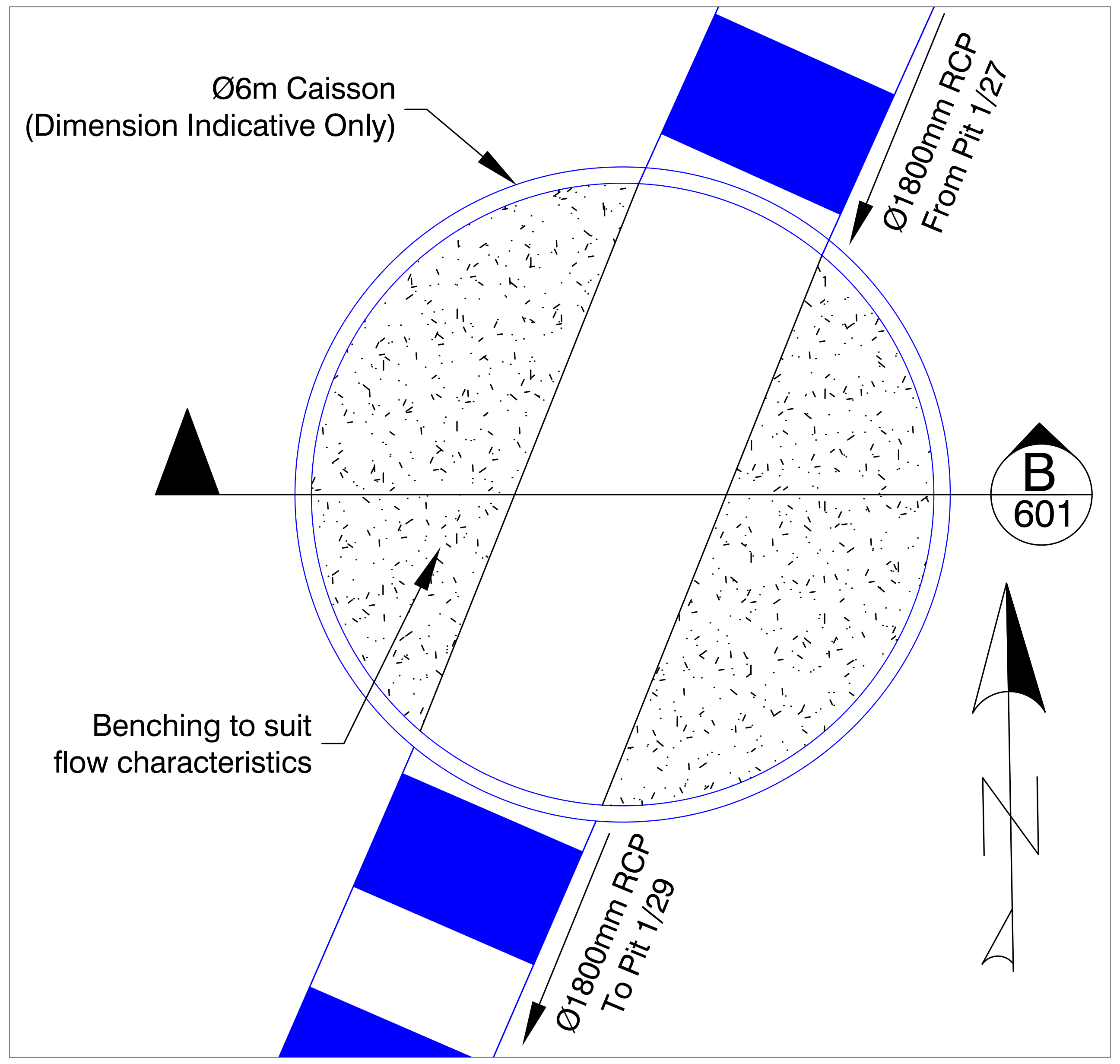
PLAN VIEW OF PIT 1/27



SECTION A 601



PLAN VIEW OF PIT 1/28



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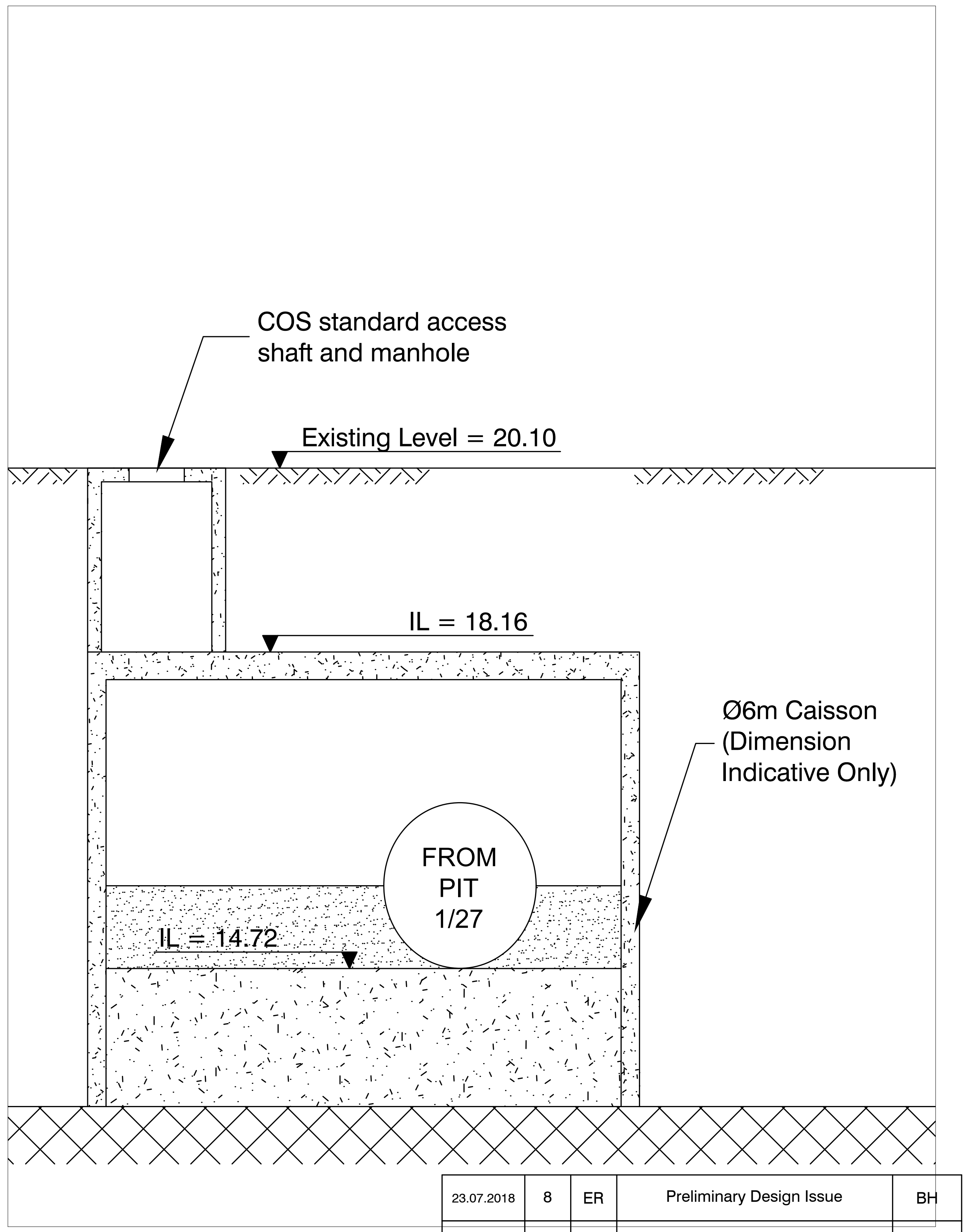
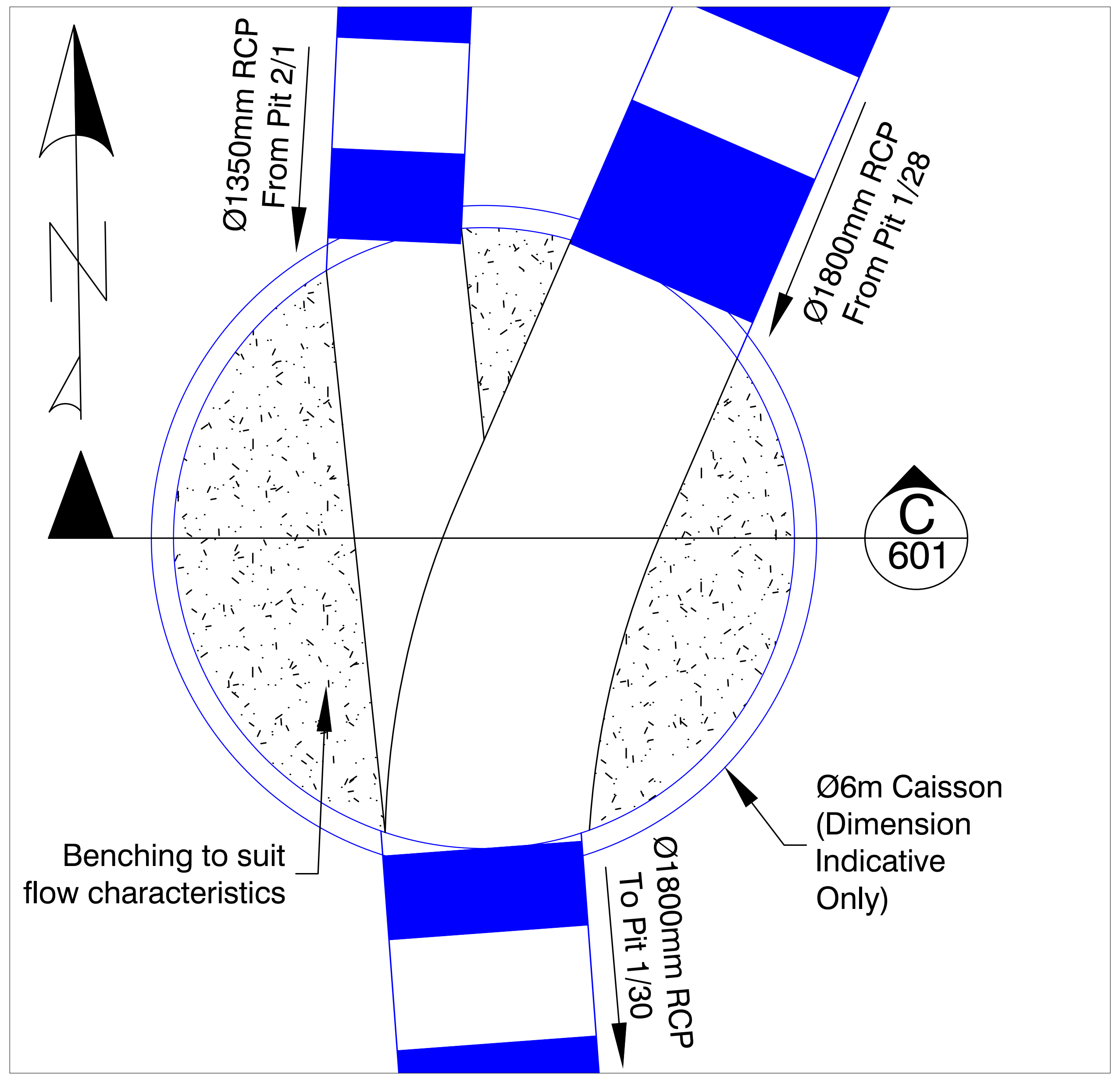


PLAN VIEW OF PIT 1/29



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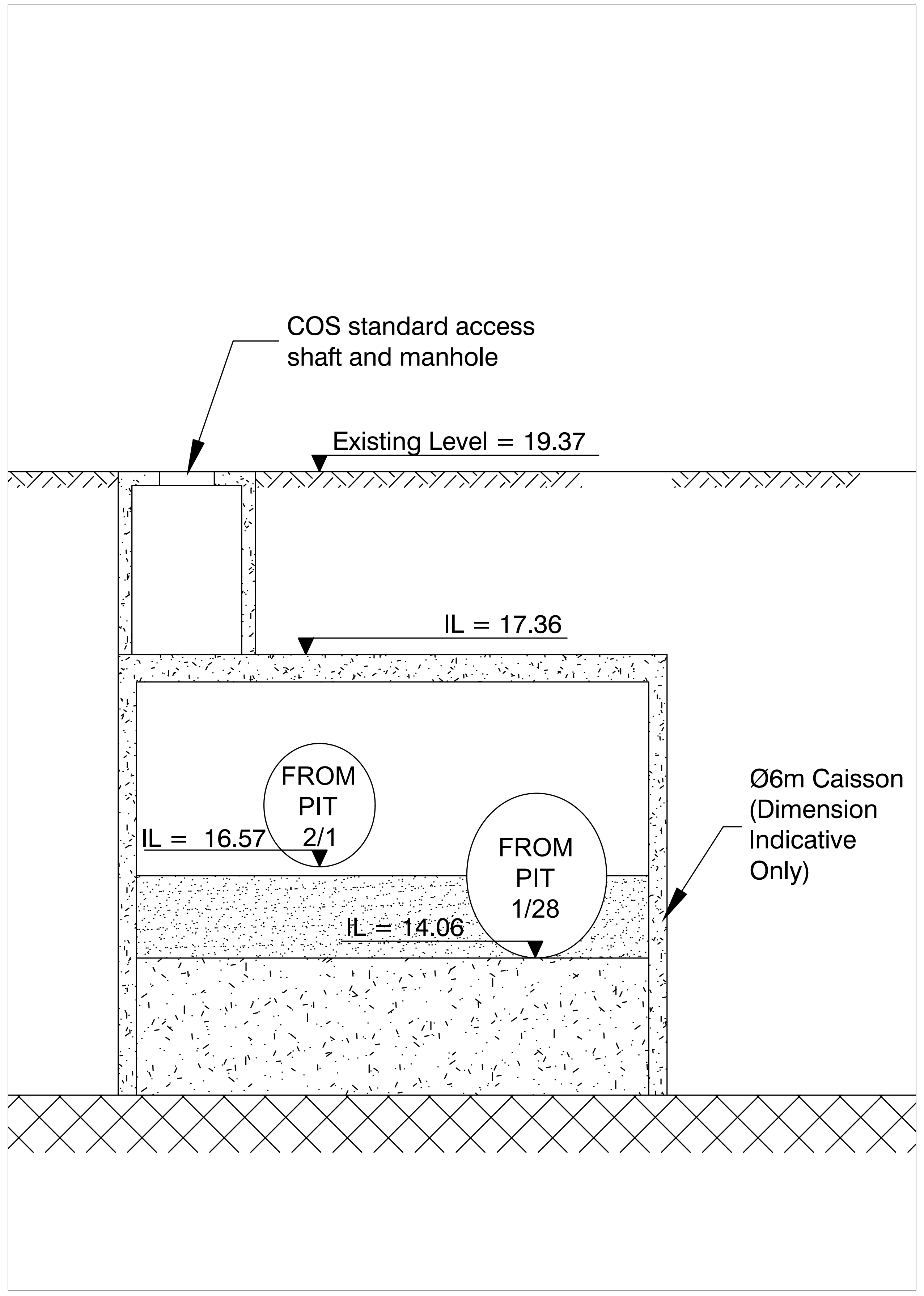

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03.06.2015	2	MS	Revised southern extents	PS
23.04.2015	1	MS	Concept Issue	PS

ROADS & DRAINAGE PLAN

JOYNTON AVENUE TRUNK DRAIN

CITY OF SYDNEY 2030

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Drawing No. E3-15/1342 - 601
Sheet No. 1 OF 2

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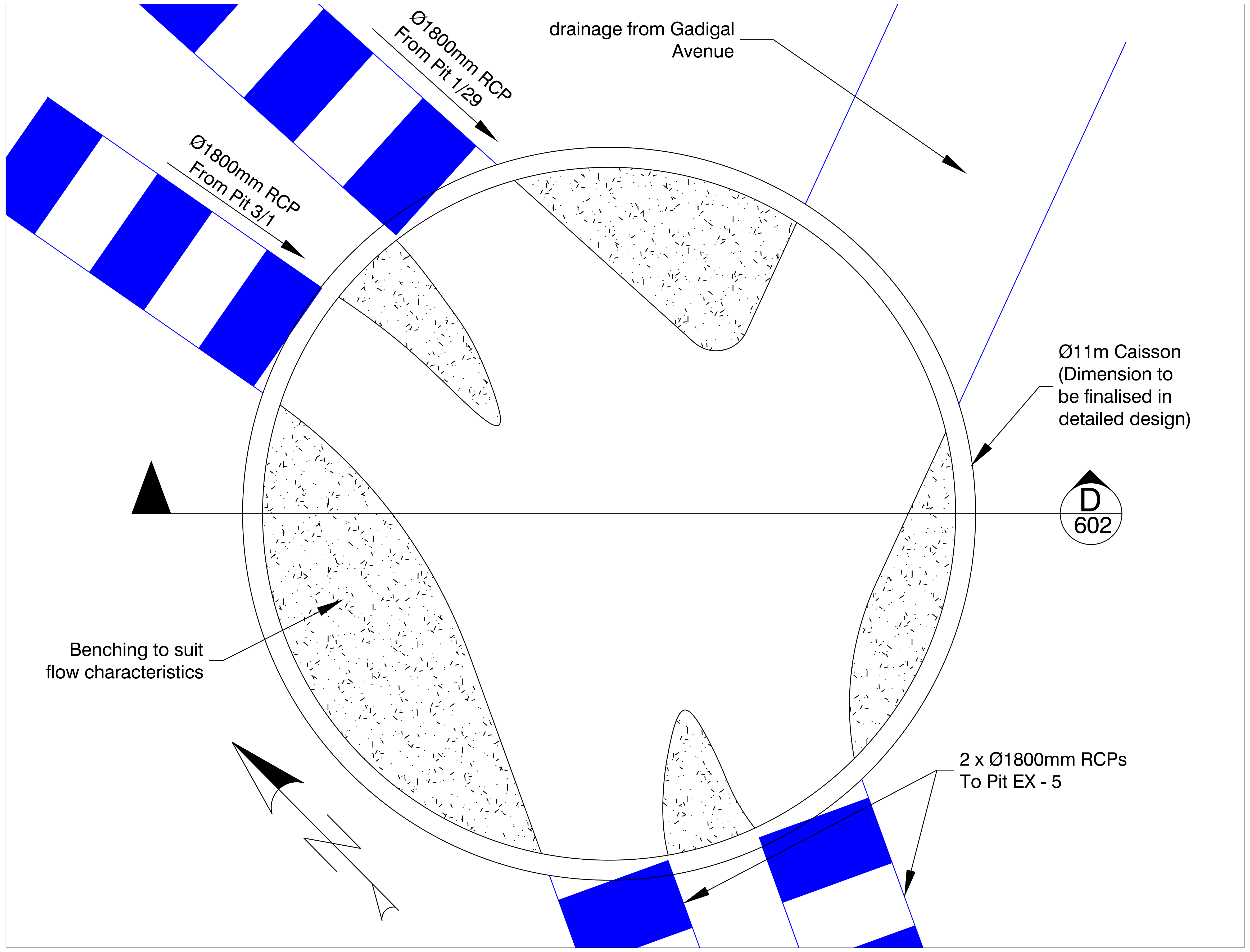
FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan

PLAN VIEW OF PIT 1/30



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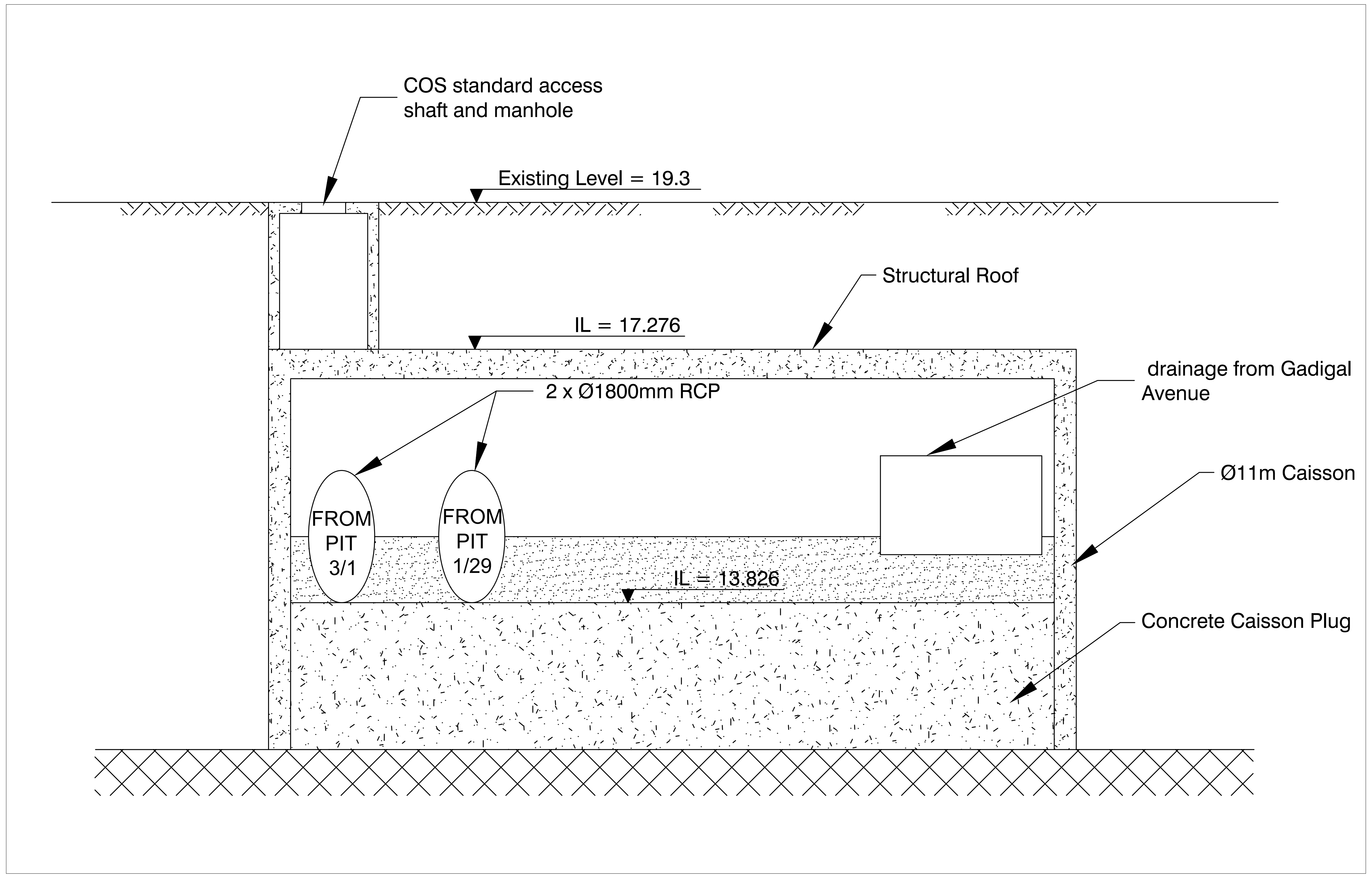
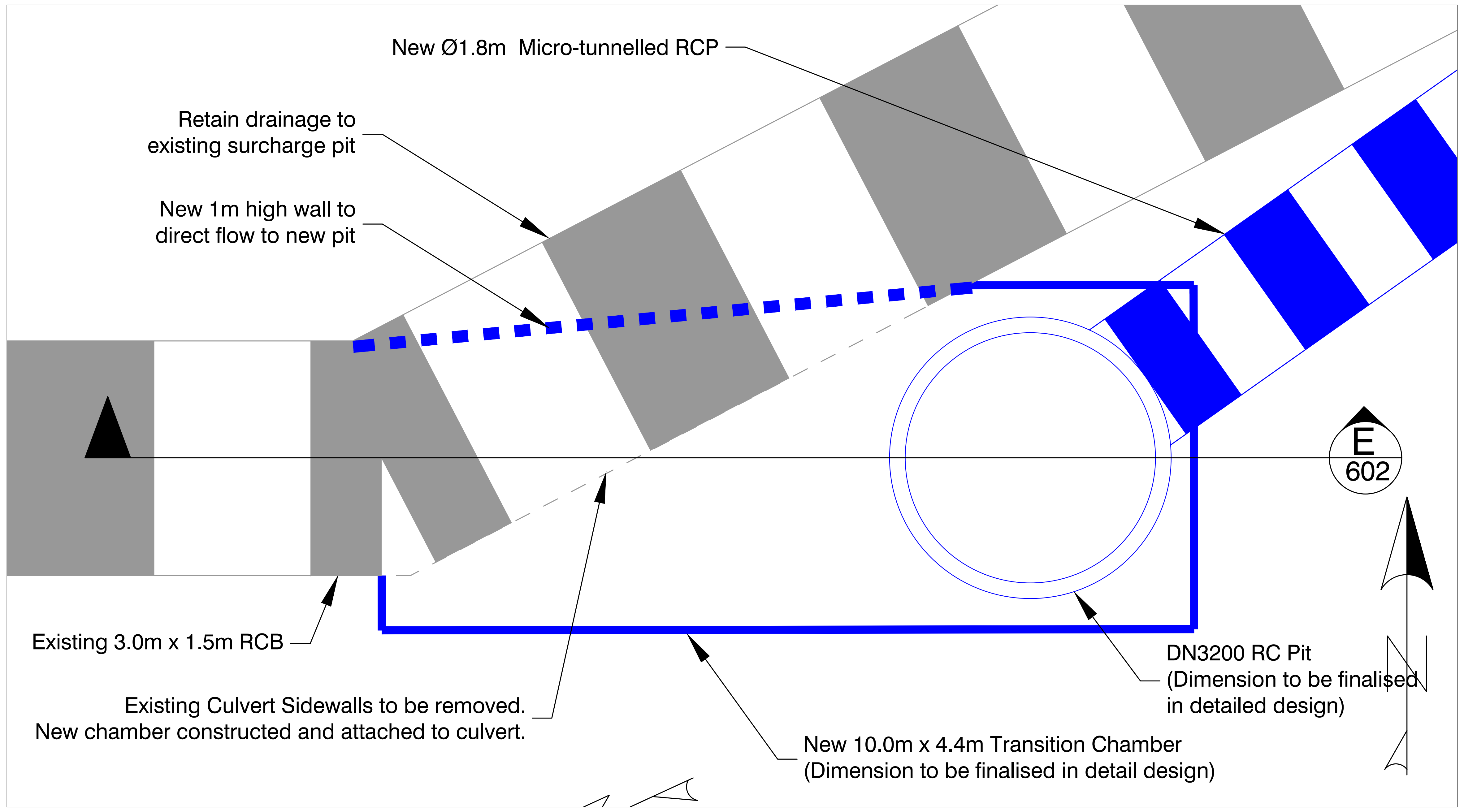


PLAN VIEW OF PIT 3/1



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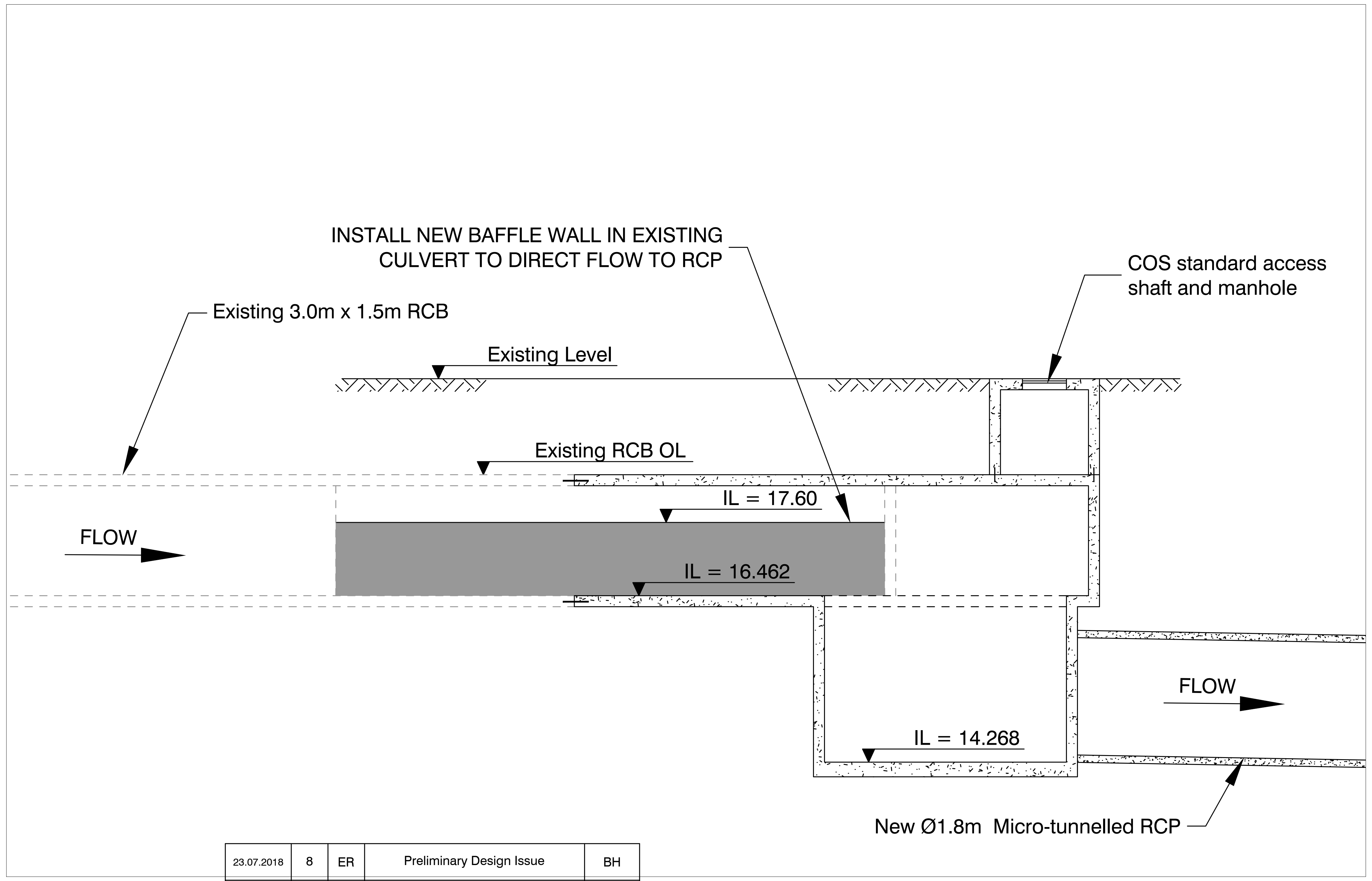

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ROADS & DRAINAGE PLAN

JOYNTON AVENUE TRUNK DRAIN

Designed: MS
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Drawing No. E3-15/1342 - 602
Sheet No. 2 OF 2

PLOTTED BY : EDY RUSTAM DATED 01/04/2015 , CITY OF SYDNEY

FILE LOCATION : W:\City Community & Cultural Services\City Infrastructure\Technical Services\Design Services (New)\04. Capital Works Projects\043. Drainage\Joynton Av\Paramesh\Plan

Appendix B ARBORICULTURAL IMPACT ASSESSMENT

EARTHSCAPE HORTICULTURAL SERVICES
Arboricultural, Horticultural and Landscape Consultants

ABN 36 082 126 027

ARBORICULTURAL IMPACT ASSESSMENT REPORT

PROPOSED STORMWATER PIPELINE

JOYNTON AVENUE, ZETLAND

March 2016

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Member of Arboriculture Australia
Member International Society of Arboriculture - Australian Chapter (ISAAC)
Member Local Government Tree Resources Association (LGTRA)

EXECUTIVE SUMMARY

This report examines the potential impact of the proposed a proposed new stormwater pipeline (trunk drainage system) on existing street trees within Joynton Avenue and Woolwash Park, Zetland. A total of forty-six (46) street trees are located in the vicinity of the proposed works. A number of the Port Jackson Figs on the eastern side of the road reserve in Joynton Avenue are listed as Heritage Items on the *Sydney Local Environmental Plan* 2012 and Councils *Significant Tree Register*. The pipeline is proposed to be installed by Horizontal Directional Drilling [micro-tunneling] beneath the existing reserve.

The proposed works will necessitate the removal of a total of nine (9) trees, all of which are considered to be of moderate retention value. With exception of T32 (a Broad-leaved Paperbark), all of these trees are relatively small and can be replaced in the short term with new tree planting.

Given the soil conditions in this area, mature trees are likely to develop a secondary root crown at some depth below surface levels, usually just above the water table. Geotechnical investigations within the site and adjoining site indicate that the water table is located at about 2.7 metres below ground level. The top of the pipeline will have between 3 and 4 metres cover (between surface levels and the top of the pipe). Therefore risk of mechanical damage to the root systems of these trees is considered unlikely as the tunneling will occur beneath the secondary root plate of the subject trees.

TABLE OF CONTENTS

1 INTRODUCTION

1.1.1 This report was commissioned by the City of Sydney to assess the health and condition of forty-six (46) trees located within the eastern side of the Joynton Avenue road reserve between the intersections of O'Dea Avenue and Gadigal Avenue and the northern section of Woolwash Park (corner Joynton and Gadigal Avenues), Zetland. The report has been prepared to aid in the preparation of a *Review of Environmental Factors* (REF) as required under Part 5 of the *Environmental Planning and Assessment Act* (EPAA) 1979. The proposed works include the installation of new stormwater infrastructure (trunk drainage system) in Joynton Avenue.

1.1.2 The purpose of this report is to assess the potential impact of the proposed development on the subject trees, together with recommendations for amendments to the design or construction methodology where necessary to minimise any adverse impact. The report also provides recommended tree protection measures to ensure the long-term preservation of the trees to be retained where appropriate.

1.1.3 This report has been prepared in accordance with the City of Sydney Council's guidelines for preparation of Arborists Reports as outlined in Schedule 8 of the *Sydney Development Control Plan* (DCP) 2012, the Scope of Work outlined in Section 4.4.1-4.4.3 of the City of Sydney's *Consultant Arboricultural Services Contract* [No. 1352] and Sections 2.3.2-2.3.5 of the Australian Standard for *Protection of Trees on Development Sites* (AS 4970:2009).

2 THE SITE

2.1.1 The subject trees are located within a section of road reserve on the eastern side of the Joynton Avenue between the intersections of O'Dea Avenue and Gadigal Avenue and the northern section of Woolwash Park (corner Joynton and Gadigal Avenues), Zetland. For the purposes of this report, the subject area will be referred to as "the Site". The majority of the site is zoned Public Recreation [RE1] under the *Sydney Local Environmental Plan* (SLEP) 2012, with the exception of the Green Square Library and Customer Service Centre (100 Joynton Avenue), which is zoned General Residential (R1). The site is relatively level with a slight southerly gradient.

2.1.2 The road reserve in Joynton Avenue contains a number of mature and semi-mature trees. These are predominantly *Ficus rubiginosa* (Port Jackson Fig), but also includes some *Melaleuca quinquenervia* (Broad-leaved Paperbark), *Corymbia citriodora* (Lemon-scented Gum) and several young *Magnolia grandiflora* (Bullbay Magnolia). Woolwash Park contains a large grove of Broad-leaved Paperbarks.

2.1.3 The landscape and soils of this area have been extensively disturbed and modified for urban development. Remnant soils of this area are typical of the Tuggerah Soil Landscape Group (as classified in the Soil Landscapes of the Sydney 1:100,000 Sheet), consisting of "deep (greater than 2000mm) *Podzols* on dunes and *Podzol/Humus Podzol* intergrades on swales." The landscape of the area was formerly gently undulating to rolling coastal dune fields with slope gradients of 1-10%.[1]

2.1.4 Most of the locally indigenous vegetation has been cleared from surrounding areas for residential and industrial development. The original vegetation of this area consisted of open woodland & Eastern Suburbs Banksia Scrub, with dominant locally-indigenous tree species formerly occurring in this area including *Angophora costata* (Sydney Red Gum), *Eucalyptus piperita* (Sydney Peppermint) and *Banksia aemula* (Wallum Banksia), with *Eucalyptus robusta* (Swamp Mahogany) and *Melaleuca quinquenervia* (Broadleaved Paperbark) occurring in low lying areas.[2]

3 SUBJECT TREES

3.1.1 The subject trees were inspected by Earthscape Horticultural Services (EHS) on the 28th July 2015. Each tree has been provided with an identification number for reference purposes denoted on the attached Tree Location Plan (**Appendix 5**), based on the survey prepared by the City of Sydney Infrastructure Traffic Operations Survey Group, Dwg. Ref No. S5-14/1175A dated 23/04/2013. The numbers used on this plan correlate with the Tree Assessment Schedule (**Appendix 3**). Tree No.s T28, T29, T30 & T31 were not shown on the original survey and have been plotted on the drawing in their approximate positions.

4 HEALTH AND CONDITION ASSESSMENT

4.1 Methodology

4.1.1 An assessment of each tree was made using the Visual Tree Assessment (VTA) procedure.[3] All of the trees were assessed in view from the ground. No aerial inspection or diagnostic testing has been undertaken as part of this assessment.

4.1.2 The following information was collected for each tree:-

- Tree Species (Botanical & Common Name);
- Approximate height;
- Canopy spread; measured using a metric tape and an average taken.
- Trunk diameter (measured at 1.4 metres from ground level);
- Live Crown Size; (measured by subtracting the total height of the tree from the lowest point of the crown and multiplying by the average crown spread to give a value in square metres).
- Health & vigour; using foliage size, colour, extension growth, presence of disease or pest infestation, canopy density, presence of deadwood, dieback and epicormic growth as indicators,
- Condition; using visible evidence of structural defects, instability, evidence of previous pruning and physical damage as indicators.
- Suitability of the tree to the site and its existing location; in consideration of damage or potential damage to services or structures, available space for future development and nuisance issues.

This information is presented in a tabulated form in **Appendix 3.**

4.2 Safe Useful Life Expectancy (SULE)

4.2.1 The remaining Safe Useful Life Expectancy[4] of the tree is an estimate of the sustainability of the tree in the landscape, calculated based on an estimate of the average age of the species in an urban area, less its estimated current age. The life expectancy of the tree has been further modified where necessary in consideration of its current health and vigour, condition and suitability to the site. The estimated SULE of each tree is shown in **Appendix 3.**

4.2.2 The following ranges have been allocated to each tree:-

- Greater than 40 years (Long)
- Between 15 and 40 years (Medium)
- Between 5 and 15 years (Short)
- Less than 5 years (Transient)
- Dead or immediately hazardous (defective or unstable)

5 LANDSCAPE SIGNIFICANCE

5.1 Methodology for Determining Landscape Significance

5.1.1 The significance of a tree in the landscape is a combination of its amenity, environmental and heritage values. Whilst these values may be fairly subjective and difficult to assess consistently, some measure is necessary to assist in determining the retention value of each tree. To ensure in a consistent approach, the assessment criterion shown in **Appendix 1** have been used in this assessment.

5.1.2 A rating has been applied to each tree to give an understanding of the relative significance of each tree in the landscape and to assist in determining priorities for retention, in accordance with the following categories:-

1. **Significant**
2. **Very High**
3. **High**
4. **Moderate**
5. **Low**
6. **Very Low**
7. **Insignificant**

5.2 Environmental Significance

5.2.1 Tree Management Controls

Prescribed trees within the City of Sydney Local Government Area (LGA) are protected under Section 3.5.3 of the *Sydney Development Control Plan* (SDCP) 2012, made pursuant to Clause 5.9 (2) of the *Sydney Local Environmental Plan* (SLEP) 2012. The SDCP generally protects all trees of a height of five (5) metres or greater or with a canopy spread of five (5) metres or greater, or trunk diameter of 300mm or greater (measured at ground level) or any tree listed on Council's Significant Tree Register. Some exemptions apply. The following trees are exempt (not protected) under the provisions of the SCCP 2012:-

Tree No.	Species	Exemption
T31#, T33#, T34#	*Magnolia grandiflora* (Bullbay Magnolia)	Less than the prescribed dimensions

5.2.2 It should be noted that Tree No.s T31, T33 & T34 [all *Magnolia grandiflora* (Bullbay Magnolia)] whilst exempt from SDCP 2012 are afforded some protection under Section 138 (c) of the *Roads Act* (NSW) 1993 and Section 629 of the *Local Government Act* (NSW) 1993, being located within the Council's Road Reserve. The remainder of the trees are protected under the SDCP 2012.

5.2.3 Wildlife Habitat

Melaleuca quinquenervia (Broad-leaved Paperbark) [T1, T2, T17, T18, T27, T32 & T35-T42], is a locally-indigenous species, representative of the original vegetation of the area and would be of benefit to native wildlife. However, none of the trees contain cavities suitable as nesting hollows for arboreal mammals or birds or other visible signs of wildlife habitation. It should be noted that all of these trees have been planted within the site (i.e. none of the trees are remnant of the original vegetation community).

5.2.4 Noxious Plants & Environmental Weeds

None of the subject trees are scheduled as Noxious Weeds under the meaning of *Noxious Weeds Act* (NSW) 1993. None of the subject trees are considered to be Environmental Weed Species within the City of Sydney LGA.

5.2.5 *Threatened Species & Ecological Communities*

None of the subject trees are listed as Threatened or Vulnerable Species or form part of Endangered Ecological Communities (EECs) under the provisions of the *Threatened Species Conservation Act* 1995 (NSW) or the *Environmental Protection and Biodiversity Conservation Act* 1999.

5.3 Heritage Significance

5.3.1 *Heritage Items*

The street trees in Joynton Avenue between the intersections of O'Dea Avenue and Gadigal Avenue are listed as items of Environmental Heritage (Item 2210) of Local Significance under Part 1, Schedule 5 of the *Sydney Local Environmental Plan* (SLEP) 2012. The former Victoria Park Racecourse group (100-106a Joynton Avenue), including the former Totaliser building, park and interpretation device (adjoining Joynton Avenue) are also listed as an item of Environmental Heritage (Item 2212) of Local Significance under Part 1, Schedule 5 of the SLEP 2012.

The street trees in Joynton Avenue considered of historical significance due to their association with the former Victoria Park Racecourse, founded by Sir James John Joynton Smith in January 1908, after whom Joynton Avenue is named. The trees on the eastern side of the roadway are predominantly Port Jackson Figs, whereas the trees on the western side of the roadway are predominantly *Ficus macrocarpa var. hillii* (Hills Weeping Fig). The trees make a positive contribution to the amenity of Joynton Avenue, their interlocking canopies forming a contiguous green archway over the street. They are representative of typical plantings of this period in the Sydney area and have a landmark quality. The Broad-leaved Paperbarks and Lemon-scented Gums are also considered to be contributory items, adding to the streetscape quality.[5]

The Totaliser Building (100 Joynton Avenue,) is the only surviving building fabric of the former Victoria Park Racecourse. It is described as a one and three storey brick inter-war period building, now adaptively re-used as the Green Square Library and Customer Service Centre.

5.3.2 *Heritage Conservation Area*

The site is *not* located within a Heritage Conservation Area under Part 2 of Schedule 5 of the SLEP 2012.

5.3.3 *Significant Tree Register*

The older Port Jackson Fig trees on the eastern side of Joynton Avenue (T6, T7, T8, T9, T10, T11, T12, T13, T22, T23 and T26), [originally a row of 14, only 11 now remain] and the nine (9) Hills Weeping Figs on the western side of Joynton Avenue are listed on Council's Register of Significant Trees Volume 2 (Significant Street Trees).[6] It is thought that the Port Jackson Figs were planted in the early 20th Century (around the time the Victoria Park Racecourse was established) and the Hills Figs were planted sometime later, probably in the Interwar Period (1919-1939) being more typical of public plantings of this era.

A large *Ficus macrophylla* (Moreton Bay Fig) located near the intersection of Joynton Avenue and Austin Grove (within 100 Joynton Avenue, adjacent the Totaliser Building) is also listed as a significant tree on Council's Register of Significant Trees Volume 2 (Significant Street Trees). This tree has not been included in this assessment, but is located adjacent the subject trees.

5.4 Amenity Value

5.4.1 Criteria for the assessment of amenity values are incorporated into **Appendix 1**. The amenity value of a tree is a measure of its live crown size, visual appearance (form, habit, crown density), visibility and position in the landscape and contribution to the visual character of an area.

Generally the larger and more prominently located the tree, and the better its form and habit, the higher its amenity value.

6 TREE RETENTION VALUES

6.1.1 The Retention Values shown in **Appendix 3** and **Appendix 5** have been determined on the basis of the estimated longevity of the trees and their landscape significance rating, in accordance with **Table One**. Together with guidelines contained in **Section 7** (Tree Protection Zones) this information should be used to determine the most appropriate position of building footprints and other infrastructure within the site, with due consideration to other site constraints, to minimise the impact on trees considered worthy of preservation.

TABLE 1 – TREE RETENTION VALUES – ASSESSMENT METHODOLOGY

	Landscape Significance Rating						
Estimated Life Expectancy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Long - Greater than 40 Years	High Retention Value	■	■	▩	▩	░	
Medium- 15 to 40 Years	■	■	Moderate Retention Value	▩	░	░	
Short - 5 to 15 years	■	▩	▩	Low Ret. Value	░		
Transient - Less than 5 Years	▩	░	░	Very Low Retention Value			
Dead or Potentially Hazardous	░						

7 TREE PROTECTION ZONES

7.1.1 The Tree Protection Zone (TPZ) is a radial distance measured from the centre of the trunk of the tree as specified in **Appendix 4**. These have been calculated in accordance with AS 4970-2009 (Protection of Trees on Development Sites).[7]

7.1.2 The intention of the TPZ is to ensure protection of the root system and canopy from the potential damage from construction works and ensure the long-term health and stability of each tree to be retained. Incursions to the root zone may occur due to excavations, changes in ground levels, (either lowering or raising the grade), trenching or other forms or soil disturbance such as ripping, grading or inverting the soil profile. Such works may cause damage or loss of part of the root system, leading to an adverse impact on the tree.

7.2 Structural Root Zone (SRZ)

7.2.1 The Structural Root Zone (SRZ) provides the bulk of mechanical support and anchorage for a tree. This is also a radial distance measured from the centre of the trunk as specified in **Appendix 4**. The SRZ has been calculated in accordance with AS 4970-2009 (Protection of Trees on Development Sites).

7.2.2 Incursions within the SRZ are not recommended as they are likely to result in the severance of woody roots which may compromise the stability of the tree or lead to its decline and demise.

7.3 Acceptable Incursions to the Tree Protection Zone.

7.3.1 Where encroachment to the TPZ is unavoidable, an incursion to the TPZ of not exceeding 10% of the area of the TPZ and outside the SRZ may be acceptable. Examples of acceptable incursions are shown in **Appendix 2**. Greater incursions to the TPZ may result in an adverse impact on the tree.

7.3.2 Where incursions greater than 10% of the TPZ are unavoidable, exploratory excavation using non-destructive methods may be required to evaluate the extent of the root system affected and determine whether or not the tree can remain viable.

7.1 Acceptable Incursions to the Canopy.

7.1.1 The removal of a small portion of the crown (foliage and branches) is generally tolerable provided that the extent of pruning required is less than 10% of the total foliage volume of the tree and the removal of branches does not create large wounds or disfigure the natural form and habit of the tree. All pruning cuts must be undertaken in accordance with AS 4373:2007. This generally involves reduction of the affected branches back to the nearest branch collar at the junction with the parent branch, rather than at an intermediate point. The latter is referred to as "lopping" and is no longer an acceptable arboricultural practice. Generally speaking, the minimum pruning as required to accommodate any proposed works is desirable. Extensive pruning can result in a detrimental impact on tree health and may lead to exposure of remaining branches to wind forces that they were previously sheltered from, leading to a greater risk of branch failure.

7.1.2 Clearance to between the building line and canopy should take into account any projecting structures, such as balconies, awnings and the roofline and any requirement for temporary scaffolding to be erected during construction (typically 1-1.5 metres wide). High structures should preferably be located outside the canopy dripline (as shown indicatively on the attached plans) in order to avoid or minimise canopy pruning.

8 PROPOSED DEVELOPMENT

8.1.1 The proposed development includes the installation of a new stormwater pipeline forming a trunk drain between the intersections of O'Dea Avenue and Gadigal Avenue and adjacent to 130 Joynton Avenue (the connection point to the Green Square trunk main). The pipeline is proposed to be installed beneath the eastern portion of the road reserve, connecting to existing stormwater pipelines at either end. The proposed pipeline is a 1.8 metre internal diameter (2.15 metre external diameter) Reinforced Concrete Pipe (RCP).

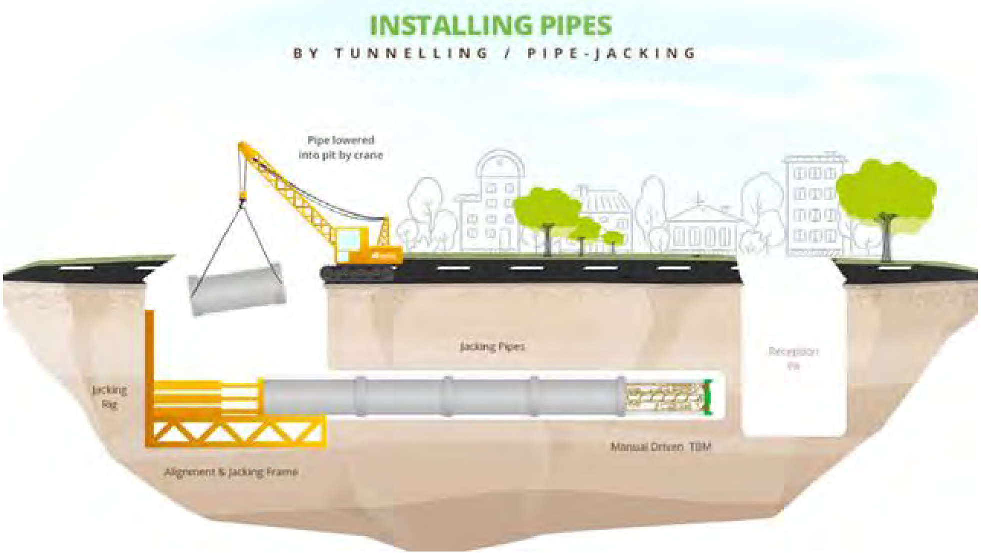

Figure 1 – Showing the proposed methodology for installation of RC pipes along Joynon Avenue.

8.1.2 The pipeline is proposed to be installed by Horizontal Directional Drilling (HDD) [micro-tunnelling], with several open excavations required along the length of the pipeline to form entry and exit (receiving) pits for the tunnelling operations as well as junction pits connecting to existing stormwater pipelines. The segmented pipes will be jacked into the tunnel as it is being formed, requiring a Jacking Rig to be installed at one end of the pipe run (refer to **Figure 1**).

8.1.3 The invert level of the pipe is between 4.9 and 6.0 metres below surface levels (3.0 to 4.0 metres cover between the top of the pipe and surface level between Pits 1/27 & 1/29). There are four (4) proposed pits along the length of the pipeline, with proposed invert levels indicated in the following table:-

Pit	Surface Level (m)	Invert Level (m)	Pipe wall thickness (m)	Pipe Barrel inside diameter (m)	Cover – Top of pipe to surface level (m)
1/27	20.70	15.77	0.175	1.8	2.96
1/28	20.16	14.87	0.175	1.8	3.32
1/29	20.16	14.19	0.175	1.8	4.00
1/30	19.30	13.97	0.175	1.8	5.33

9 IMPACT ASSESSMENT

9.1.1 The intention of this assessment is to determine the incursions to the root zones and canopies created by the proposed development and evaluate the likely impact of the proposed works on the subject trees. Details shown on the following plans were used in this assessment:-

Title	Author	Dwg No.	Date
Joynton Avenue Trunk Drain Roads and Drainage Plan	City of Sydney	E3-15/1342 – 100-104 Issue 5	04/12/2015
Joynton Avenue Trunk Drain Drainage Long Sections	City of Sydney	E3-15/1342 – 401-402 Issue 5	04/12/2015
Report on Geotechnical Investigation	Douglas Partners	P85100.00	11/2015

9.1.2 A summary of the impact of the proposed development on each tree within the site is shown in **Appendix 5**. The following criteria have been examined as part of this assessment:-

- Existing Relative Levels (R.L.);
- Tree Protection Zone (TPZ);
- Structural Root Zone (SRZ);
- Footprint and envelope of the proposed development and temporary structures (scaffolding, hoardings etc);
- Incursions to the TPZ & SRZ, including estimated cut & fill beyond the building footprint;
- Incursions to the tree canopy from the building envelope and temporary structures; and
- Assessment of the likely impact of the works on existing trees.

9.1.3 Given the soil type and depth in this area, it is likely that the larger Port Jackson Fig trees and possibly some of the Broadleaved Paperbarks and Lemon-scented Gums have developed a tap root and secondary root crown. The primary root crown is typically close to the soil surface (within 1-1.5 metres of existing ground levels), whereas the secondary root crown is normally located just above the influence of the water table (refer to **Figure 2**).

Figure 2 – Showing typical root configuration of Fig trees in deep sandy soils. The lower (secondary) root crown is usually located just above the influence of the water table.

9.1.4 A review of Geotechnical information for the adjoining development site (13 Joynton Avenue, Zetland) prepared by Asset Geotechnical indicates that the ground water table across this site has a variable gradient from about RL 17.2 to 17.5 (between 2.5 and 4.5 metres below surface levels). The boreholes undertaken by Douglas Partners alongside Joynton Avenue indicate that the water table is approximately 2.4 – 3.1 below the surface levels. An average water table depth has been estimated by Douglas Partners as 2.7 metres below surface levels, which is fairly consistent with the findings by Asset Geotechnical. The secondary root crown is therefore likely to be slightly above this level (as the root system needs a certain amount of oxygen to survive and will not grow in permanently saturated ground). Assuming this is the case, it has been calculated that the top of the proposed pipeline will be between 0.325 and 1.1 metres below water table and therefore boring operations should clear the secondary root crown as indicated in **Figure 3**.

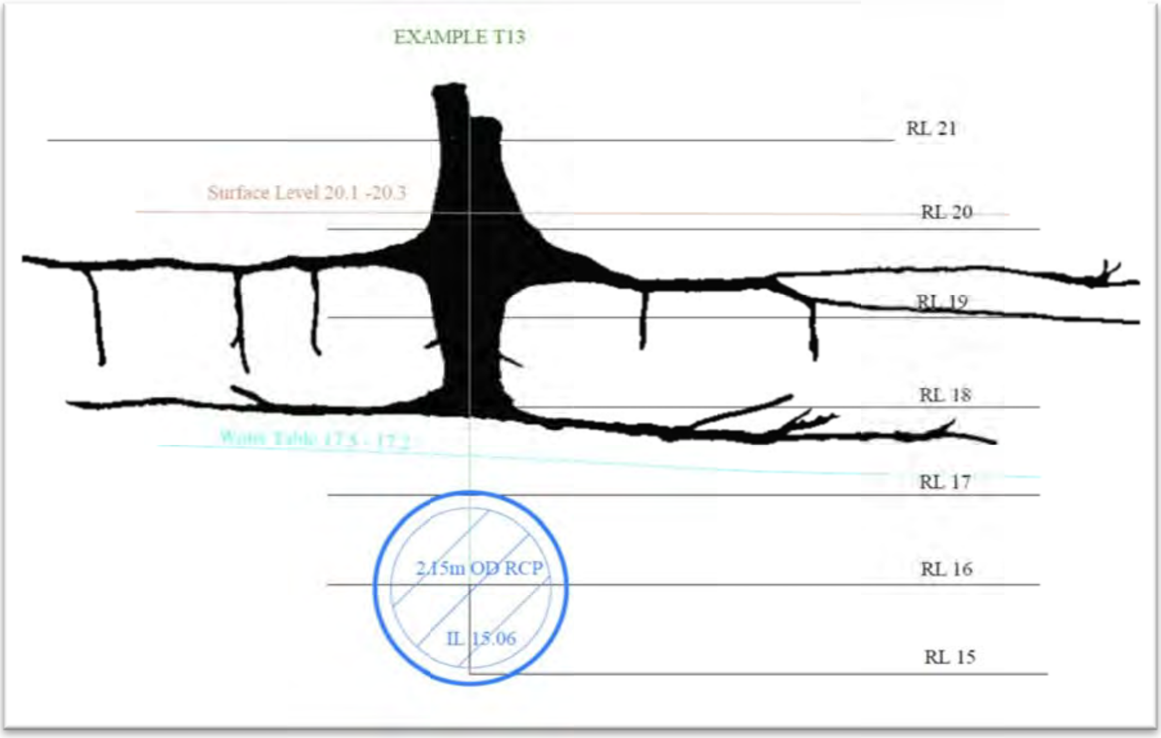

Figure 3 – Using the levels at T13 as an example, a schematic section diagram (to scale) showing

9.1.5 Whilst it is difficult to be definitive about the actual configuration of the root plate, the existence of a secondary root plate and the relationship between the pipe and the roots, this is the best estimation that can be made given the information available. The following table illustrates the analysis between surface levels, pipe levels and the water table along the length of the pipeline relative to each tree.

TABLE SHOWING THE RELATIONSHIP BETWEEN THE PROPOSED PIPELINE, WATER TABLE AND SURAFCE LEVELS RELATIVE TO THE SUBJECT TREES

	Chainage					1.975		13/10/2015			21/10/2015	
Pit No.	**dist from 0.0**	**Tree No**	**Surface RL**	**Pipe IL**	**Depth to IL**	**Cover to surface RL**	**RL to top of pipe**	**Depth to WT**	**RL to WT**	**Clearance**	**Depth to WT**	**RL WT**
1|27	0.00		20.70	15.62	5.081	3.11	17.59	2.6			3.1	
BH#1	0.00		20.60					2.6	18.000		3.1	
	0.00	**T4**	21.00	15.62	5.381	3.41	17.59	2.7	18.300	0.706		
	31.35	**T5**	20.60	15.46	5.141	3.17	17.43	2.7	17.900	0.466		
	61.90	**T6**	20.50	15.30	5.198	3.22	17.28	2.7	17.800	0.523		
	67.90	**T7**	20.41	15.27	5.138	3.16	17.25	2.7	17.710	0.463		
BH#2	81.80		20.35					2.4	17.950			
	91.60	**T8**	20.48	15.15	5.330	3.35	17.13	2.7	17.780	0.655		
	102.30	**T9**	20.39	15.10	5.294	3.32	17.07	2.7	17.690	0.619		
	108.20	**T10**	20.37	15.07	5.305	3.33	17.04	2.7	17.670	0.630		
	113.45	**T11**	20.33	15.04	5.292	3.32	17.01	2.7	17.630	0.617		
	123.60	**T12**	20.17	14.99	5.183	3.21	16.96	2.7	17.470	0.508		
	134.10	**T13**	20.10	14.93	5.167	3.19	16.91	2.7	17.400	0.492		
		T14			0.000		0.00					
	167.50	**T15**	20.24	14.76	5.478	3.50	16.74	2.7	17.540	0.803		
1|28	171.00		20.16	14.74	5.419	3.44	16.72	2.7	17.463	0.744		
1|28	0.00			14.72								
	2.90	**T16**	20.09	14.70	5.386	3.411	16.68	2.7	17.390	0.711		
		T17	19.70									
		T18	19.70									
	18.30	**T19**	20.17	14.62	5.547	3.572	16.60	2.7	17.47	0.872		
	21.20	**T20**	20.19	14.61	5.582	3.607	16.58	2.7	17.49	0.907		
BH#3			19.44					2.6	16.84		2.26	
	42.30	**T22**	20.18	14.50	5.683	3.708	16.47	2.7	17.48	1.008		
	54.20	**T23**	20.20	14.43	5.765	3.790	16.41	2.7	17.50	1.090		
	64.40	**T24**	20.00	14.38	5.618	3.643	16.36	2.7	17.30	0.943		
	74.70	**T25**	19.96	14.33	5.632	3.657	16.30	2.7	17.26	0.957		
	85.80	**T26**	19.98	14.27	5.711	3.736	16.24	2.7	17.28	1.036		
		T27	19.47									
	95.80	**T28**	20.00	14.22	5.783	3.808	16.19	2.7	17.30	1.108		
	104.50	**T29**	20.00	14.17	5.829	3.854	16.15	2.7	17.30	1.154		
BH#4			19.51					3.1	16.41			
	117.00	**T30**	20.00	14.11	5.894	3.919	16.08	2.7	17.30	1.219		
		T31	20.15									
1|29	125.00		20.16	14.064	6.099	4.124	16.04		20.16			

9.1.6 Given the estimated vertical clearance between the top of the pipe and bottom of the secondary root plate (refer highlighted column) it is considered unlikely that there will be any conflict between micro-tunnelling operations and the root crowns of the subject trees.

9.1.7 It is understood that the joints between the pipe sections will be sealed with a banded steel joint and therefore will not permit any water ingress. As such, the pipeline should not result in any long term impact on the water table (such as localised draw down of the groundwater table) and therefore the pipeline should not result in any impact on the health of the trees from the perspective of altering the water table in the long term. Some short term draw down may occur during the construction phase.

9.1.8 The open excavations associated with the proposed works will necessitate the removal of nine (9) trees of moderate retention value. These include Tree No.s T3 & T31 (Bullbay Magnolia), T4 (Port Jackson Fig) and T32, T35, T56, T37, T37 & T39 (all Broad-leaved Paperbarks). None of these trees are considered significant, but with exception of T32, all of the trees are in good health and condition and all of the trees make a fair contribution to the amenity of the streetscape. Whilst T32 has some value as a contributory item as noted in the SLEP, this tree has a large wound from a previous branch failure that has resulted in loss of about 35% of the crown. The removal of these trees to accommodate the development is considered warranted in this instance. In order to compensate for loss of amenity resulting from the removal of these trees, new trees should be planted in appropriate areas in accordance with Section 11.

9.1.9 The proposed receiving pit (1/28) is currently located within the TPZ’s of T15 (Lemon-scented Gum) and T16 (Spotted Gum). The extent of encroachment to the TPZ of T15 (assuming vertical sheet piling on the around the edge of the pit) is less than 10% of the TPZ, which is considered within acceptable limits under AS 4970:2009. The encroachment to the TPZ of T16 marginally exceeds acceptable limits (13%). Excavations for the pit have the potential to result in the severance and damage to woody roots of this tree, resulting in an adverse impact. In order to avoid any adverse impact, it is recommended that exploratory excavations be carried out within the footprint of the proposed pit, to a depth of at least 800mm below surface levels, to ascertain the presence of any woody roots. If any roots are encountered of greater than 40mm in diameter, a qualified arborist should make a further assessment to determine whether the tree can remain viable. If it is determined that the loss of any roots encountered will compromise the stability of the tree, consideration should be given to its removal.

9.1.10 Excavations for various other pits and pipelines are located within the TPZs of T2 (Broad-leaved Paperbark) [Pit 1/27], T8 & T9 (Port Jackson Figs) [Pits 6/1 & 6/2], T17 & T18 (Broadleaved Paperbarks) and T16 (Spotted Gum) [Pits 7/1 & 7/2] and T22 (Port Jackson Fig) [Pits 8/1 & 8/2]. In all instances the extent of the encroachment to the TPZs resulting from these excavations is relatively minor [less than 10% of the TPZ for all except T2 (13%)]. Provided that these excavations are undertaken with care in accordance with Section 10.7, these works will not result in any adverse impact on these trees.

9.1.11 Some minor canopy pruning of T2 (Broadleaved Paperbark) may be required to clear the entry/Jacking Pit to provide clearance for craning the pipe segments into place before jacking. This should not result in any adverse impact provided that all such pruning (that essential to clear the crane & rigging) is undertaken in accordance with Section 10.10.

9.1.12 No other trees will be adversely affected by the proposed development.

10 RECOMMENDED TREE PROTECTION MEASURES

10.1 Tree Protection Plan

10.1.1 The following Tree Protection Measures should be read in accordance with the Tree Protection Plan (**Appendix 6**). The Tree Protection Plan (TPP) indicates the position of tree protection devices and other recommended measures to ensure the protection of trees within the site to be retained as part of the proposed development.

10.2 Prohibited Activities

10.2.1 The following activities should be avoided within specified Tree Protection Zones (refer **Appendix 4 & 6** for extent of the TPZ for each tree):-

- Excavations and trenching (with exception of the approved remediation works, underground services, building foundations or pavement sub-grade);
- Soil disturbance, surface grading, compaction, tyning, ripping or cultivation of soil;
- Mechanical removal of vegetation, including extraction of tree stumps;
- Soil level changes including the placement of fill material (excluding imported validated fill for remediation works or placement of fill for approved works)
- Movement and storage of plant, equipment & vehicles (except within defined temporary haul roads, where ground protection has been installed, or within the footprint of existing floor slabs or paved areas);
- Erection of site sheds (except where approved by the site arborist);
- Affixing of signage, barricades or hoardings to trees;
- Storage of building materials, waste and waste receptacles;
- Stockpiling of spoil or fill;
- Stockpiling of bulk materials, such as soil, sand, gravel, roadbase or the like;
- Stockpiling of demolition waste;

- Disposal of waste materials and chemicals including paint, solvents, cement slurry, fuel, oil and other toxic liquids;
- Other physical damage to the trunk or root system; and
- Any other activity likely to cause damage to the tree.

10.3 Tree Protection Fencing

10.3.1 All trees within the site to be retained shall be protected prior to and during construction from all activities that may result in detrimental impact by erecting a suitable protective fence beneath the canopy to the full extent of the Tree Protection Zone, excluding the footprint of the proposed works and areas within adjoining properties, as indicated on the Tree Protection Plan. As a minimum, the fence should consist of temporary chain wire panels of 1.8 metres in height, supported by steel stakes as required and fastened together and supported to prevent sideways movement using corner braces where required (refer **Figure 4**). The fence shall be erected prior to the commencement of any work on-site and shall be maintained in good condition for the duration of construction. Where tree protection zones merge together a single fence encompassing the area is deemed to be adequate. Existing site boundary fences may form part of the enclosure.

10.3.2 Appropriate signage shall be installed on the fencing to prevent unauthorised movement of plant and equipment or entry to the Tree Protection Zone.

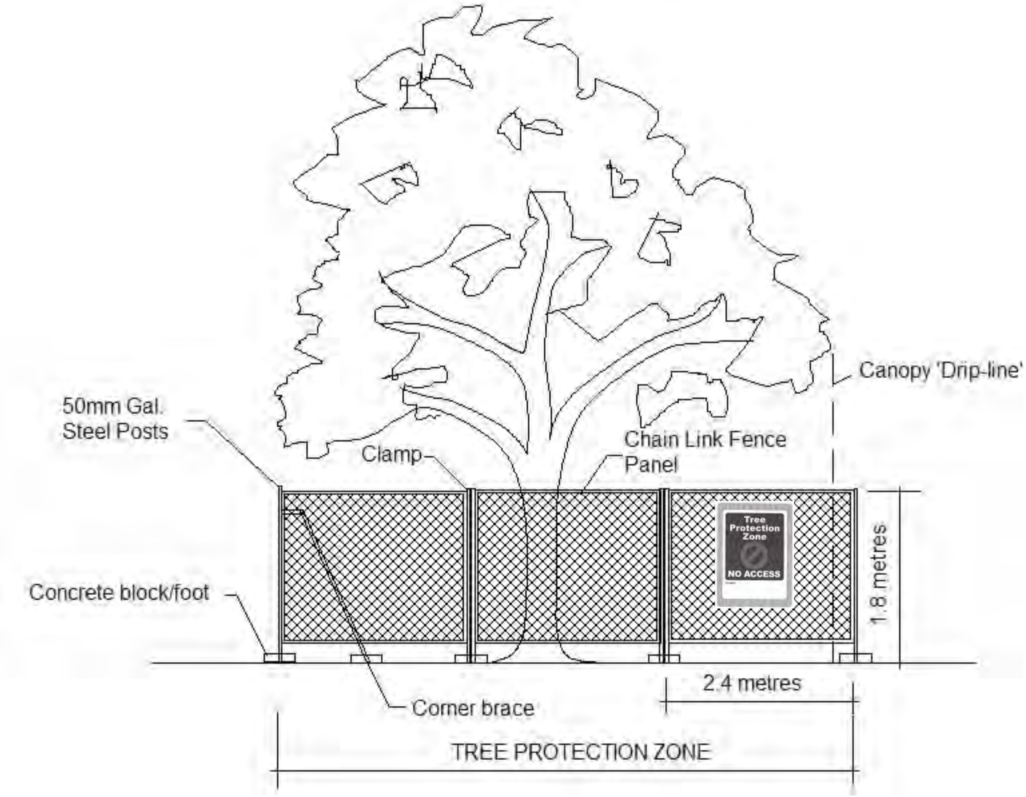

Figure 4 – Detail of Tree Protection Fence

10.4 Tree Protection Signs

10.4.1 Signs shall be installed on the Tree Protection Fence to prevent unauthorised movement of plant and equipment or entry to the Tree Protection Zone. The signs shall be securely attached to the fence using cable ties or equivalent. Signs shall be placed at minimum 10 metre intervals. The wording and layout of the sign shall comply with AS 4970-2009 as shown in **Figure 5**.

Figure 5 – Detail of Tree Protection Sign

10.5 Trunk Protection

10.5.1 Where provision of tree protection fencing is in impractical due to its proximity to the proposed building footprint, trunk protection shall be erected around nominated trees to avoid accidental damage, as indicated on the Tree Protection Plan (**Appendix 6**). The trunk protection shall consist of a layer of carpet underfelt (or similar) wrapped around the trunk, followed by 1.8 metre lengths of softwood timbers (90 x 45mm in section) aligned vertically and spaced evenly around the trunk at 150mm centres (i.e. with a 50mm gap) and secured together with 2mm galvanised wire or galvanised hoop strap as shown in **Figure 6**. Recycled timber (such as demolition waste) may be suitable for this purpose, subject to the approval of the Project Arborist. The timbers shall be wrapped around the trunk (over the carpet underfelt), but not fixed to the tree to avoid mechanical injury or damage to the trunk. Trunk protection should be installed prior to any site works and maintained in good condition for the duration of the construction period. Carpet underfelt (alone) is sufficient for trees with a trunk diameter of less than 200mm.

Figure 6 – Detail of Trunk Protection

10.6 Demolition Works within Tree Protection Zones

10.6.1 Demolition of paved areas within the Tree Protection Zones of trees to be retained shall be undertaken under the supervision of the Site Arborist. The pavement surface and sub-base within the TPZ shall be gradually removed in layers of no greater than 50mm thick using a small rubber tracked excavator or alternative approved method to avoid damage to underlying roots and minimise disturbance and compaction of the underlying soil profile. The machine shall work within the footprint of the existing paved surfaces to avoid compaction of the underlying soil. The final layer of sub-base material shall be removed using hand tools were required to avoid compaction of the underlying soil profile and damage to woody roots.

10.6.2 Following removal of the pavement surface and sub-base, clean, friable topsoil shall be used to fill in the excavated area and bring flush with surrounding levels within new landscape areas. Soil shall only be imported and spread when the underlying soil conditions are dry to avoid compaction of the soil profile. Where there is insufficient recovered site topsoil for this purpose, any imported material shall be free of rocks, vegetation, heavy clay or other extraneous matter. Any imported soil material should be similar in texture to the existing site topsoil.

10.6.3 Demolition of existing walls, kerbs and other structures within the Tree Protection Zone of trees to be retained shall be undertaken under the supervision of the Site Arborist. The structures shall be demolished using equipment on stationed outside the TPZ where possible or within the footprint of existing hardstand areas. Care shall be taken to avoid the root systems, trunks and lower branches of trees in the vicinity of the structures during demolition works, with special attention required during demolition of the footings and other sub-surface members to avoid damage to woody roots.

10.7 Excavations within Tree Protection Zones

10.7.1 Prior to any mechanical excavations for building foundations or pavement sub-grade within the Tree Protection Zone of all trees nominated for retention, exploratory excavation using non-destructive techniques shall be taken along the perimeter of the structure or pavement within the TPZ. Non-destructive excavation techniques may include the use of hand-held implements, air pressure (using an Air-spade® device) or water pressure. The exploratory excavation shall be undertaken along the perimeter of the foundation or pavement (within the TPZ) to the depth of the foundation or to a maximum of 800mm from surface levels, to locate and expose any woody roots prior to any mechanical excavation. All care shall be undertaken to preserve woody roots intact and undamaged during exploratory excavation. Any roots encountered of less than 50mm in diameter may be cleanly severed with clean sharp pruning implements at the face of the excavation. The root zone in the vicinity of the excavation shall be kept moist following excavation for the duration of construction to minimise moisture stress on the tree.

10.7.2 Where large woody roots (greater than 50mm diameter) are encountered during exploratory excavations, further advice from a qualified arborist shall be sought prior to severance. Where necessary, (to avoid severing large woody roots) consideration should be given to the installation of an elevated structure (e.g. pier and beam footing, suspended slab or floor supported on piers, cantilevered slab, up-turned edge beam etc) in preference to structures requiring a deep edge beam or continuous perimeter strip footing. The beam section of any pier and beam footing should be placed **above** grade to avoid excavation within the SRZ. Pier footings intersecting large woody roots should be slightly offset where necessary to avoid root severance.

10.7.3 For masonry walls or fences it may be acceptable to delete continuous concrete strip footings and replace with suspended in-fill panels (eg steel or timber pickets, lattice etc) fixed to pillars. For paved areas, consideration should be given to raising the proposed pavement level and using a porous fill material in preference to excavation where large woody roots are found within the sub-base.

10.8 Underground Services

10.8.1 All proposed stormwater lines and other underground services should be located outside TPZs of trees proposed to be retained wherever possible or installed by alternative measures. Alternative measures include suspending pipelines beneath the floor of a building or structure (to avoid excavation with the TPZ), non-destructive excavation methods or Horizontal Directional Drilling (HDD). Where the installation of service lines within TPZs is unavoidable, the pipelines or conduits should be installed as follows.

10.8.2 Where the extent of the incursion to the root zone is less than 10% of the TPZ including any excavations for benching and shoring the trench, the pipeline or conduit may be installed by open trenching using standard construction methods (excavator or trenching machine). 10% of the TPZ is equivalent to one-third of the TPZ radius on one side (refer to **Appendix 2**). Refer to **Appendix 4** for radial distances of TPZs for each tree.

10.8.3 Where the extent of the incursion to the root zone exceeds 10% of the TPZ, but is outside the SRZ, non-destructive excavation methods must be adopted in accordance with **Section 10.6**. Where large woody roots are encountered during excavation or trenching (root diameter greater than 50mm), these shall be retained intact wherever possible (e.g. by tunnelling beneath roots and inserting the pipeline or conduit beneath or re-routing the service etc). Where this is not practical and root pruning is the only alternative, proposed root pruning should be assessed by a qualified arborist [AQF 5] to evaluate the potential impact on the health and stability of the subject tree.

10.8.4 Excavations required for underground services within the Structural Root Zone of any tree to be retained should only be undertaken by sub-surface boring (Horizontal Directional Drilling). The Invert Level of the pipe, plus the pipe diameter, must be lower than the estimated root zone depth as specified. At this site any secondary root plate is likely to be located above the water table (varying between RL 17.2 & 17.60).

10.9 Pavements

10.9.1 Pavements should be avoided within the Tree Protection Zone of trees to be retained where possible. Proposed paved areas within the Tree Protection Zone of trees to be retained should be placed above grade to minimise excavations within the root zone and avoid root severance and damage. Pavement sub-base material should be as per **Section 10.10**.

10.10 Fill Material

10.10.1 Placement of fill material within the Tree Protection Zone of trees to be retained should be avoided wherever possible. Where placement of fill is unavoidable, the material should be a well-drained friable material, equivalent in texture to the existing site topsoil material. The fill should be free from rocks, vegetation and other extraneous material. The fill may be consolidated but should not be compacted to engineering standards. No fill material should be placed in direct contact with the trunk.

10.10.2 Where placement of fill is required for pavement sub-grade is required within TPZs of trees to be retained, a coarse, gap-graded material such as 20 – 50mm crushed basalt (Blue Metal) or equivalent shall be used to provide some aeration to the root zone. Note that Roadbase or crushed sandstone or other material containing a high percentage of fines is unacceptable for this purpose. The fill material should be consolidated with a non-vibrating roller to minimise compaction of the underlying soil. A permeable geotextile may be used beneath the sub-base to prevent migration of the stone into the sub-grade.

10.11 Canopy & Root Pruning

10.11.1 All canopy pruning work required shall be carried out in accordance with Australian Standard 4373-2007 – Pruning of Amenity Trees. Written approval from Council may be required under the Tree Preservation Order prior to undertaking this work. All pruning work shall be carried out by a qualified and experienced arborist or tree surgeon [Australian Qualification Framework Level 3] in accordance with the NSW WorkCover Code of Practice for the Amenity Tree Industry (1998). No branches of greater than 100mm in diameter should be removed or pruned without further advice from a Consulting Arborist [Australian Qualification Framework Level 5].

10.11.2 Where root pruning is required, roots shall be severed with clean, sharp pruning implements and retained in a moist condition during the construction phase using Hessian material or mulch where practical. Severed roots shall be treated with a suitable root growth hormone containing the active constituents Indol-3-yl-Butric Acid (IBA) and 1-Naphthylacetic Acid (NAA) to stimulate rapid regeneration of the root system.

10.12 Tree Damage

10.12.1 Care shall be taken when operating cranes, drilling rigs and similar equipment near trees to avoid damage to tree canopies (foliage and branches). Under no circumstances shall branches be torn-off by construction equipment. Where there is potential conflict between tree canopy and construction activities, the advice of the Site Arborist must be sought.

10.12.2 In the event of any tree becoming damaged for any reason during the construction period a consulting arborist [Australian Qualification Framework Level 5] shall be engaged to inspect and provide advice on any remedial action to minimise any adverse impact. Such remedial action shall be implemented as soon as practicable and certified by the arborist.

10.13 Tree Removal

10.13.1 The approval of City of Sydney Council shall be obtained prior to the removal or pruning of any tree protected under the Tree Preservation Order.

10.13.2 Tree removal work shall be carried out by an experienced tree surgeon in accordance with the NSW WorkCover Code of Practice for the Amenity Tree Industry (1998). Care shall be taken to avoid damage to other trees during the felling operation.

10.13.3 Stumps located within the TPZs of trees to be retained shall be grubbed-out where required using a mechanical stump grinder (or by hand where less than 150mm in diameter) without damage to the root system of other trees. Where trees to be removed are within the SRZ of any trees to be retained, consideration should be given to cutting the stump close to ground level and retaining the root crown intact. Stumps within the Tree Protection Zone of other trees to be retained shall **not** be pulled out using excavation equipment or similar.

10.14 Ground Protection

10.14.1 A 100mm layer of woodchip mulch shall be installed within designated areas of the Tree Protection Zone of nominated trees as indicated on the Tree Protection Plan (**Appendix 7**) to minimise compaction of the underlying soil profile during construction activity and haulage. A Geotextile fabric, such as Geotex® 'ST' Series manufactured by Synthetic Industries or an equivalent product, shall be installed beneath the mulch layer to minimise compaction to the underlying soil profile and limit migration of mulch into the underlying soil profile. Mulch shall be installed and spread by hand to avoid soil disturbance and compaction within the root zone. Ground protection shall be installed prior to any site works and maintained in good condition for the duration of the construction period. On completion of the works, ground protection shall be removed without damage or disturbance to the underlying soil profile.

11 REPLACEMENT PLANTING

11.1.1 In order to compensate for loss of amenity resulting from the removal of trees to accommodate the proposed development, a minimum number of one tree should be replanted (within an appropriate area) for every tree to be removed. The species should be selected in accordance with Council's Street Tree Masterplan.

Andrew Morton
EARTHSCAPE HORTICULTURAL SERVICES
24th March 2016

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Standards Australia, Sydney

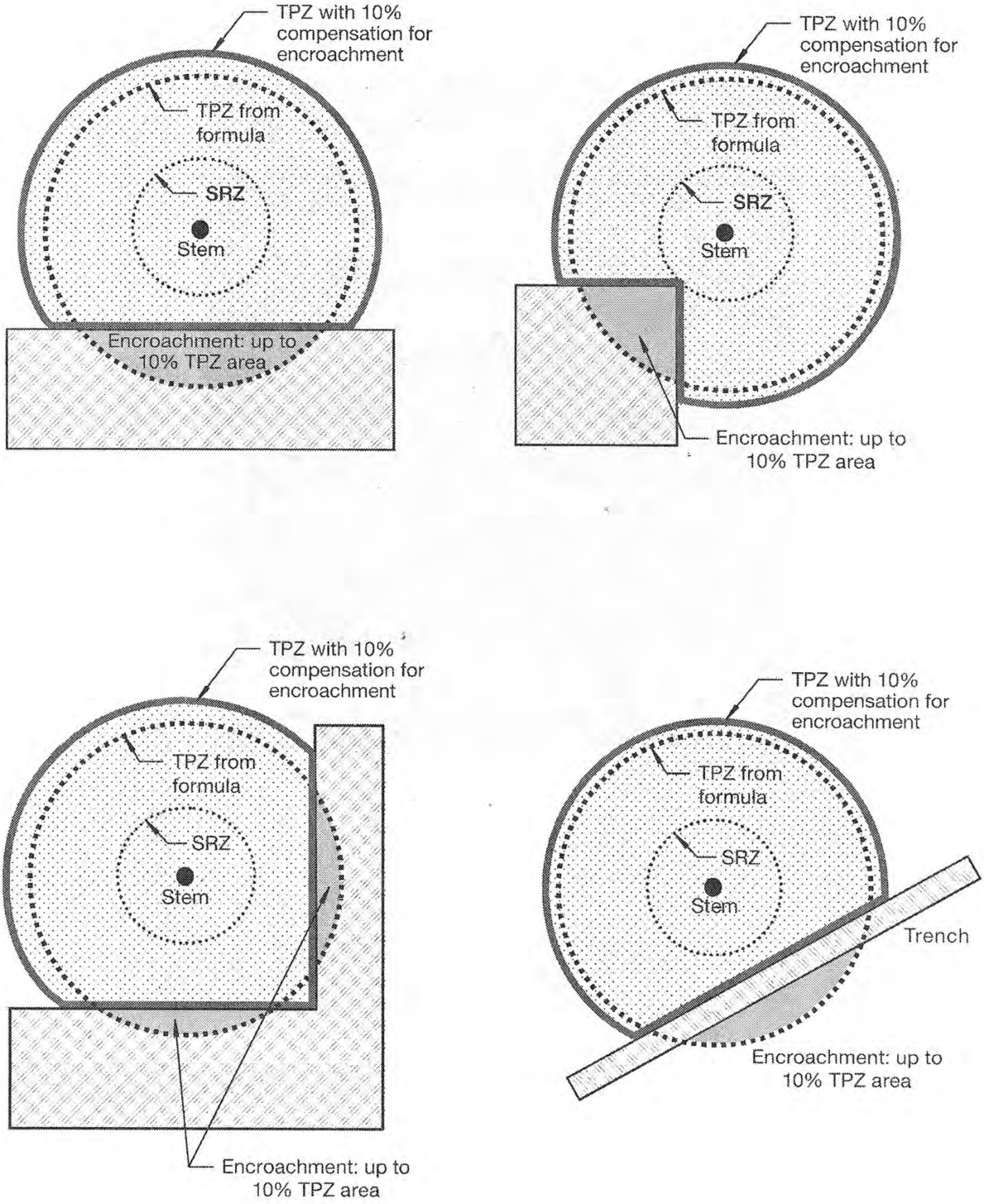
APPENDIX 1 - CRITERIA FOR ASSESSMENT OF LANDSCAPE SIGNIFICANCE

RATING	HERITAGE VALUE	ECOLOGICAL VALUE	AMENITY VALUE
1. SIGNIFICANT	The subject tree is listed as a Heritage Item under the Local Environment Plan (LEP) with a local, state or national level of significance or is listed on Council's Significant Tree Register	The subject tree is scheduled as a Threatened Species as defined under the Threatened Species Conservation Act 1995 (NSW) or the Environmental Protection and Biodiversity Conservation Act 1999	The subject tree has a very large live crown size exceeding 300m^2 with normal to dense foliage cover, is located in a visually prominent position in the landscape, exhibits very good form and habit typical of the species
	The subject tree forms part of the curtilage of a Heritage Item (building /structure /artefact as defined under the LEP) and has a known or documented association with that item	The tree is a locally indigenous species, representative of the original vegetation of the area and is known as an important food, shelter or nesting tree for endangered or threatened fauna species	The subject tree makes a significant contribution to the amenity and visual character of the area by creating a sense of place or creating a sense of identity
	The subject tree is a Commemorative Planting having been planted by an important historical person (s) or to commemorate an important historical event	The subject tree is a Remnant Tree, being a tree in existence prior to development of the area	The tree is visually prominent in view from surrounding areas, being a landmark or visible from a considerable distance.
2. VERY HIGH	The tree has a strong historical association with a heritage item (building/structure/artefact/garden etc) within or adjacent the property and/or exemplifies a particular era or style of landscape design associated with the original development of the site.	The tree is a locally-indigenous species, representative of the original vegetation of the area and is a dominant or associated canopy species of an Endangered Ecological Community (EEC) formerly occurring in the area occupied by the site.	The subject tree has a very large live crown size exceeding 200m^2; a crown density exceeding 70% (normal-dense), is a very good representative of the species in terms of its form and branching habit or is aesthetically distinctive and makes a positive contribution to the visual character and the amenity of the area
3. HIGH	The tree has a suspected historical association with a heritage item or landscape supported by anecdotal or visual evidence	The tree is a locally-indigenous species and representative of the original vegetation of the area and the tree is located within a defined Vegetation Link / Wildlife Corridor or has known wildlife habitat value	The subject tree has a large live crown size exceeding 100m^2; The tree is a good representative of the species in terms of its form and branching habit with minor deviations from normal (e.g. crown distortion/suppression) with a crown density of at least 70% (normal); The subject tree is visible from the street and surrounding properties and makes a positive contribution to the visual character and the amenity of the area
4. MODERATE	The tree has no known or suspected historical association, but does not detract or diminish the value of the item and is sympathetic to the original era of planting.	The subject tree is a non-local native or exotic species that is protected under the provisions of this DCP.	The subject tree has a medium live crown size exceeding 40m^2;The tree is a fair representative of the species, exhibiting moderate deviations from typical form (distortion/suppression etc) with a crown density of more than 50% (thinning to normal); and
			The tree is visible from surrounding properties, but is not visually prominent – view may be partially obscured by other vegetation or built forms. The tree makes a fair contribution to the visual character and amenity of the area.
5. LOW	The subject tree detracts from heritage values or diminishes the value of a heritage item	The subject tree is scheduled as exempt (not protected) under the provisions of this DCP due to its species, nuisance or position relative to buildings or other structures.	The subject tree has a small live crown size of less than 40m^2 and can be replaced within the short term (5-10 years) with new tree planting
6. VERY LOW	The subject tree is causing significant damage to a heritage Item.	The subject tree is listed as an Environment Weed Species in the relevant Local Government Area, being invasive, or is a known nuisance species.	The subject tree is not visible from surrounding properties (visibility obscured) and makes a negligible contribution or has a negative impact on the amenity and visual character of the area. The tree is a poor representative of the species, showing significant deviations from the typical form and branching habit with a crown density of less than 50% (sparse).
7. INSIGNIFICANT	The tree is completely dead and has no visible habitat value	The tree is a declared Noxious Weed under the Noxious Weeds Act (NSW) 1993 within the relevant Local Government Area.	The tree is completely dead and represents a potential hazard.

Ref:- Morton, A (2006) **Determining the Retention Value of Trees on Development Sites**

TreeNet - Proceedings of the 7th National Street Tree Symposium 2006 Government of South Australia Department for Transport, Energy and Infrastructure

APPENDIX 2 – ACCEPTABLE INCURSIONS TO THE TREE PROTECTION ZONE (TPZ)



NOTE: Less than 10% TPZ area and outside SRZ. Any loss of TPZ compensated for elsewhere.

REF:- Council of Standards Australia (August 2009)
AS 4970 – 2009 – Protection of Trees on Development Sites
Standards Australia, Sydney

APPENDIX 3 - TREE HEALTH AND CONDITION ASSESSMENT SCHEDULE

Tree Identification No.	Species	Height (m)	Spread (m)	Trunk Diameter (mm)	Live Crown Size (m^2)	Maturity Class	Condition	Previous Pruning	Health		Remaining Safe Useful Life Expectancy (SULE)	Landscape Significance Rating	Retention Value	Location
									Vigour	Pest & Disease				
1	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	13	12	800	132	M	Appears stable with fair branching structure. Exhibits multiple low bark inclusions at 2-3 metres at junctions of primary limbs.	Selectively pruned	Very Good	No Evidence	Long - more than 40 years	2	**High**	Nature strip
2	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	14	11	750	121	M	Appears stable with fair branching structure. Exhibits multiple low bark inclusions at 2-3 metres at junctions of primary limbs.	Selectively pruned	Very Good	No Evidence	Long - more than 40 years	2	**High**	Nature strip
3	***Magnolia grandiflora*** (Bullbay Magnolia)	6	5.5	204	22	SM	Appears stable with sound branching structure.	Crown lifted to 2 metres	Good	No Evidence	Long - more than 40 years	5	**Moderate**	Nature strip
4	***Ficus rubiginosa*** (Port Jackson Fig)	7	10	306	55	SM	Appears stable with sound branching structure. Exhibits multiple small wounds due branch loss at 3 metres (tertiary branches 50-80mm diameter).	No Evidence	Very Good	No Evidence	Long - more than 40 years	4	**Moderate**	Nature strip
5	***Ficus rubiginosa*** (Port Jackson Fig)	7	8	255	44	SM	Appears stable with sound branching structure.	Selectivel pruned	Very Good	No Evidence	Long - more than 40 years	4	**Moderate**	Nature strip
6	***Ficus rubiginosa*** (Port Jackson Fig)	17	16	1220	240	M	Appears stable with sound branching structure. Exhibits a small wound on west side at 6 metres due previous branch loss with decay evident.	Selectively pruned over Joynton street	Good	No Evidence	Long - more than 40 years	1	**High**	Nature strip
7	***Ficus rubiginosa*** (Port Jackson Fig)	15	13	828	169	M	Appears stable with fair branching structure. Crown suppressed on north side due to crowding. Multiple moderate wounds east side at 6-8 metres due to previous pruning with decay evident. 5% deadwood and 5% epicormic growth.	Crown lifted to 2 metres. Selectively pruned.	Fair with slightly thinning crown	No Evidence	Medium 15-40 Years	1	**High**	Nature strip
8	***Ficus rubiginosa*** (Port Jackson Fig)	18	20	1045	300	M	Appears stable with sound branching structure. Exhibits a low bark inclusion at 3 metres at junction of primary limbs.	Crown lifted to 6 metres. Selectively pruned and deadwooded	Fair with slightly thinning crown	No Evidence	Long - more than 40 years	1	**High**	Nature strip

APPENDIX 3 - TREE HEALTH AND CONDITION ASSESSMENT SCHEDULE

Tree Identification No.	Species	Height (m)	Spread (m)	Trunk Diameter (mm)	Live Crown Size (m^2)	Maturity Class	Condition	Previous Pruning	Health		Remaining Safe Useful Life Expectancy (SULE)	Landscape Significance Rating	Retention Value	Location
									Vigour	Pest & Disease				
9	***Ficus rubiginosa*** (Port Jackson Fig)	18	25	1006	325	M	Appears stable with fair branching structure. Exhibits multiple moderate bark inclusiond at 2-3 metres. Multiple small wounds at 5-6 metres with decay evident (branch collars/stubs).	Selectively pruned.	Fair with slightly thinning crown	No Evidence	Long - more than 40 years	1	**High**	Nature strip
10	***Ficus rubiginosa*** (Port Jackson Fig)	18	25	1217	350	M	Appears stable with fair branching structure. Crown suppressed on the north side due to crowding. Multiple small wounds due previous pruning with minor decay evident (branch collars/stubs).	Selectively pruned.	Fair with slightly thinning crown	No Evidence	Long - more than 40 years	1	**High**	Nature strip
11	***Ficus rubiginosa*** (Port Jackson Fig)	18	23	860	345	M	Appears stable with fair branching structure. Crown suppressed on the north side due to overshadowing. Exhibits a high bark inclusion at 5 metres. Multiple small wounds due previous pruning with minor decay evident (branch collars/stubs).	Selectively pruned	Fair with slightly thinning crown	No Evidence	Long - more than 40 years	1	**High**	Nature strip
12	***Ficus rubiginosa*** (Port Jackson Fig)	17	24	885	336	M	Appears stable with sound branching structure. Exhibits a prominent lean to the north (self corrected). Crown suppressed on the south & north side due to crowding. Large wound on lower trunk (GL-1.2 metres)	Selectively pruned	Fair with slightly thinning crown	No Evidence	Long - more than 40 years	1	**High**	Nature strip
13	***Ficus rubiginosa*** (Port Jackson Fig)	18	26	1538	364	M	Appears stable with sound branching structure. Exhibits multiple small wounds on lower trunk at GL (cambial dieback). Moderate dieback in upper crown.	Selectively pruned	Fair with thinning crown	Suspected Root Rot disease	Short 5-15 Years	1	**High**	Nature strip
14	***Corymbia citriodora*** (Lemon-scented Gum)	13	6	207	42	SM	Appears stable with fair branching structure. Exhibits a prominent lean to the south. Crown suppressed on the NW side due to overshadowing. Multiple moderate wounds at 3 metres due vehicle damage.	No Evidence	Very Good	No Evidence	Medium 15-40 Years	4	**Moderate**	Nature strip
15	***Corymbia citriodora*** (Lemon-scented Gum)	11	11	312	88	SM	Appears stable with sound branching structure.	Selectively pruned	Very Good	No Evidence	Long - more than 40 years	4	**Moderate**	Nature strip
16	***Corymbia maculata*** (Spotted Gum)	18	13	487	143	M	Appears stable with sound branching structure. Prominent lean to the north.	Selectively pruned & deadwooded	Very Good	No Evidence	Long - more than 40 years	3	**High**	Nature strip

APPENDIX 3 - TREE HEALTH AND CONDITION ASSESSMENT SCHEDULE

Tree Identification No.	Species	Height (m)	Spread (m)	Trunk Diameter (mm)	Live Crown Size (m^2)	Maturity Class	Condition	Previous Pruning	Health		Remaining Safe Useful Life Expectancy (SULE)	Landscape Significance Rating	Retention Value	Location
									Vigour	Pest & Disease				
17	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	13	9	768	99	M	Appears stable with fair branching structure. Exhibits multiple moderate bark inclusions at 2-3 metres.	Selectively pruned	Good	No Evidence	Long - more than 40 years	2	**High**	Nature strip
18	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	15	14	828	154	M	Appears stable with fair branching structure. Exhibits a prominent lean to the west.	Selectively pruned	Good	No Evidence	Long - more than 40 years	2	**High**	Nature strip
19	***Corymbia citriodora*** (Lemon-scented Gum)	23	15	589	255	M	Appears stable with sound branching structure.	Selectively pruned & deadwooded	Very Good	No Evidence	Long - more than 40 years	3	**High**	Nature strip
20	***Corymbia citriodora*** (Lemon-scented Gum)	20	13	452	130	M	Appears stable with sound branching structure. Crown suppressed on the north side due to crowding. Multiple small basal wounds & cambial dieback	Selectively pruned & deadwooded	Good	No Evidence	Long - more than 40 years	4	**Moderate**	Nature strip
21	***Lophostemon confertus*** (Brushbox)	2.5	1	40	2.5	I	Appears stable with sound branching structure. New planting.	No Evidence	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Nature strip
22	***Ficus rubiginosa*** (Port Jackson Fig)	15	20	1105	260	M	Appears stable with fair branching structure. Co-dominant primary limbs at 3 metres. Substantial dieback with 30% deadwood and 30% epicormic growth.	Selectively pruned	Poor with sparse crown	No Evidence	Short 5-15 Years	1	**High**	Nature strip
23	***Ficus rubiginosa*** (Port Jackson Fig)	5	7	258	35	I	Appears stable with sound branching structure. Multiple co-dominant primary limbs at 1.5 metres.	No Evidence	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Nature strip
24	***Ficus rubiginosa*** (Port Jackson Fig)	14	14	576	168	M	Appears stable with fair branching structure. Crown suppressed on NW side due to previous pruning. Multiple small wounds due previous pruning with decay evident (branch collars/stubs). Moderate dieback with 15% deadwood and 15% epicormic growth.	Selectively pruned	Fair with thinning crown	No Evidence	Short 5-15 Years	1	**High**	Nature strip
25	***Ficus rubiginosa*** (Port Jackson Fig)	16	17	879	246.5	M	Appears stable with sound branching structure. Exhibits a large axial wound at 5 to 7 metres due previous branch loss with decay and cavity evident.	Selectively pruned	Good	No Evidence	Long - more than 40 years	1	**High**	Nature strip

APPENDIX 3 - TREE HEALTH AND CONDITION ASSESSMENT SCHEDULE

Tree Identification No.	Species	Height (m)	Spread (m)	Trunk Diameter (mm)	Live Crown Size (m^2)	Maturity Class	Condition	Previous Pruning	Health		Remaining Safe Useful Life Expectancy (SULE)	Landscape Significance Rating	Retention Value	Location
									Vigour	Pest & Disease				
26	***Ficus rubiginosa*** (Port Jackson Fig)	15	20	975	260	M	Appears stable with sound branching structure. Multiple small wounds due previous pruning with decay evident (branch collars/stubs).	Selectively pruned	Fair with slightly thinning crown	No Evidence	Long - more than 40 years	1	**High**	Nature strip
27	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	14	9	704	108	M	Appears stable with fair branching structure. Exhibits a large wound at 1-2 metres due to branch loss.	Crown lifted to 3 metres	Very Good	No Evidence	Long - more than 40 years	2	**High**	Nature strip
28	***Ficus rubiginosa*** (Port Jackson Fig)	7	9	300	45	SM	Appears stable with sound branching structure.	Selectively pruned	Good	No Evidence	Long - more than 40 years	4	**Moderate**	Nature strip
29	***Ficus rubiginosa*** (Port Jackson Fig)	7	11	293	55	SM	Appears stable with sound branching structure.	Selectively pruned	Good	No Evidence	Long - more than 40 years	4	**Moderate**	Nature strip
30	***Ficus rubiginosa*** (Port Jackson Fig)	5	10	300	30	SM	Appears stable with sound branching structure.	Selectively pruned	Good	No Evidence	Long - more than 40 years	5	**Moderate**	Nature strip
31	***Magnolia grandiflora*** (Bullbay Magnolia)	4	3	80	9	I	Appears stable with sound branching structure.	No Evidence	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Nature strip
32	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	16	9	900	117	M	Appears stable with fair branching structure. Crown suppressed on the western side due to previous pruning. Exhibits a large wound at 1-2 metres due previous branch loss/pruning	Large primary limbs removed (remedial pruning following storm damage).	Good	No Evidence	Short 5-15 Years	2	**Moderate**	Nature strip
33	***Magnolia grandiflora*** (Bullbay Magnolia)	4	4	127	10	I	Appears stable with sound branching structure.	Crown lifted to 1.5 metres	Good	No Evidence	Long - more than 40 years	5	**Moderate**	Nature strip
34	***Magnolia grandiflora*** (Bullbay Magnolia)	4	3	111	7.5	I	Appears stable with sound branching structure.	Crown lifted to 1.5 metres	Fair with thinning crown	No Evidence	Medium 15-40 Years	5	**Low**	Nature strip
35	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	7	5	315	25	SM	Appears stable with fair branching structure. Exhibits a moderate bark inclusion at 2 metres.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve

APPENDIX 3 - TREE HEALTH AND CONDITION ASSESSMENT SCHEDULE

Tree Identification No.	Species	Height (m)	Spread (m)	Trunk Diameter (mm)	Live Crown Size (m^2)	Maturity Class	Condition	Previous Pruning	Health		Remaining Safe Useful Life Expectancy (SULE)	Landscape Significance Rating	Retention Value	Location
									Vigour	Pest & Disease				
36	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	8	6	274	36	SM	Appears stable with sound branching structure.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve
37	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	8	4	213	24	SM	Appears stable with fair branching structure. Exhibits a moderate bark inclusion at 2 metres.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve
38	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	8	5	258	30	SM	Appears stable with sound branching structure.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve
39	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	6	5	236	20	SM	Appears stable with sound branching structure.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve
40	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	9	5	325	35	SM	Appears stable with fair branching structure. Exhibits a moderate bark inclusion at 2 metres.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve
41	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	8	4	271	24	SM	Appears stable with sound branching structure.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve
42	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	8	4	239	24	SM	Appears stable with sound branching structure.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	5	**Moderate**	Reserve
43	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	14	10	850	115	M	Appears stable with fair branching structure. Exibits multiple moderate bark inclusions at 2-3 metres. Large wound at 1.5-2.5 metres due branch loss.	Selectively pruned	Good	No Evidence	Medium 15-40 Years	3	**Moderate**	Nature strip
44	***Eucalyptus grandis*** (Flooded Gum)	18	18	653	234	M	Appears stable with sound branching structure.	Crown lifted to 2 metres	Very Good	No Evidence	Long - more than 40 years	3	**High**	Nature strip

APPENDIX 3 - TREE HEALTH AND CONDITION ASSESSMENT SCHEDULE

Tree Identification No.	Species	Height (m)	Spread (m)	Trunk Diameter (mm)	Live Crown Size (m²)	Maturity Class	Condition	Previous Pruning	Health		Remaining Safe Useful Life Expectancy (SULE)	Landscape Significance Rating	Retention Value	Location
									Vigour	Pest & Disease				
45	***Robinia psuedoacacia* 'Frisia'** (Golden Robinia)	5	6	150	24	SM	Appears stable with fair branching structure. Exhibits multiple moderate bark inclusions at 1.5 metres.	No Evidence	Very Good	No Evidence	Medium 15-40 Years	5	**Low**	Reserve
46	***Robinia psuedoacacia* 'Frisia'** (Golden Robinia)	5	5	150	20	SM	Appears stable with fair branching structure. Exhibits multiple moderate bark inclusions at 1.5 metres.	No Evidence	Very Good	No Evidence	Medium 15-40 Years	5	**Low**	Reserve

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m²)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
1	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	7.2	3.0	162.8	No proposed works within TPZ	No adverse impact	To be retained - no special tree protection measures required.
2	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	6.8	2.9	143.1	Proposed new pipelines & Junction Pit (1/27) and jacking pit offset 4.0 metres east at IL 16.64 (4.4 metres below grade). Excavations for pit within SRZ/TPZ. Encroachment to TPZ = 13%. Minor canopy pruning may be required in the eastern portion of the crown over the entry pit to permit lowering of RCPs into the pit	Extent of encroachment to root zone (from pit) marginally exceeds acceptable limits underAS 4970:2009. No adverse impact provided that all excavations for junction/entry pit are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for junction/entry pit in accordance with Section 10.7. Undertake any required canopy pruning (that essential to clear crane operation) in accordance with Section 10.11.
3	***Magnolia grandiflora*** (Bullbay Magnolia)	M	3.1	1.7	29.4	Located within footprint of proposed pipe diversion to clear Gross Pollutant Trap (GPT)	Proposed works will necessitate removal	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.
4	***Ficus rubiginosa*** (Port Jackson Fig)	M	5.0	2.0	78.5	Located within footprint of proposed Gross Pollutant Trap (GPT)	Proposed works will necessitate removal	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.
5	***Ficus rubiginosa*** (Port Jackson Fig)	M	4.0	1.9	50.2	Proposed 1.8mØ pipeline directly beneath trunk at ~ IL 15.60 (5.0 metres below grade) to be installed by HDD (3.26 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	To be retained - no special tree protection measures required.
6	***Ficus rubiginosa*** (Port Jackson Fig)	M	14.6	3.6	672.7	Proposed 1.8mØ pipeline offset 1.7 metres SE at ~ IL 15.44 (5.06 metres below grade) to be installed by HDD (3.1 metres cover). Water table est. RL 17.80, top of pipe est RL 17.40 (400mm clearance to WT). No conflict with tap root/secondary root crown.	No adverse impact	To be retained - no special tree protection measures required.

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m²)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
7	***Ficus rubiginosa*** (Port Jackson Fig)	M	9.9	3.1	310.0	Proposed 1.8mØ pipeline offset 1.5 metres SE at ~ IL 15.41 (5 metres below grade) to be installed by HDD (3 metres cover). Water table est. RL 17.71, top of pipe est RL 17.38 (325 mm clearance). No conflict with tap root/secondary root crown.	No adverse impact	To be retained - no special tree protection measures required.
8	***Ficus rubiginosa*** (Port Jackson Fig)	M	12.5	3.4	493.4	Proposed 1.8mØ pipeline offset 1.3 metres SE at ~ IL 15.29 (5.20 metres below grade) to be installed by HDD (3.2 metres cover). Water table est. RL 17.78, top of pipe est RL 17.265. (500mm clearance). No conflict with secondary root crown. Proposed 375mm ø pipeline offset 4.7 metres SW. Trenching for pipeline and excavations for junction pit (6/1 & 6/2) within TPZ. May result in some root severance/damage.	No adverse impact, provided excaavtions for 375mm pipe & associated pits 6/1 & 6/2 are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for pits 6/1 & 6/2 & 375mm pipeline within TPZ in accordance with Section 10.7.
9	***Ficus rubiginosa*** (Port Jackson Fig)	M	12.1	3.3	457.9	Proposed 1.8mØ pipeline offset 1.4 metres SE at ~ IL 15.23 (5.2 metres below grade) to be installed by HDD (3.2 metres cover). Water table est. RL 17.70, top of pipe est RL 17.2 (485mm clearance). No conflict with tap root/secondary root crown. Proposed 375mm ø pipeline offset 7 metres north. Trenching for pipeline and excavations for junction pit (6/1 & 6/2) within TPZ. Minor encroachment to root zone.	No adverse impact, provided excaavtions for 375mm pipe & associated pits 6/1 & 6/2 are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for pits 6/1 & 6/2 & 375mm pipeline within TPZ in accordance with Section 10.7.
10	***Ficus rubiginosa*** (Port Jackson Fig)	M	14.6	3.6	669.2	Proposed 1.8mØ pipeline offset 1.0 metres SE at ~ IL 15.20 (5.2 metres below grade) to be installed by HDD (3.20 metres cover). Water table est. RL 17.70, top of pipe est RL 17.2 (500mm clearance). No conflict with tap root/secondary root crown.	No adverse impact	To be retained - no special tree protection measures required.

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m²)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
11	***Ficus rubiginosa*** (Port Jackson Fig)	M	10.3	3.1	334.3	Proposed 1.8mØ pipeline offset 1.1 metres SE at ~ IL 15.17 (5.2 metres below grade) to be installed by HDD (3.2 metres cover). Water table est. RL 17.63, top of pipe est RL 17.1 (500mm clearance). No conflict with tap root/secondary root crown.	No adverse impact	To be retained - no special tree protection measures required.
12	***Ficus rubiginosa*** (Port Jackson Fig)	M	10.6	3.1	354.4	Proposed 1.8mØ pipeline offset 1.3 metres SE at ~ IL 15.12 (5.05 metres below grade) to be installed by HDD (3.1 metres cover). Water table est. RL 17.47, top of pipe est RL 17.1 (400mm clearance). No conflict with tap root/secondary root crown.	No adverse impact	To be retained - no special tree protection measures required.
13	***Ficus rubiginosa*** (Port Jackson Fig)	M	15.0	4.0	706.5	Proposed 1.8mØ pipeline offset 0.6 metres SE at IL 15.06 (5.0 metres below grade) to be installed by HDD (3.1 metres cover). Water table est. RL 17.40, top of pipe est RL 17.03 (350mm clearance). No conflict with tap root/secondary root crown.	No adverse impact	To be retained - no special tree protection measures required.
14	***Corymbia citriodora*** (Lemon-scented Gum)	P	3.1	1.7	30.3	No proposed works within TPZ	No adverse impact	To be retained - no special tree protection measures required.
15	***Corymbia citriodora*** (Lemon-scented Gum)	P	5.5	2.0	95.0	Proposed 1.8mØ pipeline directly beneath trunk at IL 14.9 (5.35 metres below grade) to be installed by HDD (3.4 metres cover). Water table est. RL 17.54, top of pipe est RL 16.9 (600mm clearance). No conflict with tap root/secondary root crown. Proposed junction pit (1/28) offset 3.4 metres south. Excavation for pit & shoring within TPZ. Encroachment to TPZ = 8%.	Extent of encroachment to root zone (from pits 1/28) is within acceptable limits underAS 4970:2009. No adverse impact provided that all excavations for junction pits are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for Junction Pits 1/28 in accordance with Section 10.7. Undertake exploratory excavation within footprint of pit prior to sheet piling within TPZ prior to piling to verify the presence of any large woody roots in accorance with Section 10.6.

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m^2)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
16	***Corymbia maculata*** (Spotted Gum)	P	7.3	2.4	167.7	Proposed 1.8mØ pipeline directly beneath trunk at IL 14.80 (5.3 metres below grade) to be installed by HDD (3.2 metres cover). Water table est. RL 17.40, top of pipe est RL 16.80 (600mm clearance). No conflict. Proposed junction pit (1/28) offset 2.9 metres NE. Excavation for pit & shoring within TPZ. Encroachment to TPZ = 13%.	Extent of encroachment to root zone (from pits 1/28) exceeds acceptable limits underAS 4970:2009. No adverse impact provided that all excavations for junction pits are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for Junction Pits 1/28 in accordance with Section 10.7. Undertake exploratory excavation within footprint of pit prior to sheet piling within TPZ prior to piling to verify the presence of any large woody roots in accorance with Section 10.6.
17	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	6.9	3.0	149.8	Proposed 1.8mØ pipeline offset 6.2 metres SE at ~ IL 14.80 (5.3 metres below grade) to be installed by HDD (3.2 metres cover). No actual incursion to root zone. Proposed 375mm ø pipeline offset 4.7 metres SW. Trenching for pipeline and excavations for junction pits (7/1 & 7/2) within TPZ. Encroachment to TPZ = 7%.	Extent of encroachment to root zone (from pits 7/1 - 7/2) is within acceptable limits underAS 4970:2009. No adverse impact provided that all excavations for junction pits are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for Junction Pits 7/1 & 7/2 in accordance with Section 10.7.
18	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	7.5	3.1	174.4	Proposed 1.8mØ pipeline offset 6.0 metres SE at ~ IL 14.80 (5.3 metres below grade) to be installed by HDD (3.2 metres cover). No actual incursion to root zone. Proposed 375mm ø pipeline offset 6.4 metres NE. Trenching for pipeline and excavations for junction pits (7/1 & 7/2) within TPZ. Encroachment to TPZ = 7%.	Extent of encroachment to root zone (from pits 7/1 - 7/2) is within acceptable limits underAS 4970:2009. No adverse impact provided that all excavations for junction pits are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for Junction Pits 7/1 & 7/2 in accordance with Section 10.7.
19	***Corymbia citriodora*** (Lemon-scented Gum)	P	7.5	2.7	176.6	Proposed 1.8mØ pipeline directly beneath trunk at IL 14.75 (5.4 metres below grade) to be installed by HDD (3.4 metres cover). Water table est. RL 17.47, top of pipe est RL 16.7 (800mm clearance). Conflict with tap root/secondary root crown unlikely.	No adverse impact	Retain in accordance with recommended Tree Protection Measures (Section 10).

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m²)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
20	***Corymbia citriodora*** (Lemon-scented Gum)	P	6.8	2.4	144.5	Proposed 1.8mØ pipeline directly beneath trunk at IL 14.73 (5.4 metres below grade) to be installed by HDD (3.4 metres cover). Water table est. RL 17.50, top of pipe est RL 16.70. Conflict with tap root/secondary root crown unlikely.	No adverse impact	Retain in accordance with recommended Tree Protection Measures (Section 10).
21	***Lophostemon confertus*** (Brushbox)	M	1.5	1.0	7.1	No proposed works within TPZ	No adverse impact	To be retained - no special tree protection measures required.
22	***Ficus rubiginosa*** (Port Jackson Fig)	M	13.3	3.5	552.2	Proposed 1.8mØ pipeline offset 1.0 metres SE at ~ IL 14.60 (5.5 metres below grade) to be installed by HDD (3.6 metres cover). Water table est. RL 17.48, top of pipe est RL 16.60 (900mm clearance). Conflict with taproot & secondary root crown unlikely. Proposed 375mm ø pipeline offset 4.6 metres north. Trenching for pipeline and excavations for junction pit (8/1 & 8/2) within TPZ. Minor encroachment to root zone.	Extent of encroachment to root zone (from pits 7/1 - 7/2) is within acceptable limits underAS 4970:2009. No adverse impact provided that all excavations for junction pits are undertaken as recommended.	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5. Undertake all excavations for Junction Pits 8/1 & 8/2 in accordance with Section 10.7.
23	***Ficus rubiginosa*** (Port Jackson Fig)	M	3.9	1.9	47.0	Proposed 1.8mØ pipeline directly beneath trunk at IL 14.56 (5.6 metres below grade) to be installed by HDD (3.7 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	To be retained - no special tree protection measures required.
24	***Ficus rubiginosa*** (Port Jackson Fig)	M	7.0	2.6	153.9	Proposed 1.8mØ pipeline offset 1.0 metres SE at ~ IL 14.51 (5.5 metres below grade) to be installed by HDD (3.5 metres cover). Water table est. RL 17.30, top of pipe est RL 16.50 (800mm clearance). Conflict with taproot & secondary root crown unlikely.	No adverse impact	To be retained - no special tree protection measures required.

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m²)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
25	***Ficus rubiginosa*** (Port Jackson Fig)	M	10.5	3.1	349.3	Proposed 1.8mØ pipeline offset 0.9 metres SE at ~ IL 14.45 (5.5 metres below grade) to be installed by HDD (3.5 metres cover). Water table est. RL 17.26, top of pipe est RL 16.40 (800mm clearance). Conflict with taproot & secondary root crown unlikely.	No adverse impact	To be retained - no special tree protection measures required.
26	***Ficus rubiginosa*** (Port Jackson Fig)	M	11.7	3.3	429.4	Proposed 1.8mØ pipeline offset 1.4 metres SE at ~ IL 14.4 (5.5 metres below grade) to be installed by HDD (3.6 metres cover). Water table est. RL 17.30, top of pipe est RL 16.40 Conflict with taproot & secondary root crown unlikely.	No adverse impact	To be retained - no special tree protection measures required.
27	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	6.3	2.9	126.0	No proposed works within TPZ	No adverse impact	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Trunk Protection in accordance with Section 10.5.
28	***Ficus rubiginosa*** (Port Jackson Fig)	M	4.5	2.0	63.6	Proposed 1.8mØ pipeline offset 0.7 metres NW at ~ IL 14.34 (5.6 metres below grade) to be installed by HDD (3.6 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	To be retained - no special tree protection measures required.
29	***Ficus rubiginosa*** (Port Jackson Fig)	M	5.5	2.0	95.0	Proposed 1.8mØ pipeline offset 0.6 metres NW at ~ IL 14.3 (5.7 metres below grade) to be installed by HDD (3.7 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	To be retained - no special tree protection measures required.
30	***Ficus rubiginosa*** (Port Jackson Fig)	M	5.0	2.0	78.5	Proposed 1.8mØ pipeline offset 0.7 metres NW at ~ IL 14.23 (5.7 metres below grade) to be installed by HDD (3.8 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	To be retained - no special tree protection measures required.

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

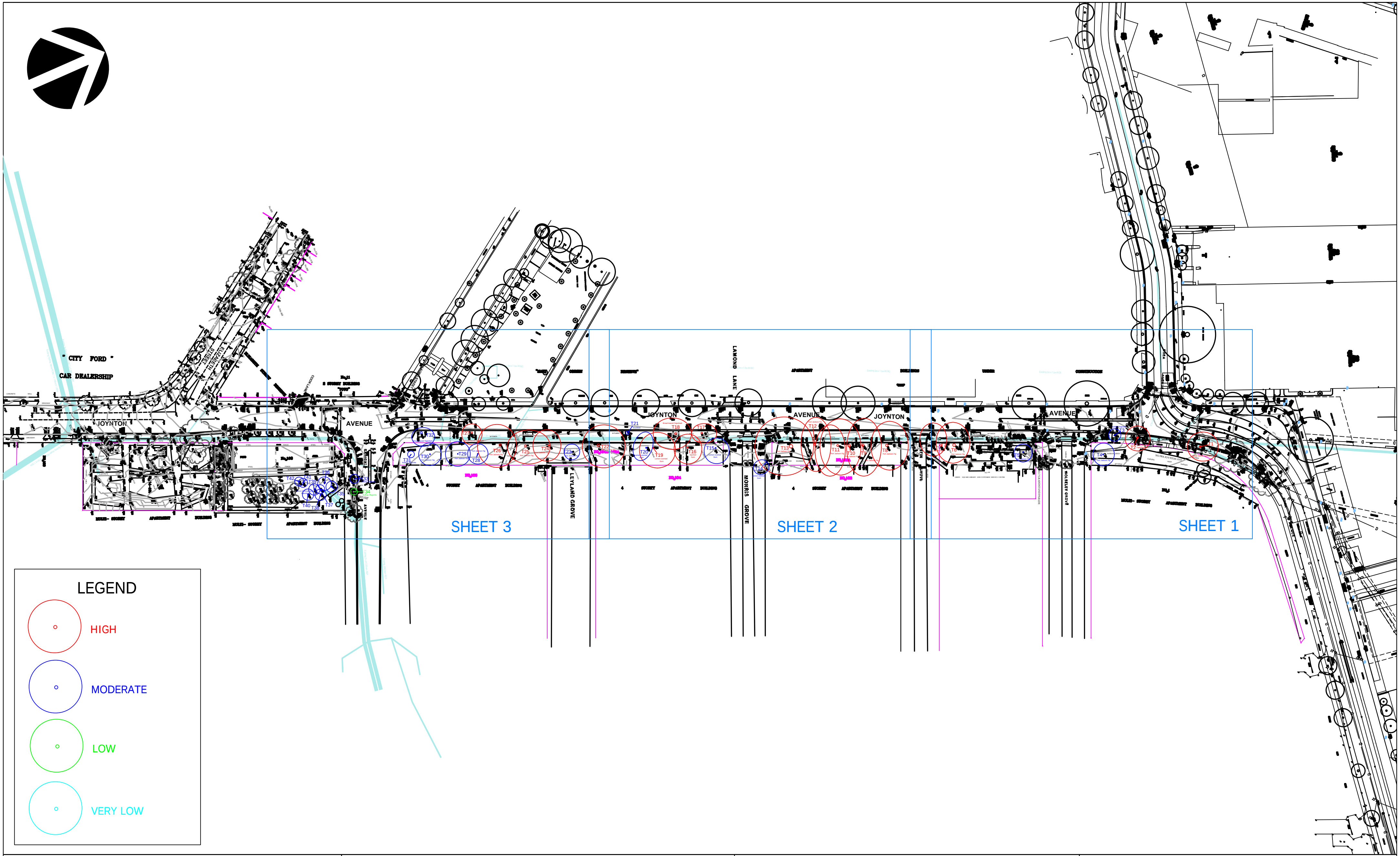
Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m²)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
31	***Magnolia grandiflora*** (Bullbay Magnolia)	M	1.5	1.1	7.1	Located within footprint of proposed junction pit (1/29) at IL 14.19 (5.9 metres below grade).	Excavations for Junction Pit are likely to result in severance and damage to woody roots, leading to demise.	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity or alternatively consider transplanting elsewhere within the site.
32	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	8.1	3.2	206.0	Proposed 1.8mØ pipeline offset 4.4 metres SW at IL ? (4.8 metres below grade) to be installed by HDD (3.0 metres cover). Potential for damage to secondary root crown & tap root. Proposed Junction Pit (3/1) offset 3.1 metres east at IL ? Proposed 1.35m ø pipe offset 2.1 metres east at IL? Proposed new 375mmØ pipe and junction pit (4/1) offset 2.4 metres SW at IL? Excavations and trenching for pipes and pits within SRZ/TPZ.	Proposed works will necessitate removal	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.
33	***Magnolia grandiflora*** (Bullbay Magnolia)	M	2.0	1.4	12.6	Proposed 1.8mØ pipeline offset 0.7 metres west at ~ IL 14.9 (4.2 metres below grade) to be installed by HDD (2.4 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	To be retained - no special tree protection measures required.
34	***Magnolia grandiflora*** (Bullbay Magnolia)	M	1.7	1.3	8.8	No proposed works within TPZ	No adverse impact	To be retained - no special tree protection measures required.
35	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	3.8	2.0	44.9	Located within footprint of proposed junction pit (1/30) at IL 13.95 (5.35 metres below grade).	Proposed works will necessitate removal	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.
36	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	3.3	1.9	33.9	Located within footprint of proposed junction pit (1/30) at IL 13.95 (5.35 metres below grade).	Proposed works will necessitate removal	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	Species	Construction Tolerance	Tree Protection Zone (m R)	Structural Root Zone (m R)	TPZ (m²)	Incursions To Root Zone &/or Canopy	Likely Impact	Recommendation
37	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	2.6	1.7	20.6	Located within footprint of proposed junction pit (1/30) at IL 13.95 (5.35 metres below grade).	Proposed works will necessitate removal	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.
38	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	3.1	1.9	30.1	Located within footprint of proposed junction pit (1/30) at IL 13.95 (5.35 metres below grade).	Extent of encroachment to to TPZ exceeds acceptable limits underAS 4970:2009. May result in an adverse impact.	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.
39	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	2.8	1.8	25.1	Located within footprint of proposed junction pit (1/30) at IL 13.95 (5.35 metres below grade).	Extent of encroachment to to TPZ exceeds acceptable limits underAS 4970:2009. May result in an adverse impact.	Remove tree. Undertake replacement planting elsewhere within the site to compensate for loss of amenity in accordance with Section 11.
40	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	3.9	2.1	47.7	Proposed 1.8mØ pipeline offset 2.0 metres NW at ~ IL 14.8 (4.5 metres below grade) to be installed by HDD (2.7 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Tree Protection Fence in accordance with Section 10.3.
41	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	3.2	1.9	33.1	Proposed 1.8mØ pipeline directly beneath trunk at IL 14.8 (4.5 metres below grade) to be installed by HDD (2.7 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Tree Protection Fence in accordance with Section 10.3.
42	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	2.9	1.8	25.8	Proposed 1.8mØ pipeline directly beneath trunk at IL 14.8 (4.5 metres below grade) to be installed by HDD (2.7 metres cover). No actual incursion to root zone (below root plate).	No adverse impact	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Tree Protection Fence in accordance with Section 10.3.
43	***Melaleuca quinquenervia*** (Broad-leaved Paperbark)	M	8.5	3.1	226.9	Proposed 1.8mØ pipeline directly beneath trunk to be installed by HDD (2.0 metres+ cover). No actual incursion to root zone (below root plate).	No adverse impact	Retain in accordance with recommended Tree Protection Measures (Section 10). Install Tree Protection Fence in accordance with Section 10.3.

APPENDIX 4 - IMPACT ASSESSMENT SCHEDULE

Tree Identification No.	**Species**	**Construction Tolerance**	**Tree Protection Zone (m R)**	**Structural Root Zone (m R)**	**TPZ (m²)**	**Incursions To Root Zone &/or Canopy**	**Likely Impact**	**Recommendation**
44	***Eucalyptus grandis*** (Flooded Gum)	M	9.8	2.8	301.1	Proposed 1.8mØ pipeline offset 4.7 metres east installed by HDD (2.0 metres+ cover). No actual incursion to root zone (below root plate). No actual incursion to root zone (below root plate).	No adverse impact	To be retained - no special tree protection measures required.
45	***Robinia psuedoacacia* 'Frisia'** (Golden Robinia)	M	3.0	1.5	28.3	No proposed works within TPZ	No adverse impact	To be retained - no special tree protection measures required.
46	***Robinia psuedoacacia* 'Frisia'** (Golden Robinia)	M	3.0	1.5	28.3	No proposed works within TPZ	No adverse impact	To be retained - no special tree protection measures required.



APPENDIX 5
TREE LOCATION PLAN SHOWING TREE RETENTION VALUES

Joynton Avenue, ZETLAND, NSW

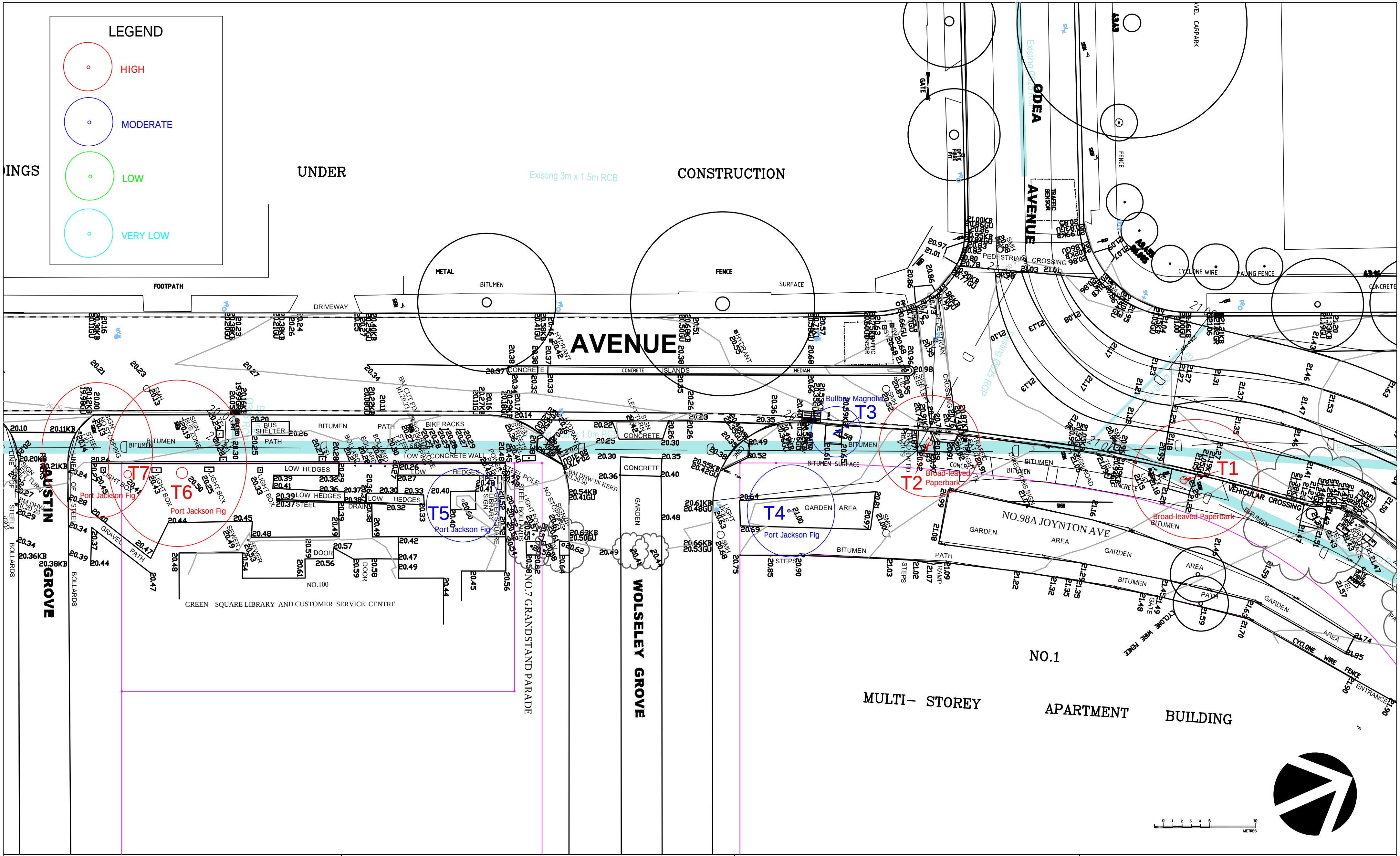
Earthscape Horticultural Services
Arboricultural and Horticultural Consultants
PO Box 364
BEROWRA NSW 2081
Ph: 02 9456 4787
Fax: 02 9456 5757 e: earthscape@iinet.net.au

Based on the Survey Drawing
prepared by City of Sydney ITO Survey Group
Dwg Ref No. S5-14/1175A
Dated 12/2014

DWG No. T15-073001

KEY PLAN

DATE: 30/07/2015



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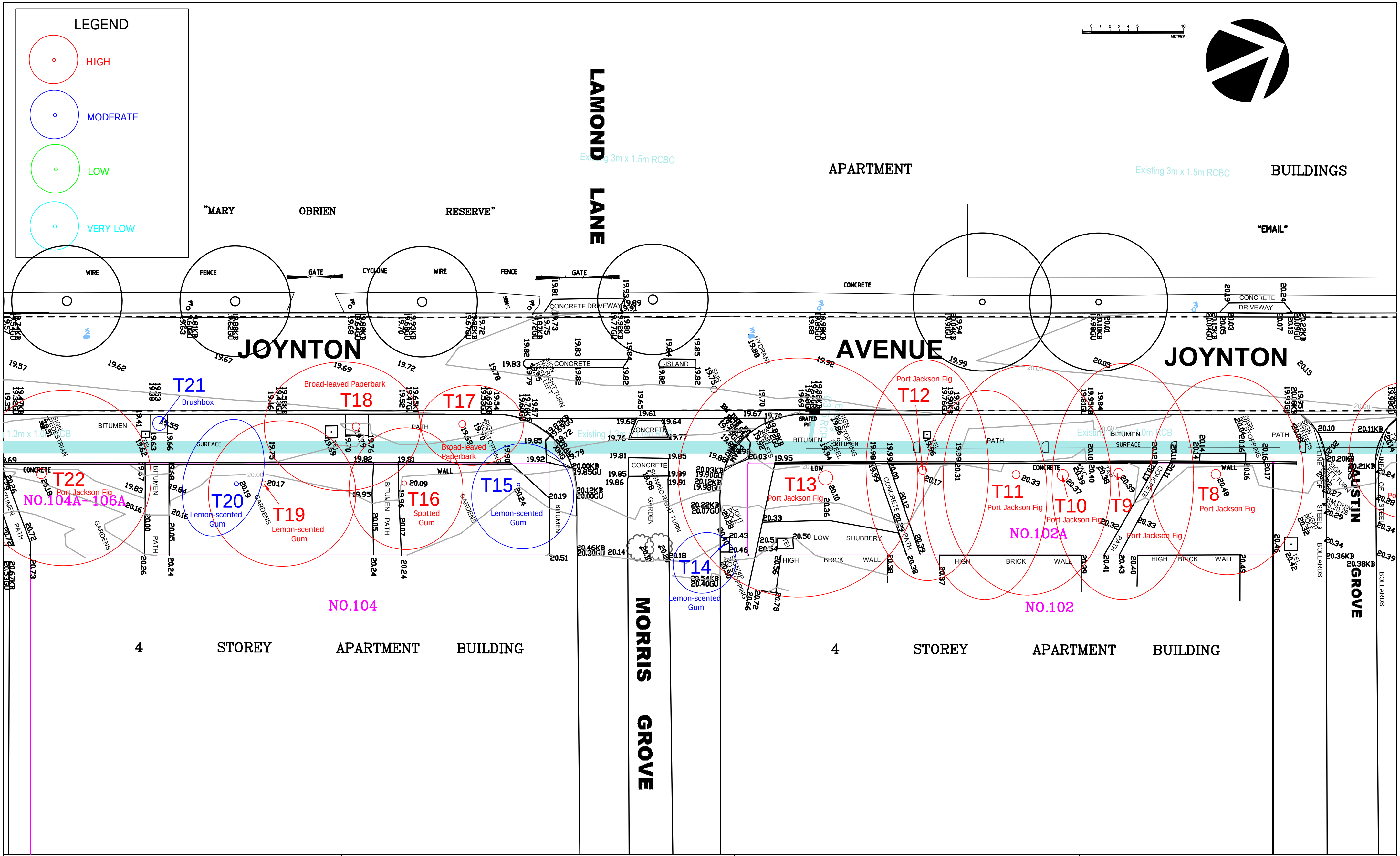

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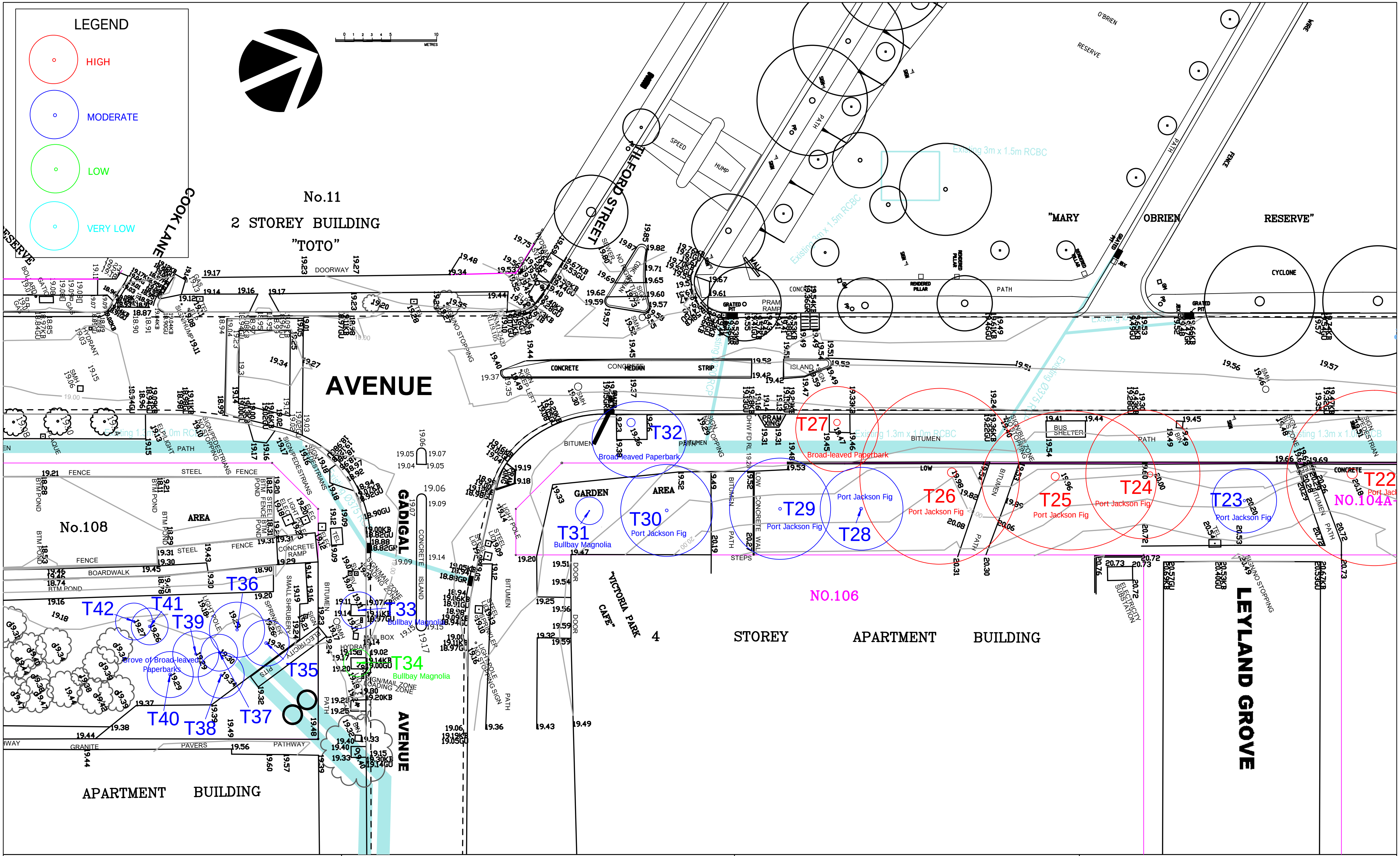
SHEET 2

DATE: 30/07/2015



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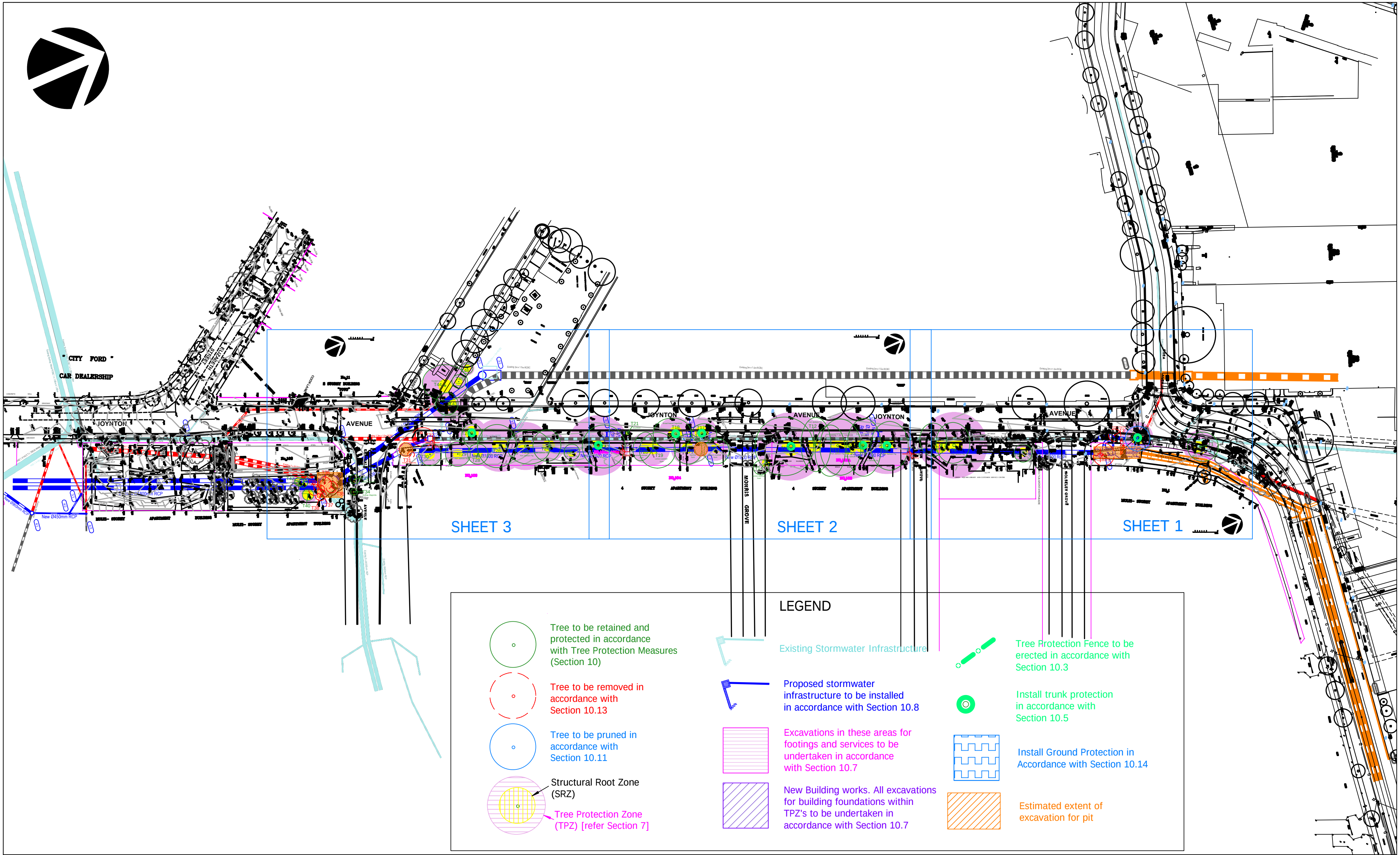
SHEET 3

DATE: 30/07/2015



LEGEND

Tree to be retained and protected in accordance with Tree Protection Measures (Section 10)

Tree to be removed in accordance with Section 10.13

Tree to be pruned in accordance with Section 10.11

Structural Root Zone (SRZ)

Tree Protection Zone (TPZ) [refer Section 7]

Existing Stormwater Infrastructure

Proposed stormwater infrastructure to be installed in accordance with Section 10.8

Excavations in these areas for footings and services to be undertaken in accordance with Section 10.7

New Building works. All excavations for building foundations within TPZ's to be undertaken in accordance with Section 10.7

Tree Protection Fence to be erected in accordance with Section 10.3

Install trunk protection in accordance with Section 10.5

Install Ground Protection in Accordance with Section 10.14

Estimated extent of excavation for pit

APPENDIX 6
TREE PROTECTION PLAN

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prepared by City of Sydney ITO Survey Group
Dwg Ref No. S5-14/1175A
Dated 12/2014

DWG No. T15-073002

KEY PLAN

DATE: 24/03/2016

LEGEND

- Tree to be retained and protected in accordance with Tree Protection Measures (Section 10)
- Tree to be removed in accordance with Section 10.13
- Tree to be pruned in accordance with Section 10.11
- Structural Root Zone (SRZ)
- Tree Protection Zone (TPZ) [refer Section 7]
- Existing Stormwater Infrastructure
- Proposed stormwater infrastructure to be installed in accordance with Section 10.8
- Excavations in these areas for footings and services to be undertaken in accordance with Section 10.7
- New Building works. All excavations for building foundations within TPZ's to be undertaken in accordance with Section 10.7
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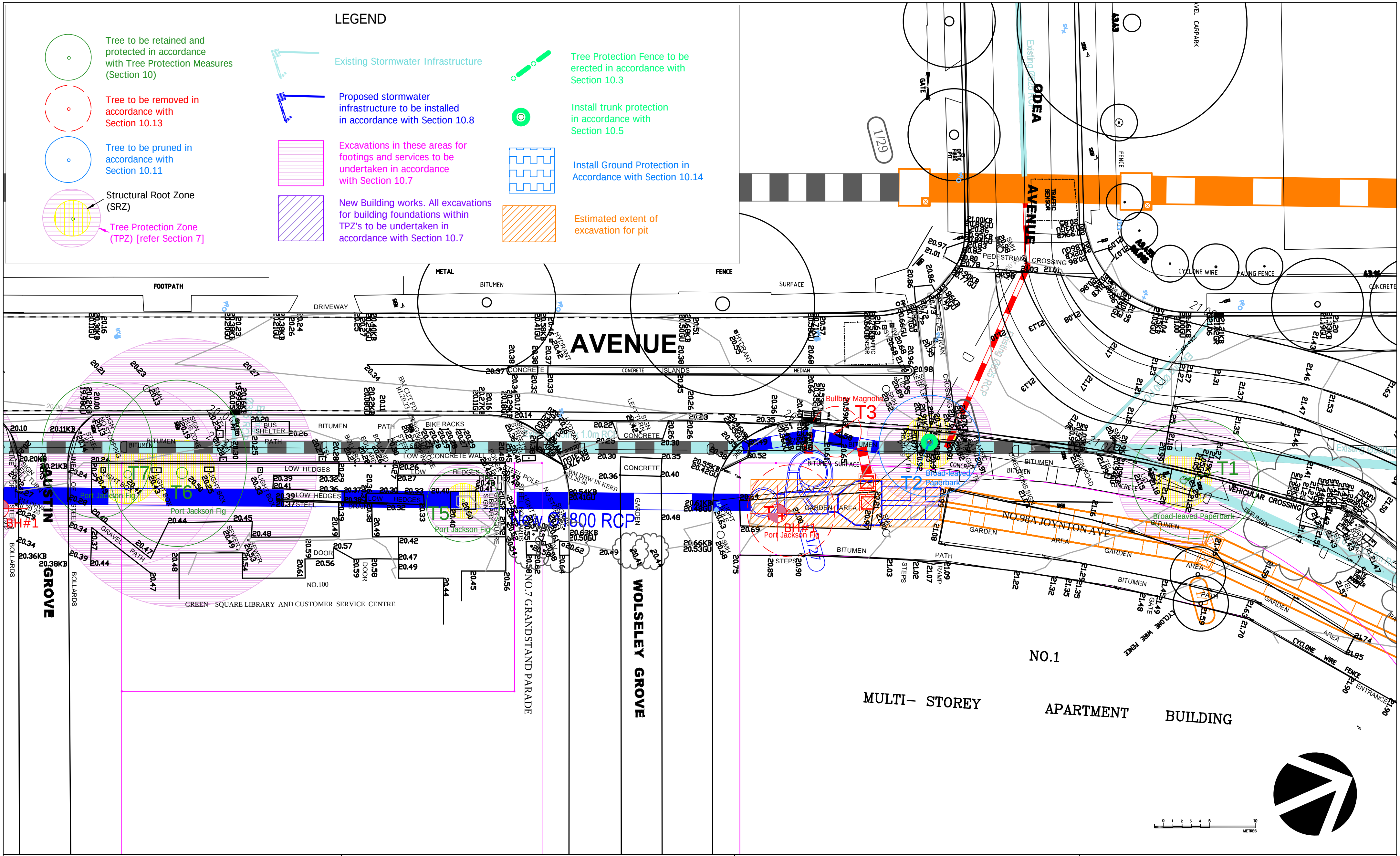
- Install Ground Protection in Accordance with Section 10.14
- Estimated extent of excavation for pit



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SHEET 1

DATE: 24/03/2016

LEGEND

○	Tree to be retained and protected in accordance with Tree Protection Measures (Section 10)
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	Existing Stormwater Infrastructure
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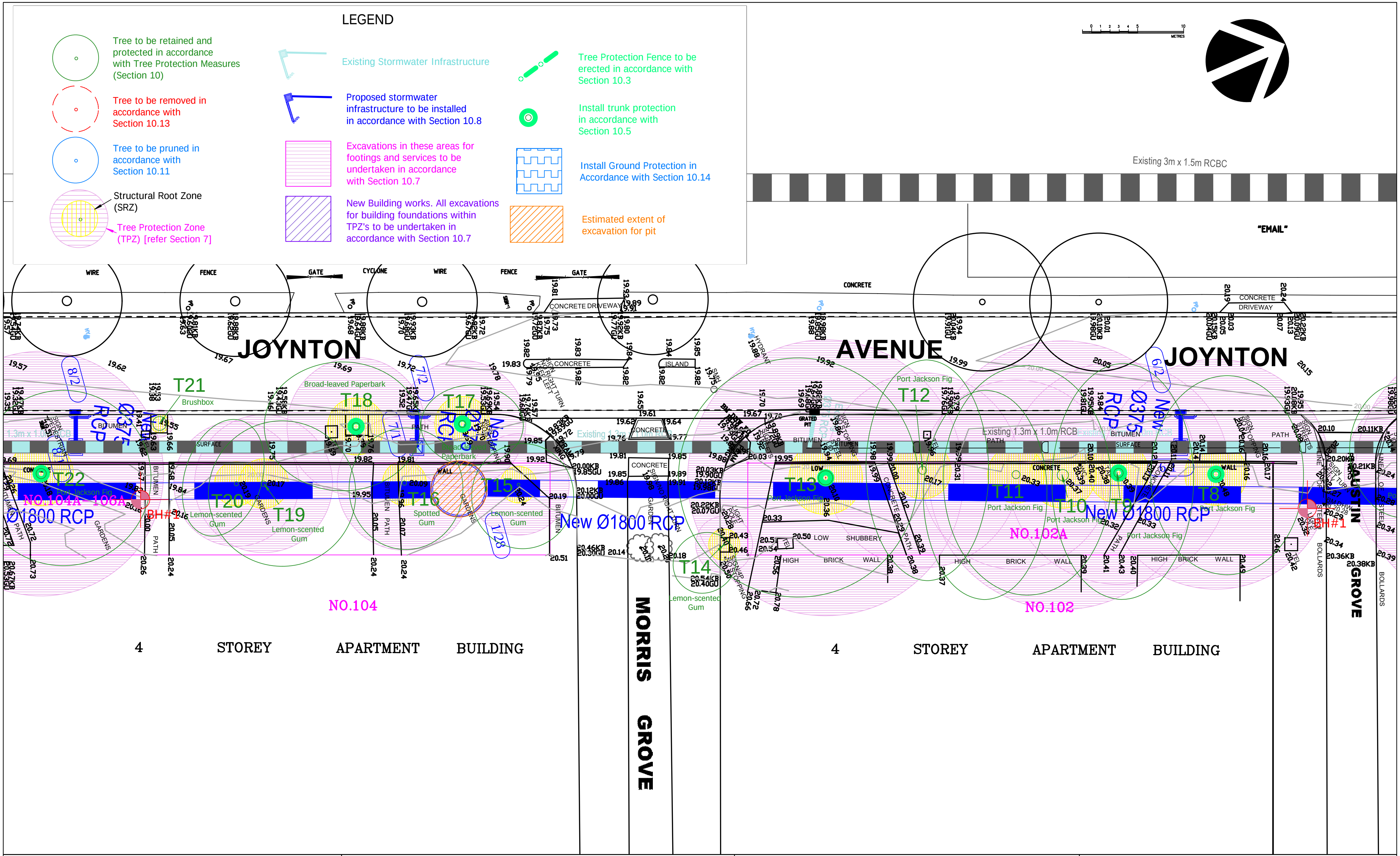
	Tree Protection Fence to be erected in accordance with Section 10.3
◎	Install trunk protection in accordance with Section 10.5
▦	Install Ground Protection in Accordance with Section 10.14
▨	Estimated extent of excavation for pit



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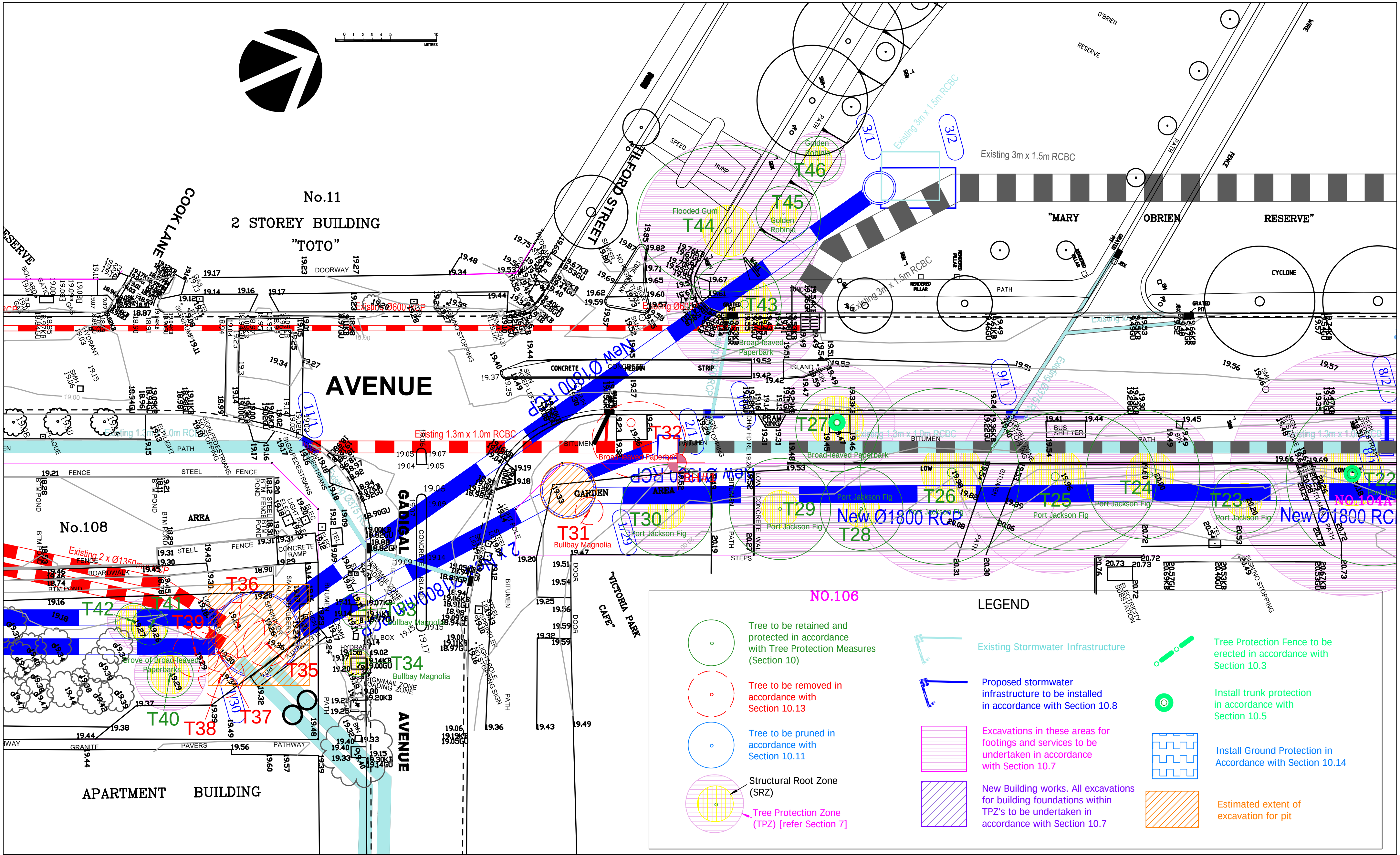

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Tree to be retained and protected in accordance with Tree Protection Measures (Section 10)

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SHEET 3

DATE: 24/03/2016

Appendix C GEOTECHNICAL AND CONTAMINATION INVESTIGATIONS

Douglas Partners
Geotechnics | Environment | Groundwater

Factual Report on Geotechnical Investigations

Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

Prepared for
City of Sydney Council

Project 85100.02
May 2018

Integrated Practical Solutions

Douglas Partners
Geotechnics | Environment | Groundwater

Document History

Document details

Project No.	85100.02	Document No.	R.001.Rev0
Document title	Factual Report on Geotechnical Investigations Joynton Avenue Stormwater Drainage Upgrade		
Site address	Joynton Avenue, Zetland		
Report prepared for	City of Sydney Council		
File name	85100.02.R.001.Rev0.docx		

Document status and review

Status	Prepared by	Reviewed by	Date issued
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Revision 0	Atha Kapitanof & Jeremy Hill	Fiona MacGregor	31 May 2018

Distribution of copies

Status	Electronic	Paper	Issued to
Draft A	1	-	Mr Edy Rustam, City of Sydney Council
Revision 0	1	-	Mr Edy Rustam, City of Sydney Council

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author	Jeremy Hill	31 May 2018
Reviewer	F MacGregor	31 May 2018

bsi. ISO 9001 Quality Management

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Table of Contents

Factual Report on Geotechnical Investigations
Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

1. Introduction

This factual report presents the results of geotechnical investigations undertaken by Douglas Partners Pty Ltd (DP) for the Joynton Avenue Stormwater Drainage Upgrade project at Joynton Avenue, Zetland. The investigations were undertaken for the City of Sydney Council.

It is understood that the Joynton Avenue Stormwater Drainage Upgrade project will provide stormwater relief for the local area and will serve as an important link between the up-gradient O'Dea Avenue Trunk Drain and the new Green Square Trunk Drain. An underbore is proposed for the installation of the proposed stormwater pipes.

The aim of the geotechnical investigations is to provide information on the ground profile and groundwater conditions along the alignment of the proposed underbore.

The investigations have been carried out in two stages. DP carried out the first stage of the investigations in October 2015 and the second stage of supplementary investigations in March 2018.

The scope of work and test locations for each of the investigation stages were nominated in briefs provided in the relevant Requests for Quotations prepared by the City of Sydney Council.

This factual report contains the results of both stages of the investigations.

2. Site Description

The alignment of the proposed underbore extends over about 470 m and is located along the eastern side of Joynton Avenue, Zetland, between O'Dea Avenue and Elizabeth Street ('the site'). In general, the ground surface levels along the proposed pipe alignment fall gently to the south-south-west at less than 1 degree.

The public roads along the proposed pipe alignment are generally paved with asphaltic concrete (AC) and there are various buildings located close to the route. There are also a number of large fig trees in the area.

3. Regional Geology and Hydrogeology

The site is situated within the Botany Basin and the regional geological maps suggest that it is underlain by fine and medium grained sands of marine origin. The sands were laid down in recent geological time as transgressive dune deposits over which freshwater swamps were formed, typical of those still existing at Centennial Park and Eastlakes. Within the swampy areas, peat soils typically were developed; although as a result of changes in topography associated with building and other development over the dunes, the swampy areas often were infilled with sand, effectively masking the presence of soft organic soils.

The published geology was confirmed by the investigations.

The Botany Sand Beds, Botany Basin, NSW Northern, Southern and Western Zones Status Report No.2 prepared by the former NSW Department of Land and Water Conservation (GWMA018, March 2000) provides an overview of the Botany sand beds. The report indicates that there are two groundwater systems operating in the region, one being a deeper confined aquifer system in the fractured Triassic bedrock and a shallower unconfined to semi-confined system which is present within the unconsolidated sediments of the Botany sand beds. The saturated portion of the Botany sand beds is known as the Botany Sands Aquifer.

The average saturated thickness of the Botany Sands Aquifer is reportedly 15 - 20 m. Hydraulic conductivity within the sand beds is highly variable and is typically around 20 m/day in clean sand. This value decreases to 5 - 10 m/day in silty or peaty sands and to less than 4 m/day in sandy peat or clay.

Groundwater flow directions are typically towards the main surface water systems (Botany Bay and Alexandra Canal being the closest to the site) with gradients variable but in the order 1 in 120. In a study of groundwater levels within the Botany Basin, Merrick (1994) reported variations of up to 2 m due to long-term seasonal, climatic, well pumping and other factors.

Water quality in the Botany Sand Aquifer is typically of low salinity (i.e. less than 150 µS/m) and pH varies between 4.3 and 8.9.

The area of the Botany Sand Aquifer, extending from Botany Bay to Surry Hills and Centennial Park, contains 32 monitoring bores operated by DPI Water (formerly the NSW Office of Water) and approximately 500 licensed bores. Extracted groundwater was once used for industrial and irrigation purposes, and is still used for irrigation at Randwick Racecourse and the University of New South Wales. The site and surrounding area is located within Zone 2 of the Botany Groundwater Management Zone where domestic groundwater use is banned.

Reference to the Acid Sulphate Soil Risk Map published by the former NSW Department of Land and Water Conservation indicates that the site is in an area of no known occurrence of acid sulphate soil conditions.

4. Field Work Methods

4.1 Scope of Investigations

The first stage of the investigation (October 2015) included the following:

- seven boreholes (BH1 to BH5, BH5A and BH5B),
- three cone penetration tests (CPT1 to CPT3),

- one dilatometer test (DMT1),
- the installation of three standpipe wells (in BH1, BH3 and BH5),
- groundwater monitoring, and
- laboratory testing of selected soil and groundwater samples.

The second stage of the investigation (March 2018) included the following:

- seven boreholes (BH101 to BH107),
- the installation of two additional standpipe monitoring wells (in BH103 and BH107),
- groundwater monitoring,
- a Ground Penetration Radar (GPR) survey, and
- laboratory testing of selected soil and groundwater samples.

The locations of the field work are shown on Drawings 1 to 3 in Appendix B.

4.2 General

Prior to commencing intrusive investigations the following works were undertaken:

- scanning and survey for buried services at all test locations using an electromagnetic scanner and ground penetrating radar (GPR), respectively, with reference to service plans obtained using the Dial-Before-You-Dig service and from the client;
- potholing for buried services using hand tools to depths of between 0.7 m and 1.5 m at all test locations;
- diatube coring through buried concrete where encountered.

The field work was supervised by geotechnical engineers who logged the strata and collected samples for laboratory testing. Where pavements were penetrated, the ground surface at each test location was repaired using coldmix at the completion of testing, except where standpipe wells were installed. At standpipe wells locations, a gatic cover was installed flush with the pavement surface to permit access to the wells.

The test locations were set out using a hand-held GPS receiver, and these locations are shown on Drawing No. 1 in Appendix B. Ground elevations at test locations were obtained either by levelling from temporary benchmarks located along the proposed pipe alignment or by interpolation between spot levels and level contours on the survey drawing provided by the client. The reduced levels of the temporary benchmarks were given as spot levels on the survey drawing provided by the client.

4.3 Boreholes

The boreholes drilled during the first stage of the investigations (October 2015) comprised:

- six boreholes (BH1 – BH5 and BH5A) drilled by a bobcat-mounted DT250 drill rig to depths of between 0.8 m and 7.5 m;

- one borehole, BH5B, drilled with a hand auger to refusal at 0.8 m depth;
- standard penetration tests (SPTs) at 1.5 m depth intervals in all boreholes except BH5B;
- recovery of discrete, disturbed soil samples from all boreholes except BH5B at regular depth intervals; and
- installation of three standpipe wells following completion of boreholes BH1, BH3 and BH5.

The rig-drilled boreholes were initially drilled to depths of between 2.7 m and 7.0 m with 110 mm diameter, continuous, spiral flight augers, and thereafter to their termination depths by rotary (wash-boring) techniques through 75 mm HW casing.

Environmental soil sampling was performed according to standard operating procedures outlined in the DP *Field Procedures Manual* and included collection using disposable nitrile gloves, and transferring samples to laboratory-prepared glass jars, capping immediately and minimising headspace. Replicate soil samples were collected in zip-lock plastic bags and screened for volatile organic compounds (VOCs), using a MiniRAE 3000 photo-ionisation detector (PID) with a 10.6 eV lamp, calibrated to 100 ppm Isobutylene.

The boreholes drilled during the second stage of the investigations (March 2018) comprised:

- six boreholes (BH101 and BH103 – BH107) drilled by a Comacchio Geo 305 drill rig to depths of between 9.0 m and 11.0 m;
- one borehole (BH102) drilled by a Hanjin DB8 drill rig to a depth of 9.0 m;
- standard penetration tests (SPTs) at 1.5 m depth intervals in all boreholes;
- recovery of discrete, disturbed soil samples from all boreholes at regular depth intervals; and
- installation of two standpipe wells following completion of boreholes BH103 and BH107.

The boreholes were initially drilled to depths of between 4.0 m and 4.5 m with 110 mm diameter, continuous, spiral flight augers, and thereafter to depths of between 8.5 m and 9.0 m by rotary (wash-boring) techniques through 78 mm HQ casing. BH103 was extended into rock to a depth of 11.0 m using NMLC-diamond coring techniques to recover 51 mm diameter rock core samples.

The boreholes were backfilled with site spoil and fine gravel, except at standpipe wells locations where a steel gatic cover was installed below the level of the lawns to permit access to the wells without impeding lawnmower use.

Following the completion of the drilling field work, a geotechnical engineer developed the standpipe monitoring wells and measured the standing groundwater levels.

4.4 Test Pits

Two test pits (TP108 and TP109) were excavated by non-destructive methods using a vacuum truck and water jet to refusal on buried obstructions at depths of 1.5 m and 0.5 m, respectively.

The test pits were backfilled with clean sand.

4.5 Cone Penetration Tests

Three continuous CPT tests (CPT1 – CPT3) were undertaken using a specialised, ballasted, truck-mounted testing rig. The CPTs were all terminated at the nominated test depth of 7 m.

In the CPTs, a 35 mm diameter instrumented cone with a following 130 mm long friction sleeve was attached to rods of the same diameter and pushed continuously into the soil by hydraulic thrust from the ballasted testing rig. Strain gauges in the cone and sleeve measured resistance to penetration, with the results displayed on a digital monitor and stored on a computer for later plotting.

4.6 Dilatometer

One dilatometer test (DMT1) was also performed using the CPT testing rig. In this test readings were taken at 200 mm depth intervals to the nominated termination depth of 7 m.

The dilatometer test consists of pushing a flat blade located at the end of a series of rods into the ground. At each testing depth (every 200 mm) a circular steel membrane located on one side of the blade is expanded horizontally into the soil. The pressure required to expand the membrane is recorded. The blade is then advanced to the next test depth and the test repeated.

4.7 GPR Survey

In accordance with the project brief, GPR profiles were collected along the proposed trunk drain alignment between boreholes BH102 and BH105.

As the required survey area was bisected by Gadigal Avenue, two separate local grids were used when positioning the GPR survey lines. Both grids used the trunk drain alignment as their y-axis, with chainage (y-axis) increasing southward.

- The local grid to the north of Gadigal Avenue has its origin located in the centre of the trunk drain alignment, with y = 0 m corresponding to the along-alignment chainage of BH102.
- The local grid to the south of Gadigal Avenue has its y-axis running parallel to and centred at the midpoint between the two parallel trunk drains, with y = 0 m corresponding to the kerb at the south side of Gadigal Avenue.

Positioning of survey grids was done using tape measurements from known features. The locations of survey lines are shown on Drawings 2 and 3 in Appendix B (north and south of Gadigal Avenue, respectively).

The GPR data acquisition was performed using the MALA Ground Explorer GPR System, coupled with the GX 160 (160 MHz) and GX 450 (450 MHz), HDR (High Dynamic Range) antennas (see Figure 1).

Profiles were collected at 0.75 m centres to the north of Gadigal Avenue and 1.0 m centres to the south of Gadigal Avenue, with planned coverage of a 3 m swath over the trunk drain alignment to the north of Gadigal Avenue and a 6 m swath over the trunk drain alignment to the south of Gadigal Avenue. However, full coverage could not be achieved at all locations due to obstacles such as vegetation, fences etc. and no data was collected on the section of the alignment crossing Gadigal Avenue.

Figure 1: Mala GPR system with GX 160 antenna during data acquisition near TP109

The data obtained from GPR was processed using ReflexW software. The processing steps included:

- Time-zero adjustment;
- Background removal;
- Time gain;
- Profile sections were combined and corrected for chainage; and
- A time-cut was performed for enhanced presentation.

5. Field Work Results

5.1 Soil Profile

The detailed results of the field work are provided in the following appendices:

- Appendix C - Boreholes
- Appendix D – Test Pits
- Appendix E – Cone Penetration Tests
- Appendix F – Dilatometer

Notes defining classification methods and descriptive terms are given in Appendix A.

A long-section presenting summary logs of the tests along the alignment is given on Drawing 4 in Appendix B. The interpreted ground profile along the proposed alignment is shown on Drawings 7A and 7B in Appendix B. It should be noted that the interpreted strata boundaries shown on Drawings 7A and 7B are approximate and should only be used as a guide, as variations in the ground profile may occur between test locations.

5.2 Groundwater Levels

Free groundwater was measured at all the test locations during the initial field work and also in standpipe wells installed. The results of the groundwater measurements are summarised in Table 1.

Table 1: Summary of Groundwater Level Measurements

Test Location	During Initial Field Work		After Well Development	
	Depth (m)	Reduced Level (m AHD)	Depth (m)	Reduced Level (m AHD)
First stage investigation (October 2015)				
BH1	2.6	18.0	3.1	17.5
BH2	2.4	18.0		
BH3	2.6	16.8	2.3	17.1
BH4	3.2	16.3		
BH5	2.6	15.3	2.8	15.1
CPT3	3.0	15.0		
Second stage investigation (March 2018)				
BH1			2.7	17.9
BH101	3.2	16.8		
BH102	3.6	16.4		
BH103	3.5	15.7	2.9	16.3
BH104	3.5	15.8		

Test Location	During Initial Field Work		After Well Development	
	Depth (m)	Reduced Level (m AHD)	Depth (m)	Reduced Level (m AHD)
BH105	3.5	15.5		
BH106	3.8	14.7		
BH107	3.2	15.1	2.8	15.5

During development and sampling of groundwater, no phase separated product was observed.

5.3 GPR Survey

The results of the GPR survey are presented as selected 2D profiles in Drawing 5 (survey area north of Gadigal Avenue) and Drawing 6 (survey area south of Gadigal Avenue) in Appendix B.

The GPR datasets were mostly of good quality, however, signal penetration was limited to a depth of about 1.0 m for the 450 MHz dataset and 1.5 m – 2.0 m in most areas for the 160 MHz dataset. The poor signal penetration was most likely due to relatively high moisture content of the filling and soils at the time the survey was undertaken.

An average velocity of 0.1 m/nanosecond was selected based on correlation with depths to layers and features in boreholes and test pits, in conjunction with a velocity analysis performed using the ReflexW software. It is noted that, based on the velocity analysis, the velocity may vary laterally across the site and likely varies with depth. It follows that the accuracy of the interpreted depths of features may vary.

5.3.1 Comparison of GPR Data with Boreholes and Test Pits

The locations of BH102 – BH105, TP108 and TP109 (as recorded relative to the GPR survey lines) are shown on Drawings 2, 3, 5 and 6 in Appendix B. Graphical representations of the bore logs are presented in Drawings 5 and 6 overlain onto the GPR profiles. The following observations were made when comparing the borehole logs with the GPR profiles:

- The horizon at 0.1 m depth in BH102 between mulch above loose silty sand filling correlates well with the depth of the base of a continuous reflector in the garden bed sections of Line 1 (160 MHz data);
- The horizon at 0.8 m depth in BH102 between loosely compacted filling above moderately compacted filling correlates well with the depth of the base of a continuous relatively high amplitude reflector in the garden bed sections of Line 1 (160 MHz data);
- The base of the filling at 1.8 m depth in BH102 correlates well with a semi-continuous, weak reflector apparent in parts of Line 1 (160 MHz data). This corresponds to the approximate maximum depth of investigation with the above equipment at the site;
- The horizon at 0.15 m depth in BH103 and 0.3 m depth on BH104 between loosely compacted filling above moderately compacted filling correlates well with the depth to the top of a continuous relatively high amplitude reflector in Line 6 (160 MHz data);

- The horizon at 0.6 m depth in BH104 between moderately compacted sand filling above moderately compacted sandstone filling correlates well with the depth to the base of a semi-continuous reflector in Line 6 (160 MHz data). The horizon is not present in BH103;
- The horizon at 0.3 m depth in TP109 correlates well with the base of a localised continuous reflector in Line 6 (160 MHz and 450 MHz data);
- The depth to refusal on a concrete slab at 0.5 m depth in TP109 correlates well with the top of a localised, semi-continuous reflector on Line 6 (160 MHz and 450 MHz data) and Line 6 (450 MHz data);
- The depth to refusal on an irregular concrete block and steel mesh at 1.5 m depth in TP108 correlates reasonably well with the base of a very weak, localised, semi-continuous, possible reflector on Line 6 at 1.3 m depth (160 MHz data),
- The depth of investigation achieved to the south of Gadigal Avenue was shallower than the base of the filling.

5.3.2 Interpretation of GPR Results

Interpretations of the GPR data are presented graphically on Drawings 5 and 6 in Appendix B.

The appearance of the GPR response from the fill material in the garden beds to the north of Gadigal Avenue is distinctly different to the response of the fill material in the park to the south of Gadigal Avenue. Based on the apparent continuous layering of reflectors from ~0 m – 1.5 m depth in the GPR profiles collected along the garden beds to the north of Gadigal Avenue, it is believed that the filling in these areas consists mainly of relatively uniform layered material. However, to the south of Gadigal Avenue the apparent layering is more discontinuous or absent.

Due to the relatively poor signal penetration achieved, it is not possible to infer the rooting depth of the trees at the site.

It is not possible to provide certainty as to whether a given hyperbolic reflection is indicative of a tree root, an underground service or some other feature. For this reason, features marked as possible services on the drawings may in fact be tree roots (or other objects), or vice-versa. Also, as most survey lines run parallel to the trunk drain alignment it is difficult to detect services which may run parallel or at a shallow angle to the trunk drain alignment.

The locations of three possible services are marked on Line 3. These features may run along/within or sub-parallel and intersecting the trunk drain alignment. However, confidence in the interpretation of these features as services is low due to the reduced penetration associated with steel reinforcement and the presence of slab joints above the interpreted services.

Line 7 (160 MHz) in Drawing 6 has a reflector at approximately 2.3 m depth which is tentatively interpreted as either a service, or a reflection from a feature at the base of a services trench (which may house the services interpreted above this feature). Alternatively this may be a multiple reflection from an obscured reflector closer to the surface.

Based on the GPR data for Line 6, the concrete slab encountered in TP109 may be interpreted as a drainage feature, an irregular concrete slab or a pair of concrete encased pipes. The feature runs approximately perpendicular to the trunk drain alignment. There is an apparent low point/channel at the centre of the top surface (or possibly a gap between two separate objects) which runs along the object's long axis. The total width of the feature appears to be approximately 4 m – 5 m. The high amplitude response from the object only continues to approximately 30 cm – 40 cm below the interpreted top surface of the object which may indicate the approximate depth extent of the object. However, below the feature, very faint apparent reflectors are visible at approximately 1 m and 1.5 m (160 MHz), indicating a possible continuation with depth. As a result of the poor signal penetration at the site, the depth extent of the feature cannot be reliably estimated.

It is possible that the concrete block discovered at TP108 may be part of a larger structure as evidenced by a faint apparent reflector at approximately 1.3 m depth (Line 6 160 MHz), which is interpreted as a possible concrete surface. However, it is noted that the reflections supporting this interpretation are very weak and that similar reflections at similar depths could be expected from layering in filling or natural sediments. To the south of TP108 on Line 6 there are features interpreted as possible services as well as high amplitude zones which are interpreted as a possible concrete surface or trench filling.

There are a number of other high amplitude features visible in the datasets for Line 6, most of which are interpreted as tree roots or layering within the filling. Other features of interest are marked as possible concrete surfaces between TP108 and the end of Line 6. It is unclear whether the concrete surface encountered in TP109 terminates at approximately 54.5 m (450 MHz interpretation) or continues to and possibly beneath the path (160 MHz interpretation). A similar feature on Line 10 (160 MHz) is also interpreted as possible concrete. Due to the poor signal penetration at the site, it is unclear from the GPR data alone whether these possible objects extend to depths which could obstruct the path of the under bore. A feature of similar appearance is located beneath the pathway on Line 6. However, this is most likely a layer of compacted fill.

6. Laboratory Testing

6.1 Geotechnical Testing

Discrete soil samples taken from the boreholes were tested in NATA-accredited laboratories for measurement of Atterberg limits, particle size distribution, ASS indication and soil aggressivity. The laboratory test certificates are provided in Appendix G.

The results of the geotechnical laboratory tests are summarised in Tables 2 and 3.

Table 2: Summary of Geotechnical Test Results (First Stage Investigation)

Borehole	**Depth (m)**	**W_L (%)**	**W_P (%)**	**PI (%)**	**D_{10} (mm)**	**D_{30} (mm)**	**D_{60} (mm)**	**pH**	**SO_4 (mg/kg)**	**Cl (mg/kg)**	**EC (µS/cm)**
BH1	2.3 – 2.5	No	No	NP	-	0.17	0.26	-	-	-	-
	2.5	-	-	-	-	-	-	4.4	44	<10	55
BH2	3.3 – 3.5	No	No	NP	0.17	0.23	0.33	-	-	-	-
	4.0	-	-	-	-	-	-	6.4	<10	<10	23
BH3	2.5	-	-	-	-	-	-	7.2	27	<10	47
	3.3 – 3.5	No	No	NP	0.17	0.24	0.34	-	-	-	-
BH4	3.3 – 3.5	No	No	NP	0.18	0.24	0.33	-	-	-	-
	4.0	-	-	-	-	-	-	6.7	22	<10	29
BH5	2.5	-	-	-	-	-	-	7.5	230	10	170
	2.9 – 3.0	25	23	2	-	0.15	0.31	-	-	-	-

Notes:
WL = Liquid Limit
WP = Plastic Limit
PI = Plasticity Index
SO_4 = Sulphate ion
Cl = Chloride ion
EC = Electrical Conductivity
NP = Non-plastic
D_x = Diameter of material for which x% is finer
No = Not applicable

Table 3: Summary of Geotechnical Test Results (Second Stage Investigation)

Borehole	**Depth (m)**	**W_L (%)**	**W_P (%)**	**PI (%)**	**D_{10} (mm)**	**D_{30} (mm)**	**D_{60} (mm)**	**pH**	**SO_4 (mg/kg)**	**Cl (mg/kg)**	**EC (µS/cm)**
BH102	2.5 – 2.95	-	-	-	0.16	0.23	0.33	-	-	-	-
	4.0 – 4.45	-	-	-	0.18	0.25	0.35	-	-	-	-
	8.5 – 8.95	22	12	10	-	-	-	-	-	-	-
BH103	0.4 – 0.5	-	-	-	-	-	-	-	-	-	-
	1.0 – 1.45	-	-	-	-	-	-	8.2	24	10	99
	2.5 – 2.95	-	-	-	-	-	-	7.8	<10	<10	36
	4.0 – 4.45	-	-	-	-	-	-	7.7	<10	<10	22
	5.5 – 5.95	-	-	-	-	-	-	7.9	<10	<10	24
	7.0 – 7.45	-	-	-	-	-	-	5.3	<10	<10	18
BH104	2.5 – 2.95	-	-	-	0.17	0.24	0.34	-	-	-	-
	4.0 – 4.45	-	-	-	0.18	0.28	0.34	-	-	-	-
BH105	0.4 – 0.5	-	-	-	-	-	-	-	-	-	-

Table 3: Summary of Geotechnical Test Results (Second Stage Investigation) Cont'd

Borehole	Depth (m)	WL (%)	WP (%)	PI (%)	D10 (mm)	D30 (mm)	D60 (mm)	pH	SO4 (mg/kg)	Cl (mg/kg)	EC (µS/cm)
BH106	2.5 – 2.95	-	-	-	0.14	0.22	0.33	-	-	-	-
	4.0 – 4.45	-	-	-	0.16	0.21	0.30	-	-	-	-
	8.5 – 8.95	50	20	30	-	-	-	-	-	-	-

Notes: WL = Liquid Limit WP = Plastic Limit
PI = Plasticity Index SO_4 = Sulphate ion
Cl = Chloride ion EC = Electrical Conductivity
NP = Non-plastic D_x = Diameter of material for which x% is finer
No = Not applicable

6.2 Environmental Testing

Selected soil and groundwater samples were dispatched in cooled and insulated containers to a NATA-accredited laboratory using chain of custody documentation for sample tracking.

The soil sample selection was made with consideration to the location and depths of potential excavation pits, horizons intersected by the underbore, and signs of contamination including stains, odours, PID screening results and the presence of anthropogenic debris.

Samples were analysed for potential contaminants of concern being:

- metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc)
- polycyclic aromatic hydrocarbons (PAH),
- total recoverable hydrocarbons (TRH),
- benzene, toluene, ethylbenzene, total xylenes (BTEX),
- organochlorine pesticides (OCP),
- polychlorinated biphenyls (PCB),
- total phenols,
- volatile organic compounds, and
- asbestos.

28 samples were also collected to be screened for pH and six of these were tested for a chromium reducible sulphur suite (S_{CR}) to assess the presence of potential or actual acid sulphate soils given the presence of peaty soils.

Following a review of the initial round of laboratory analysis, TCLP testing for lead and benzo(a)pyrene (B(a)P) was carried out on selected samples in order to determine their leachable concentrations.

The detailed test results and tables containing summaries of the results are given in Appendix H.

Duplicate samples were also collected for QA/QC purposes, the review of which is also given in Appendix H.

7. Limitations

Douglas Partners (DP) has prepared this factual report for this project at Joynton Avenue, Zetland, in accordance with DP's proposal dated 5 February 2018 and acceptance received from the City of Sydney Council by Variation Notice for Variation Change Number 2 to RFQ 7615. The work was carried out under the existing contract between City of Sydney and DP. This factual report is provided for the exclusive use of the City of Sydney Council for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

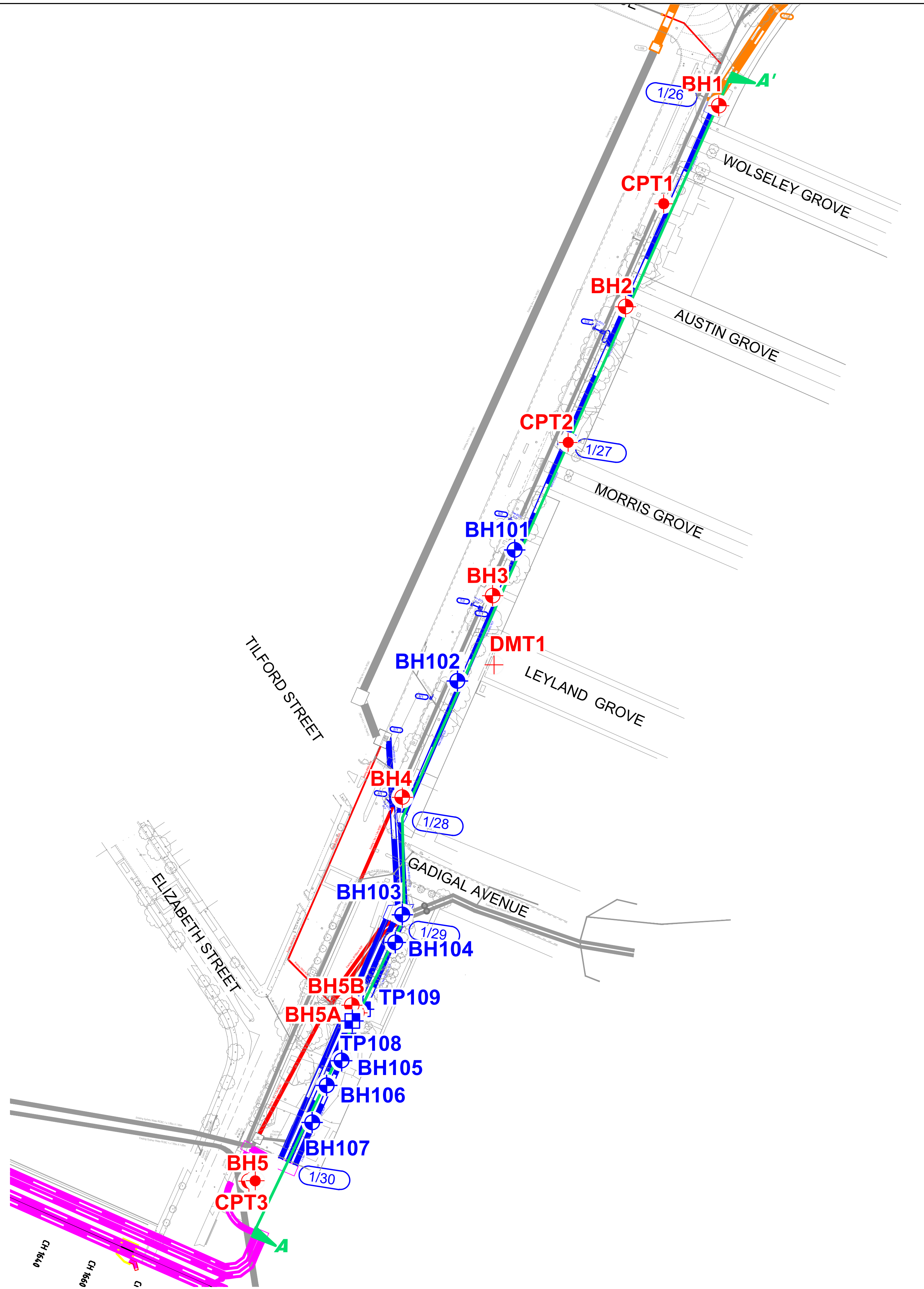
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

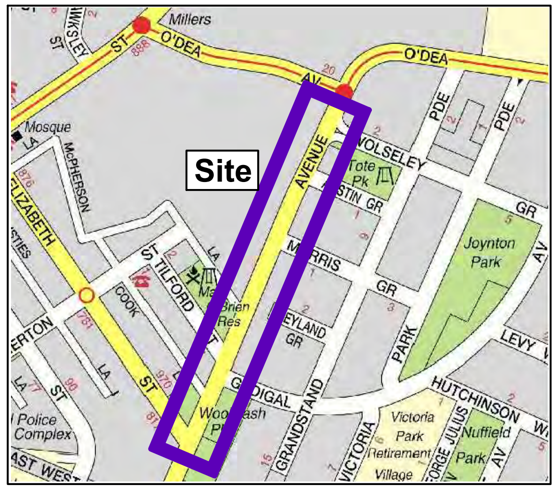
Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings





Locality Plan

LEGEND

PREVIOUS INVESTIGATION

⊕ Borehole location

● Cone penetration test location

+ Dilatometer test location

A — A' Geotechnical Cross Section A-A'

CURRENT IVESTIGATION

⊞ Test pit location

⊕ Borehole location

NOTE: 1. Base drawing from City of Sydney Council
(Dwg E3-15/1342 -100, dated 18.6.2015)
2. Test locations are approximate only and were
located using hand-held GPS.

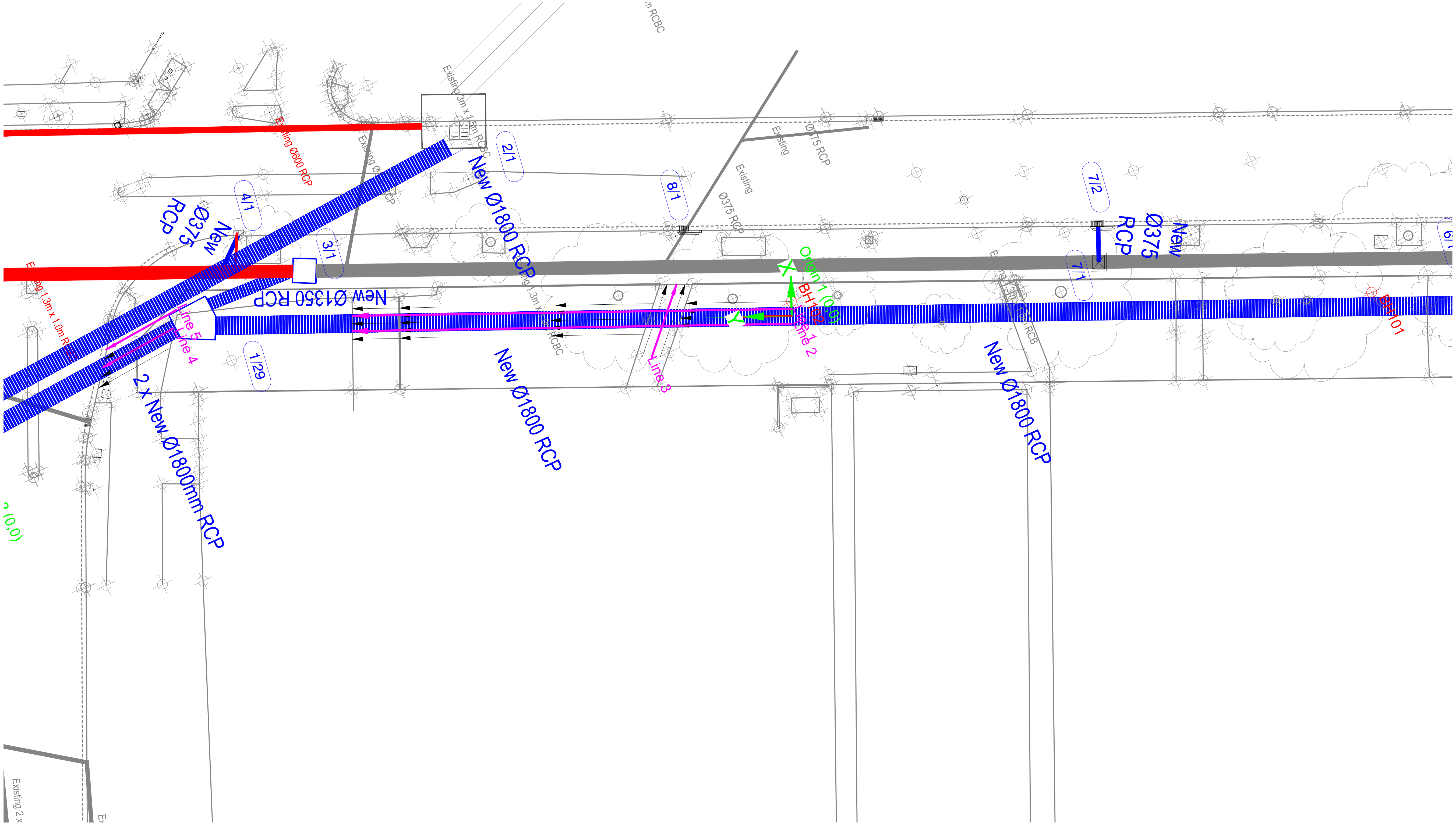
0 10 20 30 40 60 80 100 150 200m

1:2000 @ A3

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: City of Sydney Council		TITLE:	**Location of Tests**	PROJECT No: 85100.02
OFFICE: Sydney	DRAWN BY: PSCH		**Joynton Avenue Trunk Drain Project**	DRAWING No: 1
SCALE: 1:2000 @ A3	DATE: 7.5.2018		**Joynton Avenue, Zetland**	REVISION: 0

N



NOTE:
1: Base drawing from JA and DA combined.dwg
Survey for Drafting.dwg
2: Test locations are approximate only and
are shown with reference to existing features.

0 2 4 6 8 10 15 20 30 40m
1:400 @ A3

LEGEND

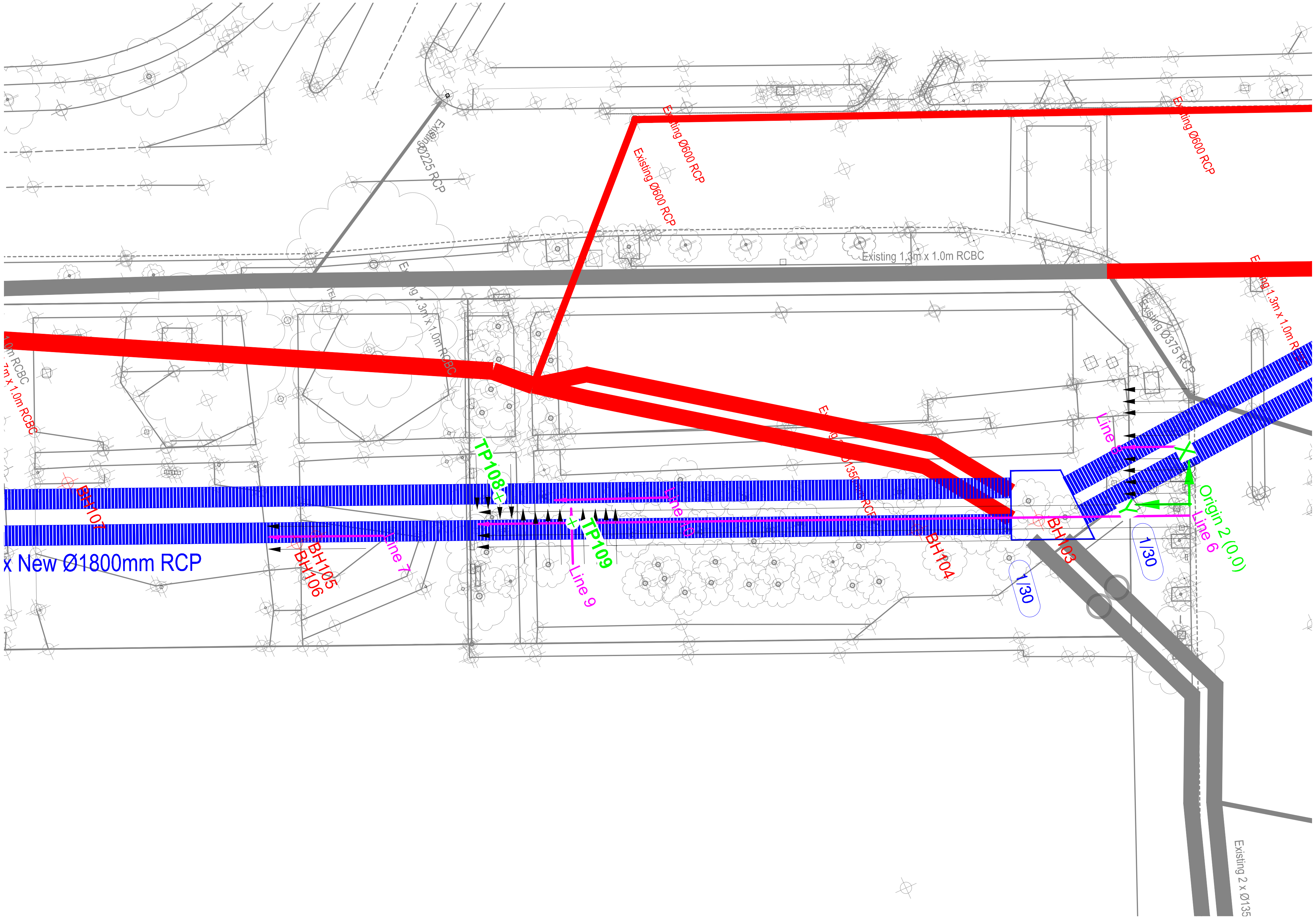
+ Test pit location
⊕ Test bore location
← Selected GPR Line location
← Other GPR Line location

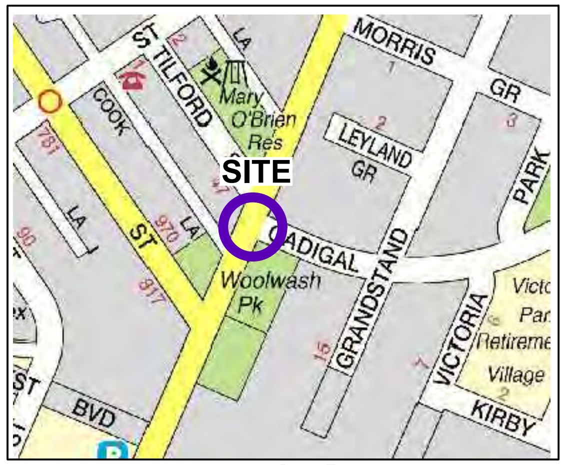
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: PSCH
SCALE: 1:400 @ A3
DATE: 24.8.2016

TITLE: **Plan of GPR Lines, Test Pits and Boreholes**
Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

PROJECT No: 85100.02
DRAWING No: 2
REVISION: 0





Locality Plan

NOTE:
1: Base drawing from JA and DA combined.dwg
Survey for Drafting.dwg
2: Test locations are approximate only and
are shown with reference to existing features.

0 2 4 6 8 10 15 20 30 40m
1:400 @ A3

LEGEND

+ Test pit location
⊕ Test bore location
← Selected GPR Line location
← Remaining GPR Line location

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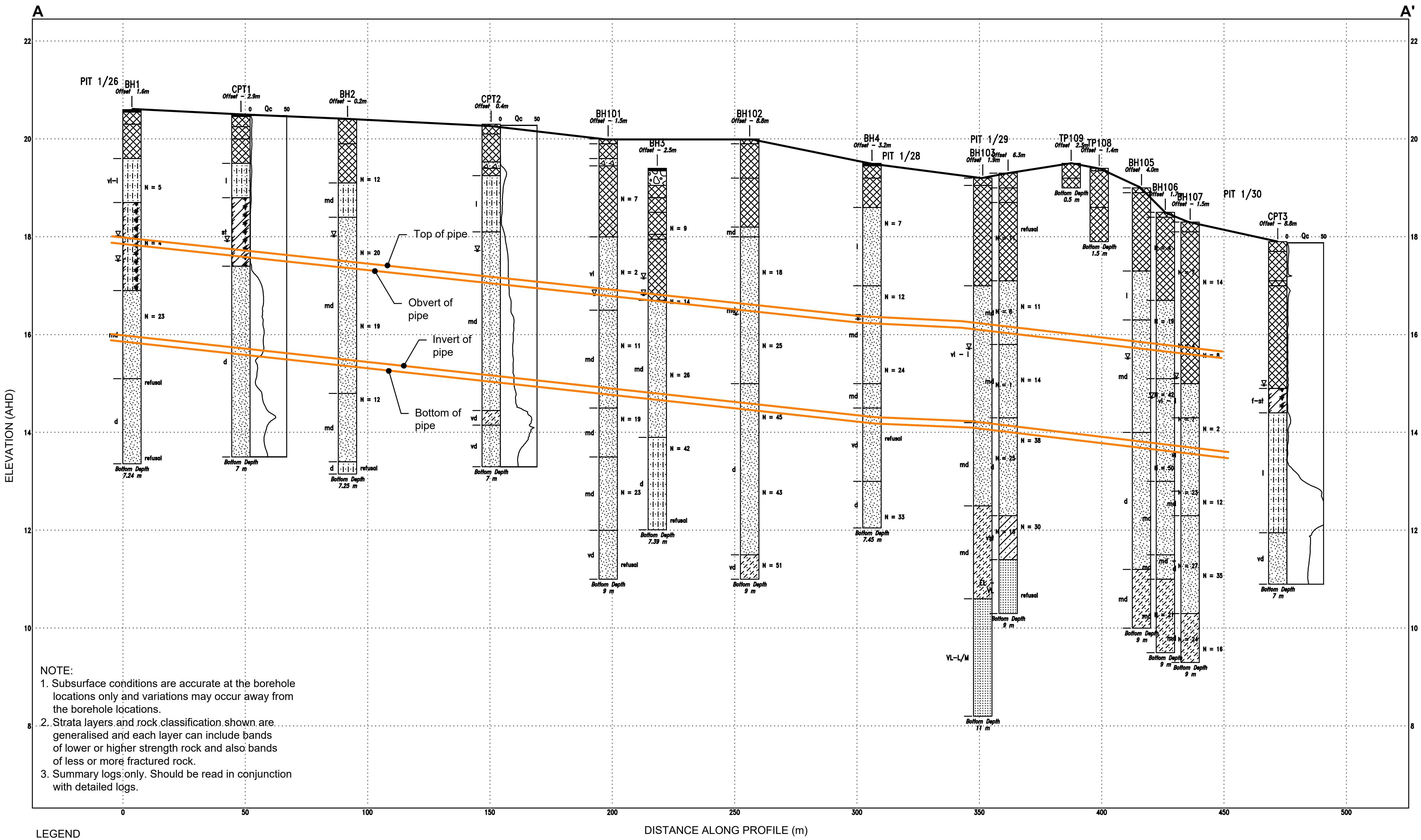
CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: PSCH
SCALE: 1:400 @ A3
DATE: 3.5.2018

TITLE: **Plan of GPR Lines, Test Pits and Boreholes**
Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

N

PROJECT No: 85100.02
DRAWING No: 3
REVISION: 0



NOTE:
1. Subsurface conditions are accurate at the borehole locations only and variations may occur away from the borehole locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs.

LEGEND

■	Asphaltic Concrete	▨	Sand	▨	Sandy Clay
▨	Filling	▨	Concrete	▨	Gravel
▨	Silty Sand	▨	Clayey Sand	▨	Peaty Clay
▨	Silty Sand	▨	Sandstone		

TESTS / OTHER
N - Standard penetration test value
▽ - Water level
PP- Pocket penetrometer test value

0 30
Horizontal Scale (metres)
Vertical Exaggeration = 20.0

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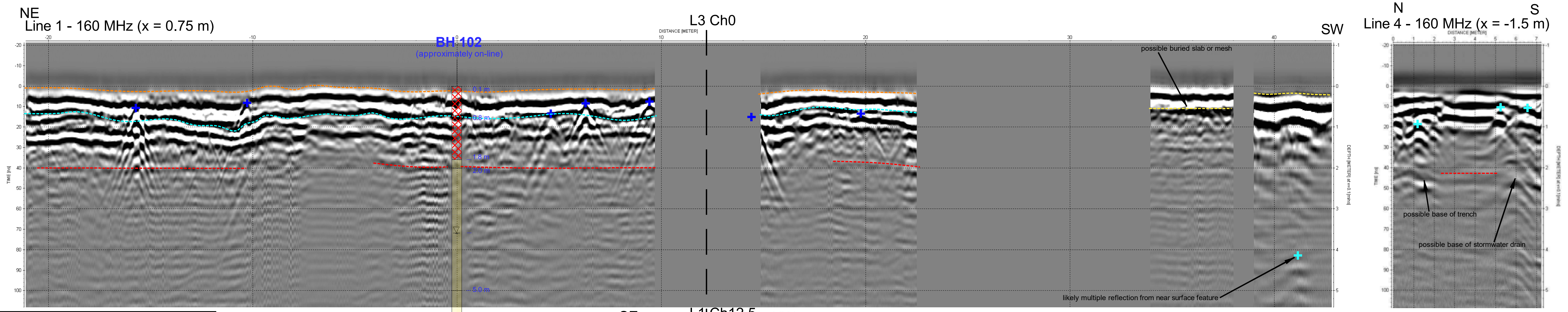
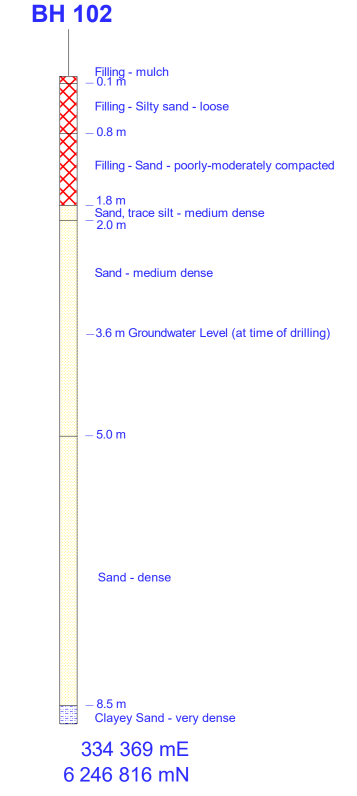
CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: AK
SCALE: 1:1500 (H) 1:75 (V) @ A3
DATE: 10.05.2018

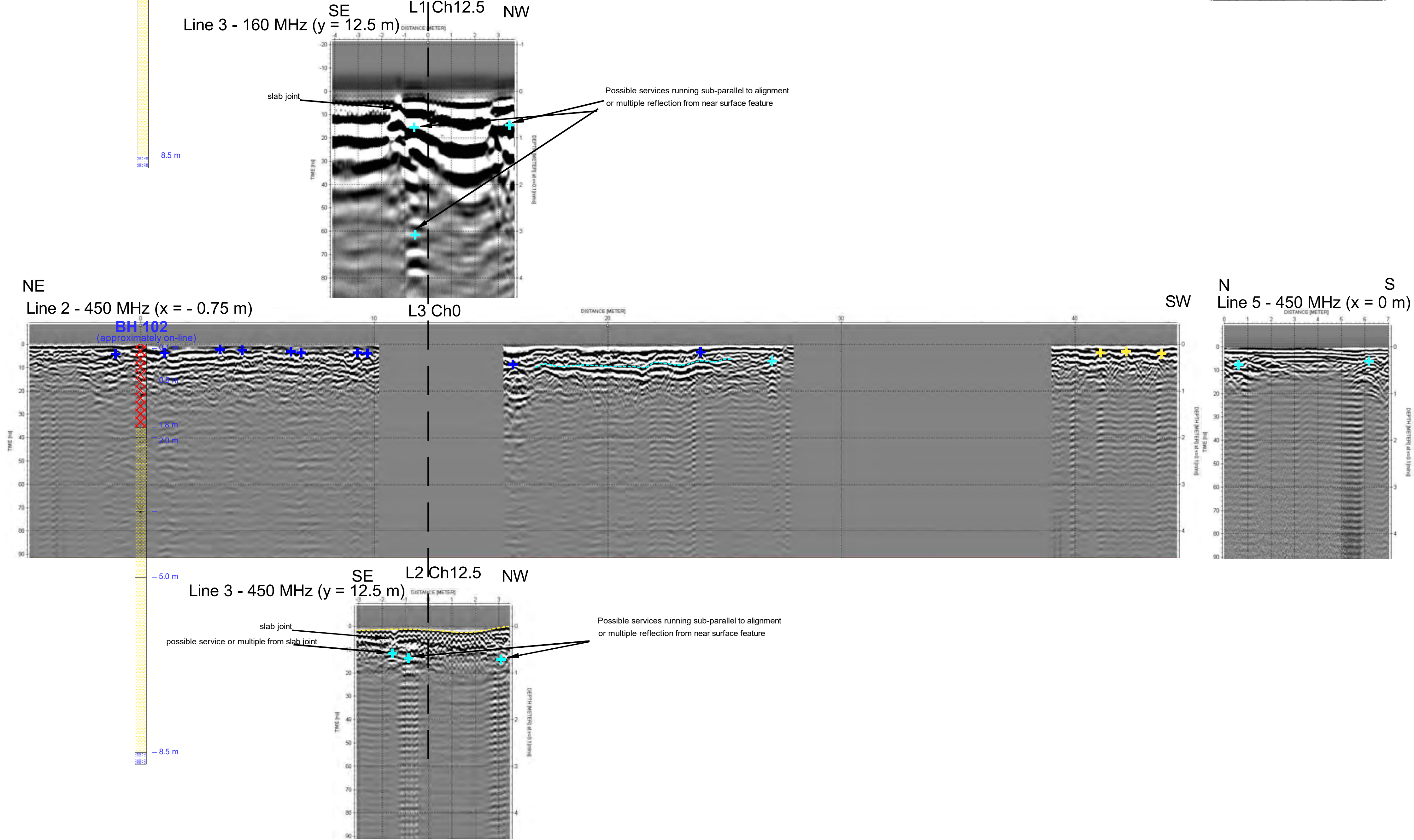
TITLE: **Long Section for Proposed Underbore**
Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

PROJECT No: 85100.02
DRAWING No: 4
REVISION: 0



SIMPLIFIED BORE LOG





KEY:

🟧	Interpreted base of mulch
🟦	Interpreted base of loose silty sand
🟥	Interpreted base of filling
🟨	Interpreted steel reinforcment/mesh
+	Possible tree roots or services
+	Possible service
+	Possible steel reinforcment

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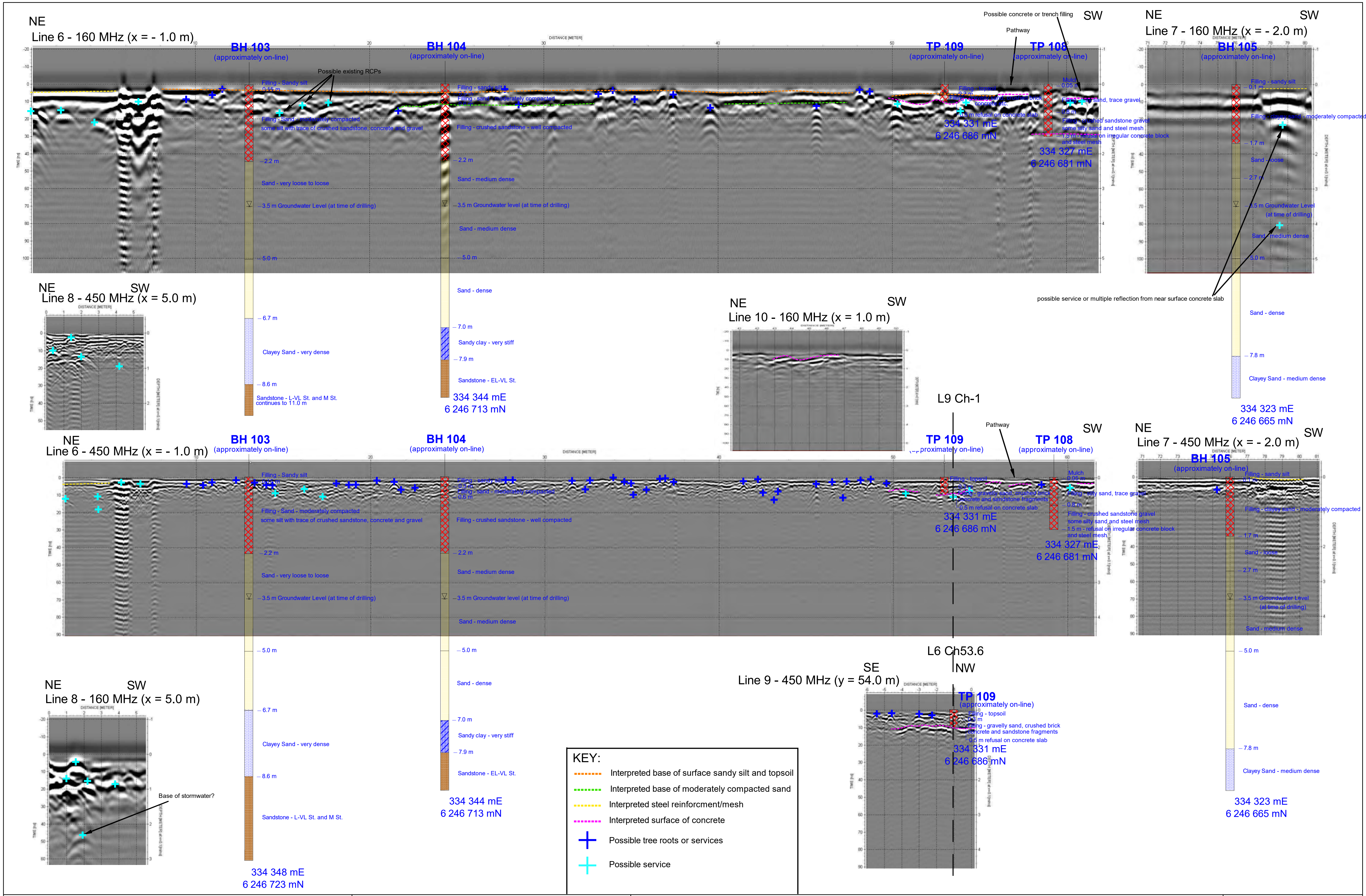
CLIENT: City of Sydney Council		TITLE: **Interpreted GPR Sections (North of Gadigal Avenue)**	PROJECT No: 85100.02
OFFICE: Sydney	DRAWN BY: JHH	**Joynton Avenue Stormwater Drainage Upgrade**	DRAWING No: 5
SCALE: as shown (V:H=2:1)	DATE: 11.05.2018	**Joynton Avenue, Zetland**	REVISION: A



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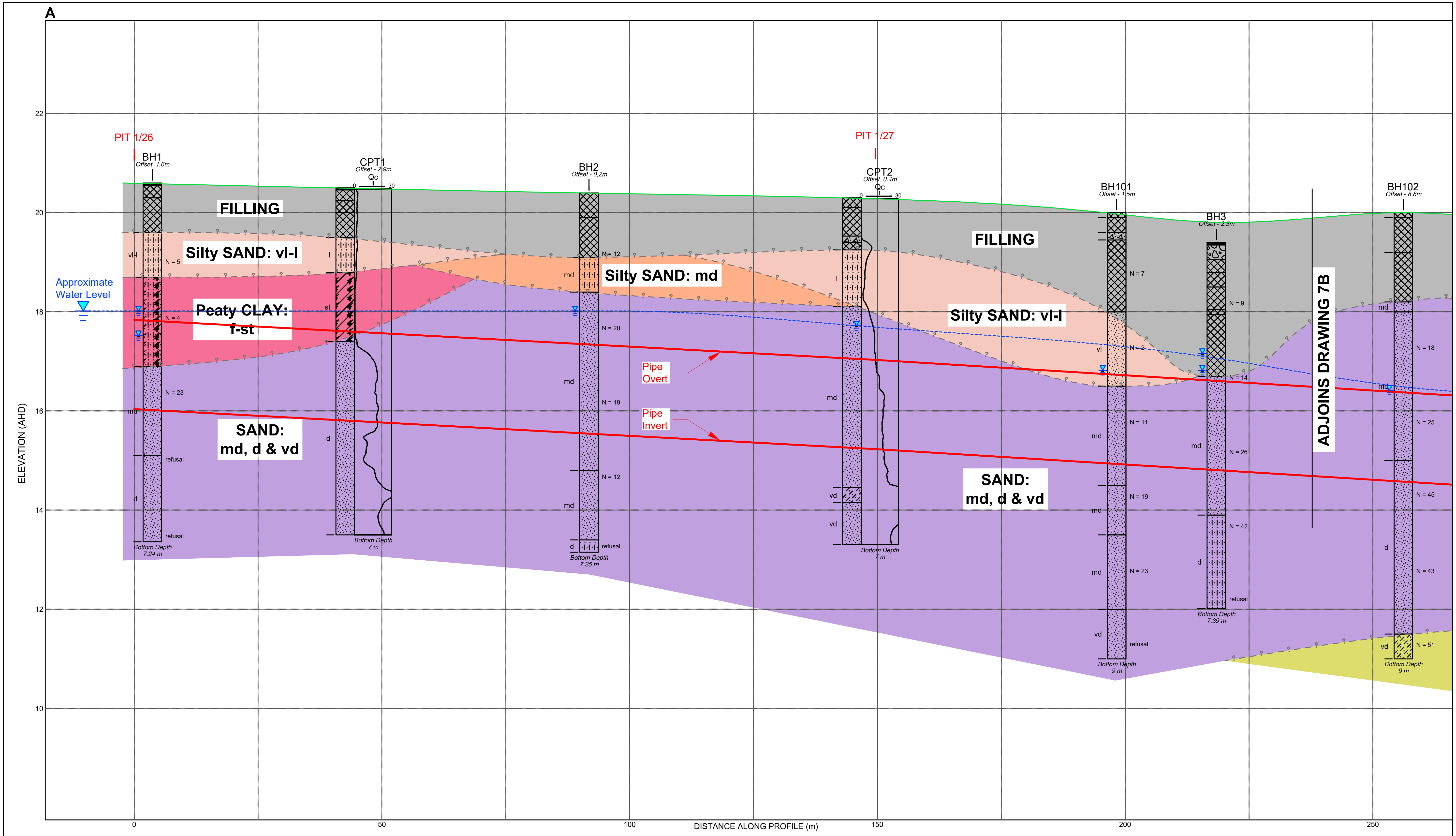
CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: JHH
SCALE: as shown (V:H=2:1)
DATE: 3.05.2018

TITLE: **Interpreted GPR Sections (South of Gadigal Avenue)**
Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

PROJECT No: 85100.02
DRAWING No: 6
REVISION: A



LEGEND

■ Asphaltic Concrete	Sand	Sandy Clay
▨ Filling	Concrete	Gravel
Silty Sand	Clayey Sand	Topsoil
Silty Sand	Sandstone	Peaty Clay

NOTE:

1. Subsurface conditions are accurate at borehole locations. Variations in subsurface conditions may occur between test locations.
2. Interpreted strata boundaries are approximate and should be used as a guide only.
3. Summary logs only. Should be read in conjunction with detailed logs.

SOIL STRENGTH/CONSISTENCY
st - Stiff
vst - Very stiff
h - Hard
l - Loose
md - Medium dense
d - Dense
vd - Very dense

ROCK STRENGTH
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High

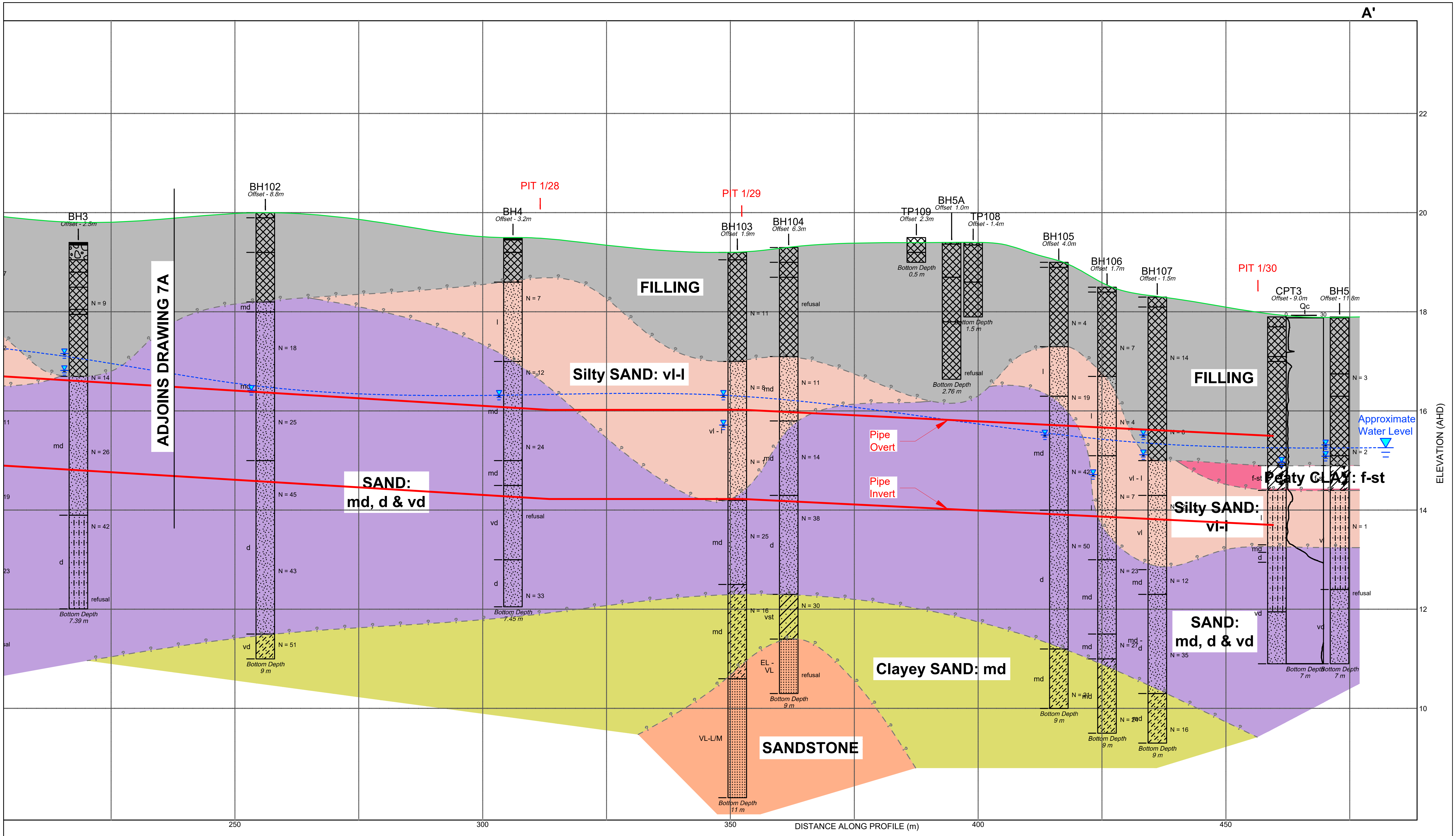
TESTS / OTHER
N - Standard penetration test value
▽ - Water level
- ? — - - Inferred Geology

0 15
Horizontal Scale (metres)

Vertical Exaggeration = 10.0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: City of Sydney Council		TITLE: **Interpreted Geotechnical Long Section - Proposed Underbore** **Joynton Avenue Trunk Drain Project** **Joynton Avenue, Zetland**	PROJECT No: 85100.02
OFFICE: Sydney	DRAWN BY: LJH/AK/FMcG		DRAWING No: 7A
SCALE: 1:750 (H) 1:75 (V) @ A3	DATE: 17.5.2018		REVISION: 0



LEGEND

■ Asphaltic Concrete
▨ Filling
▥ Silty Sand
▥ Silty Sand
░ Sand
▨ Concrete
▨ Clayey Sand
░ Sandstone
▨ Sandy Clay
▨ Gravel
▨ Topsoil
▨ Peaty Clay

NOTE:

1. Subsurface conditions are accurate at borehole locations. Variations in subsurface conditions may occur between test locations.
2. Interpreted strata boundaries are approximate and should be used as a guide only.
3. Summary logs only. Should be read in conjunction with detailed logs.

SOIL STRENGTH/CONSISTENCY
st - Stiff
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ROCK STRENGTH
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High

TESTS / OTHER
N - Standard penetration test value
▽ - Water level
- ? — - - Inferred Geology

0 15
Horizontal Scale (metres)

Vertical Exaggeration = 10.0

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CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: LJH/AK/FMcG
SCALE: 1:750 (H) 1:75 (V) @ A3
DATE: 17.5.2018

TITLE: **Interpreted Geotechnical Long Section - Proposed Underbore**
Joynton Avenue Trunk Drain Project
Joynton Avenue, Zetland

PROJECT No: 85100.02
DRAWING No: 7B
REVISION: 0

Appendix C

Boreholes

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 2007. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approximate Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and longer sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100 \text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

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Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

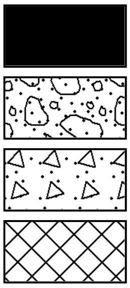
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

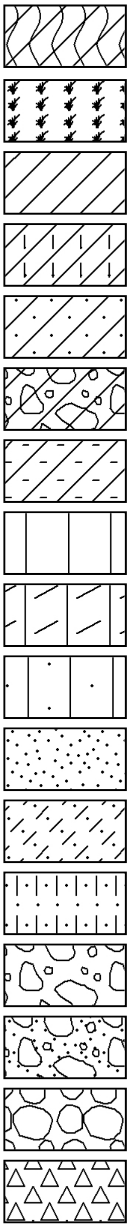
Graphic Symbols for Soil and Rock

General



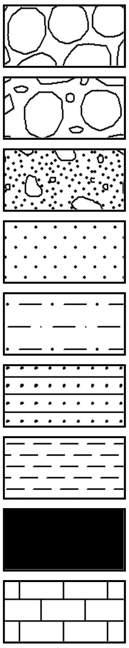
- Asphalt
- Road base
- Concrete
- Filling

Soils



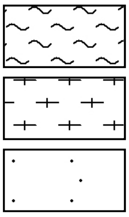
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks



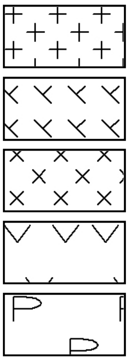
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks



- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry

BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

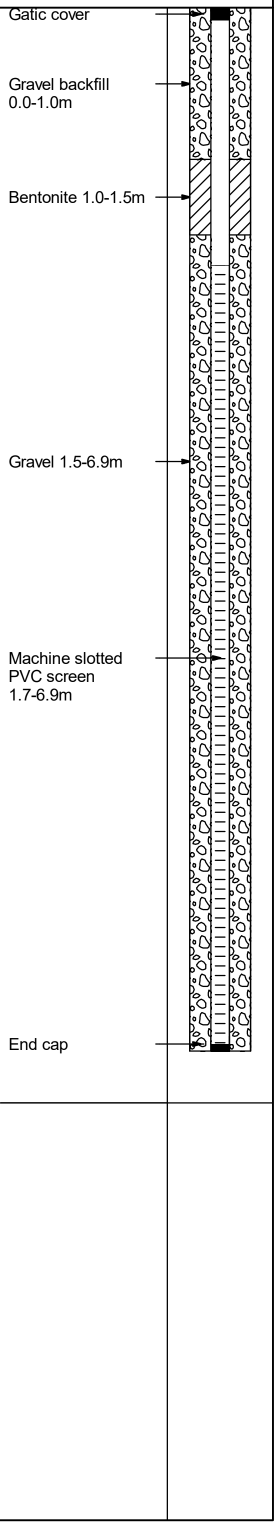
SURFACE LEVEL: 20.6 AHD
EASTING: 334473
NORTHING: 6247045
DIP/AZIMUTH: 90°/--

BORE No: BH1
PROJECT No: 85100.02
DATE: 12/10/2015
SHEET 1 OF 1

Depth (m)	Description of Strata
0.05	ASPHALT CONCRETE - footpath
0.3	FILLING - grey-brown, silty, fine to coarse sand with some concrete fragments and a trace of bricks
	FILLING - dark grey, silty, medium sand with a trace of fine to medium gravel, sandstone gravel and clinker 0.9m: some light grey sand
1.0	SILTY SAND - very loose to loose, dark grey, silty, medium sand, trace of angular gravel
1.9	PEATY SILTY SAND - dark grey, peaty silty sand, damp (no odours) - wet at 2.6m then damp again at 2.7m
3.7	SAND - medium dense, brown, medium to coarse sand, wet
5.5	SAND - dense, brown (coffee coloured), medium to coarse sand with strong organic odour
7.24	Bore discontinued at 7.24m - target depth reached

Type	Depth	Sample	Results & Comments	Water
A/E	0.05 0.1		PID=4	
A	0.15 0.2			
A/E	0.5 0.6		PID=4	
A/E	0.9 1.0			
A/E	1.0 1.3			
S	1.3 1.45		2,2,3 N = 5 PID=5	
A*	1.9 2.0			
A*	2.3 2.5		PID<1	
S	2.5 2.95		1,1,3 N = 4	21-10-15
S	4.0 4.45		8,11,12 N = 23	
S	5.5 5.65		36/150mm refusal	
S	7.0 7.24		25,25/90mm refusal	

Well Construction Details



RIG: Hand tools & DT250 **DRILLER:** GM **LOGGED:** VK/IW **CASING:** HW to 4.0m

TYPE OF BORING: Hand auger to 1.0m; 110mm diameter solid flight auger to 3.5m; Rotary (mud) drilling to 7.0m

WATER OBSERVATIONS: Free groundwater observed at 2.6m during drilling. Measured at 3.1m on 21/10/15

REMARKS: *Bag sample for ASS only

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 20.4 AHD
EASTING: 334436
NORTHING: 6246965
DIP/AZIMUTH: 90°/--

BORE No: BH2
PROJECT No: 85100.02
DATE: 12/10/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - dark brown, fine to medium sand filling with a trace of angular gravel and wood debris		A/E	0.0 0.1		PID=1		
	0.5	FILLING - light grey and brown, fine to medium sand with a trace of sandstone gravel		A/E	0.5 0.6		PID<1		
		1.0m: becoming dark brown, trace of grey clay		A/E	0.9 1.0		PID<1		
				S	1.0 1.45		2,3,9 N = 12		
	1.3	SILTY SAND - medium dense, light grey, silty, medium to coarse sand							
	2.0	SAND - medium dense, coffee brown, fine to coarse sand							
		2.4m: wet						▼ 12-10-15	
				S	2.5 2.95		5,10,10 N = 20		
				A	3.3 3.5		PID=2		
				S	4.0 4.45		8,8,11 N = 19		
		4.5m: light brown							
				S	5.5 5.95		5,4,8 N = 12		
	5.6	SAND - medium dense, dark grey-brown, fine to coarse sand, trace of silt							
	7.0	SILTY SAND - dense, dark grey-brown, silty coarse sand (slightly peaty with slight organic odour)		S	7.0 7.25		12,35/100mm refusal		
	7.25	Bore discontinued at 7.25m - target depth reached							

RIG: Hand tools & DT250 **DRILLER:** GM **LOGGED:** VK/IW **CASING:** HW to 4.0m
TYPE OF BORING: Hand auger to 1.0m; 110mm diameter solid flight auger to 3.5m; Rotary (mud) drilling to 7.0m
WATER OBSERVATIONS: Free groundwater observed at 2.4m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

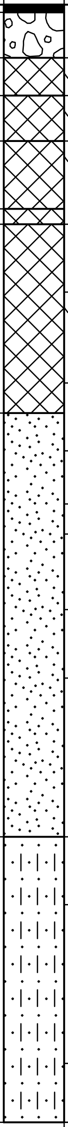
SURFACE LEVEL: 19.4 AHD
EASTING: 334383
NORTHING: 6246850
DIP/AZIMUTH: 90°/--

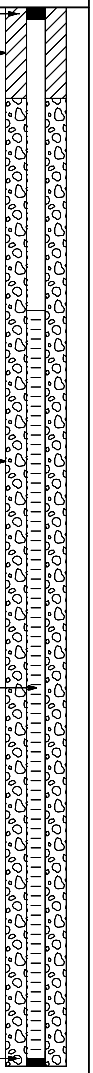
BORE No: BH3
PROJECT No: 85100.02
DATE: 13/10/2015
SHEET 1 OF 1

Depth (m)	Description of Strata	Type	Depth	Results & Comments
0.05	ASPHALT (Roadway)			
0.35	GRAVEL - stabilised gravel	E/A	0.35 0.45	
0.6	FILLING - brown, fine to medium sand filling with some angular igneous gravel and a trace of brick	E/A	0.6 0.7	
0.9	FILLING - grey-brown, medium to coarse sand with a trace of igneous angular gravel	E/A S	0.9 1.0 1.45	3,4,5 N = 9
1.35	FILLING - light grey, medium to coarse sand filling with a trace of charcoal and quartz gravel			
1.45	FILLING - bituminous gravel filling with a trace of slag, glass fragments, charcoal and roots			
	FILLING - brown and grey, silty, medium to coarse sand filling with a trace of glass and charcoal - wet at 2.3m	E/A	1.9 2.0	
2.7	SAND - medium dense, light grey-brown, fine to coarse sand, wet	S E/A S*	2.5 2.95 3.3 3.5 4.0 4.45	4,6,8 N = 14 6,12,14 N = 26
5.5	SILTY SAND - dense, brown, silty, fine to medium sand (slightly peaty)	S S	5.5 5.95 7.0 7.39	15,19,23 N = 42 20,50,36/90mm refusal
7.39	Bore discontinued at 7.39m - target depth reached			

Water: 13-10-15

Well Construction Details:
Gatic cover
Bentonite 0.0-0.6m
Gravel 0.6-7.0m
Machine slotted PVC screen 2.0-7.0m
End cap





RIG: Hand tools & DT250 **DRILLER:** GM **LOGGED:** VK **CASING:** HW to 4.0m
TYPE OF BORING: Hand auger to 1.0m; 110mm diameter solid flight auger to 4.0m; Rotary (mud) drilling to 7.0m
WATER OBSERVATIONS: Free groundwater observed at 2.6m during drilling. Measured at 2.26m on 21/10/15
REMARKS: *No sample recovered

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.5 AHD
EASTING: 334347
NORTHING: 6246770
DIP/AZIMUTH: 90°/--

BORE No: BH4
PROJECT No: 85100.02
DATE: 13/10/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT (Footpath)	A/E	0.05 0.15		PID=2		
19	0.3	FILLING - yellow, gravelly sand filling, fine to medium igneous and sandstone gravel, dry	A/E	0.3 0.4		PID=2		
	0.9	FILLING - grey, silty sand, trace of brick, tile, glass and fine to coarse gravel, dry 0.7m: light brown and grey	A/E	0.7 0.8		PID=1		
18		SAND - loose, brown, medium to coarse sand (possible filling)	S	1.0 1.45		3,3,4 N = 7		
			A/E	1.8 2.0		PID=1		
17	2.5	SAND - medium dense, grey, fine to medium sand	S	2.5 2.95		2,5,7 N = 12		
16		3.2m: wet	A/E*	3.3 3.5		PID=3	▼ 13-10-15	
			S	4.0 4.45		9,12,12 N = 24		
15	4.5	SAND - medium dense, dark brown, medium to coarse sand (possibly peaty - water return dark brown)						
14	5.0	SAND - very dense, coffee brown, medium to coarse sand, trace of silt	S	5.5 5.74		29,25/90mm refusal		
13	6.5	SAND - dense, light grey, medium to coarse sand, trace of clay	S	7.0 7.45		19,21,12 N = 33		
12 11 10	7.45	Bore discontinued at 7.45m - target depth reached						

RIG: Hand tools & DT250 **DRILLER:** GM **LOGGED:** VK/IW **CASING:** HW to 4.0m

TYPE OF BORING: Hand auger to 1.0m; 110mm diameter solid flight auger to 4.0m; Rotary (mud) drilling to 7.0m

WATER OBSERVATIONS: Free groundwater observed at 3.2m

REMARKS: *BD1-131015 taken at 3.3m to 3.5m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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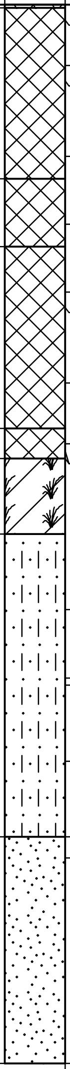
BOREHOLE LOG

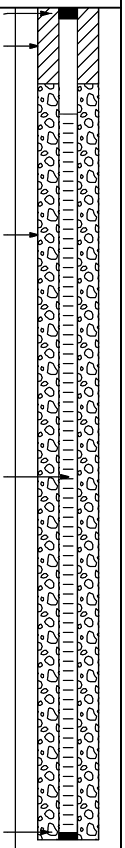
CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 17.9 AHD
EASTING: 334286
NORTHING: 6246617
DIP/AZIMUTH: 90°/--

BORE No: BH5
PROJECT No: 85100.02
DATE: 14/10/2015
SHEET 1 OF 1



Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water	Well Construction Details
0.02	TOPSOIL	A/E	0.0 0.1		PID=1		Gatic cover
	FILLING - dark brown, silty sand filling, trace of white ceramic, rootlets and igneous gravel	A/E	0.4 0.5		PID=1		Bentonite 0.0-0.5m
	0.8-0.95m: granite slab						
1.15	FILLING - light grey-brown, fine to coarse sand filling with a trace of igneous gravel	S	1.0 1.45		2,2,1 N = 3		Backfilled with gravel 0.5-5.5m
1.6	FILLING - dark brown, silty, fine to coarse sand filling with a trace of slag and brick	A/E*	1.9 2.0		PID=2		
	2.7m: brown-orange, silty sand filling	S	2.5 2.95		1,1,1 N = 2	21-1014510	
2.8	FILLING - dark brown, silty, fine to coarse sand filling with some clay, trace of paver, glass and clinker, wet	A/E	2.9 3.0		PID=5		
3.0	PEATY CLAY - firm to stiff, dark brown, peaty clay, with some silt						Machine slotted PVC screen 0.7-5.5m
3.5	SILTY SAND - very loose, dark brown silty sand, wet	S	4.0 4.45		1,1,0 N = 1 (sample loss)		
		A	4.5 5.0				
5.5	SAND - very dense, grey, fine to coarse sand, with some silt	S	5.5 5.64		35/140mm refusal		End cap
7.0	Bore discontinued at 7.0m - target depth reached						



RIG: DT250 **DRILLER:** GM **LOGGED:** VK/IW **CASING:** Uncased

TYPE OF BORING: 112mm diameter solid flight auger to 7.0m

WATER OBSERVATIONS: Free groundwater observed at 2.6m during drilling, and at 2.83m on 21/10/15

REMARKS: *BD3-141015 taken at 1.9m to 2.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.4 AHD
EASTING: 334329
NORTHING: 6246684
DIP/AZIMUTH: 90°/--

BORE No: BH5A
PROJECT No: 85100.02
DATE: 14/10/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.03	MULCH		A/E	0.03 0.1		PID<1.0		
19		FILLING - brown, silty, fine to medium sand filling with some organic material, trace of slag and igneous gravel 0.4m: clinker cobble and concrete fragments 0.5m: some yellow sandstone gravel, paver and concrete fragments		A/E	0.4 0.5		PID=2		
	0.7			E	0.7 0.8		PID<1.0		
18	1	FILLING - crushed sandstone cobbles and brown, silty, medium to coarse sand filling		S	1.0 1.45		2,3,2 N = 5		
	1.6	FILLING - dark brown, fine to coarse sand filling with a trace of silt and slag		A/E*	1.9 2.0		PID=1		
17	2			S	2.5 2.76		2,30/110mm refusal		
	2.76	Bore discontinued at 2.76m - due to refusal on concrete							

RIG: Hand tools & DT250 **DRILLER:** GM **LOGGED:** VK/IW **CASING:** Uncased

TYPE OF BORING: Hand auger to 1.0m; 110mm diameter solid flight auger to 2.7m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *BD2-141015 taken at 1.9m to 2.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.4 AHD
EASTING: 334327
NORTHING: 6246687
DIP/AZIMUTH: 90°/--

BORE No: BH5B
PROJECT No: 85100.02
DATE: 14/10/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.03	GRASS (Lawn)							
	0.7	FILLING - brown, silty, fine to medium sand filling with a trace of organic material, slag, igneous gravel and concrete	▨						
	0.8	FILLING - crushed sandstone cobbles and brown, silty, medium to coarse sand filling	▨						
		Bore discontinued at 0.8m - due to refusal on possible disused conduit							

RIG: Hand tools **DRILLER:** GM **LOGGED:** VK/IW **CASING:** Uncased
TYPE OF BORING: Hand auger to 1.0m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: *No samples retrieved

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 20.0 AHD
EASTING: 334392
NORTHING: 6246868
DIP/AZIMUTH: 90°/--

BORE No: BH101
PROJECT No: 85100.02
DATE: 23 - 29/3/2018
SHEET 1 **OF** 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
20	0.1	FILLING - mulch		A	0.05 0.1				
	0.4	FILLING - loosely placed, dark grey, silty sand filling, with some rootlets, organics and gravel, moist							
	0.55	CONCRETE SLAB		A	0.55 0.6				
19	1	FILLING - poorly compacted, dark grey, sand filling, with some ripped sandstone gravel and silt, moist		A	0.9 1.0				1
				S	1.45		2,4,3 N = 7		
18	2 2.0	SAND - very loose, light brown to brown, medium sand, damp							2
				S	2.5 2.95		1,1,1 N = 2		
17	3							▼	3
	3.5	SAND - medium dense, light brown, medium sand, wet							
16	4			S	4.0 4.45		1,4,7 N = 11		4
15	5								5
	5.5	SAND - medium dense, dark grey, medium sand, with some organic matter, wet		S	5.5 5.95		8,9,10 N = 19		
14	6								6
	6.5	SAND - medium dense, light grey, medium sand, wet							
13	7			S	7.0 7.45		8,11,12 N = 23		7
12	8 8.0	SAND - very dense, light grey, medium sand, wet							8
				S	8.5 8.9		20,21,30/100mm refusal		
11	9 9.0	Bore discontinued at 9.0m - target depth reached							9

RIG: Comacchio Geo 305
DRILLER: Ground Test
LOGGED: AT
CASING: HQ to 4.3m

TYPE OF BORING: 110mm diameter spiral flight auger (TC-bit) to 0.4m depth; 500mm diameter NDD to 0.4m depth; 125mm diameter diatube coring to 0.55m depth; 110mm spiral flight auger to 4.0m depth; rotary (washboring) to 9.0m depth

WATER OBSERVATIONS: Free groundwater observed at 3.2m depth

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 20.0 AHD
EASTING: 334362
NORTHING: 6246818
DIP/AZIMUTH: 90°/--

BORE No: BH102
PROJECT No: 85100.02
DATE: 23 - 28/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
20	0.1	FILLING - mulch							
		FILLING - loosely placed, grey, silty sand filling, with some organic matter, trace of gravel							
19	0.8	FILLING - poorly to moderately compacted, dark grey, sand filling, trace of silt and gravel							
18	1.8	SAND - medium dense, light grey to brown sand, trace of silt, damp							
	2.0	SAND - medium dense, light brown, fine to coarse sand, trace of silt, wet							
17				S	2.5 2.95		5,7,11 N = 18		
								▼	
16				S	4.0 4.45		6,11,14 N = 25		
15	5.0	SAND - dense, light brown to light grey, medium sand, wet							
14				S	5.5 5.87		8,22,23 N = 45		
13				S	7.0 7.45		14,20,23 N = 43		
12	8.5	CLAYEY SAND - very dense, light grey, medium clayey sand, low plasticity clay, damp		S	8.5 8.93		2,21,30 N = 51		
11	9.0	Bore discontinued at 9.0m - target depth reached							

RIG: Dando Terrier **DRILLER:** BG Drilling **LOGGED:** AT **CASING:** HQ to 2.5m

TYPE OF BORING: 200mm diameter NDD to 2.0m depth; rotary (washboring) to 9.0m depth

WATER OBSERVATIONS: Free groundwater observed at 3.6m depth

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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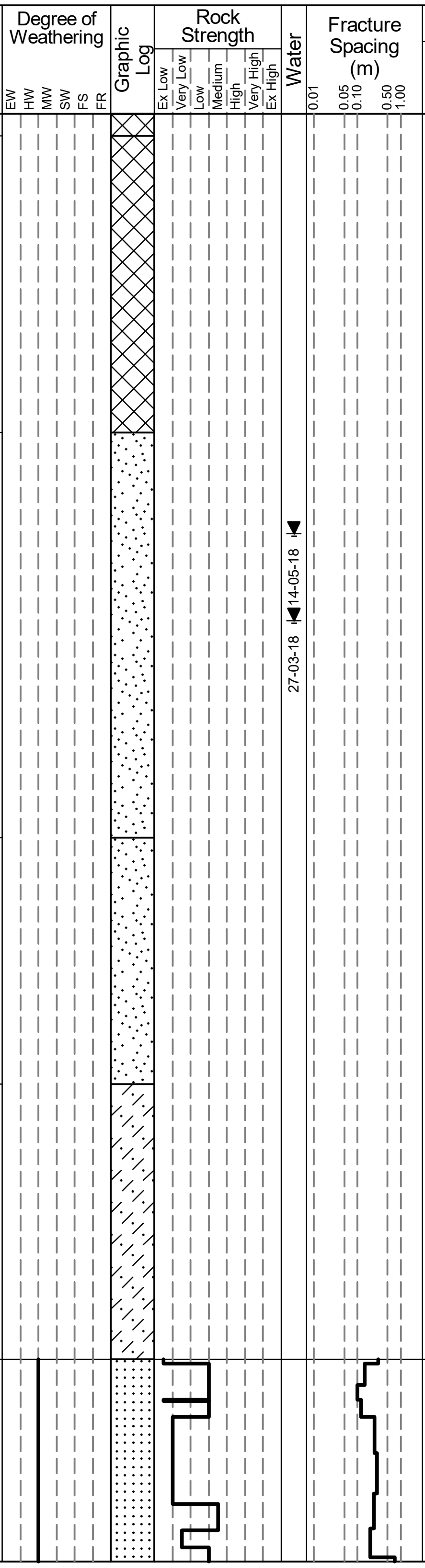
BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.2 AHD
EASTING: 334347
NORTHING: 6246724
DIP/AZIMUTH: 90°/--

BORE No: BH103
PROJECT No: 85100.02
DATE: 27/3/2018
SHEET 1 OF 2



Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
0.15	FILLING - dark brown, sandy silt filling, with some rootlets, dry to moist (topsoil)		A			
	FILLING - moderately compacted, dark grey fine to medium sand filling, with some silt, trace of ripped sandstone, concrete and igneous gravel, moist		A A S			5,5,6 N = 11
2.2	SAND - very loose to loose, light brown, medium sand, moist to wet		S S			4,4,4 N = 8 1,0,1 N = 1
5.0	SAND - medium dense, light brown, medium sand, moist to wet		S			8,11,14 N = 25
6.7	CLAYEY SAND - medium dense, light grey, clayey sand, damp	Unless otherwise stated rock is fractured along rough planar bedding, dipping at 0°-10°	S			3,6,10 N = 16
8.6	SANDSTONE - alternating bands of low to very low and medium strength, highly to moderately weathered, slightly fractured, light grey-brown and brown, fine to medium grained sandstone	8.78m: J60°, un,ro, cln 9m: B5°, cly 5mm 9.25 to 9.3m: Ds 9.53m: J70°, un, ro, fe 9.77m: B0°, cly 3mm	C	100	48	PL(A) = 0.33 PL(A) = 0.4

RIG: Comacchio Geo 305 **DRILLER:** Ground Test **LOGGED:** AT/SI **CASING:** HQ to 3.5m

TYPE OF BORING: 110mm diameter spiral flight auger (TC-bit) to 4.0m depth; rotary (washboring) to 8.5m depth; NMLC coring to 11.0m depth

WATER OBSERVATIONS: Free groundwater observed at 3.5m depth

REMARKS: Standpipe installed to 11.0m: (Screen 2.0m to 11.0m; Gravel: 0m to 1.0m; Bentonite: 1.0m to 2.0m; Gravel: 2.0m to 11.0m; Gatic cover on the top)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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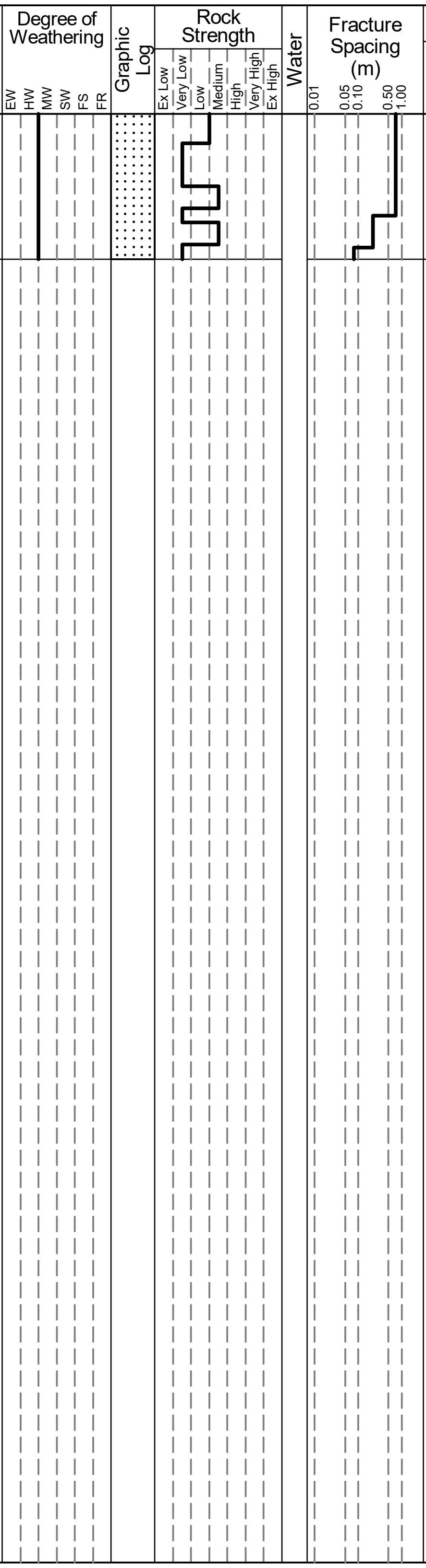
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.2 AHD
EASTING: 334347
NORTHING: 6246724
DIP/AZIMUTH: 90°/--

BORE No: BH103
PROJECT No: 85100.02
DATE: 27/3/2018
SHEET 2 OF 2



RL	Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
9		SANDSTONE - alternating bands of low to very low and medium strength, highly to moderately weathered, slightly fractured, light grey-brown and brown, fine to medium grained sandstone *(continued)*	10.7m: B0°, cly	C	100	48	PL(A) = 0.29 PL(A) = 0.4
	11 11.0	Bore discontinued at 11.0m - target depth reached					
8							
	12						
7							
	13						
6							
	14						
5							
	15						
4							
	16						
3							
	17						
2							
	18						
1							
	19						
0							

RIG: Comacchio Geo 305 **DRILLER:** Ground Test **LOGGED:** AT/SI **CASING:** HQ to 3.5m

TYPE OF BORING: 110mm diameter spiral flight auger (TC-bit) to 4.0m depth; rotary (washboring) to 8.5m depth; NMLC coring to 11.0m depth

WATER OBSERVATIONS: Free groundwater observed at 3.5m depth

REMARKS: Standpipe installed to 11.0m: (Screen 2.0m to 11.0m; Gravel: 0m to 1.0m; Bentonite: 1.0m to 2.0m; Gravel: 2.0m to 11.0m; Gatic cover on the top)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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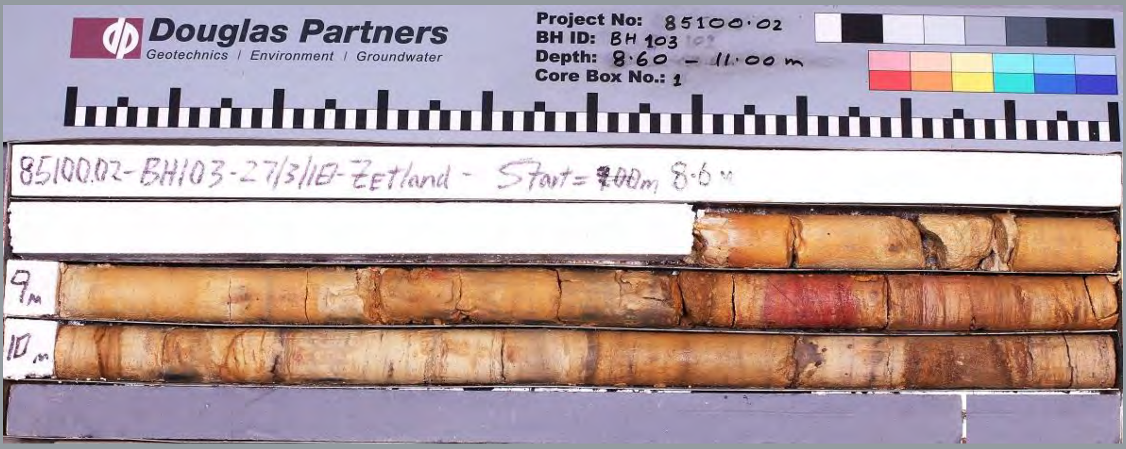
BORE: 103 PROJECT: ZETLAND MARCH 2018



8.6 – 11.0m

BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.3 AHD
EASTING: 334347
NORTHING: 6246712
DIP/AZIMUTH: 90°/--

BORE No: BH104
PROJECT No: 85100.02
DATE: 26/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - dark grey, sandy silt filling, with some rootlets, dry to moist (topsoil)		A	0.1 0.2				
	0.3	FILLING - apparently moderately compacted, brown, medium sand filling, trace of silt and igneous gravel, moist		A	0.4 0.45				
	0.6	FILLING - apparently well compacted, pale grey-brown, ripped, medium-grained sandstone filling, trace of silt, humid		A S	0.9 1.0 1.28		8,25/130mm refusal		
	2.2	SAND - medium dense, light brown to brown, fine to medium sand, trace of silt, moist		S	2.5 2.95		4,5,6 N = 11		
	3.5	SAND - medium dense, light brown to brown, fine to medium sand, trace of silt, wet		S A	4.0 4.45 4.9 5.0		1,4,10 N = 14	▷	
	5.0	SAND - dense, light brown to brown, medium sand, trace of silt, moist		S A A	5.45 5.5 6.0 6.1 6.9 7.0		9,14,24 N = 38		
	7.0	SANDY CLAY - very stiff, grey, sandy clay, medium sand, moist		S	7.45		8,8,22 N = 30		
	7.9	SANDSTONE - extremely low to very low strength, red brown to brown, medium grained sandstone, with some ironstone bands		S	8.5 8.75		12,25/100mm refusal		
	9.0	Bore discontinued at 9.0m - target depth reached							

RIG: Comacchio Geo 305 **DRILLER:** Ground Test **LOGGED:** AT **CASING:** HQ to 4.2m

TYPE OF BORING: 110mm diameter spiral flight auger (TC-bit) to 4.5m depth; rotary (washboring) to 9.0m depth

WATER OBSERVATIONS: Groundwater seepage observed at 3.5m depth

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.0 AHD
EASTING: 334323
NORTHING: 6246663
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 85100.02
DATE: 28/3/2018
SHEET 1 OF 1

Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
0.1	FILLING - dark brown, sandy silt filling, with some rootlets, dry to moist (topsoil)	A	0.05 0.1			
	FILLING - moderately compacted, red brown to brown, clayey sand filling, with some ripped sandstone, concrete and ironstone gravel	A	0.4 0.5			
		A	0.9 1.0			
		S	1.0 1.45		1,1,3 N = 4	
1.7	SAND - loose, brown to dark grey-brown, medium sand, trace of silt and organic matter, damp	S	2.5 2.95		2,7,12 N = 19	
2.7	SAND - medium dense, brown to dark brown, medium sand, wet					▼
		S	4.0 4.45		11,20,22 N = 42	
5.0	SAND - dense, brown and dark grey, medium sand, with some organic matter, damp to wet	S	5.5 5.95		15,24,26 N = 50	
7.8	CLAYEY SAND - medium dense, grey-brown, clayey sand, damp	S	8.5 8.95		5,8,13 N = 21	
9.0	Bore discontinued at 9.0m - target depth reached					

RIG: Comacchio Geo 305 **DRILLER:** Ground Test **LOGGED:** AT **CASING:** HQ to 4.2m

TYPE OF BORING: 110mm diameter spiral flight auger (TC-bit) to 4.0m depth; rotary (washboring) to 9.0m depth

WATER OBSERVATIONS: Free groundwater observed at 3.5m depth

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 18.5 AHD
EASTING: 334317
NORTHING: 6246655
DIP/AZIMUTH: 90°/--

BORE No: BH106
PROJECT No: 85100.02
DATE: 27/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	FILLING - dark brown, sandy silt filling, with some rootlets, dry to moist (topsoil)		A	0.1 0.2				
		FILLING - moderately compacted, red brown to brown, clayey sand filling, with some ripped sandstone, concrete and igneous gravel		A A S	0.4 0.5 0.9 1.0 1.45		3,4,3 N = 7		
	1.8	SAND - loose, dark grey, fine to coarse sand, with some silt, damp (possibly filling)		S	2.5 2.95		5,2,2 N = 4		
	3.4	SAND - loose, light brown to brown, fine to coarse sand, trace of silt and fine gravel, damp to wet		S	4.0 4.45		2,3,4 N = 7	▼	
	5.5	SAND - medium dense, grey-brown, medium sand, trace of organic matter, wet		S	5.5 5.95		6,10,13 N = 23		
	7.0	SAND - medium dense, brown, medium sand, wet		S	7.0 7.45		11,13,14 N = 27		
	7.5	CLAYEY SAND - medium dense, light brown to brown, medium clayey sand, medium to high plasticity clay, damp to wet		S	8.5 8.95		6,11,13 N = 24		
	9.0	Bore discontinued at 9.0m - target depth reached							

RIG: Comacchio Geo 305 **DRILLER:** Ground Test **LOGGED:** AT **CASING:** HQ to 4.2m

TYPE OF BORING: 110mm diameter spiral flight auger (TC-bit) to 4.0m depth; rotary (washboring) to 9.0m depth

WATER OBSERVATIONS: Free groundwater observed at 3.8m depth

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

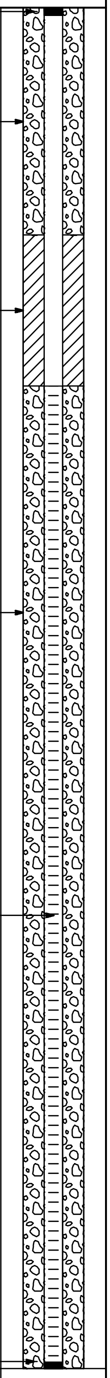
BOREHOLE LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 18.3 AHD
EASTING: 334310
NORTHING: 6246647
DIP/AZIMUTH: 90°/--

BORE No: BH107
PROJECT No: 85100.02
DATE: 28/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water	Well Construction Details
18	0.2	FILLING - dark brown, sandy silt filling, with some rootlets, dry to moist (topsoil)	A	0.05 0.1				Flush gatic cover
		FILLING - variably compacted, brown, sandy clay filling, with some ripped sandstone gravel, moist	A	0.4 0.5				
17			A	0.9 1.0				Gravel
			S	1.0 1.45		6,7,7 N = 14		
16								Bentonite
15	3.3		S	2.5 2.95		1,3,5 N = 8	▼ 28-03-18 ▼	
	4.0	SAND - very loose to loose, light brown to brown, medium sand, wet						
14		SAND - very loose, dark grey, medium sand, with some organic matter, wet	S	4.0 4.45		0,1,1 N = 2		Gravel
13	6.0	- medium dense below 5.5m depth	S	5.5 5.95		3,2,10 N = 12		
12		SAND - medium dense to dense, brown, medium sand, wet						Machine slotted PVC screen
11	8.0		S	7.0 7.45		10,14,21 N = 35		
10	9.0	CLAYEY SAND - medium dense, light brown, clayey sand, damp	S	8.5 8.95		1,6,10 N = 16		End cap
9		Bore discontinued at 9.0m - target depth reached						



RIG: Comacchio Geo 305 **DRILLER:** Ground Test **LOGGED:** AT **CASING:** HQ to 5.0m

TYPE OF BORING: 110mm diameter spiral flight auger (TC-bit) to 4.0m depth; rotary (washboring) to 9.0m depth

WATER OBSERVATIONS: Free groundwater observed at 3.2m depth

REMARKS: Standpipe installed to 9.0m: (Screen 2.5m to 9m; Gravel: 0m to 1.5m; Bentonite: 1.5m to 2.5m; Gravel: 2.5m to 9.0m; Gatic cover on the top)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Appendix D

Test Pits

TEST PIT LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.4 AHD
EASTING: 334325
NORTHING: 6246681

PIT No: TP108
PROJECT No: 85100.02
DATE: 26/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
	0.05	FILLING - mulch	▨						
		FILLING - brown silty sand filling, with some organic matter, trace of gravel	▨						
	0.8	FILLING - ripped, coarse sandstone gravel filling, with some silty sand and steel mesh	▨						
	1.5	Pit discontinued at 1.5m - due to refusal on irregular concrete block and steel mesh							

RIG: Vacuum truck **LOGGED:** AT **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: Free groundwater not observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: City of Sydney Council
PROJECT: Joynton Avenue Stormwater Drainage Upgrade
LOCATION: Joynton Avenue, Zetland

SURFACE LEVEL: 19.5 AHD
EASTING: 334333
NORTHING: 6246690

PIT No: TP109
PROJECT No: 85100.02
DATE: 26/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm)
				Type	Depth	Sample	Results & Comments		5 10 15 20
		FILLING - topsoil	▨						
	0.3	FILLING - brown, medium to coarse, gravelly sand filling, coarse gravel of crush brick, concrete and sandstone fragments, trace of clay and silt	▨						
19	0.5	Pit discontinued at 0.5m - due to refusal on concrete slab							

RIG: Vacuum truck **LOGGED:** AT **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: Free groundwater not observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Appendix E

Cone Penetration Tests

CONE PENETRATION TEST

CLIENT: CITY OF SYDNEY

PROJECT: JOYNTON AVENUE TRUNK DRAIN PROJECT

LOCATION: JOYNTON AVENUE, ZETLAND

REDUCED LEVEL: 20.51

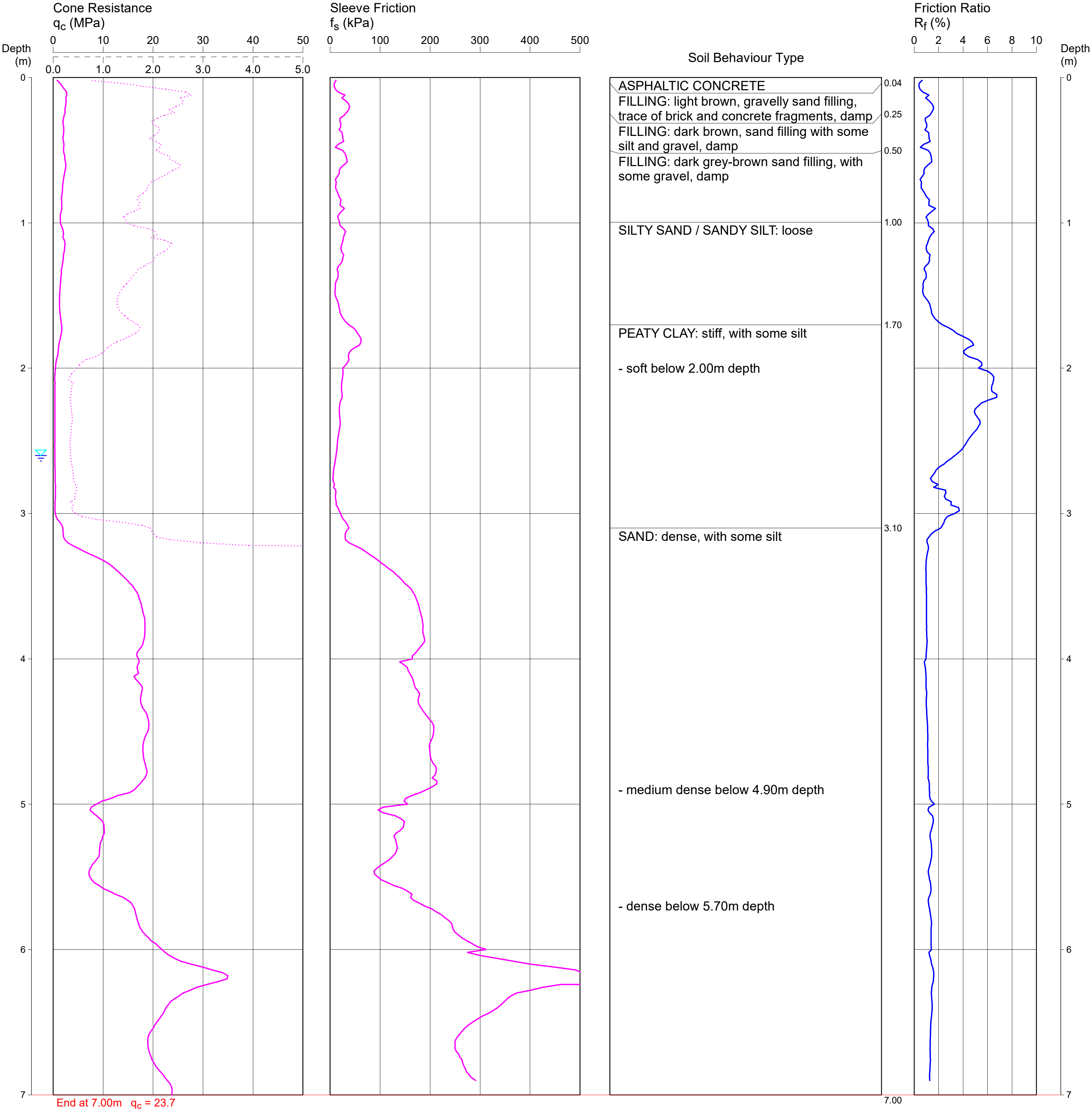
COORDINATES: 334451E 6247006N MGA94

CPT1

Page 1 of 1

DATE 12/10/2015

PROJECT No: 85100.00



0.04	ASPHALTIC CONCRETE
0.25	FILLING: light brown, gravelly sand filling, trace of brick and concrete fragments, damp
0.50	FILLING: dark brown, sand filling with some silt and gravel, damp
1.00	FILLING: dark grey-brown sand filling, with some gravel, damp
1.70	SILTY SAND / SANDY SILT: loose
3.10	PEATY CLAY: stiff, with some silt - soft below 2.00m depth
7.00	SAND: dense, with some silt - medium dense below 4.90m depth - dense below 5.70m depth

REMARKS: BITUMINOUS CONCRETE SURFACE SLAB CORED TO 0.04 m DEPTH PRIOR TO TESTING, HOLE PRE DRILLED TO 1.5 m DEPTH AND BACKFILLED PRIOR TO TESTING. HOLE COLLAPSE OBSERVED AT 2.6 m DEPTH AFTER WITHDRAWAL OF RODS.

Water depth after test: 2.60m depth (assumed)

File: P:\85100.00 - ZETLAND, Joyton Ave, Geo\4.0 Field Work\4.2 Testing\CPTs\CPT1.CP5
Cone ID: 120631 **Type:** I-CFXY-10

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: CITY OF SYDNEY

PROJECT: JOYNTON AVENUE TRUNK DRAIN PROJECT

LOCATION: JOYNTON AVENUE, ZETLAND

REDUCED LEVEL: 20.33

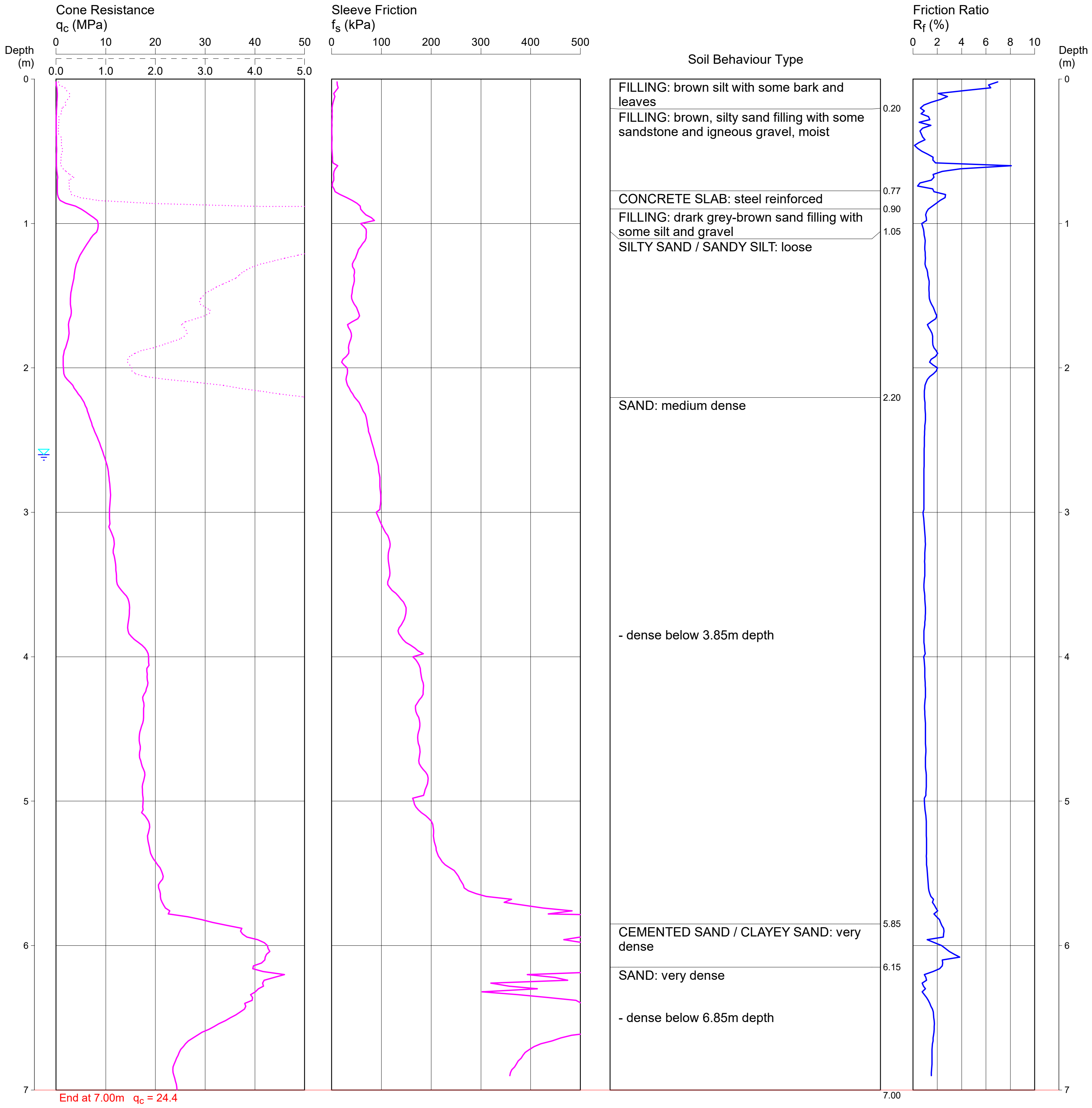
COORDINATES: 334413E 6246911N MGA94

CPT2

Page 1 of 1

DATE 13/10/2015

PROJECT No: 85100



REMARKS: CONCRETE SLAB CORED FROM 0.77 m TO 0.90 m DEPTH PRIOR TO TESTING, HOLE PRE DRILLED TO 1.0 m DEPTH AND BACKFILLED PRIOR TO TESTING. HOLE COLLAPSE OBSERVED AT 2.6 m DEPTH AFTER WITHDRAWAL OF RODS.

Water depth after test: 2.60m depth (assumed)

File: P:\85100.00 - ZETLAND, Joyton Ave, Geo\4.0 Field Work\4.2 Testing\CPTs\CPT2.CP5
Cone ID: 120631 **Type:** I-CFXY-10

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: CITY OF SYDNEY

PROJECT: JOYNTON AVENUE TRUNK DRAIN PROJECT

LOCATION: JOYNTON AVENUE, ZETLAND

REDUCED LEVEL: 17.91

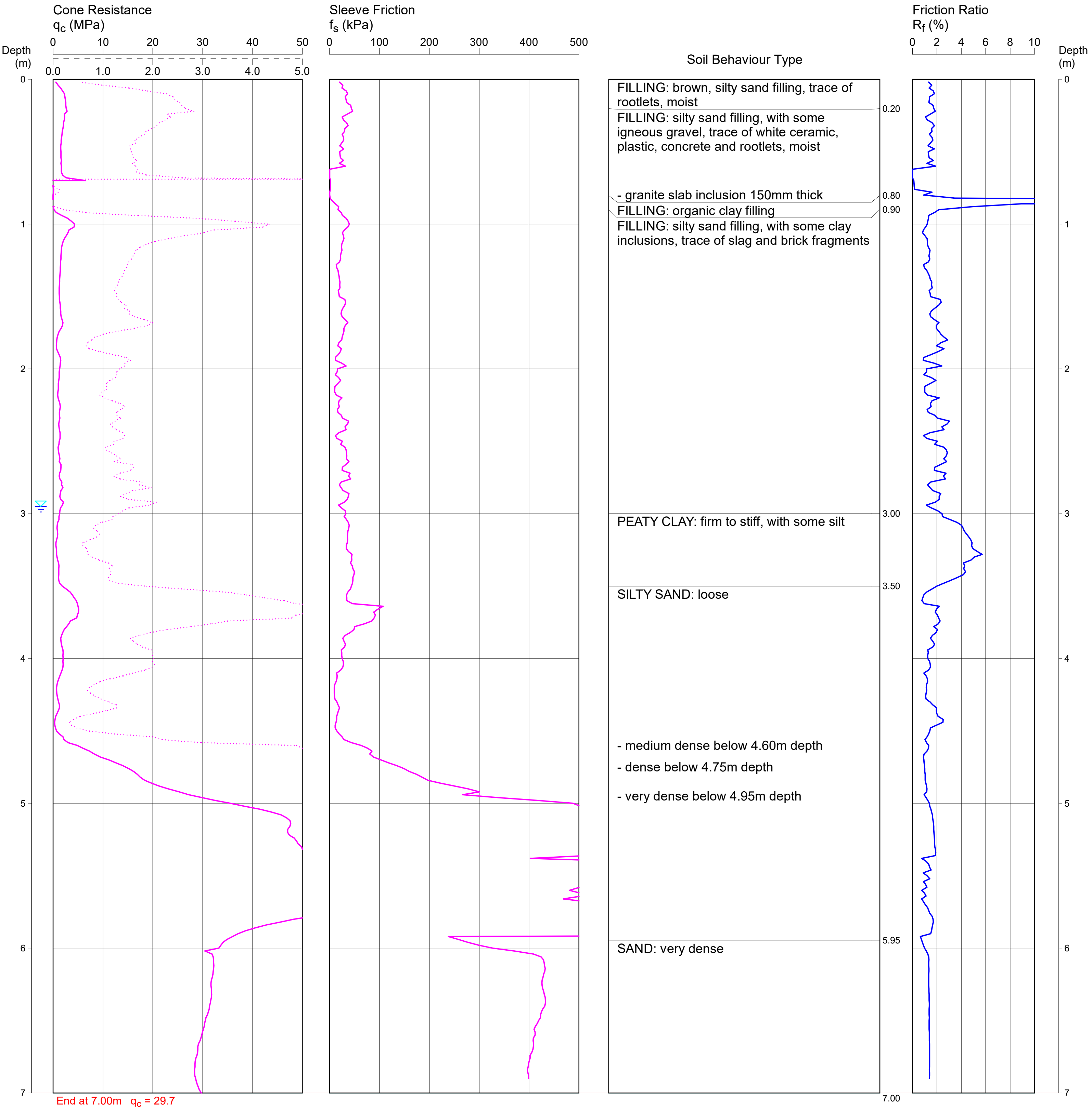
COORDINATES: 334288.55E 6246617.21N MGA94

CPT3

Page 1 of 1

DATE 13/10/2015

PROJECT No: 85100



REMARKS: HOLE PRE DRILLED TO 1.0 m DEPTH AND BACKFILLED PRIOR TO TESTING, DUMMY CONE USED FROM 0.7 m TO 1.0 m PRIOR TO TESTING.
GROUNDWATER OBSERVED AT 2.95 m DEPTH AFTER WITHDRAWAL OF RODS.

Water depth after test: 2.95m depth (measured)

File: P:\85100.00 - ZETLAND, Joyton Ave, Geo\4.0 Field Work\4.2 Testing\CPTs\CPT3.CP5
Cone ID: 120631 **Type:** I-CFXY-10

ConePlot Version 5.9.2

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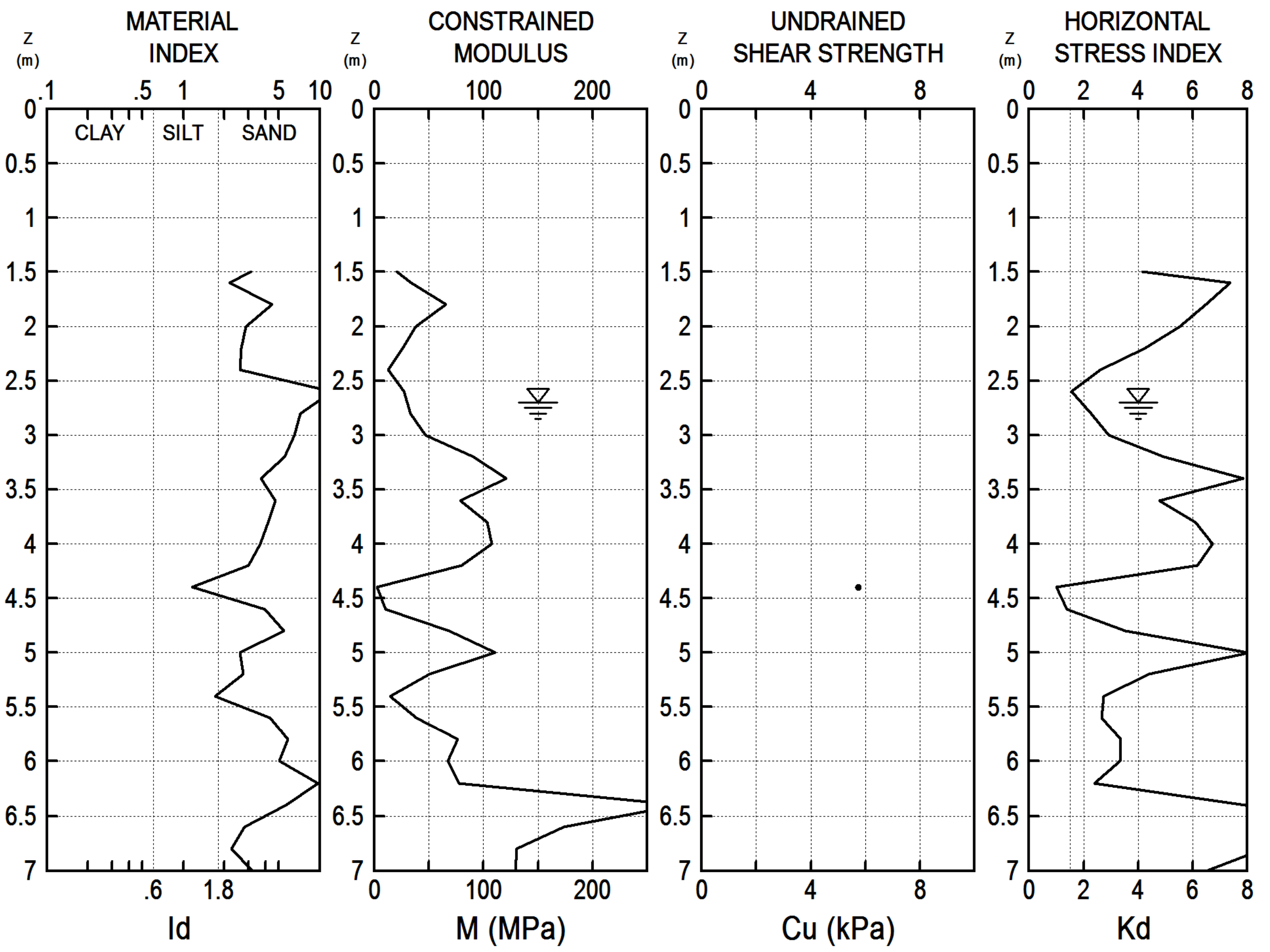
Appendix F

Dilatometer

DILATOMETER TEST (D M T)



Insitu Geotech Services

Douglas Partners

Joynton Ave Trunk Drain

Zetland NSW

INTERPRETED GEOTECHNICAL PARAMETERS

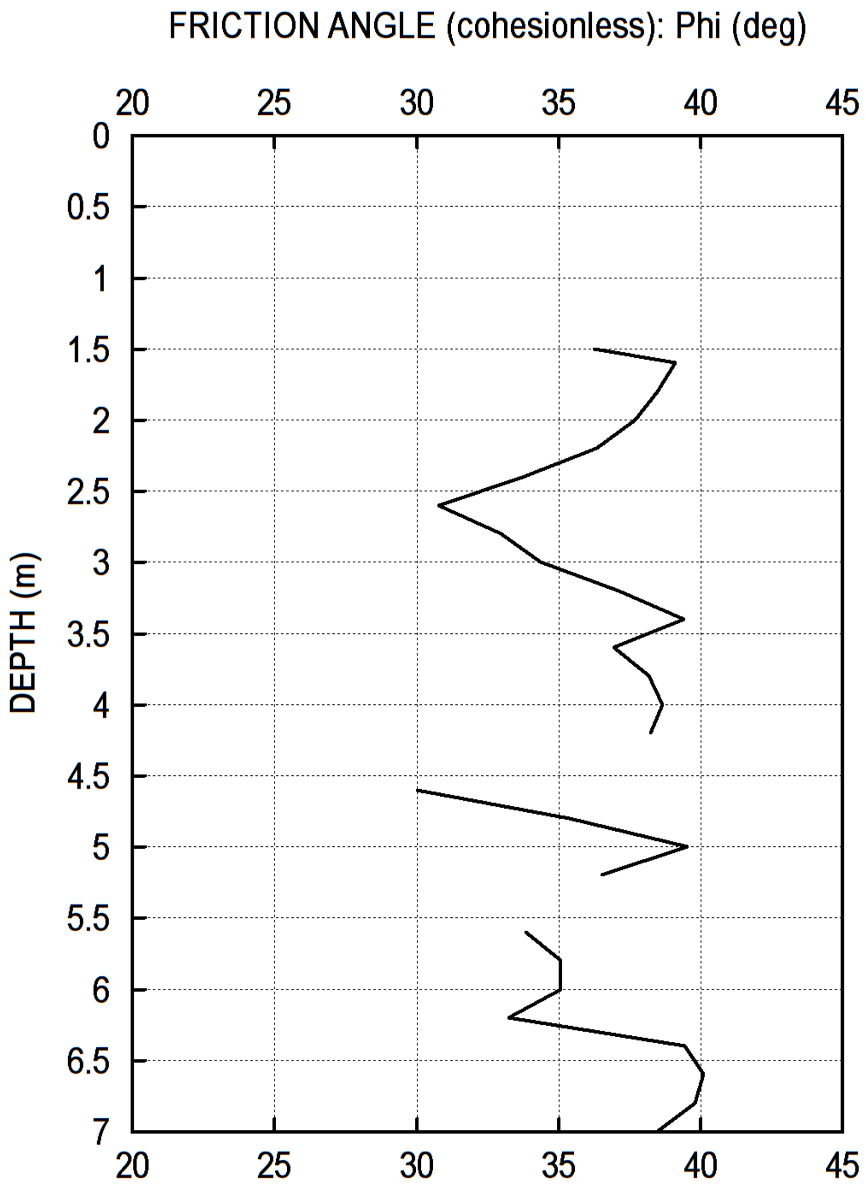
TEST

DMT01

13 OCT 2015

Insitu Geotech Services Douglas Partners
Joynton Ave Trunk Drain Zetland NSW
INTERPRETED GEOTECHNICAL PARAMETERS

TEST
DMT01
13 OCT 2015



DMT01

13 OCT 2015

Insitu Geotech Services
Douglas Partners
Joynton Ave Trunk Drain
Zetland NSW

LEGEND
Z = Depth Below Ground Level
Po,P1,P2 = Corrected A,B,C readings
Id = Material Index
Ed = Dilatometer Modulus
Ud = Pore Press. Index = (P2-Uo)/(Po-Uo)
Gamma = Bulk unit weight
Sigma' = Effective overb. stress
Uo = Pore pressure

INTERPRETED PARAMETERS
Phi = Safe floor value of Friction Angle
Ko = In situ earth press. coeff.
M = Constrained modulus (at Sigma')
Cu = Undrained shear strength
Ocr = Overconsolidation ratio
(OCR = 'relative OCR'- generally realistic. If accurate independent OCR available, apply suitable factor)

GENERAL PARAMETERS
DeltaA = 22 kPa
DeltaB = 60 kPa
GammaTop = 17.0 kN/m^3
FactorEd = 34.7
Zm = 0.0 kPa
Zabs = 0.0 m
Zw = 2.7 m

WaterTable at 2.70 m
Reduction formulae according to Marchetti, ASCE Geot.Jnl.Mar. 1980, Vol.109, 299-321; Phi according to TC16 ISSMGE, 2001

Z (m)	A (kPa)	B (kPa)	C (kPa)	Po (kPa)	P1 (kPa)	P2 (kPa)	Gamma (kN/m^3)	Sigma' (kPa)	Uo (kPa)	Id	Kd	Ed (MPa)	Ud	Ko	Ocr	Phi (Deg)	M (MPa)	Cu (kPa)	DMT01 DESCRIPTION
1.5	100	500		106	440		17.7	26	0	3.15	4.2	11.6				36	20.1		SILTY SAND
1.6	200	700		201	640		17.7	27	0	2.18	7.4	15.2				39	33.8		SILTY SAND
1.8	220	1150		200	1090		18.6	31	0	4.46	6.5	30.9				38	65.6		SAND
2.0	195	800		191	740		17.7	35	0	2.88	5.5	19.1				38	37.7		SILTY SAND
2.2	160	650		162	590		17.7	38	0	2.65	4.2	14.9				36	25.8		SILTY SAND
2.4	100	450		109	390		17.7	42	0	2.59	2.6	9.8				34	12.7		SILTY SAND
2.6	90	1000		71	940		17.7	45	0	12.31	1.6	30.2				31	26.8		SAND
2.8	125	950		110	890		17.7	48	1	7.17	2.3	27.1				33	33.0		SAND
3.0	170	1150		147	1090		17.7	49	3	6.54	2.9	32.7				34	46.9		SAND
3.2	300	1700		256	1640		18.6	51	5	5.51	4.9	48.0				37	90.7		SAND
3.4	470	2000		420	1940		19.6	53	7	3.68	7.9	52.8				39	120.8		SAND
3.6	305	1550		269	1490		18.6	55	9	4.70	4.8	42.4				37	78.7		SAND
3.8	400	1850		354	1790		18.6	56	11	4.19	6.1	49.8				38	103.1		SAND
4.0	450	1900		404	1840		19.6	58	13	3.68	6.7	49.8				39	107.5		SAND
4.2	415	1550		384	1490		18.6	60	15	2.99	6.2	38.4				38	79.7		SILTY SAND
4.4	60	210		79	150		15.7	62	17	1.15	1.0	2.5		< 0.3	<0.8		2.1	6	SILT
4.6	100	510		106	450		16.7	63	19	3.96	1.4	12.0				30	10.2		SAND
4.8	285	1550		248	1490		18.6	64	21	5.47	3.5	43.1				35	68.8		SAND
5.0	600	2000		556	1940		19.6	66	23	2.59	8.1	48.0				40	110.8		SILTY SAND
5.2	340	1200		323	1140		18.6	68	25	2.74	4.4	28.3				37	50.2		SILTY SAND
5.4	210	600		217	540		16.7	70	26	1.70	2.7	11.2					14.1		SANDY SILT
5.6	235	1100		218	1040		18.6	71	28	4.34	2.7	28.5				34	38.5		SAND
5.8	320	1750		275	1690		18.6	73	30	5.80	3.3	49.1				35	76.1		SAND
6.0	320	1600		282	1540		18.6	75	32	5.04	3.3	43.6				35	67.6		SAND
6.2	280	2050		218	1990		18.6	77	34	9.67	2.4	61.5				33	77.4		SAND
6.4	800	4200		656	4140		19.6	78	36	5.62	7.9	120.9				39	277.7		SAND
6.6	850	2900		774	2840		19.6	80	38	2.81	9.2	71.7				40	173.7		SILTY SAND
6.8	800	2400		746	2340		19.6	82	40	2.26	8.6	55.3				40	130.5		SILTY SAND
7.0	650	2400		589	2340		19.6	84	42	3.21	6.5	60.8				38	129.1		SILTY SAND

Appendix G

Geotechnical Laboratory Tests

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
96 Hermitage Road
West Ryde NSW 2114
PO Box 472
West Ryde NSW 1685
Phone (02) 9809 0666
Fax (02) 9809 4095

Results of Moisture Content, Plasticity and Linear Shrinkage Tests

Client:	**City of Sydney Council**	**Project No:**	85100
		Report No:	1
Project:	Joynton Avenue Trunk Drain Project	**Report Date:**	29/10/2015
		Date Sampled:	12/10/2015
		Date of Test:	28/10/2015
Location:	Joynton Avenue, Zetland	**Page:**	1 of 1

Test Location	Depth (m)	Description	Code	W_F %	W_L %	W_P %	PI %	*LS %
BH1	2.3-2.5	Silty sand / Peat	2,5	-	NO	NO	NP	-
BH2	3.3-3.5	Sand	2,5	-	NO	NO	NP	-
BH3	3.3-3.5	Sand	2,5	-	NO	NO	NP	-
BH4	3.3-3.5	Sand (possible fill)	2,5	-	NO	NO	NP	-
BH5	2.9-3.0	Silty clayey sand fill	2,5	-	25	23	2	-

Legend:

W_F	Field Moisture Content
W_L	Liquid limit
W_P	Plastic limit
PI	Plasticity index
LS	Linear shrinkage from liquid limit condition (Mould length)

Code:

Sample history for plasticity tests

1. Air dried
2. Low temperature (<50ºC) oven dried
3. Oven (105ºC) dried
4. Unknown

Method of preparation for plasticity tests

5. Dry sieved
6. Wet sieved
7. Natural

*Specify if sample crumbled CR or curled CU

Test Methods:

Moisture Content:	AS 1289 2.1.1
Liquid Limit:	AS 1289 3.1.2
Plastic Limit:	AS 1289 3.2.1
Plasticity Index:	AS 1289 3.3.1
Linear Shrinkage:	

Sampling Methods: Sampled by Engineering Department

Remarks:

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Tested: LW
Checked: MM

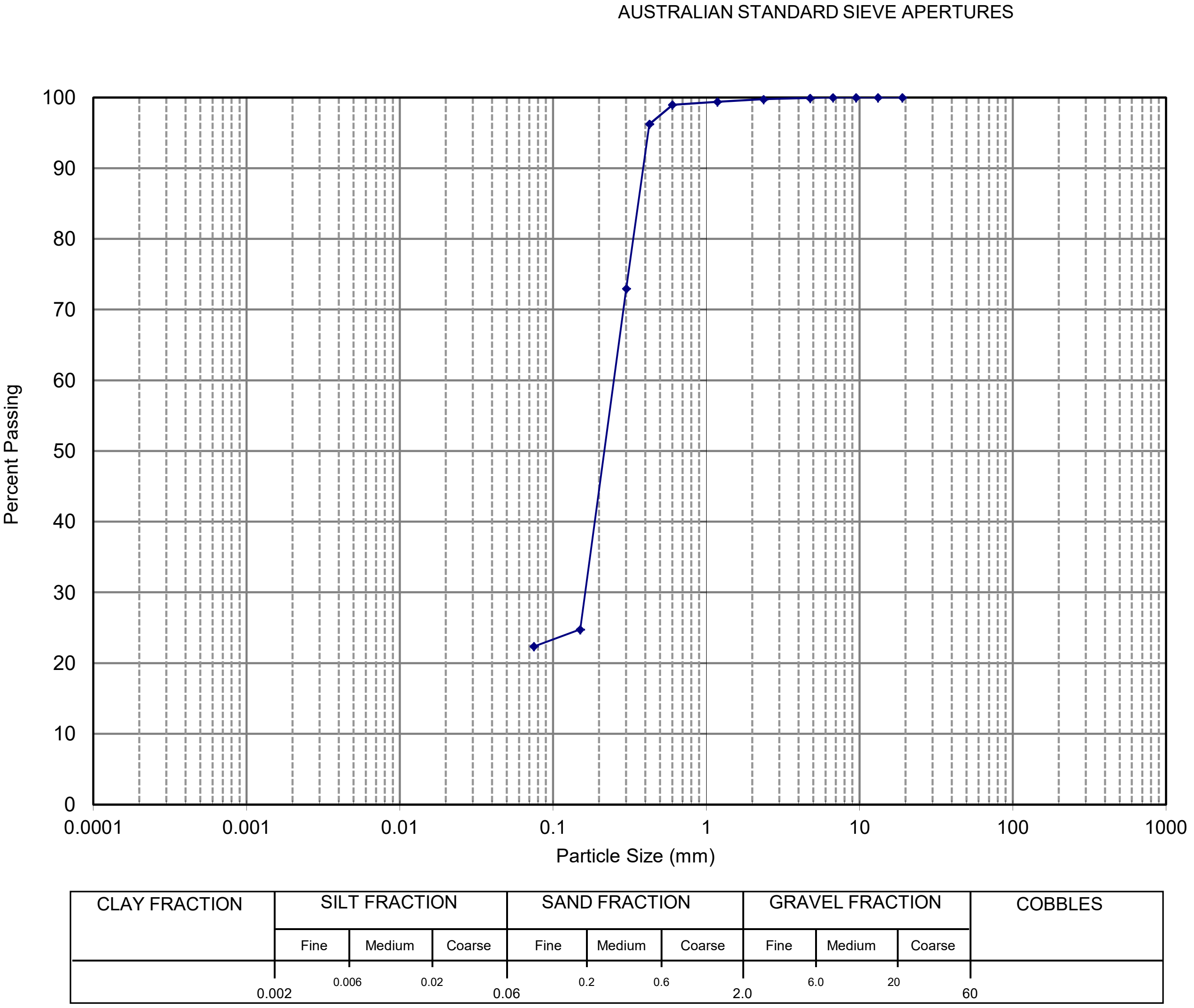
Mark Matthews
Laboratory Manager

Douglas Partners
Geotechnics | Environment | Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
96 Hermitage Road
West Ryde NSW 2114Phone (02) 9809 0666
Fax (02) 9809 4095

Results of Particle Size Distribution

Client :	City of Sydney Council	**Project No. :**	85100
		Report No. :	2
Project :	Joynton Avenue Trunk Drain Project	**Report Date :**	29/10/2015
Location :	Joynton Avenue, Zetland	**Date Sampled:**	20/10/2015
Test Location:	BH1	**Date of Test:**	20/10/2015
Depth / Layer:	2.3m - 2.5m		



Sieve Size (mm)	% Passing
150.0	~
100.0	~
75.0	~
53.0	~
37.5	~
26.5	~
19.0	**100%**
13.2	**100%**
9.5	**100%**
6.7	**100%**
4.75	**100%**
2.36	**100%**
1.18	**99%**
0.600	**99%**
0.425	**96%**
0.300	**73%**
0.150	**25%**
0.075	**22%**

Description: Silty Sand/Peat

Test Method(s): AS 1289.3.6.1

Sampling Method(s): Sampled by Engineering Department

Remarks:

NATA Accredited Laboratory Number: 828
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Mark Matthews
Laboratory Manager

Douglas Partners
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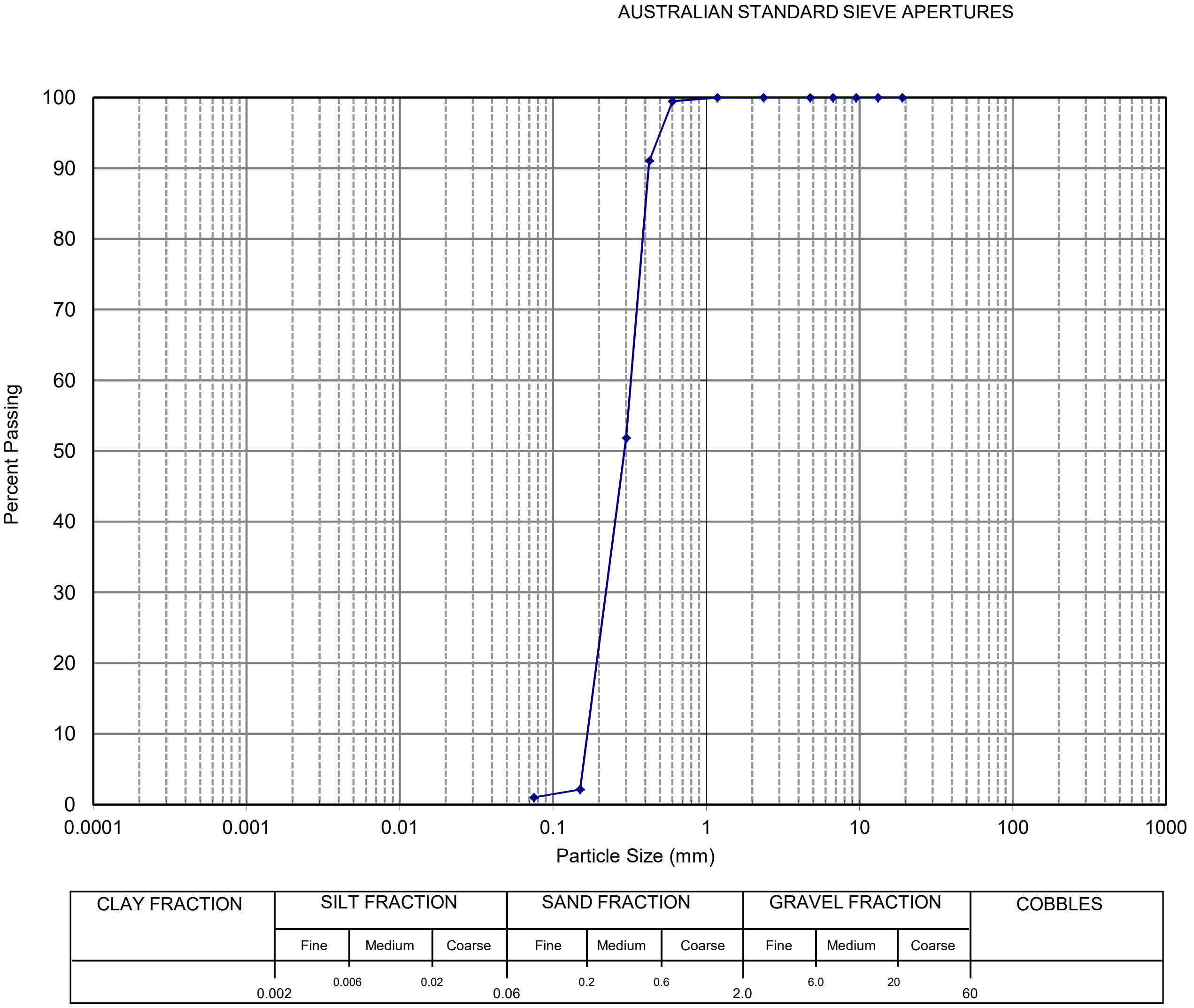
96 Hermitage Road
West Ryde NSW 2114Phone (02) 9809 0666
Fax (02) 9809 4095

Results of Particle Size Distribution

Client :	City of Sydney Council	**Project No. :**	85100
		Report No. :	3
Project :	Joynton Avenue Trunk Drain Project	**Report Date :**	29/10/2015
Location :	Joynton Avenue, Zetland	**Date Sampled:**	20/10/2015
Test Location:	BH2	**Date of Test:**	20/10/2015
Depth / Layer:	3.3m - 3.5m		



Sieve Size (mm)	% Passing
150.0	~
100.0	~
75.0	~
53.0	~
37.5	~
26.5	~
19.0	**100%**
13.2	**100%**
9.5	**100%**
6.7	**100%**
4.75	**100%**
2.36	**100%**
1.18	**100%**
0.600	**99%**
0.425	**91%**
0.300	**52%**
0.150	**2%**
0.075	**1%**

Description: Sand

Test Method(s): AS 1289.3.6.1

Sampling Method(s): Sampled by Engineering Department

Remarks:

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COMPETENCE

NATA Accredited Laboratory Number: 828
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Mark Matthews
Laboratory Manager

Douglas Partners
Geotechnics / Environment / Groundwater

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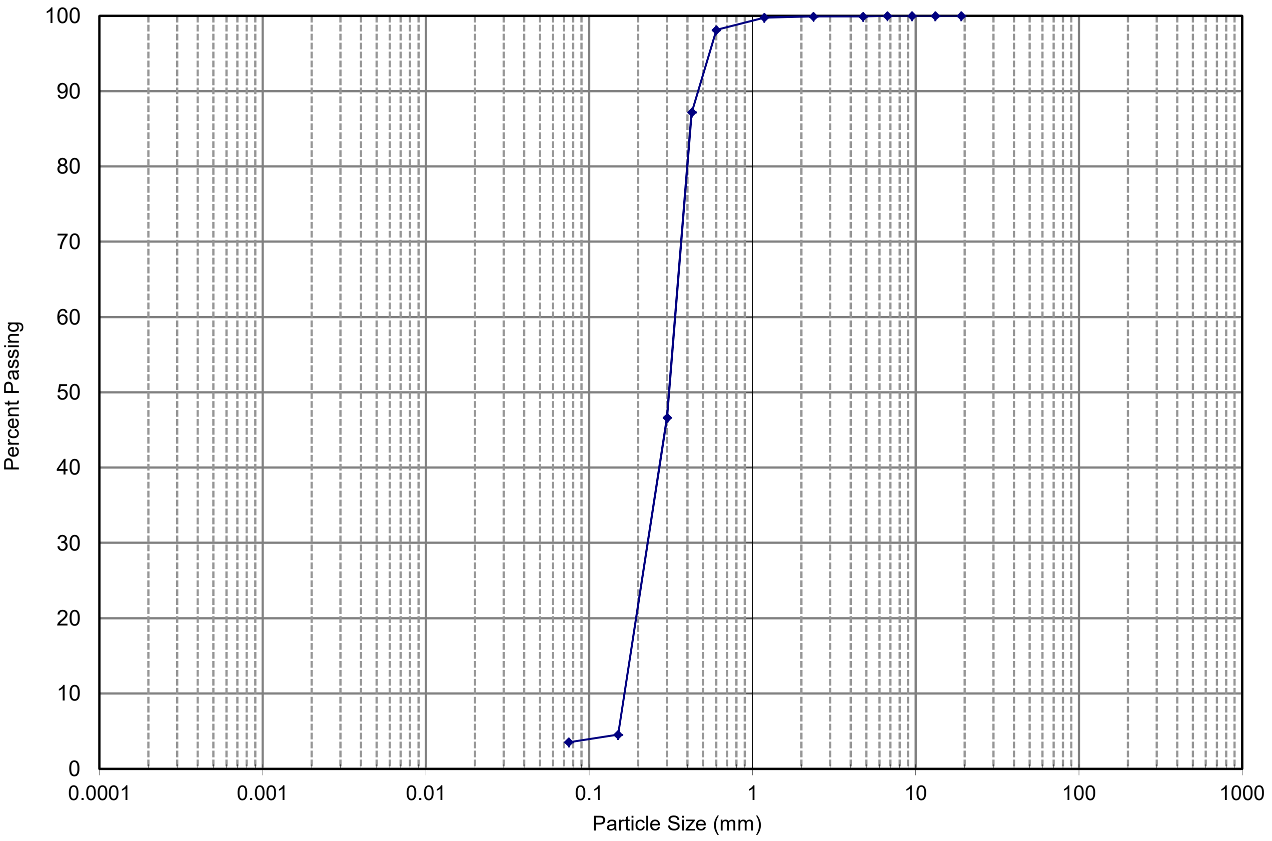
www.douglaspartners.com.au
96 Hermitage Road
West Ryde NSW 2114Phone (02) 9809 0666
Fax (02) 9809 4095

Results of Particle Size Distribution

Client :	City of Sydney Council	**Project No. :**	85100
		Report No. :	4
Project :	Joynton Avenue Trunk Drain Project	**Report Date :**	29/10/2015
Location :	Joynton Avenue, Zetland	**Date Sampled:**	20/10/2015
Test Location:	BH3	**Date of Test:**	20/10/2015
Depth / Layer:	3.3m - 3.5m		

AUSTRALIAN STANDARD SIEVE APERTURES



Sieve Size (mm)	% Passing
150.0	~
100.0	~
75.0	~
53.0	~
37.5	~
26.5	~
19.0	100%
13.2	100%
9.5	100%
6.7	100%
4.75	100%
2.36	100%
1.18	100%
0.600	98%
0.425	87%
0.300	47%
0.150	5%
0.075	4%

CLAY FRACTION	SILT FRACTION			SAND FRACTION			GRAVEL FRACTION			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.002	0.006	0.02	0.06	0.2	0.6	2.0	6.0	20	60	

Description: Sand

Test Method(s): AS 1289.3.6.1

Sampling Method(s): Sampled by Engineering Department

Remarks:

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Mark Matthews
Laboratory Manager

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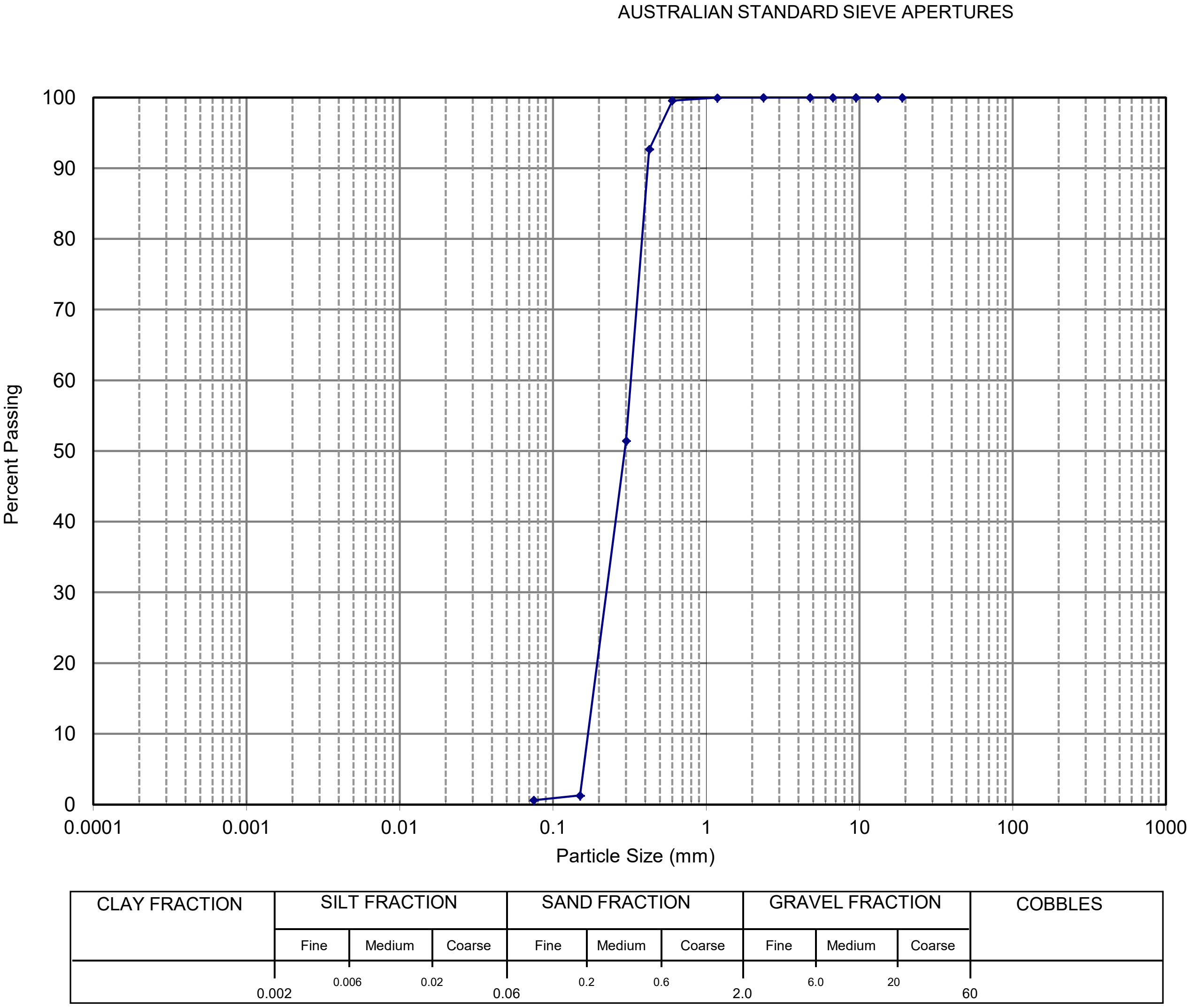
96 Hermitage Road
West Ryde NSW 2114Phone (02) 9809 0666
Fax (02) 9809 4095

Results of Particle Size Distribution

Client :	City of Sydney Council	**Project No. :**	85100
		Report No. :	5
Project :	Joynton Avenue Trunk Drain Project	**Report Date :**	29/10/2015
Location :	Joynton Avenue, Zetland	**Date Sampled:**	20/10/2015
Test Location:	BH4	**Date of Test:**	20/10/2015
Depth / Layer:	3.3m - 3.5m		



Sieve Size (mm)	% Passing
150.0	~
100.0	~
75.0	~
53.0	~
37.5	~
26.5	~
19.0	**100%**
13.2	**100%**
9.5	**100%**
6.7	**100%**
4.75	**100%**
2.36	**100%**
1.18	**100%**
0.600	**100%**
0.425	**93%**
0.300	**51%**
0.150	**1%**
0.075	**1%**

Description: Sand (Possbile filling)

Test Method(s): AS 1289.3.6.1

Sampling Method(s): Sampled by Engineering Department

Remarks:

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Mark Matthews
Laboratory Manager

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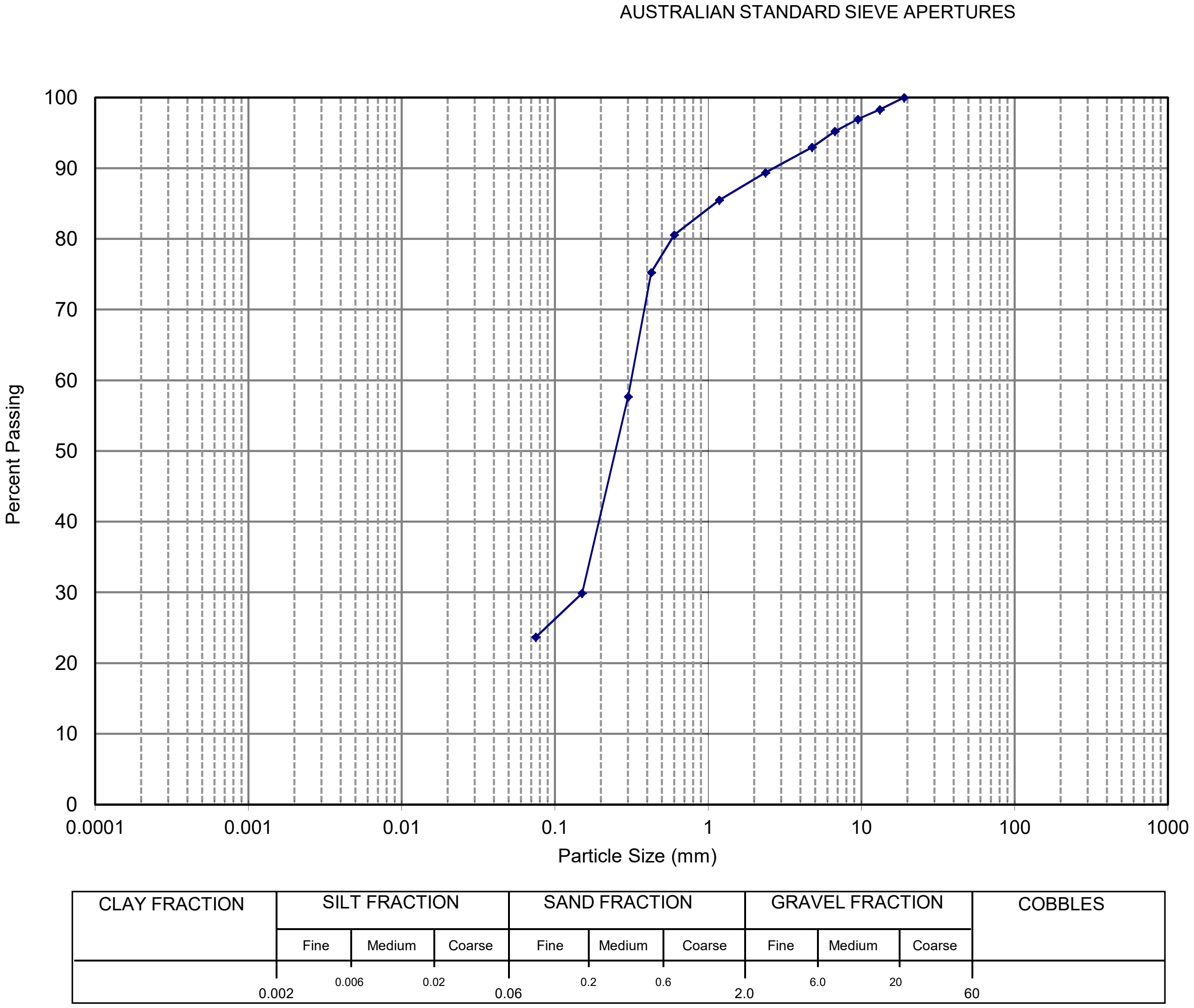
96 Hermitage Road
West Ryde NSW 2114Phone (02) 9809 0666
Fax (02) 9809 4095

Results of Particle Size Distribution

Client :	City of Sydney Council	**Project No. :**	85100
		Report No. :	6
Project :	Joynton Avenue Trunk Drain Project	**Report Date :**	29/10/2015
Location :	Joynton Avenue, Zetland	**Date Sampled:**	20/10/2015
Test Location:	BH5	**Date of Test:**	20/10/2015
Depth / Layer:	2.9m - 3m		



Sieve Size (mm)	% Passing
150.0	~
100.0	~
75.0	~
53.0	~
37.5	~
26.5	~
19.0	**100%**
13.2	**98%**
9.5	**97%**
6.7	**95%**
4.75	**93%**
2.36	**89%**
1.18	**85%**
0.600	**81%**
0.425	**75%**
0.300	**58%**
0.150	**30%**
0.075	**24%**

Description: Filling: Silty clayey sand

Test Method(s): AS 1289.3.6.1

Sampling Method(s): Sampled by Engineering Department

Remarks:

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Mark Matthews
Laboratory Manager

CERTIFICATE OF ANALYSIS 136167

Client:

Douglas Partners Pty Ltd
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Atha K

Sample log in details:

Your Reference:	**85100, Joynton Ave Trunk Drain Project**	
No. of samples:	5 Soils	
Date samples received / completed instructions received	20/10/15	/ 20/10/15

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	27/10/15	/ 22/10/15
Date of Preliminary Report:	Not Issued	

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Misc Inorg - Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	136167-1 BH1 2.5 14/10/2015 Soil	136167-2 BH2 4.0 14/10/2015 Soil	136167-3 BH3 2.5 14/10/2015 Soil	136167-4 BH4 4.0 14/10/2015 Soil	136167-5 BH5 2.5 14/10/2015 Soil
Date prepared	-	21/10/2015	21/10/2015	21/10/2015	21/10/2015	21/10/2015
Date analysed	-	21/10/2015	21/10/2015	21/10/2015	21/10/2015	21/10/2015
pH 1:5 soil:water	pH Units	4.4	6.4	7.2	6.7	7.5
Electrical Conductivity 1:5 soil:water	µS/cm	55	23	47	29	170
Chloride, Cl 1:5 soil:water	mg/kg	<10	<10	<10	<10	10
Sulphate, SO4 1:5 soil:water	mg/kg	44	<10	27	22	230

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			21/10/2015	136167-1	21/10/2015 || 21/10/2015	LCS-1	21/10/2015
Date analysed	-			21/10/2015	136167-1	21/10/2015 || 21/10/2015	LCS-1	21/10/2015
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	136167-1	4.4 || 4.4 || RPD: 0	LCS-1	100%
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	136167-1	55 || 58 || RPD: 5	LCS-1	93%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	136167-1	<10 || <10	LCS-1	102%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	136167-1	44 || 45 || RPD: 2	LCS-1	102%

QUALITY CONTROL Misc Inorg - Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	136167-2	21/10/2015
Date analysed	-	[NT]	[NT]	136167-2	21/10/2015
pH 1:5 soil:water	pH Units	[NT]	[NT]	[NR]	[NR]
Electrical Conductivity 1:5 soil:water	µS/cm	[NT]	[NT]	[NR]	[NR]
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]	136167-2	115%
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]	136167-2	109%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Douglas Partners
Geotechnics · Environment · Groundwater

CHAIN OF CUSTODY

Project Name: Joynton Avenue Trunk Drain Project
Project No: 85100 Sampler: IW
Project Mgr: AK Mob. Phone: 0418 747 383
Email: Atha.Kapitanof@douglaspartners.com.au
Date Required: Standard turnaround Lab Quote No.

To: Envirolab Services
12 Ashley Street, Chatswood NSW 2068
Attn: Aileen Hie
Phone: 02 9910 6200 Fax: 02 9910 6201
Email: ahie@envirolabservices.com.au

Sample ID	Sample Depth	Lab ID	Sampling Date	Sample Type	Container type	Analytes												
				S - soil W – water		Conductivity (1:5)	pH (1:5)	Sulphate (1:5)	Chloride (1:5)									Other
BH 1	SPT 2.5 m	1	14/10/15	S	Bag	✓	✓	✓	✓									
BH 2	SPT 4.0 m	2	14/10/15	S	Bag	✓	✓	✓	✓									
BH 3	SPT 2.5 m	3	14/10/15	S	Bag	✓	✓	✓	✓									
BH 4	4.0 m	4	14/10/15	S	Bag	✓	✓	✓	✓									
BH 5	SPT 2.5 m	5	14/10/15	S	Bag	✓	✓	✓	✓									

ENVIROLAB GROUP
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 136167
Date Received: 20/10/15
Time Received: 1830.
Received by:
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/[illegible]

Lab Report No.
Send Results to: Douglas Partners Address: 96 Hermitage Road, West Ryde 2114
Phone: (02) 9809 0666
Fax: (02) 9809 4095
Relinquished by: ATHA KAPITANOF Signed: Date & Time: 20/10/15 Received By: Date & Time: 20/10/15
Relinquished by: Signed: Date & Time: Received By: Date & Time:

Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Sydney Laboratory
96 Hermitage Road West Ryde NSW 2114
Phone: (02) 9809 0666
Fax: (02) 9809 0666
Email: lujia.wu@douglaspartners.com.au

Report Number: **85100.02-1**
Issue Number: 1
Date Issued: 24/04/2018
Client: City of Sydney Council
GPO Box 1951, Sydney NSW 2000
Contact: Edy Rustam
Project Number: 85100.02
Project Name: Joynton Avenue Stormwater Drainage Upgrade
Project Location: Joynton Avenue, Zetland
Work Request: 2803
Sample Number: 18-2803A
Date Sampled: 12/04/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH102 (2.5-2.95)**
Material: Light brown sand with trace of silt

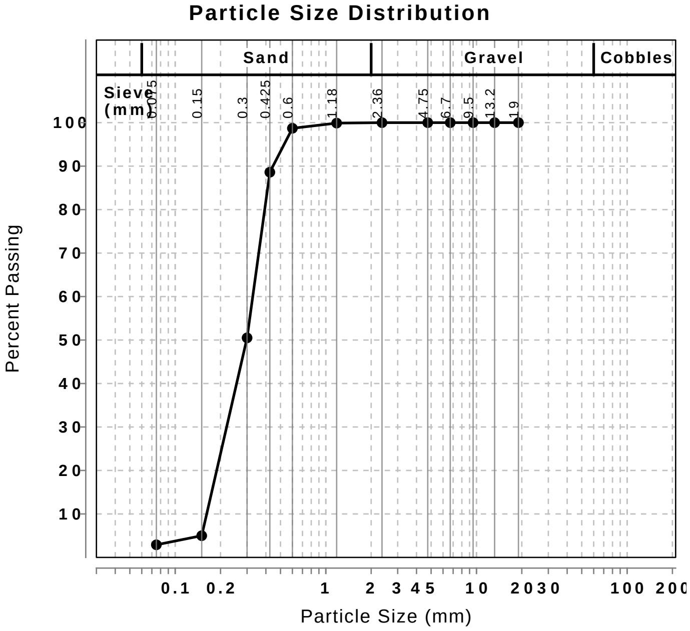
NATA WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

Lujia Wu

Approved Signatory: Lujia Wu
dp-lujia.wu
NATA Accredited Laboratory Number: 828

Particle Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**100**		
4.75 mm	**100**		
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**99**		
0.425 mm	**89**		
0.3 mm	**51**		
0.15 mm	**5**		
0.075 mm	**3**		



Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Sydney Laboratory
96 Hermitage Road West Ryde NSW 2114
Phone: (02) 9809 0666
Fax: (02) 9809 0666
Email: lujia.wu@douglaspartners.com.au

Report Number: **85100.02-1**
Issue Number: 1
Date Issued: 24/04/2018
Client: City of Sydney Council
GPO Box 1951, Sydney NSW 2000
Contact: Edy Rustam
Project Number: 85100.02
Project Name: Joynton Avenue Stormwater Drainage Upgrade
Project Location: Joynton Avenue, Zetland
Work Request: 2803
Sample Number: 18-2803B
Date Sampled: 12/04/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH102 (4-4.45)**
Material: Light brown sand

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WORLD RECOGNISED ACCREDITATION

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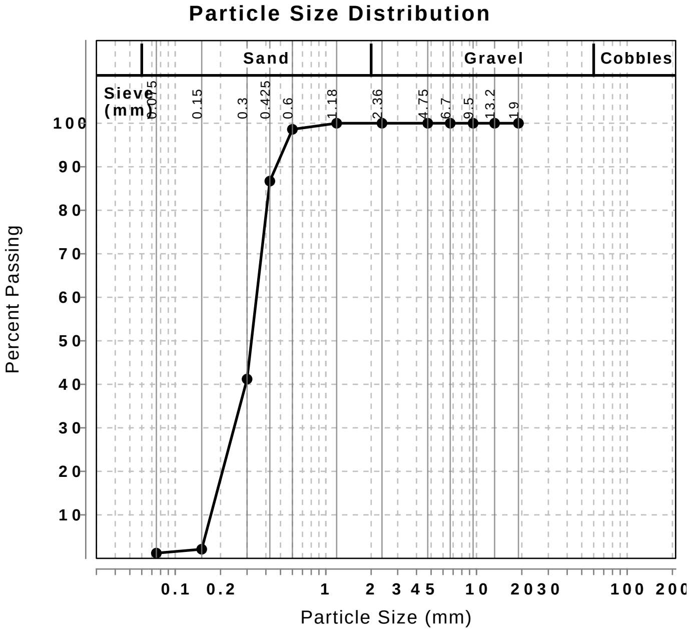
Lujia Wu

Approved Signatory: Lujia Wu
dp-lujia.wu
NATA Accredited Laboratory Number: 828

Particle Distribution (AS1289 3.6.1)

Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**100**		
4.75 mm	**100**		
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**99**		
0.425 mm	**87**		
0.3 mm	**41**		
0.15 mm	**2**		
0.075 mm	**1**		



Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater

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Sydney Laboratory
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WORLD RECOGNISED ACCREDITATION

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Lujia Wu

Approved Signatory: Lujia Wu
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NATA Accredited Laboratory Number: 828

Report Number: **85100.02-1**
Issue Number: 1
Date Issued: 24/04/2018
Client: City of Sydney Council
GPO Box 1951, Sydney NSW 2000
Contact: Edy Rustam
Project Number: 85100.02
Project Name: Joynton Avenue Stormwater Drainage Upgrade
Project Location: Joynton Avenue, Zetland
Work Request: 2803
Sample Number: 18-2803C
Date Sampled: 12/04/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH102 (8.5-8.95)**
Material: Light grey clayey sand

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	22		
Plastic Limit (%)	12		
Plasticity Index (%)	**10**		

Material Test Report

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Report Number:	**85100.02-1**
Issue Number:	1
Date Issued:	24/04/2018
Client:	City of Sydney Council GPO Box 1951, Sydney NSW 2000
Contact:	Edy Rustam
Project Number:	85100.02
Project Name:	Joynton Avenue Stormwater Drainage Upgrade
Project Location:	Joynton Avenue, Zetland
Work Request:	2803
Sample Number:	18-2803D
Date Sampled:	12/04/2018
Sampling Method:	Sampled by Engineering Department
Sample Location:	**BH104 (2.5-2.95)**
Material:	Light brown to brown clayey sand with trace of silt

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Approved Signatory: Lujia Wu
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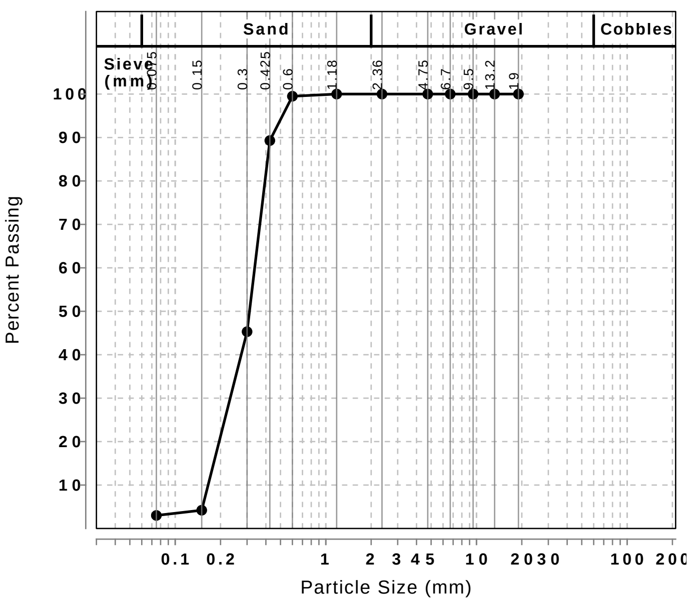
NATA Accredited Laboratory Number: 828

Particle Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**100**		
4.75 mm	**100**		
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**100**		
0.425 mm	**89**		
0.3 mm	**45**		
0.15 mm	**4**		
0.075 mm	**3**		



Particle Size Distribution

Material Test Report

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Report Number: **85100.02-1**
Issue Number: 1
Date Issued: 24/04/2018
Client: City of Sydney Council
GPO Box 1951, Sydney NSW 2000
Contact: Edy Rustam
Project Number: 85100.02
Project Name: Joynton Avenue Stormwater Drainage Upgrade
Project Location: Joynton Avenue, Zetland
Work Request: 2803
Sample Number: 18-2803E
Date Sampled: 12/04/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH104 (4-4.45)**
Material: Light brown to brown sand

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Approved Signatory: Lujia Wu
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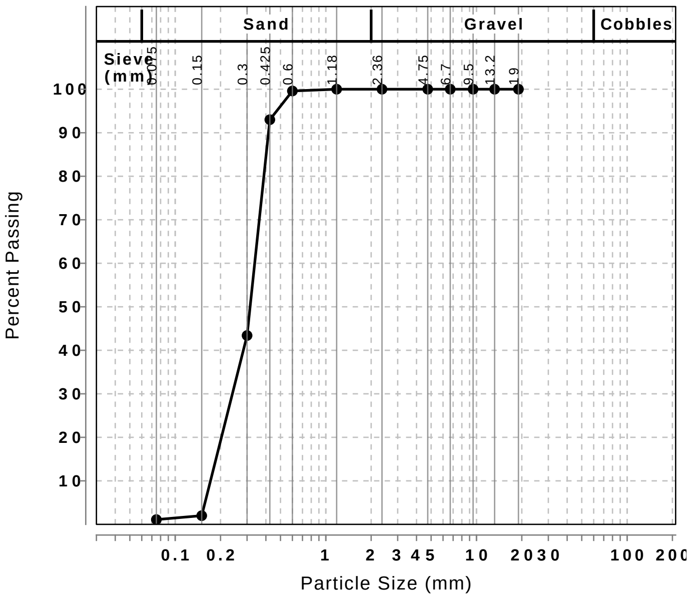
NATA Accredited Laboratory Number: 828

Particle Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**100**		
4.75 mm	**100**		
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**100**		
0.425 mm	**93**		
0.3 mm	**43**		
0.15 mm	**2**		
0.075 mm	**1**		

Particle Size Distribution



Material Test Report

Report Number:	**85100.02-1**
Issue Number:	1
Date Issued:	24/04/2018
Client:	City of Sydney Council GPO Box 1951, Sydney NSW 2000
Contact:	Edy Rustam
Project Number:	85100.02
Project Name:	Joynton Avenue Stormwater Drainage Upgrade
Project Location:	Joynton Avenue, Zetland
Work Request:	2803
Sample Number:	18-2803F
Date Sampled:	12/04/2018
Sampling Method:	Sampled by Engineering Department
Sample Location:	**BH106 (2.5-2.95)**
Material:	Light brown to brown sand with some silt

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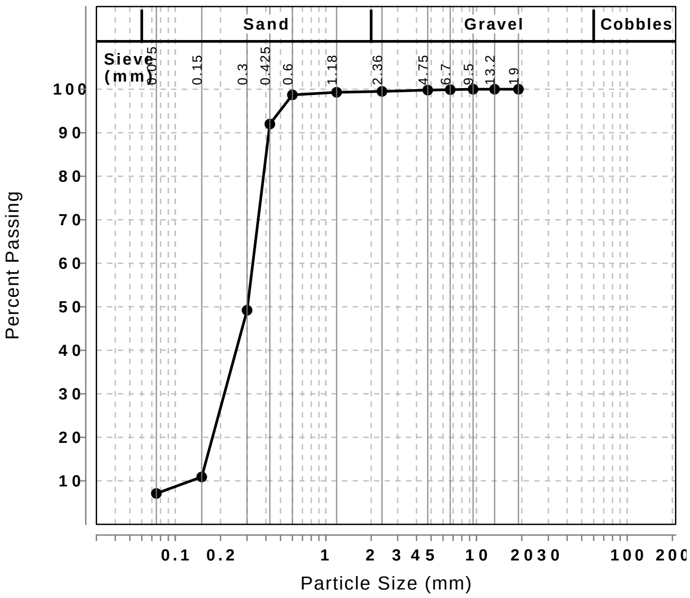
NATA Accredited Laboratory Number: 828

Particle Distribution (AS1289 3.6.1)

Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**100**		
4.75 mm	**100**		
2.36 mm	**100**		
1.18 mm	**99**		
0.6 mm	**99**		
0.425 mm	**92**		
0.3 mm	**49**		
0.15 mm	**11**		
0.075 mm	**7**		

Particle Size Distribution



Material Test Report

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Report Number: **85100.02-1**
Issue Number: 1
Date Issued: 24/04/2018
Client: City of Sydney Council
GPO Box 1951, Sydney NSW 2000
Contact: Edy Rustam
Project Number: 85100.02
Project Name: Joynton Avenue Stormwater Drainage Upgrade
Project Location: Joynton Avenue, Zetland
Work Request: 2803
Sample Number: 18-2803G
Date Sampled: 12/04/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH106 (4-4.45)**
Material: Light brown to brown sand with trace of silt

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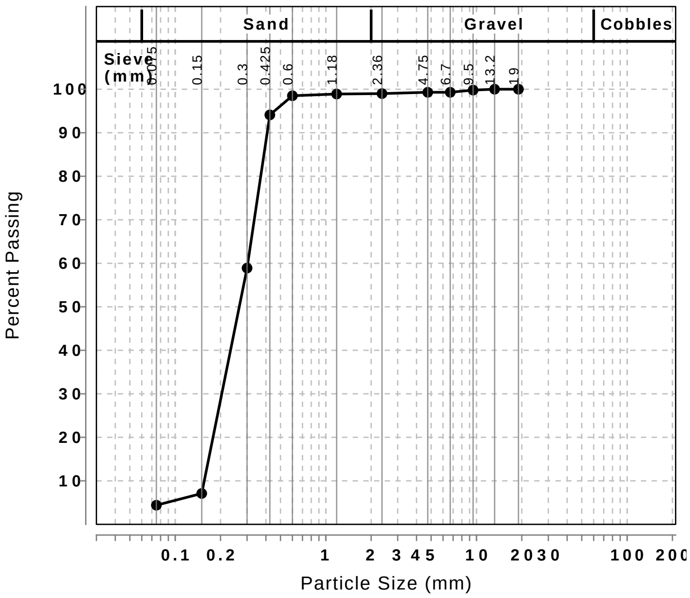
Lujia Wu

Approved Signatory: Lujia Wu
dp-lujia.wu
NATA Accredited Laboratory Number: 828

Particle Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**99**		
4.75 mm	**99**		
2.36 mm	**99**		
1.18 mm	**99**		
0.6 mm	**99**		
0.425 mm	**94**		
0.3 mm	**59**		
0.15 mm	**7**		
0.075 mm	**4**		

Particle Size Distribution



Material Test Report

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NATA Accredited Laboratory Number: 828

Report Number: **85100.02-1**
Issue Number: 1
Date Issued: 24/04/2018
Client: City of Sydney Council
GPO Box 1951, Sydney NSW 2000
Contact: Edy Rustam
Project Number: 85100.02
Project Name: Joynton Avenue Stormwater Drainage Upgrade
Project Location: Joynton Avenue, Zetland
Work Request: 2803
Sample Number: 18-2803H
Date Sampled: 12/04/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH106 (8.5-8.95)**
Material: Light brown to brown clayey sand

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	50		
Plastic Limit (%)	20		
Plasticity Index (%)	**30**		

Envirolab Services Pty Ltd
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ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 189115

Client Details

Client	Douglas Partners Pty Ltd
Attention	Atha Kapitanof
Address	96 Hermitage Rd, West Ryde, NSW, 2114

Sample Details

Your Reference	**85100.02, Joynton Ave Stormwater Drainage Upgrade**
Number of Samples	26 Soil
Date samples received	10/04/2018
Date completed instructions received	10/04/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	12/04/2018
Date of Issue	12/04/2018

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Results Approved By
Nick Sarlamis, Inorganics Supervisor
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

ACCREDITED FOR TECHNICAL COMPETENCE

sPOCAS field test						
Our Reference		189115-1	189115-2	189115-3	189115-4	189115-5
Your Reference	UNITS	BH101	BH101	BH101	BH101	BH101
Depth		0.55-0.6	1.0-1.45	2.5-2.95	4.0-4.45	5.5-5.95
Date Sampled		29/03/2018	29/03/2018	29/03/2018	29/03/2018	29/03/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	11/04/2018	11/04/2018	11/04/2018	11/04/2018	11/04/2018
Date analysed	-	11/04/2018	11/04/2018	11/04/2018	11/04/2018	11/04/2018
pH_F (field pH test)*	pH Units	8.2	7.1	8.2	7.5	6.8
pH_{FOX} (field peroxide test)*	pH Units	5.6	3.0	5.9	5.2	4.0
Reaction Rate*	-	Moderate	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference		189115-6	189115-7	189115-8	189115-9	189115-10
Your Reference	UNITS	BH101	BH101	BH103	BH103	BH103
Depth		7.0-7.45	8.5-8.95	0.4-0.5	1.0-1.45	2.5-2.95
Date Sampled		29/03/2018	29/03/2018	27/03/2018	27/03/2018	27/03/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	11/04/2018	11/04/2018	11/04/2018	12/04/2018	12/04/2018
Date analysed	-	11/04/2018	11/04/2018	11/04/2018	12/04/2018	12/04/2018
pH_F (field pH test)*	pH Units	7.1	6.9	5.9	7.4	7.4
pH_{FOX} (field peroxide test)*	pH Units	4.5	4.2	3.1	4.4	5.0
Reaction Rate*	-	Slight	Slight	Moderate	Moderate	Slight

sPOCAS field test						
Our Reference		189115-11	189115-12	189115-13	189115-14	189115-15
Your Reference	UNITS	BH103	BH103	BH103	BH105	BH105
Depth		4.0-4.45	5.5-5.95	7.0-7.45	0.4-0.5	1.0-1.45
Date Sampled		27/03/2018	27/03/2018	27/03/2018	28/03/2018	28/03/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/04/2018	12/04/2018	12/04/2018	11/04/2018	11/04/2018
Date analysed	-	12/04/2018	12/04/2018	12/04/2018	11/04/2018	11/04/2018
pH_F (field pH test)*	pH Units	7.1	7.2	5.7	7.3	7.1
pH_{FOX} (field peroxide test)*	pH Units	3.6	4.8	3.6	4.4	5.0
Reaction Rate*	-	Slight	Slight	High	Slight	Slight

sPOCAS field test						
Our Reference	UNITS	189115-16	189115-17	189115-18	189115-19	189115-20
Your Reference		BH105	BH105	BH105	BH105	BH105
Depth		2.5-2.95	4.0-4.45	5.5-5.95	7.0-7.45	8.5-8.95
Date Sampled		28/03/2018	28/03/2018	28/03/2018	28/03/2018	28/03/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	11/04/2018	11/04/2018	11/04/2018	11/04/2018	11/04/2018
Date analysed	-	11/04/2018	11/04/2018	11/04/2018	11/04/2018	11/04/2018
pH_F (field pH test)*	pH Units	7.3	7.5	7.1	7.1	5.7
pH_{FOX} (field peroxide test)*	pH Units	3.8	4.5	4.3	4.7	3.9
Reaction Rate*	-	Slight	Slight	Slight	Slight	High

sPOCAS field test						
Our Reference	UNITS	189115-21	189115-22	189115-23	189115-24	189115-25
Your Reference		BH107	BH107	BH107	BH107	BH107
Depth		1.0-1.45	2.5-2.95	4.0-4.45	5.5-5.95	7.0-7.45
Date Sampled		28/03/2018	28/03/2018	28/03/2018	28/03/2018	28/03/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	11/04/2018	11/04/2018	11/04/2018	11/04/2018	11/04/2018
Date analysed	-	11/04/2018	11/04/2018	11/04/2018	11/04/2018	11/04/2018
pH_F (field pH test)*	pH Units	7.7	7.5	7.6	7.4	7.3
pH_{FOX} (field peroxide test)*	pH Units	7.5	6.3	1.7	4.4	4.0
Reaction Rate*	-	High	High	Moderate	Slight	Slight

sPOCAS field test		
Our Reference	UNITS	189115-26
Your Reference		BH107
Depth		8.5-8.95
Date Sampled		28/03/2018
Type of sample		Soil
Date prepared	-	11/04/2018
Date analysed	-	11/04/2018
pH_F (field pH test)*	pH Units	5.7
pH_{FOX} (field peroxide test)*	pH Units	4.9
Reaction Rate*	-	Moderate

Misc Inorg - Soil						
Our Reference		189115-9	189115-10	189115-11	189115-12	189115-13
Your Reference	UNITS	BH103	BH103	BH103	BH103	BH103
Depth		1.0-1.45	2.5-2.95	4.0-4.45	5.5-5.95	7.0-7.45
Date Sampled		27/03/2018	27/03/2018	27/03/2018	27/03/2018	27/03/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/04/2018	12/04/2018	12/04/2018	12/04/2018	12/04/2018
Date analysed	-	12/04/2018	12/04/2018	12/04/2018	12/04/2018	12/04/2018
pH 1:5 soil:water	pH Units	8.2	7.8	7.7	7.9	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	99	36	22	24	18
Chloride, Cl 1:5 soil:water	mg/kg	10	<10	<10	<10	<10
Sulphate, SO4 1:5 soil:water	mg/kg	24	<10	<10	<10	<10

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			12/04/2018	[NT]	[NT]	[NT]	[NT]	12/04/2018	[NT]
Date analysed	-			12/04/2018	[NT]	[NT]	[NT]	[NT]	12/04/2018	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	89	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	91	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Douglas Partners
Geotechnics / Environment / Groundwater

CHAIN OF CUSTODY DESPATCH SHEET

Project No: 85100.02	**Suburb:** Zetland	**To:** Envirolab Services	
Project Name: Joynton Avenue Stormwater Drainage Upgrade	**Order Number**		
Project Manager: AK	**Sampler:** AT	**Attn:**	
Emails: atha.kapitanof@douglaspartners.com.au		**Phone:**	
Date Required: Same day ☐ 24 hours ☐ 48 hours ☑ 72 hours ☐ Standard ☐		**Email:**	
Prior Storage: ☑ Esky ☑ Fridge ☐ Shelved			

Sample ID	Lab ID	Date Sampled	Sample Type S - soil W - water	Container Type G - glass B-bag	Analytes pHF	pHFOX	pH	EC	SO4	Cl				Notes/preservation
BH101, 0.55-0.6m	1	29/03/18	S	B	●	●								
BH101, 1.0-1.45m	2	29/03/18	S	B	●	●								
BH101, 2.5-2.95m	3	29/03/18	S	B	●	●								
BH101, 4.0-4.45m	4	29/03/18	S	B	●	●								
BH101, 5.5-5.95m	5	29/03/18	S	B	●	●								
BH101, 7.0-7.45m	6	29/03/18	S	B	●	●								
BH101, 8.5-8.95m	7	29/03/18	S	B	●	●								
BH103, 0.4-0.5m	8	27/03/18	S	B	●	●								
BH103, 1.0-1.45m	9	27/03/18	S	B	●	●	●	●	●	●				
BH103, 2.5-2.95m	10	27/03/18	S	B	●	●	●	●	●	●				
BH103, 4.0-4.45m	11	27/03/18	S	B	●	●	●	●	●	●				
BH103, 5.5-5.95m	12	27/03/18	S	B	●	●	●	●	●	●				
BH103, 7.0-7.45m	13	27/03/18	S	B	●	●	●	●	●	●				
BH105, 0.4-0.5m	14	28/03/18	S	B	●	●								
BH105, 1.0-1.45m	15	28/03/18	S	B	●	●								
PQL (S) mg/kg												ANZECC PQLs req'd for all water analytes ☐		

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph. (02) 9910 6200
Job No: 189115
Date Received: 10/4/18
Time Received: 15:30
Received by: MT
Temp: Cool/Ambient 10.3
Cooling: Ice/Icepack
Security: Intact/Broken/None

PQL = practical quantitation limit. If none given, default to Laboratory Method Detection Limit

Lab Report/Reference No: 189115

Metals to Analyse: 8HM unless specified here:

Total number of samples in container: 17 Relinquished by: AK Transported to laboratory by:

Send Results to: Douglas Partners Pty Ltd Address Phone: Fax:

Signed: Received by: MT Date & Time: 10/4/18 15:30

Revised COC recd 110418 0940

Douglas Partners
Geotechnics / Environment / Groundwater

CHAIN OF CUSTODY DESPATCH SHEET

Project No: 85100.02	**Suburb:** Zetland	**To:** Envirolab Services	
Project Name: Joynton Avenue Stormwater Drainage Upgrade	**Order Number**		
Project Manager: AK	**Sampler:** AT	**Attn:**	
Emails: atha.kapitanof@douglaspartners.com.au		**Phone:**	
Date Required: Same day ☐ 24 hours ☐ 48 hours ☑ 72 hours ☐ Standard ☐		**Email:**	
Prior Storage: ☑ Esky ☑ Fridge ☐ Shelved			

Sample ID	Lab ID	Sampling Date	Sample Type	Container Type	Analytes									Notes/preservation
			S - soil W - water	G - glass B-bag	pHF	pHFOX								
BH105, 2.5-2.95m	16	28/03/18	S	B	●	●								
BH105, 4.0-4.45m	17	28/03/18	S	B	●	●								
BH105, 5.5-5.95m	18	28/03/18	S	B	●	●								
BH105, 7.0-7.45m	19	28/03/18	S	B	●	●								
BH105, 8.5-8.95m	20	28/03/18	S	B	●	●								
BH107, 0.4-0.5m	NR	28/03/18	S	B	●	●								
BH107, 1.0-1.45m	21	28/03/18	S	B	●	●								
BH107, 2.5-2.95m	22	28/03/18	S	B	●	●								
BH107, 4.0-4.45m	23	28/03/18	S	B	●	●								
BH107, 5.5-5.95m	24	28/03/18	S	B	●	●								
BH107, 7.0-7.45m	25	28/03/18	S	B	●	●								
BH107, 8.5-8.95m	26	28/03/18	S	B	●	●								
PQL (S) mg/kg														**ANZECC PQLs req'd for all water analytes** ☐

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 189115
Date Received: 10/4/18
Time Received: 15:30
Received by: MT
Temp: [✓ Cool]/Ambient 10-3
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit. If none given, default to Laboratory Method Detection Limit

Lab Report/Reference No: 189115

Metals to Analyse: 8HM unless specified here:

Total number of samples in container: 11 **Relinquished by:** AK **Transported to laboratory by:**

Send Results to: Douglas Partners Pty Ltd **Address** **Phone:** **Fax:**

Signed: **Received by:** MT **Date & Time:** 10/4/18 15:30.

Appendix H

Environmental Laboratory Tests

Table H1: Soil Results - Waste Classification

					Metals									PAH					BTEX						TPH													
				Moisture	**Arsenic**	**Cadmium**	**Chromium (III+VI)**	**Copper**	**Lead**	**Lead in TCLP**	**Mercury**	**Nickel**	**Zinc**	**Benzo(a) pyrene**	**Benzo(a) pyrene in TCLP**	**B(a)P Total Potency Equivalent**	**Naphthalene**	**PAHs (Sum of total)**	**Benzene**	**Ethylbenzene**	**Toluene**	**Xylene (m & p)**	**Xylene (o)**	**C6-C10 less BTEX (F1)**	**C10-C16**	**C16-C34**	**C34-C40**	**F2-NAPHTHALENE**	**C6 - C9**	**C10 - C14**	**C15 - C28**	**C29-C36**	**C6-C10**	**Phenolics Total**	**Organochlorine Pesticides***	**Polychlorinated Biphenyls***	**VOC ***	**Asbestos**
				%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/L	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/L	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	g/kg
EQL				0.1	4	0.4	1	1	1		0.1	1	1	0.05	0.001	0.5	0.1		0.2	1	0.5	2	1	25	50	100	100	50	25	50	100	100	25	5	0.1	0.1	1	0.1
ANZECC 1992 Background Levels					**0.2-30**	**0.04-2**	**0.5-100**	**1-190**	**<2-200**		**0.001-0.1**	**2-400**	**2-180**					**0.95-5**	**0.05-1**		**0.1-1**													**0.03-0.5**				
NSW 2014 General Solid Waste (No Leaching) CT1					**100**	**20**			**100**		**4**	**40**		**0.8**				**200**	**10**	**600**	**288**																	
NSW 2014 General Solid Waste (with leached) SCC1/TCLP1					**500**	**100**			**1500**	**5**	**50**	**1050**		**10**	**0.04**			**200**	**18**	**1080**	**518**								**650**									
NSW 2014 Restricted Solid Waste (No Leaching) CT2					**400**	**80**			**400**		**16**	**160**		**3.2**				**800**	**40**	**2400**	**1152**																	
NSW 2014 Restricted Solid Waste (with leached) SCC2/TCLP2					**2000**	**400**			**6000**	**20**	**200**	**4200**		**23**	**0.16**			**800**	**72**	**4320**	**2073**								**2600**									
Field_ID	**Sample_Depth**	**Sampled_Date**	**Matrix**																																			
BH1	0.5-0.6	12/10/2015	Filling	13	11	0.8	7	52	**220**	0.08	0.4	8	270	0.71		1	<0.1	6.8	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	1.3-1.5	12/10/2015	Natural	4.8	<4	<0.4	2	6	16		<0.1	1	25	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	2.3-2.5	12/10/2015	Natural	24	<4	<0.4	3	1	4		<0.1	1	16	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	-	-	-	-	-
BH2	0.5-0.6	12/10/2015	Filling	5	<4	<0.4	2	4	16		<0.1	2	13	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	2.3-2.5	12/10/2015	Natural	5.3	<4	<0.4	2	1	3		<0.1	<1	5	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	-	-	-	-	-
	3.3-3.5	12/10/2015	Natural	18	<4	<0.4	<1	<1	<1		<0.1	<1	15	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	-	-	-	-	-
BH3	0.35-0.45	13/10/2015	Filling	9.5	<4	<0.4	20	63	30		0.1	11	47	0.6		0.9	<1 - 0.3	8.6	<0.2	<1	<0.5	<2	<1	<25	<50	<100	130	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	0.9-1	13/10/2015	Filling	4.2	<4	<0.4	<1	2	3		<0.1	<1	7	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	1.9-2.0	13/10/2015	Filling	9.1	<4	<0.4	2	7	62		<0.1	1	14	0.1		<0.5	<0.1	1.1	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	-	-	-	-	-
	3.3-3.5	13/10/2015	Natural	18	<4	<0.4	<1	<1	<1		<0.1	<1	2	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	-	-	-	-	-
BH4	0.7-0.8	13/10/2015	Filling	4.1	<4	<0.4	3	9	29		<0.1	1	38	0.1		<0.5	<0.1	1.4	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	1.8-2	13/10/2015	Natural	1.6	<4	<0.4	5	2	5		<0.1	2	9	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	<50	<100	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	3.3-3.5	13/10/2015	Natural	16	<4	<0.4	1	<1	1		<0.1	<1	6	<0.05		<0.5	<0.1	0	<0.2	<1	<0.5	<2	<1	<25	300	390	<100	300	<25	96	580	<100	<25	-	-	-	-	-
BH5	0.4-0.5	15/10/2015	Filling	16	11	1	31	260	**4700**	2.1	1.4	20	890	**9.7**	<0.001	14	<1 - 0.3	93	<0.2	<1	<0.5	<2	<1	<25	<50	410	100	<50	<25	<50	250	210	<25	<5	<0.1	<0.1	<1	NAD
	1.9-2	15/10/2015	Filling	11	6	1	10	96	**310**	0.1	0.6	10	490	**4**	<0.001	5.6	<1 - 0.2	37	<0.2	<1	<0.5	<2	<1	<25	<50	170	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD
	2.9-3	15/10/2015	Filling	26	8	0.9	30	220	**6100**	**5.6**	1	14	530	**3.3**	<0.001	4.7	<1 - 0.2	33	<0.2	<1	<0.5	<2	<1	<25	<50	110	<100	<50	<25	<50	<100	<100	<25	<5	<0.1	<0.1	<1	NAD

NOTES

*	All component analytes < LOR
NAD	No asbestos detected at reporting limit of 0.1g/kg
TCLP	Toxicity Characteristic Leaching Procedure

Table H2: Results of Groundwater Analysis (All results in μg/L unless otherwise stated)

Sample ID	Sample Date	Heavy Metals								PAH		TRH				BTEX				VOC^{4}	OCP	PCB	Phenols
		As	Cd	Cr^{1}	Cu	Pb	Hg	Ni	Zn	Naphthalene	Benzo(a)pyrene	C_6-C_9	C_{10}-C_{36}	C6 - C10^{2}	>C10 - C16^{3}	Benzene	Toulene	Ethyl-benzene	Total Xylenes	Cis-1,2-dichloroethene			
MW1	21/10/2015	5	<0.1	<1	<1	1	<0.05	1	**96**	<0.2	<0.1	<10	<250	<10	<50	<1	<1	<1	<3	2	<LOR	<LOR	<0.05
MW3	21/10/2015	<1	<0.1	<1	<1	<1	<0.05	1	**13**	<0.2	<0.1	120	<250	120	<50	<1	<1	<1	<3	110	<LOR	<LOR	<0.05
MW5	21/10/2015	4	<0.1	<1	<1	<1	<0.05	1	**34**	<0.2	<0.1	<10	<250	<10	<50	<1	<1	<1	<3	5	<LOR	<LOR	<0.05
GIL1		13	0.6	1	4	16.7	0.06	27.5	20	16	-	-	-	-	-	950	-	-	350/200	-	LOR^{5}	LOR^{5}	3.6
GIL 2			1.1		7.3	40.3		57.5	41.8														
HSL-D		-	-	-	-	-	-	-	-	NL	-	-	-	6000	LOR	5000	NL	NL	NL	-	-	-	-

NOTES:

1	All Chromium are assumed to exist in the stable Cr(III) oxidation state, as Cr(VI) will be too reactive and unstable under the normal environment
2	F1: TRH C_6-C_{10} less BTEX
3	F2: TRH >C_{10}-C_{16} less Napthalene
4	Detectable volatile coumpounds
5	Various available, not listed as not detected above LOR
GIL	NEPC 2013, Schedule B1 - Table 1C, Groundwater Investigation Levels for Fresh Waters (applies to typical slightly -moderately disturbed systems).
GIL 1	Applicable to MW1 and MW3
GIL 2	Applicable to MW5
HSL-D	NEPC 2013, Schedule B1 - Table 1A (4) Groundwater Health Screening Levels for Vapour Intrusion for commercial/industrial- sand 2 to <4 m
LOR	Limit of reporting
Bold	Exceeds adopted GIL
-	not defined/ not analysed/ not applicable
NL	not limiting

Table H3: Screening and Laboratory results of samples submitted for analysis on ASS

Sample ID		Summary Soil Description	"Field" Screening Results				Laboratory Chromium Reducible Sulphur Results							
			pH_f	pH_{ox}	pH_{ox}-pH_f	Strength of Reaction	pH_{kcl}	s-TAA	SCR	s-ANC	s-Net Acidity	a-Net Acidity	a-Net Acidity without ANC	liming rate (FOS=1.5)
			pH units	pH units	pH units	-	pH units	%w/w S	%w/w	%w/w S	%w/w S	moles H^+/t	moles H^+/t	kg $CaCO_3$/t
Test pit / Depth interval		Five Boreholes												
BH1	1.5	Loose, Dark grey silty medium sand	5.47	3.18	2.29	1	4.2	0.09	0.008	<0.05	0.1	61	61	**4.6**
BH1	1.9	Dark grey peaty silty sand	4.12	2.01	2.11	1	4	0.11	0.01	<0.05	0.12	76	76	**5.7**
BH101	0.55 - 0.6	Dark grey sand filling with some ripped sandstone and silt	8.2	5.6	2.6	2	-	-	-	-	-	-	-	-
BH101	1.0 - 1.45	Dark grey sand filling with some ripped sandstone and silt	7.1	3.0	4.1	1	6.1	<0.01	<0.005	<0.05	<0.005	<5	<5	**<0.75**
BH101	2.5 – 2.95	Light brown to brown, medium sand	8.2	5.9	2.3	1	-	-	-	-	-	-	-	-
BH101	4.0 – 4.45	Light brown, medium sand	7.5	5.2	2.3	1	-	-	-	-	-	-	-	-
BH101	5.5 – 5.95	Dark grey, medium sand with some organic matter	6.8	4.0	2.8	1	-	-	-	-	-	-	-	-
BH101	7.0 – 7.45	Light grey, medium sand	7.1	4.5	2.6	1	-	-	-	-	-	-	-	-
BH101	8.5 – 8.95	Light grey, medium sand	6.9	4.2	2.7	1	-	-	-	-	-	-	-	-
BH103	0.4 - 0.5	Dark grey, fine to medium sand filling, with some silt	5.9	3.1	2.8	2	5.8	<0.01	<0.005	<0.05	<0.005	<5	<5	**<0.75**
BH103	1.0 – 1.45	Dark grey, fine to medium sand filling, with some silt	7.4	4.4	3	2	-	-	-	-	-	-	-	-
BH103	2.5 – 2.95	Light brown, medium sand	7.4	5	2.4	1	-	-	-	-	-	-	-	-
BH103	4.0 – 4.45	Light brown, medium sand	7.1	3.6	3.5	1	-	-	-	-	-	-	-	-
BH103	5.5 – 5.95	Light brown, medium sand	7.2	4.8	2.4	1	-	-	-	-	-	-	-	-
BH103	7.0 - 7.45	Light grey, clayey sand	5.7	3.6	2.1	3	3.8	0.04	<0.005	<0.05	0.038	24	24	**1.8**
BH105	0.4 – 0.5	Red-brown to brown, sandy clay filling with some ripped sandstone	7.3	4.4	2.9	1	-	-	-	-	-	-	-	-
BH105	1.0 – 1.45	Red-brown to brown, sandy clay filling with some ripped sandstone	7.1	5	2.1	1	-	-	-	-	-	-	-	-
BH105	2.5 – 2.95	Brown to dark grey-brown, medium sand	7.3	3.8	3.5	1	-	-	-	-	-	-	-	-
BH105	4.0 – 4.45	Brown to dark brown, medium sand	7.5	4.5	3	1	-	-	-	-	-	-	-	-
BH105	5.5 – 5.95	Brown and dark grey, medium sand with some organic matter	7.1	4.3	2.8	1	-	-	-	-	-	-	-	-
BH105	7.0 – 7.45	Brown and dark grey, medium sand with some organic matter	7.1	4.7	2.4	1	-	-	-	-	-	-	-	-
BH105	8.5 – 8.95	Grey-brown, clayey sand	5.7	3.9	1.8	3	-	-	-	-	-	-	-	-
BH107	1.0-1.45	Brown, sandy clay filling with some ripped sandstone	7.7	7.5	0.2	3	-	-	-	-	-	-	-	-
BH107	2.5-2.95	Brown, sandy clay filling with some ripped sandstone	7.5	6.3	1.2	3	-	-	-	-	-	-	-	-
BH107	4.0-4.45	Dark grey medium sand with some organic matter	7.6	1.7	5.9	2	6.8	<0.01	0.007	<0.05	<0.005	<5	<5	**<0.75**
BH107	5.5-5.95	Dark grey, medium sand with some organic matter	7.4	4.4	3	1	-	-	-	-	-	-	-	-
BH107	7.0-7.45	Brown, medium sand	7.3	4	3.3	1	-	-	-	-	-	-	-	-
BH107	8.5-8.95	Light brown, clayey sand	5.7	4.9	0.8	2	-	-	-	-	-	-	-	-
ASSMAC Action Criteria for disturbance of more than 1000 tonnes for coarse texture sands to loamy sand											0.03		18	

Notes

pH_f	field pH
pH_{ox}	peroxide pH
pH_{kcl}	pH in KCL
Strength of Reaction	1 - denotes no or slight effervescence 2 - denotes moderate effervescence 3 - denotes vigorous effervescence 3 - denotes very vigorous effervescence with gas evolution and heat f - denotes "frothy" reaction, indicative of organics
s-TAA	Titratable Actual Acidity
SCR	Chromium Reducible Sulfur
s-ANC	acid neutralising capacity (back titration)
liming rate	Liming rate with 1.5 factor of safety for ag lime
SHADED	exceedance of criteria
BOLD	liming rate for detected ASS

DATA QUALITY ASSESSMENT

Q1. FIELD AND LABORATORY QUALITY ASSURANCE and CONTROL

Q1.1 QA/QC Summary

The field and laboratory quality control (QC) procedures and results are summarised in Tables Q1 and Q2.

Table Q1: Field QC

Item	Frequency	Acceptance Criteria	Achievement
Intra-laboratory replicates	>5% primary samples per borehole sample collection.	RPD <30% inorganics), <50% (organics)	yes[1]
Inter-laboratory replicates	>5% primary samples per borehole sample collection.	RPD <30% inorganics), <50% (organics)	yes[1]
Trip Spikes	1 per sample batch	60-140% recovery	yes
Trip Blanks	1 per sample batch	<PQL/LOR	yes

NOTE: 1 qualitative assessment of RPD results overall; refer Section Q1.2 and Q1.3

Table Q2: Laboratory QC

Item	Frequency	Acceptance Criteria	Achievement
Analytical laboratories used		NATA accreditation	yes
Holding times		In accordance with NEPC (2013) which references various Australian and international standards	yes
Laboratory / Reagent Blanks	1 per lab batch	<PQL	yes
Laboratory duplicates	10% primary samples	Laboratory specific [1]	yes
Matrix Spikes	1 per lab batch	70-130% recovery (inorganics); 60-140% (organics); 10-140% (SVOC, speciated phenols)	yes
Surrogate Spikes	organics by GC	70-130% recovery (inorganics); 60-140% (organics); 10-140% (SVOC, speciated phenols)	yes
Control Samples	1 per lab batch	70-130% recovery (inorganics); 60-140% (organics); 10-140% (SVOC, speciated phenols)	yes

Notes: 1 ELS: <5xPQL – any RPD; >5xPQL – 0-50%RPD

Mgt: <10xPQL – any RPD; 10-20 x PQL – 0-50 %; >20 x PQL – 0-30%

A 10% QA/QC analysis frequency was achieved for soil sampling. In summary, the QC data is considered to be of sufficient quality to be acceptable for the assessment.

Q1.2 Intra-Laboratory Replicates

Intra-laboratory replicates were analysed as an internal check of the reproducibility within the primary laboratory ELS and as a measure of consistency of sampling techniques. The comparative results of analysis between original and intra-laboratory replicate samples are summarised in Table Q3.

Note that, where both samples are below LOR/PQL the difference and RPD has been given as zero. Where one sample is reported below LOR/PQL, but a concentration is reported for the other, the LOR/PQL value has been used for calculation of the RPD for the less than LOR/PQL sample.

Results show that the calculated RPD values were within the acceptable range of ± 30 for inorganic analytes and ± 50% for organics with the exception of the values shown in bold. However these are not considered to be significant given the actual low differences in the concentrations of the replicate pairs.

Table Q3: Relative Percentage Difference Results – Intra-laboratory Replicates

Lab	Sample ID	Date Sampled	Media	Units	Metals								PAH	TRH				BTEX			
					As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Naphthalene	C6-C10	>C10-C16	>C16-C34	>C34-C40	Benzene	Toluene	Ethylbenzene	xylene
ELS	BH4/3.3-3.5	13/10/2015	Sand	mg/kg	<4	<0.4	1	<1	5	<0.1	2	9	<1	<25	300	390	<100	<0.2	<0.5	<1	<3
ELS	BD1/131015	13/10/2015	Sand	mg/kg	<4	<0.4	1	<1	2	<0.1	<1	6	<1	<25	240	310	<100	<0.2	<0.5	<1	<3
Difference				mg/kg	-	-	-	-	3	-	1	3	-	-	60	80	-	-	-	-	-
RPD				%	-	-	-	-	**86**	-	**67**	**40**	-	-	22	23	-	-	-	-	-
ELS	MW1	21/10/2015	Water	mg/kg	5	<0.1	<1	<1	1	<0.05	1	96	<0.1	<10	<50	<100	<100	<1	<1	<1	<3
ELS	BD1/211015	21/10/2015	water	mg/kg	5	<0.1	<1	<1	<1	<0.05	<1	86	<0.1	<10	<50	<100	<100	<1	<1	<1	<3
Difference				mg/kg	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-
RPD				%	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-

Note: - not applicable, not tested

Q1.3 Inter-Laboratory Replicates

Inter-laboratory replicates were conducted as a check of the reproducibility of results between the primary laboratory ELS and the secondary laboratory, Eurofins Mgt (Mgt) as a measure of consistency of sampling techniques.

The comparative results of analysis between original and inter-laboratory replicate samples are summarised in Table Q4.

Note that, where both samples are below LOR/PQL the difference and RPD has been given as zero. Where one sample is reported below LOR/PQL, but a concentration is reported for the other, the LOR/PQL value has been used for calculation of the RPD for the less than LOR/PQL sample.

Results show that the calculated RPD values were within the acceptable range of ± 30 for inorganic analytes and ± 50% for organics with the exception of the values shown in bold. However these are not considered to be significant given the actual low differences in the concentrations of the replicate pairs.

Table Q4: Relative Percentage Difference Results – Inter-laboratory Replicates

Lab	Sample ID	Date Sampled	Media	Units	Metals								PAH	TRH				BTEX			
					As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Naphthalene	C6-C10	>C10-C16	>C16-C34	>C34-C40	Benzene	Toluene	Ethylbenzene	xylene
ELS	BH5/1.9-2.0	14/10/2015	Filling	mg/kg	6	1	10	96	310	0.6	10	490	<1	<25	<250	170	<100	<0.2	<0.5	<1	<3
Mgt	BD3/141015	14/10/2015	Filling	mg/kg	6.3	0.7	9.9	97	290	0.5	8.7	470	<0.5	<20	<50	210	<100	<0.1	<0.1	<0.1	<0.3
Difference				mg/kg	0.3	0.3	0.1	1	20	0.1	1.3	20	-	-	-		-	-	-	-	-
RPD				%	5	**35**	1	1	7	18	14	4	-	-	-		-	-	-	-	-

Note: - not applicable, not tested

Q2. DATA QUALITY INDICATORS

The reliability of field procedures and analytical results was assessed against the following data quality indicators (DQIs):

- Completeness – a measure of the amount of usable data from a data collection activity;
- Comparability – the confidence (qualitative) that data may be considered to be equivalent for each sampling and analytical event;
- Representativeness – the confidence (qualitative) of data representativeness of media present on-site;
- Precision – a measure of variability or reproducibility of data; and
- Accuracy – a measure of closeness of the data to the 'true' value.

The DQIs were assessed as outlined in the following Table Q5.

Table Q5: Data Quality Indicators

Data Quality Indicator	Method(s) of Achievement
Completeness	Preparation of field logs, sample location plan and chain of custody (COC) records; Laboratory sample receipt information received confirming receipt of samples intact and appropriateness of the chain of custody; Samples analysed for contaminants of potential concern (COPC); Completion of COC documentation; NATA endorsed laboratory certificates provided by the laboratory; Satisfactory frequency and results for field and laboratory QC samples as discussed in Section Q1.
Comparability	Using appropriate techniques for sample recovery, storage and transportation, which were the same for the duration of the project; Works undertaken by appropriately experienced and trained DP environmental scientist / engineer; Use of NATA registered laboratories, with test methods the same or similar between laboratories; Satisfactory results for field and laboratory QC samples.
Representativeness	Target media sampled; Sample numbers recovered and analysed are considered to be representative of the target media; Samples were extracted and analysed within holding times; Samples were analysed in accordance with the analysis request.

Data Quality Indicator	Method(s) of Achievement
Precision	Acceptable RPD between original samples and replicates; Satisfactory results for all other field and laboratory QC samples.
Accuracy	Satisfactory results for all field and laboratory QC samples.

Based on the above, it is considered that the DQIs have been complied with. As such, it is concluded that the field and laboratory test data obtained are reliable and useable for this assessment.

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CERTIFICATE OF ANALYSIS 135957

Client:

Douglas Partners Pty Ltd
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Veronica Ku, Atha K

Sample log in details:

Your Reference:	**85100.01, Zetland, Trunk Drain**
No. of samples:	21 Soils
Date samples received / completed instructions received	15/10/15 / 15/10/15

This report replaces the R00 due to changes in sample's ID.

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	22/10/15 / 26/10/15
Date of Preliminary Report:	Not Issued

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

VOCs in soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------ ------------	135957-1 BH1 0.5-0.6 12/10/2015 Soil	135957-2 BH1 1.3-1.5 12/10/2015 Soil	135957-4 BH2 0.5-0.6 12/10/2015 Soil	135957-7 BH3 0.35-0.45 13/10/2015 Soil	135957-8 BH3 0.9-1.0 13/10/2015 Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
Dichlorodifluoromethane	mg/kg	<1	<1	<1	<1	<1
Chloromethane	mg/kg	<1	<1	<1	<1	<1
Vinyl Chloride	mg/kg	<1	<1	<1	<1	<1
Bromomethane	mg/kg	<1	<1	<1	<1	<1
Chloroethane	mg/kg	<1	<1	<1	<1	<1
Trichlorofluoromethane	mg/kg	<1	<1	<1	<1	<1
1,1-Dichloroethene	mg/kg	<1	<1	<1	<1	<1
trans-1,2-dichloroethene	mg/kg	<1	<1	<1	<1	<1
1,1-dichloroethane	mg/kg	<1	<1	<1	<1	<1
cis-1,2-dichloroethene	mg/kg	<1	<1	<1	<1	<1
bromochloromethane	mg/kg	<1	<1	<1	<1	<1
chloroform	mg/kg	<1	<1	<1	<1	<1
2,2-dichloropropane	mg/kg	<1	<1	<1	<1	<1
1,2-dichloroethane	mg/kg	<1	<1	<1	<1	<1
1,1,1-trichloroethane	mg/kg	<1	<1	<1	<1	<1
1,1-dichloropropene	mg/kg	<1	<1	<1	<1	<1
Cyclohexane	mg/kg	<1	<1	<1	<1	<1
carbon tetrachloride	mg/kg	<1	<1	<1	<1	<1
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
dibromomethane	mg/kg	<1	<1	<1	<1	<1
1,2-dichloropropane	mg/kg	<1	<1	<1	<1	<1
trichloroethene	mg/kg	<1	<1	<1	<1	<1
bromodichloromethane	mg/kg	<1	<1	<1	<1	<1
trans-1,3-dichloropropene	mg/kg	<1	<1	<1	<1	<1
cis-1,3-dichloropropene	mg/kg	<1	<1	<1	<1	<1
1,1,2-trichloroethane	mg/kg	<1	<1	<1	<1	<1
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
1,3-dichloropropane	mg/kg	<1	<1	<1	<1	<1
dibromochloromethane	mg/kg	<1	<1	<1	<1	<1
1,2-dibromoethane	mg/kg	<1	<1	<1	<1	<1
tetrachloroethene	mg/kg	<1	<1	<1	<1	<1
1,1,1,2-tetrachloroethane	mg/kg	<1	<1	<1	<1	<1
chlorobenzene	mg/kg	<1	<1	<1	<1	<1
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
bromoform	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
styrene	mg/kg	<1	<1	<1	<1	<1
1,1,2,2-tetrachloroethane	mg/kg	<1	<1	<1	<1	<1
o-Xylene	mg/kg	<1	<1	<1	<1	<1

VOCs in soil Our Reference:	UNITS	135957-1	135957-2	135957-4	135957-7	135957-8
Your Reference	-------------	BH1	BH1	BH2	BH3	BH3
Depth	------------	0.5-0.6	1.3-1.5	0.5-0.6	0.35-0.45	0.9-1.0
Date Sampled		12/10/2015	12/10/2015	12/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
1,2,3-trichloropropane	mg/kg	<1	<1	<1	<1	<1
isopropylbenzene	mg/kg	<1	<1	<1	<1	<1
bromobenzene	mg/kg	<1	<1	<1	<1	<1
n-propyl benzene	mg/kg	<1	<1	<1	<1	<1
2-chlorotoluene	mg/kg	<1	<1	<1	<1	<1
4-chlorotoluene	mg/kg	<1	<1	<1	<1	<1
1,3,5-trimethyl benzene	mg/kg	<1	<1	<1	<1	<1
tert-butyl benzene	mg/kg	<1	<1	<1	<1	<1
1,2,4-trimethyl benzene	mg/kg	<1	<1	<1	<1	<1
1,3-dichlorobenzene	mg/kg	<1	<1	<1	<1	<1
sec-butyl benzene	mg/kg	<1	<1	<1	<1	<1
1,4-dichlorobenzene	mg/kg	<1	<1	<1	<1	<1
4-isopropyl toluene	mg/kg	<1	<1	<1	<1	<1
1,2-dichlorobenzene	mg/kg	<1	<1	<1	<1	<1
n-butyl benzene	mg/kg	<1	<1	<1	<1	<1
1,2-dibromo-3-chloropropane	mg/kg	<1	<1	<1	<1	<1
1,2,4-trichlorobenzene	mg/kg	<1	<1	<1	<1	<1
hexachlorobutadiene	mg/kg	<1	<1	<1	<1	<1
1,2,3-trichlorobenzene	mg/kg	<1	<1	<1	<1	<1
Surrogate Dibromofluorometha	%	100	98	100	99	99
Surrogate aaa-Trifluorotoluene	%	111	114	116	114	119
Surrogate Toluene-d_8	%	100	99	100	99	99
Surrogate 4-Bromofluorobenzene	%	99	99	98	100	98

VOCs in soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------ ------------	135957-10 BH4 0.7-0.8 13/10/2015 Soil	135957-11 BH4 1.8-2.0 13/10/2015 Soil	135957-13 BH5 0.4-0.5 15/10/2015 Soil	135957-14 BH5 1.9-2.0 15/10/2015 Soil	135957-15 BH5 2.9-3.0 15/10/2015 Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
Dichlorodifluoromethane	mg/kg	<1	<1	<1	<1	<1
Chloromethane	mg/kg	<1	<1	<1	<1	<1
Vinyl Chloride	mg/kg	<1	<1	<1	<1	<1
Bromomethane	mg/kg	<1	<1	<1	<1	<1
Chloroethane	mg/kg	<1	<1	<1	<1	<1
Trichlorofluoromethane	mg/kg	<1	<1	<1	<1	<1
1,1-Dichloroethene	mg/kg	<1	<1	<1	<1	<1
trans-1,2-dichloroethene	mg/kg	<1	<1	<1	<1	<1
1,1-dichloroethane	mg/kg	<1	<1	<1	<1	<1
cis-1,2-dichloroethene	mg/kg	<1	<1	<1	<1	<1
bromochloromethane	mg/kg	<1	<1	<1	<1	<1
chloroform	mg/kg	<1	<1	<1	<1	<1
2,2-dichloropropane	mg/kg	<1	<1	<1	<1	<1
1,2-dichloroethane	mg/kg	<1	<1	<1	<1	<1
1,1,1-trichloroethane	mg/kg	<1	<1	<1	<1	<1
1,1-dichloropropene	mg/kg	<1	<1	<1	<1	<1
Cyclohexane	mg/kg	<1	<1	<1	<1	<1
carbon tetrachloride	mg/kg	<1	<1	<1	<1	<1
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
dibromomethane	mg/kg	<1	<1	<1	<1	<1
1,2-dichloropropane	mg/kg	<1	<1	<1	<1	<1
trichloroethene	mg/kg	<1	<1	<1	<1	<1
bromodichloromethane	mg/kg	<1	<1	<1	<1	<1
trans-1,3-dichloropropene	mg/kg	<1	<1	<1	<1	<1
cis-1,3-dichloropropene	mg/kg	<1	<1	<1	<1	<1
1,1,2-trichloroethane	mg/kg	<1	<1	<1	<1	<1
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
1,3-dichloropropane	mg/kg	<1	<1	<1	<1	<1
dibromochloromethane	mg/kg	<1	<1	<1	<1	<1
1,2-dibromoethane	mg/kg	<1	<1	<1	<1	<1
tetrachloroethene	mg/kg	<1	<1	<1	<1	<1
1,1,1,2-tetrachloroethane	mg/kg	<1	<1	<1	<1	<1
chlorobenzene	mg/kg	<1	<1	<1	<1	<1
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
bromoform	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
styrene	mg/kg	<1	<1	<1	<1	<1
1,1,2,2-tetrachloroethane	mg/kg	<1	<1	<1	<1	<1
o-Xylene	mg/kg	<1	<1	<1	<1	<1
1,2,3-trichloropropane	mg/kg	<1	<1	<1	<1	<1

VOCs in soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	135957-10 BH4 0.7-0.8 13/10/2015 Soil	135957-11 BH4 1.8-2.0 13/10/2015 Soil	135957-13 BH5 0.4-0.5 15/10/2015 Soil	135957-14 BH5 1.9-2.0 15/10/2015 Soil	135957-15 BH5 2.9-3.0 15/10/2015 Soil
isopropylbenzene	mg/kg	<1	<1	<1	<1	<1
bromobenzene	mg/kg	<1	<1	<1	<1	<1
n-propyl benzene	mg/kg	<1	<1	<1	<1	<1
2-chlorotoluene	mg/kg	<1	<1	<1	<1	<1
4-chlorotoluene	mg/kg	<1	<1	<1	<1	<1
1,3,5-trimethyl benzene	mg/kg	<1	<1	<1	<1	<1
tert-butyl benzene	mg/kg	<1	<1	<1	<1	<1
1,2,4-trimethyl benzene	mg/kg	<1	<1	<1	<1	<1
1,3-dichlorobenzene	mg/kg	<1	<1	<1	<1	<1
sec-butyl benzene	mg/kg	<1	<1	<1	<1	<1
1,4-dichlorobenzene	mg/kg	<1	<1	<1	<1	<1
4-isopropyl toluene	mg/kg	<1	<1	<1	<1	<1
1,2-dichlorobenzene	mg/kg	<1	<1	<1	<1	<1
n-butyl benzene	mg/kg	<1	<1	<1	<1	<1
1,2-dibromo-3-chloropropane	mg/kg	<1	<1	<1	<1	<1
1,2,4-trichlorobenzene	mg/kg	<1	<1	<1	<1	<1
hexachlorobutadiene	mg/kg	<1	<1	<1	<1	<1
1,2,3-trichlorobenzene	mg/kg	<1	<1	<1	<1	<1
Surrogate Dibromofluorometha	%	98	98	98	98	98
Surrogate aaa-Trifluorotoluene	%	118	119	113	108	110
Surrogate Toluene-d8	%	100	99	99	100	99
Surrogate 4-Bromofluorobenzene	%	99	99	98	98	100

vTRH(C6-C10)/BTEXN in Soil						
Our Reference:	UNITS	135957-1	135957-2	135957-3	135957-4	135957-5
Your Reference	-------------	BH1	BH1	BH1	BH2	BH2
Depth	------------	0.5-0.6	1.3-1.5	2.3-2.5	0.5-0.6	2.3-2.5
Date Sampled		12/10/2015	12/10/2015	12/10/2015	12/10/2015	12/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
TRH C_6 - C_9	mg/kg	<25	<25	<25	<25	<25
TRH C_6 - C_{10}	mg/kg	<25	<25	<25	<25	<25
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
naphthalene	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	111	114	96	116	101

vTRH(C6-C10)/BTEXN in Soil						
Our Reference:	UNITS	135957-6	135957-7	135957-8	135957-9	135957-10
Your Reference	-------------	BH2	BH3	BH3	BH3	BH4
Depth	------------	3.3-3.5	0.35-0.45	0.9-1.0	3.3-3.5	0.7-0.8
Date Sampled		12/10/2015	13/10/2015	13/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
TRH C_6 - C_9	mg/kg	<25	<25	<25	<25	<25
TRH C_6 - C_{10}	mg/kg	<25	<25	<25	<25	<25
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
naphthalene	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	98	114	119	96	118

vTRH(C6-C10)/BTEXN in Soil						
Our Reference:	UNITS	135957-11	135957-12	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	1.8-2.0	3.3-3.5	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
TRH C_6 - C_9	mg/kg	<25	<25	<25	<25	<25
TRH C_6 - C_{10}	mg/kg	<25	<25	<25	<25	<25
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
naphthalene	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	119	99	113	108	110

vTRH(C6-C10)/BTEXN in Soil						
Our Reference:	UNITS	135957-16	135957-17	135957-18	135957-19	135957-20
Your Reference	-------------	BD1/131015	TS/121015	TB/121015	TS/131015	TB/131015
Depth	------------	3.3-3.5	-	-	-	-
Date Sampled		13/10/2015	12/10/2015	12/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
TRH C_6 - C_9	mg/kg	<25	[NA]	[NA]	[NA]	[NA]
TRH C_6 - C_{10}	mg/kg	<25	[NA]	[NA]	[NA]	[NA]
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	[NA]	[NA]	[NA]	[NA]
Benzene	mg/kg	<0.2	94%	<0.2	90%	106%
Toluene	mg/kg	<0.5	94%	<0.5	89%	106%
Ethylbenzene	mg/kg	<1	95%	<1	89%	107%
m+p-xylene	mg/kg	<2	93%	<2	90%	105%
o-Xylene	mg/kg	<1	94%	<1	91%	105%
naphthalene	mg/kg	<1	[NA]	[NA]	[NA]	[NA]
Surrogate aaa-Trifluorotoluene	%	97	97	108	96	102

svTRH (C10-C40) in Soil						
Our Reference:	UNITS	135957-1	135957-2	135957-3	135957-4	135957-5
Your Reference	-------------	BH1	BH1	BH1	BH2	BH2
Depth	------------	0.5-0.6	1.3-1.5	2.3-2.5	0.5-0.6	2.3-2.5
Date Sampled		12/10/2015	12/10/2015	12/10/2015	12/10/2015	12/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
TRHC_{10} - C_{14}	mg/kg	<50	<50	<50	<50	<50
TRHC_{15} - C_{28}	mg/kg	<100	<100	<100	<100	<100
TRHC_{29} - C_{36}	mg/kg	<100	<100	<100	<100	<100
TRH>C_{10}-C_{16}	mg/kg	<50	<50	<50	<50	<50
TRH>C_{10} - C_{16} less Naphthalene (F2)	mg/kg	<50	<50	<50	<50	<50
TRH>C_{16}-C_{34}	mg/kg	<100	<100	<100	<100	<100
TRH>C_{34}-C_{40}	mg/kg	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	87	88	89	90	88

svTRH (C10-C40) in Soil						
Our Reference:	UNITS	135957-6	135957-7	135957-8	135957-9	135957-10
Your Reference	-------------	BH2	BH3	BH3	BH3	BH4
Depth	------------	3.3-3.5	0.35-0.45	0.9-1.0	3.3-3.5	0.7-0.8
Date Sampled		12/10/2015	13/10/2015	13/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
TRHC_{10} - C_{14}	mg/kg	<50	<50	<50	<50	<50
TRHC_{15} - C_{28}	mg/kg	<100	<100	<100	<100	<100
TRHC_{29} - C_{36}	mg/kg	<100	<100	<100	<100	<100
TRH>C_{10}-C_{16}	mg/kg	<50	<50	<50	<50	<50
TRH>C_{10} - C_{16} less Naphthalene (F2)	mg/kg	<50	<50	<50	<50	<50
TRH>C_{16}-C_{34}	mg/kg	<100	<100	<100	<100	<100
TRH>C_{34}-C_{40}	mg/kg	<100	130	<100	<100	<100
Surrogate o-Terphenyl	%	88	88	89	86	88

svTRH (C10-C40) in Soil						
Our Reference:	UNITS	135957-11	135957-12	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	1.8-2.0	3.3-3.5	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
TRHC$_{10}$ - C$_{14}$	mg/kg	<50	96	<50	<50	<50
TRHC$_{15}$ - C$_{28}$	mg/kg	<100	580	250	<100	<100
TRHC$_{29}$ - C$_{36}$	mg/kg	<100	<100	210	<100	<100
TRH>C$_{10}$-C$_{16}$	mg/kg	<50	300	<50	<50	<50
TRH>C$_{10}$ - C$_{16}$ less Naphthalene (F2)	mg/kg	<50	300	<50	<50	<50
TRH>C$_{16}$-C$_{34}$	mg/kg	<100	390	410	170	110
TRH>C$_{34}$-C$_{40}$	mg/kg	<100	<100	100	<100	<100
Surrogate o-Terphenyl	%	89	#	90	89	91

svTRH (C10-C40) in Soil		
Our Reference:	UNITS	135957-16
Your Reference	-------------	BD1/131015
Depth	------------	3.3-3.5
Date Sampled		13/10/2015
Type of sample		Soil
Date extracted	-	16/10/2015
Date analysed	-	17/10/2015
TRHC$_{10}$ - C$_{14}$	mg/kg	80
TRHC$_{15}$ - C$_{28}$	mg/kg	460
TRHC$_{29}$ - C$_{36}$	mg/kg	<100
TRH>C$_{10}$-C$_{16}$	mg/kg	240
TRH>C$_{10}$ - C$_{16}$ less Naphthalene (F2)	mg/kg	240
TRH>C$_{16}$-C$_{34}$	mg/kg	310
TRH>C$_{34}$-C$_{40}$	mg/kg	<100
Surrogate o-Terphenyl	%	#

PAHs in Soil Our Reference:	UNITS	135957-1	135957-2	135957-3	135957-4	135957-5
Your Reference	-------------	BH1	BH1	BH1	BH2	BH2
Depth	------------	0.5-0.6	1.3-1.5	2.3-2.5	0.5-0.6	2.3-2.5
Date Sampled		12/10/2015	12/10/2015	12/10/2015	12/10/2015	12/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	1	<0.1	<0.1	<0.1	<0.1
Pyrene	mg/kg	1.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	mg/kg	0.6	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	0.8	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	1	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	mg/kg	0.71	<0.05	<0.05	<0.05	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	0.9	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	1.0	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	1.0	<0.5	<0.5	<0.5	<0.5
Total Positive PAHs	mg/kg	6.8	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	94	89	90	90	91

PAHs in Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	135957-6 BH2 3.3-3.5 12/10/2015 Soil	135957-7 BH3 0.35-0.45 13/10/2015 Soil	135957-8 BH3 0.9-1.0 13/10/2015 Soil	135957-9 BH3 3.3-3.5 13/10/2015 Soil	135957-10 BH4 0.7-0.8 13/10/2015 Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Naphthalene	mg/kg	<0.1	0.3	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	<0.1	1.4	<0.1	<0.1	<0.1
Anthracene	mg/kg	<0.1	0.4	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	1.4	<0.1	<0.1	0.2
Pyrene	mg/kg	<0.1	1.4	<0.1	<0.1	0.2
Benzo(a)anthracene	mg/kg	<0.1	0.7	<0.1	<0.1	0.1
Chrysene	mg/kg	<0.1	0.8	<0.1	<0.1	0.2
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	1	<0.2	<0.2	0.3
Benzo(a)pyrene	mg/kg	<0.05	0.60	<0.05	<0.05	0.1
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	0.3	<0.1	<0.1	0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1	0.3	<0.1	<0.1	0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	0.8	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	0.9	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	0.9	<0.5	<0.5	<0.5
Total Positive PAHs	mg/kg	NIL (+)VE	8.6	NIL (+)VE	NIL (+)VE	1.4
Surrogate p-Terphenyl-d14	%	90	91	91	89	90

PAHs in Soil						
Our Reference:	UNITS	135957-11	135957-12	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	1.8-2.0	3.3-3.5	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Naphthalene	mg/kg	<0.1	<0.1	0.3	0.2	0.2
Acenaphthylene	mg/kg	<0.1	<0.1	1.0	0.6	0.6
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	0.3	0.1	0.3
Phenanthrene	mg/kg	<0.1	<0.1	6.5	2.2	2.6
Anthracene	mg/kg	<0.1	<0.1	1.6	0.6	0.8
Fluoranthene	mg/kg	<0.1	<0.1	14	5.3	5.0
Pyrene	mg/kg	<0.1	<0.1	15	5.7	5.3
Benzo(a)anthracene	mg/kg	<0.1	<0.1	9.0	3.4	3.0
Chrysene	mg/kg	<0.1	<0.1	9.9	4.0	3.4
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	<0.2	15	6.1	5.1
Benzo(a)pyrene	mg/kg	<0.05	<0.05	9.7	4.0	3.3
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	<0.1	5.2	2.2	1.7
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1	1.1	0.3	0.3
Benzo(g,h,i)perylene	mg/kg	<0.1	<0.1	4.9	2.1	1.7
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	<0.5	14	5.6	4.7
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	<0.5	14	5.6	4.7
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	<0.5	14	5.6	4.7
Total Positive PAHs	mg/kg	NIL (+)VE	NIL (+)VE	93	37	33
Surrogate p-Terphenyl-d14	%	90	95	94	94	94

PAHs in Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	135957-16 BD1/131015 3.3-3.5 13/10/2015 Soil
Date extracted	-	16/10/2015
Date analysed	-	16/10/2015
Naphthalene	mg/kg	<0.1
Acenaphthylene	mg/kg	<0.1
Acenaphthene	mg/kg	<0.1
Fluorene	mg/kg	<0.1
Phenanthrene	mg/kg	<0.1
Anthracene	mg/kg	<0.1
Fluoranthene	mg/kg	<0.1
Pyrene	mg/kg	<0.1
Benzo(a)anthracene	mg/kg	<0.1
Chrysene	mg/kg	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2
Benzo(a)pyrene	mg/kg	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5
Total Positive PAHs	mg/kg	NIL (+)VE
Surrogate p-Terphenyl-d14	%	96

Organochlorine Pesticides in soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	135957-1 BH1 0.5-0.6 12/10/2015 Soil	135957-2 BH1 1.3-1.5 12/10/2015 Soil	135957-4 BH2 0.5-0.6 12/10/2015 Soil	135957-7 BH3 0.35-0.45 13/10/2015 Soil	135957-8 BH3 0.9-1.0 13/10/2015 Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	102	104	104	103	107

Organochlorine Pesticides in soil Our Reference:	UNITS	135957-10	135957-11	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	0.7-0.8	1.8-2.0	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	104	104	102	102	105

PCBs in Soil Our Reference:	UNITS	135957-1	135957-2	135957-4	135957-7	135957-8
Your Reference	-------------	BH1	BH1	BH2	BH3	BH3
Depth	------------	0.5-0.6	1.3-1.5	0.5-0.6	0.35-0.45	0.9-1.0
Date Sampled		12/10/2015	12/10/2015	12/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCLMX	%	102	104	104	103	107

PCBs in Soil Our Reference:	UNITS	135957-10	135957-11	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	0.7-0.8	1.8-2.0	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	17/10/2015	17/10/2015	17/10/2015	17/10/2015	17/10/2015
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCLMX	%	104	104	102	102	105

Acid Extractable metals in soil						
Our Reference:	UNITS	135957-1	135957-2	135957-3	135957-4	135957-5
Your Reference	------------	BH1	BH1	BH1	BH2	BH2
Depth	------------	0.5-0.6	1.3-1.5	2.3-2.5	0.5-0.6	2.3-2.5
Date Sampled		12/10/2015	12/10/2015	12/10/2015	12/10/2015	12/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Arsenic	mg/kg	11	<4	<4	<4	<4
Cadmium	mg/kg	0.8	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	7	2	3	2	2
Copper	mg/kg	52	6	1	4	1
Lead	mg/kg	220	16	4	16	3
Mercury	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	8	1	1	2	<1
Zinc	mg/kg	270	25	16	13	5

Acid Extractable metals in soil						
Our Reference:	UNITS	135957-6	135957-7	135957-8	135957-9	135957-10
Your Reference	------------	BH2	BH3	BH3	BH3	BH4
Depth	------------	3.3-3.5	0.35-0.45	0.9-1.0	3.3-3.5	0.7-0.8
Date Sampled		12/10/2015	13/10/2015	13/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Arsenic	mg/kg	<4	<4	<4	<4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	<1	20	<1	<1	3
Copper	mg/kg	<1	63	2	<1	9
Lead	mg/kg	<1	30	3	<1	29
Mercury	mg/kg	<0.1	0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	<1	11	<1	<1	1
Zinc	mg/kg	15	47	7	2	38

Acid Extractable metals in soil						
Our Reference:	UNITS	135957-11	135957-12	135957-13	135957-14	135957-15
Your Reference	------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	1.8-2.0	3.3-3.5	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Arsenic	mg/kg	<4	<4	11	6	8
Cadmium	mg/kg	<0.4	<0.4	1	1	0.9
Chromium	mg/kg	5	1	31	10	30
Copper	mg/kg	2	<1	260	96	220
Lead	mg/kg	5	1	4,700	310	6,100
Mercury	mg/kg	<0.1	<0.1	1.4	0.6	1.0
Nickel	mg/kg	2	<1	20	10	14
Zinc	mg/kg	9	6	890	490	530

Acid Extractable metals in soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	135957-16 BD1/131015 3.3-3.5 13/10/2015 Soil
Date prepared	-	16/10/2015
Date analysed	-	16/10/2015
Arsenic	mg/kg	<4
Cadmium	mg/kg	<0.4
Chromium	mg/kg	1
Copper	mg/kg	<1
Lead	mg/kg	2
Mercury	mg/kg	<0.1
Nickel	mg/kg	<1
Zinc	mg/kg	6

Moisture						
Our Reference:	UNITS	135957-1	135957-2	135957-3	135957-4	135957-5
Your Reference	-------------	BH1	BH1	BH1	BH2	BH2
Depth	------------	0.5-0.6	1.3-1.5	2.3-2.5	0.5-0.6	2.3-2.5
Date Sampled		12/10/2015	12/10/2015	12/10/2015	12/10/2015	12/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	19/10/2015	19/10/2015	19/10/2015	19/10/2015	19/10/2015
Moisture	%	13	4.8	24	5.0	5.3

Moisture						
Our Reference:	UNITS	135957-6	135957-7	135957-8	135957-9	135957-10
Your Reference	-------------	BH2	BH3	BH3	BH3	BH4
Depth	------------	3.3-3.5	0.35-0.45	0.9-1.0	3.3-3.5	0.7-0.8
Date Sampled		12/10/2015	13/10/2015	13/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	19/10/2015	19/10/2015	19/10/2015	19/10/2015	19/10/2015
Moisture	%	18	9.5	4.2	18	4.1

Moisture						
Our Reference:	UNITS	135957-11	135957-12	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	1.8-2.0	3.3-3.5	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	19/10/2015	19/10/2015	19/10/2015	19/10/2015	19/10/2015
Moisture	%	1.6	16	16	11	26

Moisture		
Our Reference:	UNITS	135957-16
Your Reference	-------------	BD1/131015
Depth	------------	3.3-3.5
Date Sampled		13/10/2015
Type of sample		Soil
Date prepared	-	16/10/2015
Date analysed	-	19/10/2015
Moisture	%	16

Misc Soil - Inorg						
Our Reference:	UNITS	135957-1	135957-2	135957-4	135957-7	135957-8
Your Reference	-------------	BH1	BH1	BH2	BH3	BH3
Depth	------------	0.5-0.6	1.3-1.5	0.5-0.6	0.35-0.45	0.9-1.0
Date Sampled		12/10/2015	12/10/2015	12/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Total Phenolics (as Phenol)	mg/kg	<5	<5	<5	<5	<5

Misc Soil - Inorg						
Our Reference:	UNITS	135957-10	135957-11	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	0.7-0.8	1.8-2.0	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Date analysed	-	16/10/2015	16/10/2015	16/10/2015	16/10/2015	16/10/2015
Total Phenolics (as Phenol)	mg/kg	<5	<5	<5	<5	<5

Asbestos ID - soils						
Our Reference:	UNITS	135957-1	135957-2	135957-4	135957-7	135957-8
Your Reference	-------------	BH1	BH1	BH2	BH3	BH3
Depth	------------	0.5-0.6	1.3-1.5	0.5-0.6	0.35-0.45	0.9-1.0
Date Sampled		12/10/2015	12/10/2015	12/10/2015	13/10/2015	13/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	21/10/2015	21/10/2015	21/10/2015	21/10/2015	21/10/2015
Sample mass tested	g	Approx. 60g	Approx. 45g	Approx. 50g	Approx. 20g	Approx. 45g
Sample Description	-	Brown coarse grain soil & rocks	Brown sandy soil & rocks	Brown sandy soil & rocks	Brown coarse grain soil & rocks	Brown sandy soil & rocks
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

Asbestos ID - soils						
Our Reference:	UNITS	135957-10	135957-11	135957-13	135957-14	135957-15
Your Reference	-------------	BH4	BH4	BH5	BH5	BH5
Depth	------------	0.7-0.8	1.8-2.0	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		13/10/2015	13/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	21/10/2015	21/10/2015	21/10/2015	21/10/2015	21/10/2015
Sample mass tested	g	Approx. 40g	Approx. 65g	Approx. 40g	Approx. 40g	Approx. 60g
Sample Description	-	Brown sandy soil & rocks	Brown sandy soil & rocks	Brown sandy soil & rocks	Brown sandy soil & rocks	Brown coarse grain soil & rocks
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

Method ID	Methodology Summary
Org-014	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-016	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-003	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'TEQ PQL' values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'TEQ zero' values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'TEQ half PQL' values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore" Total +ve PAHs" is simply a sum of the positive individual PAHs.
Org-005	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-006	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Metals-021 CV-AAS	Determination of Mercury by Cold Vapour AAS.
Inorg-008	Moisture content determined by heating at 105+/-5 deg C for a minimum of 12 hours.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
ASB-001	Asbestos ID - Qualitative identification of asbestos in bulk samples using Polarised Light Microscopy and Dispersion Staining Techniques including Synthetic Mineral Fibre and Organic Fibre as per Australian Standard 4964-2004.

QUALITY CONTROL VOCs in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-2	16/10/2015
Date analysed	-			17/10/2015	135957-1	17/10/2015 || 17/10/2015	LCS-2	17/10/2015
Dichlorodifluoromethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Chloromethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Vinyl Chloride	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Bromomethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Chloroethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Trichlorofluoromethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,1-Dichloroethene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
trans-1,2-dichloroethene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,1-dichloroethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	117%
cis-1,2-dichloroethene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
bromochloromethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
chloroform	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	116%
2,2-dichloropropane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2-dichloroethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	118%
1,1,1-trichloroethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	117%
1,1-dichloropropene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Cyclohexane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
carbon tetrachloride	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Benzene	mg/kg	0.2	Org-014	<0.2	135957-1	<0.2 || <0.2	[NR]	[NR]
dibromomethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2-dichloropropane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
trichloroethene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	109%
bromodichloromethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	113%
trans-1,3-dichloropropene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
cis-1,3-dichloropropene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,1,2-trichloroethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Toluene	mg/kg	0.5	Org-014	<0.5	135957-1	<0.5 || <0.5	[NR]	[NR]
1,3-dichloropropane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
dibromochloromethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	110%
1,2-dibromoethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
tetrachloroethene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	LCS-2	109%
1,1,1,2-tetrachloroethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
chlorobenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Ethylbenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
bromoform	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
m+p-xylene	mg/kg	2	Org-014	<2	135957-1	<2 || <2	[NR]	[NR]
styrene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,1,2,2-tetrachloroethane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
o-Xylene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2,3-trichloropropane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]

QUALITY CONTROL VOCs in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
isopropylbenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
bromobenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
n-propyl benzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
2-chlorotoluene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
4-chlorotoluene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,3,5-trimethyl benzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
tert-butyl benzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2,4-trimethyl benzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,3-dichlorobenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
sec-butyl benzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,4-dichlorobenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
4-isopropyl toluene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2-dichlorobenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
n-butyl benzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2-dibromo-3-chloropropane	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2,4-trichlorobenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
hexachlorobutadiene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
1,2,3-trichlorobenzene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Surrogate Dibromofluorometha	%		Org-014	95	135957-1	100 || 99 || RPD: 1	LCS-2	94%
Surrogate aaa-Trifluorotoluene	%		Org-014	120	135957-1	111 || 112 || RPD: 1	LCS-2	121%
Surrogate Toluene-d_8	%		Org-014	99	135957-1	100 || 100 || RPD: 0	LCS-2	100%
Surrogate 4-Bromofluorobenzene	%		Org-014	99	135957-1	99 || 100 || RPD: 1	LCS-2	101%

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-2	16/10/2015
Date analysed	-			17/10/2015	135957-1	17/10/2015 || 17/10/2015	LCS-2	17/10/2015
TRHC_6 - C_9	mg/kg	25	Org-016	<25	135957-1	<25 || <25	LCS-2	120%
TRHC_6 - C_{10}	mg/kg	25	Org-016	<25	135957-1	<25 || <25	LCS-2	120%
Benzene	mg/kg	0.2	Org-016	<0.2	135957-1	<0.2 || <0.2	LCS-2	121%
Toluene	mg/kg	0.5	Org-016	<0.5	135957-1	<0.5 || <0.5	LCS-2	118%
Ethylbenzene	mg/kg	1	Org-016	<1	135957-1	<1 || <1	LCS-2	119%
m+p-xylene	mg/kg	2	Org-016	<2	135957-1	<2 || <2	LCS-2	120%
o-Xylene	mg/kg	1	Org-016	<1	135957-1	<1 || <1	LCS-2	125%
naphthalene	mg/kg	1	Org-014	<1	135957-1	<1 || <1	[NR]	[NR]
Surrogate aaa-Trifluorotoluene	%		Org-016	120	135957-1	111 || 112 || RPD: 1	LCS-2	121%

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-2	16/10/2015
Date analysed	-			16/10/2015	135957-1	17/10/2015 || 17/10/2015	LCS-2	16/10/2015
TRHC_{10} - C_{14}	mg/kg	50	Org-003	<50	135957-1	<50 || <50	LCS-2	88%
TRHC_{15} - C_{28}	mg/kg	100	Org-003	<100	135957-1	<100 || <100	LCS-2	73%
TRHC_{29} - C_{36}	mg/kg	100	Org-003	<100	135957-1	<100 || <100	LCS-2	80%
TRH>C_{10}-C_{16}	mg/kg	50	Org-003	<50	135957-1	<50 || <50	LCS-2	88%
TRH>C_{16}-C_{34}	mg/kg	100	Org-003	<100	135957-1	<100 || <100	LCS-2	73%
TRH>C_{34}-C_{40}	mg/kg	100	Org-003	<100	135957-1	<100 || <100	LCS-2	80%
Surrogate o-Terphenyl	%		Org-003	90	135957-1	87 || 88 || RPD: 1	LCS-2	92%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-2	16/10/2015
Date analysed	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-2	16/10/2015
Naphthalene	mg/kg	0.1	Org-012	<0.1	135957-1	<0.1 || <0.1	LCS-2	101%
Acenaphthylene	mg/kg	0.1	Org-012	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Acenaphthene	mg/kg	0.1	Org-012	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Fluorene	mg/kg	0.1	Org-012	<0.1	135957-1	<0.1 || <0.1	LCS-2	96%
Phenanthrene	mg/kg	0.1	Org-012	<0.1	135957-1	0.4 || 0.2 || RPD: 67	LCS-2	97%
Anthracene	mg/kg	0.1	Org-012	<0.1	135957-1	0.1 || <0.1	[NR]	[NR]
Fluoranthene	mg/kg	0.1	Org-012	<0.1	135957-1	1 || 0.5 || RPD: 67	LCS-2	98%
Pyrene	mg/kg	0.1	Org-012	<0.1	135957-1	1.1 || 0.5 || RPD: 75	LCS-2	103%
Benzo(a)anthracene	mg/kg	0.1	Org-012	<0.1	135957-1	0.6 || 0.3 || RPD: 67	[NR]	[NR]
Chrysene	mg/kg	0.1	Org-012	<0.1	135957-1	0.8 || 0.4 || RPD: 67	LCS-2	119%
Benzo(b,j+k) fluoranthene	mg/kg	0.2	Org-012	<0.2	135957-1	1 || 0.8 || RPD: 22	[NR]	[NR]

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Benzo(a)pyrene	mg/kg	0.05	Org-012	<0.05	135957-1	0.71 || 0.4 || RPD: 56	LCS-2	116%
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-012	<0.1	135957-1	0.4 || 0.3 || RPD: 29	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-012	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-012	<0.1	135957-1	0.4 || 0.3 || RPD: 29	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	88	135957-1	94 || 90 || RPD: 4	LCS-2	101%

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-2	16/10/2015
Date analysed	-			17/10/2015	135957-1	17/10/2015 || 17/10/2015	LCS-2	17/10/2015
HCB	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
alpha-BHC	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	94%
gamma-BHC	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
beta-BHC	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	83%
Heptachlor	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	81%
delta-BHC	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Aldrin	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	87%
Heptachlor Epoxide	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	84%
gamma-Chlordane	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
alpha-chlordane	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Endosulfan I	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
pp-DDE	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	82%
Dieldrin	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	111%
Endrin	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	95%
pp-DDD	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	89%
Endosulfan II	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
pp-DDT	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Endrin Aldehyde	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Endosulfan Sulphate	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	LCS-2	77%
Methoxychlor	mg/kg	0.1	Org-005	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Surrogate TCMX	%		Org-005	106	135957-1	102 || 104 || RPD: 2	LCS-2	100%

QUALITY CONTROL PCBs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-2	16/10/2015
Date analysed	-			17/10/2015	135957-1	17/10/2015 || 17/10/2015	LCS-2	17/10/2015
Aroclor 1016	mg/kg	0.1	Org-006	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1221	mg/kg	0.1	Org-006	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1232	mg/kg	0.1	Org-006	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1242	mg/kg	0.1	Org-006	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1248	mg/kg	0.1	Org-006	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1254	mg/kg	0.1	Org-006	<0.1	135957-1	<0.1 || <0.1	LCS-2	101%
Aroclor 1260	mg/kg	0.1	Org-006	<0.1	135957-1	<0.1 || <0.1	[NR]	[NR]
Surrogate TCLMX	%		Org-006	106	135957-1	102 || 104 || RPD: 2	LCS-2	100%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-6	16/10/2015
Date analysed	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-6	16/10/2015
Arsenic	mg/kg	4	Metals-020 ICP-AES	<4	135957-1	11 || 12 || RPD: 9	LCS-6	107%
Cadmium	mg/kg	0.4	Metals-020 ICP-AES	<0.4	135957-1	0.8 || 0.8 || RPD: 0	LCS-6	102%
Chromium	mg/kg	1	Metals-020 ICP-AES	<1	135957-1	7 || 8 || RPD: 13	LCS-6	101%
Copper	mg/kg	1	Metals-020 ICP-AES	<1	135957-1	52 || 49 || RPD: 6	LCS-6	106%
Lead	mg/kg	1	Metals-020 ICP-AES	<1	135957-1	220 || 200 || RPD: 10	LCS-6	98%
Mercury	mg/kg	0.1	Metals-021 CV-AAS	<0.1	135957-1	0.4 || 0.4 || RPD: 0	LCS-6	92%
Nickel	mg/kg	1	Metals-020 ICP-AES	<1	135957-1	8 || 9 || RPD: 12	LCS-6	97%
Zinc	mg/kg	1	Metals-020 ICP-AES	<1	135957-1	270 || 260 || RPD: 4	LCS-6	99%

QUALITY CONTROL Misc Soil - Inorg	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-1	16/10/2015
Date analysed	-			16/10/2015	135957-1	16/10/2015 || 16/10/2015	LCS-1	16/10/2015
Total Phenolics (as Phenol)	mg/kg	5	Inorg-031	<5	135957-1	<5 || <5	LCS-1	101%

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date extracted	-	135957-12	16/10/2015 || 16/10/2015
Date analysed	-	135957-12	17/10/2015 || 17/10/2015
TRHC_6 - C_9	mg/kg	135957-12	<25 || <25
TRHC_6 - C_{10}	mg/kg	135957-12	<25 || <25
Benzene	mg/kg	135957-12	<0.2 || <0.2
Toluene	mg/kg	135957-12	<0.5 || <0.5
Ethylbenzene	mg/kg	135957-12	<1 || <1
m+p-xylene	mg/kg	135957-12	<2 || <2
o-Xylene	mg/kg	135957-12	<1 || <1
naphthalene	mg/kg	135957-12	<1 || <1
Surrogate aaa-Trifluorotoluene	%	135957-12	99 || 96 || RPD: 3

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	135957-12	16/10/2015 || 16/10/2015	135957-2	16/10/2015
Date analysed	-	135957-12	17/10/2015 || 17/10/2015	135957-2	17/10/2015
TRHC_{10} - C_{14}	mg/kg	135957-12	96 || 87 || RPD: 10	135957-2	103%
TRHC_{15} - C_{28}	mg/kg	135957-12	580 || 490 || RPD: 17	135957-2	97%
TRHC_{29} - C_{36}	mg/kg	135957-12	<100 || <100	135957-2	97%
TRH>C_{10}-C_{16}	mg/kg	135957-12	300 || 270 || RPD: 11	135957-2	103%
TRH>C_{16}-C_{34}	mg/kg	135957-12	390 || 320 || RPD: 20	135957-2	97%
TRH>C_{34}-C_{40}	mg/kg	135957-12	<100 || <100	135957-2	97%
Surrogate o-Terphenyl	%	135957-12	# || #	135957-2	88%

QUALITY CONTROL PAHs in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	135957-12	16/10/2015 || 16/10/2015	135957-2	16/10/2015
Date analysed	-	135957-12	16/10/2015 || 16/10/2015	135957-2	16/10/2015
Naphthalene	mg/kg	135957-12	<0.1 || <0.1	135957-2	101%
Acenaphthylene	mg/kg	135957-12	<0.1 || <0.1	[NR]	[NR]
Acenaphthene	mg/kg	135957-12	<0.1 || <0.1	[NR]	[NR]
Fluorene	mg/kg	135957-12	<0.1 || <0.1	135957-2	96%
Phenanthrene	mg/kg	135957-12	<0.1 || <0.1	135957-2	97%
Anthracene	mg/kg	135957-12	<0.1 || <0.1	[NR]	[NR]
Fluoranthene	mg/kg	135957-12	<0.1 || <0.1	135957-2	97%

QUALITY CONTROL PAHs in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Pyrene	mg/kg	135957-12	<0.1 || <0.1	135957-2	102%
Benzo(a)anthracene	mg/kg	135957-12	<0.1 || <0.1	[NR]	[NR]
Chrysene	mg/kg	135957-12	<0.1 || <0.1	135957-2	116%
Benzo(b,j+k)fluoranthene	mg/kg	135957-12	<0.2 || <0.2	[NR]	[NR]
Benzo(a)pyrene	mg/kg	135957-12	<0.05 || <0.05	135957-2	108%
Indeno(1,2,3-c,d)pyrene	mg/kg	135957-12	<0.1 || <0.1	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	135957-12	<0.1 || <0.1	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	135957-12	<0.1 || <0.1	[NR]	[NR]
Surrogate p-Terphenyl-d14	%	135957-12	95 || 96 || RPD: 1	[NR]	[NR]

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	135957-2	16/10/2015
Date analysed	-	[NT]	[NT]	135957-2	17/10/2015
HCB	mg/kg	[NT]	[NT]	[NR]	[NR]
alpha-BHC	mg/kg	[NT]	[NT]	135957-2	91%
gamma-BHC	mg/kg	[NT]	[NT]	[NR]	[NR]
beta-BHC	mg/kg	[NT]	[NT]	135957-2	79%
Heptachlor	mg/kg	[NT]	[NT]	135957-2	78%
delta-BHC	mg/kg	[NT]	[NT]	[NR]	[NR]
Aldrin	mg/kg	[NT]	[NT]	135957-2	84%
Heptachlor Epoxide	mg/kg	[NT]	[NT]	135957-2	81%
gamma-Chlordane	mg/kg	[NT]	[NT]	[NR]	[NR]
alpha-chlordane	mg/kg	[NT]	[NT]	[NR]	[NR]
Endosulfan I	mg/kg	[NT]	[NT]	[NR]	[NR]
pp-DDE	mg/kg	[NT]	[NT]	135957-2	79%
Dieldrin	mg/kg	[NT]	[NT]	135957-2	108%
Endrin	mg/kg	[NT]	[NT]	135957-2	91%
pp-DDD	mg/kg	[NT]	[NT]	135957-2	85%
Endosulfan II	mg/kg	[NT]	[NT]	[NR]	[NR]
pp-DDT	mg/kg	[NT]	[NT]	[NR]	[NR]
Endrin Aldehyde	mg/kg	[NT]	[NT]	[NR]	[NR]
Endosulfan Sulphate	mg/kg	[NT]	[NT]	135957-2	70%
Methoxychlor	mg/kg	[NT]	[NT]	[NR]	[NR]
Surrogate TCMX	%	[NT]	[NT]	135957-2	98%

QUALITY CONTROL PCBs in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	135957-2	16/10/2015
Date analysed	-	[NT]	[NT]	135957-2	17/10/2015
Aroclor 1016	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1221	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1232	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1242	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1248	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1254	mg/kg	[NT]	[NT]	135957-2	101%
Aroclor 1260	mg/kg	[NT]	[NT]	[NR]	[NR]
Surrogate TCLMX	%	[NT]	[NT]	135957-2	98%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	135957-12	16/10/2015 || 16/10/2015	135957-2	16/10/2015
Date analysed	-	135957-12	16/10/2015 || 16/10/2015	135957-2	16/10/2015
Arsenic	mg/kg	135957-12	<4 || <4	135957-2	101%
Cadmium	mg/kg	135957-12	<0.4 || <0.4	135957-2	107%
Chromium	mg/kg	135957-12	1 || 1 || RPD: 0	135957-2	101%
Copper	mg/kg	135957-12	<1 || <1	135957-2	109%
Lead	mg/kg	135957-12	1 || 1 || RPD: 0	135957-2	105%
Mercury	mg/kg	135957-12	<0.1 || <0.1	135957-2	89%
Nickel	mg/kg	135957-12	<1 || <1	135957-2	101%
Zinc	mg/kg	135957-12	6 || 5 || RPD: 18	135957-2	107%

QUALITY CONTROL Misc Soil - Inorg	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	135957-2	16/10/2015
Date analysed	-	[NT]	[NT]	135957-2	16/10/2015
Total Phenolics (as Phenol)	mg/kg	[NT]	[NT]	135957-2	104%

Report Comments:

sTRH in soil: # Percent recovery is not possible to report as the high concentration of analytes in the sample/s have caused interference.

Asbestos: Excessive sample volume was provided for asbestos analysis. A portion of the supplied sample was sub-sampled according to Envirolab procedures. We cannot guarantee that this sub-sample is indicative of the entire sample. Envirolab recommends supplying 40-50g (50mL) of sample in its own container as per AS4964-2004.
Note: Samples 135957-1,2,4,8,10,11,13,14,15 were sub-sampled from bags provided by the client.

PAH's in soil: The RPD for duplicate results is accepted due to the non homogenous nature of the sample/s.

Asbestos ID was analysed by Approved Identifier:	Lulu Scott
Asbestos ID was authorised by Approved Signatory:	Lulu Scott

INS: Insufficient sample for this test
NR: Test not required
<: Less than

PQL: Practical Quantitation Limit
RPD: Relative Percent Difference
>: Greater than

NT: Not tested
NA: Test not required
LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

CHAIN OF CUSTODY

Douglas Partners
Geotechnics / Environment / Groundwater

Client: Douglas Partners
Contact Person: Veronica Ku
Project Mgr: Veronica Ku/Atha Kapitanof
Address: 96 Hermitage Road
West Ryde NSW 2114
Phone: 9809 0666 **Mob:** 0407 630 549
Email: veronica.ku@douglaspartners.com.au

Project Number 85100.01
Project Name: Zetland, Trunk Drain
PO No.:
lab Quote No. :
Date results required: 22/10/2015 (standard)
Or choose:
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / PDF / Excel
Comments:

To: Envirolab Services
Contact Person: Aileen Hie
Address: 12 Ashley Street
Chatswood NSW 2068
Phone: 02 9910 6200
Fax: 02 9910 6201
Email: ahie@envirolab.com.au
Laboratory Report No:
Lab Comments:

Sample information						**Tests Required**											**Comments**
Lab Sample ID	**Field Sample ID**	**Depth**	**Date sampled**	**Container Type**	**Type of sample**	8 metals - As, Cd, Cr, Cu, Pb, Hg, Ni, Zn	TRH	BTEX	PAH	phenols	PCB, OCP	VOC	asbestos			**Combo**	**Provide as much information about the sample as you can**
1	BH1	0.5-0.6	12/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
2		1.3-1.5	12/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
3		2.3-2.5	12/10/2015	g+p	s	x	x	x	x							3	
4	BH2	0.5-0.6	12/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
5		2.3-2.5	12/10/2015	g+p	s	x	x	x	x							3	
6		3.3-3.5	12/10/2015	g+p	s	x	x	x	x							3	
7	BH3	0.35-0.45	13/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
8		0.9-1.0	13/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
9		3.3-3.5	13/10/2015	g+p	s	x	x	x	x							3	
10	BH4	0.7-0.8	13/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
11		1.8-2.0	13/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
12		3.3-3.5	13/10/2015	g+p	s	x	x	x	x							3	
13	BH5	0.4-0.5	15/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
14		1.9-2.0	15/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
15		2.9-3.0	15/10/2015	g+p	s	x	x	x	x	x	x	x	x			7a	
16	BD1/131015	3.3-3.5	13/10/2015	g	s	x	x	x	x							3	
*	BD3/141015	1.9-2.0	14/10/2015	g	s	x	x	x	x								Pls forward to Eurofins
17	TS/121015	9/10/15	-	g	s			x									
18	TB/121015	9/10/15	-	g	s			x									
19	TS/131015	10/10/15	-	g	s			x									
20	TB/131015	10/10/15	-	g	s			x									
21	BH4	03~0.4															

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

ENVIROLAB GROUP

Job No: 135957
Date Received: 15/10/15
Time Received: 1230.
Received by:
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

Relinquished by: Douglas Partners
Courier (by whom) HUNTER EXPRESS
Condition of Sample at dispatch Cool or Ambient (circle)
Temperature (if Applicable):
Print Name: VERONICA KU
Date & Time 15/10/15; 2pm
Signature:

Sample Receipt
Received by (Company): ELS.
Print Name: KEVIN.
Date & Time: 15.10.15 1730.
Signature:

Lab use only:
Samples Received: [✓ Cool] or Ambient (circle one)
Temperature Received at: 2.6. **(if applicable)**
Transported by: Hand delivered / courier

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
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SAMPLE RECEIPT ADVICE

Client Details	
Client	Douglas Partners Pty Ltd
Attention	Veronica Ku, Atha K

Sample Login Details	
Your Reference	85100.01, Zetland, Trunk Drain
Envirolab Reference	135957
Date Sample Received	15/10/2015
Date Instructions Received	15/10/2015
Date Results Expected to be Reported	22/10/2015

Sample Condition	
Samples received in appropriate condition for analysis	YES
No. of Samples Provided	21 Soils
Turnaround Time Requested	Standard
Temperature on receipt (°C)	21
Cooling Method	Ice
Sampling Date Provided	YES

Comments
Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples
extra sample - BH4 0.3-0.4

Please direct any queries to:

Aileen Hie	**Jacinta Hurst**
Phone: 02 9910 6200	Phone: 02 9910 6200
Fax: 02 9910 6201	Fax: 02 9910 6201
Email: ahie@envirolabservices.com.au	Email: jhurst@envirolabservices.com.au

Sample and Testing Details on following page

Sample Id	*VOCs in soil*	*vTRH(C6-C10)/BTEXN in Soil*	*svTRH (C10-C40) in Soil*	*PAHs in Soil*	*Organochlorine Pesticides in soil*	*PCBs in Soil*	*Acid Extractable metals in soil*	*Misc Soil - Inorg*	*Asbestos ID - soils*	*On Hold*
BH1-0.5-0.6	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH1-1.3-1.5	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH1-2.3-2.5		✓	✓	✓			✓			
BH2-0.5-0.6	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH2-2.3-2.5		✓	✓	✓			✓			
BH2-3.3-3.5		✓	✓	✓			✓			
BH3-0.35-0.45	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH3-0.9-1.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH3-3.3-3.5		✓	✓	✓			✓			
BH4-0.7-0.8	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH4-1.8-2.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH4-3.3-3.5		✓	✓	✓			✓			
BH5-0.4-0.5	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH5-1.9-2.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH5-3.9-3.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	
BD1/131015-3.3-3.5		✓	✓	✓			✓			
TS/121015		✓								
TB/121015		✓								
TS/131015		✓								
TB/131015		✓								
BH4-0.3-0.4										✓

12 Ashley Street, Chatswood, NSW 2067
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email: sydney@envirolab.com.au
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Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 135957-A

Client:

Douglas Partners Pty Ltd
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Veronica Ku, Atha K

Sample log in details:

Your Reference:	**85100.01, Zetland, Trunk Drain**
No. of samples:	Additional testing on 4 soils
Date samples received / completed instructions received	15/10/15 / 26/10/15

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	2/11/15 / 28/10/15
Date of Preliminary Report:	Not Issued

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

ACCREDITED FOR TECHNICAL COMPETENCE

PAHs in TCLP (USEPA 1311) Our Reference:	UNITS	135957-A-13	135957-A-14	135957-A-15
Your Reference	-------------	BH5	BH5	BH5
Depth	------------	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil
Date extracted	-	27/10/2015	27/10/2015	27/10/2015
Date analysed	-	27/10/2015	27/10/2015	27/10/2015
Naphthalene in TCLP	mg/L	<0.001	<0.001	<0.001
Acenaphthylene in TCLP	mg/L	<0.001	<0.001	<0.001
Acenaphthene in TCLP	mg/L	<0.001	<0.001	<0.001
Fluorene in TCLP	mg/L	<0.001	<0.001	<0.001
Phenanthrene in TCLP	mg/L	<0.001	<0.001	<0.001
Anthracene in TCLP	mg/L	<0.001	<0.001	<0.001
Fluoranthene in TCLP	mg/L	<0.001	<0.001	<0.001
Pyrene in TCLP	mg/L	<0.001	<0.001	<0.001
Benzo(a)anthracene in TCLP	mg/L	<0.001	<0.001	<0.001
Chrysene in TCLP	mg/L	<0.001	<0.001	<0.001
Benzo(bjk)fluoranthene in TCLP	mg/L	<0.002	<0.002	<0.002
Benzo(a)pyrene in TCLP	mg/L	<0.001	<0.001	<0.001
Indeno(1,2,3-c,d)pyrene - TCLP	mg/L	<0.001	<0.001	<0.001
Dibenzo(a,h)anthracene in TCLP	mg/L	<0.001	<0.001	<0.001
Benzo(g,h,i)perylene in TCLP	mg/L	<0.001	<0.001	<0.001
Total +ve PAH's	mg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	91	93	101

Metals in TCLP USEPA1311 Our Reference:	UNITS	135957-A-1	135957-A-13	135957-A-14	135957-A-15
Your Reference	-------------	BH1	BH5	BH5	BH5
Depth	------------	0.5-0.6	0.4-0.5	1.9-2.0	2.9-3.0
Date Sampled		12/10/2015	15/10/2015	15/10/2015	15/10/2015
Type of sample		Soil	Soil	Soil	Soil
Date extracted	-	27/10/2015	27/10/2015	27/10/2015	27/10/2015
Date analysed	-	27/10/2015	27/10/2015	27/10/2015	27/10/2015
pH of soil for fluid# determ.	pH units	7.1	7.3	8.1	8.1
pH of soil for fluid # determ. (acid)	pH units	1.4	1.3	1.4	1.4
Extraction fluid used	-	1	1	1	1
pH of final Leachate	pH units	5.2	5.1	5.0	5.1
Lead in TCLP	mg/L	0.08	2.1	0.1	5.6

Method ID	Methodology Summary
Org-012	Leachates are extracted with Dichloromethane and analysed by GC-MS.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS.
Inorg-004	Toxicity Characteristic Leaching Procedure (TCLP) based upon AS 4439 and USEPA 1311. Additional information as required in AS4439.3 section 11 can be provided on request.
EXTRACT.7	Toxicity Characteristic Leaching Procedure (TCLP).
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.

QUALITY CONTROL PAHs in TCLP (USEPA 1311)	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			27/10/2015	[NT]	[NT]	LCS-W1	27/10/2015
Date analysed	-			27/10/2015	[NT]	[NT]	LCS-W1	27/10/2015
Naphthalene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	LCS-W1	72%
Acenaphthylene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	[NR]	[NR]
Acenaphthene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	[NR]	[NR]
Fluorene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	LCS-W1	83%
Phenanthrene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	LCS-W1	73%
Anthracene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	[NR]	[NR]
Fluoranthene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	LCS-W1	75%
Pyrene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	LCS-W1	72%
Benzo(a)anthracene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	[NR]	[NR]
Chrysene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	LCS-W1	80%
Benzo(bjk)fluoranthene in TCLP	mg/L	0.002	Org-012	<0.002	[NT]	[NT]	[NR]	[NR]
Benzo(a)pyrene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	LCS-W1	83%
Indeno(1,2,3-c,d)pyrene - TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	[NR]	[NR]
Dibenzo(a,h)anthracene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	[NR]	[NR]
Benzo(g,h,i)perylene in TCLP	mg/L	0.001	Org-012	<0.001	[NT]	[NT]	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	124	[NT]	[NT]	LCS-W1	91%

QUALITY CONTROL Metals in TCLP USEPA1311	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			27/10/2015	[NT]	[NT]	LCS-W1	27/10/2015
Date analysed	-			27/10/2015	[NT]	[NT]	LCS-W1	27/10/2015
Lead in TCLP	mg/L	0.03	Metals-020 ICP-AES	<0.03	[NT]	[NT]	LCS-W1	112%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test
NR: Test not required
<: Less than

PQL: Practical Quantitation Limit
RPD: Relative Percent Difference
>: Greater than

NT: Not tested
NA: Test not required
LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

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Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 136424

Client:

Douglas Partners Pty Ltd
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Veronica Ku

Sample log in details:

Your Reference:	**85100.01, Zetland-Trunk Drain**
No. of samples:	1 Soil
Date samples received / completed instructions received	26/10/2015 / 26/10/2015

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	2/11/15 / 30/10/15
Date of Preliminary Report:	Not Issued

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Results Approved By:

Jacinta Hurst
Laboratory Manager

ACCREDITED FOR TECHNICAL COMPETENCE

vTRH(C6-C10)/BTEXN in Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	136424-1 BH3 1.9-2.0 13/10/2015 Soil
Date extracted	-	27/10/2015
Date analysed	-	28/10/2015
TRH C_6 - C_9	mg/kg	<25
TRH C_6 - C_{10}	mg/kg	<25
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25
Benzene	mg/kg	<0.2
Toluene	mg/kg	<0.5
Ethylbenzene	mg/kg	<1
m+p-xylene	mg/kg	<2
o-Xylene	mg/kg	<1
naphthalene	mg/kg	<1
Surrogate aaa-Trifluorotoluene	%	98

svTRH (C10-C40) in Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------ ------------	136424-1 BH3 1.9-2.0 13/10/2015 Soil
Date extracted	-	27/10/2015
Date analysed	-	29/10/2015
TRHC $_{10}$ - C $_{14}$	mg/kg	<50
TRHC $_{15}$ - C $_{28}$	mg/kg	<100
TRHC $_{29}$ - C $_{36}$	mg/kg	<100
TRH>C $_{10}$-C $_{16}$	mg/kg	<50
TRH>C $_{10}$ - C $_{16}$ less Naphthalene (F2)	mg/kg	<50
TRH>C $_{16}$-C $_{34}$	mg/kg	<100
TRH>C $_{34}$-C $_{40}$	mg/kg	<100
Surrogate o-Terphenyl	%	83

PAHs in Soil Our Reference:	UNITS	136424-1
Your Reference	-------------	BH3
Depth	------------	1.9-2.0
Date Sampled		13/10/2015
Type of sample		Soil
Date extracted	-	27/10/2015
Date analysed	-	27/10/2015
Naphthalene	mg/kg	<0.1
Acenaphthylene	mg/kg	<0.1
Acenaphthene	mg/kg	<0.1
Fluorene	mg/kg	<0.1
Phenanthrene	mg/kg	0.3
Anthracene	mg/kg	<0.1
Fluoranthene	mg/kg	0.3
Pyrene	mg/kg	0.2
Benzo(a)anthracene	mg/kg	0.1
Chrysene	mg/kg	0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2
Benzo(a)pyrene	mg/kg	0.1
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5
Total Positive PAHs	mg/kg	1.1
Surrogate p-Terphenyl-d14	%	86

Acid Extractable metals in soil		
Our Reference:	UNITS	136424-1
Your Reference	-------------	BH3
Depth	------------	1.9-2.0
Date Sampled		13/10/2015
Type of sample		Soil
Date prepared	-	27/10/2015
Date analysed	-	27/10/2015
Arsenic	mg/kg	<4
Cadmium	mg/kg	<0.4
Chromium	mg/kg	2
Copper	mg/kg	7
Lead	mg/kg	62
Mercury	mg/kg	<0.1
Nickel	mg/kg	1
Zinc	mg/kg	14

Moisture		
Our Reference:	UNITS	136424-1
Your Reference	-------------	BH3
Depth	------------	1.9-2.0
Date Sampled		13/10/2015
Type of sample		Soil
Date prepared	-	27/10/2015
Date analysed	-	28/10/2015
Moisture	%	9.1

Method ID	Methodology Summary
Org-016	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-014	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-003	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'TEQ PQL' values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'TEQ zero' values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'TEQ half PQL' values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore" Total +ve PAHs" is simply a sum of the positive individual PAHs.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Metals-021 CV-AAS	Determination of Mercury by Cold Vapour AAS.
Inorg-008	Moisture content determined by heating at 105+/-5 deg C for a minimum of 12 hours.

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			27/10/2015	[NT]	[NT]	LCS-6	27/10/2015
Date analysed	-			28/10/2015	[NT]	[NT]	LCS-6	28/10/2015
TRHC$_{6}$ - C$_{9}$	mg/kg	25	Org-016	<25	[NT]	[NT]	LCS-6	102%
TRHC$_{6}$ - C$_{10}$	mg/kg	25	Org-016	<25	[NT]	[NT]	LCS-6	102%
Benzene	mg/kg	0.2	Org-016	<0.2	[NT]	[NT]	LCS-6	98%
Toluene	mg/kg	0.5	Org-016	<0.5	[NT]	[NT]	LCS-6	102%
Ethylbenzene	mg/kg	1	Org-016	<1	[NT]	[NT]	LCS-6	100%
m+p-xylene	mg/kg	2	Org-016	<2	[NT]	[NT]	LCS-6	105%
o-Xylene	mg/kg	1	Org-016	<1	[NT]	[NT]	LCS-6	105%
naphthalene	mg/kg	1	Org-014	<1	[NT]	[NT]	[NR]	[NR]
Surrogate aaa-Trifluorotoluene	%		Org-016	87	[NT]	[NT]	LCS-6	95%

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			27/10/2015	[NT]	[NT]	LCS-6	27/10/2015
Date analysed	-			28/10/2015	[NT]	[NT]	LCS-6	28/10/2015
TRHC$_{10}$ - C$_{14}$	mg/kg	50	Org-003	<50	[NT]	[NT]	LCS-6	103%
TRHC$_{15}$ - C$_{28}$	mg/kg	100	Org-003	<100	[NT]	[NT]	LCS-6	75%
TRHC$_{29}$ - C$_{36}$	mg/kg	100	Org-003	<100	[NT]	[NT]	LCS-6	80%
TRH>C$_{10}$-C$_{16}$	mg/kg	50	Org-003	<50	[NT]	[NT]	LCS-6	103%
TRH>C$_{16}$-C$_{34}$	mg/kg	100	Org-003	<100	[NT]	[NT]	LCS-6	75%
TRH>C$_{34}$-C$_{40}$	mg/kg	100	Org-003	<100	[NT]	[NT]	LCS-6	80%
Surrogate o-Terphenyl	%		Org-003	83	[NT]	[NT]	LCS-6	111%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			27/10/2015	[NT]	[NT]	LCS-6	27/10/2015
Date analysed	-			27/10/2015	[NT]	[NT]	LCS-6	27/10/2015
Naphthalene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	LCS-6	85%
Acenaphthylene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	[NR]	[NR]
Acenaphthene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	[NR]	[NR]
Fluorene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	LCS-6	97%
Phenanthrene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	LCS-6	85%
Anthracene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	[NR]	[NR]
Fluoranthene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	LCS-6	84%
Pyrene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	LCS-6	83%
Benzo(a)anthracene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	[NR]	[NR]
Chrysene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	LCS-6	90%
Benzo(b,j+k) fluoranthene	mg/kg	0.2	Org-012	<0.2	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Benzo(a)pyrene	mg/kg	0.05	Org-012	<0.05	[NT]	[NT]	LCS-6	91%
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-012	<0.1	[NT]	[NT]	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	86	[NT]	[NT]	LCS-6	107%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			27/10/2015	[NT]	[NT]	LCS-3	27/10/2015
Date analysed	-			27/10/2015	[NT]	[NT]	LCS-3	27/10/2015
Arsenic	mg/kg	4	Metals-020 ICP-AES	<4	[NT]	[NT]	LCS-3	111%
Cadmium	mg/kg	0.4	Metals-020 ICP-AES	<0.4	[NT]	[NT]	LCS-3	108%
Chromium	mg/kg	1	Metals-020 ICP-AES	<1	[NT]	[NT]	LCS-3	107%
Copper	mg/kg	1	Metals-020 ICP-AES	<1	[NT]	[NT]	LCS-3	109%
Lead	mg/kg	1	Metals-020 ICP-AES	<1	[NT]	[NT]	LCS-3	106%
Mercury	mg/kg	0.1	Metals-021 CV-AAS	<0.1	[NT]	[NT]	LCS-3	99%
Nickel	mg/kg	1	Metals-020 ICP-AES	<1	[NT]	[NT]	LCS-3	104%
Zinc	mg/kg	1	Metals-020 ICP-AES	<1	[NT]	[NT]	LCS-3	105%

Report Comments:

Asbestos ID was analysed by Approved Identifier: Not applicable for this job
Asbestos ID was authorised by Approved Signatory: Not applicable for this job

INS: Insufficient sample for this test
NR: Test not required
<: Less than

PQL: Practical Quantitation Limit
RPD: Relative Percent Difference
>: Greater than

NT: Not tested
NA: Test not required
LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

CHAIN OF COUNTY

Douglas Partners
Geotechnics / Environment / Groundwater

Client: Douglas Partners
Contact Person: Veronica Ku
Project Mgr: Veronica Ku/Atha Kapitanof
Address: 96 Hermitage Road
West Ryde NSW 2114
Phone: 9809 0666 **Mob:** 0407 630 549
Email: veronica.ku@douglaspartners.com.au

Project Number 85100.01
Project Name: Zetland, Trunk Drain
PO No.:
lab Quote No. :
Date results required: 2/11/2015 (standard)
Or choose:
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / PDF / Excel
Comments:

To: Envirolab Services
Contact Person: Aileen Hie
Address: 12 Ashley Street
Chatswood NSW 2068
Phone: 02 9910 6200
Fax: 02 9910 6201
Email: ahie@envirolab.com.au
Laboratory Report No:
Lab Comments:

Sample information						Tests Required											Comments
Lab Sample ID	**Field Sample ID**	**Depth**	**Date sampled**	**Container Type**	**Type of sample**	8 metals - As, Cd, Cr, Cu, Pb, Hg, Ni, Zn	TRH	BTEX	PAH	phenols	PCB, OCP	VOC	asbestos			**Combo**	**Provide as much information about the sample as you can**
1	BH3	1.9-2.0	13/10/2015	g+p	s	x	x	x	x							3	

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
ENVIROLAB GROUP
Job No: 136424
Date Received: 26/10/15
Time Received: 14:20.
Received by:
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

Relinquished by: Douglas Partners
Courier (by whom) HUNTER EXPRESS
Condition of Sample at dispatch Cool or Ambient (circle)
Temperature (if Applicable):
Print Name: VERONICA KU
Date & Time: 26/10/15; 12pm
Signature:

Sample Receipt
Received by (Company): ELS
Print Name: Kevin Wang
Date & Time: 26/10/15 14:20
Signature:

Lab use only:
Samples Received: Cool or Ambient (circle one)
Temperature Received at: (if applicable)
Transported by: Hand delivered / courier

Page 1 of 1

Certificate of Analysis

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Douglas Partners (Syd)
96 Hermitage Road
West Ryde
NSW 2114

Attention: **Veronica Ku**

Report **476173-S**
Project name ZETLAND TRUNK DRAIN
Project ID 85100.01
Received Date Oct 16, 2015

Client Sample ID **Sample Matrix** **Eurofins | mgt Sample No.** **Date Sampled** Test/Reference	LOR	Unit	**BD3/141015** **Soil** **S15-Oc11926** **Oct 14, 2015**
Total Recoverable Hydrocarbons - 1999 NEPM Fractions			
TRH C6-C9	20	mg/kg	< 20
TRH C10-C14	20	mg/kg	< 20
TRH C15-C28	50	mg/kg	120
TRH C29-C36	50	mg/kg	120
TRH C10-36 (Total)	50	mg/kg	240
BTEX			
Benzene	0.1	mg/kg	< 0.1
Toluene	0.1	mg/kg	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2
o-Xylene	0.1	mg/kg	< 0.1
Xylenes - Total	0.3	mg/kg	< 0.3
4-Bromofluorobenzene (surr.)	1	%	84
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
Naphthalene[N02]	0.5	mg/kg	< 0.5
TRH C6-C10	20	mg/kg	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	< 50
Polycyclic Aromatic Hydrocarbons			
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	5.9
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	5.9
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	5.9
Acenaphthene	0.5	mg/kg	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5
Anthracene	0.5	mg/kg	0.5
Benz(a)anthracene	0.5	mg/kg	2.8
Benzo(a)pyrene	0.5	mg/kg	3.7
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	2.8
Benzo(g.h.i)perylene	0.5	mg/kg	3.1
Benzo(k)fluoranthene	0.5	mg/kg	2.5
Chrysene	0.5	mg/kg	2.9
Dibenz(a.h)anthracene	0.5	mg/kg	1.1
Fluoranthene	0.5	mg/kg	3.8
Fluorene	0.5	mg/kg	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	2.3

Client Sample ID Sample Matrix Eurofins | mgt Sample No. Date Sampled Test/Reference	LOR	Unit	BD3/141015 Soil S15-Oc11926 Oct 14, 2015
Polycyclic Aromatic Hydrocarbons			
Naphthalene	0.5	mg/kg	< 0.5
Phenanthrene	0.5	mg/kg	1.9
Pyrene	0.5	mg/kg	3.8
Total PAH*	0.5	mg/kg	31
2-Fluorobiphenyl (surr.)	1	%	93
p-Terphenyl-d14 (surr.)	1	%	86
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
TRH >C10-C16	50	mg/kg	< 50
TRH >C16-C34	100	mg/kg	210
TRH >C34-C40	100	mg/kg	< 100
Heavy Metals			
Arsenic	2	mg/kg	6.3
Cadmium	0.4	mg/kg	0.7
Chromium	5	mg/kg	9.9
Copper	5	mg/kg	97
Lead	5	mg/kg	290
Mercury	0.1	mg/kg	0.5
Nickel	5	mg/kg	8.7
Zinc	5	mg/kg	470
% Moisture	0.1	%	11

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results (regarding both quality and NATA accreditation).

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Oct 19, 2015	14 Day
- Method: TRH C6-C36 - LTM-ORG-2010			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 19, 2015	14 Day
- Method: TRH C6-C40 - LTM-ORG-2010			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 19, 2015	14 Day
- Method: TRH C6-C40 - LTM-ORG-2010			
BTEX	Melbourne	Oct 19, 2015	14 Day
- Method: TRH C6-C40 - LTM-ORG-2010			
Polycyclic Aromatic Hydrocarbons	Melbourne	Oct 19, 2015	14 Day
- Method: USEPA 8270 Polycyclic Aromatic Hydrocarbons			
Metals M8	Melbourne	Oct 19, 2015	28 Day
- Method: LTM-MET-3030 by ICP-OES (hydride ICP-OES for Mercury)			
% Moisture	Melbourne	Oct 16, 2015	14 Day
- Method: LTM-GEN-7080 Moisture			

Company Name: Douglas Partners (Syd)
Address: 96 Hermitage Road
West Ryde
NSW 2114

Project Name: ZETLAND TRUNK DRAIN
Project ID: 85100.01

Order No.:
Report #: 476173
Phone: 02 9809 0666
Fax:

Received: Oct 16, 2015 2:15 PM
Due: Oct 23, 2015
Priority: 5 Day
Contact Name: Veronica Ku

Eurofins | mgt Client Manager: Charl Du Preez

Sample Detail					Polycyclic Aromatic Hydrocarbons	Metals M8	BTEX	Moisture Set	Total Recoverable Hydrocarbons
Laboratory where analysis is conducted									
Melbourne Laboratory - NATA Site # 1254 & 14271					X	X	X	X	X
Sydney Laboratory - NATA Site # 18217									
Brisbane Laboratory - NATA Site # 20794									
External Laboratory									
Sample ID	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**					
BD3/141015	Oct 14, 2015		Soil	S15-Oc11926	X	X	X	X	X

Eurofins | mgt Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
4. Results are uncorrected for matrix spikes or surrogate recoveries.
5. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
6. Samples were analysed on an 'as received' basis. 7. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Advice.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

****NOTE:** pH duplicates are reported as a range NOT as RPD

UNITS

mg/kg: milligrams per Kilogram	**mg/l:** milligrams per litre
ug/l: micrograms per litre	**ppm:** Parts per million
ppb: Parts per billion	**%:** Percentage
org/100ml: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres	

TERMS

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery
CRM	Certified Reference Material - reported as percent recovery
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
Batch Duplicate	A second piece of analysis from a sample outside of the clients batch of samples but run within the laboratory batch of analysis.
Batch SPIKE	Spike recovery reported on a sample from outside of the clients batch of samples but run within the laboratory batch of analysis.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
ASLP	Australian Standard Leaching Procedure (AS4439.3)
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within
TEQ	Toxic Equivalency Quotient

QC - ACCEPTANCE CRITERIA

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries : Recoveries must lie between 50-150% - Phenols 20-130%.

QC DATA GENERAL COMMENTS

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxophene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxophene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Arochlor 1260 in Matrix Spikes and LCS's.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPD's are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/kg	< 20			20	Pass	
TRH C10-C14	mg/kg	< 20			20	Pass	
TRH C15-C28	mg/kg	< 50			50	Pass	
TRH C29-C36	mg/kg	< 50			50	Pass	
Method Blank							
BTEX							
Benzene	mg/kg	< 0.1			0.1	Pass	
Toluene	mg/kg	< 0.1			0.1	Pass	
Ethylbenzene	mg/kg	< 0.1			0.1	Pass	
m&p-Xylenes	mg/kg	< 0.2			0.2	Pass	
o-Xylene	mg/kg	< 0.1			0.1	Pass	
Xylenes - Total	mg/kg	< 0.3			0.3	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/kg	< 0.5			0.5	Pass	
TRH C6-C10	mg/kg	< 20			20	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
TRH >C10-C16	mg/kg	< 50			50	Pass	
TRH >C16-C34	mg/kg	< 100			100	Pass	
TRH >C34-C40	mg/kg	< 100			100	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/kg	< 2			2	Pass	
Cadmium	mg/kg	< 0.4			0.4	Pass	
Chromium	mg/kg	< 5			5	Pass	
Copper	mg/kg	< 5			5	Pass	
Lead	mg/kg	< 5			5	Pass	
Mercury	mg/kg	< 0.1			0.1	Pass	
Nickel	mg/kg	< 5			5	Pass	
Zinc	mg/kg	< 5			5	Pass	
LCS - % Recovery							

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	96			70-130	Pass	
TRH C10-C14	%	118			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	101			70-130	Pass	
Toluene	%	101			70-130	Pass	
Ethylbenzene	%	97			70-130	Pass	
m&p-Xylenes	%	115			70-130	Pass	
Xylenes - Total	%	110			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	110			70-130	Pass	
TRH C6-C10	%	85			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	94			70-130	Pass	
Acenaphthylene	%	95			70-130	Pass	
Anthracene	%	103			70-130	Pass	
Benz(a)anthracene	%	98			70-130	Pass	
Benzo(a)pyrene	%	109			70-130	Pass	
Benzo(b&j)fluoranthene	%	96			70-130	Pass	
Benzo(g.h.i)perylene	%	116			70-130	Pass	
Benzo(k)fluoranthene	%	99			70-130	Pass	
Chrysene	%	94			70-130	Pass	
Dibenz(a.h)anthracene	%	120			70-130	Pass	
Fluoranthene	%	79			70-130	Pass	
Fluorene	%	96			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	116			70-130	Pass	
Naphthalene	%	90			70-130	Pass	
Phenanthrene	%	97			70-130	Pass	
Pyrene	%	77			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
TRH >C10-C16	%	110			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	86			80-120	Pass	
Cadmium	%	99			80-120	Pass	
Chromium	%	106			80-120	Pass	
Copper	%	104			80-120	Pass	
Lead	%	101			80-120	Pass	
Mercury	%	94			75-125	Pass	
Nickel	%	104			80-120	Pass	
Zinc	%	114			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C6-C9	M15-Oc11794	NCP	%	86			70-130	Pass	
TRH C10-C14	S15-Oc12100	NCP	%	110			70-130	Pass	
Spike - % Recovery									
BTEX				Result 1					
Benzene	M15-Oc11794	NCP	%	83			70-130	Pass	
Toluene	M15-Oc11794	NCP	%	80			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Ethylbenzene	M15-Oc11794	NCP	%	80			70-130	Pass	
m&p-Xylenes	M15-Oc11794	NCP	%	95			70-130	Pass	
o-Xylene	M15-Oc11794	NCP	%	82			70-130	Pass	
Xylenes - Total	M15-Oc11794	NCP	%	91			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
Naphthalene	M15-Oc11794	NCP	%	94			70-130	Pass	
TRH C6-C10	M15-Oc11794	NCP	%	76			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	M15-Oc13759	NCP	%	105			70-130	Pass	
Acenaphthylene	M15-Oc13759	NCP	%	107			70-130	Pass	
Anthracene	M15-Oc13759	NCP	%	115			70-130	Pass	
Benz(a)anthracene	M15-Oc13759	NCP	%	111			70-130	Pass	
Benzo(a)pyrene	M15-Oc13759	NCP	%	118			70-130	Pass	
Benzo(b&j)fluoranthene	M15-Oc13759	NCP	%	102			70-130	Pass	
Benzo(g.h.i)perylene	M15-Oc13759	NCP	%	121			70-130	Pass	
Benzo(k)fluoranthene	M15-Oc13759	NCP	%	110			70-130	Pass	
Chrysene	M15-Oc13759	NCP	%	104			70-130	Pass	
Dibenz(a.h)anthracene	M15-Oc13759	NCP	%	120			70-130	Pass	
Fluoranthene	M15-Oc13759	NCP	%	88			70-130	Pass	
Fluorene	M15-Oc13759	NCP	%	106			70-130	Pass	
Indeno(1.2.3-cd)pyrene	M15-Oc13759	NCP	%	124			70-130	Pass	
Naphthalene	M15-Oc13759	NCP	%	100			70-130	Pass	
Phenanthrene	M15-Oc13759	NCP	%	107			70-130	Pass	
Pyrene	M15-Oc13759	NCP	%	86			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
TRH >C10-C16	S15-Oc12100	NCP	%	112			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	M15-Oc12349	NCP	%	79			75-125	Pass	
Cadmium	M15-Oc12349	NCP	%	96			75-125	Pass	
Chromium	M15-Oc12349	NCP	%	95			75-125	Pass	
Copper	M15-Oc12349	NCP	%	102			75-125	Pass	
Lead	M15-Oc14190	NCP	%	98			75-125	Pass	
Mercury	M15-Oc12349	NCP	%	91			70-130	Pass	
Nickel	M15-Oc12349	NCP	%	85			75-125	Pass	
Zinc	M15-Oc14190	NCP	%	89			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C6-C9	S15-Oc11261	NCP	mg/kg	< 20	< 20	<1	30%	Pass	
TRH C10-C14	S15-Oc12099	NCP	mg/kg	< 20	< 20	<1	30%	Pass	
TRH C15-C28	S15-Oc12099	NCP	mg/kg	260	330	25	30%	Pass	
TRH C29-C36	S15-Oc12099	NCP	mg/kg	220	310	35	30%	Fail	Q15
Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	S15-Oc11261	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Toluene	S15-Oc11261	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Ethylbenzene	S15-Oc11261	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
m&p-Xylenes	S15-Oc11261	NCP	mg/kg	< 0.2	< 0.2	<1	30%	Pass	
o-Xylene	S15-Oc11261	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Xylenes - Total	S15-Oc11261	NCP	mg/kg	< 0.3	< 0.3	<1	30%	Pass	

Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	S15-Oc11261	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
TRH C6-C10	S15-Oc11261	NCP	mg/kg	< 20	< 20	<1	30%	Pass	
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Phenanthrene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	M15-Oc13758	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
TRH >C10-C16	S15-Oc12099	NCP	mg/kg	< 50	< 50	<1	30%	Pass	
TRH >C16-C34	S15-Oc12099	NCP	mg/kg	410	540	27	30%	Pass	
TRH >C34-C40	S15-Oc12099	NCP	mg/kg	< 100	130	59	30%	Fail	Q15
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	S15-Oc11849	NCP	mg/kg	10	9.8	2.0	30%	Pass	
Cadmium	S15-Oc11849	NCP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	S15-Oc11849	NCP	mg/kg	22	23	5.0	30%	Pass	
Copper	S15-Oc11849	NCP	mg/kg	42	42	1.0	30%	Pass	
Lead	S15-Oc12097	NCP	mg/kg	240	240	1.0	30%	Pass	
Mercury	M15-Oc12348	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	S15-Oc11849	NCP	mg/kg	15	15	2.0	30%	Pass	
Zinc	M15-Oc14167	NCP	mg/kg	34	35	4.0	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	S15-Oc11278	NCP	%	18	17	5.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q15	The RPD reported passes Eurofins | mgt's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised By

Charl Du Preez	Analytical Services Manager
Carroll Lee	Senior Analyst-Organic (VIC)
Carroll Lee	Senior Analyst-Volatile (VIC)
Emily Rosenberg	Senior Analyst-Metal (VIC)
Huong Le	Senior Analyst-Inorganic (VIC)

Glenn Jackson
National Operations Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

Company Name: Douglas Partners (Syd)
Address: 96 Hermitage Road
West Ryde
NSW 2114

Project Name: ZETLAND TRUNK DRAIN
Project ID: 85100.01

Order No.:
Report #: 476173
Phone: 02 9809 0666
Fax:

Received: Oct 16, 2015 2:15 PM
Due: Oct 23, 2015
Priority: 5 Day
Contact Name: Veronica Ku

Eurofins | mgt Client Manager: Charl Du Preez

Sample Detail					Polycyclic Aromatic Hydrocarbons	Metals M8	BTEX	Moisture Set	Total Recoverable Hydrocarbons
Laboratory where analysis is conducted									
Melbourne Laboratory - NATA Site # 1254 & 14271					X	X	X	X	X
Sydney Laboratory - NATA Site # 18217									
Brisbane Laboratory - NATA Site # 20794									
External Laboratory									
Sample ID	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**					
BD3/141015	Oct 14, 2015		Soil	S15-Oc11926	X	X	X	X	X

eurofins | mgt

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NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Sample Receipt Advice

Company name:	**Douglas Partners (Syd)**
Contact name:	Veronica Ku
Project name:	ZETLAND TRUNK DRAIN
Project ID:	85100.01
COC number:	Not provided
Turn around time:	5 Day
Date/Time received:	Oct 16, 2015 2:15 PM
Eurofins | mgt reference:	**476173**

Sample information

☑ A detailed list of analytes logged into our LIMS, is included in the attached summary table.

☑ All samples have been received as described on the above COC.

☑ COC has been completed correctly.

☑ Attempt to chill was evident.

☑ Appropriately preserved sample containers have been used.

☑ All samples were received in good condition.

☑ Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.

☑ Appropriate sample containers have been used.

☒ Some samples have been subcontracted.

N/A Custody Seals intact (if used).

Contact notes

If you have any questions with respect to these samples please contact:

Charl Du Preez on Phone : +61 (2) 9900 8400 or by e.mail: charldupreez@eurofins.com.au

Results will be delivered electronically via e.mail to Veronica Ku - veronica.ku@douglaspartners.com.au.

CERTIFICATE OF ANALYSIS 136244

Client:

Douglas Partners Pty Ltd
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Veronica Ku

Sample log in details:

Your Reference:	**85100.01, Zetland Trunk Drain**
No. of samples:	7 waters
Date samples received / completed instructions received	21/10/15 / 21/10/15

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	28/10/15 / 27/10/15
Date of Preliminary Report:	Not Issued

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

VOCs in water Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	136244-1 MW1 21/10/2015 Water	136244-2 MW3 21/10/2015 Water	136244-3 MW5 21/10/2015 Water
Date extracted	-	22/10/2015	22/10/2015	22/10/2015
Date analysed	-	23/10/2015	23/10/2015	23/10/2015
Dichlorodifluoromethane	µg/L	<10	<10	<10
Chloromethane	µg/L	<10	<10	<10
Vinyl Chloride	µg/L	<10	<10	<10
Bromomethane	µg/L	<10	<10	<10
Chloroethane	µg/L	<10	<10	<10
Trichlorofluoromethane	µg/L	<10	<10	<10
1,1-Dichloroethene	µg/L	<1	<1	<1
Trans-1,2-dichloroethene	µg/L	<1	<1	<1
1,1-dichloroethane	µg/L	<1	<1	<1
Cis-1,2-dichloroethene	µg/L	2	110	5
Bromochloromethane	µg/L	<1	<1	<1
Chloroform	µg/L	<1	<1	<1
2,2-dichloropropane	µg/L	<1	<1	<1
1,2-dichloroethane	µg/L	<1	<1	<1
1,1,1-trichloroethane	µg/L	<1	<1	<1
1,1-dichloropropene	µg/L	<1	<1	<1
Cyclohexane	µg/L	<1	<1	<1
Carbon tetrachloride	µg/L	<1	<1	<1
Benzene	µg/L	<1	<1	<1
Dibromomethane	µg/L	<1	<1	<1
1,2-dichloropropane	µg/L	<1	<1	<1
Trichloroethene	µg/L	<1	<1	<1
Bromodichloromethane	µg/L	<1	<1	<1
trans-1,3-dichloropropene	µg/L	<1	<1	<1
cis-1,3-dichloropropene	µg/L	<1	<1	<1
1,1,2-trichloroethane	µg/L	<1	<1	<1
Toluene	µg/L	<1	<1	<1
1,3-dichloropropane	µg/L	<1	<1	<1
Dibromochloromethane	µg/L	<1	<1	<1
1,2-dibromoethane	µg/L	<1	<1	<1
Tetrachloroethene	µg/L	<1	<1	<1
1,1,1,2-tetrachloroethane	µg/L	<1	<1	<1
Chlorobenzene	µg/L	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1
Bromoform	µg/L	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2
Styrene	µg/L	<1	<1	<1
1,1,2,2-tetrachloroethane	µg/L	<1	<1	<1
o-xylene	µg/L	<1	<1	<1
1,2,3-trichloropropane	µg/L	<1	<1	<1

VOCs in water Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	136244-1 MW1 21/10/2015 Water	136244-2 MW3 21/10/2015 Water	136244-3 MW5 21/10/2015 Water
Isopropylbenzene	µg/L	<1	<1	<1
Bromobenzene	µg/L	<1	<1	<1
n-propyl benzene	µg/L	<1	<1	<1
2-chlorotoluene	µg/L	<1	<1	<1
4-chlorotoluene	µg/L	<1	<1	<1
1,3,5-trimethyl benzene	µg/L	<1	<1	<1
Tert-butyl benzene	µg/L	<1	<1	<1
1,2,4-trimethyl benzene	µg/L	<1	<1	<1
1,3-dichlorobenzene	µg/L	<1	<1	<1
Sec-butyl benzene	µg/L	<1	<1	<1
1,4-dichlorobenzene	µg/L	<1	<1	<1
4-isopropyl toluene	µg/L	<1	<1	<1
1,2-dichlorobenzene	µg/L	<1	<1	<1
n-butyl benzene	µg/L	<1	<1	<1
1,2-dibromo-3-chloropropane	µg/L	<1	<1	<1
1,2,4-trichlorobenzene	µg/L	<1	<1	<1
Hexachlorobutadiene	µg/L	<1	<1	<1
1,2,3-trichlorobenzene	µg/L	<1	<1	<1
Surrogate Dibromofluoromethane	%	101	102	101
Surrogate toluene-d8	%	99	98	98
Surrogate 4-BFB	%	85	86	86

vTRH(C6-C10)/BTEXN in Water						
Our Reference:	UNITS	136244-1	136244-2	136244-3	136244-4	136244-5
Your Reference	-------------	MW1	MW3	MW5	BD1/211015	R/211015
Date Sampled	------------	21/10/2015	21/10/2015	21/10/2015	21/10/2015	21/10/2015
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	22/10/2015	22/10/2015	22/10/2015	23/10/2015	23/10/2015
Date analysed	-	23/10/2015	23/10/2015	23/10/2015	24/10/2015	24/10/2015
TRHC_6 - C_9	µg/L	<10	120	<10	<10	14
TRHC_6 - C_{10}	µg/L	<10	120	<10	<10	15
TRHC_6 - C_{10} less BTEX (F1)	µg/L	<10	120	<10	<10	15
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	101	102	101	108	108
Surrogate toluene-d8	%	99	98	98	98	100
Surrogate 4-BFB	%	85	86	86	90	90

vTRH(C6-C10)/BTEXN in Water			
Our Reference:	UNITS	136244-6	136244-7
Your Reference	-------------	TS/211015	TB/211015
Date Sampled	------------	21/10/2015	21/10/2015
Type of sample		Water	Water
Date extracted	-	23/10/2015	23/10/2015
Date analysed	-	24/10/2015	24/10/2015
Benzene	µg/L	99%	<1
Toluene	µg/L	97%	<1
Ethylbenzene	µg/L	95%	<1
m+p-xylene	µg/L	98%	<2
o-xylene	µg/L	98%	<1
Surrogate Dibromofluoromethane	%	102	106
Surrogate toluene-d8	%	97	100
Surrogate 4-BFB	%	103	90

svTRH (C10-C40) in Water Our Reference:	UNITS	136244-1	136244-2	136244-3	136244-4	136244-5
Your Reference	-------------	MW1	MW3	MW5	BD1/211015	R/211015
Date Sampled	------------	21/10/2015	21/10/2015	21/10/2015	21/10/2015	21/10/2015
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	22/10/2015	22/10/2015	22/10/2015	22/10/2015	22/10/2015
Date analysed	-	23/10/2015	23/10/2015	23/10/2015	23/10/2015	23/10/2015
TRHC $_{10}$ - C $_{14}$	µg/L	<50	<50	<50	<50	<50
TRHC $_{15}$ - C $_{28}$	µg/L	<100	<100	<100	<100	<100
TRHC $_{29}$ - C $_{36}$	µg/L	<100	<100	<100	<100	<100
TRH>C $_{10}$ - C $_{16}$	µg/L	<50	<50	<50	<50	<50
TRH>C $_{10}$ - C $_{16}$ less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH>C $_{16}$ - C $_{34}$	µg/L	<100	<100	<100	<100	<100
TRH>C $_{34}$ - C $_{40}$	µg/L	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	88	94	119	74	99

PAHs in Water - Low Level Our Reference:	UNITS	136244-1	136244-2	136244-3	136244-4
Your Reference	-------------	MW1	MW3	MW5	BD1/211015
Date Sampled	------------	21/10/2015	21/10/2015	21/10/2015	21/10/2015
Type of sample		Water	Water	Water	Water
Date extracted	-	22/10/2015	22/10/2015	22/10/2015	22/10/2015
Date analysed	-	22/10/2015	22/10/2015	22/10/2015	22/10/2015
Naphthalene	µg/L	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	0.1	NIL (+)VE
Surrogate p-Terphenyl-d14	%	71	77	98	68

PAHs in Water Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	136244-5 R/211015 21/10/2015 Water
Date extracted	-	22/10/2015
Date analysed	-	22/10/2015
Naphthalene	µg/L	<1
Acenaphthylene	µg/L	<1
Acenaphthene	µg/L	<1
Fluorene	µg/L	<1
Phenanthrene	µg/L	<1
Anthracene	µg/L	<1
Fluoranthene	µg/L	<1
Pyrene	µg/L	<1
Benzo(a)anthracene	µg/L	<1
Chrysene	µg/L	<1
Benzo(b,j+k)fluoranthene	µg/L	<2
Benzo(a)pyrene	µg/L	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1
Dibenzo(a,h)anthracene	µg/L	<1
Benzo(g,h,i)perylene	µg/L	<1
Benzo(a)pyrene TEQ	µg/L	<5
Total +ve PAH's	µg/L	NIL (+)VE
Surrogate p-Terphenyl-d14	%	96

OCP in water Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	136244-1 MW1 21/10/2015 Water	136244-2 MW3 21/10/2015 Water	136244-3 MW5 21/10/2015 Water
Date extracted	-	22/10/2015	22/10/2015	22/10/2015
Date analysed	-	22/10/2015	22/10/2015	22/10/2015
HCB	µg/L	<0.2	<0.2	<0.2
alpha-BHC	µg/L	<0.2	<0.2	<0.2
gamma-BHC	µg/L	<0.2	<0.2	<0.2
beta-BHC	µg/L	<0.2	<0.2	<0.2
Heptachlor	µg/L	<0.2	<0.2	<0.2
delta-BHC	µg/L	<0.2	<0.2	<0.2
Aldrin	µg/L	<0.2	<0.2	<0.2
Heptachlor Epoxide	µg/L	<0.2	<0.2	<0.2
gamma-Chlordane	µg/L	<0.2	<0.2	<0.2
alpha-Chlordane	µg/L	<0.2	<0.2	<0.2
Endosulfan I	µg/L	<0.2	<0.2	<0.2
pp-DDE	µg/L	<0.2	<0.2	<0.2
Dieldrin	µg/L	<0.2	<0.2	<0.2
Endrin	µg/L	<0.2	<0.2	<0.2
pp-DDD	µg/L	<0.2	<0.2	<0.2
Endosulfan II	µg/L	<0.2	<0.2	<0.2
pp-DDT	µg/L	<0.2	<0.2	<0.2
Endrin Aldehyde	µg/L	<0.2	<0.2	<0.2
Endosulfan Sulphate	µg/L	<0.2	<0.2	<0.2
Methoxychlor	µg/L	<0.2	<0.2	<0.2
Surrogate TCMX	%	70	83	93

PCBs in Water Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	136244-1 MW1 21/10/2015 Water	136244-2 MW3 21/10/2015 Water	136244-3 MW5 21/10/2015 Water
Date extracted	-	22/10/2015	22/10/2015	22/10/2015
Date analysed	-	22/10/2015	22/10/2015	22/10/2015
Aroclor 1016	µg/L	<2	<2	<2
Aroclor 1221	µg/L	<2	<2	<2
Aroclor 1232	µg/L	<2	<2	<2
Aroclor 1242	µg/L	<2	<2	<2
Aroclor 1248	µg/L	<2	<2	<2
Aroclor 1254	µg/L	<2	<2	<2
Aroclor 1260	µg/L	<2	<2	<2
Surrogate TCLMX	%	70	83	93

Total Phenolics in Water				
Our Reference:	UNITS	136244-1	136244-2	136244-3
Your Reference	-------------	MW1	MW3	MW5
Date Sampled	------------	21/10/2015	21/10/2015	21/10/2015
Type of sample		Water	Water	Water
Date extracted	-	22/10/2015	22/10/2015	22/10/2015
Date analysed	-	22/10/2015	22/10/2015	22/10/2015
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05	<0.05

HM in water - dissolved						
Our Reference:	UNITS	136244-1	136244-2	136244-3	136244-4	136244-5
Your Reference	-------------	MW1	MW3	MW5	BD1/211015	R/211015
Date Sampled	------------	21/10/2015	21/10/2015	21/10/2015	21/10/2015	21/10/2015
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	22/10/2015	22/10/2015	22/10/2015	22/10/2015	22/10/2015
Date analysed	-	22/10/2015	22/10/2015	22/10/2015	22/10/2015	22/10/2015
Arsenic-Dissolved	µg/L	5	<1	4	5	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	<1	<1	<1	<1
Lead-Dissolved	µg/L	1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	1	1	1	<1	<1
Zinc-Dissolved	µg/L	96	13	34	86	2

Cations in water Dissolved Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	136244-1 MW1 21/10/2015 Water	136244-2 MW3 21/10/2015 Water	136244-3 MW5 21/10/2015 Water
Date digested	-	23/10/2015	23/10/2015	23/10/2015
Date analysed	-	23/10/2015	23/10/2015	23/10/2015
Calcium - Dissolved	mg/L	37	23	62
Magnesium - Dissolved	mg/L	5.2	10	14
Hardness	mgCaCO3 /L	110	100	210

Method ID	Methodology Summary
Org-013	Water samples are analysed directly by purge and trap GC-MS.
Org-016	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-003	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-005	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-006	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Metals-022 ICP-MS	Determination of various metals by ICP-MS.
Metals-021 CV-AAS	Determination of Mercury by Cold Vapour AAS.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.

QUALITY CONTROL VOCs in water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			22/10/2015	136244-1	22/10/2015 || 26/10/2015	LCS-W3	22/10/2015
Date analysed	-			23/10/2015	136244-1	23/10/2015 || 26/10/2015	LCS-W3	23/10/2015
Dichlorodifluoromethane	µg/L	10	Org-013	<10	136244-1	<10 || <10	[NR]	[NR]
Chloromethane	µg/L	10	Org-013	<10	136244-1	<10 || <10	[NR]	[NR]
Vinyl Chloride	µg/L	10	Org-013	<10	136244-1	<10 || <10	[NR]	[NR]
Bromomethane	µg/L	10	Org-013	<10	136244-1	<10 || <10	[NR]	[NR]
Chloroethane	µg/L	10	Org-013	<10	136244-1	<10 || <10	[NR]	[NR]
Trichlorofluoromethane	µg/L	10	Org-013	<10	136244-1	<10 || <10	[NR]	[NR]
1,1-Dichloroethene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Trans-1,2-dichloroethene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,1-dichloroethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	95%
Cis-1,2-dichloroethene	µg/L	1	Org-013	<1	136244-1	2 || 1 || RPD: 67	[NR]	[NR]
Bromochloromethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Chloroform	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	96%
2,2-dichloropropane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,2-dichloroethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	95%
1,1,1-trichloroethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	94%
1,1-dichloropropene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Cyclohexane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Carbon tetrachloride	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Benzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Dibromomethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,2-dichloropropane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Trichloroethene	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	106%
Bromodichloromethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	95%
trans-1,3-dichloropropene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
cis-1,3-dichloropropene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,1,2-trichloroethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Toluene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,3-dichloropropane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Dibromochloromethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	92%
1,2-dibromoethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Tetrachloroethene	µg/L	1	Org-013	<1	136244-1	<1 || <1	LCS-W3	93%
1,1,1,2-tetrachloroethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Chlorobenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Ethylbenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Bromoform	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
m+p-xylene	µg/L	2	Org-013	<2	136244-1	<2 || <2	[NR]	[NR]
Styrene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,1,2,2-tetrachloroethane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
o-xylene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]

QUALITY CONTROL VOCs in water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
1,2,3-trichloropropane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Isopropylbenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Bromobenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
n-propyl benzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
2-chlorotoluene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
4-chlorotoluene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,3,5-trimethyl benzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Tert-butyl benzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,2,4-trimethyl benzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,3-dichlorobenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Sec-butyl benzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,4-dichlorobenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
4-isopropyl toluene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,2-dichlorobenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
n-butyl benzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,2-dibromo-3-chloropropane	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,2,4-trichlorobenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Hexachlorobutadiene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
1,2,3-trichlorobenzene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Surrogate Dibromofluoromethane	%		Org-013	104	136244-1	101 || 85 || RPD: 17	LCS-W3	97%
Surrogate toluene-d8	%		Org-013	94	136244-1	99 || 95 || RPD: 4	LCS-W3	103%
Surrogate 4-BFB	%		Org-013	82	136244-1	85 || 85 || RPD: 0	LCS-W3	105%

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			23/10/2015	136244-1	22/10/2015 || 26/10/2015	LCS-W3	22/10/2015
Date analysed	-			24/10/2015	136244-1	23/10/2015 || 26/10/2015	LCS-W3	23/10/2015
TRHC_{6} - C_{9}	µg/L	10	Org-016	<10	136244-1	<10 || <10	LCS-W3	97%
TRHC_{6} - C_{10}	µg/L	10	Org-016	<10	136244-1	<10 || <10	LCS-W3	97%
Benzene	µg/L	1	Org-016	<1	136244-1	<1 || <1	LCS-W3	96%
Toluene	µg/L	1	Org-016	<1	136244-1	<1 || <1	LCS-W3	94%
Ethylbenzene	µg/L	1	Org-016	<1	136244-1	<1 || <1	LCS-W3	97%
m+p-xylene	µg/L	2	Org-016	<2	136244-1	<2 || <2	LCS-W3	98%
o-xylene	µg/L	1	Org-016	<1	136244-1	<1 || <1	LCS-W3	99%
Naphthalene	µg/L	1	Org-013	<1	136244-1	<1 || <1	[NR]	[NR]
Surrogate Dibromofluoromethane	%		Org-016	112	136244-1	101 || 110 || RPD: 9	LCS-W3	97%
Surrogate toluene-d8	%		Org-016	98	136244-1	99 || 95 || RPD: 4	LCS-W3	103%
Surrogate 4-BFB	%		Org-016	89	136244-1	85 || 85 || RPD: 0	LCS-W3	105%

QUALITY CONTROL svTRH (C10-C40) in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Date analysed	-			21/10/2015	136244-1	23/10/2015 || 23/10/2015	LCS-W1	22/10/2015
TRHC_{10} - C_{14}	µg/L	50	Org-003	<50	136244-1	<50 || <50	LCS-W1	102%
TRHC_{15} - C_{28}	µg/L	100	Org-003	<100	136244-1	<100 || <100	LCS-W1	85%
TRHC_{29} - C_{36}	µg/L	100	Org-003	<100	136244-1	<100 || <100	LCS-W1	102%
TRH>C_{10} - C_{16}	µg/L	50	Org-003	<50	136244-1	<50 || <50	LCS-W1	102%
TRH>C_{16} - C_{34}	µg/L	100	Org-003	<100	136244-1	<100 || <100	LCS-W1	85%
TRH>C_{34} - C_{40}	µg/L	100	Org-003	<100	136244-1	<100 || <100	LCS-W1	102%
Surrogate o-Terphenyl	%		Org-003	89	136244-1	88 || 78 || RPD: 12	LCS-W1	117%

QUALITY CONTROL PAHs in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Date analysed	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Naphthalene	µg/L	0.2	Org-012	<0.2	136244-1	<0.2 || <0.2	LCS-W1	79%
Acenaphthylene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	[NR]	[NR]
Acenaphthene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	[NR]	[NR]
Fluorene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	LCS-W1	75%
Phenanthrene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	LCS-W1	84%
Anthracene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	[NR]	[NR]
Fluoranthene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	LCS-W1	83%
Pyrene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	LCS-W1	88%

QUALITY CONTROL PAHs in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Benzo(a)anthracene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	[NR]	[NR]
Chrysene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	LCS-W1	94%
Benzo(b,j+k) fluoranthene	µg/L	0.2	Org-012	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
Benzo(a)pyrene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	LCS-W1	87%
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	[NR]	[NR]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	[NR]	[NR]
Benzo(g,h,i)perylene	µg/L	0.1	Org-012	<0.1	136244-1	<0.1 || <0.1	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	83	136244-1	71 || 72 || RPD: 1	LCS-W1	83%

QUALITY CONTROL PAHs in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			22/10/2015	[NT]	[NT]	LCS-W1	22/10/2015
Date analysed	-			22/10/2015	[NT]	[NT]	LCS-W1	22/10/2015
Naphthalene	µg/L	1	Org-012	<1	[NT]	[NT]	LCS-W1	79%
Acenaphthylene	µg/L	1	Org-012	<1	[NT]	[NT]	[NR]	[NR]
Acenaphthene	µg/L	1	Org-012	<1	[NT]	[NT]	[NR]	[NR]
Fluorene	µg/L	1	Org-012	<1	[NT]	[NT]	LCS-W1	75%
Phenanthrene	µg/L	1	Org-012	<1	[NT]	[NT]	LCS-W1	84%
Anthracene	µg/L	1	Org-012	<1	[NT]	[NT]	[NR]	[NR]
Fluoranthene	µg/L	1	Org-012	<1	[NT]	[NT]	LCS-W1	83%
Pyrene	µg/L	1	Org-012	<1	[NT]	[NT]	LCS-W1	88%
Benzo(a)anthracene	µg/L	1	Org-012	<1	[NT]	[NT]	[NR]	[NR]
Chrysene	µg/L	1	Org-012	<1	[NT]	[NT]	LCS-W1	94%
Benzo(b,j+k) fluoranthene	µg/L	2	Org-012	<2	[NT]	[NT]	[NR]	[NR]
Benzo(a)pyrene	µg/L	1	Org-012	<1	[NT]	[NT]	LCS-W1	87%
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-012	<1	[NT]	[NT]	[NR]	[NR]
Dibenzo(a,h)anthracene	µg/L	1	Org-012	<1	[NT]	[NT]	[NR]	[NR]
Benzo(g,h,i)perylene	µg/L	1	Org-012	<1	[NT]	[NT]	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	83	[NT]	[NT]	LCS-W1	83%

QUALITY CONTROL OCP in water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Date analysed	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
HCB	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
alpha-BHC	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	95%
gamma-BHC	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
beta-BHC	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	96%
Heptachlor	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	85%
delta-BHC	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
Aldrin	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	83%
Heptachlor Epoxide	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	82%
gamma-Chlordane	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
alpha-Chlordane	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
Endosulfan I	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
pp-DDE	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	86%
Dieldrin	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	86%
Endrin	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	86%
pp-DDD	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	89%
Endosulfan II	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
pp-DDT	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
Endrin Aldehyde	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
Endosulfan Sulphate	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	LCS-W1	91%
Methoxychlor	µg/L	0.2	Org-005	<0.2	136244-1	<0.2 || <0.2	[NR]	[NR]
Surrogate TCMX	%		Org-005	82	136244-1	70 || 75 || RPD: 7	LCS-W1	88%

QUALITY CONTROL PCBs in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Date analysed	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Aroclor 1016	µg/L	2	Org-006	<2	136244-1	<2 || <2	[NR]	[NR]
Aroclor 1221	µg/L	2	Org-006	<2	136244-1	<2 || <2	[NR]	[NR]
Aroclor 1232	µg/L	2	Org-006	<2	136244-1	<2 || <2	[NR]	[NR]
Aroclor 1242	µg/L	2	Org-006	<2	136244-1	<2 || <2	[NR]	[NR]
Aroclor 1248	µg/L	2	Org-006	<2	136244-1	<2 || <2	[NR]	[NR]
Aroclor 1254	µg/L	2	Org-006	<2	136244-1	<2 || <2	LCS-W1	98%
Aroclor 1260	µg/L	2	Org-006	<2	136244-1	<2 || <2	[NR]	[NR]
Surrogate TCLMX	%		Org-006	82	136244-1	70 || 75 || RPD: 7	LCS-W1	88%

QUALITY CONTROL Total Phenolics in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			22/10/2015	[NT]	[NT]	LCS-W1	22/10/2015
Date analysed	-			22/10/2015	[NT]	[NT]	LCS-W1	22/10/2015
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	[NT]	[NT]	LCS-W1	106%

QUALITY CONTROL HM in water - dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Date analysed	-			22/10/2015	136244-1	22/10/2015 || 22/10/2015	LCS-W1	22/10/2015
Arsenic-Dissolved	µg/L	1	Metals-022 ICP-MS	<1	136244-1	5 || 5 || RPD: 0	LCS-W1	96%
Cadmium-Dissolved	µg/L	0.1	Metals-022 ICP-MS	<0.1	136244-1	<0.1 || <0.1	LCS-W1	99%
Chromium-Dissolved	µg/L	1	Metals-022 ICP-MS	<1	136244-1	<1 || 1	LCS-W1	93%
Copper-Dissolved	µg/L	1	Metals-022 ICP-MS	<1	136244-1	<1 || <1	LCS-W1	97%
Lead-Dissolved	µg/L	1	Metals-022 ICP-MS	<1	136244-1	1 || <1	LCS-W1	101%
Mercury-Dissolved	µg/L	0.05	Metals-021 CV-AAS	<0.05	136244-1	<0.05 || <0.05	LCS-W1	96%
Nickel-Dissolved	µg/L	1	Metals-022 ICP-MS	<1	136244-1	1 || 1 || RPD: 0	LCS-W1	95%
Zinc-Dissolved	µg/L	1	Metals-022 ICP-MS	<1	136244-1	96 || 94 || RPD: 2	LCS-W1	100%

QUALITY CONTROL Cations in water Dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			23/10/2015	136244-1	23/10/2015 || 23/10/2015	LCS-W1	23/10/2015
Date analysed	-			23/10/2015	136244-1	23/10/2015 || 23/10/2015	LCS-W1	23/10/2015
Calcium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	136244-1	37 || 36 || RPD: 3	LCS-W1	86%
Magnesium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	136244-1	5.2 || 5.1 || RPD: 2	LCS-W1	85%
Hardness	mgCaCO3/L	3		[NT]	136244-1	110 || 110 || RPD: 0	[NR]	[NR]

QUALITY CONTROL svTRH (C10-C40) in Water	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	136244-2	22/10/2015
Date analysed	-	[NT]	[NT]	136244-2	23/10/2015
TRHC_{10} - C_{14}	µg/L	[NT]	[NT]	136244-2	104%
TRHC_{15} - C_{28}	µg/L	[NT]	[NT]	136244-2	91%
TRHC_{29} - C_{36}	µg/L	[NT]	[NT]	136244-2	83%
TRH>C_{10} - C_{16}	µg/L	[NT]	[NT]	136244-2	104%
TRH>C_{16} - C_{34}	µg/L	[NT]	[NT]	136244-2	91%
TRH>C_{34} - C_{40}	µg/L	[NT]	[NT]	136244-2	83%
Surrogate o-Terphenyl	%	[NT]	[NT]	136244-2	94%

QUALITY CONTROL PAHs in Water - Low Level	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	136244-2	22/10/2015
Date analysed	-	[NT]	[NT]	136244-2	22/10/2015
Naphthalene	µg/L	[NT]	[NT]	136244-2	75%
Acenaphthylene	µg/L	[NT]	[NT]	[NR]	[NR]
Acenaphthene	µg/L	[NT]	[NT]	[NR]	[NR]
Fluorene	µg/L	[NT]	[NT]	136244-2	70%
Phenanthrene	µg/L	[NT]	[NT]	136244-2	79%
Anthracene	µg/L	[NT]	[NT]	[NR]	[NR]
Fluoranthene	µg/L	[NT]	[NT]	136244-2	79%
Pyrene	µg/L	[NT]	[NT]	136244-2	83%
Benzo(a)anthracene	µg/L	[NT]	[NT]	[NR]	[NR]
Chrysene	µg/L	[NT]	[NT]	136244-2	88%
Benzo(b,j+k)fluoranthene	µg/L	[NT]	[NT]	[NR]	[NR]
Benzo(a)pyrene	µg/L	[NT]	[NT]	136244-2	84%
Indeno(1,2,3-c,d)pyrene	µg/L	[NT]	[NT]	[NR]	[NR]
Dibenzo(a,h)anthracene	µg/L	[NT]	[NT]	[NR]	[NR]
Benzo(g,h,i)perylene	µg/L	[NT]	[NT]	[NR]	[NR]
Surrogate p-Terphenyl-d14	%	[NT]	[NT]	136244-2	75%

QUALITY CONTROL OCP in water	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	136244-2	22/10/2015
Date analysed	-	[NT]	[NT]	136244-2	22/10/2015
HCB	µg/L	[NT]	[NT]	[NR]	[NR]
alpha-BHC	µg/L	[NT]	[NT]	136244-2	102%
gamma-BHC	µg/L	[NT]	[NT]	[NR]	[NR]
beta-BHC	µg/L	[NT]	[NT]	136244-2	96%
Heptachlor	µg/L	[NT]	[NT]	136244-2	100%
delta-BHC	µg/L	[NT]	[NT]	[NR]	[NR]
Aldrin	µg/L	[NT]	[NT]	136244-2	98%
Heptachlor Epoxide	µg/L	[NT]	[NT]	136244-2	96%
gamma-Chlordane	µg/L	[NT]	[NT]	[NR]	[NR]
alpha-Chlordane	µg/L	[NT]	[NT]	[NR]	[NR]
Endosulfan I	µg/L	[NT]	[NT]	[NR]	[NR]
pp-DDE	µg/L	[NT]	[NT]	136244-2	102%
Dieldrin	µg/L	[NT]	[NT]	136244-2	102%
Endrin	µg/L	[NT]	[NT]	136244-2	102%
pp-DDD	µg/L	[NT]	[NT]	136244-2	110%
Endosulfan II	µg/L	[NT]	[NT]	[NR]	[NR]
pp-DDT	µg/L	[NT]	[NT]	[NR]	[NR]
Endrin Aldehyde	µg/L	[NT]	[NT]	[NR]	[NR]
Endosulfan Sulphate	µg/L	[NT]	[NT]	136244-2	107%
Methoxychlor	µg/L	[NT]	[NT]	[NR]	[NR]
Surrogate TCMX	%	[NT]	[NT]	136244-2	85%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test
NR: Test not required
<: Less than
PQL: Practical Quantitation Limit
RPD: Relative Percent Difference
>: Greater than
NT: Not tested
NA: Test not required
LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

CHAIN OF CUSTODY

Douglas Partners
Geotechnics / Environment / Groundwater

Client: Douglas Partners
Contact Person: Veronica Ku
Project Mgr: Veronica Ku/Atha Kapitanof
Address: 96 Hermitage Road
West Ryde NSW 2114
Phone: 9809 0666 **Mob:** 0407 630 549
Email: veronica.ku@douglaspartners.com.au

Project Number 85100.01
Project Name: Zetland, Trunk Drain
PO No.:
lab Quote No. :
Date results required: 28/10/2015 (standard)
Or choose:
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / PDF / Excel
Comments:

To: Envirolab Services
Contact Person: Aileen Hie
Address: 12 Ashley Street
Chatswood NSW 2068
Phone: 02 9910 6200
Fax: 02 9910 6201
Email: ahie@envirolab.com.au
Laboratory Report No:
Lab Comments:

Sample information						Tests Required											Comments
Lab Sample ID	**Field Sample ID**	**Depth**	**Date sampled**	**Container Type**	**Type of sample**	8 metals - As, Cd, Cr, Cu, Pb, Hg, Ni, Zn	TRH	BTEX	low level PAH	phenols	PCB, OCP	VOC	hardness	PAH		**Combo**	**Provide as much information about the sample as you can**
1	MW1	-	21/10/2015	bottles	water	x	x	x	x	x	x	x	x			7 L	
2	MW3	-	21/10/2015	bottles	water	x	x	x	x	x	x	x	x			7 L	
3	MW5	-	21/10/2015	bottles	water	x	x	x	x	x	x	x	x			7 L	
4	BD1/211015	-	21/10/2015	bottles	water	x	x	x	x							3 L	
5	R/211015	-	21/10/2015	bottles	water	x	x	x						x		3	
6	TS/211015	-	21/10/2015	bottles	water			x									
7	TB/211015	-	21/10/2015	bottles	water			x									

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 136244
Date Received: 21/10/15
Time Received: 18:00
Received by: PT
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

Relinquished by: Douglas Partners
Courier (by whom) HUNTER EXPRESS
Condition of Sample at dispatch Cool or Ambient (circle)
Temperature (if Applicable):
Print Name: VERONICA KU
Date & Time 21/10/15; 12pm
Signature:

Sample Receipt
Received by (Company): els
Print Name: PT
Date & Time: 21/10/15 18:00
Signature: PT

Lab use only:
Samples Received: Cool or Ambient (circle one)
Temperature Received at: (if applicable)
Transported by: Hand delivered / courier

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client Details	
Client	Douglas Partners Pty Ltd
Attention	Veronica Ku

Sample Login Details	
Your Reference	85100.01, Zetland Trunk Drain
Envirolab Reference	136244
Date Sample Received	21/10/2015
Date Instructions Received	21/10/2015
Date Results Expected to be Reported	28/10/2015

Sample Condition	
Samples received in appropriate condition for analysis	YES
No. of Samples Provided	7 waters
Turnaround Time Requested	Standard
Temperature on receipt (°C)	14.8
Cooling Method	Ice
Sampling Date Provided	YES

Comments
Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples

Please direct any queries to:

Aileen Hie	**Jacinta Hurst**
Phone: 02 9910 6200	Phone: 02 9910 6200
Fax: 02 9910 6201	Fax: 02 9910 6201
Email: ahie@envirolabservices.com.au	Email: jhurst@envirolabservices.com.au

Sample and Testing Details on following page

Sample Id	***VOCs in water***	***vTRH(C6-C10)/BTEXN in Water***	***svTRH (C10-C40) in Water***	***PAHs in Water - Low Level***	***PAHs in Water***	***OCP in water***	***PCBs in Water***	***Total Phenolics in Water***	***HM in water - dissolved***	***Cations in water Dissolved***
MW1	✓	✓	✓	✓		✓	✓	✓	✓	✓
MW3	✓	✓	✓	✓		✓	✓	✓	✓	✓
MW5	✓	✓	✓	✓		✓	✓	✓	✓	✓
BD1/211015		✓	✓	✓					✓	
R/211015		✓	✓		✓				✓	
TS/211015		✓								
TB/211015		✓								

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200   fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 189115-A

Client Details

Client	Douglas Partners Pty Ltd
Attention	Atha Kapitanof
Address	96 Hermitage Rd, West Ryde, NSW, 2114

Sample Details

Your Reference	**85100.02, Joynton Ave Stormwater Drainage Upgrade**
Number of Samples	Additional analysis 4 soils
Date samples received	10/04/2018
Date completed instructions received	11/05/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	16/05/2018
Date of Issue	16/05/2018

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Nick Sarlamis, Inorganics Supervisor

Authorised By

Jacinta Hurst, Laboratory Manager

Chromium Suite					
Our Reference	UNITS	189115-A-2	189115-A-8	189115-A-13	189115-A-23
Your Reference		BH101	BH103	BH103	BH107
Depth		1.0-1.45	0.4-0.5	7.0-7.45	4.0-4.45
Date Sampled		29/03/2018	27/03/2018	27/03/2018	28/03/2018
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	14/05/2018	14/05/2018	14/05/2018	14/05/2018
Date analysed	-	14/05/2018	14/05/2018	14/05/2018	14/05/2018
pH $_{kcl}$	pH units	6.1	5.8	3.8	6.8
s-TAA pH 6.5	%w/w S	<0.01	<0.01	0.04	<0.01
TAA pH 6.5	moles H^+ /t	<5	<5	24	<5
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	0.007
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	5
S_{HCl}	%w/w S	<0.005	<0.005	<0.005	<0.005
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	0.006
S_{NAS}	%w/w S	<0.005	<0.005	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	<0.05	<0.05	<0.05	0.15
s-ANC_{BT}	%w/w S	<0.05	<0.05	<0.05	<0.05
s-Net Acidity	%w/w S	<0.005	<0.005	0.038	<0.005
a-Net Acidity	moles H^+ /t	<5	<5	24	<5
Liming rate	kg $CaCO_3$ /t	<0.75	<0.75	1.8	<0.75
a-Net Acidity without ANCE	moles H^+ /t	<5	<5	24	<5
Liming rate without ANCE	kg $CaCO_3$ /t	<0.75	<0.75	1.8	<0.75
s-Net Acidity without ANCE	%w/w S	<0.005	<0.005	0.038	0.0070

Method ID	Methodology Summary
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL: Chromium Suite					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			14/05/2018	[NT]	[NT]	[NT]	[NT]	14/05/2018	[NT]
Date analysed	-			14/05/2018	[NT]	[NT]	[NT]	[NT]	14/05/2018	[NT]
pH $_{kcl}$	pH units		Inorg-068	[NT]	[NT]	[NT]	[NT]	[NT]	95	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	[NT]	[NT]	[NT]	[NT]	95	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	[NT]	[NT]	[NT]	[NT]	95	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
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Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.
Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.	

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

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Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

From: Atha Kapitanof <Atha.Kapitanof@douglaspartners.com.au>
Sent: Friday, 11 May 2018 3:12 PM
To: Nancy Zhang
Cc: Aileen Hie
Subject: DP Project Number 85100.02

Importance: High

ELS Ref: 189115-A
Std TAT
Due 180518

Nancy,

Pursuant to the results of the previous testing (Ref: Certificate Number 189115), can you please undertake additional ASS SCr Suite (Complete) testing of the following soil samples:

Borehole	Depth (m)	
BH101	1.0-1.45	#2
BH103	0.4-0.5	#8
BH103	7.0-7.45	#13.
BH107	4.0-4.45	#23

We require a maximum three-day turnaround for these results, so your urgent attention would be greatly appreciated.

Regards,

Atha Kapitanof | Associate / Geotechnical Engineer
Douglas Partners Pty Ltd | ABN 75 053 980 117 | www.douglaspartners.com.au
96 Hermitage Road West Ryde NSW 2114 | PO Box 472 West Ryde NSW 1685
P: 02 8878 0685 | F: 02 9809 4095 | M: 0418 747 383 | E: Atha.Kapitanof@douglaspartners.com.au

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Integrated Practical Solutions

Interpretive Report on Geotechnical Investigations

Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

Prepared for
City of Sydney Council

Project 85100.02
May 2018

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

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Distribution of copies

Status	Electronic	Paper	Issued to
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Revision 0	1	-	Mr Edy Rustam, City of Sydney Council

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		31 May 2018
Reviewer		31 May 2018

bsi. ISO 9001 Quality Management

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Table of Contents

Interpretive Report on Geotechnical Investigations
Joynton Avenue Stormwater Drainage Upgrade
Joynton Avenue, Zetland

1. Introduction

This interpretive report presents geotechnical engineering advice for the Joynton Avenue Stormwater Drainage Upgrade at Joynton Avenue, Zetland, based on the results of the geotechnical investigations presented in the accompanying factual report (Ref: 85100.02.R.001.DftA dated 11 May 2018). The investigations were commissioned by the City of Sydney Council.

It is understood that the Joynton Avenue Stormwater Drainage Upgrade will provide stormwater relief for the local area and will serve as an important link between the up-gradient O'Dea Avenue Trunk Drain and the new Green Square Trunk Drain. An underbore is proposed for the installation of the proposed stormwater pipes in order to limit adverse impacts on the site amenities during construction.

The aim of this report is to provide an interpreted geotechnical model based on the results of the geotechnical investigations and comments upon geotechnical aspects of the design and construction of the project.

The investigations have been carried out in two stages. DP carried out the first stage of the investigations in October 2015 and the second stage of supplementary investigations in March 2018.

The scope of work and test locations for each of the investigation stages were nominated in briefs provided in the relevant Requests for Quotations prepared by the City of Sydney Council.

This interpretive report is based on the results of both stages of the investigations.

2. Geotechnical Model

The interpreted ground profile along the proposed alignment is shown on Drawings 7A and 7B in Appendix B.

The ground profile varies along the proposed route but basically comprises:

- FILLING – silty sand, sand and clayey sand with included silt, gravel and building rubble to depths ranging from 0.9 m to 3.5 m; overlying
- SILTY SAND – very loose to loose, between 0.7 m and 2.0 m thick in the northern part and at the southern end of the alignment only; overlying
- SAND – medium dense, dense and very dense, but mostly medium dense with some very dense layers to depths ranging from 6.7 m to 8.5 m; overlying
- CLAYEY SAND – medium dense, residual soil; overlying

- SANDSTONE – intersected in two boreholes (BH103 and BH104) below depths of 8.6 m and 7.9 m, respectively.

It is also noted that local layers of peaty clay were present were intersected just below the filling at both the northern and southern ends of the proposed pipe alignment.

As indicated on Drawings 7A and 7B, the ground conditions vary significantly along the route and there may be other changes between test locations.

The groundwater levels typically range between depths of 2.3 m and 3.2 m below the ground surface.

3. Proposed Development

It is understood that the Joynton Avenue Stormwater Drainage Upgrade will provide stormwater relief for the local area and will serve as an important link between the up-gradient O'Dea Avenue Trunk Drain and the new Green Square Trunk Drain. It is further understood that installation of the proposed stormwater pipes via trenchless methods is proposed, in order to limit adverse impacts on the site amenities during construction; in particular, significant trees and existing buried services that line Joynton Avenue directly above the proposed pipe alignment.

In an email dated 11 November 2015, the City of Sydney Council advised that Humes J-Series DN1800 jacking pipes (or their equivalent) will be specified for the stormwater pipe. With reference to the Humes Concrete Pipe Manual (2009), it is understood that these pipes have an internal diameter (ID) of 1800 mm and an external diameter (OD) of 2150 mm for Load Class 4 pipes.

The location of the proposed stormwater drainage pipe is shown on Drawing 1 in Appendix B, based on Preliminary Drawing No. E3-15/1342 – 100 Issue 1 by the City of Sydney dated 18 June 2015. Drawing 1 shows that the proposed stormwater drainage line comprises, from north to south, a single pipe between Pit 1/26 and Pit 1/28 (an approximate length of 323 m), then twin pipes between Pit 1/28 and Pit 1/29 (an approximate length of 40 m), with the final section comprising triple pipes between Pit 1/29 and Pit 1/30 (an approximate length of 105 m).

A projected long-section of the proposed pipe alignment is shown on Drawings 7A and 7B in Appendix B, based on Preliminary Drawing No. E3-15/1342 – 401 Issue 2 by the City of Sydney dated 3 June 2015). The proposed pipe levels are shown 600 mm deeper than the original alignment shown on the client's drawing, in accordance with the emailed advice received from Council on 13 November 2015. On the basis of the pipe alignment shown on Drawings 7A and 7B in Appendix B, the depth of cover to the crown of the proposed stormwater pipe will vary between 2.5 m and 3.5 m with a median depth of cover of 3.1 m.

Entry and exit pits at the northern and southern ends of the proposed pipe alignment are proposed for the underbore. It is further understood that, due to the total length of the drive (some 470 m), an intermediate pit is proposed approximately half-way along the proposed alignment. It is anticipated that the pits will be excavated to levels slightly below the base of the proposed tunnel at their respective locations, such that depths of excavation of between 4.5 m and 6.0 m would be required.

4. Comments

4.1 Underboring Method

Due to the sandy ground profile encountered, the shallow groundwater depths and the relatively shallow proposed underbore alignment, the trenchless pipe-jacking method is considered to be the most appropriate underboring method for this project, in order to maintain full support of the tunnel during construction. Further, the underboring method will need to maintain an earth pressure balance at the cutting face to reduce the risk of collapse of the face during drilling, due to the potential for ‘running sand’ conditions.

4.2 Pit Excavations

Pit excavations are expected to be carried out through sandy filling, peaty clay and natural sand. All material should readily be excavated using conventional earthmoving equipment, i.e. excavators. Without dewatering, the groundwater table would be expected to intersect the bulk excavations at least 2 m above the bulk excavation level (BEL). Unsupported excavations are considered unfeasible due to insufficient room to batter slopes and the need for temporary dewatering.

4.3 Pit Support

In these ground conditions with an elevated groundwater table, it will be necessary to provide continuous support to the sides of the pits using walls installed prior to the commencement of excavation. Suitable systems of temporary excavation support could include:

- concrete caisson shafts;
- sheet piles with struts and walers;
- shields and trench boxes.

Retaining walls that are capable of some outward rotation (e.g. cantilever walls) may be designed using a triangular earth pressure distribution on the rear of the walls, with a soil unit weight of 20 kN/m^3 and an active earth pressure coefficient (K_a) of 0.35 for the retaining filling and natural soils. This value of K_a should generally be increased by 50% to reduce lateral (inward) wall deflections near sensitive, existing structures, although cantilevered shoring walls should not be used to support adjacent building foundations or generally within a distance corresponding to the excavation depth, behind the wall. Additional allowance should also be made for lateral pressures due to surcharge loads above the walls and also for hydrostatic pressures.

The ultimate, passive resistance (Kp) for short term loading available in medium dense sand should be taken as 3.5 for preliminary design purposes. Also, particular care should be taken in the design of the shoring system to ensure that there is an adequate factor of safety against piping failure (that is, “base heave”).

4.4 Groundwater and Dewatering

Based on groundwater measurements and comparison with the invert levels of the proposed pipeline, groundwater will be encountered within the expected depth of both the underbore and pits. Although standing groundwater was measured at depths of between 2.3 m and 3.2 m during the investigations, experience in the area suggests that groundwater level fluctuations of about 1 – 2 m could be expected due to wet weather. On this basis, it is suggested that the design of temporary shoring walls and dewatering systems be based on a groundwater depth of about 1.5 m. For permanent substructures, it is suggested that design should be based on a groundwater depth of 0 m.

Generally the groundwater level should be lowered to at least 1 m below the pit excavation level to allow man access and machinery to operate, and to prevent flooding during heavy rainfall. To reduce the risk of lowering the groundwater table outside the site and potentially damaging adjacent structures, utilities and roads, a system of recharge wells close to the pits may be required to reinject pumped groundwater back into the ground to maintain the groundwater level outside the pit excavations. Monitoring of the groundwater levels outside the perimeter walls of the pits will, nevertheless, be required to ensure that adjacent properties are not adversely affected.

Hydraulic conductivity within the sand beds can be highly variable and is typically around 20 m/day in clean sand, which should be used for preliminary design of the dewatering system. Numerical modelling should be carried out to assess the effectiveness of the proposed dewatering system and to predict drawdown levels, once details of the proposed shoring and dewatering system are available.

Based on the laboratory results undertaken during the investigations, groundwater at the site is probably not contaminated and treatment during dewatering will not be required. Further testing of the groundwater should, however, be undertaken during construction to confirm this.

4.5 Potential Obstructions to Underbore

Two boreholes drilled during the first stage of investigations, namely BH5A and BH5B, encountered obstructions within the filling that resulted in practical auger refusal at depths of 2.8 m and 0.8 m, respectively. The borehole logs record that refusal occurred due to concrete and possibly a disused conduit.

Further investigations were carried as part of the second stage of the investigations to identify the extent and composition of these obstructions. These further investigations comprised:

- the excavation of test pits by non-destructive methods, namely TP108 and TP109; and
- the conduct of a GPR survey.

TP108 was excavated near BH5A and exposed an irregular concrete block with steel mesh at a depth of 1.5 m, 1.3 m above the refusal depth of the borehole. Based on the GPR survey data, it is possible that the concrete block exposed at TP108 may be part of a larger structure, as evidenced by a faint apparent reflector at approximately 1.3 m depth, which is interpreted as a possible concrete surface. However, it is noted that the reflections supporting this interpretation are very weak and that similar reflections at similar depths could be expected from layering in filling or natural sediments.

TP109 was excavated near BH5B and exposed a concrete slab at 0.5 m depth, 0.3 m above the refusal depth of the borehole. Based on the GPR survey data, the concrete slab encountered in TP109 may be interpreted as a drainage feature, an irregular concrete slab or a pair of concrete encased pipes. The feature runs approximately perpendicular to the trunk drain alignment. There is an apparent low point/channel at the centre of the top surface (or possibly a gap between two separate objects) which runs along the object's long axis. The total width of the feature appears to be approximately 4 m – 5 m. The high amplitude response from the object only continues to approximately 30 cm – 40 cm below the interpreted top surface of the object which may indicate the approximate depth extent of the object. However, below the feature, very faint apparent reflectors are visible at approximately 1 m and 1.5 m (160 MHz), indicating a possible continuation with depth. As a result of the poor signal penetration at the site, the depth extent of the feature cannot be reliably estimated.

For the purpose of comparison, DP reviewed and compared aerial photographs of this location dating from both 1943 and present day available on the NSW Government's online mapping tool "SIX Maps" (Ref: www.six.nsw.gov.au). The relevant images are shown in Figures 1 and 2, respectively.

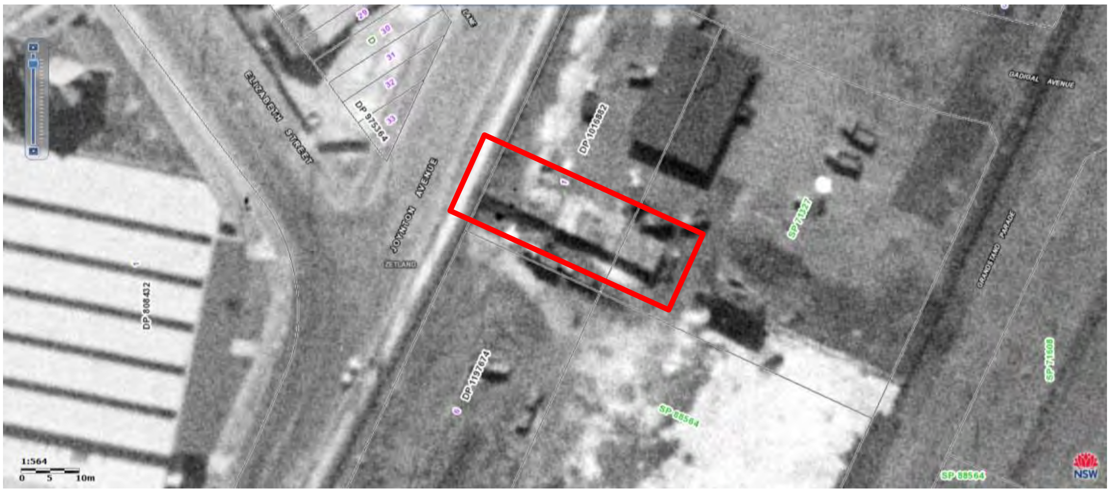

Figure 1: SIX Maps image circa 1943

Figure 2: SIX Maps image circa present day

The feature highlighted by a red box in Figure 1 may be a box culvert under construction at the time of the photograph, within an area that may have been in the process of being backfilled, as can be seen from the batters to the north east of the feature and an apparently lower area to the south of it, surrounded by what appear to be dump trucks. Using the distance measurement tool on the website, the visible part of the possible box culvert structure is estimated to be approximately 6 m wide and about 33 m long, extending east-south-east from the Joynton Avenue frontage of Lot 1 DP 1016882 (102 – 112 Joynton Avenue) parallel to, and offset by about 8 m from, the south-south-eastern boundary of the lot. There is, however, no way to estimate the feature's height from the photograph.

The location corresponding to that of the feature shown in Figure 1 is also highlighted by a red box in Figure 2. Comparison with the results of the test pit TP109 and the GPR survey near TP109 indicates the concrete slab encountered during the field work corresponds with the location of the feature shown in Figure 1, and may therefore be the same feature, particularly given that a similar total width was estimated from the GPR survey data.

4.6 Surface Settlement due to Underbore

The stability of the underbore will depend largely on the degree of skill and experience of the contractor and the suitability of the equipment and procedures used during installation. Excavation for the pipe will alter in-situ stresses around the bore, causing slight movement and may result in slight differential movement of the ground surface. Due to the largely cohesionless nature of the deposits, the inflow of sand at the excavation face will require careful control and monitoring. It is important that the jacking/boring rate matches the spoil return rate as overboring may result in significant subsidence or sink holes opening in the overlying ground surface. This may become more problematic where mixed face conditions are encountered, such as between the peaty clay and sand horizons. Sand may also enter the pipe during down times, such as overnight if works were to cease.

The estimated maximum settlement is, in addition to the factors described above, a function of the ground loss due to the degree of over-reaming by the cutter head to permit the jacking pipes to be advanced. As such, the annulus between the tunnel drilled by the cutter head and the jacking pipe should be minimised to reduce the risk of excessive settlements.

Analysis was undertaken to estimate the elastic settlement along the ground surface induced by installation of the underbore.

The method used was based on a closed-form, strain-driven solution, which provided an elastic displacement field, assuming that the radial strain distribution is constant around the underbore. The strain input is a constant value of radial ground loss, i.e. radial movement towards the centre line of the underbore alignment. The solution is based on the Verruijt and Booker (1996) published solution, which cannot readily take into account traffic surcharge loading. This method was used to estimate settlement when elastic behaviour governs.

This analysis requires a radial strain input that corresponds to the ground loss experienced at the underbore wall. From discussions with the client, the cutter head diameter is not presently known, so DP has analysed a range of radial ground loss (which is equivalent to the annulus between the cutter head and the casing), to assess the effect of different annulus sizes on ground settlements. The definition of radial ground loss is the ratio of change in radius over the original excavated radius of the hole.

The closed-form analytical solution for ground surface settlement (Verruijt and Booker, 1996) estimates the tunnelling-induced ground deformation at the surface using the following equation:

$$U_0 = 2\varepsilon R^2.(m+1)/m.h/(x^2+h^2)$$

where:
U_0 = ground surface settlement;
R = tunnel radius;
h = depth of tunnel axis level;
v = Poisson's ratio of soil;
ε = radial ground loss ratio;
x = lateral distance from tunnel centre-line; and
m = $1/(1-2v)$

This analytical method accounts only for the case of uniform, radial displacement around the tunnel, but allows rapid estimation of the ground surface deformation and requires only an estimate of Poisson's ratio, which was estimated to be 0.3 for the predominately sandy soil present within the ground profile.

The surface settlement trough estimates from the closed-form analytical method of analysis are shown on Drawing 8 in Appendix B.

The estimated maximum surface settlement within the settlement trough for a range of radial ground loss values can be found in Table 1.

Table 1: Summary of Maximum Settlement Estimates

Radial Ground Loss (%)	Annulus Size[1] (mm)	Maximum Settlement (mm)
0.5	5	4
1.0	11	8
2.0	22	16
4.0	45	34
8.0	93	73
16.0	205	176

[1] The annulus size is the difference in radius between the cutter head and the permanent casing.

It should be noted that, due to the elevated groundwater table along the proposed alignment, the jacking pipe will be subject to uplift pressures during its installation, where water tightness of the pipe is maintained. The uplift pressure on the pipe should, however, be adequately resisted by the weight of the soil overburden above the pipe.

From a settlement risk point of view, there is still a risk of unanticipated ground loss and therefore monitoring will be required as suggested in Section 4.8.

4.7 Uplift on Pits

Due to the high groundwater levels, it will be necessary to prevent the permanent pits from floating and tilting under hydrostatic uplift pressure acting on their bases. During construction, these hydrostatic pressures can be reduced by keeping the groundwater table drawn down by continuous pumping or by ballasting the pits by flooding or other means. It will, however, be necessary to provide some positive anchorage to the pits to prevent flotation on a permanent basis. Uplift may be permanently resisted by means of either ballasting with dead weight, (e.g. thickening of the base slab) or by means of permanent anchor piles tied into the base slab and socketed into the underlying bedrock. Where rock-socketed anchor piles are contemplated, an allowable shaft adhesion in very low to low strength sandstone not exceeding 25 kPa may be used for anchor pile design, provided the rock socket is adequately cleaned.

4.8 Construction Monitoring

To respond to potential claims for damages resulting from construction activities, it is recommended that allowance be made for dilapidation surveys to be carried out on nearby structures that may be susceptible to damage caused by settlements or vibrations that may result from the underboring activities. This would in particular be of concern for any nearby or adjacent buildings supported on shallow footings. This activity should be performed prior to the commencement of work on site along the alignment of the pipe within a zone up to 10 m on either side of the pipe alignment, in order to provide a baseline for comparison in the event of any claims for damages.

It is important that as part of the monitoring, surface levels are measured during construction within the zone above along the alignment of the pipe. It is suggested that the accuracy of this survey levelling should be to 1 mm or better. Baseline readings should be established along the proposed alignment prior to the commencement of construction activities with monitoring continued through the works and post-installation. The survey should also include regular levelling of nearby structures, utilities and roads.

Variation of the soil units during drilling may be indicated by significant variation in jacking pressure. If encountered, the geotechnical engineer should be notified.

4.9 Waste Classification

Based on the results, the filling material encountered at the site has a preliminary classification for off-site disposal purposes as **General Solid Waste (non-putrescible)** with the exception of filling material at BH5. Given the elevated lead concentrations, BH5/0.4-0.5 has a preliminary classification of **Restricted Solid Waste**.

Moreover, the total and leachable lead concentrations for BH5/2.9-3.0 exceed the restricted solid waste criteria (without applying a mobilisation) and hence further testing is recommended to assess the lateral extent of the material comprising clinker and slag. This is particularly the case for its potential occurrence north of BH5 at a proposed excavation pit and occurrence north of this where the subsoils are unknown between BH5 and BH4. As a first step, it is recommended that material excavated from the excavation pit be visually inspected and anthropogenic inclusions such as clinker and furnace slag should be noted. Based on an excavation depth of up to 5 m for the excavation pit, both filling and natural horizons will be intersected. Materials should be stockpiled separately during excavation to prevent cross contamination. Sampling is to be retrieved from *ex-situ* material and should be tested to confirm opportunities for re-use (VENM) and confirm the waste classification. Whilst asbestos was not detected within filling, building rubble was recorded within filling at all bores which is indicative of the potential presence of asbestos. Where suspicious or unknown materials are encountered during the works, an Environmental Engineer/Scientist should inspect the material and advise accordingly.

Acid sulphate soils have been confirmed at BH1 and BH103 will need to be appropriately managed and treated during excavation of the pits. As the presence of ASS across the site has been confirmed at two sample locations, additional sampling and testing is to be carried out, either *in situ or ex situ,* to provide guidance on the presence of ASS and management and disposal requirements for the soils to be disturbed/generate the spoil.

5. Further Work

It is recommended that further investigation and, if necessary, removal of the possible obstructions encountered in TP108 and TP109 be undertaken by the contractor, as the depth extent of the features could not be interpreted with certainty using GPR due to the limitations of the method and the ground conditions encountered.

It is further recommended that the contractor undertake their own services searches and that all services which may intersect or run along the proposed trunk drain alignment be positively identified on site by the contractor using non-destructive methods before any intrusive works are undertaken.

6. References

1. Verruijt, A and Booker, J R (1996), Surface Settlements due to Deformation of a Tunnel in an Elastic Half Plane, Geotechnique, London, England, 46(4), pp. 753 - 756).

7. Limitations

Douglas Partners (DP) has prepared this interpretive report for this project at Joynton Avenue, Zetland, in general accordance with DP’s proposal dated 5 February 2018 and acceptance received from the City of Sydney Council by Variation Notice for Variation Change Number 2 to RFQ 7615. The work was carried out under the existing contract between City of Sydney and DP. This interpretive report is provided for the exclusive use of the City of Sydney Council for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

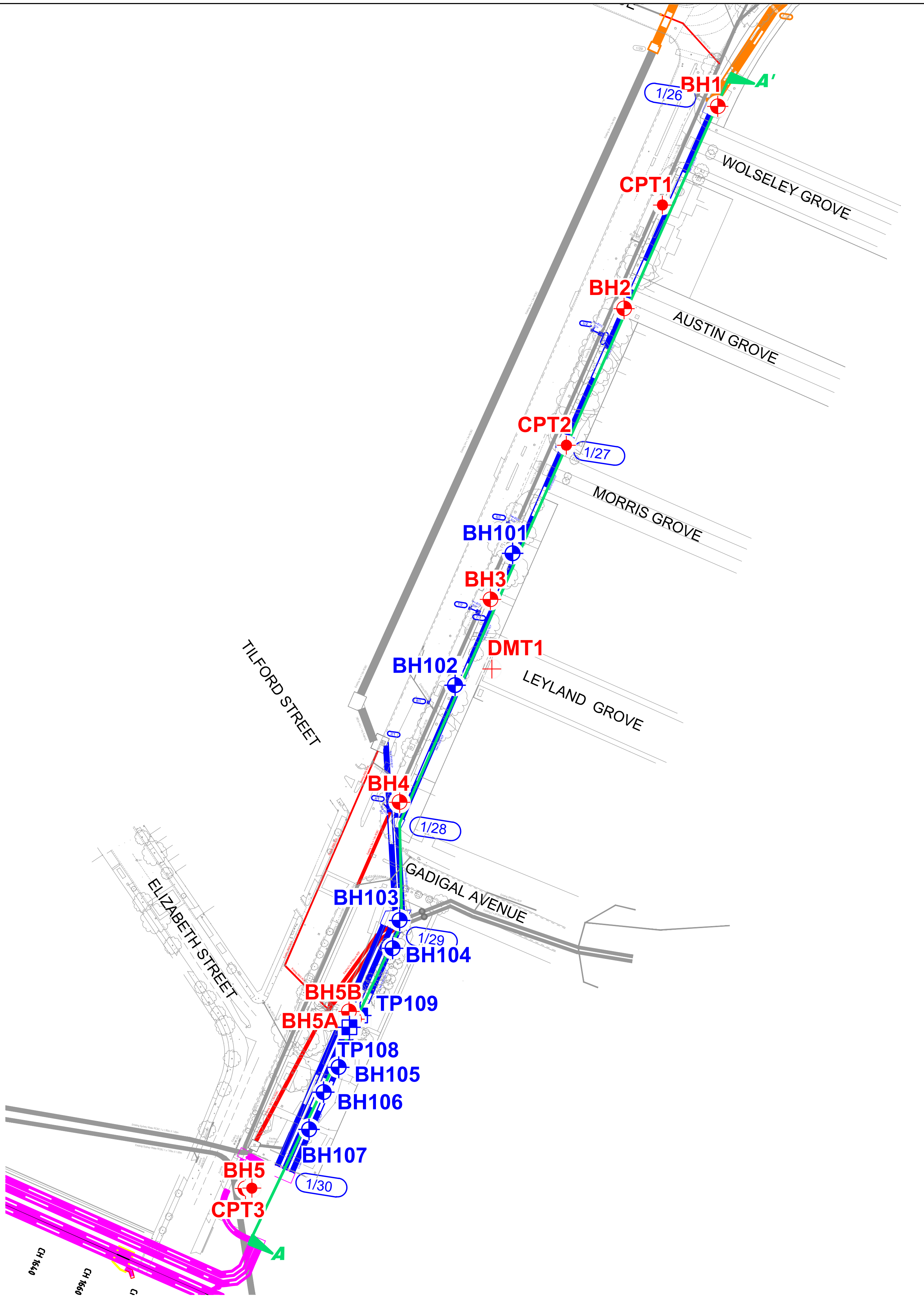
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

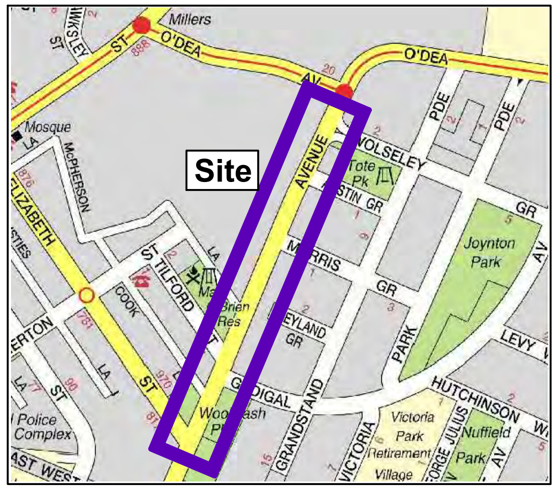
Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings





Locality Plan

NOTE: 1. Base drawing from City of Sydney Council
(Dwg E3-15/1342 -100, dated 18.6.2015)
2. Test locations are approximate only and were
located using hand-held GPS.

0 10 20 30 40 60 80 100 150 200m

1:2000 @ A3

LEGEND

PREVIOUS INVESTIGATION

- ⊕ Borehole location
- ◆ Cone penetration test location
- + Dilatometer test location
- A —— A' Geotechnical Cross Section A-A'

CURRENT IVESTIGATION

- ⊞ Test pit location
- ⊕ Borehole location

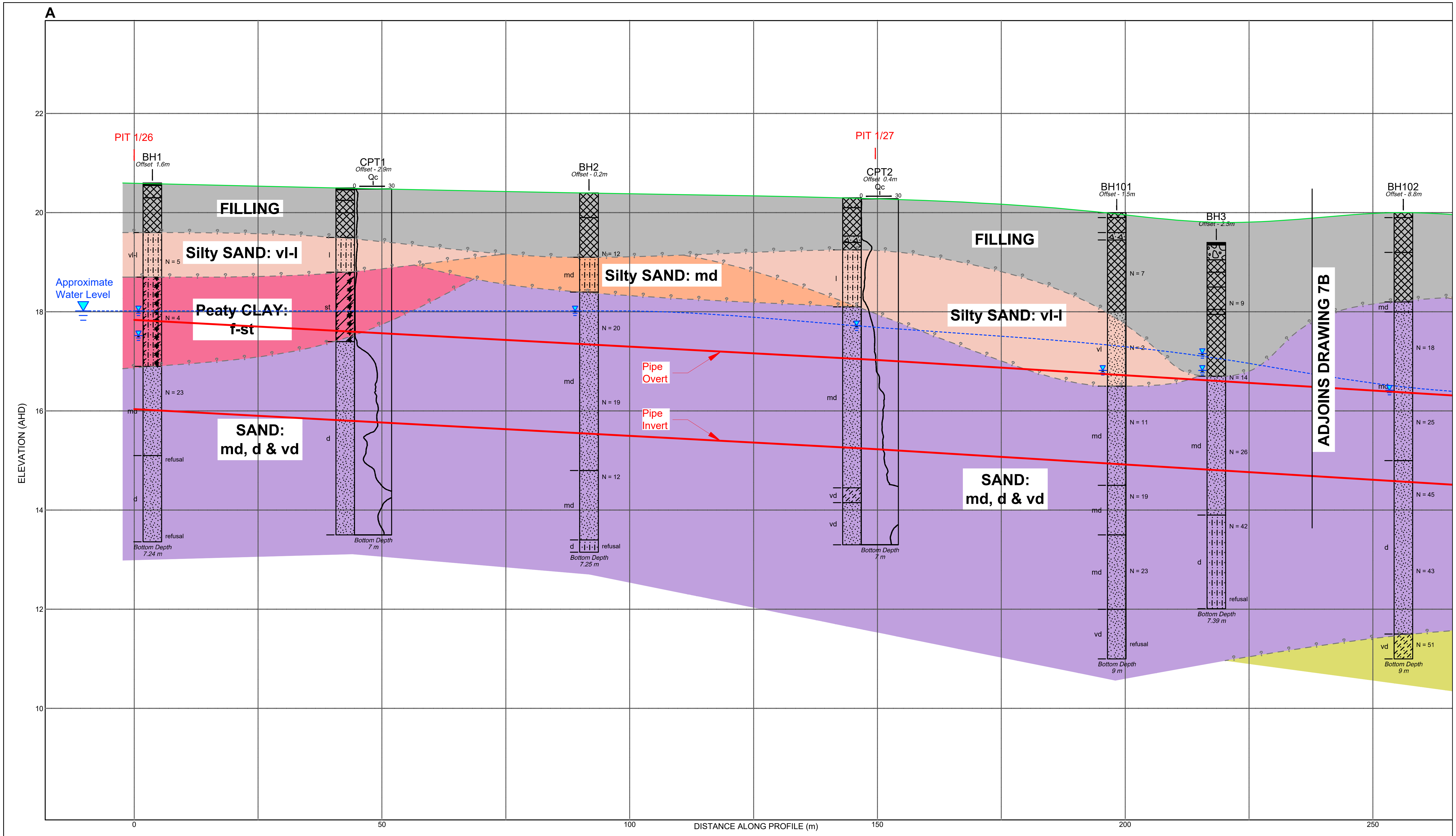
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: PSCH
SCALE: 1:2000 @ A3
DATE: 7.5.2018

TITLE: **Location of Tests**
Joynton Avenue Trunk Drain Project
Joynton Avenue, Zetland

N

PROJECT No: 85100.02
DRAWING No: 1
REVISION: 0



LEGEND

■	Asphaltic Concrete	▨	Sand	▨	Sandy Clay
▨	Filling	▨	Concrete	▨	Gravel
▨	Silty Sand	▨	Clayey Sand	▨	Topsoil
▨	Silty Sand	▨	Sandstone	▨	Peaty Clay

NOTE:

1. Subsurface conditions are accurate at borehole locations. Variations in subsurface conditions may occur between test locations.
2. Interpreted strata boundaries are approximate and should be used as a guide only.
3. Summary logs only. Should be read in conjunction with detailed logs.

SOIL STRENGTH/CONSISTENCY

st - Stiff
vst - Very stiff
h - Hard
l - Loose
md - Medium dense
d - Dense
vd - Very dense

ROCK STRENGTH

EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High

TESTS / OTHER

N - Standard penetration test value
▽ - Water level
- ? - - - Inferred Geology

0 15
Horizontal Scale (metres)

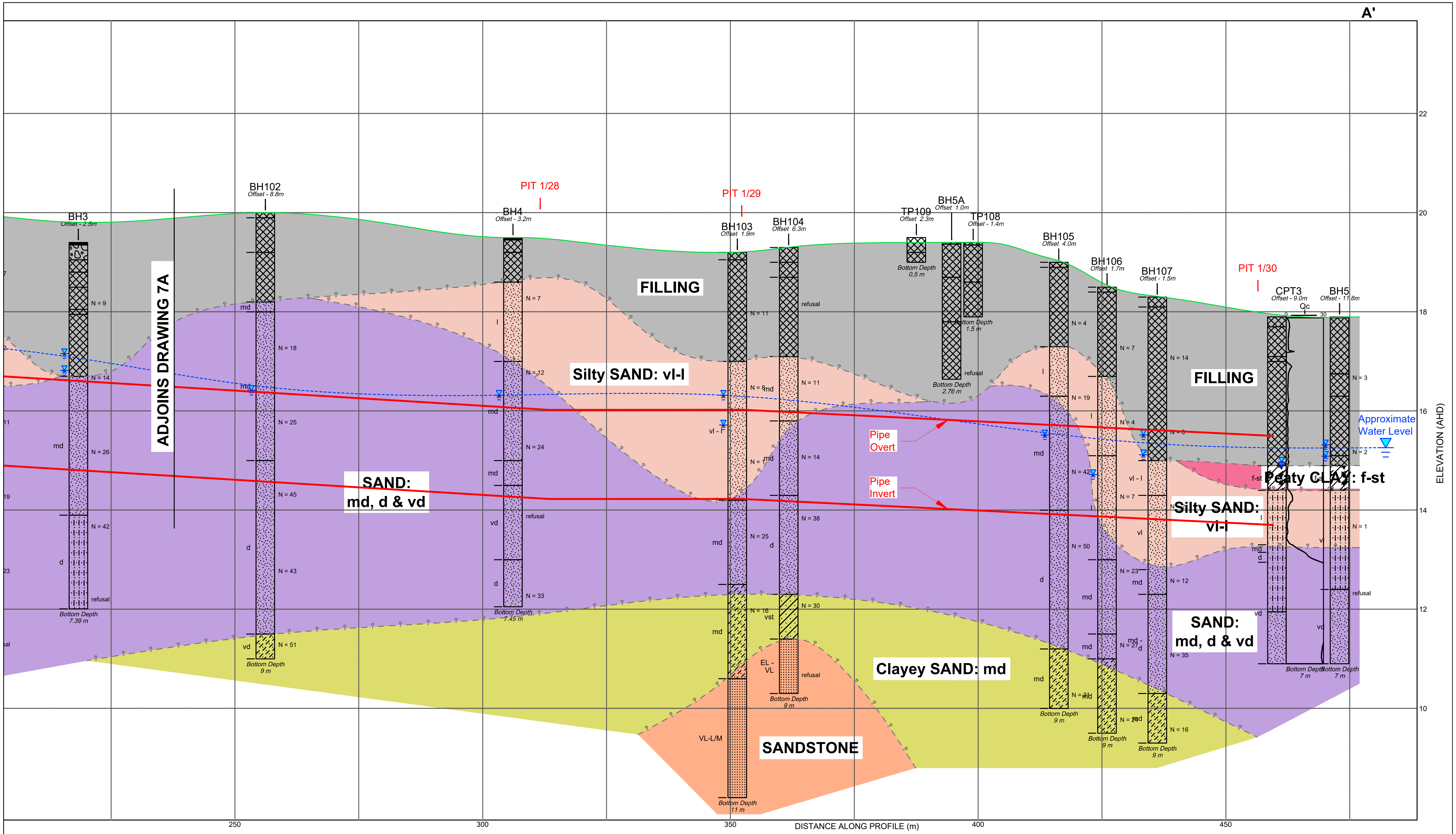
Vertical Exaggeration = 10.0

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: LJH/AK/FMcG
SCALE: 1:750 (H) 1:75 (V) @ A3
DATE: 17.5.2018

TITLE: **Interpreted Geotechnical Long Section - Proposed Underbore**
Joynton Avenue Trunk Drain Project
Joynton Avenue, Zetland

PROJECT No: 85100.02
DRAWING No: 7A
REVISION: 0



LEGEND

- Asphaltic Concrete
- Filling
- Silty Sand
- Silty Sand
- Sand
- Concrete
- Clayey Sand
- Sandstone
- Sandy Clay
- Gravel
- Topsoil
- Peaty Clay

NOTE:

1. Subsurface conditions are accurate at borehole locations. Variations in subsurface conditions may occur between test locations.
2. Interpreted strata boundaries are approximate and should be used as a guide only.
3. Summary logs only. Should be read in conjunction with detailed logs.

SOIL STRENGTH/CONSISTENCY

st -	Stiff
vst -	Very stiff
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ROCK STRENGTH

EL -	Extremely low
VL -	Very low
L -	Low
M -	Medium
H -	High

TESTS / OTHER

N - Standard penetration test value
▽ - Water level
- ? - - Inferred Geology

0 15
Horizontal Scale (metres)

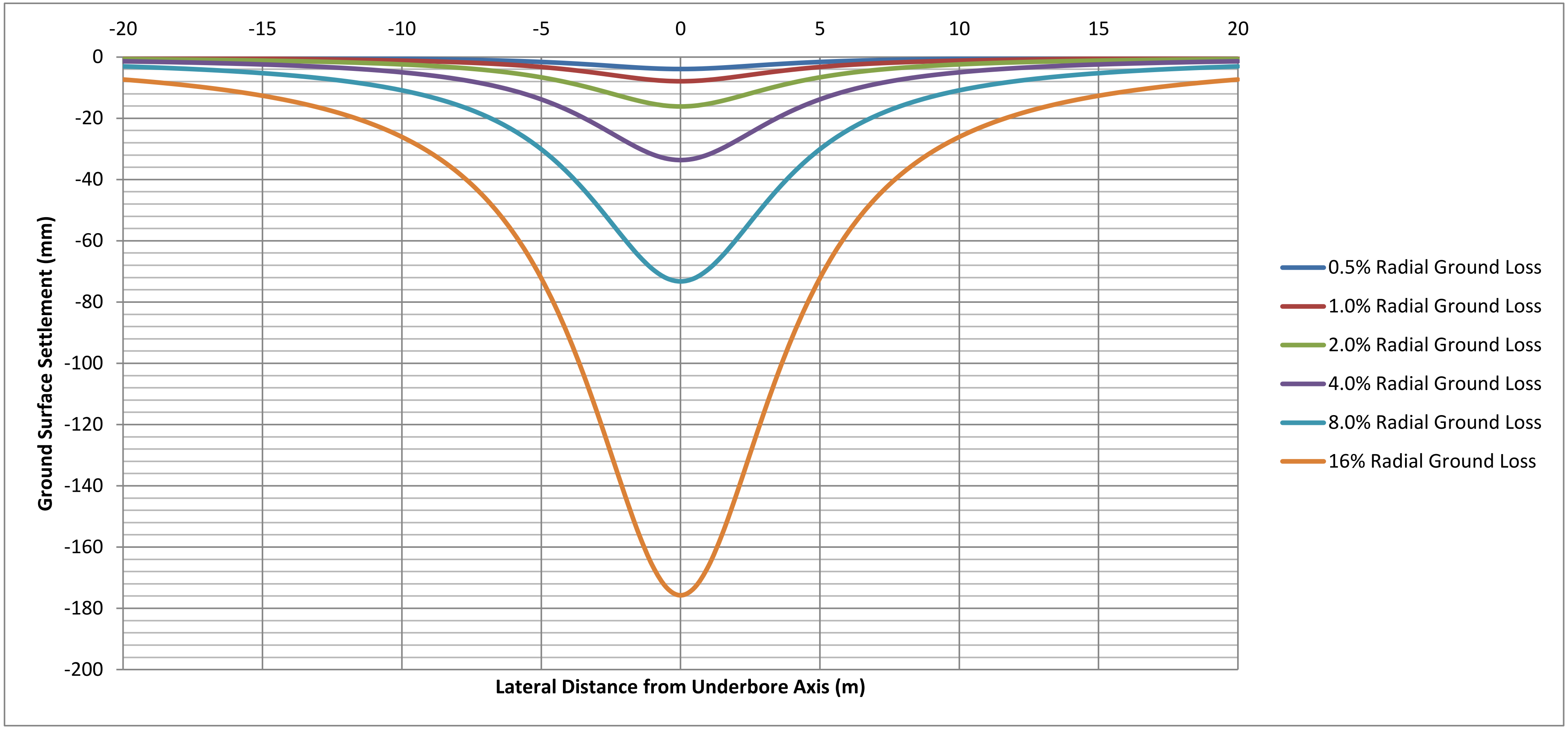
Vertical Exaggeration = 10.0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: City of Sydney Council
OFFICE: Sydney
DRAWN BY: LJH/AK/FMcG
SCALE: 1:750 (H) 1:75 (V) @ A3
DATE: 17.5.2018

TITLE: **Interpreted Geotechnical Long Section - Proposed Underbore**
Joynton Avenue Trunk Drain Project
Joynton Avenue, Zetland

PROJECT No: 85100.02
DRAWING No: 7B
REVISION: 0



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT:	City of Sydney Council	**Surface Settlement Trough Estimates** **Joynton Avenue Stormwater Drainage Upgrade** **Zetland**	PROJECT No:	85100.02
OFFICE:	Sydney		DRAWING No:	8
DATE:	13 May 2018		REVISION:	0

Appendix D **NOISE AND VIBRATION ASSESSMENT**

Acoustics
Vibration
Structural Dynamics

JOYTON AVENUE, ZETLAND - STORMWATER DRAINAGE UPGRADE

REF Noise and Vibration Assessment

8 August 2018

NGH Environmental

TH579-01F02 Report (r3).docx

Document details

Detail	Reference
Doc reference:	TH579-01F02 Report (r3).docx
Prepared for:	NGH Environmental
Address:	Unit 18, 21 Mary Street Surry Hills NSW 2010
Attention:	Clancy Bowman

Document control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Authorised
01.03.2016	Generate report	0	1	WC	MCH	MCH
10.05.2016	Amend sleep disturbance predictions		2	WC		WC
08.08.2018	Update report		3	WC		WC

Important Disclaimer:

The work presented in this document was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

This document is issued subject to review and authorisation by the Team Leader noted by the initials printed in the last column above. If no initials appear, this document shall be considered as preliminary or draft only and no reliance shall be placed upon it other than for information to be verified later.

This document is prepared for the particular requirements of our Client referred to above in the 'Document details' which are based on a specific brief with limitations as agreed to with the Client. It is not intended for and should not be relied upon by a third party and no responsibility is undertaken to any third party without prior consent provided by Renzo Tonin & Associates. The information herein should not be reproduced, presented or reviewed except in full. Prior to passing on to a third party, the Client is to fully inform the third party of the specific brief and limitations associated with the commission.

In preparing this report, we have relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, we have not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

We have derived data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination and re-evaluation of the data, findings, observations and conclusions expressed in this report.

We have prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

The information contained herein is for the purpose of acoustics only. No claims are made and no liability is accepted in respect of design and construction issues falling outside of the specialist field of acoustics engineering including and not limited to structural integrity, fire rating, architectural buildability and fit-for-purpose, waterproofing and the like. Supplementary professional advice should be sought in respect of these issues.

Contents

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1 Introduction

Renzo Tonin & Associates was engaged by the City of Sydney Council, through NGH Environmental, to undertake a noise and vibration assessment of the proposed stormwater drainage upgrade at Joynton Avenue, Zetland.

More specifically, this report quantifies potential impacts from the construction and operation of the upgrade and assesses the potential noise and vibration impact on sensitive receiver locations within the vicinity of the site.

In accordance with relevant guidelines, this document addresses the following issues regarding noise and vibration for the proposed upgrade:

- Identify potential sources of noise and vibration during the proposed construction works;
- Specify noise and vibration criteria for the proposed construction works;
- Describe in detail what actions and measures could be implemented to enable the construction works to comply with the relevant noise and vibration criteria;
- Describe how the effectiveness of these actions and measures would be monitored during the proposed construction works, clearly indicating who would conduct the monitoring, how often this monitoring would be conducted, how the results of this monitoring would be recorded and if any non-compliance is detected;
- Procedures to handle complaints; and
- Determine potential noise impacts during the operational phase of the project.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

2 Project Description

2.1 Background Information

The project site is located within Joynton Avenue between O'Dea Avenue and just south of Elizabeth Street, Zetland. The project will provide stormwater relief as well as providing an important link between the new upstream O'Dea Avenue truck drain and the new Green Square trunk drain heading into Alexandra Canal.

Due to constraints at either end of the Joynton Avenue trunk main, the pipe alignment was locked in to match the adjacent upstream alignment and the invert and tie in locations for the O'Dea Avenue and Green Square trunk mains respectively. In addition, an adjacent existing box culvert at capacity running under the footpath, a large diameter water main and a sewer main prevents the trunk main from being positioned in the road corridor.

The sensitive area surrounding Joynton Avenue combined with heritage listed significant trees, and buried utilities directly above the pipe alignment demands an innovative method of construction for the trunk main. Trenchless construction and microtunnelling has been identified as the viable construction method. However, there may be some opportunity to carry out traditional open trench excavation in localised areas of the trunk main.

2.2 Receiver Locations

The nearest affected receivers were identified during a site visit and presented in the table below.

Table 2.1 – Receiver Locations

Receiver ID	Address	Description
R1	2-6 Tilford Street	Double storey residential property located approximately 73m directly west of the project area.
R2	13 Joynton Avenue	Multi-storey residential property located approximately 28m directly west of the project area.
R3	19 Joynton Avenue	Multi-storey residential property located approximately 28m directly west of the project area.
R4	5 O'Dea Avenue	Multi-storey residential property located approximately 28m directly west of the project area
R5	98 Joynton Avenue	Multi-storey residential property located approximately 5m directly east of the project area.
R6	102 Joynton Avenue	Multi-storey residential property located approximately 8m directly east of the project area.
R7	104 Joynton Avenue	Multi-storey residential property located approximately 8m directly east of the project area
R8	106 Joynton Avenue	Multi-storey residential property located approximately 6m directly east of the project area.
R9	30 Gadigal Avenue	Multi-storey residential property located approximately 16m directly east of the project area.

Receiver ID	Address	Description
R10	128 Joynton Avenue	Multi-storey residential property located approximately 17m directly east of the project area.
R11	Green Square Neighbourhood Service Centre (100 Joynton Avenue)	Commercial property located approximately 5m directly east of the project area.
R12	811 Elizabeth Street	Commercial property located approximately 32m directly west of the project area.
R13	966-968 Elizabeth Street	Industrial property located approximately 37m directly west of the project area.
R14	11 Joynton Avenue	Commercial property located approximately 17m directly west of the project area.
R15	Mary O'Brien Park	Parrk located approximately 25m directly west of the project area.
R16	47 Tilford Street	Single storey residential property located approximately 20m directly west of the project area.
R17	43 Tilford Street	Single storey residential property located approximately 26m directly west of the project area.
R18	41 Tilford Street	Single storey residential property located approximately 35m directly west of the project area.
R19	39 Tilford Street	Single storey residential property located approximately 39m directly west of the project area.
R20	37 Tilford Street	Single storey residential property located approximately 45m directly west of the project area.
R21	35 Tilford Street	Double storey residential property located approximately 51m directly west of the project area.
R22	33 Tilford Street	Double storey residential property located approximately 56m directly west of the project area.
R23	31 Tilford Street	Double storey residential property located approximately 60m directly west of the project area.
R24	29 Tilford Street	Double storey residential property located approximately 64m directly west of the project area.
R25	27 Tilford Street	Double storey residential property located approximately 68m directly west of the project area.
R26	25A Tilford Street	Double storey residential property located approximately 72m directly west of the project area.
R27	25 Tilford Street	Double storey residential property located approximately 77m directly west of the project area.
R28	23 Tilford Street	Double storey residential property located approximately 81m directly west of the project area.
R29	21 Tilford Street	Double storey residential property located approximately 85m directly west of the project area.
R30	19 Tilford Street	Double storey residential property located approximately 90m directly west of the project area.
R31	17 Tilford Street	Double storey residential property located approximately 94m directly west of the project area.
R32	15 Tilford Street	Double storey residential property located approximately 98m directly west of the project area.
R33	13 Tilford Street	Double storey residential property located approximately 103m directly west of the project area.

Receiver ID	Address	Description
R34	11 Tilford Street	Double storey residential property located approximately 107m directly west of the project area.
R35	9 Tilford Street	Double storey residential property located approximately 112m directly west of the project area.
R36	13 Joyton Avenue (Chinese restaurant)	Chinese restaurant located approximately 28m directly west of the project area.
R37	1/30 Gadigal Avenue (Pizza Restaurant)	Pizza restaurant located approximately 16m directly east of the project area.
R38	33/106 Joynton Avenue (Café)	Cafe located approximately 6m directly east of the project area.

Figure 1 provides details of the site, surrounds and receiver locations

Figure 1 – Site, Surrounds and Receiver and Noise Monitoring Locations

2.3 Proposed Construction

2.3.1 Summary of Construction Activities

Construction activities associated with the stormwater drainage upgrade include the following:

- Trenchless construction - microtunneling works involved with the trunk main installation
- Excavation of launch and retrieval pits
- Open trenching required to lay local stormwater connections

2.3.2 Construction Hours

The proposed construction works will be undertaken during construction hours as follows:

Mondays to Fridays:	7:30am to 5:30pm
Saturdays:	7:30m to 3:30pm
Sundays & Public Holidays:	No work performed

Should night shifts occur this will be restricted to 9:00pm to 5:00am Sunday to Thursday. The respite nights for the area are Friday and Saturday.

2.4 Proposed Operation

The stormwater pipes will be installed underground and potential noise source is the noise of water flow through the pipes during operation. The noise of water flow through the pipes will be significantly attenuated by both the pipes and the ground. Operational noise at the ground surface is expected to be inaudible and therefore noise to nearby receiver locations are also expected to be inaudible due to further distance separation. Therefore operational noise is not considered further from herein

3 Existing Noise Environment

Background noise varies over the course of any 24 hour period, typically from a minimum at 3am in the morning to a maximum during morning and afternoon traffic peak hours. Therefore, the NSW 'Industrial Noise Policy' (INP – Environment Protection Authority NSW 2000) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. The NSW INP defines these periods as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

3.1 Noise Monitoring Locations

Noise monitoring is to be undertaken at the nearest or potentially most affected residential locations. In this case the nearest and potentially most affected location where noise monitoring was undertaken was as follows.

- **Location M1 –** **100 Joynton Avenue, Zetland**
  Noise monitor located along the western facade of the building, facing Joynton Avenue and on top of the entry awning. Noise data represents the background and ambient noise environment for residences surrounding the project area.

To quantify the existing ambient noise environment, long-term (unattended) noise monitoring was conducted at Location M1 between Wednesday 3rd and Monday 15th February 2016.

Appendix A of this report presents a description of noise terms. Appendix B details the noise monitoring methodology and the graphical recorded outputs from long term noise monitoring are included in Appendix C. The graphs in Appendix C were analysed to determine an assessment background level (ABL) for each day, evening and night period in each 24 hour period of noise monitoring, and based on the median of individual ABLs an overall single Rating Background Level (RBL) for the day, evening and night period is determined over the entire monitoring period in accordance with the NSW INP.

3.2 Existing Background & Ambient Noise Levels

Existing background and ambient noise levels are presented in Table 3.1 below.

Table 3.1 – Measured Existing Background (L_{90}) & Ambient (L_{eq}) Noise Levels, dB(A)

Location	L_{90} Background Noise Levels			L_{eq} Ambient Noise Levels		
	Day	Evening	Night	Day	Evening	Night
M1 – 100 Joynton Avenue, Zetland (Green Square Neighbourhood Service Centre)	54	50	40	63	61	55

4 Construction Noise Assessment

This section provides an assessment of construction noise emissions from the site and recommends noise mitigation measures and management measures that can be used to minimise noise impacts at nearby receivers surrounding the site.

4.1 Construction Noise Criteria

4.1.1 Construction Noise Management Levels

The NSW *'Interim Construction Noise Guideline'* (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- *Use of L_{Aeq} as the descriptor for measuring and assessing construction noise*

  NSW noise policies, including the INP, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- *Application of reasonable and feasible noise mitigation measures*

  As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints.

  Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the length of the construction works proposed, a quantitative assessment is carried out herein, consistent with the ICNG requirements.

Table 4.1 reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 4.1 – Noise Management Levels at Residential Receivers

Time of Day	Management Level $L_{Aeq\ (15\ min)}$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB(A)	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Table 4.2 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the noise monitoring outlined in Section 3.1, the proposed construction hours and the above ICNG requirements. The receiver locations are marked in Figure 1.

Table 4.2 – Construction Noise Management Levels at Residential Receivers

Receiver Location	Noise Management Level $L_{Aeq(15\ min)}$	
All residential receivers (R1 to R10)	Day Standard Hours	54 + 10 = **64dB(A)**
	Day Outside Standard Hours	54 + 5 = **59dB(A)**
	Evening	50 + 5 = **55dB(A)**
	Night	40 + 5 = **45dB(A)**

In addition to the above noise management levels for residential type receivers, Table 4.3 sets out the ICNG noise management levels for other noise sensitive receiver locations. As identified for residential receivers, a 'highly affected' noise objective of $L_{Aeq(15min)}$ 75dB(A) is adopted for all noise sensitive receivers, with exceedances addressed as described in Table 4.1.

Table 4.3 – Noise Management Levels at Other Noise Sensitive Land Uses

Land use	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

Notes: 1. Noise management levels apply when receiver areas are in use only.

The external to internal noise level reductions have been estimated based on each receiver type's building construction, and these reductions range from 10 to 20dB(A). For this project a conservative 10dB(A) reduction from external to internal noise levels has been adopted to allow an external assessment. Therefore, for classrooms the equivalent external noise management level would be **55dB(A)**.

4.1.2 Sleep Disturbance

Given that night works may occur from Monday to Thursday, noise emanating from construction works associated with the project has been assessed for its potential to disturb sleep. The NSW EPA has made the following policy statement with respect to sleep disturbance:

> *"Peak noise level events, such as reversing beepers, noise from heavy items being dropped or other high noise level events, have the potential to cause sleep disturbance. The potential for high noise level events at night and effects on sleep should be addressed in noise assessments for both the construction and operational phases of a development. The INP does not specifically address sleep disturbance from high noise level events.*
>
> *Research on sleep disturbance is reviewed in the NSW Road Noise Policy. This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.*
>
> *From the research, the EPA recognised that the current sleep disturbance criterion of an LA1, (1 minute) not exceeding the LA90, (15 minute) by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, the EPA will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*
>
> *The detailed analysis should cover the maximum noise level or LA1, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the NSW Road Noise Policy. Other factors that may be important in assessing the extent of impacts on sleep include:*
>
> - *how often high noise events will occur*

> - *time of day (normally between 10pm and 7am)*
> - *whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*
>
> *The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under 'fast' time response. The EPA will accept analysis based on either LA1, (1 minute) or LA, (Max)."*
>
> *Source: http://www.epa.nsw.gov.au/noise/applicnotesindustnoise.htm Downloaded: 04.12.2014*

In summary, the sleep disturbance criteria of $L_{A1(1min)} \leq L_{A90(15min)}$ + 15dB(A) is to be used for initial assessment. The L_{Amax} may be used as an alternative to the $L_{A1(1min)}$. It is noted that the background $L_{A90(15minute)}$ noise level used for establishing the sleep disturbance criteria includes all background noise including noise from the project.

Where the background noise level is very low, this may result in a limit which is unnecessarily strict. As stated in the NSW Road Noise Policy section 5.4:

> *"Further studies by the enHealth Council (2004) and the guidelines published by the World Health Organisation (1999) were reviewed and analysed in terms of the guidance on noise exposure and sleep disturbance. The enHealth report states that:*
>
> *'as a rule for planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) LA, (Max) more than 10 or 15 times per night'."*

Therefore, where the screening limit $L_{A90(15min)}$ + 15 is less than 55dB(A) outside, a value of 55dB(A) would be appropriate to ensure the internal noise level does not exceed 45 dB(A), on the assumption that there is a 10dB(A) outside-to-inside noise loss through an open window (see NSW Industrial Noise Policy, p17). Where windows are likely to remain closed on the basis of adequate ventilation that meets the Building Code of Australia's ventilation requirements, then outside noise levels can be greater than 65dB(A), on the assumption that there is a minimum 20dB(A) outside-to-inside noise loss through a closed window.

The sleep disturbance criteria for the project are presented in Table 4.4.

Table 4.4 – Sleep Disturbance Criteria

Receiver Location	Sleep disturbance criteria, 10pm - 7am, L_{Amax}, dB(A)
All residential receivers (R1 to R10)	40 + 15 = **55dB**

4.2 Construction Noise Sources

Construction activities will comprise of the following three (3) phases:

1. Excavation of launch and retrieval pits – Construction of the pits will need to be first supported by sheet piles. Once the sheet piles are installed, typical excavation operations will be undertaken.

2. Trenchless construction – A closed face shield Tunnel Boring Machine (TBM) will be used for drilling operation where the TBM will be jacked along (using a hydraulic jack) by pipes instead at the rear of the TBM. A large 20T excavator or crane will be required to lift the pipes into the launch pit. Noise from the TBM and jacking ram will be largely attenuated due to the equipment being located below ground level within the shaft.

3. Open trenching to lay local stormwater connections – Initial phase of open trenching will include the excavation of trench and laying/installing pipes. Reinforced concrete pits for junctions and connections will be constructed. The second phase will conclude the open trenching activity by closure of the trench and concrete pits.

The following table lists plant and equipment likely to be used by the contractor to carry out the necessary construction works for the project.

Table 4.5 – Construction Activity & Equipment List

Activity	Plant/ Equipment	No. Units
Excavation of launch and retrieval pits	Sheet piling Excavator Truck and Dog Tip Truck Dewatering Pump Vacuum Truck Bobcat Compressor Jack Hammer Concrete Truck	1 for each
Trenchless construction	Mobile Crane Excavator Pump Diesel Generator Slurry Treatment Plant Slurry Shield Pump	1 for each

Activity	Plant/ Equipment	No. Units
Open trenching to lay local stormwater connections – excavation and installation	Mobile Crane Excavator Pump Diesel Generator Tip Truck Vacuum Truck Bobcat Concrete Pump Jack Hammer Compressor Dewatering pump	1 for each
Open trenching to lay local stormwater connections – closure	Compactor Asphalt Plant Excavator Tip Truck Bobcat Concrete Pump Jack Hammer Compressor Dewatering Pump	1 for each

The following table lists the sound power levels of the plant and equipment likely to be used by the contractor to carry out the necessary construction work for this project.

Table 4.6 – Typical Construction Equipment & Sound Power Levels, dB(A) re. 1pW

Plant Description	Sound Power Levels, dB(A)	
	L_{Aeq}	$L_{A1(1min)}$
Asphalt Plant	103	116
Bobcat	107	115
Compressor	95	105
Concrete Pump	102	109
Concrete Truck	106	110
Concrete Vibrator	100	105
Compactor	110	116
Dewatering Pump	102	109
Diesel Generator	100	106
Excavator	107	115
Jack Hammer	110	115
Mobile Crane	110	115
Tip Truck	108	117
Truck and Dog	105	110
Sheet piling	111	119
Slurry Shield Pump	108	115

Plant Description	Sound Power Levels, dB(A)	
	L_{Aeq}	$L_{A1(1min)}$
Slurry Treatment Plant	103	110
Vacuum Truck	107	117

The sound power levels for the majority of activities presented in the above table are provided by the client, based on maximum levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the ICNG, information from past projects and/or information held in our library files.

4.3 Construction Noise Assessment

Noise emissions were predicted by modelling the noise sources, receiver locations, topographical features of the intervening area, and possible noise control treatments using CadnaA (version 4.5) noise modelling computer program. The program calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise from a site.

The noise prediction models takes into account:

- Location of noise sources and receiver locations;
- Height of sources and receivers;
- Separation distances between sources and receivers;
- Ground type between sources and receivers (soft); and
- Attenuation from barriers (natural and purpose built).

Noise levels at any receptors resulting from construction would depend on the above and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary substantially over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Table 4.4 presents noise levels likely to be experienced at the nearby affected receiver locations during the construction works. The presented levels are a worst case maximum with all plant and equipment operating concurrently.

Table 4.7 – Predicted $L_{Aeq,15min}$ Construction Noise Levels at Receiver Locations, dB(A)

Receiver location	Noise Management Level[1]	Predicted Construction Noise Levels, $L_{Aeq,(15min)}$ [2]				Comply? (Yes/No)
		Excavation of pits	Trenchless construct-ion	Open trenching excavat-ion and install	Open trenching closure	
R1 - 2-6 Tilford Street	**64** *(Day – Standard Hours)* **59** *(Day – Outside Standard Hours)* **55** *(Evening)* **45** *(Night)*	26-**59**	31-**56**	18-**64**	18-**63**	No, exceed by up to 19dB(A)
R2 - 13 Joynton Avenue		36-**74**	41-**71**	32-**78**	32-**77**	No, exceed by up to 33dB(A)
R3 - 19 Joynton Avenue		31-**69**	36-**66**	28-**75**	28-**75**	No, exceed by up to 30dB(A)
R4 - 5 O'Dea Avenue		25-**77**	30-**74**	22-**77**	22-**76**	No, exceed by up to 32dB(A)
R5 - 98 Joynton Avenue		28-**89**	33-**86**	23-**88**	23-**87**	No, exceed by up to 44dB(A)
R6 - 102 Joynton Avenue		35-**86**	40-**83**	26-**86**	26-**85**	No, exceed by up to 41dB(A)
R7 - 104 Joynton Avenue		36-**80**	41-**77**	27-**86**	27-**86**	No, exceed by up to 41dB(A)
R8 - 106 Joynton Avenue		31-**73**	36-**69**	31-**88**	31-**88**	No, exceed by up to 43dB(A)
R9 - 30 Gadigal Avenue		14-**80**	19-**77**	14-**81**	14-**80**	No, exceed by up to 36dB(A)
R10 - 128 Joynton Avenue		16-**72**	21-**69**	16-**78**	16-**77**	No, exceed by up to 33dB(A)
R11 - Green Square Neighbourhood Service Centre	**70**	32-**70**	37-**67**	29-**90**	29-**89**	No, exceed by up to 20dB(A)
R12 - 811 Elizabeth Street	**70**	27-**65**	32-**62**	26-**73**	26-**72**	No, exceed by up to 3dB(A)
R13 - 966-968 Elizabeth Street	**75**	27-**71**	32-**68**	27-**70**	27-**70**	Yes
R14 - 11 Joynton Avenue	**70**	32-**78**	37-**75**	31-**77**	31-**77**	No, exceed by up to 7dB(A)
R15 - Mary O'Brien Park	**65**	32-**63**	37-**60**	31-**72**	31-**71**	No, exceed by up to 7dB(A)
R16 - 47 Tilford Street	**64** *(Day – Standard Hours)* **59** *(Day – Outside Standard Hours)* **55** *(Evening)* **45** *(Night)*	32-**66**	37-**63**	26-**79**	26-**78**	No, exceed by up to 34dB(A)
R17 - 43 Tilford Street		32-**60**	37-**57**	24-**76**	24-**75**	No, exceed by up to 31dB(A)
R18 - 41 Tilford Street		29-**58**	34-**55**	25-**71**	25-**71**	No, exceed by up to 26dB(A)
R19 - 39 Tilford Street		32-**61**	37-**57**	25-**73**	25-**72**	No, exceed by up to 28dB(A)
R20 - 37 Tilford Street		32-**61**	37-**58**	26-**71**	26-**71**	No, exceed by up to 26dB(A)
R21 - 35 Tilford Street		35-**64**	40-**61**	35-**73**	35-**72**	No, exceed by up to 28dB(A)
R22 - 33 Tilford Street		34-**62**	39-**59**	28-**72**	28-**72**	No, exceed by up to 27dB(A)
R23 - 31 Tilford Street		34-**62**	39-**59**	28-**71**	28-**71**	No, exceed by up to 26dB(A)
R24 - 29 Tilford Street		34-**62**	39-**59**	29-**71**	29-**70**	No, exceed by up to 26dB(A)
R25 - 27 Tilford Street		32-**62**	37-**59**	27-**70**	27-**70**	No, exceed by up to 25dB(A)
R26 - 25A Tilford Street		32-**62**	37-**59**	26-**70**	26-**69**	No, exceed by up to 25dB(A)
R27 - 25 Tilford Street		31-**62**	36-**59**	24-**69**	24-**69**	No, exceed by up to 24dB(A)
R28 - 23 Tilford Street		29-**59**	34-**56**	22-**66**	22-**66**	No, exceed by up to 21dB(A)
R29 - 21 Tilford Street		29-**59**	34-**56**	21-**66**	21-**65**	No, exceed by up to 21dB(A)
R30 - 19 Tilford Street		29-**59**	34-**56**	19-**65**	19-**65**	No, exceed by up to 20dB(A)
R31 - 17 Tilford Street		29-**59**	34-**56**	18-**65**	18-**64**	No, exceed by up to 20dB(A)
R32 - 15 Tilford Street		28-**59**	33-**56**	17-**64**	17-**64**	No, exceed by up to 19dB(A)

Receiver location	Noise Management Level[1]	Predicted Construction Noise Levels, $L_{Aeq,(15min)}$ [2]				Comply? (Yes/No)
		Excavation of pits	Trenchless construction	Open trenching excavation and install	Open trenching closure	
R33 - 13 Tilford Street		28-**59**	33-**56**	14-**64**	14-**63**	No, exceed by up to 19dB(A)
R34 - 11 Tilford Street		23-**59**	28-**56**	13-**64**	13-**63**	No, exceed by up to 19dB(A)
R35 - 9 Tilford Street		23-**55**	28-**52**	14-**63**	14-**63**	No, exceed by up to 18dB(A)
R36 - 13 Joynton Avenue (Chinese restaurant)	**70**	31-**74**	36-**71**	27-**76**	27-**75**	No, exceed by up to 6dB(A)
R37 – 1/30 Gadigal Avenue (Pizza restaurant)	**70**	10-**77**	15-**73**	10-**77**	10-**76**	No, exceed by up to 7dB(A)
R38 – 33/106 Joynton Avenue (Café)	**70**	20-**75**	25-**72**	20-**85**	20-**85**	No, exceed by up to 15dB(A)

Notes:
1. Noise Management Level for day, evening and night.
2. Based on all construction plant and equipment operating concurrently. Higher level in range occurs when plant and equipment are at closest proximity to receiver and lower level in range occurs when single plant and equipment item is furthest.
3. **Bold** font represents exceedances

Based on the predicted construction noise levels presented in the table above, the construction management levels would be exceeded when works are conducted at the closest proximity to Receivers R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R14, R15, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37 and R38. Predicted construction noise levels at Receiver R13 would comply with the applicable construction management levels.

Furthermore, construction noise levels are predicted to exceed the highly noise affected level of 75dB(A) at Receivers R2, R4, R5, R6, R7, R8, R9, R1, R11, R14, R16, R17, R36, R37 and R38.

It should be noted that the exceedances predicted are based on all plant and equipment operating concurrently and at a location closest to the corresponding receiver location. This scenario would not typically occur on site.

Nevertheless, in light of the predicted noise exceedances, it is recommended that a feasible and reasonable approach towards noise management measures be applied to reduce noise levels as much as possible to manage the impact from construction noise.

Further details on construction noise mitigation and management measures are provided in Section 4.5 below.

4.4 Sleep Disturbance Assessment

In addition to the above predicted noise levels, Table 4.8 below presents a summary of the predicted L_{Amax} noise levels at residential receivers during night time works for the applicable stages. In accordance with the ICNG the sleep disturbance assessment is only applicable where construction works are planned to extend over more than two consecutive nights. It is noted that utility relocation works are transient in nature and would not necessarily require two consecutive nights of works at one location. The presented levels are a range of maximum noise level where the highest level in the range occurs when the works are at the closest proximity to the receiver and the lowest level in the range occurs when the works are at the furthest extent to the receiver.

Table 4.8 – Predicted L_{Amax} Construction Noise Levels for Night Time Construction Works, dB(A)

Receiver location	Sleep disturbance criteria, 10:00pm - 7:00am, $L_{A1,1minute}$	Predicted Construction Noise Levels			
		Excavation of pits	Trenchless construct-ion	Open trenching excavation and install	Open trenching closure
R1 - 2-6 Tilford Street	*40 + 15 =* ***55dB(A)***	50-**61**	46-**57**	40-**64**	40-**64**
R2 - 13 Joynton Avenue		**60**-**76**	**56**-**72**	54-**78**	54-**78**
R3 - 19 Joynton Avenue		55-**71**	51-**67**	50-**76**	50-**76**
R4 - 5 O'Dea Avenue		49-**79**	45-**75**	44-**77**	44-**77**
R5 - 98 Joynton Avenue		52-**91**	48-**87**	45-**88**	45-**88**
R6 - 102 Joynton Avenue		**59**-**88**	55-**84**	48-**86**	48-**86**
R7 - 104 Joynton Avenue		**60**-**82**	**56**-**78**	49-**87**	49-**87**
R8 - 106 Joynton Avenue		55-**74**	51-**70**	53-**89**	53-**89**
R9 - 30 Gadigal Avenue		38-**82**	34-**78**	36-**81**	36-**81**
R10 - 128 Joynton Avenue		40-**74**	36-**70**	38-**78**	38-**78**
R16 - 47 Tilford Street		**56**-**68**	52-**64**	48-**79**	48-**79**
R17 - 43 Tilford Street		**56**-**62**	52-**58**	46-**76**	46-**76**
R18 - 41 Tilford Street		53-**60**	49-**56**	47-**72**	47-**72**
R19 - 39 Tilford Street		**56**-**62**	52-**58**	47-**73**	47-**73**
R20 - 37 Tilford Street		**56**-**62**	52-**58**	48-**72**	48-**72**
R21 - 35 Tilford Street		**59**-**66**	55-**62**	**57**-**73**	**57**-**73**
R22 - 33 Tilford Street		**58**-**64**	54-**60**	50-**72**	50-**72**
R23 - 31 Tilford Street		**58**-**64**	54-**60**	50-**72**	50-**72**
R24 - 29 Tilford Street		**58**-**64**	54-**60**	51-**71**	51-**71**
R25 - 27 Tilford Street		**56**-**64**	52-**60**	49-**70**	49-**70**
R26 - 25A Tilford Street		**56**-**64**	52-**60**	48-**70**	48-**70**
R27 - 25 Tilford Street		55-**64**	51-**60**	46-**69**	46-**69**
R28 - 23 Tilford Street		53-**61**	49-**57**	44-**66**	44-**66**
R29 - 21 Tilford Street		53-**61**	49-**57**	43-**66**	43-**66**
R30 - 19 Tilford Street		53-**61**	49-**57**	41-**65**	41-**65**
R31 - 17 Tilford Street		53-**61**	49-**57**	40-**65**	40-**65**
R32 - 15 Tilford Street		52-**61**	48-**57**	39-**65**	39-**65**
R33 - 13 Tilford Street		52-**61**	48-**57**	36-**64**	36-**64**
R34 - 11 Tilford Street		47-**61**	43-**57**	35-**64**	35-**64**
R35 - 9 Tilford Street		47-**57**	43-53	36-**64**	36-**64**

Notes: 1. **Bold** denotes exceedance of sleep disturbance criteria

For the assessment of sleep disturbance, it can be seen that predicted external L_{Amax} noise levels will generally exceed the background plus 15dB(A) criteria at all receiver locations. Therefore, in accordance with the requirements of the ICNG, construction works should not occur over more than two consecutive nights to allow respite to nearby residences.

Nevertheless, a reasonable and feasible approach towards noise management measures would be required to reduce noise levels as much as possible to manage the impact from construction noise during night time periods.

4.5 Construction Noise Mitigation and Management Measures

The following recommendations provide in-principle feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

4.5.1 General Engineering Noise Controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 "Guide to Noise Control on Construction, Demolition and Maintenance Sites", are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 4.9 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 4.9 – Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical Noise Reduction Possible in Practice		Maximum Noise Reduction Possible in Practice	
		AS 2436	Renzo Tonin & Associates	AS 2436	Renzo Tonin & Associates
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	5 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30

Noise Control Method	Practical Examples	Typical Noise Reduction Possible in Practice		Maximum Noise Reduction Possible in Practice	
		AS 2436	Renzo Tonin & Associates	AS 2436	Renzo Tonin & Associates
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

Table 4.10 below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 4.10 – Noise Control Measures for Likely Construction Plant

Plant Description	Screening	Acoustic Enclosures	Silencing	Alternative Process
Asphalt Plant	✔	✖	✔	✖
Bobcat	✔	✖	✔	✖
Compressor	✔	✔	✔	✖
Concrete Pump	✔	✔	✔	✖
Concrete Truck	✔	✖	✔	✖
Compactor	✔	✖	✔	✖
Dewatering Pump	✔	✔	✔	✖
Diesel Generator	✔	✔	✔	✖
Excavator	✔	✖	✔	✖
Jack Hammer	✔	✖	✔	✖
Mobile Crane	✔	✖	✔	✖
Tip Truck	✔	✖	✔	✖
Truck and Dog	✔	✖	✔	✖
Sheet piling	✔	✖	✔	✖
Slurry Shield Pump	✔	✔	✔	✖
Slurry Treatment Plant	✔	✔	✔	✖
Vacuum Truck	✔	✖	✔	✖

4.5.2 Noise Management Measures

The following recommendations provide in-principle feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

The following reasonable and feasible noise management measures should be considered.

- Use less noisy plant and equipment, where feasible and reasonable.
- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work should be switched off.
- In addition to the noise mitigation measures outlined above, a management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits. See Appendix D for an example of a complaint handling procedure and form.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters.

Where noise level exceedances cannot be avoided, then consideration may be given to implementing time restrictions and/or providing periods of repose for residents, where feasible and reasonable. That is, daily periods of respite from noisy activities may also be scheduled for building occupants during business hours.

Some items of plant may exceed noise limits even after noise treatment is applied. To reduce the overall noise impact, the use of noisy plant may be restricted to within certain time periods, where feasible and reasonable and to be negotiated with Council and the residents. For example, between 10am and 3pm (with one-hour break for lunch between 12pm and 1pm), noisy activities could occur with no noise level restrictions over a limited time period. Residents would be notified of the potential noise impact during this time period so that they can organise their day around the noisy period. Allowing the construction activities to proceed, despite the noise exceedance may be the preferred method in order to complete the works expeditiously.

5 Construction Vibration Assessment

5.1 Vibration Criteria

Construction vibration is associated with three main types of impact:

- disturbance to building occupants;
- potential damage to buildings; and
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The SI unit for distance is the meter (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is meters per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is meters per second squared (m/s^2). Construction vibration goals are summarised below.

Construction vibration goals are summarised below.

5.1.1 Disturbance to Buildings Occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the DECC '*Assessing Vibration; a technical guideline*' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 5.1 provides definitions and examples of each type of vibration.

Table 5.1 – Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

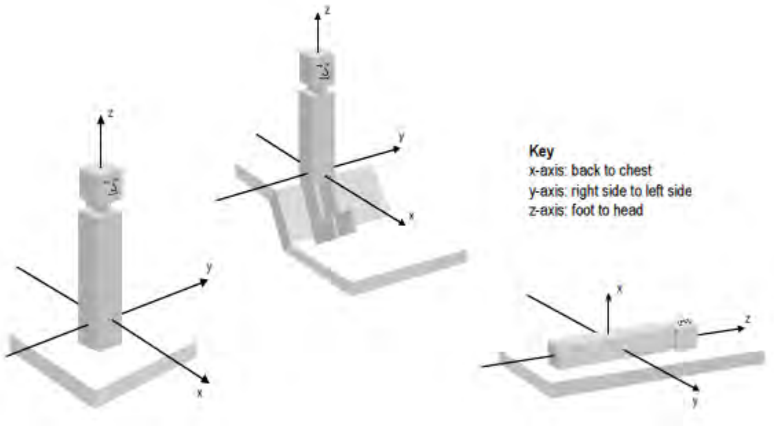
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 2 – Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and the values applicable to the receivers surrounding the site are reproduced in Table 5.2.

Table 5.2 – Preferred and Maximum Levels for Human Comfort

Location	Assessment Period[1]	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous Vibration (Weighted RMS Acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive Vibration (Weighted RMS Acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and the values applicable to the receivers surrounding the site are reproduced in Table 5.3.

Table 5.3 – Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

5.1.2 Building Damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*

- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *"7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."*

Within DIN4150-3, damage is defined as *"any permanent effect of vibration that reduces the serviceability of a structure or one of its components"* (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls;*
> - *existing cracks in the building are enlarged;*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage. " (DIN4150.3, 1990, p.3)*

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

British Standard

British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 5.4 sets out the BS7385 criteria for cosmetic, minor and major damage.

Table 5.4 – BS 7385 Structural Damage Criteria

Group	Type of Structure	Damage Level	Peak Component Particle Velocity[1], mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

Notes:
1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.
2. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

German Standard

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure*' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases. The limits applicable to the receivers surrounding the site are presented in Table 5.5.

Table 5.5 – DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15

5.2 Potential Vibration Impacts

Based on the proposed plant items presented in Section 4.2, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 5.6 below. The assessment is relevant to the identified residential, commercial and industrial type buildings

Table 5.6 – Potential Vibration for Residential, Commercial and Industrial Properties

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
R1	73m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R2	28m	Residential	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R3	28m	Residential	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R4	28m	Residential	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R5	5m	Residential	Medium risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R6	8m	Residential	Medium risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R7	8m	Residential	Medium risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
R8	6m	Residential	Medium risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R9	16m	Residential	Low risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R10	17m	Residential	Low risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R11	5m	Commercial	Low risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R12	32m	Commercial	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R13	37m	Industrial	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R14	17m	Commercial	Low risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R16	20m	Residential	Low risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R17	26m	Residential	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R18	35m	Residential	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R19	39m	Residential	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R20	45m	Residential	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R21	51m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
R22	56m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R23	60m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R24	64m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R25	68m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R26	72m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R27	77m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R28	81m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R29	85m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R30	90m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R31	94m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R32	98m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R33	103m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R34	107m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
R35	112m	Residential	Very low risk of structural damage from construction works.	Very low risk of adverse comment as a result of construction works	Not required.
R36	28m	Commercial	Very low risk of structural damage from construction works.	Low risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R37	16m	Commercial	Low risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.
R38	6m	Commercial	Low risk of structural damage from construction works.	Medium risk of adverse comment as a result of construction works	Vibration monitoring shall be conducted, where required.

Recommendations for reducing potential vibration impacts, including minimum working distances for construction plant are provided in Section 5.3 below.

5.3 Recommended Minimum Buffer Distances

The pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Accordingly, based on a database containing vibration measurements from past projects and library information, Table 5.7 below presents the recommended indicative minimum working distances for high vibration generating plant.

Table 5.7 – Recommended Minimum Working Distances for Vibration Intensive Plant

Plant Item	Rating / Description	Minimum Working Distance	
		Cosmetic Damage	Human Response
Compactor[2]	-	15m	100m
Excavator/Bobcat[1]	<=30 Tonne (travelling/ digging)	10m	15m
Jack Hammer	Hand held	1m (nominal)	Avoid contact with structure
Sheet Piling[2]	≤ 800 mm	2m (nominal)	N/A
Truck movements[2]	Truck and Dog, Concrete Truck, Tip Truck, Vacuum Truck	-	10m

Notes:
1. TCA Construction Noise Strategy (Rail Projects) November 2011
2. Renzo Tonin & Associates project files, databases & library

Site specific buffer distances should be determined once vibration emission levels are measured from each plant item prior to the commencement of their regular use on site. Where construction activity occurs in close proximity to sensitive receivers, minimum buffer distances for building damage should be determined by site measurements and maintained.

5.4 Vibration Management Measures

The following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers and to meet the relevant human comfort and building damage vibration limits:

1. The proper implementation of a vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with occupants and property owners is recommended and should be aimed at providing a communication path directly to the contractor.
2. A management procedure would be implemented to deal with vibration complaints. Each complaint would be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences. An example of a vibration complaint management procedure and complaint form is presented in APPENDIX E of this report.
3. Carry out vibration testing of actual equipment on site prior to the construction works to determine acceptable buffer distances to the sensitive receivers.
4. Carry out additional vibration monitoring as specified in APPENDIX D when construction activities are at the nearest point to the nominated occupancies. This monitoring may signal to the contractor by way of a buzzer or flashing light etc, when levels approach/exceed the recommended limits in nearby occupancies.
5. Carry out periodic vibration monitoring at all critical or sensitive areas and assess the vibration levels for compliance with the set vibration limits. This monitoring shall be undertaken in accordance with the vibration monitoring program described in APPENDIX D.
6. Where vibration is found to be excessive, management measures should be considered to ensure vibration compliance is achieved.
7. Before, during and after the construction works we recommend preparation of dilapidation reports on the state of the existing buildings surrounding the construction site.

6 Construction Traffic Noise Assessment

Noise impact from the potential increase in traffic on the surrounding road network due to construction activities is assessed against the NSW 'Road Noise Policy' (RNP). The RNP sets out criteria to be applied to particular types of road and land uses. These noise criteria are to be applied when assessing noise impact and determining mitigation measures for sensitive receivers that are potentially affected by road traffic noise associated with the construction of the Proposal, with the aim of preserving the amenity appropriate to the land use.

All truck access to and from the site will be via Joynton Avenue.

6.1 Road Traffic Noise Criteria

Based on functionality, Joynton Avenue is categorised as a sub-arterial road. For residential receivers on Joynton Avenue affected by additional traffic generated by the construction works associated with the project, the following road traffic noise criteria apply. It is noted that the criteria presented are only applicable for residential type receivers.

Table 6.1 – RNP Road Traffic Noise Criteria, dB(A)

Road Category	Type of Project/Land Use	Assessment Criteria, dB(A)	
		Day 7am – 10pm	Night 10pm – 7am
Freeway/arterial/sub-arterial roads	3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,(15 hour)}$ 60 (external)	$L_{Aeq,(9 hour)}$ 55 (external)

6.2 Predicted Road Traffic Noise

As advised by the client, it is anticipated that up to 10 trucks will access the site per day. Based on 10 trucks per day, a total of 20 truck movements (i.e 10 truck movements in and 10 truck movements out) have been used for the traffic noise assessment.

Joynton Avenue carries approximately 12,500 vehicles per day (from the City of Sydney Council). For the prediction of traffic noise levels it was assumed that the day time (15hr – 7am to 10pm) traffic volume is 80% of the daily volume and the night time (9hr – 10pm to 7am) traffic volume is 20% of the volume. Therefore, it is assumed that the day time 15 hour traffic volume is 10,000 vehicles and the night time 9 hour traffic volume is 2,500.

Results of the road traffic noise predictions are presented in the table below.

Table 6.2 – Predicted Road Traffic Noise Levels Along Public Roads, dB(A)

Receiver	Period	Predicted Existing Traffic Noise Level[1]	Predicted Project Traffic Noise Level	Total Traffic Noise Level	Criteria	Exceeds Criteria?
Residences along Joynton Avenue	Day	67	40	67	$L_{Aeq, (15 hour)}$ 60	Yes[1]
	Night	63	42	63	$L_{Aeq, (9 hour)}$ 55	Yes[1]

Notes: 1. Existing traffic noise levels predicted based on traffic volume being 80% of AADT for day and 20% of AADT for night, obtained from the City of Sydney Council

Existing traffic noise levels along Joynton Avenue was predicted to already exceed both the day and night time RNP criteria of $L_{Aeq (15 hour)}$ 60dB(A) and $L_{Aeq (9 hour)}$ 55dB(A), respectively. The predicted day time construction traffic noise level is 27dB(A) below the existing traffic noise level and 20dB(A) below the day time RNP criterion, while the predicted night time construction traffic noise level is 21dB(A) below the existing traffic noise level and 13dB(A) below the night time RNP criterion.

Therefore, traffic associated with the construction works will not contribute to the existing day time and night time traffic noise levels.

7 Conclusion

A noise and vibration assessment has been prepared for the stormwater drainage upgrade along Joynton Avenue in Zetland. Specifically, this report aims to manage noise and vibration impacts during the construction works through noise and vibration control measures.

In-principle recommendations are provided in Section 4.5 and Section 5.4 to limit the potential impact of noise and vibration generated by construction activities to acceptable levels. In addition, buffer distances for vibration compliance have been provided as guidance; however, should be determined in more detail prior to the start of construction works through on site measurements of vibration.

Construction traffic noise impacts on the surrounding road network has been assessed and was determined to not contribute to the existing traffic noise levels experienced by the affected residences.

Furthermore, operational noise from water flow though the underground drainage pipeline is expected to be negligible and inaudible at the nearest affected receiver locations.

APPENDIX A Glossary of Terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The “equivalent noise level” is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Specification for Determining the Sound Power Levels of Construction Plant

B.1 Scope

This document specifies methods for determination of sound power levels for construction plant including earthmoving equipment and other ancillary plant and equipment used during construction.

B.2 Referenced Standards

- AS IEC 61672.1 2004 '*Electroacoustics - Sound Level Meters*'
- AS 2012.1-1990 '*Acoustics - Measurement of airborne noise emitted by earth-moving machinery and agricultural tractors - Stationary test condition - Determination of compliance with limits for exterior noise*'
- ISO 3744:2010 '*Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Engineering methods for an essentially free field over a reflecting plane*'
- ISO 3746:2010 '*Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane*'
- ISO 6393:2008 '*Earth-moving machinery - Determination of sound power level - Stationary test conditions*'
- ISO 6395:2008 '*Earth-moving machinery - Determination of sound power level - Dynamic test conditions*'

B.3 Testing Procedures – Earthmoving Machinery

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

Each significant plant item shall be tested in terms of both the ‘stationary’ and the ‘dynamic’ testing procedures detailed below.

All sound level meters used must be Type 1 instruments as described in AS IEC 61672.1 2004 '*Electroacoustics - Sound Level Meters*' and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the meters shall be checked in the field before and after the noise measurement period.

B.4 Stationary Testing

Stationary measurements shall be performed on all earthmoving plant according to the method of AS 2012.1-1990 and/or ISO 6393:2008.

In addition to measuring overall A-weighted noise levels, third-octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 50Hz to 20kHz inclusive. Background noise shall also be recorded in the same third-octave band frequency range, and corrections to measured third-octave band noise levels shall be applied as described in Table 1 of AS2012.1-1990.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 6dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all third-octave band frequencies.

Measured third-octave band $L_{Aeq,T}$ noise levels shall also be processed as described in Section 8 of that Standard to establish third-octave band sound power levels.

The overall A-weighted sound power levels shall be determined for $L_{Aeq,T}$, $L_{A10,T}$ and $L_{A1,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

All measured noise level data and determined sound power levels shall be included in the test reports.

B.5 Dynamic Testing

Details of equipment operation during testing will vary depending on the equipment type. Dynamic measurements shall be performed on all earthmoving plant according to the method in International Standard ISO 6395.

In addition to measuring overall A-weighted noise levels, third-octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 50Hz to 20kHz inclusive. Background noise shall also be recorded in the same third-octave band frequency range, and corrections to measured third-octave band noise levels shall be applied as described in International Standard ISO 6395.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 6dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all third-octave band frequencies.

Measured third-octave band $L_{Aeq,T}$ noise levels shall also be processed to establish third-octave band sound power levels.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

The overall A-weighted sound power levels shall be determined for $L_{Aeq,T}$, $L_{A10,T}$ and $L_{A1,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

All measured noise level data and determined sound power levels shall be included in the test reports.

B.6 Testing Procedures – Other Construction Plant

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All sound level meters used must be Type 1 instruments as described in AS IEC 61672.1 2004 '*Electroacoustics - Sound Level Meters*'. The calibration of the meters shall be checked in the field before and after the noise measurement period.

Noise measurements shall be performed on all non-earthmoving construction plant according to the methods of either ISO 3744:2010 or ISO 3746:2010, whichever is applicable to the items of plant being tested.

Machinery shall be operated at high idle speed. In the case of drilling, boring and rock-breaking machines, the testing location shall allow for these machines to be operated in rock of characteristics that are typical for the project site.

In addition to measuring overall A-weighted noise levels, third-octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 50Hz to 20kHz inclusive. Background noise shall also be recorded in the same third-octave band frequency range, and corrections to measured third-octave band noise levels shall be applied as described in Table 1 of AS2012.1-1990.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 6dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all third-octave band frequencies.

Measured third-octave band $L_{Aeq,T}$ noise levels shall also be processed as described in Section 8 of that Standard to establish third-octave band sound power levels.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$, $L_{A10,T}$ and $L_{A1,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

All measured noise level data and determined sound power levels shall be included in the test reports.

APPENDIX C Specification for Construction Noise Monitoring

C.1 Scope

This document specifies methods for undertaking noise monitoring during the construction phase of the project.

C.2 Referenced Standards and Guidelines

- Australian Standard AS IEC 61672.1 2004 '*Electroacoustics - Sound Level Meters - Specifications*'
- Australian Standard AS 1259.2-1990 '*Acoustics - Sound Level Meters*'
- Australian Standard AS 1055-1997 '*Acoustics - Description and Measurement of Environmental Noise*'
- NSW '*Interim Construction Noise Guideline*' (Department of Environment and Climate Change 2009)
- NSW '*Industrial Noise Policy*' (Environment Protection Authority 2000)

C.3 Testing Procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All noise monitoring equipment used must be at least Type 2 instruments as described in AS 1259.2-1990 and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the monitoring equipment shall also be checked in the field before and after the noise measurement period, and in the case of long-term noise monitoring, calibration levels shall be checked at minimum weekly intervals.

Long-term noise monitoring equipment or Noise Loggers, consist of sound level meters housed in weather resistant enclosures. The operator may retrieve the data at the conclusion of each monitoring period in person or remotely if the logger is fitted with mobile communications.

All environmental noise measurements shall be taken with the following meter settings:

Time constant:	FAST (ie 125 milliseconds)
Frequency weightings:	A-weighting
Sample period:	15 minutes

All outdoor noise measurements shall be undertaken with a windscreen over the microphone. Windscreens reduce wind noise at the microphones.

Measurements of noise should be disregarded when it is raining and/or the wind speed is greater than 5m/s (18km/h).

C.4 Long-term (Unattended) Noise Monitoring

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

Noise monitoring equipment shall be placed at positions which have unobstructed views of general site activities, while acoustically shielded as much as possible from non-construction site noise (eg. road traffic, rail noise and other surrounding noise).

Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory for later retrieval is the following A-weighted noise levels: L_{min}, L_{90}, L_{eq}, L_{10}, L_1 and L_{max}.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Meteorological conditions including wind velocity, wind direction and rainfall shall be monitored over the entire noise monitoring period, either on site or recorded from the nearest weather station to the project site.

C.5 Short-term (Attended) Monitoring

Where noise complaints or requests from relevant authorities are received, attended short-term noise monitoring shall also be conducted at the requested outdoor location (unless the issue is related to regenerated noise from tunnelling and driveage works) and at any other relevant noise receiver location with closest proximity to the construction activities.

Short-term noise monitoring shall be used to supplement long-term noise monitoring undertaken at nearby locations, and to establish whether noise levels measured by the long-term noise monitors are determined by construction activities carried out on site.

All attended short-term noise monitoring shall be recorded over 15 minute sample intervals. Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory and reported is the following A-weighted noise levels: L_{min}, L_{90}, L_{eq}, L_{10}, L_1 and L_{max}.

In addition to measuring and reporting overall A-weighted noise levels, statistical L_{90}, L_{eq}, L_{10} noise levels shall be measured and reported in third-octave band frequencies from 31.5Hz to 8kHz.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Outdoor noise monitoring is to be undertaken with the microphone at a height of 1.2 – 1.5m from the ground, unless noise measurements are taken from a balcony or veranda, in which case the same microphone height shall apply off the floor.

Noise measurements inside buildings should be at least 1m from the walls or other major reflecting surfaces, 1.2 m to 1.5m above the floor, and 1.5m from windows.

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Results of field calibration checks before and after measurements;
- Description of the time aspects of each measurement (ie sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details and number of measurements at each location;
- Weather conditions during measurements, including wind velocity, wind direction, temperature, relative humidity and cloud cover
- Operation and load conditions of the noise sources under investigation
- Any adjustment made for presence or absence of nearby reflecting surfaces; and
- Noise due to other sources (eg traffic, aircraft, trains, dogs barking, insects etc).

APPENDIX D Specification for Construction Vibration Monitoring

D.1 Scope

This document specifies methods for undertaking vibration monitoring during the construction phase of the project. Vibration monitoring during construction activities may be carried out for the following reasons:

- To confirm acceptability of construction techniques, or confirm compliance with limits for structural or cosmetic damage of buildings; or
- To assess compliance with vibration limits for human exposure to vibration.

Monitoring may be carried out in response to specific conditions of approval or complaint. However, the recommended work practice is to conduct proactive monitoring and establish procedures that provide greater assurance of compliance with relevant policy guidelines and Standards throughout all phases of the project works. It is noted that this specification does not address monitoring of blasting activities.

D.1.1 Requirements for Vibration Monitoring

Vibration monitoring is to be carried out at the following times in accordance with this CNVMP:

- At the commencement of operation of each piece of plant equipment or site activity which has the potential to generate significant vibration levels. The objective of this monitoring is to refine the indicative working distances for vibration generating equipment and provide site-specific minimum working distances. Refer to procedure below for establishment Vibration Minimum Working Distances.
- Where vibration complaints or requests from relevant authorities, at the requested location and at any other relevant vibration receiver location with closest proximity to the construction activities. This may be carried out with short-term or long-term monitoring methods.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- **Displacement** (x) measurement is the distance or amplitude displaced from a resting position. The SI unit for distance is the meter (m), although common industrial standards (including the TfNSW vibration limits) include mm.
- **Velocity** ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is meters per second (m/s), although common industrial standards (including the TfNSW vibration limits) include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.

- **Acceleration** (a=Δv/Δt) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is meters per second squared (m/s^2).

D.2 Referenced Standards and Guidelines

- AS 2775-2004 *Mechanical vibration and shock – Mechanical mounting of accelerometers*
- AS 2670.2-1990 *Evaluation of human exposure to whole body vibration*
- BS 6472-1992 *Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*
- BS 6841–1987 *Guide to measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock*
- BS 7482–1991 Parts 1 and 3: *Instrumentation for the measurement of vibration exposure of human beings*
- BS 7385:1 *Evaluation and Measurement for Vibration in Buildings – Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings*
- BS 7385:2 *Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground borne Vibration*
- DIN 4150-1999 Part 3 *Structural vibration – Effects of vibration on structures*
- ISO 4866 *Mechanical Vibration & Shock – Vibration of Buildings – Guidelines for the Management of the Vibrations and Evaluation of their Effects on Buildings*
- NSW DEC (EPA) 2006 *Assessing Vibration: A technical guide*

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and guidelines listed above; however, the following notes of importance are included herein.

D.3 Vibration Minimum Working Distances

Minimum working distances are to be established for each vibration generating item of equipment, as identified, to provide a site-specific minimum working distances.

The testing regime should commence at a suitable time to allow sufficient time to amend construction techniques as necessary, without affecting the overall construction program.

Minimum working distances are to be established using identical equipment or simulated practices at a location removed from the sensitive structure or receiver.

Sufficient measurements are to be carried out in accordance with the relevant Standards to confirm the minimum working distances and confirm the acceptable work practices that are likely to be compliant given the proximity of actual works to sensitive receivers and structures.

Consultation between consultants, engineers and the construction team may be required where revision to work practices is required.

D.3.1 Personnel and Equipment

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be calibrated at least once every two years to Standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics).

Vibration monitors consist of a computer unit connected by cable to a tri-axial vibration transducer which senses vertical, axial and horizontal vibration, or three separate uni-axial vibration transducers positioned in the vertical, axial and horizontal axes. The parameters to be measured differ dependent upon the relevant Standards but may include:

Assessment type	Type of vibration	Relevant standard/guideline	Measurement parameters
Human comfort	Continuous and impulsive	DECC guideline BS 6472-1992	RMS acceleration, 1-80Hz. 1/3 octave weighted as defined in BS6841-1987
	Intermittent vibration	DECC guideline BS 6472-1992	RMS acceleration, 1-80Hz Vibration Dose Values (VDVs) in accordance with BS6472-1992
Structural damage	Non-blasting	DIN 4150-1999 Part 3	Peak-particle velocity (PPV), 1-100Hz
	Non-blasting	BS 7385 Part 2	Peak-particle velocity (PPV), 4-250Hz
Structural damage – sensitive structures	Non-blasting	DIN 4150-1999 Part 3	Peak-particle velocity (PPV), 1-100Hz

Short-term vibration monitors should allow real-time analysis of vibration levels to assist assessment and feedback on the subject operations and procedures.

D.3.2 Monitoring Procedure

Vibration monitoring equipment should be installed in accordance with the following guidance:

- At a location equivalent to the site and ground conditions at the sensitive receiver location. The working distances should not be established via immediate measurement and activities near the sensitive structure.
- The surface should be solid and rigid in order to best represent the vibration levels entering the building/structure under investigation.
- The vibration sensor or transducer should not be mounted on loose gravel or other unstable surfaces.

- The vibration geophone or transducer(s) should be directly mounted to the vibrating surface using bees wax, double sided adhesive tape, or magnetically fixed to a mounting plate fastened to the vibrating surface.
- Where a suitable mounting surface is unavailable, a metal stake (at least 300mm in length) with a mounting plate should be driven into solid ground adjacent to the building of interest. The vibration sensor or transducer shall be fixed on top of the mounting plate.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Description of the time aspects of each measurement (i.e. sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details (including distance from vibrating source) and number of measurements at each location;
- Operation and load conditions of the vibrating plant under investigation and distance from the measurement location; and
- Possible vibration influences from other sources (e.g. other mechanical plant, traffic, railway).

D.4 Long-term (Unattended) Monitoring

Long-term unattended vibration monitoring shall be undertaken continuously whilst the vibrating plant is operational within the pre-determined ‘minimum working distances’ from potentially affected buildings or sensitive structures. Long-term unattended vibration monitoring is generally carried out for the assessment of structural or cosmetic damage rather than human exposure.

D.4.1 Personnel and Equipment

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be calibrated at least once every two years to Standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics).

Vibration monitors consist of a computer unit connected by cable to a tri-axial vibration transducer which senses vertical, axial and horizontal vibration, or three separate uni-axial vibration transducers positioned in the vertical, axial and horizontal axes.

Long-term monitoring for the management of structural and cosmetic damage should include the following:

- Vibration levels are to be monitored continuously with the following parameters being stored at a maximum interval period of 5 minutes:
  - Peak-particle velocity (PPV) between 1 Hz and 100 Hz for each direction of the tri-axial geophone (or transducers) and vector-sum peak-particle velocity [DIN4150.3];
  - Peak-particle velocity (PPV) between 4 Hz and 250 Hz for each direction of the tri-axial geophone (or transducers) and vector-sum peak-particle velocity [BS 7385.2].
- Vibration levels are to be stored at the pre-defined intervals in the logger memory for record, data analysis or post-processing. Data may be retrieved at the conclusion of each monitoring period either by operator download or remotely via a telephone modem if the logger is fitted with a remote communications option.
- Monitors should be fitted with an audible, visual, SMS or email alert system, triggered to provide warning when the measured level of vibration approaches or exceeds the limits defined by the relevant Standard.
- Where the trigger limits are exceeded, a detailed waveform recording should be stored including a detailed frequency spectrum for assessment against the frequency limit curve.

D.4.2 Monitoring Location and Mounting

Vibration monitoring equipment should be installed in accordance with the following guidance:

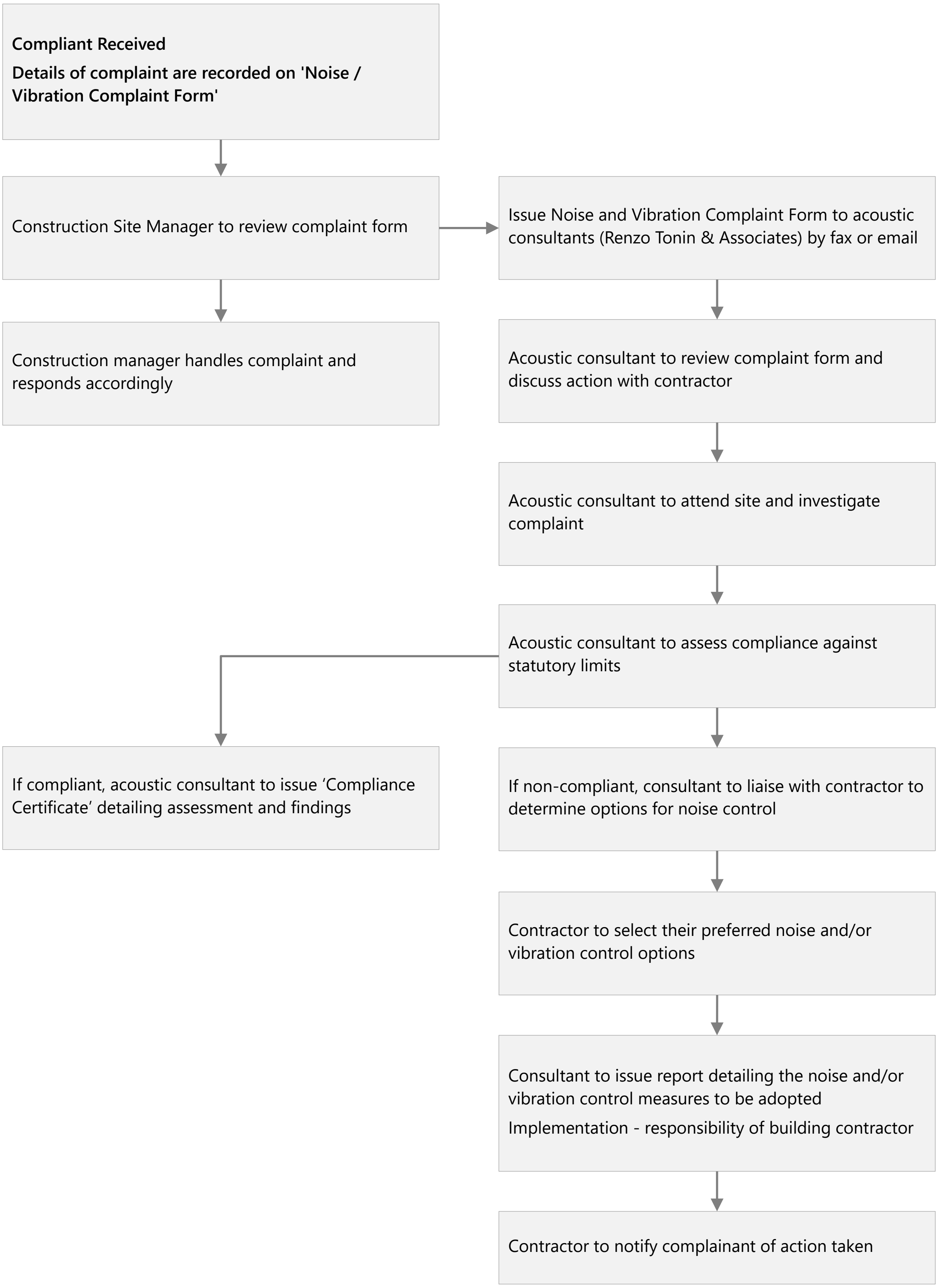
- Equipment should be positioned at the footings or foundations of the building of interest, closest to the vibrating plant.
- The mounting surface should be solid and rigid in order to best represent the vibration levels entering the structure of the building under investigation.
- The vibration geophone or transducer(s) should not be mounted on loose tiles, loose gravel or other unstable surfaces.
- The vibration geophone or transducer(s) should be directly mounted to the vibrating surface using bees wax, double sided adhesive tape, or magnetically fixed to a mounting plate fastened to the vibrating surface.
- Where a suitable mounting surface is unavailable, a metal stake (at least 300mm in length) with a mounting plate should be driven into solid ground adjacent to the building of interest. The vibration sensor or transducer shall be fixed to the mounting plate.

D.5 Vibration Measurements in Response to Complaints

Proactive vibration monitoring and establishment of procedures that comply with the policy guidelines and Standards is the recommended work practice to reduce the risk of complaint regarding vibration from the site.

There may however be cases where specific monitoring is required to investigate a complaint or issue identified during the project works. Vibration monitoring may be carried out using either short-term or long-term methodologies depending on the nature of the complaint. Short-term attended manned procedures would generally be carried out when measurements are required inside a property or where immediate action and detailed observations are required to be made at the time of measurements. Short-term monitoring would generally follow the procedures outlined for the establishment of Minimum Working Distances. Long-term monitoring would be carried out as described in section D.4 above.

APPENDIX E Noise / Vibration Complaint Management Procedure



NOISE AND VIBRATION COMPLAINT FORM

Project title: **Date:**

Site contractor: **Phone:**

Site contact: **Email:**

Complaint Details

Received by (circle): Phone / Email / In person / Other:

Name: H Ph:

Address: W Ph

Email: M Ph

Describe when the problem occurred (date and time), what equipment caused the complaint (if known) and where person was standing when he/she experienced the noise:

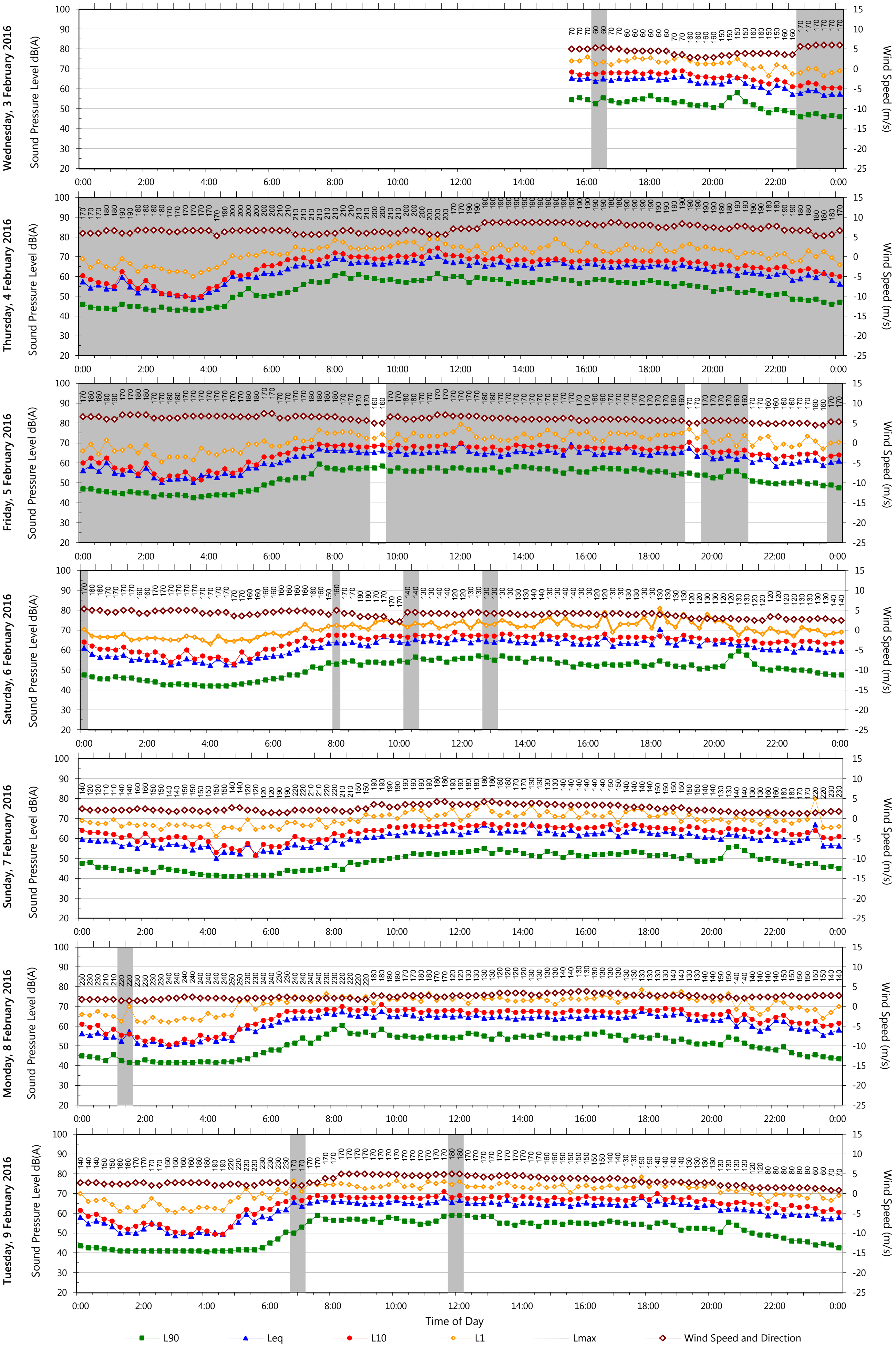
Investigation

Question foreman responsible on site and obtain information on what equipment or processes would most likely have caused the complaint:

Following approval from the Project Manager, email/fax this form to Renzo Tonin & Associates

APPENDIX F Long Term Noise Monitoring Results

Unattended Monitoring Results **Location: 100 Joynton Avenue, Zetland**



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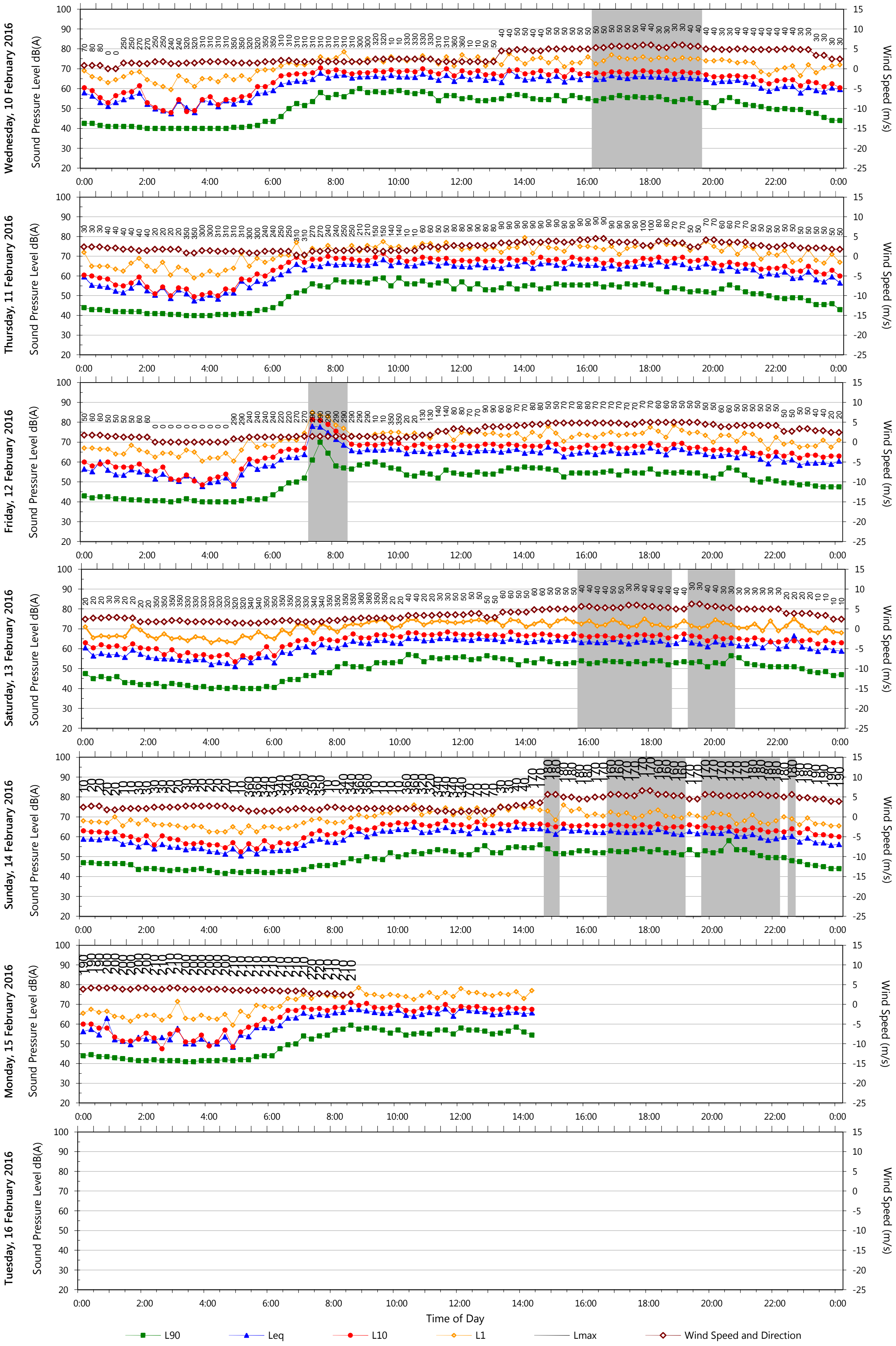
Template: QTE-26 (rev 5) Logger Graphs Program

Unattended Monitoring Results **Location: 100 Joynton Avenue, Zetland**



Data File: 2016-02-03_15-00-00_001_RTA.xls

Template: QTE-26 (rev 5) Logger Graphs Program

Appendix E BIODIVERSITY DATABASE SEARCHES AND THREATENED SPECIES EVALUATIONS

E.1 BIODIVERSITY DATABASE SEARCHES

Bionet search completed 21.08.2018

Row Labels	Count of ScientificName	Count of NSWStatus
Fauna	**779**	**779**
Amphibia	**17**	**17**
Aves	**95**	**95**
Mammalia	**667**	**667**
Flora	**110**	**110**
Flora	**110**	**110**
Acacia gordonii	1	1
(blank)	**1**	**1**
E1,P	1	1
Acacia terminalis subsp. terminalis	31	31
Sunshine Wattle	**31**	**31**
E1,P	31	31
Caladenia tessellata	1	1
Thick Lip Spider Orchid	**1**	**1**
E1,P,2	1	1
Dichanthium setosum	1	1
Bluegrass	**1**	**1**
V,P	1	1
Doryanthes palmeri	2	2
Giant Spear Lily	**2**	**2**
V,P	2	2
Eucalyptus fracta	1	1
Broken Back Ironbark	**1**	**1**
V,P	1	1
Eucalyptus nicholii	1	1
Narrow-leaved Black Peppermint	**1**	**1**
V,P	1	1
Eucalyptus pulverulenta	1	1
Silver-leafed Gum	**1**	**1**
V,P	1	1
Eucalyptus scoparia	3	3
Wallangarra White Gum	**3**	**3**
E1,P	3	3
Hibbertia puberula	1	1
(blank)	**1**	**1**
E1,P	1	1
Melaleuca deanei	6	6
Deane's Paperbark	**6**	**6**
V,P	6	6
Persoonia hirsuta	2	2
Hairy Geebung	**2**	**2**
E1,P,3	2	2
Prostanthera marifolia	3	3
Seaforth Mintbush	**3**	**3**
E4A,P,3	3	3
Syzygium paniculatum	56	56
Magenta Lilly Pilly	**56**	**56**

E1,P	56	56
Grand Total	**889**	**889**

Australian Government

Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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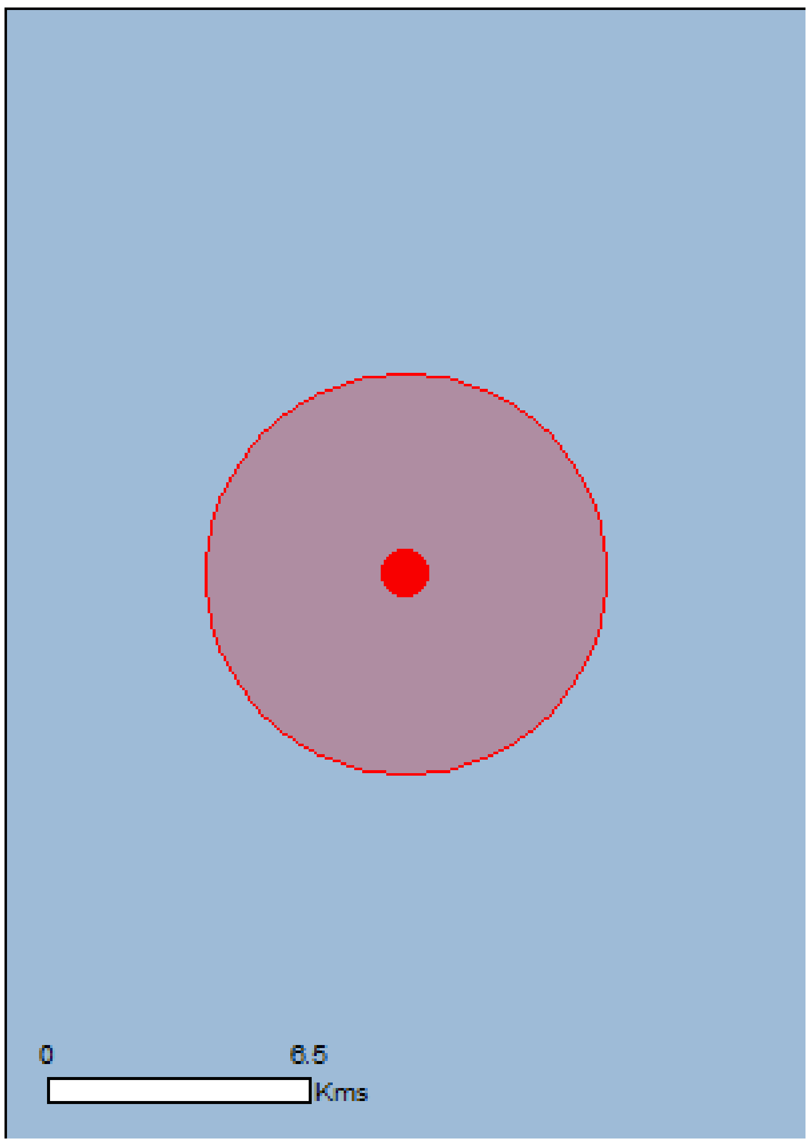
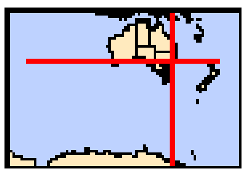


Coordinates

Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	3
National Heritage Places:	3
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	6
Listed Threatened Species:	71
Listed Migratory Species:	74

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	38
Commonwealth Heritage Places:	20
Listed Marine Species:	98
Whales and Other Cetaceans:	11
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	48
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Australian Convict Sites (Hyde Park Barracks Buffer Zone)	NSW	Buffer zone
Sydney Opera House - Buffer Zone	NSW	Buffer zone
Australian Convict Sites (Hyde Park Barracks)	NSW	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Indigenous		
Cyprus Hellene Club - Australian Hall	NSW	Listed place
Historic		
First Government House Site	NSW	Listed place
Hyde Park Barracks	NSW	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Towra point nature reserve	Within 10km of Ramsar

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	Endangered	Community may occur within area
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Coastal Upland Swamps in the Sydney Basin Bioregion	Endangered	Community may occur within area
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered	Community may occur within area
Eastern Suburbs Banksia Scrub of the Sydney Region	Endangered	Community known to occur within area
Western Sydney Dry Rainforest and Moist Woodland on Shale	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Species or species habitat known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat likely to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Macquaria australasica Macquarie Perch [66632]	Endangered	Species or species habitat may occur within area
Prototroctes maraena Australian Grayling [26179]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat may occur within area
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Isoodon obesulus obesulus Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat may occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Plants		
Acacia pubescens Downy Wattle, Hairy Stemmed Wattle [18800]	Vulnerable	Species or species habitat may occur within area
Acacia terminalis subsp. terminalis MS Sunshine Wattle (Sydney region) [88882]	Endangered	Species or species habitat known to occur within area
Allocasuarina glareicola [21932]	Endangered	Species or species habitat may occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat likely to occur within area
Genoplesium baueri Yellow Gnat-orchid [7528]	Endangered	Species or species habitat likely to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat may occur within area
Persoonia hirsuta Hairy Geebung, Hairy Persoonia [19006]	Endangered	Species or species habitat may occur within area
Pimelea curviflora var. curviflora [4182]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Pimelea spicata Spiked Rice-flower [20834]	Endangered	Species or species habitat may occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hoplocephalus bungaroides Broad-headed Snake [1182]	Vulnerable	Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons Little Tern [82849]		Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat known to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat likely to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Pluvialis squatarola Grey Plover [865]		Species or species habitat known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Species or species habitat known to occur within area
Tringa incana Wandering Tattler [831]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Airservices Australia
Commonwealth Land - Australian & Overseas Telecommunications Corporation
Commonwealth Land - Australian Broadcasting Corporation
Commonwealth Land - Australian National University
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Postal Corporation
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Australian Telecommunications Corporation
Commonwealth Land - Commonwealth Bank of Australia
Commonwealth Land - Commonwealth Trading Bank of Australia
Commonwealth Land - Defence Housing Authority
Commonwealth Land - Defence Service Homes Corporation
Commonwealth Land - Director of War Service Homes
Commonwealth Land - Reserve Bank of Australia
Commonwealth Land - Telstra Corporation Limited
Defence - DEFENCE PLAZA SYDNEY
Defence - DSTO PYRMONT - (SEE SITE 1177)
Defence - FLEET BASE WHARVES
Defence - FOREST LODGE (SYDNEY) TRG DEP
Defence - GARDEN ISLAND
Defence - HMAS KUTTABUL (AC 30/5 Lot4 DP218946)
Defence - JENNER BUILDING
Defence - KENSINGTON DEPOT
Defence - KISMET/HMAS KUTTABUL-POTTS PT
Defence - MARITIME COMD CTRE-POTTS POINT ; BOMERAH/TARANA
Defence - MARITIME HEADQUARTERS
Defence - MATERIAL RESEARCH LAB
Defence - OXFORD ST SYDNEY
Defence - PARKVIEW BUILDING - SYDNEY
Defence - RANDWICK (CARRINGTON RD)
Defence - RANDWICK BARRACKS
Defence - RANDWICK FRENCHMANS TRG
Defence - SYDNEY UNIVERSITY REGIMENT - DARLINGTON
Defence - TRESCO
Defence - VICTORIA BARRACKS - PADDINGTON
Defence - WOOLLOOMOOLOO CARPARK
Defence - ZETLAND NAVY SUPPLY CENTRE

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Historic		
Botany Post Office	NSW	Listed place
Building VB1 and Parade Ground	NSW	Listed place
Building VB2 Guard House	NSW	Listed place
Buildings MQVB16 and VB56	NSW	Listed place
Buildings VB13, 15, 16 & 17	NSW	Listed place
Buildings VB41, 45 & 53	NSW	Listed place
Buildings VB60 and VB62	NSW	Listed place
Buildings VB69, 75 & 76 including Garden	NSW	Listed place
Buildings VB83, 84, 85, 87 & 89	NSW	Listed place
Buildings VB90, 91, 91A & 92	NSW	Listed place
Gazebo	NSW	Listed place
General Post Office	NSW	Listed place
Paddington Post Office	NSW	Listed place
Pyrmont Post Office	NSW	Listed place
Reserve Bank	NSW	Listed place
School of Musketry and Officers Mess, Randwick Army Barracks	NSW	Listed place

Name	State	Status
Sydney Customs House (former)	NSW	Listed place
Victoria Barracks Perimeter Wall and Gates	NSW	Listed place
Victoria Barracks Precinct	NSW	Listed place
Victoria Barracks Squash Courts	NSW	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat likely to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Pluvialis squatarola Grey Plover [865]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche sp. nov. Pacific Albatross [66511]	Vulnerable*	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Species or species habitat known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Carduelis chloris European Greenfinch [404]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern,		Species or species

Name	Status	Type of Presence
Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		habitat likely to occur within area
Asparagus asparagoides		
Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus		
Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens		
Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera		
Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata		
Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius		
Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Dolichandra unguis-cati		
Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista linifolia		
Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana		
Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum		
African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Botany Wetlands	NSW

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-33.906985 151.208162

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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E.2 THREATENED SPECIES EVALUATIONS

The tables in this appendix present the habitat evaluation for threatened species, ecological communities and endangered populations listed for in the *Atlas of NSW Wildlife*[1] and those identified as potentially occurring in the area according to the Commonwealth EPBC *Protected Matters Search Tool*[2].

The likelihood of occurrence is based on presence of habitat, proximity of nearest records and mobility of the species (where relevant). The assessment of potential impact is based on the nature of the proposal, the ecology of the species and its likelihood of occurrence. The following classifications are used:

Presence of habitat:

Present:	Potential or known habitat is present within the study area
Absent:	No potential or known habitat is present within the study area

Likelihood of occurrence

Unlikely:	Species known or predicted within the locality but unlikely to occur in the study area
Possible:	Species could occur in the study area
Present:	Species was recorded during the field investigations

Possible to be impacted

No:	The proposal would not impact this species or its habitats. No Assessment of Significance (AoS) is necessary for this species
Yes:	The proposal could impact this species or its habitats. An AoS has been applied to these entities.

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[1] The *Atlas of NSW Wildlife* is administered by the NSW Department of Environment, Climate Change and Water (OEH) and is an online database of fauna and flora records that contains over four million recorded sightings.

[2] This online tool is designed for the public to search for matters protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is managed by the Commonwealth Department of the Environment, Water, Heritage and the Arts.

E.3 EVALUATION OF THE LIKELIHOOD AND EXTENT OF IMPACT ON THREATENED FLORA SPECIES

Species	Description of habitat[3]	Presence of habitat	Likelihood of occurrence	Possible impact?
Trees				
Eucalyptus fracta Broken Back Ironbark V,P	The dominant tree in a narrow band along the upper edge of a sandstone escarpment. Occurs in dry eucalypt woodland in shallow soils. Associated species in slightly deeper soils include Eucalyptus sparsifolia, E. punctata, Corymbia maculata and,Angophora euryphylla.	Absent	Low	Negligible
Eucalyptus nicholii Narrow-leaved Black Peppermint V,P	Typically grows in dry grassy woodland, on shallow soils of slopes and ridges. Found primarily on infertile soils derived from granite or metasedimentary rock. Seedling recruitment is common, even in disturbed soils, if protected from grazing and fire.	Absent	Low	Negligible
Eucalyptus pulverulenta Silver-leafed Gum V,P	Grows in shallow soils as an understorey plant in open forest, typically dominated by Brittle Gum (Eucalyptus mannifera), Red Stringybark (E. macrorhynca), Broad-leafed Peppermint (E. dives), Silvertop Ash (E. sieberi) and Apple Box (E. bridgesiana).	Absent	Low	Negligible
Eucalyptus scoparia Wallangarra White Gum E1,P	Found in open eucalypt forest, woodland and heaths on well-drained granite/rhyolite hilltops, slopes and rocky outcrops, typically at high altitudes. At lower elevations can occur in less rocky soils in damp situations.	Absent	Low	Negligible

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[3] Information sourced from species profiles on NSW OEH's threatened species database or the Australian Government's Species Profiles and Threats database (SPRAT) unless otherwise stated.

OEH threatened species database: http://www.threatenedspecies.environment.nsw.gov.au/index.aspx
SPRAT: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Species	Description of habitat[3]	Presence of habitat	Likelihood of occurrence	Possible impact?
Shrubs				
Acacia gordonii E1,P	Grows in dry sclerophyll forest and heathlands amongst or within rock platforms on sandstone outcrops. Flowers August to September and produces fruit October to February. The fruit is a pod containing hard-coated seed. The seed ultimately forms a persistent soil stored seedbank.	Absent	Low	Negligible
Acacia terminalis subsp. terminalis Sunshine Wattle E1,P	Very limited distribution, mainly in near-coastal areas from the northern shores of Sydney Harbour south to Botany Bay, with most records from the Port Jackson area and the eastern suburbs of Sydney. Coastal scrub and dry sclerophyll woodland on sandy soils. Habitat is generally sparse and scattered. Most areas of habitat or potential habitat are small and isolated.	Absent	Low	Negligible
Hibbertia puberula E1,P	Habitats are typically dry sclerophyll woodland communities, although heaths are also occupied. One of the recently (2012) described subspecies also favours upland swamps.	Absent	Low	Negligible
Melaleuca deanei Deane's Paperbark V,P	The species occurs mostly in ridgetop woodland, with only 5% of sites in heath on sandstone. Flowers appear in summer but seed production appears to be small and consequently the species exhibits a limited capacity to regenerate.	Absent	Low	Negligible
Persoonia hirsuta Hairy Geebung E1,P,3	The Hairy Geebung is found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. It is usually present as isolated individuals or very small populations. It is probably killed by fire (as other Persoonia species are) but will regenerate from seed.	Absent	Low	Negligible

Species	Description of habitat[3]	Presence of habitat	Likelihood of occurrence	Possible impact?
Prostanthera marifolia Seaforth Mintbush E4A,P,3	Occurs in localised patches in or in close proximity to the endangered Duffys Forest ecological community. Located on deeply weathered clay-loam soils associated with ironstone and scattered shale lenses, a soil type which only occurs on ridge tops and has been extensively urbanised.	Absent	Low	Negligible
Syzygium paniculatum Magenta Lilly Pilly E1,P	On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral (coastal) rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	Absent	Low	Negligible
Herbs & Forbs				
Dichanthium setosum Bluegrass V,P	Often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture. (Often collected from disturbed open grassy woodlands on the northern tablelands, where the habitat has been variously grazed, nutrient-enriched and water-enriched). It is open to question whether the species tolerates or is promoted by a certain amount of disturbance, or whether this is indicative of the threatening processes behind its depleted habitat.	Absent	Low	Negligible
Doryanthes palmeri Giant Spear Lily V,P	Giant Spear Lily occurs on exposed rocky outcrops on infertile soils or on bare rock. It grows in a narrow band of vegetation along the cliff-tops and on steep cliff-faces or rocky ledges in montane heath next to subtropical rainforest, warm temperate rainforest or wet eucalypt forest.	Absent	Low	Negligible
Orchids				

Species	Description of habitat[3]	Presence of habitat	Likelihood of occurrence	Possible impact?
Caladenia tessellata Thick Lip Spider Orchid E1,P,2	Generally found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil. The single leaf regrows each year.	Absent	Low	Negligible
EECs				
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community E		Absent	Low	Negligible
Coastal Upland Swamps in the Sydney Basin Bioregion E		Absent	Low	Negligible

E.4 EVALUATION OF THE LIKELIHOOD AND EXTENT OF IMPACT ON THREATENED FAUNA

Marine species have been omitted from this evaluation due to the low likelihood of occurrence.

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Aves				
Litoria aurea Green and Golden Bell Frog E1,P	Its former distribution was predominantly coastal but extended inland to the central and southern tablelands, including Bathurst in the west. It was known from the northern coastal part of NSW from around Brunswick Heads south along the entire NSW coast extending into the north-eastern portion of Victoria. There are presently 43 identified remaining key populations, most of which have a small fragmented distribution of mainly near coastal locations. Large populations in NSW are located around the metropolitan areas of Sydney, Shoalhaven and mid north coast. There is only one known population on the NSW Southern Tablelands. Inhabits marshes, dams and stream-sides, particularly those containing Typha (Typha spp.) or spikerushes (Eleocharis spp.). Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (Gambusia holbrooki), have a grassy area nearby and diurnal sheltering sites available. Some sites, particularly in the Greater Sydney region occur in highly disturbed areas. The species is active by day and usually breeds in summer when conditions are warm and wet. Tadpoles feed on algae and other plant-matter; adults eat mainly insects, but also other frogs. Preyed upon by various wading birds and snakes.	Present – however the nature of Woolwash Pond, being largely disconnected from other waterbodies would make colonisation difficult	Low	Low
Heleioporus australiacus Giant Burrowing Frog V	Found in heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based. Spends more than 95% of its time in non-breeding habitat in areas up to 300 m from breeding sites. Whilst in non-breeding habitat it burrows below the soil surface or in the leaf litter. Individual frogs occupy a series of burrow sites, some of which are used repeatedly. The home ranges of both sexes appear to be non-overlapping suggesting exclusivity of non-breeding habitat. Home ranges are approximately 0.04 ha in size.	Absent	Low	Negligible

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Aves				
Anseranas semipalmata Magpie Goose V,P	Mainly found in shallow wetlands (less than 1 m deep) with dense growth of rushes or sedges. Equally at home in aquatic or terrestrial habitats; often seen walking and grazing on land; feeds on grasses, bulbs and rhizomes. Activities are centred on wetlands, mainly those on floodplains of rivers and large shallow wetlands formed by run-off; breeding can occur in both summer and winter dominated rainfall areas and is strongly influenced by water level; most breeding now occurs in monsoonal areas; nests are formed in trees over deep water; breeding is unlikely in south-eastern NSW. Often seen in trios or flocks on shallow wetlands, dry ephemeral swamps, wet grasslands and floodplains; roosts in tall vegetation.	Present	Moderate	Negligible – unlikely to be locally important habitat for this species
Anthochaera phrygia Regent Honeyeater E4A,P	The Regent Honeyeater is a generalist forager, although it feeds mainly on the nectar from a relatively small number of eucalypts that produce high volumes of nectar. Key eucalypt species include Mugga Ironbark, Yellow Box, White Box and Swamp Mahogany. Other tree species may be regionally important. For example the Lower Hunter Spotted Gum forests have recently been demonstrated to support regular breeding events. Flowering of associated species such as Thin-leaved Stringybark Eucalyptus eugenioides and other Stringybark species, and Broad-leaved Ironbark E. fibrosa can also contribute important nectar flows at times. Nectar and fruit from the mistletoes Amyema miquelii, A. pendula and A. cambagei are also utilised. When nectar is scarce lerp and honeydew can comprise a large proportion of the diet. Insects make up about 15% of the total diet and are important components of the diet of nestlings	Foraging habitat present	Moderate – low	Negligible – unlikely to be locally important habitat for this species

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[4] Information sourced from species profiles on NSW OEH's threatened species database or the Australian Government's *Species Profiles and Threats* database (SPRAT) unless otherwise stated.

OEH threatened species database: http://www.threatenedspecies.environment.nsw.gov.au/index.aspx
SPRAT: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Artamus cyanopterus cyanopterus Dusky Woodswallow V,P	Primarily inhabit dry, open eucalypt forests and woodlands, including mallee associations, with an open or sparse understorey of eucalypt saplings, acacias and other shrubs, and ground-cover of grasses or sedges and fallen woody debris. It has also been recorded in shrublands, heathlands and very occasionally in moist forest or rainforest. Also found in farmland, usually at the edges of forest or woodland.	Absent	Low	Negligible
Botaurus poiciloptilus Australasian Bittern E1,P	Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (Typha spp.) and spikerushes (Eleocharis spp.). Hides during the day amongst dense reeds or rushes and feed mainly at night on frogs, fish, yabbies, spiders, insects and snails. Feeding platforms may be constructed over deeper water from reeds trampled by the bird; platforms are often littered with prey remains. Breeding occurs in summer from October to January; nests are built in secluded places in densely-vegetated wetlands on a platform of reeds; there are usually six olive-brown eggs to a clutch.	Present	Low	Low
Burhinus grallarius Bush Stone-curlew E1,P	The bush stone-curlew inhabits open forests and grassy woodlands. It is found in all states, except for Tasmania, and numbers have drastically declined in south-eastern parts of Australia. If you see one of these birds, count yourself lucky.	Absent	Low	Negligible
Calidris ferruginea Curlew Sandpiper E1,P	It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes inland. It forages in or at the edge of shallow water, occasionally on exposed algal mats or waterweed, or on banks of beach-cast seagrass or seaweed. It roosts on shingle, shell or sand beaches; spits or islets on the coast or in wetlands; or sometimes in salt marsh, among beach-cast seaweed, or on rocky shores.	Absent	Low	Negligible

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Calidris tenuirostris Great Knot V,P	Occurs within sheltered, coastal habitats containing large, intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons. Often recorded on sandy beaches with mudflats nearby, sandy spits and islets and sometimes on exposed reefs or rock platforms. Migrates to Australia from late August to early September, although juveniles may not arrive until October-November.	Absent	Low	Negligible
Calyptorhynchus lathami Glossy Black-Cockatoo V,P,2	The glossy black-cockatoo lives in coastal woodlands and drier forest areas, open inland woodlands, or timbered watercourses where its main food source, the casuarina (she-oak) is common. Scientists think that glossy black-cockatoos prefer to live in rugged country, where extensive clearing has not taken place. Brigalow scrub or hilly rocky country containing casuarina species tend to be their preferred habitat in inland NSW.	Absent	Low	Negligible
Dasyornis brachypterus Eastern Bristlebird E	Habitat for central and southern populations is characterised by dense, low vegetation including heath and open woodland with a heathy understorey. In northern NSW the habitat occurs in open forest with dense tussocky grass understorey and sparse mid-storey near rainforest ecotone; all of these vegetation types are fire prone.	Marginal forage present	Low	Negligible
Grantiella picta Painted Honeyeater	Inhabits Boree/ Weeping Myall (Acacia pendula), Brigalow (A. harpophylla) and Box-Gum Woodlands and Box-Ironbark Forests. A specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus Amyema. Insects and nectar from mistletoe or eucalypts are occasionally eaten. Nest from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping eucalypts, she-oak, paperbark or mistletoe branches.	Marginal forage present	Low	Negligible

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Epthianura albifrons White-fronted Chat V,P White-fronted Chat population in the Sydney Metropolitan Catchment Management Area E2,V,P	Gregarious species, usually found foraging on bare or grassy ground in wetland areas, singly or in pairs. They are insectivorous, feeding mainly on flies and beetles caught from or close to the ground. Have been observed breeding from late July through to early March, with 'open-cup' nests built in low vegetation. Nests in the Sydney region have also been seen in low isolated mangroves. Nests are usually built about 23 cm above the ground (but have been found up to 2.5 m above the ground).	Marginal present	Low – moderate	Low
Erythrotriorchis radiatus Red Goshawk E4A,P,2	Red Goshawks inhabit open woodland and forest, preferring a mosaic of vegetation types, a large population of birds as a source of food, and permanent water, and are often found in riparian habitats along or near watercourses or wetlands. In NSW, preferred habitats include mixed subtropical rainforest, Melaleuca swamp forest and riparian Eucalyptus forest of coastal rivers.	Marginal present	Low – moderate	Low
Haliaeetus leucogaster White-bellied Sea-Eagle V,P	abitats are characterised by the presence of large areas of open water including larger rivers, swamps, lakes, and the sea. Occurs at sites near the sea or sea-shore, such as around bays and inlets, beaches, reefs, lagoons, estuaries and mangroves; and at, or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs and saltmarsh. Terrestrial habitats include coastal dunes, tidal flats, grassland, heathland, woodland, and forest (including rainforest). Breeding habitat consists of mature tall open forest, open forest, tall woodland, and swamp sclerophyll forest close to foraging habitat. Nest trees are typically large emergent eucalypts and often have emergent dead branches or large dead trees nearby which are used as 'guard roosts'. Nests are large structures built from sticks and lined with leaves or grass.	Absent	Low	Negligible

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Hieraaetus morphnoides Little Eagle V,P	Occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used. Nests in tall living trees within a remnant patch, where pairs build a large stick nest in winter.	Absent	Low	Negligible
Limosa limosa Black-tailed Godwit V,P	Primarily a coastal species. Usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sandflats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps.	Absent	Low	Negligible
Lophoictinia isura Square-tailed Kite V,P,3	Found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses. In arid north-western NSW, has been observed in stony country with a ground cover of chenopods and grasses, open acacia scrub and patches of low open eucalypt woodland.	Absent	Low	Negligible
Neophema chrysogaster Orange-bellied Parrot *CE*	On the mainland, the Orange-bellied Parrot spends winter mostly within 3 km of the coast in sheltered coastal habitats including bays, lagoons, estuaries, coastal dunes and saltmarshes. The species also inhabits small islands and peninsulas and occasionally saltworks and golf courses. Birds forage in low samphire herbland or taller coastal shrubland.	Marginal forage present	Low	Negligible
Ninox strenua Powerful Owl V,P,3	The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine Syncarpia glomulifera, Black She-oak Allocasuarina littoralis, Blackwood Acacia melanoxylon, Rough-barked Apple Angophora floribunda, Cherry Ballart Exocarpus cupressiformis and a number of eucalypt species.	Absent	Low	Negligible

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew CE	The Eastern Curlew is found on intertidal mudflats and sandflats, often with beds of seagrass, on sheltered coasts, especially estuaries, mangrove swamps, bays, harbours and lagoons.	Absent	Low	Negligible
Ptilinopus superbus Superb Fruit-Dove V,P	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms. It may also forage in eucalypt or acacia woodland where there are fruit-bearing trees. Part of the population is migratory or nomadic. There are records of single birds flying into lighted windows and lighthouses, indicating that birds travel at night. At least some of the population, particularly young birds, moves south through Sydney, especially in autumn.	Present	Moderate	Low - moderate
Stagonopleura guttata Diamond Firetail V,P	Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum Eucalyptus pauciflora Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.	Absent	Low	Negligible
Sternula albifrons Little Tern E1,P	Almost exclusively coastal, preferring sheltered environments; however may occur several kilometres from the sea in harbours, inlets and rivers (with occasional offshore islands or coral cay records). Nests in small, scattered colonies in low dunes or on sandy beaches just above high tide mark near estuary mouths or adjacent to coastal lakes and islands.	Absent	Low	Negligible
Stictonetta naevosa Freckled Duck V,P	Prefer permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. Generally rest in dense cover during the day, usually in deep water. Feed at dawn and dusk and at night on algae, seeds and vegetative parts of aquatic grasses and sedges and small invertebrates.	Marginal present	Low moderate	Low

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Rostratula australis Australian Painted-snipe E	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds. The nest consists of a scrape in the ground, lined with grasses and leaves. Breeding is often in response to local conditions; generally occurs from September to December. Incubation and care of young is all undertaken by the male only. Forages nocturnally on mud-flats and in shallow water. Feeds on worms, molluscs, insects and some plant-matter.	Present	Moderate	Low - moderate
Fish				
Macquaria australasica Macquarie Perch E	Macquarie Perch are found in both river and lake habitats; especially the upper reaches of rivers and their tributaries.	Absent	Low	Negligible
Mammals				
Miniopterus schreibersii oceanensis Eastern Bentwing-bat V,P	Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. Maternity caves have very specific temperature and humidity regimes.	Absent	Low	Negligible
Myotis macropus Southern Myotis V,P	Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface.	Absent	Low	Negligible

Species and Status	Description of habitat[4]	Presence of habitat	Likelihood of occurrence	Potential for impact?
Pteropus poliocephalus Grey-headed Flying-fox V,P	Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy.	Present	Moderate	Moderate
Saccolaimus flaviventris Yellow-bellied Sheathtail-bat V,P	Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.	Present	Moderate	Moderate

Appendix F **HERITAGE SEARCHES**

AHIMS Web Services (AWS)

Search Result

Purchase Order/Reference : 18-028 Joynton Avenue REF

Client Service ID : 360279

NGH Heritage - Fyshwick
17/27 Yallourn St
Fyshwick Australian Capital Territory 2609
Attention: Ingrid Cook
Email: ingrid.c@nghenvironmental.com.au

Date: 27 July 2018

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lot : 11, DP:DP1198745 with a Buffer of 1000 meters, conducted by Ingrid Cook on 27 July 2018.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.

A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

0	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (http://www.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Office of Environment and Heritage's Aboriginal Heritage Information Unit upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Office of Environment and Heritage and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date .Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

Appendix G **CLAUSE 228 CHECKLIST**

A checklist of factors that should be considered in the assessment of impacts prior to its determination is included within Clause 228 of the *Environmental Planning and Assessment Regulation 2000*. This clause identifies sixteen issues that need to be addressed. The following text provides summary details of each of the issues, the majority of which have been addressed within the body of this document.

Factor
a. **Any environmental impact on a community?** During construction, there will be impacts to the community with regard to access, use of public spaces, dust, noise and visual impact.
b. **Any transformation of a locality?** The proposal will not transform the locality in the long term, provided the tunnelling is successful and does not result in the loss of large trees within the proposal area.
c. **Any environmental impact on the ecosystems of the locality?** No significant impacts are likely.
d. **Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality?** During construction, the proposal will diminish the recreational value of the proposal area. Provided the tunnelling is successful and does not result in the loss of large trees within the proposal area, no significant impacts are predicated.
e. **Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations?** No significant impacts are likely.
f. **Any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)?** No significant impacts are likely.
g. **Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air?** No significant impacts are likely.
h. **Any long-term effects on the environment?** No significant impacts are likely.
i. **Any degradation of the quality of the environment?** No significant impacts are likely.
j. **Any risk to the safety of the environment?** No significant impacts are likely.
k. **Any reduction in the range of beneficial uses of the environment?** No significant impacts are likely.
l. **Any pollution of the environment?** Provided careful management of waste streams and acid sulphate soils is undertaken during construction, no significant impacts are likely.
m. **Any environmental problems associated with the disposal of waste?** Provided careful management of waste streams and acid sulphate soils is undertaken during construction, no significant impacts are likely.

Factor
n. **Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply?** No significant impacts are likely.
o. **Any cumulative environmental effect with other existing or likely future activities?** The area is subject to a range of construction and development activity, with which this proposal will constitute a cumulative impact. However, the
p. **Any impact on coastal processes and coastal hazards, including those under projected climate change conditions?** No significant impacts are likely.