Australian Government

NSW GOVERNMENT

sydney METRO

Sydney Metro –
Western Sydney Airport

Technical Paper 7
Groundwater

Sydney Metro

Sydney Metro - Western Sydney Airport

Technical Paper 7: Groundwater

SMGW-ARP-AEC-GE-REP-0002447

Issue | October 2020

Job number 265549

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Executive Summary

Sydney Metro – Western Sydney Airport (the project) would be located within the Penrith and Liverpool Local Government Areas (LGAs) and would involve the construction and operation of a new metro railway line around 23 kilometres in length between the T1 Western Line at St Marys in the north and the Western Sydney Aerotropolis in the south. This would include a section of the alignment which passes through and provides access to Western Sydney International. The project is planned to be constructed in parallel with the airport and commence operations in 2026.

The project is characterised into components that are located outside the future Western Sydney International (Nancy-Bird Walton) Airport (hereafter referred to as Western Sydney International) (off-airport) and components that are located within Western Sydney International (on-airport), to align with their different planning approval pathways required under State and Commonwealth legislation.

This Technical Paper has been prepared to support the Environmental Impact Statement for the project. This Technical Paper provides an assessment of the potential impacts from the construction and operation of the project on the groundwater environment, and those receptors that may be reliant upon groundwater. The assessment has been undertaken with consideration to:

- the current groundwater environment; that is, prior to construction of the project,
- the potential interaction of the project with the groundwater environment, the nature of the potential impacts, and their magnitude,
- groundwater monitoring and environmental management measures that can be implemented to ensure potential impacts are adequately defined and managed.

The project has several elements that may interact with the groundwater environment. These elements include below-ground cuttings, station excavations, driven tunnels and permanent fill placement area. The elements which have the potential to cause the greatest change to the groundwater environment are those structures that are located below the water table.

A combination of 2D numerical modelling and analytical element modelling has been applied to estimate groundwater inflows and changes to the groundwater level due to construction and operation of the project. Other impacts and risks to the groundwater environment are viewed qualitatively based on the conceptual understanding of the hydrogeological environment. The availability of groundwater monitoring data in the study area is variable and as a result assumptions and approaches used in the assessment tend towards being conservative. Geotechnical investigations are being undertaken to provide additional hydrogeological data and which would allow validation of the assessment assumptions and results as the data becomes available.

The project is in an area of western Sydney that is underlain by residual and alluvial soils, and Bringelly Shale bedrock, which all generally possess low hydraulic conductivity. Groundwater movement in such materials is slow and the yield from wells constructed in these units is low. Additionally, groundwater has limited beneficial use in the region due to its high salinity. These conditions generally preclude the use of, or reliance on groundwater in the study area, decreasing the general risk of having significant impact on the groundwater environment. However, the results of the assessment indicate that changes to groundwater levels may occur:

1. During construction at St Marys, Orchard Hills Station, Western Sydney International, Bringelly Services Facility and Aerotropolis Core Station due to the presence of drained (un-tanked) excavations
2. During operation at all other below ground infrastructure as a result of undrained (tanked) structures, likely resulting in minor changes to groundwater level

Construction

During construction, groundwater drawdown would occur at locations with drained (un-tanked) excavations. These excavations would allow groundwater ingress to occur which would result in a lowering of the groundwater levels in the adjacent soils and bedrock. Drained (un-tanked) excavations are located at St Marys Station, at the cutting south of Orchard Hills Station, Western Sydney International tunnel portal, Airport Terminal Station, Bringelly Services Facility and at Aerotropolis Core Station.

St Marys Station

Predicted drawdown (lowering of water levels) at St Marys is predicted to extend to around 340m from the excavation for the period of construction (assumed to be two years). The drawdown is not anticipated to extend to any groundwater dependent ecosystems or supply wells.

Orchard Hills Station

At Orchard Hills Station, groundwater levels within the shale are approximately five to six metres below ground level and a maximum drawdown of about five metres is predicted at the face of the deepest part of the rail cutting. Away from the cutting and the station, to the east, the maximum predicted drawdown (within the proposed construction footprint) is about 2.5 metres. The furthest extent of the one metre drawdown contour is to the north east of the station, at around 440 metres from the cutting.

Groundwater drawdown is predicted to occur beneath an area of potentially groundwater dependent native vegetation (shale gravel transition forest) to the east of Orchards Hill. Predicted drawdown below these vegetation communities is predicted to be less than two metres. Groundwater at this location within the Bringelly Shale is at a depth of approximately five to six metres below ground level with a measured salinity of around 14,500 mg/l). Potential impacts on native vegetation is discussed in Technical Paper 3 (Biodiversity Development Assessment Report). No supply wells are anticipated to be affected by the groundwater drawdown.

Western Sydney International

Groundwater drawdown associated with construction of the tunnel portal and Airport Terminal Station is predicted to extend to between 270 and 290m from the excavations over the period of construction. The drawdown is not anticipated to extend to any groundwater dependent ecosystems or supply wells.

Bringelly Services Facility

Groundwater drawdown associated with construction of the Bringelly services facility is predicted to extend to approximately 315m from the excavations over a two-year construction period. The drawdown extends to below some areas of Cumberland Shale Plain Woodland (a groundwater dependent ecosystem) in the surrounding area. No supply wells are anticipated to be affected by the groundwater drawdown.

Aerotropolis Core Station

Groundwater drawdown associated with construction of the Aerotropolis Core Station is predicted to extend to approximately 270m from the excavations the period of construction. The drawdown is not anticipated to extend to any groundwater dependent ecosystems or supply wells.

Operation

During operation, all stations, tunnels and shafts are designed as undrained (tanked) structures such that groundwater ingress would be limited. Water levels at those locations which were drained (un-tanked) during construction would recover during the operational phase. Furthermore, these undrained (tanked) structures would present a barrier to the natural groundwater flow, since the shale and residual soils would have been removed and replaced with a largely impermeable barrier. This would lead to an increase in groundwater levels upgradient of any structure and a lowering downgradient. Long term changes in water level are anticipated to be relatively small and within the range of seasonal and long-term groundwater fluctuation. The extent of changes to groundwater level are expected to be localised around the structures.

Other considerations

Cumulative long-term groundwater inflow rates for the project are predicted to be around 24kL/d which is low: this is due to the low permeability of the deposits and because many of the below ground structures are designed as undrained (tanked) structures. Inflows may be greater than this during wetter periods or during the initial period as groundwater levels surrounding the project stabilise. Cumulative maximum predicted construction inflows are higher at 660 kL/d, although they would probably be much lower than this figure, because it assumes that maximum inflow rates occur at the same time at all locations during construction.

Due to the limited beneficial use of the groundwater in the area, and the low permeability cover, potential impacts to groundwater quality are unlikely. The main risks include accidental spills and releases of chemicals or fuels used during construction and operation and infiltration of contaminated surface water. Risk areas of potentially existing contaminated groundwater have also been highlighted in Technical Paper 11 (Contamination). These are principally located around the St Marys, Claremont Meadows services facility and the Aerotropolis Core Station areas.

Groundwater captured in excavations for stations, shafts, cuts and tunnels would need to be managed by collection and separation of the groundwater and pumping to water quality treatment plants. All groundwater would need to be treated to the appropriate environmental standard prior to discharge.

Mitigation

Performance outcomes relating to groundwater include the requirement for groundwater availability and quality for water supply and environmental benefit not to be affected beyond the requirements described in the NSW Aquifer Interference Policy.

A detailed project geotechnical investigation and groundwater monitoring exercise would be carried out to supplement the existing baseline groundwater monitoring data that forms the basis of the assessment in this Technical Paper. This includes ongoing groundwater level monitoring and groundwater sampling of existing wells.

Mitigation measures include the development of detailed geological and hydrogeological models for the project during future design development phases, as additional geological and hydrogeological information is obtained. These would be used to refine predicted groundwater level changes at groundwater dependent ecosystems or other sensitive groundwater receptors.

Where changes to groundwater levels are predicted at locations where groundwater dependent ecosystems or other sensitive groundwater receivers are present, an appropriate groundwater monitoring program would be developed and implemented during construction as part of the Groundwater Management Plan. Trigger levels for monitoring changes in groundwater levels would be developed for monitoring during construction in order to manage potential groundwater impacts. The monitoring program would aim to confirm no adverse impacts on the receiver during construction, or to effectively manage any impacts with the implementation of appropriate corrective actions.

Construction groundwater monitoring across the project would be in accordance with the Construction Environmental Management Framework (Appendix F of the Environmental Impact Statement).

Risks associated with impacts to groundwater quality during construction would be managed through the implementation of construction environmental management plans. The management plans would also be developed in accordance with the Construction Environmental Management Framework and would include requirements for appropriate handling of fuels and chemicals, surface drainage to manage clean and dirty water and water treatment to minimise the risks from infiltration to groundwater.

During operation, ongoing groundwater inflows from drained project elements (or incidental flows) would be treated and tested before discharge to comply with any relevant Environmental Protection Licence or agreed discharge criteria.

Abbreviations and units

Term/acronym	Meaning
AEPR	Airport (Environment Protection) Regulations
AIP	Aquifer Interference Policy 2012
ANZECC	Australia and New Zealand Guidelines for Fresh and Marine Water Quality
ADWG	Australian Drinking Water Guidelines
BoM	Bureau of Meteorology
CSSI	Critical State Significant Infrastructure
CEMF	Construction Environmental Management Framework
CEMP	Construction and Environmental Management Plan
DPIE	Department of Planning, Industry and Environment
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Environmental Protection and Biodiversity Conservation Act, 1999
GDE	Groundwater dependent ecosystem
LTAAEL	Long-term average annual extraction limit
kL/d	Kilolitres (thousand litres) per day
mm	Millimetre
m	metres
mAHD	Metres Australian Height Datum of land in metres above mean sea level
mbgl	Metres below ground level
mg/l	Milligrams per litre
ML/yr	Megalitres (million litres) per year
MPa	Megapascals
m/s	Metres per second
NWQMS	National Water Quality Management Strategy
SEARs	Secretary's Environmental Assessment Requirements
SMWSA	Sydney Metro – Western Sydney Airport (the project)
SM	Sydney Metro
TBM	Tunnel boring machine
TDS	Total Dissolved Solids
TfNSW	Transport for New South Wales
WAL	Water access licence
WM Act	NSW Water Management 2000
VWP	Vibrating Wire Piezometer
WSP	Water Sharing Plan
ºC	Degrees Celsius
µS/cm	Micro siemens per centimetre

Glossary

Term/acronym	Meaning
Anisotropy	Relationship between hydraulic conductivity of a material in different directions
Alluvium	Material deposited by the action of surface water typically within river channels, comprising unconsolidated gravels, sands, clays and silts.
Aquifer	A groundwater bearing unit which is capable of transmitting and yielding groundwater (normally in the context of providing adequate volumes for water supply)
Bedrock	Lithified units that underlie soil units
Borehole	A hole sunk into the ground using drilling techniques either for investigating the geology or for installation of devices to monitor or extract groundwater.
Catchment	The area that is drained by a stream, lake or other body
Cross passages	A short tunnel that is constructed, normally at regular intervals, between two parallel tunnels which may house equipment, sumps and pumps or act as refuge points
Drained structure	Drained (un-tanked) structures are those in which groundwater can enter the structure to lower the groundwater levels adjacent to the structure.
Drawdown	A reduction in piezometric head (water level) within a material
Groundwater	Water present within soils or rocks below the ground surface
Ground improvement	Techniques that are used to improve the stability or strength of the ground, or to reduce its permeability to reduce groundwater inflows during construction.
Grouting	The injection of a cement or resin-based fluid into pore spaces or defects within the ground. Once cured the grout may improve the strength of the ground, or reduce its permeability to groundwater
Hydraulic Conductivity	The constant of proportionality relating groundwater flow rate under a unit hydraulic gradient in through a unit area of aquifer measured perpendicular to flow direction (Darcy's Law). It is a measure of a materials capacity to transmit water
Hydrogeology	The study of groundwater
Fracture	Discontinuities within rocks caused by stresses within the earth
Hydraulic gradient	The vector gradient between two or more head (or water level) measurements
Infiltration	The downward movement of water into soil and rock
Pore water pressure	The groundwater pressure held within a soil or rock
Recharge	The process of addition of water into the saturated part of an aquifer typically through infiltration of water though the unsaturated zone via vertical movement
Residual soil	Soils that are derived from the in-situ weathering of bedrock
Runoff	The proportion of rainfall that ends up as surface water stream flow (as opposed to infiltrating into the ground)

Term/acronym	Meaning
Salinity	The total soluble mineral salt content of water or soil. Concentrations of salt in water are measured in mg/l and in soil mg/kg.
Specific storage	The volume of water released from confined aquifer storage per unit area per unit decline in hydraulic head.
Specific yield	The volume of water which is released from an unconfined aquifer per unit area per unit decline in head, because of gravity drainage of the material
Standpipe	A hole sunk into the ground and completed with a slotted pipe and backfill with the specific purpose of monitoring groundwater levels or taking water samples
Surface water	Water that is derived from precipitation and which is present at the surface in creeks, rivers, lakes or dams
Topography	The arrangement and distribution of physical features of an area
Transmissivity	The rate of flow under a unit hydraulic gradient through a unit width of aquifer of a given saturated thickness
Undrained structure	Undrained (tanked) structures are those in which groundwater is stopped from entering them either by cut-off or waterproofing thereby limiting groundwater drawdown in the aquifer surrounding the structure.
Water level	A point measurement of the piezometric surface or water table within a material relative to a datum.
Water supply work	A device for taking water which may be groundwater wells, dams, weirs, irrigation channels, banks and levees. Groundwater works are typically supply wells that are sunk into the ground for extracting groundwater.
Water table	The surface in an unconfined aquifer where the porewater pressure is equal to zero. It defines where material below is fully saturated and material above is partially or fully unsaturated.
Water quality	Chemical, physical and biological characteristics of water
Vibrating wire piezometer	A pressure measuring device that in the context of groundwater is normally installed within a hole sunk into the ground to measure the porewater pressure at a defined level.

1 Introduction

1.1 Project context and overview

The Greater Sydney Region Plan (Greater Sydney Commission, 2018a) sets the vision and strategy for Greater Sydney to become a global metropolis of three unique and connected cities; the Eastern Harbour City, the Central River City and the Western Parkland City. The Western Parkland City incorporates the future Western Sydney International (Nancy-Bird Walton) Airport (hereafter referred to as Western Sydney International) and Western Sydney Aerotropolis (hereafter referred to as the Aerotropolis).

Sydney Metro Western (the project) (see Figure 1) is identified in the Greater Sydney Region Plan as a key element to delivering an integrated transport system for the Western Parkland City. The project would be located within the Penrith and Liverpool Local Government Areas (LGAs) and would involve the construction and operation of a new metro railway line around 23 kilometres in length between the T1 Western Line at St Marys in the north and the Aerotropolis in the south. This would include a section of the alignment which passes through and provides access to Western Sydney International.

The project is characterised into components that are located outside Western Sydney International (off-airport) and components that are located within Western Sydney International (on-airport), to align with their different planning approval pathways required under State and Commonwealth legislation.

1.2 Key project features

- Key operational features of the project are shown on Figure 2 and would include:
  - around 4.3 kilometres of twin rail tunnels (generally located side by side) between St Marys (the northern extent of the project) and Orchard Hills
  - a cut-and-cover tunnel around 350 metres long (including tunnel portal), transitioning to an in-cutting rail alignment south of the M4 Western Motorway at Orchard Hills
  - around 10 kilometres of rail alignment between Orchard Hills and Western Sydney International, consisting of a combination of viaduct and surface rail alignment
  - around two kilometres of surface rail alignment within Western Sydney International
  - around 3.3 kilometres of twin rail tunnels (including tunnel portal) within Western Sydney International
  - around three kilometres of twin rail tunnels between Western Sydney International and the Aerotropolis Core
  - six new metro stations:
    - four off-airport stations:
      - St Marys (providing interchange with the T1 Western Line)

        - Orchard Hills
        - Luddenham Road
        - Aerotropolis Core
    - two on-airport stations:
        - Airport Business Park
        - Airport Terminal
- grade separation of the track alignment at key locations including:
    - where the alignment interfaces with existing infrastructure such as the Great Western Highway, M4 Western Motorway, Lansdowne Road, Patons Lane, Warragamba to Prospect Water Supply pipelines, Luddenham Road, the future M12 Motorway, Elizabeth Drive, Derwent Road and Badgerys Creek Road
    - crossings of Blaxland Creek, Cosgroves Creek, Badgerys Creek and other small waterways to provide flood immunity for the project
- modifications to the existing Sydney Trains station and rail infrastructure at St Marys (where required) to support interchange and customer transfer between the new metro station and the T1 Western Line
- a stabling and maintenance facility and operational control centre located to the south of Blaxland Creek and east of the proposed metro track
- new pedestrian, cycle, park-and-ride and kiss-and-ride facilities, public transport interchange infrastructure, road infrastructure and landscaping as part of the station precincts.

The project would also include:

- turnback track arrangements (turnbacks) at St Marys and Aerotropolis Core to allow trains to turn back and run in the opposite direction
- additional track stubs to the east of St Marys Station and south of the Aerotropolis Core Station to allow for potential future extension of the line to the north and south respectively without impacting future metro operations
- an integrated tunnel ventilation system including services facilities at Claremont Meadows and at Bringelly
- all operational systems and infrastructure such as crossovers, rail sidings, signalling, communications, overhead wiring, power supply, lighting, fencing, security and access tracks/paths
- retaining walls at required locations along the alignment
- environmental protection measures such as noise barriers (if required), on-site water detention, water quality treatment basins and other drainage works.

Off-airport project components

The off-airport components of the project would include the track alignment and associated operational systems and infrastructure north and south of Western

Sydney International, four metro stations, the stabling and maintenance facility, two service facilities and a tunnel portal.

On-airport project components

The on-airport components of the project would include the track alignment and associated operational systems and infrastructure within Western Sydney International, two metro stations and a tunnel portal.

The key project features and the design development process are described in more detail in Chapter 7 (project description – operation) of the Environmental Impact Statement.

1.3 Project construction

Construction of the project would involve the following key stages:

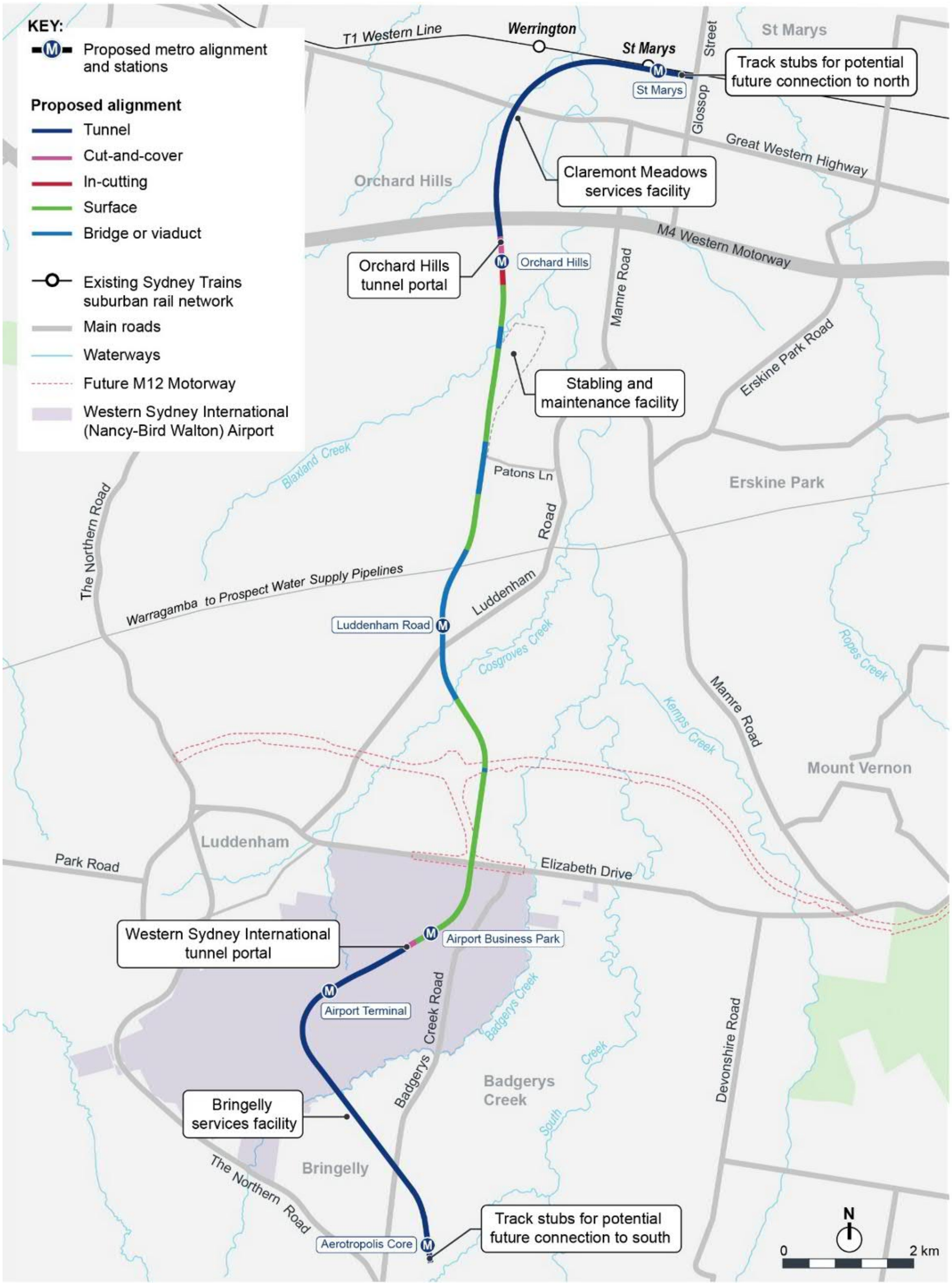
- enabling works
- main construction works, including:
  - tunnelling and associated works
  - corridor and associated works
  - stations and associated works
  - ancillary facilities and associated works
  - construction of ancillary infrastructure including the stabling and maintenance facility
- rail systems fitout
- finishing works and testing and commissioning.

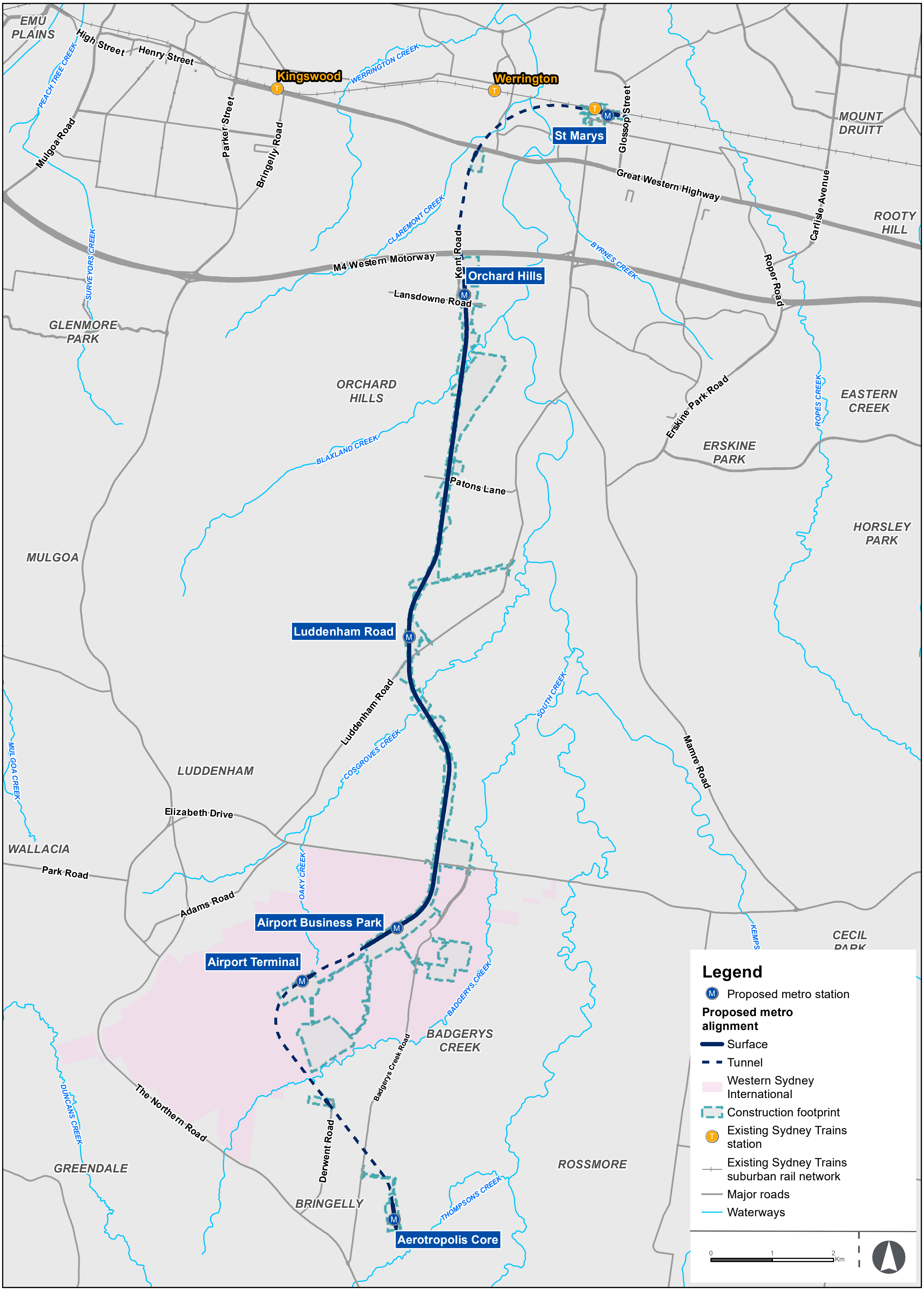
These activities are described in more detail in Chapter 8 (project description – construction) of the Environmental Impact Statement.

The construction footprint for the project is shown on Figure 2.

Construction of the project is expected to commence in 2021, subject to planning approval, and take around five years to complete. An overview of the construction program is provided in Chapter 8 (project description – construction) of the Environmental Impact Statement.

Figure 1: Project alignment and key features





Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Construction footprint overview

Figure 2

1.4 Purpose of this Technical Paper

This technical Paper, Technical Paper 12 Groundwater, is one of a number of technical documents that forms part of the Environmental Impact Statement. The purpose of this technical Paper is to assess the potential impacts to groundwater from construction and operation of the project, and when required, identify feasible and reasonable mitigation measures.

This technical Paper describes the current state of understanding of the hydrogeological environment, acknowledging that detailed hydrogeological investigations have recently been completed with ongoing monitoring to supplement the existing dataset. This technical Paper presents the anticipated changes to the hydrogeological environment resulting from construction and operation of the project and assessment of the impact of the changes in groundwater level (pressure) and quality on potential receptors.

The Technical Paper responds directly to the assessment requirements outlined in Section 1.4.1

1.4.1 Assessment Requirements

The Secretary's environmental assessment requirements relating to groundwater, and where these requirements are addressed in this Technical Paper, are outlined in Table 1. These requirements were issued by the NSW Department of Planning, Industry and Environment (DPIE) to support the Critical State Significant Infrastructure application.

Table 1: Hydrogeological related project SEARS

Secretary's requirement	Where addressed in Technical Paper
11 Water – Hydrology	
1. Surface and groundwater resources (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Section 4.2
2. Surface and groundwater hydrology in accordance with the current guidelines, including:	
(b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	Section 5.2, 5.3, Section 6.2, 6.3
(c) changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	Section 6.6
(f) water take (direct or passive) from all sources with estimates of annual volumes during construction	Section 5.4, Section 6.4
12 Water - Quality	
(i) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Section 3.4, Section 8
13 Soils and contamination	

Secretary's requirement	Where addressed in Technical Paper
3. Determine the presence, extent and severity of soil salinity within the project area and the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Section 4.2, Section 6.2

The Commonwealth Minister for the Environment has advised that the on-Airport aspects of the project would be assessed based on the provision of preliminary documentation. Further information was requested to guide the assessment of the on-Airport aspects of the project. This information is included in Appendix J of the Environmental Impact Statement.

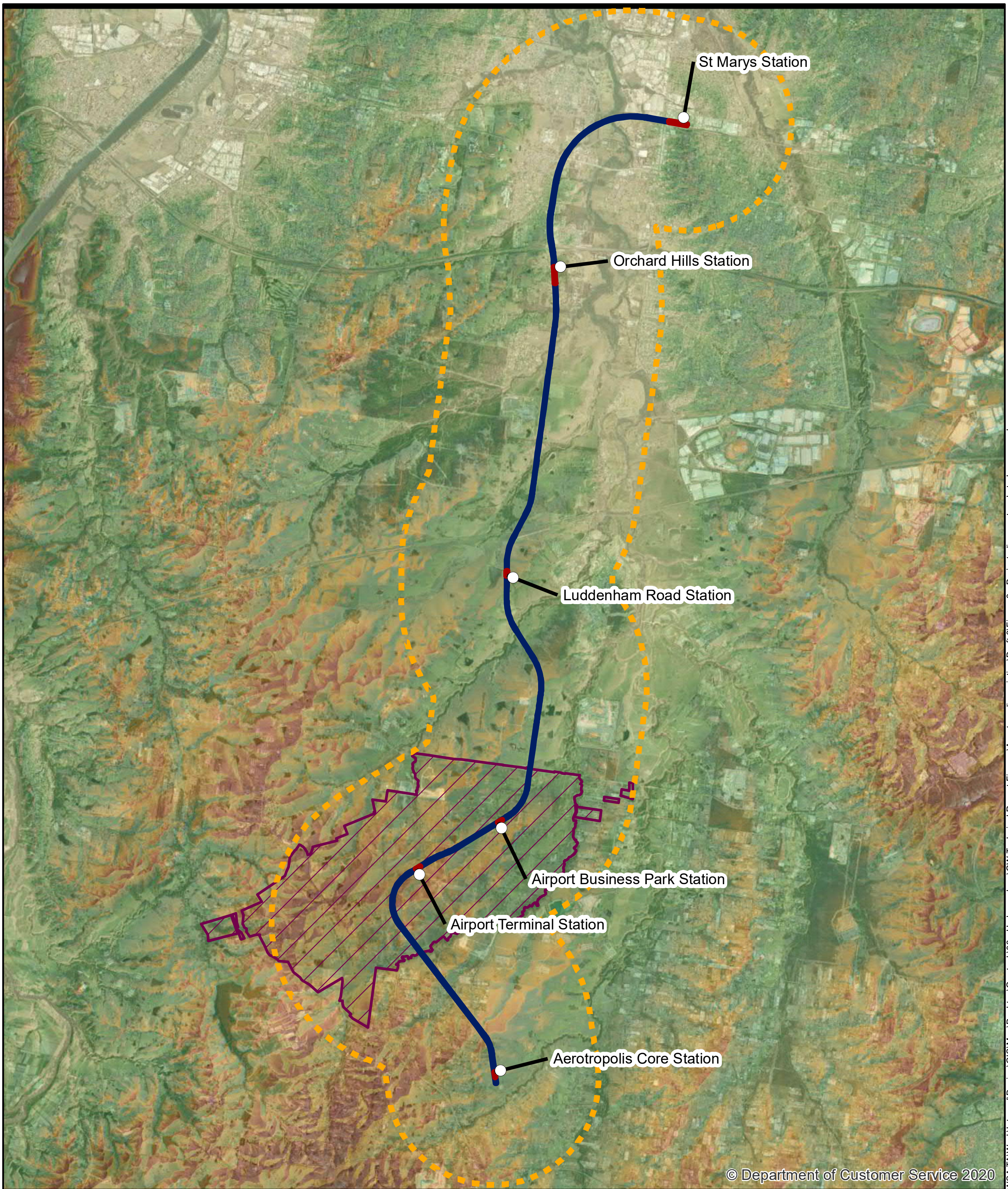
1.4.2 Structure of the Technical Paper

The Technical Paper is structured into the following sections:

- section 1 presents the introductory information
- section 2 presents the legislative and policy context in relation to groundwater
- section 3 presents the assessment methodology
- section 4 presents the baseline environmental assessment
- section 5 presents the potential impacts for the construction phase
- section 6 presents the potential impacts for the operation phase
- section 7 presents the potential cumulative impacts of the project
- section 8 presents the proposed management and mitigation approach
- section 9 presents the conclusions of the assessment.

1.5 Study area

The study area for the groundwater assessment refers to a broader region surrounding the project alignment. The study area encompasses a 2 km area around the project alignment. A 2 km search area was chosen as a conservative distance from the project covering a much broader area than the likely zone of impact and is shown in Figure 3.



Legend

- Study area
- Stations
- Project Alignment
- Western Sydney International

Topography

mAHD

High : 250

Low : 0

Client

Sydney Metro

Job Title

Sydney Metro – Western Sydney Airport

Figure Title

Project study area and topography

Metres

0 1,000 2,000 3,000 4,000

D1	29/04/2020	CJ	JL	JL
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Scale at A4	Figure Status
1:100,000	**Issue**

Coordinate System

GDA 1994 MGA Zone 56

Job No	Figure No
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\\global.arup.com\australasia\SYD\Projects\265000\265549-00 SMWSA TA\Work\Internal\Design\GIS\Map\Desktop\Geotech\03 - Hydrogeology\GW Technical Report Figures\Aerotropolis variation\Draft 3\Figure 3 - Project alignment and study area.mxd

2 Legislative and policy context

2.1 Introduction

This section presents relevant regulation, legislation and policy governing management of groundwater as it relates to the project.

2.2 Commonwealth legislation and policy

2.2.1 Environmental Protection and Biodiversity Conservation Act, 1999

The Environmental Protection and Biodiversity Conservation Act, 1999 (EPBC) is commonwealth environmental legislation dealing with matters of national environmental significance. Actions that have or are likely to have a significant impact on a matter of national environmental significance, require approval from the Australian Government Minister for the Environment. Of nine matters of National Significance outlined within the EPBC Act, the following are generally of more relevance to groundwater:

- listed threatened species and ecological communities
- wetlands of international importance (listed under the Ramsar Convention)
- a water resource, in relation to coal seam gas development and large coal mining development.

2.2.2 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) aims to provide a nationally coordinated framework to facilitate water quality management for the productive and sustainable use of Australia's waters. The NWQMS provides national guideline documents and policy which relate to the protection of surface water and groundwater resources for local implementation.

The main document for groundwater under the NWQMS is the Guidelines for Groundwater Protection in Australia which sets out a risk-based approach to protecting or improving groundwater quality. The Environmental Value of groundwater (which replaced Beneficial Use in previous documents) is used to define values or uses of the water resource based on established water quality criteria for each value as outlined in the Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) and the Australian Drinking Water Guidelines (ADWG). Environmental Values outlined in the guidance include:

- aquatic ecosystems (those which are to some degree dependent on groundwater to maintain the ecosystem health, i.e. groundwater dependent ecosystems)
- primary industry (irrigation and general water uses, stock drinking water, aquaculture and human consumers of aquatic foods)

- recreation and aesthetics
- drinking water
- industrial water
- cultural and spiritual values.

Guideline water quality criteria for the environmental values of aquatic ecosystems, primary industry, recreation and aesthetics and drinking water set out in the ANZECC and ARMCANZ (2000) guideline documents and are used in this Technical Paper as comparison vales for available groundwater quality data.

2.2.3 Airports (Environmental Protection) Regulations 1997

The Airports Environmental Protection Regulations provide regulation and accountability for activities at airports that generate or have a potential to generate pollution. This regulatory framework applies to the management of all on-ground environmental issues, including air, soil, water, noise and chemical pollution on-airport.

2.2.4 Western Sydney Airport Plan, 2016

The Western Sydney Airport Plan is a transitional planning instrument that has been implemented to guide development on the site until a masterplan is put in place and to authorise the first stage of airport development subject to conditions. The Airport Plan was determined by the Commonwealth Infrastructure Minister in December 2016 following preparation and exhibition of an Environmental Impact Statement, and incorporates the conditions specified by the Commonwealth Environment Minister. Those conditions include the requirement for preparation and approval of a Construction Plan and several Construction Environment Management Plans prior to commencement of main construction works.

2.3 State legislation and policy

2.3.1 NSW Water Management Act 2000

The NSW *Water Management Act 2000* (WM Act) is administered by the NSW Department of Primary Industries (DPI). The WM Act is intended to ensure the sustainable and integrated management of water resources so that they are conserved and properly managed for both present and future generations. The WM Act is intended as the primary means to protect and enhance environmental qualities of river and groundwater systems and associated wetlands, floodplains and estuaries as well as providing protection of catchment conditions.

In accordance with Section 5.23 (1) of the EP&A Act, the following authorisations are not required for approved State Significant Infrastructure Projects:

- a water use approval under Section 89 of the WM Act
- a water management work approval under Section 90 of the WM Act

- an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act.

2.3.2 NSW Water Sharing Plans

Water sharing plans (WSP) are the main tool in the Water Management Act 2000 to allocate and provide water for the environmental health of rivers and groundwater systems, while also providing licence holders access to water. Water sharing plans define the rules for how water is allocated and have been developed under the WM Act for all water sources in NSW. The aims of the water sharing plans are to:

- clarify the rights of the environment, basic landholders, town water suppliers and other licensed users
- define the long-term average annual extraction limit (LTAAEL) for water sources
- set rules to manage the impacts of extractions
- facilitate the trading of water between users.

2.3.2.1 Groundwater

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2015 (NSW, 2015) covers 13 groundwater sources in eastern NSW. The project lies within the Sydney Central Basin Groundwater Source, which is classified in the Plan as a porous rock groundwater source.

Table 2 identifies the licensed water extraction for the Sydney Central Basin Groundwater Source at the date of commencement of the WSP (July 2011). The long-term annual average annual extraction limit for the water source is also presented in the table which is the estimated stainable extraction limit for the water source. Groundwater use for the Sydney Central Basin Groundwater Source is well within the sustainable limits of groundwater availability.

Table 2: GMR groundwater source extraction entitlement and limit

Groundwater Source	Licensed quantity at commencement of WSP (ML/unit share/yr)	Licensed quantity 2019 (ML/yr)	long-term average annual extraction limit (ML/yr)
Sydney Basin Central	2,592	3,429	45,915

The WSP also sets out several rules in relation to water supply works approvals and for water take from the groundwater resource. These include distance restrictions for new water supply works to minimise interference and environmental impact.

2.3.2.2 Surface Water

For surface water, the project is located within the area covered by the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources

2018 (NSW, 2018). The project is located entirely within the Hawkesbury and Lower Nepean Rivers extraction management unit of the WSP.

The Project alignment and study area are located within two management zones, the Upper South Creek Management Zone and the Lower South Creek Management Zone. The boundary between the two management zones is located at the north of the alignment, south of St Marys and runs along the watershed between Claremont Creek and Blaxland Creek. The South Creek Management zone is described as having a high economic dependence on extraction for irrigation and town and/or industrial water supplies.

2.3.3 Aquifer Interference Policy 2012

The purpose of the Aquifer Interference Policy (*DPI, 2012*) is to clarify the role and requirements of the Minister in charge of administering the WM Act in the water licensing and assessment processes for aquifer interference activities in NSW. The policy applies to all aquifer interference activity but has been developed to address a range of high-risk activity such as large infrastructure developments that require dewatering or ongoing drainage into excavations. An aquifer interference approval is generally required for any works that involve:

- the penetration of an aquifer
- the interference with water in an aquifer
- the obstruction of flow of water in an aquifer
- the taking of water from an aquifer during carrying out mining or any other activity prescribed by the regulations
- the disposal of water from an aquifer.

The Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and groundwater dependent ecosystems (GDEs), be assessed against minimal impact considerations outlined in the policy. Minimal impact considerations depend on the productivity of the groundwater source (the Sydney Basin Central Groundwater Source is declared to be a “less productive Groundwater Source”). If the predicted impacts are less than the Level 1 minimal impact considerations, then the impacts are deemed to be acceptable. In addition to the above considerations the impact assessment must consider the potential for:

- acidity issues to arise, for example exposure off acid sulfate soils
- water logging or water table rise to occur, which could potentially affect land use, GDEs and other aquifer interference activities.

Due to the presence of below ground excavation and construction, the Project would be an aquifer interference activity and this Policy has been used to evaluate the potential impacts on the groundwater environment.

2.3.4 NSW Groundwater Policy Framework Document, 1997

The groundwater policy framework document is used to provide ecologically sustainable management guidance about groundwater resources, so they can sustain environmental, social and economic uses for the people of NSW. The policy is divided into three components:

NSW Groundwater Quantity Management Policy

This policy is designed to maintain and protect groundwater within sustainable limits and to ensure groundwater extraction is managed to prevent unacceptable local impacts

NSW Groundwater Quality Protection Policy

This policy is designed to maintain and protect groundwater quality with the aims of slowing, halting or reversing any degradation in the quality of groundwater resources add to minimise risks to the groundwater environment from potentially polluting activities.

NSW Groundwater Dependent Ecosystems Policy

This policy is designed to protect valuable ecosystems that rely on groundwater to survive, maintain the biophysical functions and preserve these ecosystems for the resources of future generations. Furthermore, the policy provides practical guidelines that can be used as tools to suit a specific need based on a given groundwater dependant ecosystem or environment.

2.3.5 NSW Water Extraction Monitoring Policy 2007

The objective of the Water Extraction Monitoring Policy is to increase the extent of active monitoring of water extraction with a future aim of having 90 per cent of the total volume of water in each water sharing plan being subject to active monitoring. This policy sets out the rules and guidelines for holders of groundwater extraction licenses.

2.3.6 NSW Water Quality and River Flow Objectives

The NSW Water Quality and River Flow Objectives have been set out for fresh and estuarine surface waters to identify the community's values and uses of these surface waters and the water quality indicators to assess the current condition of the waterways. These water quality and flow objectives are consistent with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.

2.3.7 Risk Assessment Guidelines for Groundwater Dependent Ecosystems 2012

The risk assessment guidelines are used to manage land and water use activities that pose a potential threat to groundwater dependant ecosystems. The guidelines consist of four volumes that include the conceptual framework, worked examples, identification of high potential groundwater dependant ecosystems and their ecological value for coastal aquifers, and the risk of groundwater extraction on the coastal plains of NSW.

3 Methodology

3.1 Overview

The groundwater impact assessment was undertaken using the following staged approach:

- a review of the proposed project was undertaken to identify the key features which might interact directly or indirectly with groundwater, in terms of quantity (groundwater flows and levels) or quality
- desktop characterisation of the existing environment including climate, geology, groundwater occurrence, existing users, GDEs and other environmental factors
- assessment of available hydrogeological ground investigation including some field investigations for the project
- production of groundwater conceptual models
- establishment of impact assessment criteria based on the legislative requirements,
- assessment of groundwater impacts using qualitative, analytical and numerical approaches
- assessment of the potential impacts against the minimal impact requirements of the Aquifer Interference Policy
- recommendations for groundwater monitoring and management of impacts through mitigation measures as necessary.

Each of the methodology sections are detailed further below.

3.2 Key project design elements

The project comprises several elements which have the potential to affect the hydrogeological environment. A review of the proposed project and construction methodologies was undertaken to evaluate those areas which are most likely to have an impact on groundwater, and those which are less likely to. Table 3 gives a summary of the construction of each and the groundwater management approach in each case. Project elements are subject to ongoing design development. Figure 4 shows the location of the major project components. Further information on the proposed structures is presented in Chapter 8 (project description – construction) of the Environmental Impact Statement.

Table 3: Project design elements

Element	Typology	Groundwater management approach [1]
Rail tunnels		
Rail tunnels	St Marys to Orchard Hills	Undrained [2]
	Western Sydney International to Aerotropolis Core Station	Undrained [2]
Cross passages and sumps	Mined tunnel	Undrained [2]
Portal structures		
Orchard Hills tunnel portal	Cut and cover	Undrained [3]
Western Sydney International tunnel portal [4]	Cut and cover	Undrained [2]
Stations		
St Marys Station	Cut and Cover station	Undrained [2]
Orchard Hills Station	In cutting station	Undrained [3]
Luddenham Road Station	Viaduct station	N/a
Airport Business Park Station [4]	At grade station	N/a
Airport Terminal Station [4]	Cut and cover station	Undrained [2]
Aerotropolis Core Station	Cut and cover station	Undrained [2]
Services facilities		
Claremont Meadows services facility	Cut and cover	Undrained [3]
Bringelly services facility	Cut and cover	Undrained [2]
Cuttings		
Orchard Hills Dive	Cutting	Drained
Minor cuts between Luddenham Road Station and Airport Business Park Station	Cutting	Drained
Surface and viaduct sections		
Viaducts	Piled foundations and buried concrete pier footing	N/a
Embankments	-	N/a
Permanent spoil placement area [4]	-	N/a
Stabling and Maintenance Facility	-	N/a

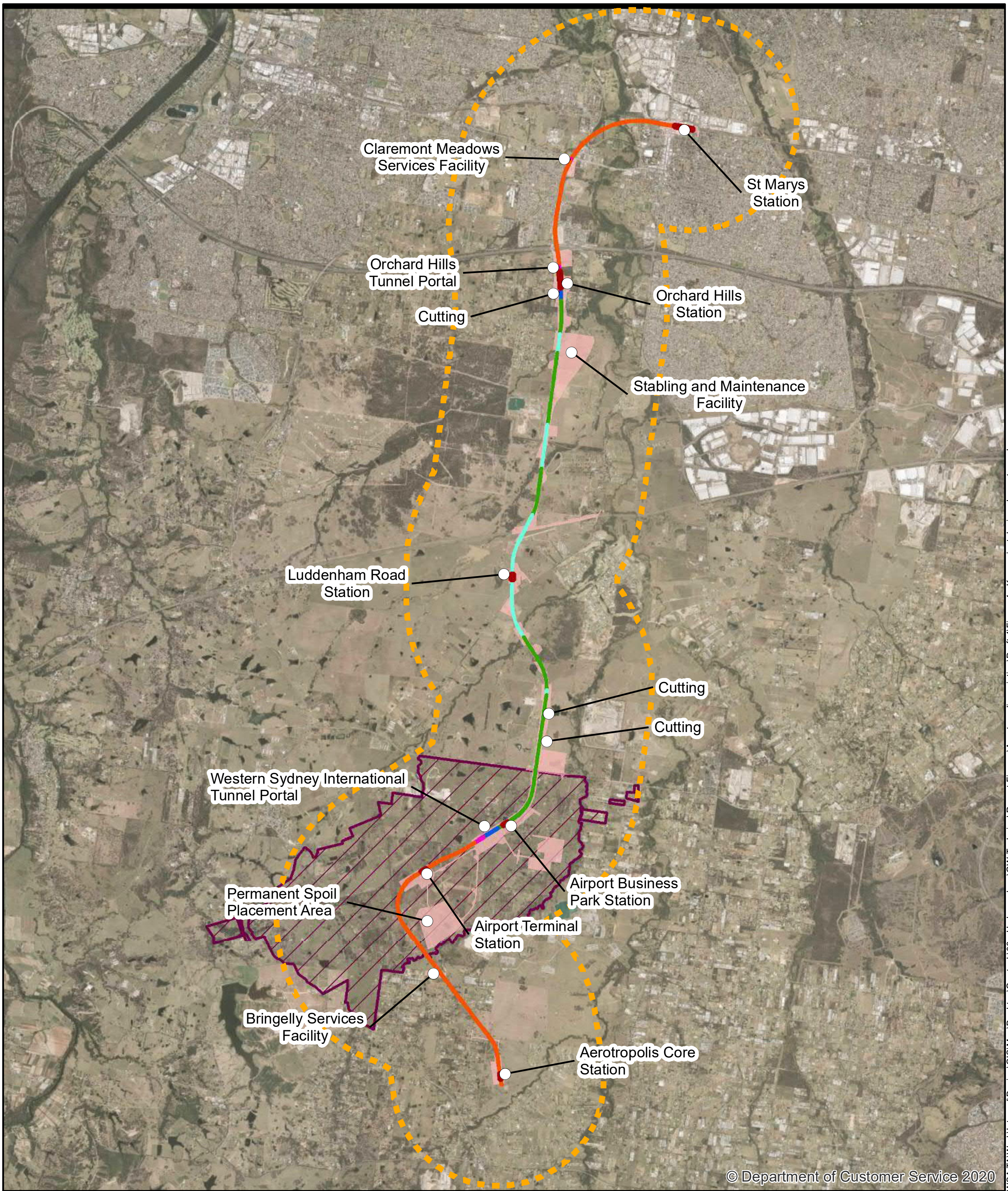
Notes

[1] Drained (un-tanked) structures, as distinct from undrained (tanked) structures, are those in which groundwater can enter the tunnel, station box or cutting in order to lower the groundwater pressure acting on the structure.

[2] Undrained (tanked) in permanent case, drained (un-tanked) temporarily during construction.

[3] Temporary retaining walls are designed to act as a full cut-off however some groundwater ingress may still occur through the excavation base

[4] Western Sydney International



Legend

- Study area
- Stations
- EIS_Construction_footprint
- Western Sydney International

Project element

- At grade
- Bridge or viaduct
- Cut and cover
- TBM tunnel
- Cutting

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Key project design elements

Metres
0 1,000 2,000 3,000 4,000

D1	20/08/2020	CJ	JL	JL
Issue	Date	By	Chkd	Appd

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Scale at A4	Figure Status
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Coordinate System
GDA 1994 MGA Zone 56

Job No	Figure No
265549-00	**004**

\\global.arup.com\australasia\SYD\Projects\265000\265549-00 SMWSA TA\Work\Internal\Design\GIS\Map\Desktop\Geotech\03 - Hydrogeology\GW Technical Report Figures\Aerotropolis variation\Draft 4\Figure 4 - Key project design elements.mxd

3.2.1 Rail tunnels

Rail tunnels would be constructed as part of the project between Orchard Hills Station and St Marys Station in the north, and between Western Sydney International tunnel portal and Aerotropolis Core Station in the south. These tunnels would be excavated using tunnel boring machines (TBMs) which form tunnels which are circular in section, supported using pre-cast concrete segmental lining installed by the TBM as the tunnel is excavated. The TBM tunnels would be twin tunnels constructed using individual TBMs.

Cross passages, which link the twin rail tunnels at regular intervals (for refuge, equipment and drainage) would be constructed using standard mined tunnel approaches (road headers/rock breakers). Cross passages are constructed at right angles to the main tunnels and after the main tunnels are constructed, by breaking though the segmental linings.

3.2.2 Portal structures

Proposed tunnel portal structures would be located at Orchard Hills and Western Sydney International. These structures would be constructed using a cut and cover methodology and act as the launch location for the TBM machines during construction.

3.2.3 Stations

All underground stations are currently proposed to be constructed using a cut and cover approach. Temporary retaining walls would be constructed to support the excavation sides within which the permanent station structure would be built.

3.2.4 Services facilities

Services facilities would be constructed Claremont Meadows, at the junction of Gipps Street and Great Western Highway in the north of the project and at Bringelly, near Derwent Road in the south. The services facilities provide emergency access/egress and ventilation to the tunnel sections.

3.2.5 Embankments

Fill embankments would be constructed at various locations along the alignment to maintain the grade of the rail alignment. The major areas of fill associated with the alignment are surface sections between Orchard Hills Station and Airport Business Park.

3.2.6 Cuttings

There are several areas of cut (battered slopes or retained walls) along the alignment which would be drained (un-tanked) during both construction and operation. These are:

- directly south of Orchard Hills Station, which is approximately 250 metres long. The cutting would be within drained (un-tanked) retaining walls to a depth of about 10 metres below ground level
- two shallow cuts are located between Luddenham Road Station and Western Sydney International. These cuts are approximately 100 metres and 340 metres long, with maximum cut depths of between one and four metres below ground level respectively.

Planned earthworks being undertaken at Western Sydney International mean that parts of the alignment which are currently at surface may subsequently be within a cutting once the airport is operational, as the ground level is changed at the site.

3.2.7 Viaducts

Several viaduct bridges are planned along the alignment at major road and infrastructure and creek crossings. Luddenham Road Station would be constructed as a viaduct station. Foundations for piers and abutments comprise cast in situ concrete footings supported by piled foundations. The shallow buried footings may variably extend below the groundwater surface however the piles will extend into the Bringelly Shale and are likely to be below groundwater level at most locations.

3.2.8 Permanent spoil placement area

Excavated material from below-ground stations and tunnel excavation during construction would be transported and stored in permanent spoil placement area at Western Sydney International. Additional information on these spoil stockpiles is presented in the Environmental Impact Statement Chapter 8 – project description – construction.

3.3 Assessment methodology

This groundwater assessment has considered the potential groundwater impacts within the project study area (see Figure 5). The assessment considered key hydrogeological attributes and features of the environment within the study area in order develop conceptual models of the baseline hydrogeological environment. The key features included:

- climate, rainfall and groundwater recharge
- hydrological setting (creeks, lakes, wetlands)
- regional and local geological setting including consideration of principal geological units (bedrock and soils), and structural features
- hydrogeological properties of the relevant geological units
- distribution of groundwater within hydrogeological units and groundwater levels together with response to climate/rainfall variation
- groundwater quality including condition of the groundwater system with respect to beneficial uses of the groundwater

- location of GDEs within the study area
- location of groundwater users (supply wells)
- potential for acid sulfate soil and soil salinity within the study area
- sensitivity of the system to changes (in one or more component element).

Several data sources were used in the desktop assessment. These include publicly available data sources and literature information, design documentation prepared as part of the feasibility design, geotechnical and hydrogeological reports prepared specifically for the project and hydrogeological information obtained by Sydney Metro from other projects in the study area. A list of the principal sources of information and data is given in Table 4.

Table 4: Sources of information

Type	Information	Source
Publicly available information	5m DEM Topographic survey information	Geoscience Australia, 2015
	Climate data	Bureau of Meteorology, Commonwealth of Australia
	National groundwater borehole database	
	Groundwater Dependent Ecosystem Atlas	
	Water NSW real time groundwater monitoring network	WaterNSW, 2019
	Australia-wide acid sulfate soil risk map	CSIRO, 2013, Australian Soil Resource Information System.
	NSW statewide acid sulfate soil risk map	Department of Land and Water Conservation (DLWC), 1998. Acid sulfate Soils Risk Map Series, Sydney
	Soil salinity mapping	Department of Infrastructure, Planning and Natural Resources (DoIPNR), 2002. Salinity potential in Western Sydney
	Hydrogeological landscapes of Western Sydney	Office of Environment and Heritage NSW, 2011
	Soil landscapes information	Bannerman S.M. and Hazelton P.A., 1990, Soil Landscapes of the Penrith 1: 100,000 Sheet Map and Report
	Geological mapping	Geological Survey of NSW, 1991, Geology of the Penrith 1: 100,000 Sheet 9030
	Aerial imagery, 50cm standard coverage imagery and high resolution urban and project imagery	NSW Best of Imagery Cache, 2017, Department of Finance, Services and Innovation Spatial Services NSW.
	Hydrological datasets	NSW Hydro Area Dataset, 2012, NSW Spatial Data Catalogue
	NSW Wetland dataset	Office of Environment and Heritage NSW, 2016

Type	Information	Source
	Groundwater recharge	Sydney basin bioregion assessment, 2018, Australian Government
Project reports	SMGW Geotechnical desk study	SMGW-ARP-SWD-GE-REP-000001
	SMGW Scoping design report	SMGW-ARP-SWD-RC-REP-000351
	SMGW Geotechnical Interpretative Report	SMGW-ARP-SWD-GE-REP-000237
	SMGW Ground Movement Report	SMGW-ARP-SWD-GE-REP-000239
	SMGW Advanced GI factual reports	19122621-004-R-Rev0-GWMR1 (Golder 2019 groundwater monitoring report) 19122621-003-R-RevA (Golder, 2019 Factual contamination report – preliminary site investigation)
Other data and reports	Hydrogeological monitoring data from Western Sydney International	Various, prepared and issued by Western Sydney International for period 2017 to 2019
	Groundwater technical report for Western Sydney International Stage 1 Environmental Impact Statement	GHD, 2015
	Groundwater quality and hydrology assessment report for M12 Environmental Impact Statement	TfNSW, 2019
	Historical geotechnical and environmental investigation reports	Various (full list presented in SMGW-ARP-SWD-GE-REP-000001)

3.4 Hydrogeological investigations

3.4.1 SMGW geotechnical investigations

A preliminary phase of geotechnical investigations was undertaken at key locations as part of the definition design development process, which included hydrogeological testing and monitoring. The locations and details of the investigations along the alignment are provided in Table 5. These investigations were undertaken between May and July 2019.

A larger second phase of geotechnical investigations is currently ongoing at the time of writing this paper. The scope include drilling geotechnical boreholes across the alignment with hydrogeological monitoring and testing at a number of the locations (Table 5).

Table 5: Summary of project geotechnical investigations with groundwater information

Borehole	Location	Ground Elevation (mAHD)	Total depth (mbgl)	Permeability testing	Groundwater installation	Standpipe install depth (mbgl)	GW Quality sampling
SMGW-BH-A001	St Marys	34.4	60	Packer test	VWP x4	8, 18, 26, 31	N
SMGW-BH-A002	St Marys	36.2	50	Packer test, slug test	Standpipe	22 – 28	Y
SMGW-BH-A003	St Marys	35.3	80	Packer test	-	-	-
SMGW-BH-A004	St Marys	36.8	50	Packer test	-	-	-
SMGW-BH-A011	South Creek	20.1	53	Packer test	VWP x4	5.5, 10.5, 23.5, 30	N
SMGW-BH-A011S	South Creek	20.0	5	Slug test	Standpipe	2 – 5	Y
SMGW-BH-A012	Werrington	29.5	56	Packer test, slug test	Standpipe	25 – 34	Y
SMGW-BH-A017	Orchard Hills	43.6	33	Packer test, slug test	Standpipe	15 – 24	Y
SMGW-BH-A018	Gipps Street	21.8	59	Packer test	-	-	-
SMGW-BH-A019	Gipps Street	42.2	53	Packer test, slug test	Standpipe	28 – 34	Y
SMGW-BH-C001S	Badgerys Creek	67.0	9	Slug test	Standpipe	2 – 4	Y
SMGW-BH-C002	Badgerys Creek	66.8	45	Packer test, slug test	Standpipe	6 - 15	Y
SMGW-BH-A100	St Marys	47.4	50	Packer test	-	-	-
SMGW-BH-A101	St Mary	46.4	50	Packer test	-	-	-
SMGW-BH-A102	St Mary	36.8	41	Packer test, slug test	Standpipe	3 – 8	Y
SMGW-BH-A103	St Mary	30.6	39	Packer test, slug test	Standpipe	15 – 24	Y
SMGW-BH-A104	St Mary	24.5	38	Packer test	-	-	-
SMGW-BH-A105	South Creek	22.6	42	Packer test, slug test	Standpipe	15 – 28	Y
SMGW-BH-A105S	South Creek	22.6	9	Slug test	Standpipe	2 – 8	Y
SMGW-BH-A106	South Creek	22.5	43	Packer test	-	-	-

Borehole	Location	Ground Elevation (mAHD)	Total depth (mbgl)	Permeability testing	Groundwater installation	Standpipe install depth (mbgl)	GW Quality sampling
SMGW-BH-A107	South Werrington	22.5	41	Packer test, slug test	Standpipe	19 – 26	Y
SMGW-BH-A107S	South Werrington	22.4	6	Slug test	Standpipe	3 – 5	Y
SMGW-BH-A108	South Werrington	24.1	41	Packer test	-	-	-
SMGW-BH-A109	Claremont Meadows Services Facility	27.4	42	Packer test, slug test	Standpipe	16 – 25	Y
SMGW-BH-A109S	Claremont Meadows Services Facility	27.4	6	Slug test	Standpipe	3.5 – 5.0	Y
SMGW-BH-A110	Claremont Meadows	32.0	46	Packer test	-	-	-
SMGW-BH-A111	Gipps Street	41.7	54	Packer test, slug test	Standpipe	29 – 38	Y
SMGW-BH-A113	M4 motorway	43.4	43	Packer test, slug test	Standpipe	20 – 29	Y
SMGW-BH-A115	Orchard Hills	40.4	45	Packer test	VWP x3	7, 18, 21	N
SMGW-BH-A117	Orchard Hills	38.9	24	Packer test, slug test	Standpipe	10 – 16	Y
SMGW-BH-A117S	Orchard Hills	38.8	5	Slug test	Standpipe	2 – 4	Y
SMGW-BH-A121	Gipps Street	38.6	53	Packer test, slug test	Standpipe	15 – 21	Y
SMGW-BH-A122	Gipps Street	41.4	50	Packer test, slug test	Standpipe	25 – 35	Y
SMGW-BH-A123	Kent Street	49.0	53	Packer test, slug test	Standpipe	30 – 39	Y
SMGW-BH-A124	Kent Street	51.8	56	Packer test	-	-	-
SMGW-BH-B106	Orchard Hills Station to Luddenham Road Station	39.4	25	Packer test, slug test	Standpipe	1 – 4	Y
SMGW-BH-B109	Orchard Hills Station to Luddenham Road Station	41.5	30	Slug test	Standpipe	4 – 13	Y
SMGW-BH-B120	Luddenham Road Station	52.6	30	Slug test	Standpipe	5 – 14	Y
SMGW-BH-B121	Luddenham Road Station	56.6	30	Slug test	Standpipe	2 – 3	Y
SMGW-BH-B122	Luddenham Road Station	59.0	30	Packer test	VWP x2	4, 20	N

Borehole	Location	Ground Elevation (mAHD)	Total depth (mbgl)	Permeability testing	Groundwater installation	Standpipe install depth (mbgl)	GW Quality sampling
SMGW-BH-B123	Luddenham Road Station	57.2	30	Slug test	Standpipe	5 – 14	Y
SMGW-BH-B130	Elizabeth Drive	60.3	28	Packer test, slug test	Standpipe	5 – 14	Y
SMGW-BH-C107	Western Sydney International Terminal Station	74.0	32	Packer test	-	-	-
SMGW-BH-C111	Badgerys Creek	65.8	33	Packer test	VWP x3	6.4, 13.9, 21.9	N
SMGW-BH-D103	Bringelly Services Facility	74.7	50	Packer test	VWP x3	10, 25, 40	N
SMGW-BH-D107	Aerotropolis Core Station	74.9	44	Packer test	-	-	-
SMGW-BH-D109	Aerotropolis Core Station	72.6	41	Packer test, slug test	Standpipe	11 – 20	Y
SMGW-BH-D109S	Aerotropolis Core Station	72.4	10	Slug test	Standpipe	6 – 9	Y

Notes

Sydney Metro concept design geotechnical investigations were ongoing during the preparation of this Technical Paper. Groundwater data available in groundwater monitoring reports prior to May-20 have been incorporated into this Technical Paper.

The combined geotechnical investigations undertaken for the project comprised:

- 52 boreholes with core drilling and sampling to depths ranging from 5 to 80 metres below ground level
- 48 borehole locations in total with groundwater testing, installation or sampling
- 219 in situ packer permeability tests at 36 locations
- downhole imaging
- lithological sampling and laboratory testing
- construction of groundwater monitoring standpipes at 30 locations and installation of multi-level vibrating wire piezometers (VWP) at six locations
- installation of downhole transducers and dataloggers to provide continuous groundwater level monitoring
- slug testing at standpipe locations to evaluate hydraulic conductivity
- groundwater sampling and laboratory testing to evaluate groundwater quality.

At many groundwater monitoring locations only a short period of data was available at the time of writing the Environmental Impact Statement. However, groundwater level and quality monitoring of these standpipes and piezometers is ongoing and will provide longer term groundwater quality and level information for the project. Additional geotechnical investigations for the southern areas of the project are also currently being undertaken and will provide additional ongoing monitoring data for future assessment and design development.

These datasets have been used in conjunction with other available larger datasets to supplement and inform the assessment. The availability of groundwater monitoring data in the study area is variable and as a result assumptions and approaches used in the assessment tend towards being conservative. The ongoing geotechnical investigations would provide additional hydrogeological data to allow ongoing validation of the assessment assumptions and results.

3.4.2 Other investigation data

In addition to the advance geotechnical investigation, groundwater monitoring data from within the study area was obtained from other historic geotechnical investigations.

The quantity of monitoring locations and amount of data varies significantly across the study area. Western Sydney International has the most comprehensive dataset (number of locations and length of monitoring period) due to historic and ongoing monitoring being undertaken at the site. Almost all other groundwater monitoring locations are limited to a single groundwater level or groundwater quality data (i.e. no long-term monitoring).

Table 6 provides a summary of the total number of locations of available groundwater data within the study area (including the project investigations available at the time of writing). Appendix A1 provides a full list of groundwater monitoring locations with available data used as part of the assessment. Appendix A2 presents figures showing the locations of the boreholes within the study area.

Table 6: Summary of available groundwater locations within study area during preparation of Environmental Impact Statement

Station	Groundwater level [1]	Groundwater quality [2]	Hydraulic conductivity testing
St Marys Station	12	20	35 packer tests 15 variable head tests
St Marys Station to Orchard Hills Station	22	18	119 packer tests 31 variable head tests
Orchard Hills Station	6	7	12 packer tests 8 variable head tests
Orchard Hills Station to Western Sydney International	15	14	10 packer tests 9 variable head tests
Western Sydney International	91	85	38 packer tests 23 variable head tests
Western Sydney International to Aerotropolis Core Station	12	12	17 packer tests 1 variable head test

Note

[1] Number of locations, not measurements

[2] Groundwater quality refers to any sample with some groundwater quality information (basic or comprehensive)

3.5 Impact assessment criteria

Groundwater has a variety of functions which include:

- a water resource for drinking, agricultural and industrial uses
- environmental supply to ecosystems, either as baseflow to existing waterways and associated vegetation or through deep rooted terrestrial vegetation
- a transport mechanism for contamination
- a support load within compressible soils.

Changes to groundwater level and quality may impact on the function and overall value of the groundwater. Comparison of the potential impacts require assessment criteria to compare against to evaluate the significance of the impact.

For this assessment, the impacts to the groundwater environment were assessed against the Aquifer Interference Policy minimal impact considerations which are outlined in Section 2.3. The minimal impact criteria in the Aquifer Interference Policy define acceptable levels of change for groundwater level (or pressure) and quality.

Additionally, the impacts of the project on the groundwater environment were assessed against the project SEARs and other requirements including the distance-based requirements and availability of the groundwater resource, as set out in the WSP legislation.

3.6 Impact assessment methodology

3.6.1 Overview

Assessment of the potential impacts on the groundwater environment was undertaken through a process of qualitative and quantitative assessment. Impact pathways that are associated with risks are linked to changes in groundwater level and quality. Examples of potential impacts may include:

- lowering of groundwater levels that may reduce the availability of groundwater (quantity). This may impact on groundwater user or environmental receptors such as GDEs or wetlands
- lowering of groundwater levels that may lead to drawdown settlement due to consolidation of compressible soils with impacts on buried or surface structures
- increases in groundwater level that may lead to increased water at shallow depths (waterlogging) or lead to increased salt loading and deterioration of soils or vegetation
- changes in groundwater level that may result in changes to natural chemistry of the groundwater (from exposure of acid sulfate material or changes to salinity)
- changes to groundwater quality from spillage of hazardous materials or because of migration of existing contamination caused by changes to groundwater levels.

All excavation works and permanent underground structures have the potential to affect groundwater level, flow or quality where they extend below the groundwater surface. The potential effect differs depending whether the element is drained (un-tanked) or undrained (tanked). The ways in which groundwater level and flow might be affected by each type of project element are summarised in Table 7.

Table 7: Summary of potential changes to groundwater levels and flow due to project elements

Structure type	Potential changes
Drained (un-tanked) rail cuttings/stations	Drained (un-tanked) structures, as distinct from undrained (tanked) structures, are those in which groundwater can enter the tunnel, station box or cutting in order to lower the groundwater pore pressure in the ground adjacent to the structure. Lowering of groundwater levels adjacent to the structures, potentially extending for some distance, depending on the hydraulic properties of the aquifer, the depth of drainage, how long the drainage continues for and the recharge regime.
Undrained (tanked) stations/ tunnel portal structures/ tunnels/shafts	Undrained (tanked) structures have the potential to affect groundwater levels through the damming effect of the introduction of an impermeable object into saturated, permeable ground. The effect is likely to be a rise in groundwater levels up-gradient of the structure and lowered levels down-gradient. Groundwater flow paths are altered as the water is diverted around the structure. The changes in water level are due to the extra head required for the water to move around the structure. These changes in water level at a particular location as a result of the introduction below the water table of an undrained (tanked) , impermeable structure are determined by the hydraulic properties of the aquifer, the size and depth of the undrained (tanked) structure and its orientation in relation to the baseline groundwater flow direction.
Viaduct abutment and pier foundations	During construction, local excavation of the footing is required. Where the groundwater table is high, some groundwater management may be required in order to keep the excavation dry. This may lead to localised depression of groundwater levels in the surrounding soils where groundwater pumping is undertaken. The permanent structures have the potential to act as a local barrier to groundwater flow which may lead to minor changes in groundwater up and down gradient of the structure. However, these structures are typically small enough compared to the aquifer extent to have a negligible impact on groundwater level or flow.
Fill embankments and stockpiles	Fill embankments comprising of compacted engineered fill can locally reduce recharge to the aquifer, leading to a local reduction in groundwater levels. Where adequate drainage is not provided, runoff may be channelled from the embankment leading to waterlogging, erosion and leaching.

Changes to groundwater quality can result from construction activities which extend below the groundwater table, directly interacting with the groundwater and changing the quality. Other construction and operational activities have the potential to affect groundwater quality indirectly: for example, through spillage of chemicals at the surface which then seep into the underlying groundwater.

3.6.2 Changes in groundwater level

Changes to groundwater level caused by the project may lead to impacts on the environment or on groundwater users within the study area. To evaluate the potential impacts, methods of predicting the extent and size of those changes in groundwater level is required. Two methods were used in the evaluation of potential changes to the groundwater levels for the project:

- Simplified 2D numerical modelling assessment was undertaken for temporarily drained (un-tanked) structures that are only drained (un-tanked) for the duration of construction.
- Analytical element modelling was undertaken at Orchard Hills to supplement the numerical modelling, in order to evaluate the potential for long term drawdown associated with the drained (un-tanked) cutting south of the station. Although Orchard Hills Station is undrained (tanked) during the operational stage of the project, the cutting to the south of the station would be drained (un-tanked).

Details of the assessment undertaken is summarised below and further details are provided in Appendix B.

Numerical modelling

2-D numerical groundwater modelling was undertaken to evaluate the potential groundwater seepage rates and drawdown during a 2-year construction period.

Simplified geological sections were produced for each of the following structures which are drained (un-tanked) during construction:

- St Marys Station
- Western International tunnel portal
- Airport Terminal Station
- Bringelly Services Facility
- Aerotropolis Station.

The 2D models were simplified with uniform thickness layers specific to each location based on geotechnical interpretation of the ground conditions along the alignment. Each of the layers were assigned hydraulic properties based on hydrogeological testing data available from within the study area and included average and high permeability scenarios.

The groundwater models were used to estimate groundwater inflow and changes to groundwater level by incorporating drainage boundaries into the model along the geometry of the excavations. The assessment was undertaken as a transient scenario to evaluate the potential construction seepage rates and amount of drawdown that might occur over a two-year construction period. The predicted inflow rates for each 2D model were multiplied by the total perimeter length of the excavation in order to estimate the total groundwater inflow rate.

A full summary of the modelling exercise methodology and uncertainty is presented in Appendix B1.

Analytical assessment

An analytical assessment was undertaken to evaluate the potential for long-term changes in groundwater levels at Orchard Hills due to the construction of the undrained (tanked) station, the portal structure and the drained (un-tanked) cutting south of the station. The assessment was undertaken using analytical element modelling software package AnAqSim which allows for the assessment of simple 3-D hydrogeological problems.

Due to the limited amount of groundwater level information in these areas, a full calibration exercise was not undertaken. Instead, the models were set up based on:

- assigning hydraulic parameters based on the available testing data within the entire study area, and where available, site-specific data
- assigning boundary conditions based on the location of creek lines
- adjusting recharge rates to achieve hydraulic gradients of between 1% and 2%, (based on gradients observed within the Western Sydney International groundwater catchment) and calibrating to the available water level monitoring points.

The simplified modelling approach and relatively short period data provide an indictive assessment of the potential changes in water level during construction and operation. Further development of the modelling would be undertaken during design development once additional groundwater investigation data is available. This will provide a broader understanding of the hydrogeological setting and refinement of the groundwater drawdown predictions.

Full details of the assessment methodology and model setup is presented in Appendix B2.

Given the limited groundwater information available at the time of the assessment, the assumptions made in relation to aquifer parameters and the behaviour of groundwater in the shale (and therefore the modelling results) are considered conservative. Validation and update of the assessment would be completed as part of further design development, once longer-term groundwater monitoring information is available and once additional investigation data is available at critical locations. Further geotechnical investigations for the project have commenced and monitoring data will be available to support further design development.

3.6.3 Groundwater inflows

Groundwater inflow rates for the project were estimated using the results of the analysis outlined in Section 3.6.2. For sections of the alignment where a modelling or analytical assessment was not undertaken (for instance the smaller cuts), inflows were estimated using the results of the numerical modelling factoring for differences in cut depth, length and inferred groundwater levels.

Construction inflows to the TBM tunnels were estimated using the Heuer-Goodman (2005) analytical approximation for flow to a tunnel. A nominal 10 metre length of twin TBM tunnel was assumed to be open to groundwater inflow at any one time. The average hydraulic conductivity data from packer testing was used ($6x10^{-7}$ metres per second) as well as at the location of the greatest head gradient into the tunnel, to evaluate the average groundwater inflow. To assess the maximum potential inflow, the highest observed hydraulic conductivity from packer testing data was used ($1x10^{-5}$ m/s). However, it is highly unlikely that this flow rate would be encountered across the full diameter or length of the tunnel since the upper bound hydraulic conductivity was only encountered in three of the packer tests undertaken for the project.

For undrained (tanked) infrastructure, groundwater inflow limits developed for previous Sydney Metro projects are given in Table 8. Maximum allowable inflow rates for undrained (tanked) infrastructure was estimated based on these rates and the surface area (base and sides) of the structures to estimate combined inflow rates to the project. These waterproofing requirements are set for permanent undrained (tanked) structures.

Table 8: Waterproofing criteria for undrained (tanked) structures set on Sydney Metro City and South West project

Undrained (tanked) structure
2.0 millilitres per hour per square metre of concrete lining surfaces
5.0 millilitres per hour per square metre of concrete lining surfaces for any 10-metre length of concrete lining

4 Existing environment

4.1 Overview

This section provides information relevant to the hydrogeological environment broadly across the entire study area (within 2km of the project). Information which is relevant to the general understanding of the hydrogeological environment is described in Section 4.2, information that is specific to off-airport parts of the study area is described in Section 4.3 and information that is specific to on-airport parts of the study area (within the Western Sydney International airport development boundary) is described in Section 4.4.

4.2 General information

4.2.1 Land use

The current land zoning within the study area is presented in Chapter 19 (Land use and property) of the Environmental Impact Statement. North of the alignment around St Marys, land use is predominantly intensive (land uses that involve high levels of interference with natural processes). The land uses include urban residential, services, transport and utilities and recreational parkland (NSW Planning). South of the M4 the land use becomes semi-rural with areas of native vegetation, grazing, irrigated cropping, intensive animal husbandry and rural farmland.

Key existing infrastructure within the study area includes (from north to south):

- T1 Western line
- Great Western Highway
- M4 motorway
- Warragamba to Prospect Water Supply Pipelines (the pipelines) connecting Warragamba and Prospect reservoirs
- Luddenham Road
- Elizabeth Drive
- Northern Road
- Badgerys Creek Road

The Western Parkland City and Western Economic Corridor would lead to significant development and changes in land use in the study area over the next 50 years. Key future infrastructure within the Western Sydney area in addition to this project include:

- Future M12 motorway connecting Western Sydney International, the M7 motorway and Northern Road

- stage 1 of Western Sydney International located between Elizabeth Drive and Badgerys Creek.

Further information on the land use within the project study area is provided in Chapter 19 (Land use and property) of the Environmental Impact Statement.

4.2.2 Topography

In general, the topography of the Western Sydney area is characterised by flat plains and gently rolling hills. The ground elevation gradually increases along the reference alignment from north to south, with the elevation around St Marys station in the north around 30 to 40 metres Australian Height Datum (AHD) and the elevation around the Aerotropolis station in the south about 70 to 90 metres AHD.

Approximately 7.5 kilometres to the west of the reference alignment, the elevation increases sharply up to around 200 metres AHD in the foothills of the Blue Mountains beyond the Nepean River (the Lapstone Monocline). Figure 3 shows the topographic setting of the study area and further details are provided in Table 9.

Table 9: Summary description of alignment topography

Alignment area	Description of topography
St. Marys	Flat or level to undulating terrain with an elevation between 30 and 40 metres AHD.
St. Marys to Western Sydney International	West of St Marys station the topography is relatively flat (elevation ~30 metres AHD) decreasing in elevation at South Creek. South of this area the topography is undulating with elevation ranging from 30 metres AHD to 80 metres AHD. Localised topographic lows are associated with Blaxland Creek and other tributaries of South Creek.
Western Sydney International	Around the two stations located on the Western Sydney International site the topography is characterised by gently rolling hills ranging in elevation from 60 to 80 metres AHD. A prominent ridgeline of elevation up to 110 metres AHD is located approximately 250 metres to the west of the alignment. This feature is located on the Western Sydney International site and is associated with the Luddenham Dyke.
Western Sydney International to Aerotropolis Core	The topography between Western Sydney International and the Aerotropolis is characterised by gently rolling hills. Elevation ranges from 70 to 90 metres AHD.

4.2.3 Climate

There are three weather stations within 15 kilometres of the project alignment. The two nearest stations are Badgerys Creek at the Western Sydney International and Orchard Hills towards the north of the alignment. The locations of these weather stations are shown in Figure 8.

Sydney has a humid subtropical climate with no distinct wet or dry season although there is a slight propensity for higher rainfall in Western Sydney in the summer months than in the winter (Bureau of Meteorology). Variation in rainfall averages between the three weather stations is shown on Figure 6. All three weather stations show similar patterns of monthly rainfall although on average Badgerys Creek receives approximately 100 millimetres per year less rainfall than Camden Airport and 150 millimetres per year less than Orchard Hills.

Western Sydney often experiences temperatures that are several degrees Celsius hotter compared to suburbs closer to the coast due to its greater distance from the cooling effects of the sea. The average maximum temperature at Badgerys Creek is 30.3 ºC in January and average minimum temperature of 4.1 ºC in July. Climatological averages for Badgerys Creek are presented in Figure 5 (BOM, 2019a).

Cumulative rainfall departure curves from monthly rainfall data at each of the three weather stations are presented in Figure 7. These curves plot the cumulative difference between the measured rainfall and long-term average rainfall and provide a long-term indication of periods of above or below average rainfall. These graphs typically correlate well with groundwater levels since periods of above average rainfall also reflect above average recharge to the aquifer.

Data from the three weather stations is generally well aligned. Periods of above average rainfall were observed between 1970 and 1978, and 1984 and 1990. A significant period of below average rainfall was observed between 1990 and 2006. Following this, the patterns at the rainfall gauges correlate less well; between 2006 and 2016, Badgerys Creek experienced a period of above average rainfall, Orchard Hills experienced a period of average rainfall, and Camden Airport was generally below average. Rainfall at all three weather stations over the last two years has been below average.

Pan evaporation rates are highest in summer and lowest in winter. Pan evaporation data from Sydney Airport (which is the nearest available from the bureau of meteorology, generally covering a large area) indicates that monthly average pan evaporation rates would exceed monthly rainfall. Due to the hotter climate of western Sydney, pan evaporation rates are likely to exceed those at Sydney Airport.

Figure 5: Climate data (Badgerys Creek) from period 1995 to 2019

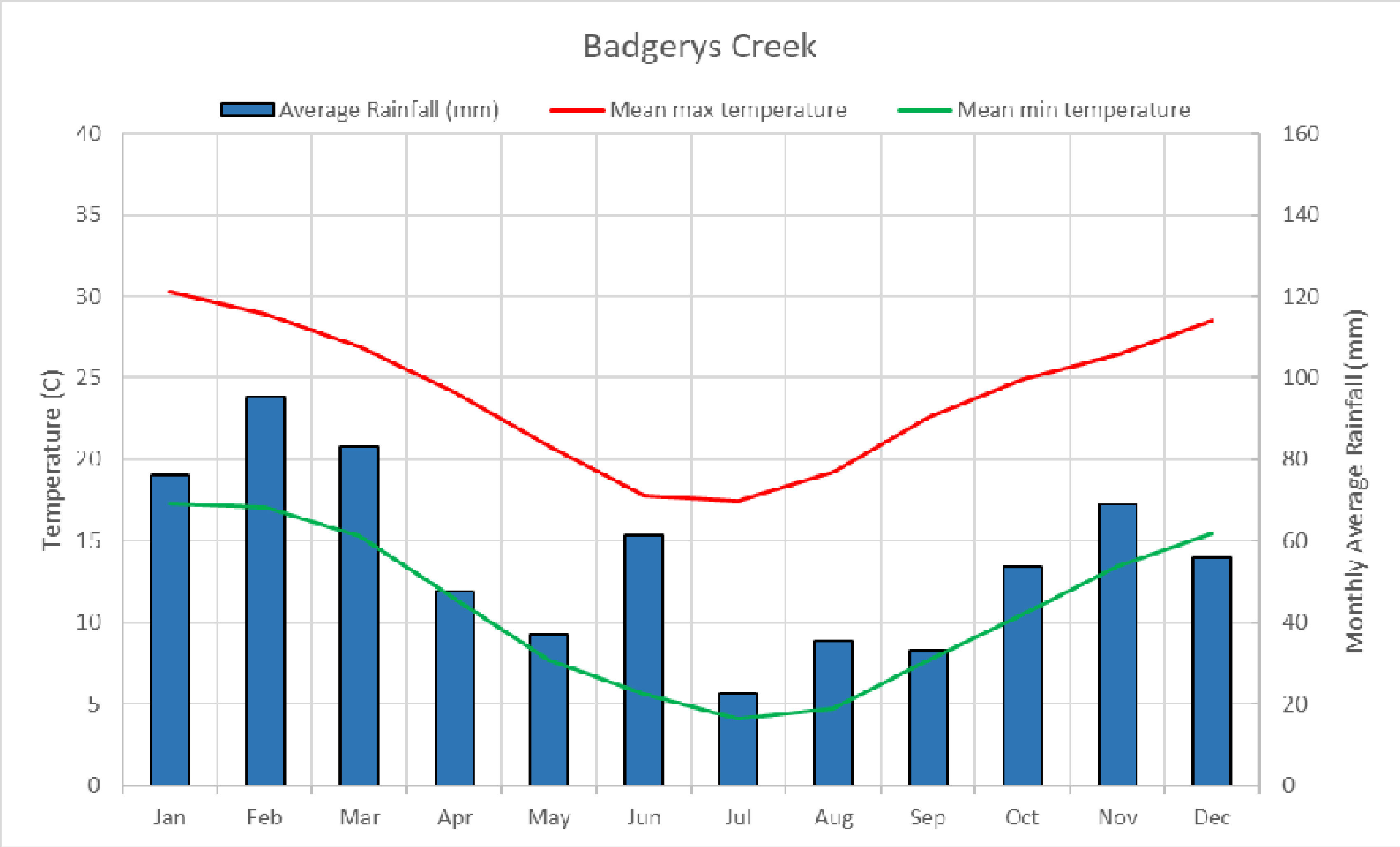


Figure 6: Average monthly rainfall variation between Badgerys Creek (1995 – 2019), Orchard Hills (1970 – 2019) and Camden Airport (1943 – 2019)

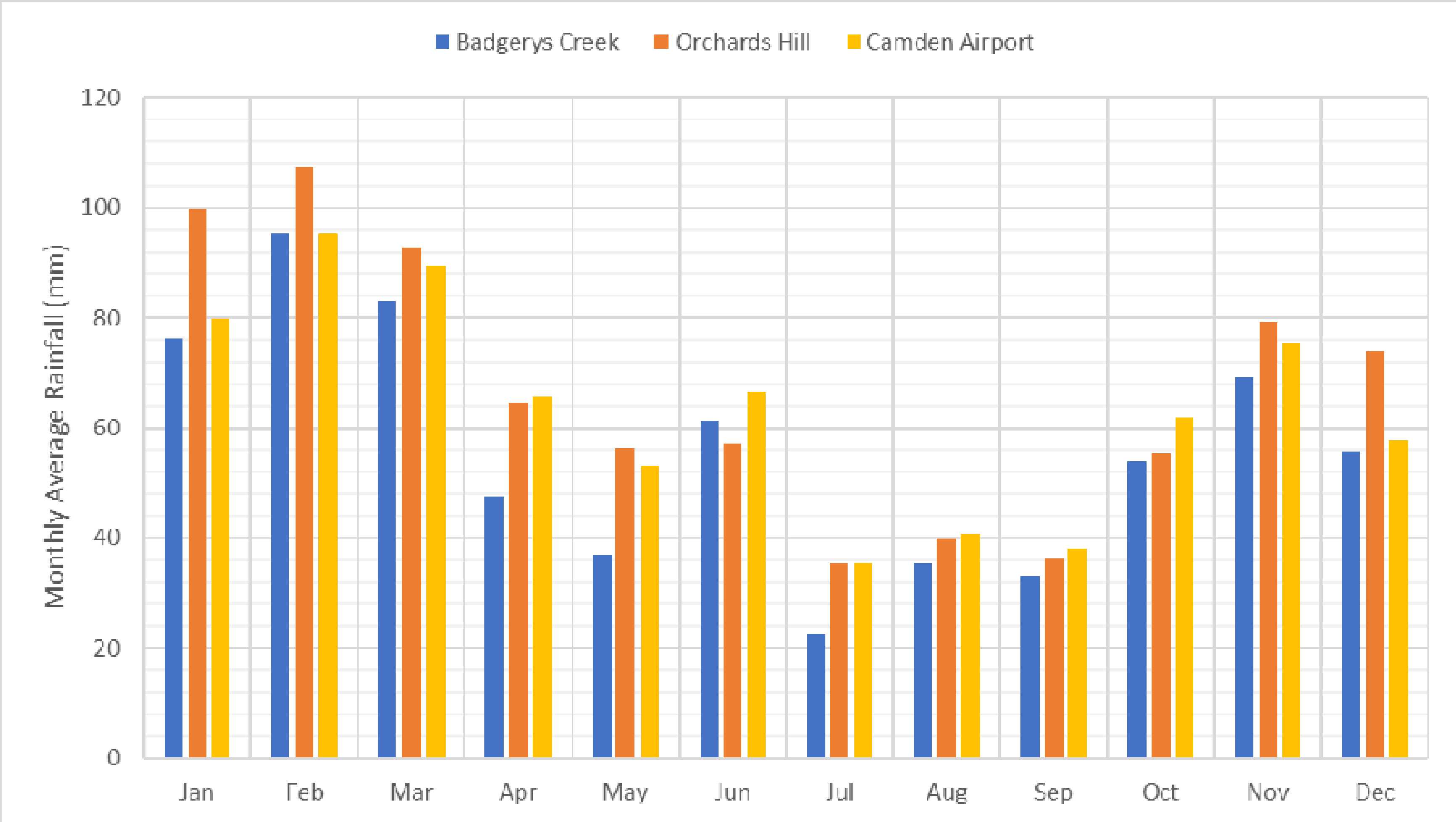
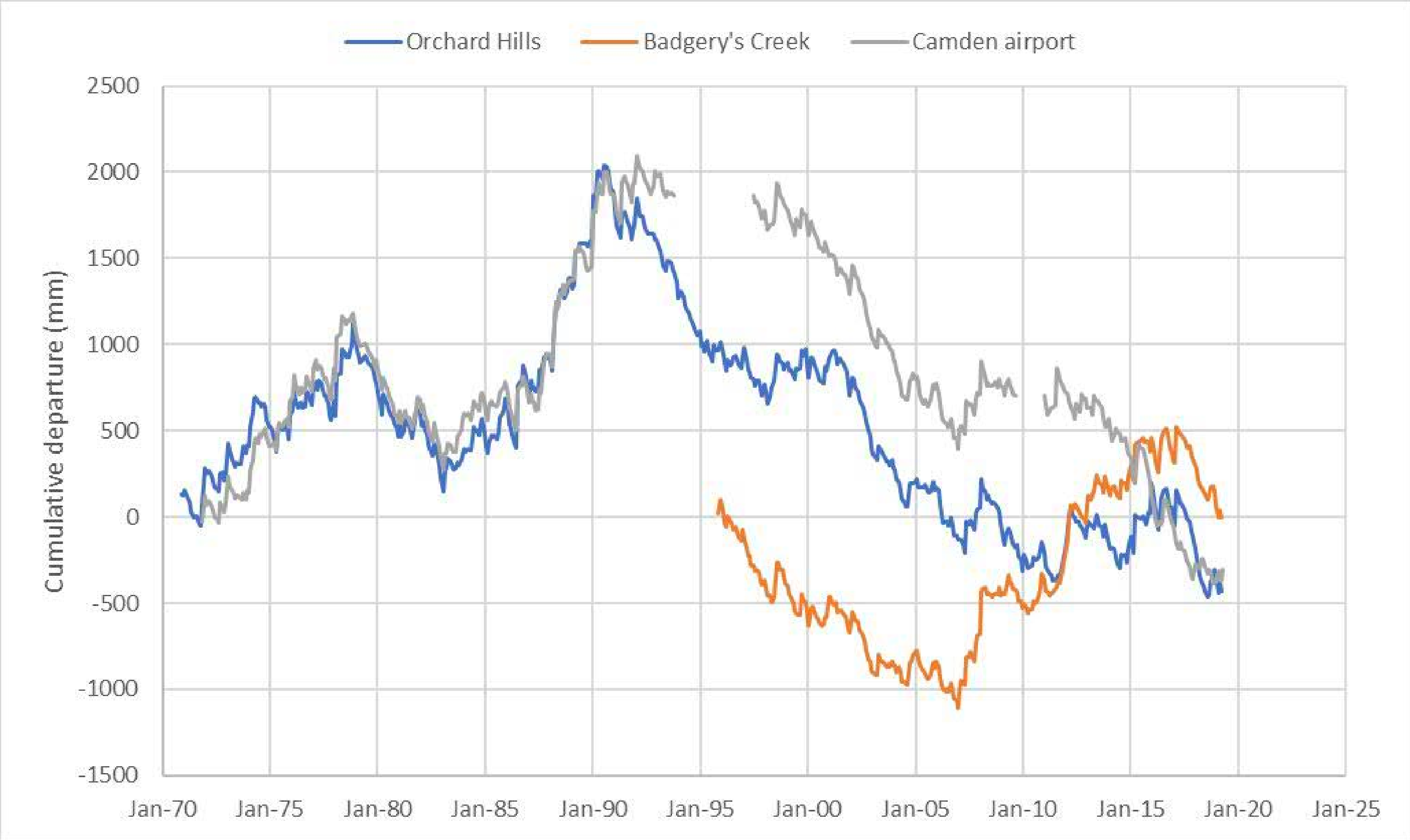


Figure 7: Cumulative monthly rainfall departure at Badgerys Creek (1995 – 2019), Orchard Hills (1970 – 2019) and Camden Airport (1971 – 2019)



4.2.4 Surface water

The project alignment is located in the east of the Hawkesbury-Nepean catchment which has an aerial extent of 21,400 square kilometres. The catchment is the longest coastal catchment in NSW. The Nepean river flows for nearly 470 kilometres from its headwaters south of Goulburn where it drains into the Hawkesbury River which discharges to Broken Bay, north of Sydney.

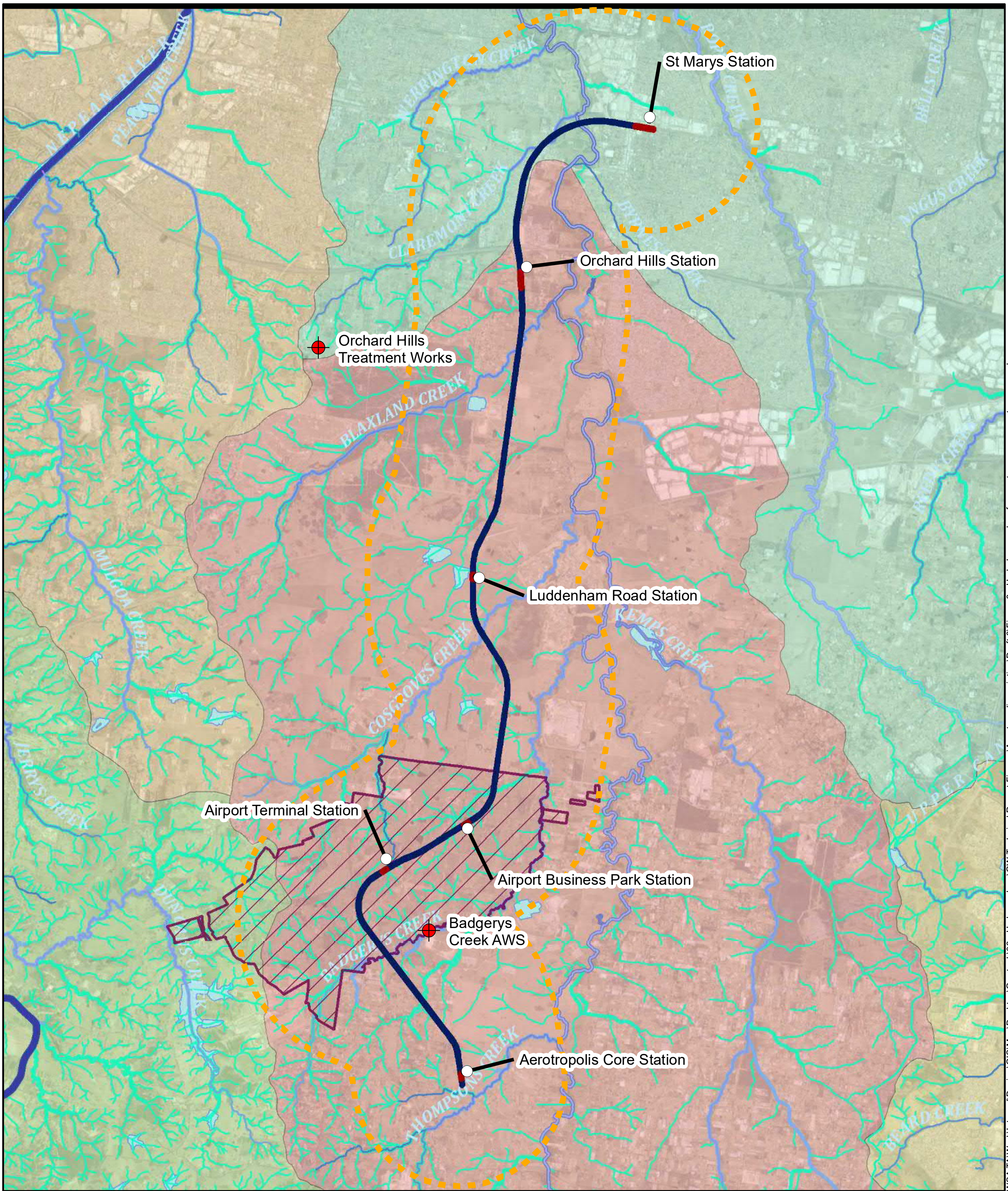
All of the smaller sub catchments along the project alignment drain to the Hawkesbury Nepean system downstream of Lake Burragorang, via South Creek, which has a sub-catchment area of 414 square kilometres. The project alignment crosses several smaller creek catchments which all flow toward the South Creek sub-catchment. Figure 8 presents the location of the catchments and water courses within the study area. The South Creek catchment is extensively modified due to land clearing, urbanisation and agriculture within the hydrological catchment. As a result, South Creek and its catchment is a degraded catchment (NSW, 2018). The project is located outside of the Sydney drinking water catchment (Water NSW).

The project alignment crosses several lower order creeks, all of which are tributaries of South Creek. These creeks all broadly align in a north east - southwest orientation with flow towards the northeast. To the east of the alignment, South Creek flows towards the north where it eventually flows into the Hawkesbury River. Flow in the tributary creeks is ephemeral.

From north to south, the creek lines which the alignment crosses are:

- South Creek
- Claremont Creek
- Blaxland Creek
- Cosgroves Creek
- Kemps Creek
- Oakys Creek
- Badgerys Creek
- Thompsons Creek.

Further information relating to the creeks and water quality is presented in Technical Paper 6 (Hydrology, flooding and water quality).



Legend

- Study area
- Western Sydney International
- Stations
- Project Alignment
- Weather stations

Surface water management zones

- Cabramatta Creek
- Lower Nepean River
- Lower South Creek
- Mid Nepean River Catchment
- Upper South Creek

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Hydrology and surface water management zones

Metres
0 1,000 2,000 3,000 4,000

Issue	Date	By	Chkd	Appd
D1	2/07/2020	CJ	JL	JL

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Figure Status
Issue

Coordinate System
GDA 1994 MGA Zone 56

Job No
265549-00

Figure No
008

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4.2.5 Regional geology

The study area is located within the Cumberland Basin, which is part of the Sydney Basin, a structural and topographical basin which extends from Batemans Bay to Port Stephens and was infilled with a thick sediment sequence. The maximum total thickness of sediments accumulated in the Sydney Basin is estimated to be around 4800 metres (Mayne et al., 1974).

Deposition of sediments in the Sydney Basin began in the Late Permian, with these sediments overlying Lower to Middle Palaeozoic igneous and metamorphic basement rocks (Branagan, 1985). The main Sydney Basin geological groups/formations (from oldest to youngest) are the Shoalhaven Group, Illawarra Coal Measures, Narrabeen Group, Hawkesbury Sandstone, Mittagong Formation, and the Wianamatta Group (Jones and Clark, 1991).

After the sedimentation events in Permian-Triassic, some isolated igneous activities occurred in the Sydney Basin in the Jurassic. Igneous intrusions from this period include dykes (which are typically subvertical and follow planes of weaknesses in the sedimentary country rocks), and diatremes (which are the remnants of short-lived explosive vents). The bedrock was subsequently weathered to residual soil. Superficial processes such as fluvial and slope activities led to the depositions of alluvium and colluvium from the Paleogene to Holocene periods (Jones and Clark, 1991).

The Wianamatta Group

The Western Sydney area is characterised by the Middle Triassic-aged sedimentary rocks of the Wianamatta Group, which were deposited after the Hawkesbury Sandstone subsidence in the Sydney Basin (William, 2004).

The Wianamatta Formation (from oldest to youngest) consists of the Ashfield Shale, the Minchinbury Sandstone and the Bringelly Shale of which only the Bringelly Shale is present at outcrop in the study area.

The Wianamatta Group is locally overlain by Tertiary deposits and unconsolidated Quaternary deposits.

Structural geology

The Sydney Basin forms the southernmost part of the Sydney-Bowen Basin, a major structural basin which extends from Durras Lake near Batemans Bay to central coastal Queensland (Herbert and Helby, 1980). Structurally, this basin lies between two fold belts, the Lachlan Orogen and the New England Orogen (Jones and Clark, 1991).

Based on structural features, the Sydney Basin can be subdivided into several smaller basins and plateaus. In Western Sydney these include the Cumberland Basin, which itself can be subdivided into the Penrith and Fairfield Basins. Mapped folds in the Western Sydney area include the Rossmore Anticline and the Camden Syncline. The Lapstone Monocline separates the Cumberland Basin from the Blue Mountains Plateau.

Mapped faults in the Western Sydney area are generally associated with the Lapstone Monocline, forming the Lapstone Structural Complex (Jones and Clark, 1991). Other faults in the region have been inferred from magnetic surveys.

Jones and Clark (1991) suggest that the Narellan Lineament may act as a structural control on the northward flowing South Creek, as the lineament underlies the creek.

Between St Marys Station and Western Sydney International, there are also three second order fracture traces mapped that intersect the proposed alignment (Jones and Clark, 1991). These fracture traces are northeast-southwest trending.

4.2.6 Geology of the study area

The Penrith 1:100,000 Geological Map (1991) indicates that the geological conditions within the study area comprise:

- Quaternary Alluvium (Qa); and
- Triassic Bringelly Shale (Rwb), of the Wianamatta Group.

Discrete igneous intrusions are present in the Western Sydney area in the form of diatremes and dykes. The geology of the study area is presented in Figure 9. Geological interpretation along the alignment, for those areas which are predominantly below ground surface (Orchard Hills Station to St Marys Station and Airport Business Park Station to Aerotropolis Core Station) is provided in geological long sections in Appendix E.

Bringelly Shale (Rwb)

The Triassic Bringelly Shale is the uppermost unit of the Wianamatta Group and is a sedimentary succession which conformably overlies the other units of the Wianamatta Group (Michinbury Sandstone and Ashfield Shale). The Bringelly Shale is comprised of the following lithologies in decreasing volumetric significance:

- claystone and siltstone
- laminite
- sandstone
- coal and highly carbonaceous claystone
- tuff.

Igneous intrusions (Jd_7, Jd_{13}, Jv)

Basic igneous intrusions occur throughout the Sydney Basin and there are a number in the Western Sydney area (including both dykes and diatremes). There are two dykes mapped within 500 metres of the alignment. These are the Claremont Dyke and the Luddenham Dyke.

Claremont Dyke (Jd_7) - The proposed alignment potentially crosses the Claremont Dyke between St Marys station and Western Sydney International however an inclined borehole was drilled to explore its mapped position and was not encountered. The Claremont Dyke is of olivine dolerite with a strike of 040° TN and a vertical dip. It is 2.4 to 3.7 metres wide and extends as a series of en-echelon segments for a distance of 2.4 kilometres.

Luddenham Dyke (Jd_{13}) - The Luddenham Dyke is located southwest of the alignment on the Western Sydney International site. The Luddenham Dyke is the largest dyke in the Western Sydney area and has been recorded with a strike of 132° True North, dipping vertically to 85° to the southwest. It has a typical width of 6 to 12 metres and can be traced over a distance of 8.5 kilometres, outcropping as a series of en-echelon segments.

Quaternary alluvium (Qa)

Quaternary alluvial soils are present along creek lines within the study area. These soils represent active and historical stream deposits and are associated with the active drainage channels in the area, including South Creek, Blaxland Creek, Cosgroves Creek and Badgerys Creek (Figure 9).

Published information describes Quaternary alluvial deposits as unconsolidated fine-grained sands, silts and clays, with a dominant soil type of silty clayey sand (Jones and Clark, 1991). However, geotechnical investigations undertaken for the project indicate that alluvial deposits present across the project alignment are predominantly clay dominated with some minor sands and gravels.

The alluvial deposits are generally broad but thin ranging up to around six metres in thickness (as measured at boreholes drilled at South Creek). The alluvial deposits are most extensive along South Creek where the width of the deposits is up to 1km. Smaller creek lines typically have less extensive alluvial deposits.

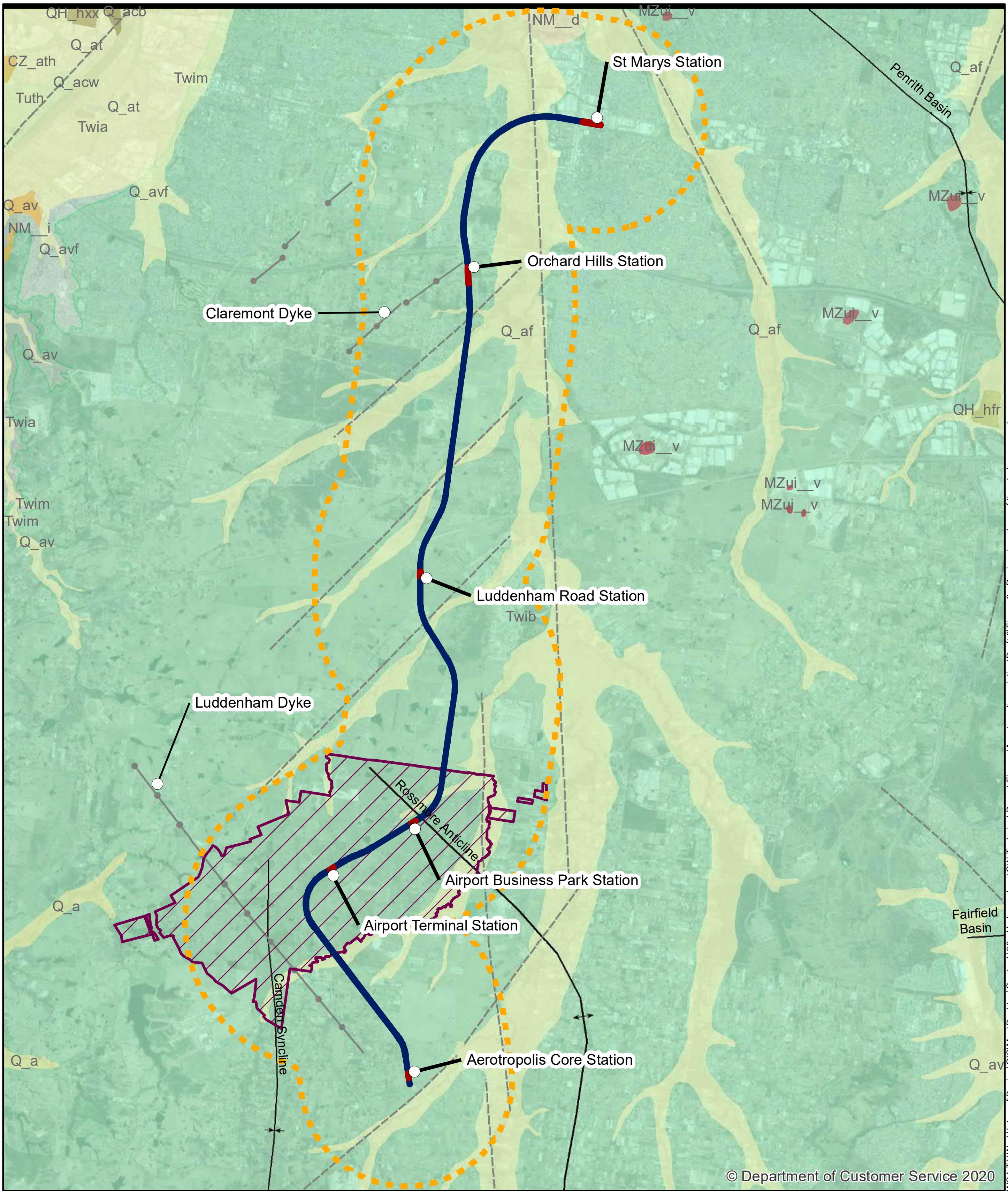
Fill

In addition to these natural soils, fill is also likely to be encountered in some areas along the alignment, in particular:

- around built up areas such as St Marys;
- around and associated with existing infrastructure; and
- around farm dams.

Folds

The Penrith 1:100,000 Geological Map indicates that the northwest-southeast trending Rossmore Anticline intersects the proposed alignment approximately 200 metres northeast of the Airport Business Park Station. The geological map also indicates that the north-south trending Camden Syncline is located approximately 400 metres west of the alignment on the Western Sydney International site.



Legend

- Study area
- Stations
- Project Alignment
- EIS_Construction_footprint
- Western Sydney International

Geological units

- QH_hfr - Anthropogenic deposits - fill on Quaternary deposits
- QH_hxx - Anthropogenic deposits - extensive excavation of Quaternary deposits
- Q_a - Quaternary alluvium (various codes)
- CZ_ath - Alluvial terrace deposits - high-stand facies
- NM__d - Londonderry Clay
- NM__i - Rickabys Creek Gravel
- MZui__v - Volcanic breccia
- Twib - Bringelly Shale
- Twim - Minchinbury Sandstone
- Twia - Ashfield Shale
- Tuth - Hawkesbury Sandstone

Structural geology

- Dyke or Vein
- Lineament
- Anticline, position accurate
- Syncline, position accurate

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Regional geology of the study area

Metres
0 1,000 2,000 3,000 4,000

D1	2/07/2020	CJ	JL	JL
Issue	Date	By	Chkd	Appd

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Scale at A4	Figure Status
1:100,000	**Issue**
Coordinate System	
GDA 1994 MGA Zone 56	
Job No	Figure No
265549-00	**009**

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Faults

According to the Penrith 1:100,000 Geological Map, there are no faults within the study area. A series of SW-NE lineaments are present within the study area, aligning with the tributaries of South Creek over which the project alignment crosses. Potential faults were also identified in project boreholes at St Marys Station, below the depth of the alignment.

4.2.7 Acid sulphate materials

Acid Sulphate Soils are acidic soil horizons or layers resulting from the aeration of soil materials that are rich in iron sulphides, primarily pyrite (FeS_2). They are generally likely to be present in:

- marine and estuarine sediments of the recent (Holocene) geological age
- soils usually not more than five metres above mean sea level
- marine or estuarine settings

When drainage or excavation brings air into these previously waterlogged soils, the iron sulphides are oxidised to produce sulfuric acid. The acid reacts with clay minerals and dissolves metals in the soil such as iron and magnesium. The resulting acid and dissolved metals that leach from the soil are often toxic to flora and fauna.

The Wianamatta Group is not known to have significant net acid producing potential although elevated iron concentrations are commonly found in groundwater from the Hawkesbury Sandstone and Ashfield Shale.

The Australian-wide Atlas of Australian Acid Sulphate Soils map (CSIRO, 2013) indicates that the probability of encountering acid sulphate soils along the reference alignment is “extremely low” to “low”. The NSW Acid Sulphate Soils Risk map (Naylor et al., 1998) indicates that the risk of acid sulphate soils is not reported along the alignment. The geomorphological setting of the project is one that is not generally predisposed to the presence of acid sulphate soils. Typical settings in which these soils occur are coastal or estuarine environments, waterlogged and oxygen deprived soils or at elevations less than 10m AHD.

Potential acid sulphate soil testing has been undertaken at Western Sydney International as part of ongoing investigations (GHD, 2018). A total of 97 soil samples were tested for possible acid sulphate soils which indicated that only 2 samples had a slight marginal presence of PASS. A small number of samples were also screened for ASS testing and indicated that there was a low likelihood of the presence of ASS (Golders 2019). Testing undertaken on samples collected from project boreholes also confirmed that acid sulphate soils and rock have not been encountered to date. This indicates that potential acid sulphate materials are unlikely to occur within the study area.

4.2.8 Soil salinity

Dryland salinity issues in Western Sydney are well documented (DoIPNR, 2002; Nicholson et al., 2011) and the study area is located within a high salinity hazard area. Dryland salinity mapping of Western Sydney (DoIPNR, 2002) indicates that the main areas of high salinity potential are located along creek lines. Creeks and topographically lower areas tend to be associated with higher salinity risk since they are zones of groundwater discharge which can lead to concentration of salts within the soils. The alignment crosses some areas of known salinity i.e. those which have been mapped at surface (see Figure 10). These are located at:

- Claremont Creek
- Cosgroves Creek
- Oaky Creek
- Badgerys Creek

Further information on soil salinity is presented in Chapter 16 (Contamination and Soils) of the Environmental Impact Statement.

4.2.9 Regional hydrogeological setting

The geology of the Sydney Metropolitan and Western Sydney areas is dominated by thick sequences of Permian and Triassic bedrock comprised of the Wianamatta Group (Bringelly Shale, Minchinbury Sandstone, Ashfield Shale), Mittagong Formation and Hawkesbury Sandstone.

Bedrock units form heterogenous fractured rock aquifers where groundwater flow occurs within defects (such as joints, sheared zones and bedding partings) within the rock mass. The hydraulic conductivity and groundwater flow within fractured bedrock units varies significantly depending on the degree of fracturing and weathering, and the presence of major structural features (such as faults) which can act as high transmissivity zones (Hewitt, 2012). Significant vertical and horizontal heterogeneity is known to occur in these aquifers; higher hydraulic conductivity bedrock is likely near subvertical dykes, major structural features and within palaeochannels below creeks.

Owing to more favourable hydraulic properties and better-quality water, the Hawkesbury Sandstone aquifer is used for some irrigation and local water supply purposes. The shale tends to have poorer quality water and are generally not used for supply purposes. In Western Sydney, thick sequences of Bringelly Shale and Ashfield Shale tend to act as confining units to the underlying Hawkesbury Sandstone, although groundwater is still present within these shale units.

Quaternary alluvial aquifers overlie the bedrock in creek channels and drowned river valleys. These deposits tend to occur along the main drainage channels and creek lines in the region. In Western Sydney, this includes major creek lines such as South Creek and its tributaries. Perched groundwater systems also exist within residual soils overlying the bedrock surfaces, however the extent and distribution of these is highly variable (Nicholson et al, 2011).

Groundwater within residual and Quaternary soils occurs within the pore spaces of the soil structure with groundwater flow controlled by the grain size and distribution of the material. Quaternary deposits typically comprise of a wide variety of material including gravels, sands, silts and clays and therefore have a wide range of hydraulic conductivities. Residual soils derived from fine-grained sedimentary rocks, which are the dominant rock type in the Bringelly and Ashfield Shale units, are typically clay-rich and often have low hydraulic conductivity.

Quaternary alluvial deposits and creeks generally have some hydraulic connection with groundwater in the underlying bedrock aquifers with creek lines either acting as discharge points for the groundwater within the bedrock or as sources of supplemental recharge into the underlying bedrock.

4.2.10 Hydrogeological landscapes

The hydrogeological setting of Western Sydney has been investigated by the NSW Department of Environment, Climate Change and Water as detailed in the Hydrogeological Landscapes (HGL) for the Hawkesbury-Nepean Catchment Management Authority Report (Nicholson *et al.,* 2011). The findings of the report indicate that hydrogeological landscapes within the study area are:

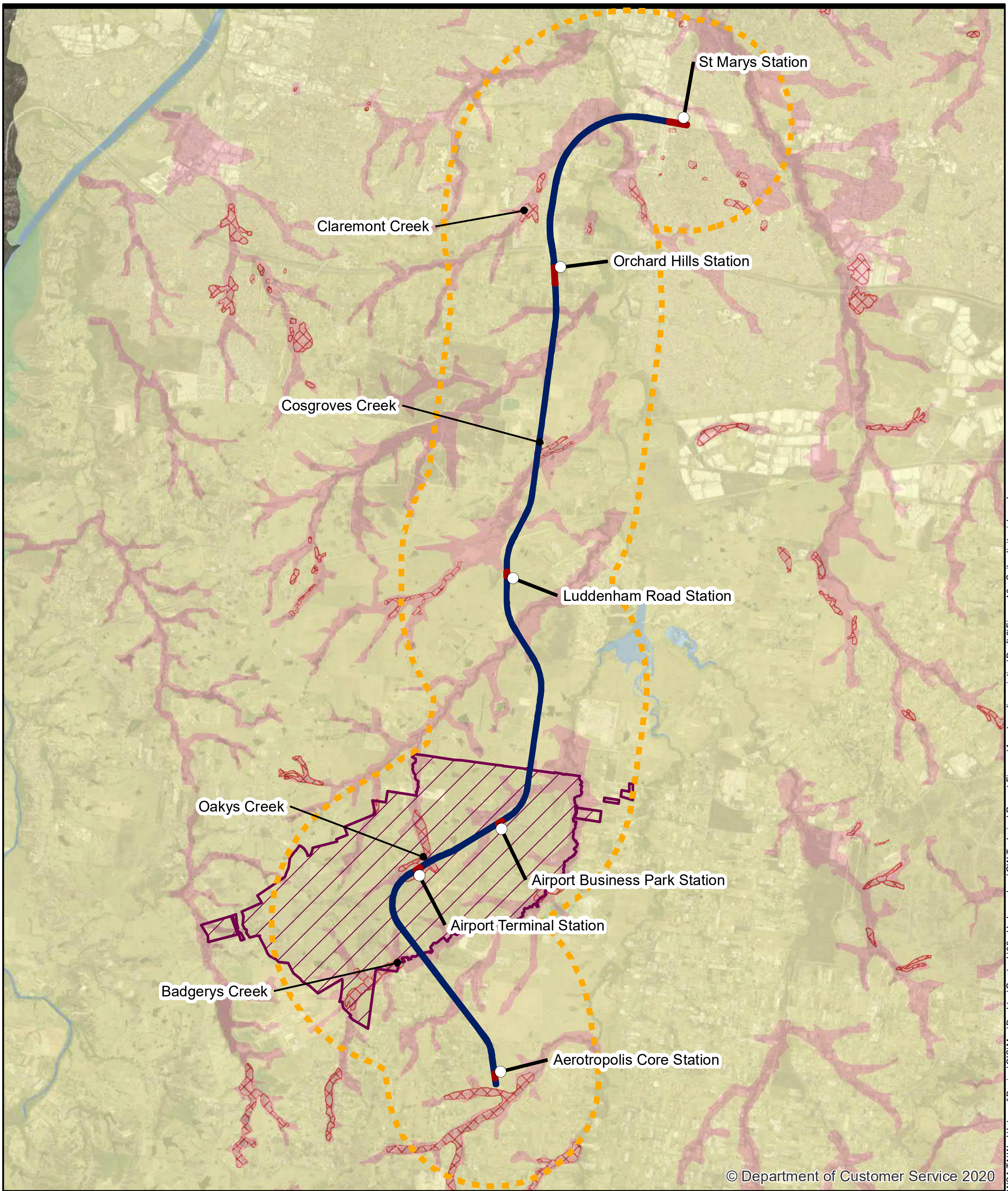
- Shale Plains (St Marys area); and
- Upper South Creek (from South Creek, west of St Marys to Aerotropolis).

A summary of the hydrogeological setting in each of these landscapes is presented in Table 10.

Table 10: Hydrogeological landscapes summary information relevant to alignment

Feature	Upper South Creek & Shale Plains hydrogeological landscape unit
Lithology	• Recent Alluvium – fine grained sand, silt and clay • Bringelly Shale (shale, carbonaceous claystone, laminite, lithic sandstone, rare coal)
Regolith/ landforms	Gently undulating low hills and rises (10 – 50 metres), foot slopes and plains (5 – 30 metres) on floodplains (0 – 10 metres). Crests and ridges are broad and rounded. Large dish-shaped swampy depressions which are permanently or periodically waterlogged occur above the active floodplain.
Aquifer types	Unconfined alluvial sediments Unconfined to semi-confined fractured rock Vertical and lateral flow components Local perched groundwater within soils
Hydraulic conductivity	10^{-8} metres per second to 10^{-6} metres per second
Transmissivity	Low to moderate (<2 – 20 square metres per day)
Specific yield	Moderate 5 – 15%
Hydraulic gradient	Gentle (<10%)
Salinity	Brackish to saline
Depth to water table	2 – 6m
Typical catchment	Medium (<1,000 hectares)
Scale (flow length)	Local (<5 kilometres)

Feature	Upper South Creek & Shale Plains hydrogeological landscape unit
Residence time	Medium (years)



Legend

- Study area
- Stations
- Project Alignment
- Western Sydney International

Western Sydney Salinity Potential

- Recorded salt site
- High
- Moderate
- Low
- Water

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Soil salinity risk

Metres
0 1,000 2,000 3,000 4,000

D1	2/07/2020	CJ	JL	JL
Issue	Date	By	Chkd	Appd

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Scale at A4	Figure Status
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Coordinate System
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Job No	Figure No
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\\global.arup.com\australasia\SYD\Projects\265000\265549-00 SMWSA TA\Work\Internal\Design\GIS\Map\Desktop\Geotech\03 - Hydrogeology\GW Technical Report Figures\Aerotropolis variation\Draft 3\Figure 10 - Soil salinity risk.mxd

4.2.11 Hydrogeology of the study area

The following hydrogeological units are present in the study area:

- Quaternary alluvium along drainage lines of tributaries associated with the South Creek
- residual soils
- Wianamatta Group fractured bedrock (Bringelly Shale, Minchinbury Sandstone, Ashfield Shale)
- Hawkesbury Sandstone at depths likely exceeding 100 mbgl.

Hydrogeological characteristics of each of the study area units is described below.

4.2.12 Aquifer parameters

The three main material properties which describe the mechanisms of hydrogeological behaviour are:

Hydraulic conductivity

A measure of the materials capacity to transmit water which is the constant of proportionality that relates the discharge of water through a porous medium per unit hydraulic gradient where:

$$q = -K\mathrm{i}$$

q – specific discharge (m/s)

K – hydraulic conductivity (m/s)

i – hydraulic gradient (-)

Specific storage

Specific storage is the volume of water released from confined aquifer storage as a result of changes in the elastic behaviour of the material, per unit area per unit decline in hydraulic head. Specific storage is related to the aquifer compressibility and porosity where:

$$S_s = \rho g(\alpha + n\beta)$$

S_s – specific storage (m^{-1})

ρ – density of water (kg/m^3)

g – gravitational acceleration (m/s^{-2})

α – aquifer compressibility (m^2/N)

n – total porosity (-)

β – compressibility of water (m^2/N)

Specific yield

Specific yield is the volume of water which is released from an unconfined aquifer because of gravity drainage of the material, per unit area per unit decline in head. The drainable storage of an unconfined aquifer is usually significantly higher than the specific storage of a confined aquifer.

The hydraulic conductivity of a unit may be measured *in situ* using a variety of test methods which includes packer testing, variable head displacement tests and aquifer pumping tests. As a result, hydraulic conductivity tends to have a greater density of data. Storage parameters, on the other hand, can only be directly measured using aquifer pumping tests and as a result data relating to these parameters is normally scarcer.

Table 11 provides a summary of the estimated hydraulic parameters for units within the study area based on published literature (Bertuzzi, 2014).

Table 11: Aquifer parameter summary table

Unit	Hydraulic conductivity (m/s)	Specific storage	Specific yield
Residual soil	$<1x10^{-9}$ to $2x10^{-5}$	10^{-3} to 10^{-4}	0.02 – 0.10
Alluvium	10^{-8} to 10^{-4}	10^{-3} to 10^{-5}	0.02 – 0.30
Bringelly Shale	$<1x10^{-9}$ to $3x10^{-6}$	10^{-4} to 10^{-6}	0.001 – 0.10

Residual soil

Residual soils overlie Bringelly Shale bedrock across most of the study area. Residual soils form due to the complete in situ weathering of bedrock whereas colluvial deposits are from weathering and downslope movement, tending to accumulate towards the base of hill slopes.

Residual soils within the study area derive from the underlying Bringelly Shale. The thickness and distribution of these soils varies across the study area generally ranging from a few metres up to 10 metres. The unit is unlikely to act as a single groundwater body, instead presenting as a series of disconnected local perched systems. Although the number of groundwater monitoring points in the residual soil is limited, measured groundwater levels indicate that the residual soil is often unsaturated, above the bedrock aquifer groundwater surface.

It is likely that groundwater may be temporarily retained in the soil unit following rainfall events. This perched groundwater then drains vertically into the underlying fractured bedrock aquifer and/or moves laterally within the soils towards drainage lines and creeks. The quantity of groundwater that is stored and flowing through these materials is likely to be small but may be locally important for some vegetation communities.

Residual soils within the study area tend to comprise of fine-grained materials (clays and silts) due to the underlying shale from which they are formed, which is predominantly a fine-grained bedrock. As a result, they are anticipated to be of generally low to very low hydraulic conductivity. Published data indicates that the hydraulic conductivity of the residual soil may vary from less than $1x10^{-9}$ m/s to $2x10^{-5}$ m/s (McNally, 2004).

There is limited hydrogeological testing data available for residual soil units in the study area. Slug testing was undertaken on two standpipes screened within the residual soil. At each location three falling head and three rising head tests were undertaken. A single falling head has also historically been undertaken on a standpipe screened in residual soil at the WSI site (GHD, 2016). The results of the tests provided a range of hydraulic conductivity values from $1x10^{-7}$ m/s to $6x10^{-9}$ m/s.

There is no in situ test information relating to the storage parameters of the residual soil. Estimated porosity (from void ratio data) of four samples of residual soil ranged from 0.25 to 0.41. Based on the stiffness of residual soils encountered in geotechnical investigations within the study area (10 to 30 MPa), specific storage has been estimated to be between $3x10^{-4}$ and $1x10^{-3}$ m^{-1}.

Clay soils can typically have high porosity but low drainable storage (due to narrow and closed pore spaces). Typical specific yield values for clay soils range from 2% to 10% (Heath, 1983, Morris and Johnson 1967).

Alluvium

Quaternary alluvium aquifers overly the bedrock and residual soils along the line of creek channels. These deposits occur along major creek lines such as South Creek and its tributaries. Figure 9 shows the distribution of alluvial deposits within the study area. The Quaternary alluvial deposits are inherently variable in material types and comprise of a mixture of unconsolidated silts, clays, fine-grained sands and occasional gravels which have been deposited due to the action of surface water flow within the drainage channels and floodplain. Boreholes drilled through alluvial deposits at Badgerys Creek (BH-C002) indicated generally clay-dominated material, whereas at South Creek (BH-A011) the material was generally made up of clays with some clayey sand and clayey gravel. Limited geotechnical investigation in the study area indicates that alluvium within the study area tend to comprise cohesive, finer-grained, units with sand and gravel being less common.

Groundwater within alluvial deposits is likely to be unconfined and have a direct connection to creek water. Clay lenses or layers within the alluvial deposits may also locally cause groundwater to act as a semi-confined aquifer system. Although many of the creeks along the alignment are ephemeral, groundwater within the underlying alluvium is likely to be found year-round (see Figure 8). Riparian vegetation communities along South Creek are likely to be at least partially groundwater dependent.

There is limited hydrogeological testing of alluvial deposits along the alignment. Slug testing was undertaken at four standpipe locations screened within alluvium as part of project-specific investigations. The test results indicated a low hydraulic conductivity for clay dominated alluvium ($1x10^{-7}$ m/s) but higher for coarser grained sand and gravel units ($6x10^{-4}$ m/s).

Four falling head tests have historically been undertaken on alluvium at the airport and showed that hydraulic conductivity ranged from between $4x10^{-8}$ m/s to $6x10^{-6}$ m/s (GHD, 2016). The results indicate that the hydraulic conductivity of the alluvial deposits would be highly heterogeneous owing to the variability in material.

Storage parameters for alluvial deposits have not been directly measured. Specific storage values are anticipated to be similar to the residual soils based on similar stiffnesses however where softer soils are encountered, the specific storage would be higher. Granular units within the alluvium are also likely to have lower specific storage, depending on the density of the material. Due to the variability of the material, specific yield is also likely to be variable, being higher for granular units than fine grained units.

Recharge to the alluvial deposits is likely to be through rainfall recharge and recharge from creek water during periods of high flow. Discharge of groundwater from the fractured bedrock to the alluvial aquifer is a function of the hydraulic connectivity between the units. Groundwater level monitoring of the alluvial deposits and fractured bedrock indicates that water levels in the alluvial aquifer may be higher than in the bedrock, with vertical gradients observed. This indicates that the alluvial aquifer may be a source of recharge to the underlying fractured bedrock. Additional longer-term groundwater level information is required to establish the exact connectivity between the units within the study area.

Bringelly Shale

Bringelly Shale fractured bedrock is located across the entire study area, below the residual soil and Quaternary alluvium. Groundwater is present and principally moves through the Bringelly Shale within bedding partings and joints. Where weathered, groundwater may also move through the pore spaces of the material. Groundwater is likely to be semi confined within the Bringelly Shale bedrock.

Groundwater within Sydney shales has been studied as part of other engineering projects (Hewitt, 2004) however these have principally been focused on the Ashfield Shale. There have been few other major tunnelling projects within the Bringelly Shale upon which to assess the hydrogeological response to construction.

Published hydraulic conductivity values for Ashfield Shales indicate that they are generally low (Table 12). Class IV and V shales tend to lower hydraulic conductivity values due to increased weathering and clay content. Class I and II shales also tend to have lower hydraulic conductivity because of less frequent and tighter fracture spacing.

Table 12: Published hydraulic conductivity values for Sydney shales from lugeon packer test data (Bertuzzi, 2014)

Shale Class	**Hydraulic Conductivity (m/s)**		
	Min	**Average**	**Max**
Class IV/V Shale	1.3E-09	2.6E-09	3.3E-06
Class III Shale	1.3E-08	1.3E-07	6.5E-06
Class I/II Shale	1.3E-07	1.3E-07	3.3E-06

A total of 237 packer tests (which includes historic data and those undertaken for geotechnical investigation for the project) were carried out within the study area from depths ranging from 9 to 68 metres below ground level. The cumulative distribution of packer test data within the study area is presented in Figure 11. The results indicate that the hydraulic conductivity of the Bringelly Shale ranged from less than $1x10^{-8}$ m/s (below the lower quantitation limit) to greater than $1x10^{-5}$ m/s (upper quantitation limit). Approximately 30% of all packer tests had a hydraulic conductivity of less than 10^{-8} m/s. Figure 19 and Figure 22 show the distribution of packer testing off airport and on airport plotted against elevation.

The arithmetic average of all the data was around $7x10^{-7}$ m/s, which is higher than published averages, but within the given range of published data. A summary of the available test data for on-airport and off-airport areas is presented in Section 4.3.1 and Section 4.4.1.

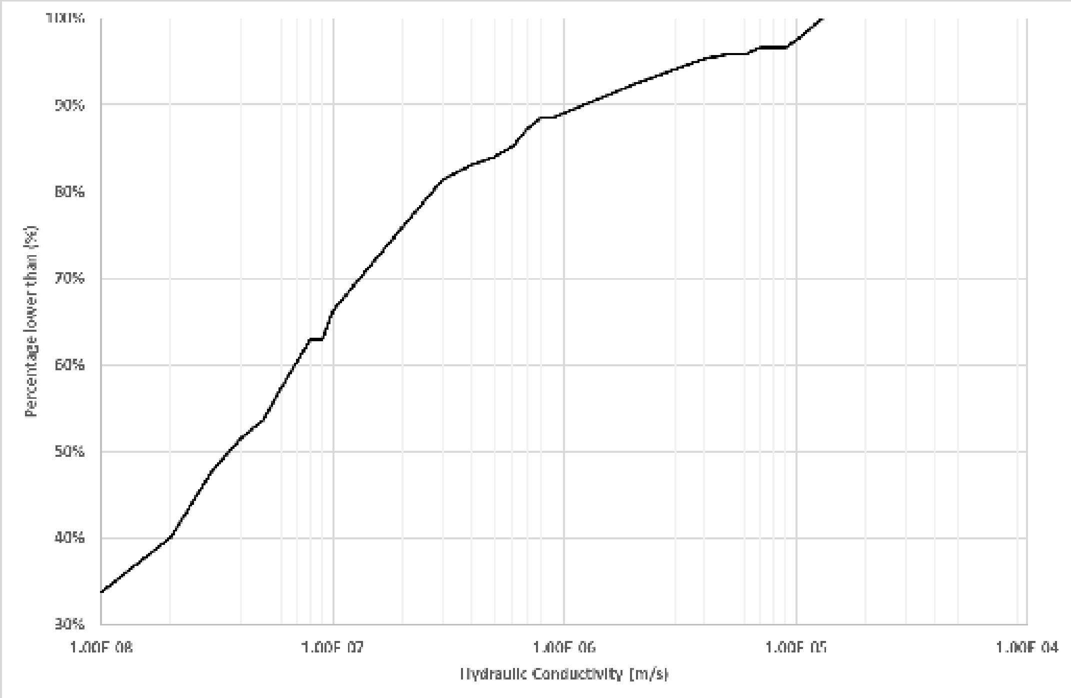
There is some indication that hydraulic conductivity of the Bringelly Shale decreases with depth although the data shows significant scatter. The hydraulic conductivity of rock below major creek and drainage channels is often higher possibly as a result of increased weathering and stress relief in the rock mass. Some of the highest observed hydraulic conductivity values were from tests undertaken adjacent to South Creek and Badgerys Creek although not exclusively.

The Bringelly Shale is likely to be highly anisotropic with the vertical hydraulic conductivity much lower than the horizontal. This is likely due to the predominance of groundwater flow through sub-horizontal bedding planes within the intact rock. Although there is no test data to confirm this at present, groundwater measurements in the shale shows often significant vertical gradients, which may be indicative of vertically anisotropic material.

Storage parameters for the Bringelly shale have not been directly measured. Estimated specific storage values based on rock stiffness of between 50 MPa (Class V) and 1000 MPa (Class II) range from $1x10^{-5}$ and $2x10^{-4}$ m^{-1}. The specific yield of the Bringelly shale is expected to be low. Groundwater storage in the shale is principally within the rock discontinuities, which make up a small percentage of the rock mass. Where weathered, the specific yield of the rock mass is likely to be higher. Typical ranges of specific yield for shale bedrock are presented in Table 11 although the certainty around these values is low.

Recharge to the Bringelly Shale bedrock is expected to occur principally from rainfall recharge through the overlying residual and alluvial soils.

Figure 11: Bringelly Shale packer permeability test summary within study area



Hawkesbury Sandstone

The Hawkesbury Sandstone is located at depth below the study area. Lithological information obtained from boreholes in the Western Sydney area drilled for irrigation purposes (BoM, 2019) indicate that there is at least 100 metres of rock, including Bringelly Shale, Minchinbury Sandstone and Ashfield Shale, overlying the Hawkesbury Sandstone.

The Hawkesbury Sandstone is a regionally significant aquifer with moderate yields of quality water in many areas. The Hawkesbury Sandstone is not anticipated to be encountered by any element of the project however there are water supply wells in the study area which appear to tap Hawkesbury Sandstone at depth. There is limited groundwater level information from the Hawkesbury Sandstone within the study area however standing water levels from a small number of supply wells indicates static water levels varying between around 40 to 80 metres. This indicates that groundwater within the Hawkesbury Sandstone aquifer is likely to be confined by the overlying Bringelly Shales.

Other units

Two subvertical igneous intrusions are mapped within the study area; the Luddenham dyke and the Claremont dyke (Figure 9). Dykes in the Sydney Basin are often associated with zones of higher hydraulic conductivity which can result in higher inflows to tunnels and excavations. Depending on the weathering state of the material however, dykes can also represent areas of lower hydraulic conductivity, representing barriers to groundwater flow. The alignment is not anticipated to cross the Luddenham Dyke and no evidence of the Claremont Dyke was encountered during drilling north of Orchard Hills Station.

4.2.13 Recharge

The principal mode of recharge to groundwater systems is through rainfall. Generally, the proportion of rainfall that makes its way into the underlying groundwater is small and would be dependent on rainfall duration and intensity, slope and landform, evapotranspiration rates, vegetation types and the level of soil moisture prior to the rainfall event. The average annual rainfall in the study area ranges from 672 millimetres per year at Badgerys Creek to 822 millimetres per year at Orchard Hills (Figure 6).

Estimates of recharge to groundwater in the Sydney region have previously been undertaken using several methods. The Sydney bioregional assessment program (Sydney Bioregional Assessment, 2018) attempted to estimate recharge using regression equations developed from the point estimates of recharge using the chloride mass balance. The regression equations were created from a relationship between the annual average rainfall and average annual recharge for different surface geology groupings. Within the study area, this method provided estimates of recharge ranging from 5 to over 200 millimetres per year (along creek lines). Based on the average annual rainfall at Badgerys Creek, this equates to an annual recharge rate of between 0.7% and 30%.

Based on a limited number of soil samples, GHD (2011) estimated that groundwater recharge at WSI could vary from between 0.3 millimetres per year (0.04%) and 36 millimetres per year (5.2%).

Given the predominantly clay lithology of the residual shale soils, groundwater recharge to the underlying shale is likely to be low. McNally (2004) estimates that recharge to the underlying shale aquifers in Western Sydney is likely to be no more than 1 – 2% of average annual rainfall, suggesting that rainfall runoff of throughflow (within shallow soil profiles) is likely to dominate hydrological processes in the region. Groundwater recharge may also occur locally at agricultural dams which are present throughout the study area and other surface water bodies such as lakes or creeks.

Much of the study area is currently rural residential with low-built coverage, particularly in comparison to other more urban areas of metropolitan Sydney. It is likely that with increased development as a result of Western Parklands City over the medium to long term, groundwater recharge is likely to change. Increased hardstand areas are likely to reduce direct recharge from rainfall, however leaking services and garden irrigation may ultimately offset these decreases. The ultimate change in recharge due to increasing development is unknown.

4.2.14 Groundwater levels

Groundwater levels hydrographs from monitoring locations along the alignment are presented in Appendix C. The geological long sections showing groundwater levels between Orchard Hills Station and St Marys Station and between Airport Business Park Station and Aerotropolis Core Station are presented in Appendix E.

Residual soil

Groundwater level monitoring installations have been installed in the residual soil at several locations across the project. However, at this stage, the period of monitoring has been short and disturbed by development, testing and sampling activity. The groundwater monitoring data so far indicates that water levels are generally between 2 to 5 mbgl. A sustained but slow response to a significant rainfall event in February was observed at one location (BH-A107S). Groundwater levels were observed to rise approximately 2m over a one-month period following a four-day period in February 2020 in which over 350mm of rainfall fell in Western Sydney. No other monitoring location in the residual soil had adequate data to discern a similar response.

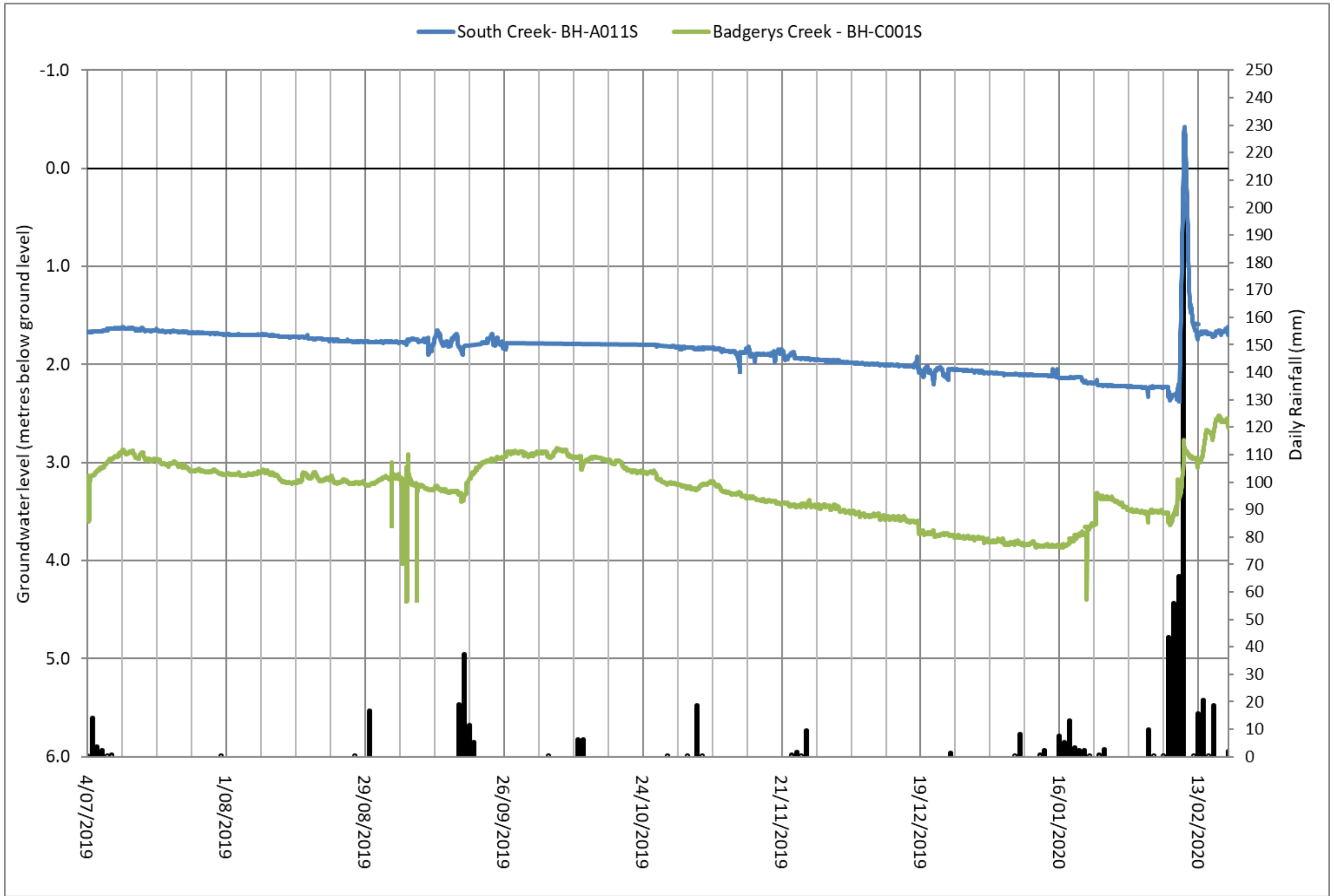
Vibrating wire piezometers installed within the residual soil at Western Sydney International typically indicate that they are variably saturated, and it is likely that these soils may contain perched groundwater and be partially saturated for periods following periods of sustained rainfall. At locations where groundwater monitoring is only available from the underlying shale units, the measured groundwater level is often within the residual soil units, either indicating that the overlying soils are saturated or that they may be acting as confining units to groundwater within the shale.

Shallow soils within the study area are often affected by seasonal waterlogging (Nicholson et al, 2012) particularly in topographically lower areas. Waterlogging can occur because of the low hydraulic conductivity soils following rainfall or where groundwater levels within the underlying shale are close to the ground surface.

Alluvium

Groundwater level information from alluvial deposits within the study area is limited to Badgerys Creek and South Creek. Groundwater levels from three standpipes installed within the alluvial deposits varied from between 2.8 metres below ground level to 0.4m above ground level. The alluvial standpipe at South Creek only registered water levels above ground level for approximately half a day following substantial rainfall in February 2020. This likely corresponds to high water levels in South Creek following the rainfall event. Groundwater level response at the two standpipe locations with monitoring data between July 2019 and February 2020 are presented in Figure 12 and separately in Appendix C2.

Figure 12: Groundwater levels in standpipes screened with alluvium



Groundwater elevations at Badgerys Creek from historical investigations at Western Sydney International varied from 55 mAHD to 77.5 mAHD declining in an easterly direction along the creek line, in line with the general topographic slope of the creek. Groundwater in alluvial deposits is likely to flow in the same direction as the creek; in the study area this is in a north and north easterly direction.

Bringelly Shale

Groundwater level monitoring from standpipes and vibrating wire piezometers installed for the project generally indicates that groundwater within the shale is quite variable but typically within 7m of the ground surface. Deeper groundwater levels (up to 18mbgl) have been recorded at Western Sydney International, where the topography is generally higher than elsewhere in the project. Groundwater in the shale shows variable response to rainfall, many locations showing negligible response, with others showing rapid rises and falls in levels following large rainfall events.

Differences in porewater pressure are observed at some vibrating wire piezometers installed at different depths within the shale. At St Marys station, and to a lesser degree at Orchard Hills, these are observed to be lower than hydrostatic indicating negative vertical head gradients, hence a downward flow direction. At South Creek these are observed to be greater than hydrostatic indicating positive head gradients, hence upward flow. This are anticipated to be a result of groundwater recharge occurring in the topographically elevated areas and discharge occurring at or close to the creek lines. Groundwater hydrographs from vibrating wire piezometers installed at St Marys and South Creek are presented in Figure 13 and Figure 14. The gap in observed data shown in Figure 14 between October-19 and January-20 was as a result of equipment failure.

Further detail on groundwater levels within the Bringelly Shale are presented in Section 4.3.1 and Section 4.4.1.

Figure 13: Groundwater hydrograph BH-A001 (St Marys)

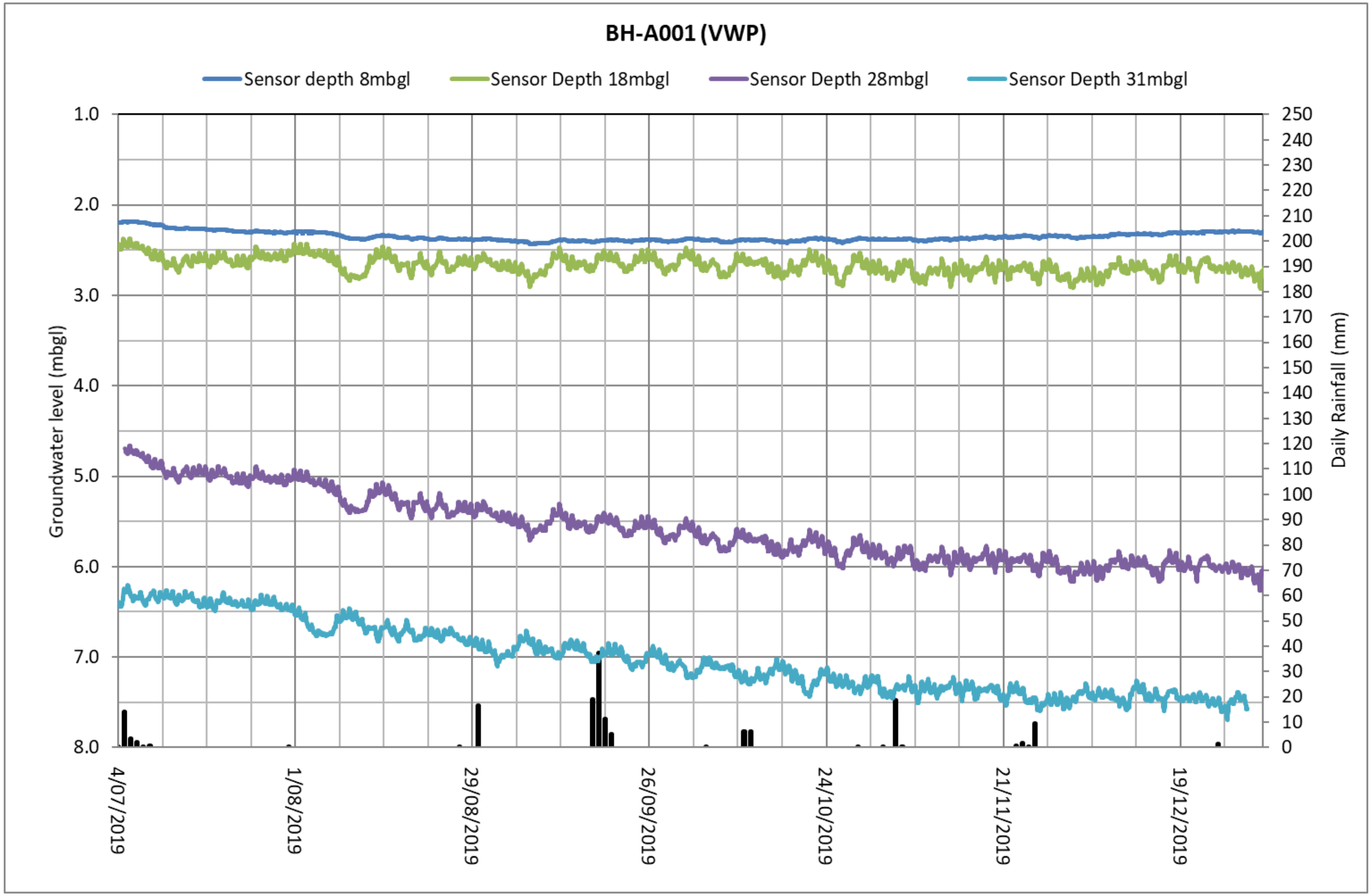
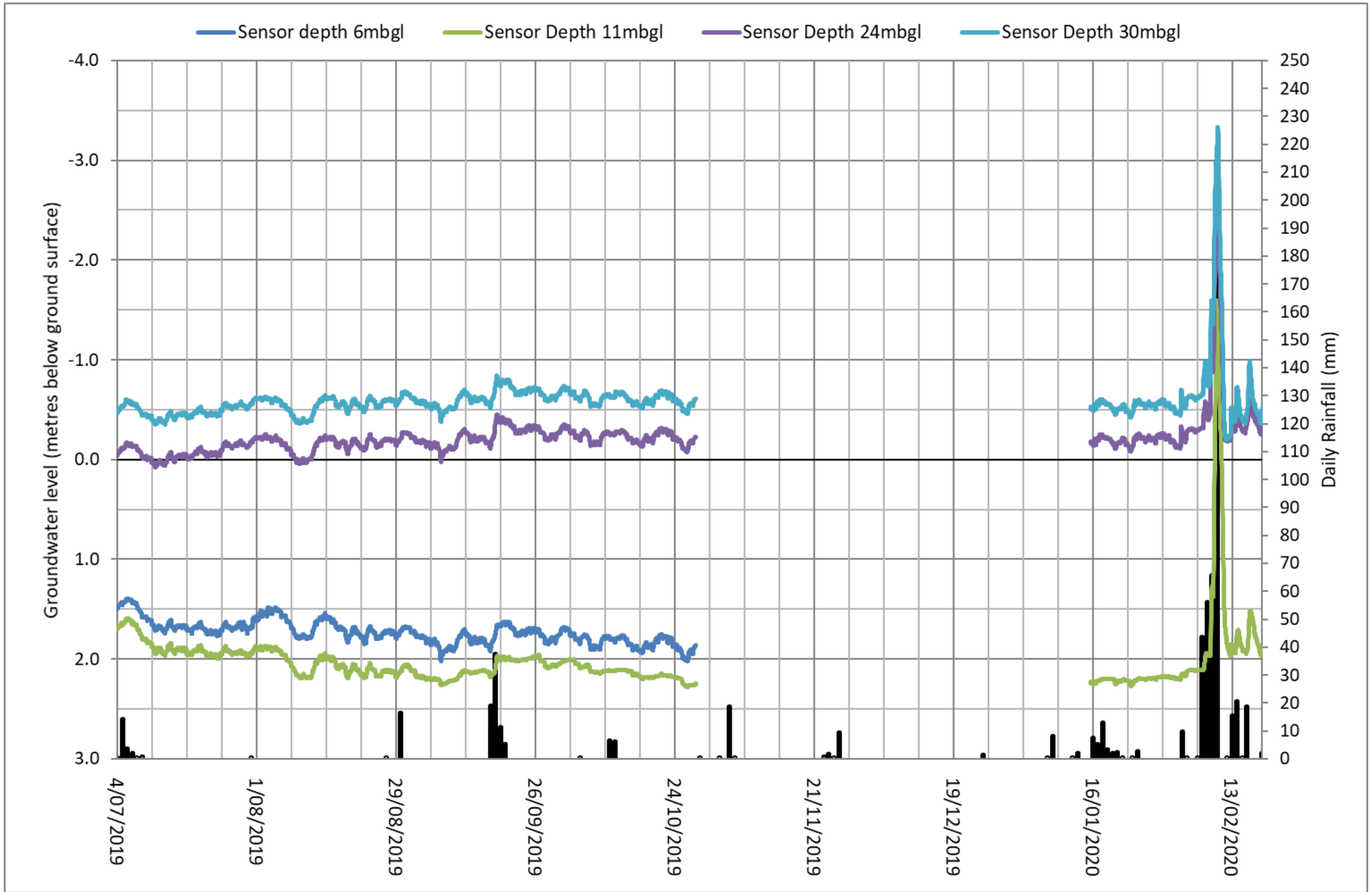


Figure 14: Groundwater hydrograph BH-A011 (South Creek)



4.2.15 Groundwater quality

Groundwater sampling results from historical geotechnical investigation reports and geotechnical investigations carried out for the project were used to assess groundwater quality. A total of 79 monitoring locations had some form of groundwater quality data within the study area, however the range of quality determinants varied substantially. Salinity (electrical conductivity) and pH were the most commonly obtained results (from field observations) followed by sulphate and chloride. Contamination testing was restricted to a number of groundwater monitoring locations at the Western Sydney International site (Section 4.4.2) and the geotechnical investigation undertaken for the project (Section 4.3.2).

The pH of the groundwater in the region is observed to be generally acidic to neutral. The pH of groundwater samples ranged from 4.2 to 9.2 however most samples collected had a pH in the range of 5 to 7.5.

A piper plot of the groundwater major ion chemistry from geotechnical investigations undertaken for the project is presented in Figure 15. The results are distributed by hydrogeological unit however the results are generally consistent and indicate groundwater which is dominated by sodium and chloride with lesser amounts of magnesium and calcium cations. Elevated concentrations of sulphate cations were also recorded in several samples; the results indicate that generally the water chemistry is of a sodium chloride to mixed type.

Further information on the groundwater quality is presented in Section 4.3.2 and Section 4.4.2.

4.2.16 Groundwater salinity

Groundwater salinity as measured from groundwater samples indicates that groundwater ranges from fresh (less than 1,000 milligrams per litre, mg/l) to saline (greater than 5,000 mg/l). The maximum observed salinity was approximately 33,000 mg/l, observed in the Bringelly Shale near Aerotropolis Station. High salinity (27,000 mg/l) was also observed in alluvial deposits along Badgerys Creek at the south of Western Sydney International. This location corresponds to known locations of soil salinity (Figure 10).

Table 13 provides a cumulative distribution of the groundwater salinity results from Bringelly Shale and Alluvium groundwater samples. The results shows that most of the Bringelly Shale groundwater samples (90%) fall within the saline category (greater than 5,000 mg/l). Approximately 50% of the samples had a measured salinity is greater than the maximum which can be used for the most salt tolerant of livestock (sheep, at approximately 13,000 mg/l).

Groundwater samples collected from Alluvium were generally better quality than the Bringelly Shale, although had an overall range of measured values that was consistent. 47% of the alluvium groundwater samples were of marginal quality or better (less than 3,000 mg/l). Approximately 50% of the samples were saline (greater than 5,000 mg/l).

Most (97%) of the groundwater samples from the Bringelly Shale exceeded the salinity criteria for lowland rivers of 125 to 2,200 micro siemens per centimetre (μS/cm) whereas approximately 75% of the Alluvium groundwater samples were greater than the criteria. Figure 17 presents a summary of the salinity data within the study area. Ranges of water quality shown are defined by the Environmental Protection Authority.

4.2.17 Surface water - groundwater interaction

Groundwater within the alluvial deposits in the study area is likely to be in connection with the surface water within the creeks (when flowing). Although there may be connectivity between the underlying Bringelly Shale and the alluvial deposits, the interflow between them is expected to be low due to the generally low hydraulic conductivity associated with the units. Alluvial groundwater is likely to provide some baseflow to local creeks in the area, particularly during periods of low rainfall and surface run off.

Creek lines are likely to be discharge areas for groundwater within the Bringelly shale groundwater catchments, but the total amount of groundwater discharge is likely to be small compared to the overall flow in the creeks and alluvial aquifers. GHD (2016) observed that groundwater salinity is generally an order of magnitude higher than in surface water samples collected from Badgerys Creek. The salinity of water within South Creek is also generally much lower than the surrounding Bringelly Shale groundwater which indicates that the total flow volume into the creeks from the shale is sufficiently small to be significantly diluted.

It is often the case that the same creek can be gaining and losing in different section of its course due to differences in groundwater and stream elevations. When flowing, upper reaches of creeks, which tend to be at higher elevations, may contribute to groundwater recharge. In lower reaches the opposite is often true with creeks acting as discharge points for the underlying groundwater.

Groundwater level information (GHD, 2016) from Badgerys Creek indicates that water levels within the alluvial deposits at Badgerys Creek may be higher than the underlying Bringelly Shale (GHD, 2016). Under these groundwater levels it is plausible that surface waters could be losing streams (i.e. contributing to groundwater recharge through the river base), however the rate at which water is lost would be dependent on the permeability of the underlying deposits and is likely low.

Groundwater level information from South Creek (BH-A011) indicates that water pressures in the shale at depth are higher than at shallower elevations, indicating a positive head gradient (upward flow). This may be indicative of a creek which is gaining (i.e. being supplied by groundwater discharge), albeit at low flow rates controlled by the low hydraulic conductivity of the shale.

Figure 15: Groundwater piper diagram from SMGW groundwater monitoring bores

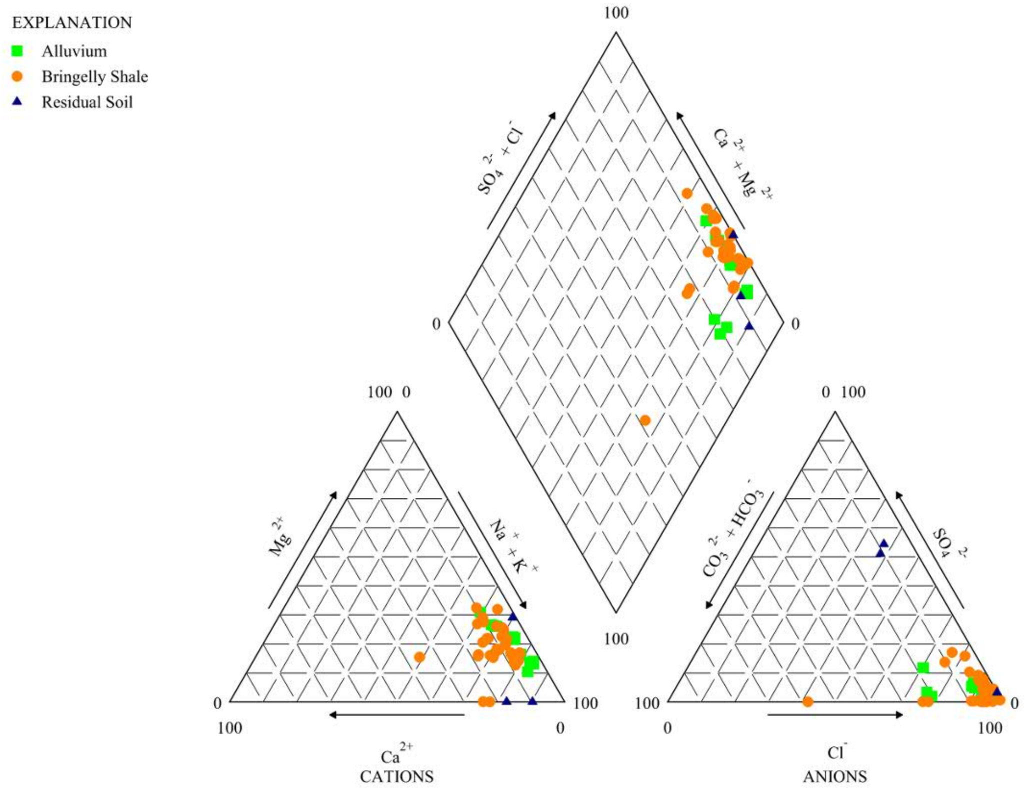
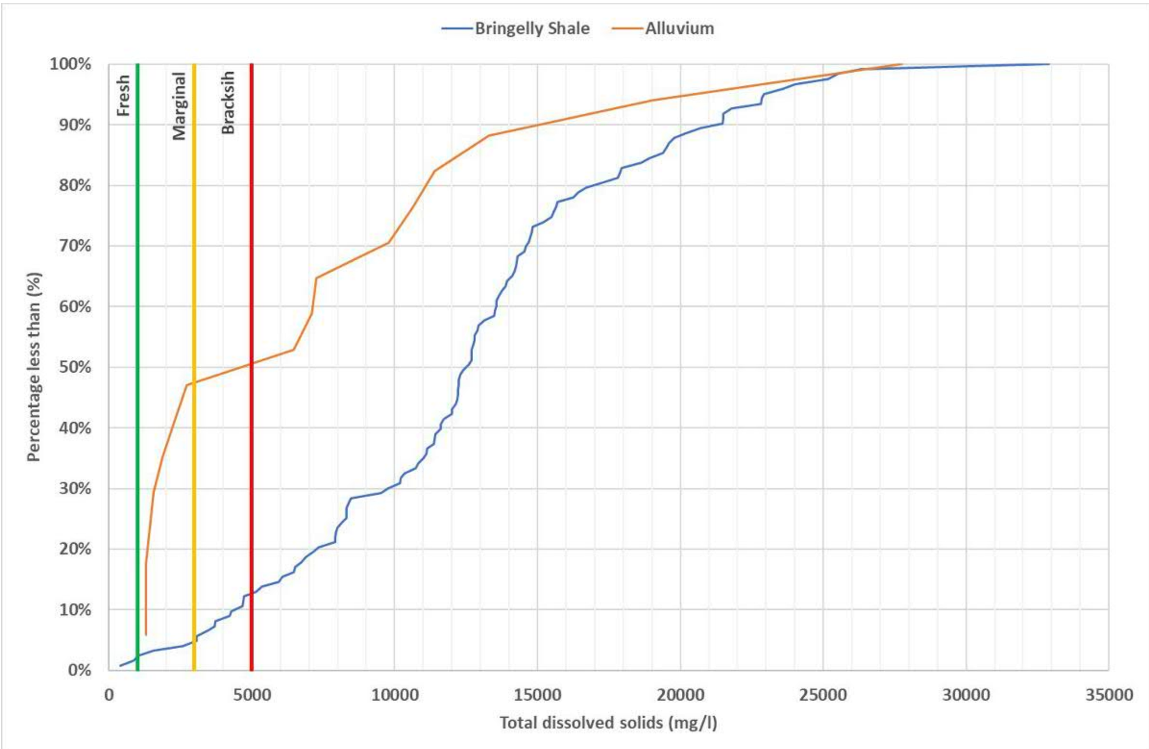
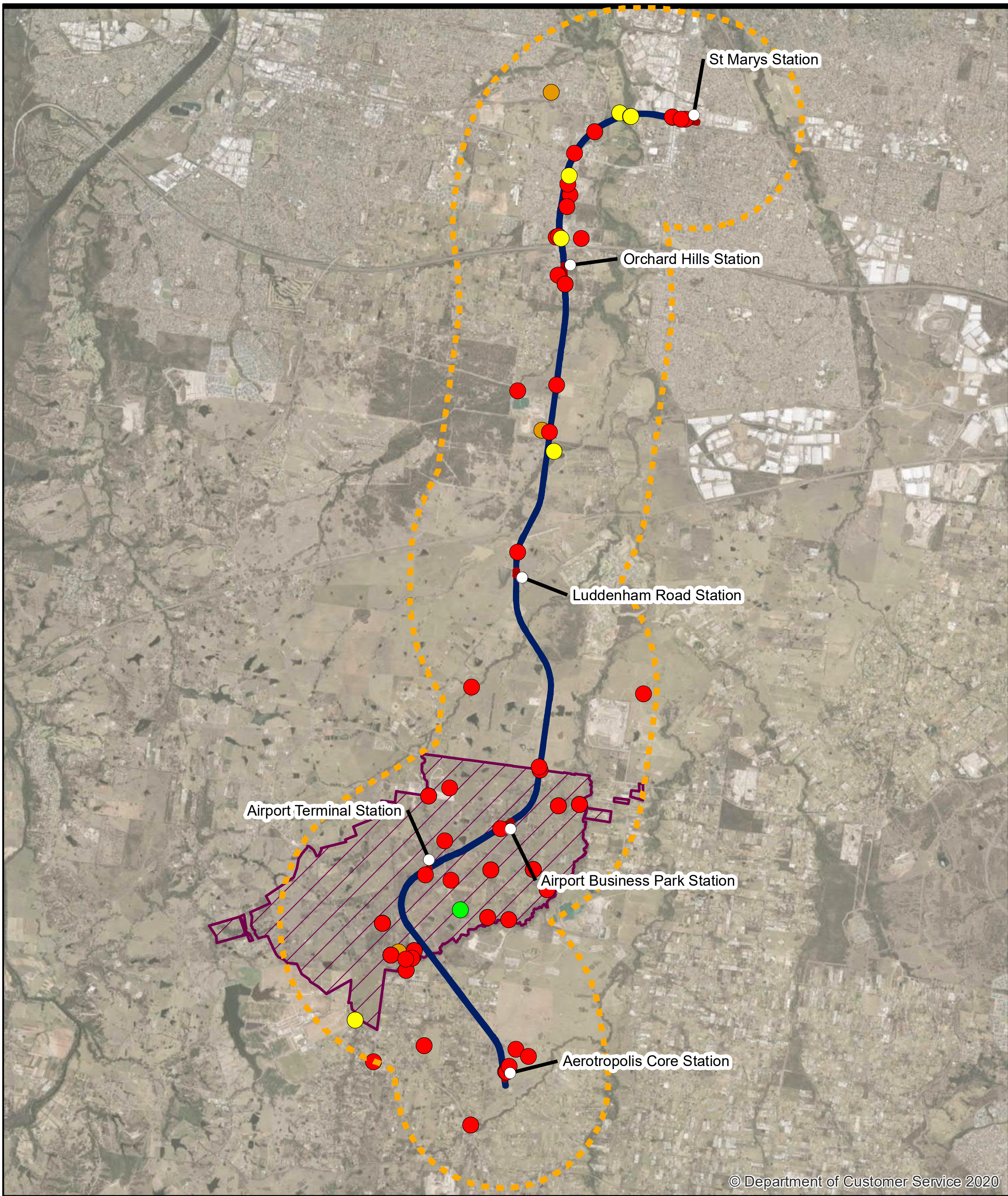


Figure 16: Cumulative distribution of groundwater salinity in Bringelly Shale and alluvium





Legend

- Study area
- Stations
- Project Alignment
- Western Sydney International

Groundwater Salinity mg/l

- 30 - 1000
- 1001 - 3000
- 3001 - 5000
- 5001 - 27744

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Groundwater Salinity Distribution

Metres
0 1,000 2,000 3,000 4,000

Issue	Date	By	Chkd	Appd
D1	13/08/2020	CJ	JL	JL

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151 Clarence St,
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Scale at A4	Figure Status
1:100,000	**Issue**

Coordinate System
GDA 1994 MGA Zone 56

Job No	Figure No
265549-00	**017**

\\global.arup.com\australasia\SYD\Projects\265000\265549-00 SMWSA TA\Work\Internal\Design\GIS\Map\Desktop\Geotech\03 - Hydrogeology\GW Technical Report Figures\Aerotropolis variation\Draft 4\Figure 17 (100k) - Groundwater salinity distribution.mxd

4.2.18 Groundwater dependent ecosystems

GDEs are ecosystems which require access to groundwater on a permanent or intermittent basis to maintain their communities of flora and fauna, ecological and ecosystem processes. There are three types of GDEs based on the type of groundwater reliance. These are:

- aquatic GDEs dependent on surface expression of groundwater (i.e. groundwater fed wetlands or river baseflow ecosystems)
- terrestrial GDEs dependent on subsurface expression of groundwater (i.e. terrestrial and riparian vegetation)
- GDEs dependent on subterranean presence of groundwater (i.e. karst and cave ecosystems).

GDEs are most likely to be present where groundwater is shallow, where the capillary zone of the water table is within the root zone of vegetation communities. Typical examples of where this occurs is on alluvial aquifers along major drainage lines or spring lines where groundwater emerges close to or at the surface. The dependence on groundwater can be variable, ranging from partial and infrequent (i.e. seasonal) to continual dependence (DPI, 2012).

Assessment of the potential for GDEs to be present in the study area was evaluated using the Australian Government's Bureau of Meteorology (BoM, 2019) Groundwater Dependent Ecosystems Atlas, the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (NSW, 2015) and native vegetation mapping data (see Technical Paper 3: (Biodiversity Development Assessment Report).

The location of potential GDEs on-airport and off-airport site are described in Section 4.3.3 and Section 4.4.3.

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (NSW, 2015) lists high priority GDEs in Clause 1, Schedule 4 of the plan. There are four high priority terrestrial GDEs (endangered ecological vegetation communities) listed in the schedule - these are: Cumberland Shale Plain Woodland, Castlereagh Ironbark Forest, River-Flat Eucalypt Forest and Shale Gravel Transition Forest.

The exact dependency on groundwater of these communities is unclear. Communities present along creek lines such as the Cumberland River Flat Forest are likely to have some dependency on groundwater within alluvial soils, in connection with the creek water. The degree of dependence on groundwater in the Bringelly Shale is unclear because it is typically high salinity.

There are no high priority aquatic or karst GDEs listed in the Water Sharing Plan located within the study area.

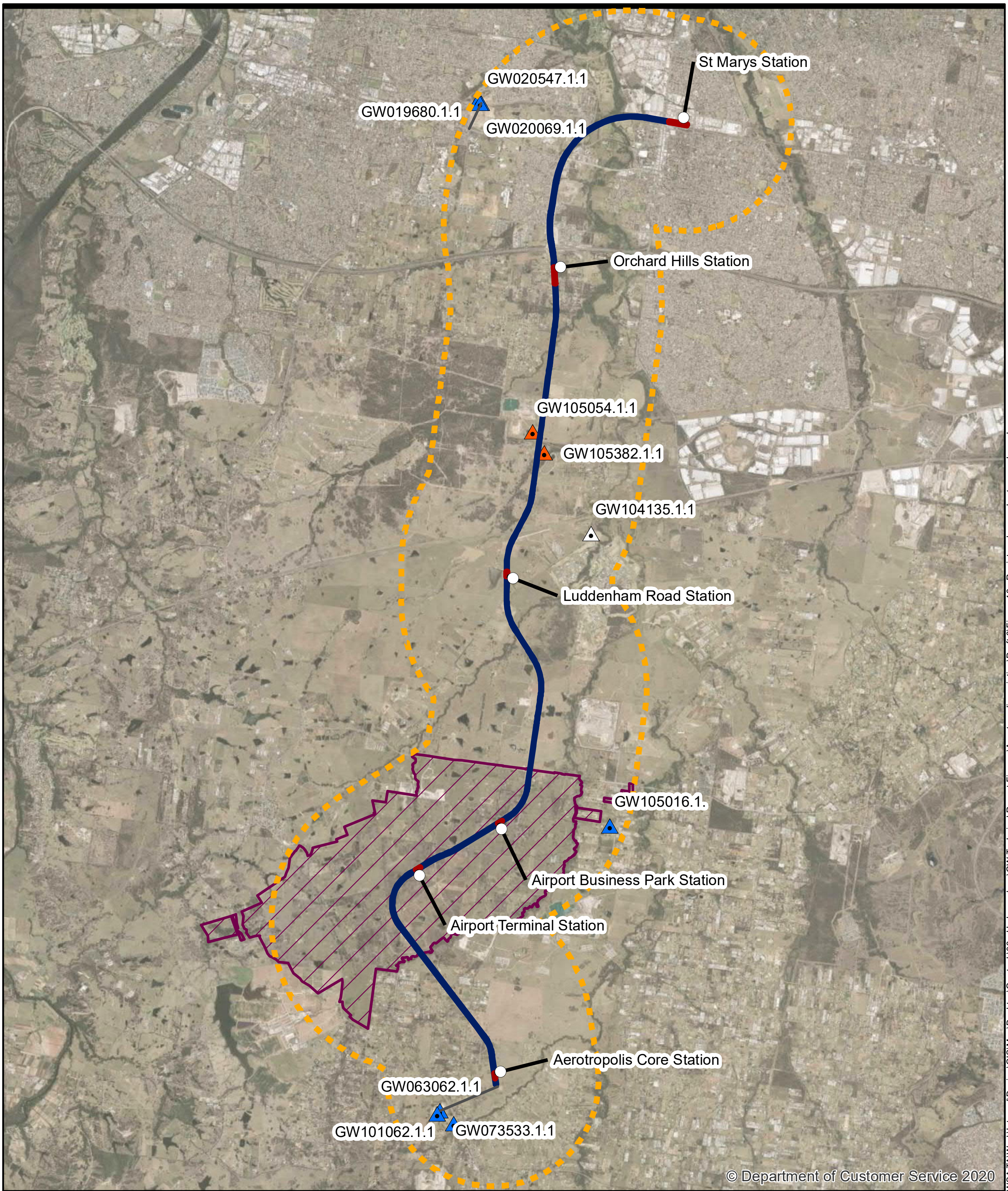
4.2.19 Groundwater users

There are 13 groundwater supply wells within the study area listed on the National Groundwater Information System (NGIS) (BoM, 2019b). Details of these groundwater bores including purpose of the well are summarised in Table 13 and the locations are presented in Figure 18.

The data indicates that groundwater is not extensively used in the study area. Those wells that have been drilled for supply are deep and probably draw fresher water from the underlying Hawkesbury Sandstone. Two wells are used for commercial or industrial supplies; most of the remainder are used for household water supply. There are no supply wells located on the Western Sydney International site.

Table 13: Registered groundwater supply works within study area

Groundwater well ID	Easting (m)	Northing (m)	Ground elevation (mAHD)	Well depth (mbgl)	Type	Approximate distance from alignment (m)	Area
GW020069	290458	6262298	38.7	75.5	Water supply	1,900	North west of study area, west of TBM tunnels
GW019680	290432	6262298	38.8	53.3	Water supply	1,900	
GW020547	290380	6262327	38.4	91.4	Water supply, Industrial	1,950	
GW105054	291424	6256068	44.2	210.0	Commercial and industrial	150	South of Orchard Hills Station
GW105382	291651	6255672	40.9	252.0	Commercial and industrial	125	
GW104135	292536	6254144	37.5	366.0	Unknown	1,300	East of Luddenham Road Station
GW105016	292895	6248599	61.8	252.5	Household Water supply	1,700	East of Airport Business Park Station
GW063062	289671	6243201	88.2	151.0	Household Water supply	1,100	Southwest of Aerotropolis Core Station
GW073533	289618	6243139	91.3	330.0	Household Water supply	1,100	
GW101062	289934	6242958	76.3	220.0	Household Water supply	900	



Legend

- Study area
- Stations
- Project Alignment
- Western Sydney International

Groundwater supply well

- Commercial and Industrial
- Irrigation
- Unknown
- Water supply

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Registered groundwater supply works within study area

Metres
0 1,000 2,000 3,000 4,000

D1	2/07/2020	CJ	JL	JL
Issue	Date	By	Chkd	Appd

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Coordinate System	
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Job No	Figure No
265549-00	**018**

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4.2.20 Environmental values of groundwater

Aquatic ecosystems

Under natural conditions groundwater in the study area ultimately discharges to the numerous creek lines which dissect the landscape. South Creek is the main drainage channel to which groundwater along the alignment ultimately discharges. The salinity contrast between the groundwater and creek flow indicates that the contribution from groundwater is likely to be a small percentage of the total flow.

Despite South Creek being a disturbed creek, water quality criteria for the project have been set to 95% species protection. Discharge from tunnel or station seepage may result in an increase in groundwater discharge rates to surface water. The natural groundwater quality is unlikely to meet the 95% species protection thresholds and any captured water would likely require treatment prior to discharge to the environment.

Drinking water

Groundwater salinity within the study area precludes its use as a potable supply, without significant treatment. The hydraulic conductivity of the Bringelly Shale is also typically very low and would generally be unlikely to yield sufficient water for anything but the smallest supply purposes. Groundwater within alluvial deposits within the study area may be less saline but is still not expected to of adequate quality for drinking water supply.

Irrigation water

Groundwater salinity within the study area is likely to preclude the use of groundwater for irrigation water supply. Groundwater wells drilled within the Bringelly Shale are also likely to be very low yielding and typically may not be suitable for irrigation supply purposes. Groundwater within alluvial deposits within the study area may be less saline and could possibly be of adequate quality to be used as irrigation water. However alluvial deposits within the study area are generally thin and clay dominated and may be unlikely to supply sufficient yield for irrigation purposes. There are no shallow groundwater supply bores screened in alluvial deposits within the study area indicating that they are not used for water supply.

Stock water

Groundwater in some locations within the study area may be within the salinity range for stock drinking water. However, a large proportion of the water quality data is beyond the salinity of the most salt tolerant species.

4.3 Off-airport existing environment

This section provides a summary of the existing off-airport environment. It only considers hydrogeological and environmental data that has been obtained outside of the Western Sydney International site.

4.3.1 Hydrogeology

Hydraulic conductivity

A summary of packer test and slug test data from locations off-airport is presented in Figure 19. All packer test data is from project-specific geotechnical investigations undertaken in 2019 and 2020. The variable head test data is from airport investigations (GHD, 2016) although the data is from locations off site and project investigations. The majority of the test data is from Bringelly Shale, with results ranging from less than $1x10^{-8}$ m/s to more than $1x10^{-5}$ m/s.

A statistical assessment indicated that the average hydraulic conductivity from the off-airport site packer permeability testing was around $6x10^{-7}$ m/s.

Groundwater levels

A summary of the groundwater levels off-airport is presented in Table 14**.**

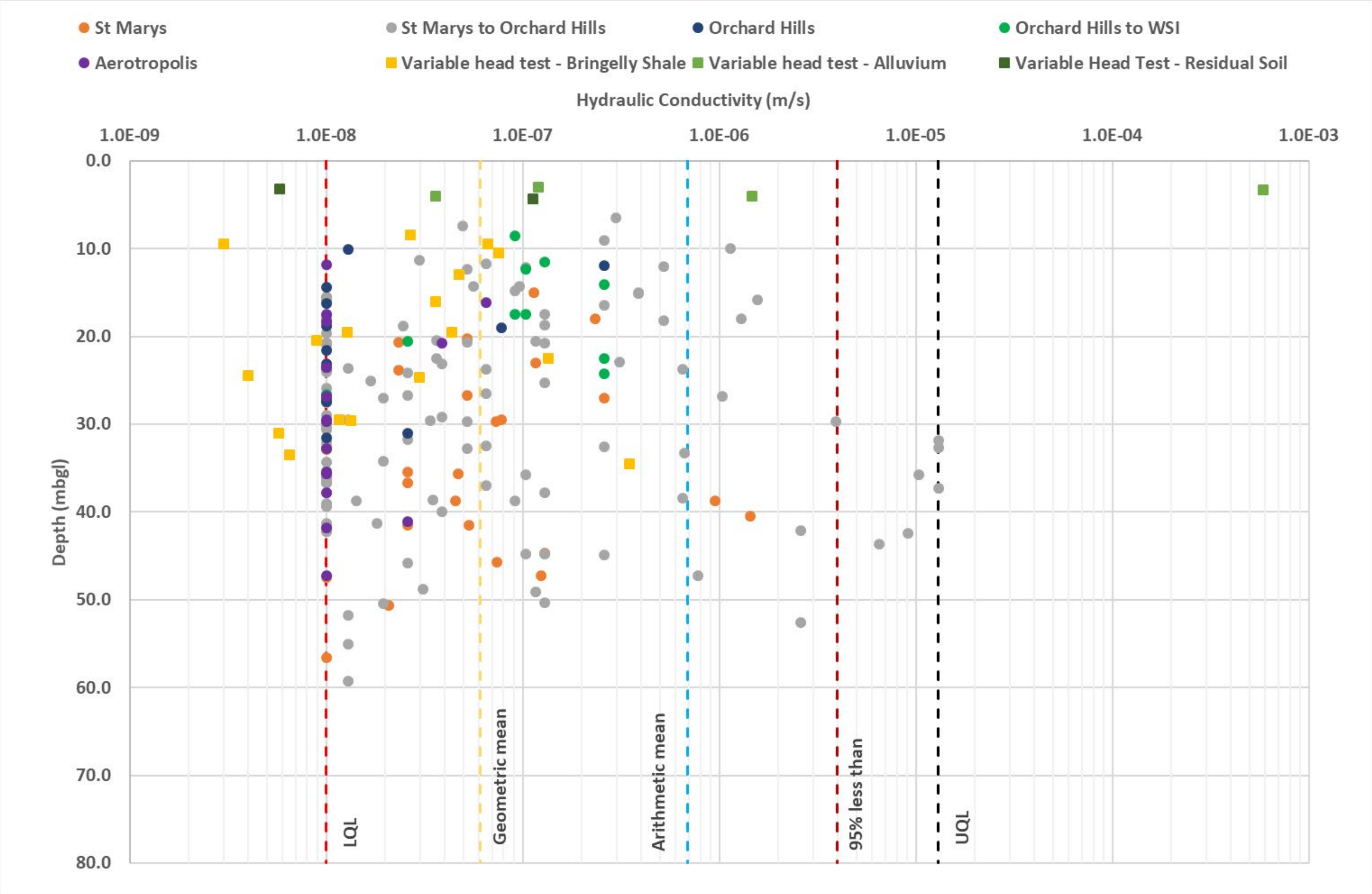
Table 14: Summary groundwater level information – Key off-airport locations

Location	Groundwater level (mbgl)	Groundwater elevation (mAHD)
St Marys Station	-1.7 [1] to 7.7	26.7 to 36.0
Claremont Meadows services facility	1.5 – 2.5	24.9 – 25.6
Orchard Hills Station	3.3 to 5.7	36.2 to 38.1
Aerotropolis Station	1.8 to 5.0	57.6 to 67.3
Notes 1 Rapid pressure response observed in VWP following extreme rainfall event on 10 February 2020. Water pressure observed above ground level for approximately 1.5 days. No similar response was observed in nearby groundwater standpipe		

Table 15 provides details of the groundwater monitoring locations outside of the airport site with dataloggers and a summary of the available groundwater monitoring data.

Figure 20 provides a summary of groundwater monitoring data within the study area. The amount of groundwater level data is insufficient to infer groundwater flow directions. However, it is assumed that similar groundwater conditions to those observed at Western Sydney International are likely to occur along the rest of the alignment.

Figure 19: Hydraulic conductivity summary data – off-airport site (statistics for all packer testing data)



As noted in the hydrogeological landscapes report (OEH, 2011), the shale bedrock in western Sydney forms relatively small to medium side catchments with relatively local flow scales (on the order of a few kilometres). The groundwater catchments appear to broadly align with the surface water catchments (as observed at Western Sydney International, see Section 4.4.1).

Along most of the north-south oriented alignment, geomorphological conditions are repetitive, and consist of a series of NE-SW oriented creek channels, with broad hilly areas in between. Groundwater within each of these smaller catchment areas is likely to follow similar flow directions and gradients, following the topography of the land. Groundwater within the Bringelly Shale can therefore be expected to be nearest the surface close to creek lines and deepest in topographically higher areas and near to catchment watersheds.

Groundwater levels as monitored by multilevel vibrating wire piezometers installed at St Marys and South Creek indicate that there are vertical hydraulic gradients present in these locations. At St Marys, groundwater levels measured in deeper instruments are lower than hydrostatic compared to levels measured by shallower instruments. At South Creek, the opposite occurs and measurements in the deeper shale indicate water levels greater than hydrostatic. This is likely to represent the differences between areas of shale recharge (St Marys) and shale discharge (South Creek). Hydrographs showing the available monitoring data at these locations is presented in Appendix C.

Table 15: Groundwater monitoring well locations (Off-airport site) and data available for assessment

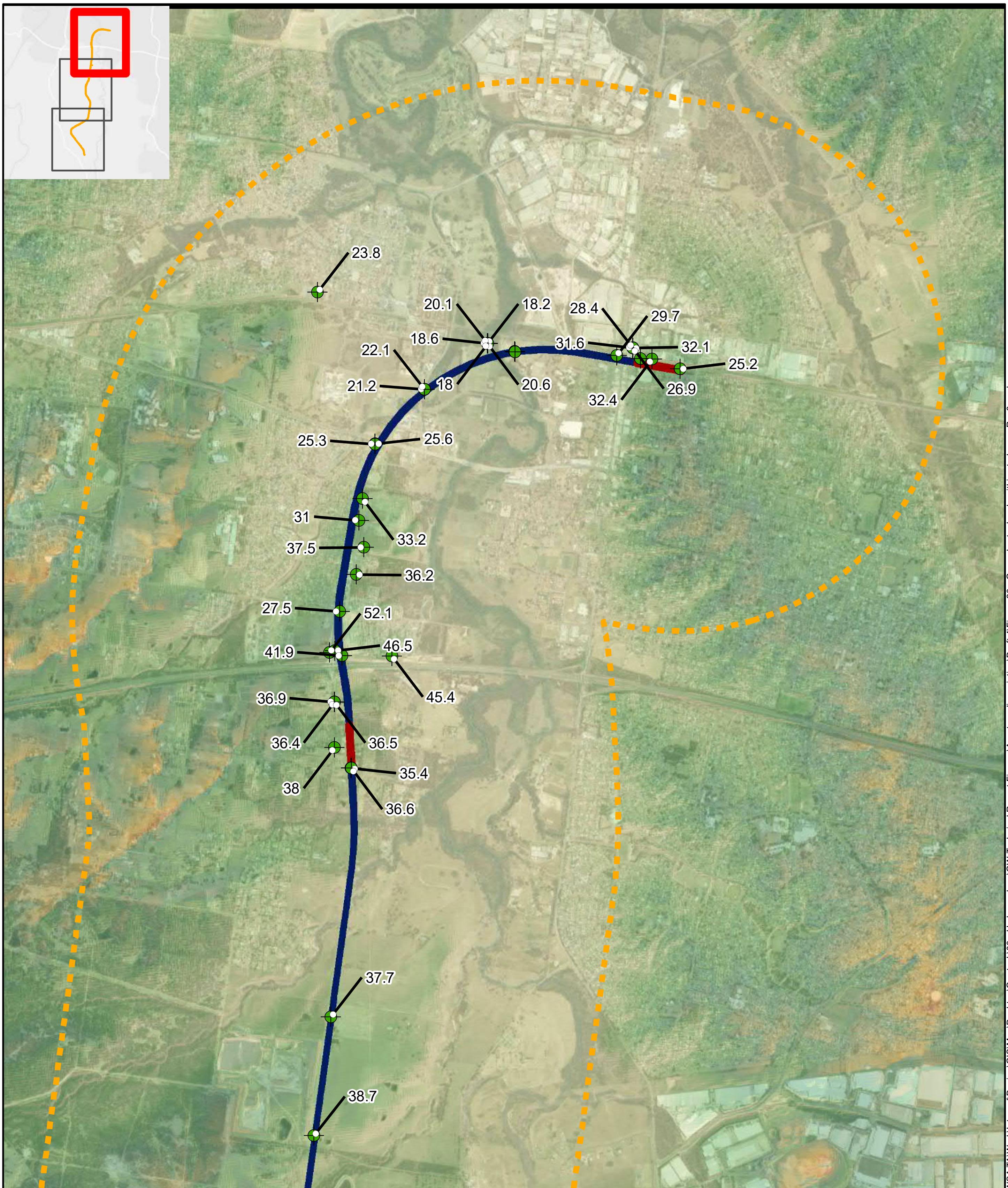
Bore ID	Location	Ground Elevation (mAHD)	Type	Screened interval or VWP installation depth (mbgl)	Unit	Data available from / to [1]	Groundwater level (mbgl)	
							High	Low
SMGW-BH-A001	St Marys	34.4	VWP	8	Residual soil	July-19 – Apr-20	-1.7	2.4
			VWP	18	Bringelly Shale		1.1	2.9
			VWP	26	Bringelly Shale		3.4	6.3
			VWP	31	Bringelly Shale		6.6	7.7
SMGW-BH-A002	St Marys	36.2	Standpipe	22 – 28	Bringelly Shale	Aug-19 – Apr-20	3.7	3.9
SMGW-BH-A011	South Creek	20.1	VWP	5.5	Residual soil	July-19 – Apr-20	-1.5	2.0
			VWP	10.5	Bringelly Shale		1.8	2.2
			VWP	23.5	Bringelly Shale		-2.9	0
			VWP	30	Bringelly Shale		-3.4	-0.4
SMGW-BH-A011S	South Creek	20.0	Standpipe	2 – 5	Alluvium	July-19 – Apr-20	-0.4	2.3
SMGW-BH-A012	Werrington	29.4	Standpipe	25 – 34	Bringelly Shale	July-19 – Apr-20	5.5	5.6
SMGW-BH-A017	Orchard Hills Station	43.6	Standpipe	15 – 24	Bringelly Shale	July-19 – Apr-20	5.5	5.7
SMGW-BH-A019	Gipps Street	42.2	Standpipe	28 – 34	Bringelly Shale	July-19 – Apr-20	4.2	5.2
SMGW-BH-A102	St Marys	36.8	Standpipe	3 - 8	Residual soil	Feb-20 – Apr-20	4.2	4.5
SMGW-BH-A103	St Marys	31.0	Standpipe	15 – 24	Bringelly Shale	Jan-20 – Apr-20	5.8	6.5

Bore ID	Location	Ground Elevation (mAHD)	Type	Screened interval or VWP installation depth (mbgl)	Unit	Data available from / to [1]	Groundwater level (mbgl)	
							High	Low
SMGW-BH-A105	South Creek	22.6	Standpipe	15 – 28	Bringelly Shale	Dec-19 – Apr-20	1.7	2.0
SMGW-BH-A105S	South Creek	22.6	Standpipe	2 – 8	Residual soil	Feb-20 – Apr-20	3.4	3.6
SMGW-BH-A107	South Creek	22.5	Standpipe	19 – 26	Bringelly Shale	Dec-19 – Apr-20	1.3	1.8
SMGW-BH-A107S	South Creek	22.5	Standpipe	3 – 5	Residual soil	Dec-19 – Apr-20	0.4	2.5
SMGW-BH-A109	Claremont Meadows	27.1	Standpipe	16 – 25	Bringelly Shale	Dec-19 – Apr-20	1.5	1.8
SMGW-BH-A109S	Claremont Meadows	27.4	Standpipe	3 – 5	Alluvium	Jan-20 – Apr-20	2.1	2.5
SMGW-BH-A111	Claremont Meadows	41.7	Standpipe	29 - 38	Bringelly Shale	Jan-20 – Apr-20	10.7	11.1
SMGW-BH-A115	Orchard Hills	40.4	VWP	7	Bringelly Shale	Jan-20 – Apr-20	3.3	3.6
			VWP	18	Bringelly Shale	Jan-20 – Apr-20	3.8	4.2
			VWP	21	Bringelly Shale	Jan-20 – Apr-20	3.8	4.1
SMGW-BH-A117	Orchard Hills	38.9	Standpipe	10 – 16	Bringelly Shale	Dec-19 – Apr-20	3.4	4.1
SMGW-BH-A117S	Orchard Hills	38.9	Standpipe	2 – 4	Residual soil	Dec-19 – Apr-20	2.2	2.8
SMGW-BH-A121	Claremont Meadows	38.6	Standpipe	15 – 21	Bringelly Shale	Dec-19 – Apr-20	5.4	7.3
SMGW-BH-A122	Claremont Meadows	41.4	Standpipe	25 – 35	Bringelly Shale	Jan-20 – Apr-20	5.2	5.6

Bore ID	Location	Ground Elevation (mAHD)	Type	Screened interval or VWP installation depth (mbgl)	Unit	Data available from / to [1]	Groundwater level (mbgl)	
							High	Low
SMGW-BH-A123	Orchard Hills	49.0	Standpipe	30 – 39	Bringelly Shale	Feb-20 – Apr-20	21.5	21.8
SMGW-BH-B106	Luddenham Road	39.4	Standpipe	1 – 4	Fill	Apr-20 – Apr-20	1.8	2.3
SMGW-BH-B109	Luddenham Road	41.5	Standpipe	4 – 13	Bringelly Shale	Mar-20 – Apr-20	2.8	3.2
SMGW-BH-B120	Luddenham Road	52.6	Standpipe	5 – 14	Bringelly Shale	Mar-20 – Apr-20	2.8	3.1
SMGW-BH-B121	Luddenham Road	56.6	Standpipe	2 – 3	Residual soil	Mar-20 – Apr-20	3.1	3.6
SMGW-BH-B122	Luddenham Road	59.0	VWP	4	Bringelly Shale	Jan-20– Apr-20	3.7	3.9
				20	Bringelly Shale	Jan-20 – Apr-20	N/A	
SMGW-BH-B123	Luddenham Road	57.2	Standpipe	5 – 14	Bringelly Shale	Mar-20 – Apr-20	N/A	
SMGW-BH-B130	Elizabeth Drive	60.3	Standpipe	5 - 14	Bringelly Shale	Mar-20 – Apr-20	2.6	3.3
SMGW-BH-D103	Bringelly Services	74.7	VWP	10	Bringelly Shale	Feb-20 – Apr-20	5.7	6.1
				25	Bringelly Shale	Feb-20 – Apr-20	7.2	73
				40	Bringelly Shale	Feb-20 – Apr-20	7.6	7.8

[1] Due to data collection issues including problems with telemetry instruments, continuous monitoring of water levels is not available at each location. Groundwater hydrographs in Appendix C2 present the available data at each location over the period of monitoring

N/A – Monitoring ongoing but data not currently available



Legend

- Groundwater Monitoring locations
- Study area
- Stations
- Project Alignment
- Western Sydney International

Topography

mAHD

High : 250

Low : 0

Client

Sydney Metro

Job Title

Sydney Metro – Western Sydney Airport

Figure Title

Groundwater elevations within study area

Metres

0 250 500 750 1,000

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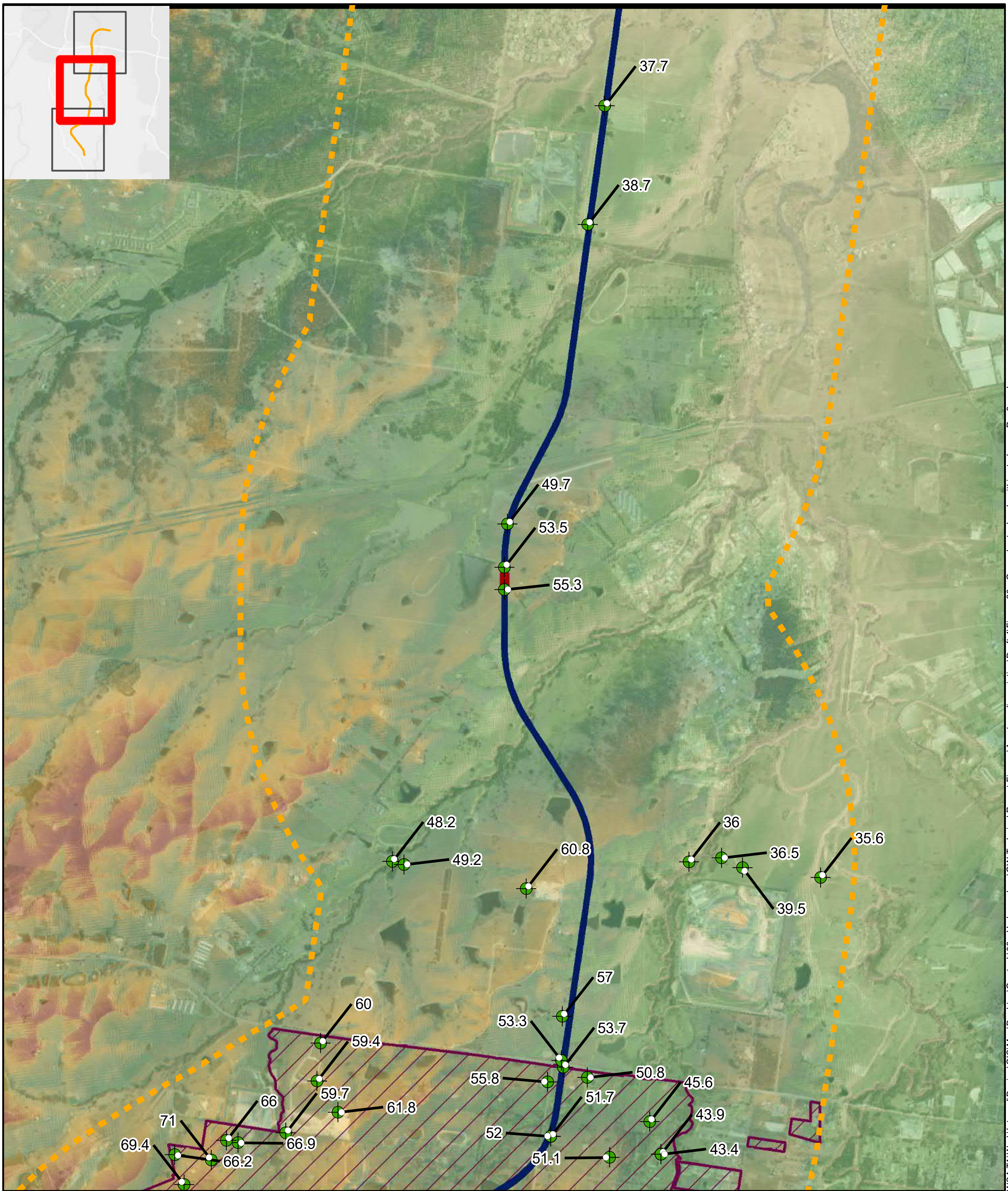

Legend

- Groundwater Monitoring locations
- Study area
- Stations
- Project Alignment
- Western Sydney International

Topography

mAHD

High : 250

Low : 0

Client
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Job Title
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Figure Title
Groundwater elevations within study area

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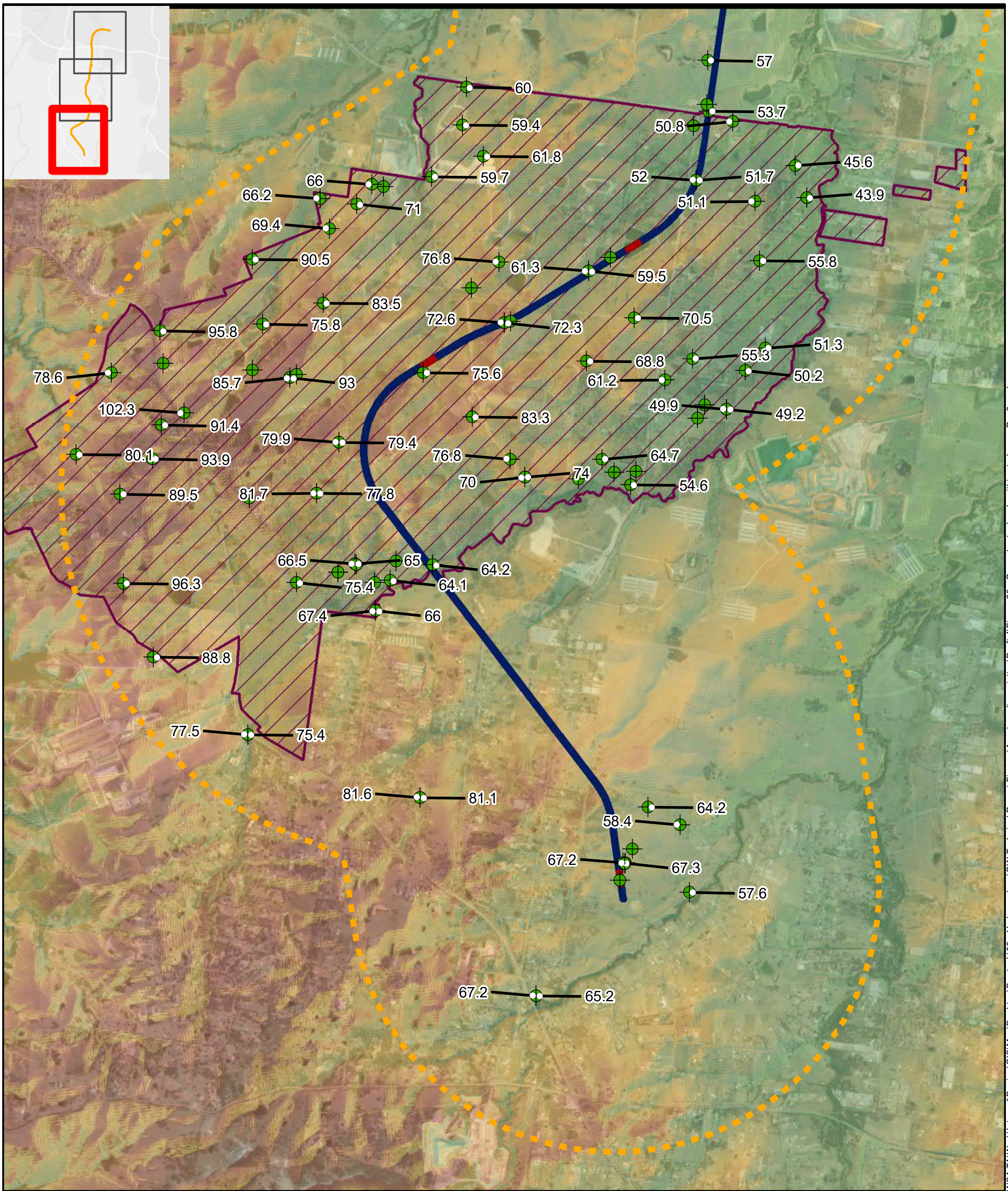

Legend

- Groundwater Monitoring locations
- Study area
- Stations
- Project Alignment
- Western Sydney International

Topography

mAHD

High : 250

Low : 0

Client
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Job Title
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Figure Title
Groundwater elevations within study area

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4.3.2 Groundwater quality

Groundwater quality in the off-airport areas is expected to be as described in Section 4.2.15. Groundwater salinity is mostly saline although some marginal to brackish quality water has been observed in the off-airport data available.

Groundwater contamination testing was undertaken at 19 off-airport locations from standpipes installed as part of geotechnical investigations for the project. The results were compared to trigger levels for assessing fresh and marine water quality based on the ANZECC 95% threshold for freshwater ecosytem guidelines (ANZG, 2018).

Table 16 provides a summary of the quality and contamination testing data measured at off-airport site locations. Electrical conductivity of the available data showed values ranging from 1,500 to 36,000 µS/cm with a mean of 11,500 µS/cm. These are predominantly above the salinity criteria for lowland rivers of NSW (125 to 2,200 µS/cm).

Contamination testing data indicates exceedances above the 95% threshold for ammonia, nitrate, phosphorous and several heavy metals. Elevated ammonia and phosphorous (above the 95th percentile criteria) were observed in just under half of the samples. It is possible that the nutrients are present in groundwater due to the rural setting; farming practices introduce fertilisers and other organic material to the soils diffusely over a wide area which can migrate into underlying groundwater.

A range of elevated heavy metals were detected in the groundwater with a number of exceedances above the 95% threshold. Cobalt, Nickel and Zinc had the greatest number of exceedances compared to the number of samples collected. Given the wide distribution of groundwater samples, it is unlikely that heavy metals within the groundwater are from a point source and may either be naturally elevated or from a diffuse source. Parameters that exceeded the 95% threshold water quality criteria are presented in Table 16.

A standpipe was installed at BH-A019 adjacent to Gipps Street landfill with a screen interval between 28 and 34 metres below ground level. The groundwater sample obtained had unusually high hydroxide alkalinity (resulting in a high pH) and exceedances of nitrogen and phosphorous. Other than the hydroxide alkalinity, no other contaminants outside of those observed more broadly in the study area were noted at this location. It is noted that the high pH and alkalinity at this location was as a result of a defective groundwater installation with grout contamination and is therefore not representative of the groundwater quality.

The results of groundwater quality testing indicate that groundwater across the project alignment is expected to have elevated salinity and contain elevated concentrations of heavy metals and nutrient loading. Planned future groundwater quality testing from across the alignment would be used to confirm site specific groundwater quality at each of the project elements. Detailed groundwater quality testing results are presented in Appendix D.

Table 16: Groundwater quality test results summary from off-airport site project locations

Parameter [1]	ANZECC 2018 freshwater ecosystem guideline (95%)	Test Results		
		Minimum	Maximum	No of tests (exceedances)
pH Value [2]	6.5 – 8.5 (lowland rivers – NSW)	5.1	9.8	37 (7)
EC @ 25°C (µS/cm) [2]	125 – 2,200 (lowland rivers – NSW)	1,490	33,600	38 (35)
Ammonia	900	< 10	12,500	42 (16)
Nitrate	500	< 10	4,000	42 (2)
Total Phosphorous	50	< 20	680	43 (18)
Aluminium	55	< 10	2,400	43 (5)
Cadmium	0.2	< 0.1	0.6	45 (2)
Chromium	1	<1	107	44 (2)
Cobalt	1	< 1	497	44 (35)
Copper	1.4	< 1	37	45 (12)
Lead	3.4	< 1	3.7	45 (2)
Manganese	1,900	< 1	7,920	45 (7)
Nickel	11	< 1	18	45 (38)
Selenium	5	< 1	30	43 (2)
Zinc	8	< 5	33	45 (19)

[1] Table only includes parameters which exceed the 95% for freshwater ecosystem criteria
[2] Includes recorded field measurements
All units in µg/l unless otherwise stated
< indicates limit of detection of analysis method

4.3.3 Groundwater dependent ecosystems

Table 17 provides a summary of the potential GDEs (from the BoM data GDE database) within the study area located off the airport site. These are shown on Figure 21. Each of the vegetation communities listed in Table 17 are 'high probability groundwater dependent ecosystems' according to the NSW Office of Water Risk guidelines for GDEs (DPI, 2012).

Aquatic GDEs

The entire length of the main channel of South Creek is mapped as a high potential aquatic GDE (Figure 21). It is anticipated that any GDE along South Creek is likely to be reliant on alluvial groundwater, rather than that from the Bringelly Shale bedrock. Although groundwater interflow between the Bringelly Shale and the alluvium occurs, the discharge rate is expected to be low and represents a small proportion of the total flow within the creek (with minimal influence on GDE communities).

Terrestrial GDEs

High potential terrestrial GDEs are associated with most creek lines within the study area. These GDE communities are predominantly Cumberland River Flat Forest and Swamp Oak floodplain forest. Other potential GDE communities within the study area include Cumberland Shale Plain woodland and Cumberland Shale Hills Woodland.

Vegetation mapping data (OEH, 2017) indicates that there are many areas of potentially groundwater dependent remnant native vegetation that are thinned or scattered across the study area. The main areas of intact vegetation communities close to the rail alignment are areas of River Flat Forest between Orchard Hills Station and Luddenham Road Station, and Shale Gravel Transition Forest located adjacent (to the east) of Orchard Hills Station. Technical Paper 3 ((Biodiversity Development Assessment Report) presents further information relating to native vegetation communities and mapping showing the location of these communities along the project alignment.

Subterranean GDEs

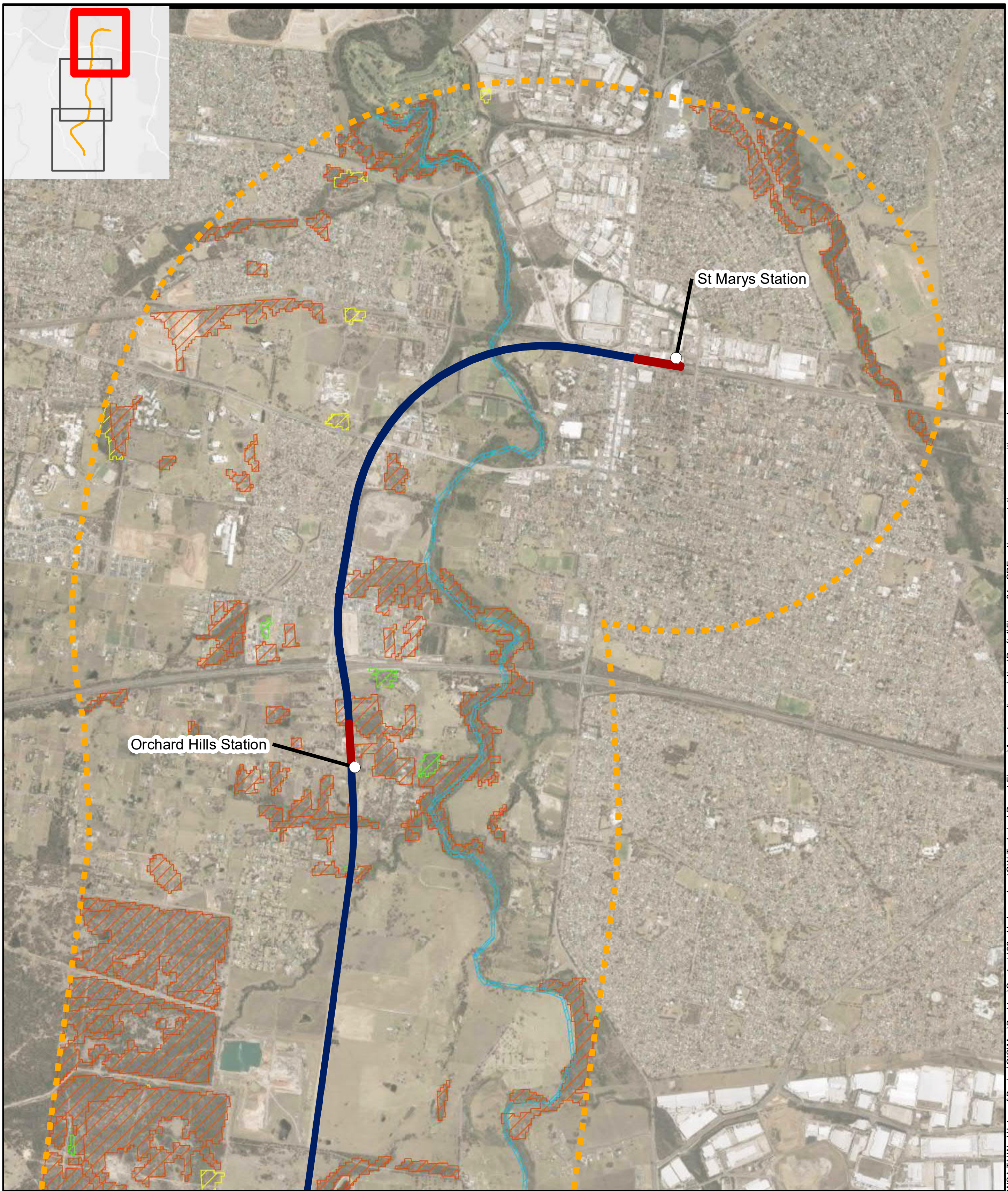
No Subterranean GDEs are known to exist in the off-airport study area. The Water Sharing Plan for the Sydney Metropolitan Region Groundwater Sources (NSW, 2015) lists no subterranean GDEs within the water sharing region.

Wetlands

There are no Ramsar or nationally important wetland systems within the study area. The Water Sharing Plan for the Sydney Metropolitan Region Groundwater Sources (OEH, 2011) indicates that there are no high priority wetland GDEs within the study area.

Table 17: Potential GDEs off-airport site (from BoM GDE Atlas)

GDE Potential	Type	Ecosystem type/PCT Type	Location
High from national assessment	Aquatic	River (South Creek)	South Creek
Moderate to high from national assessment	Terrestrial	Cumberland River Flat Forest/ PCT 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Along major creek lines including South Creek, Cosgroves Creek, Blaxland Creek, Claremont Creek, Thompsons Creek
Moderate to high from national assessment	Terrestrial	Cumberland Shale Plains Woodland/ PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Various locations throughout study area although predominantly located in small patches south of Elizabeth Drive. Larger areas of woodland between M4 and Luddenham Road Station (within Cumberland Plain Priority Conservation Lands)
Moderate to high from national assessment	Terrestrial	Cumberland Shale Hills Woodland/ PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Predominantly located in small patches south of Badgerys Creek
Moderate from national assessment	Terrestrial	Castlereagh Ironbark Forest/ PCT 725 Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	A small area east of Badgerys Creek, adjacent to Elizabeth Drive,
High from national assessment	Terrestrial	Castlereagh Shale Gravel Transition Forest / PCT 724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Along Ropes Creek to the north of study area and adjacent to Orchard Hills Station



Legend

- Study area
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Groundwater dependent ecosystems (BoM, 2017)

- High potential Terrestrial GDE - from national assessment
- Moderate potential Terrestrial GDE - from national assessment
- Low potential Terrestrial GDE - from national assessment
- High potential Aquatic GDE - from national assessment

Client
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Job Title
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Figure Title
Groundwater dependent ecosystems

Metres
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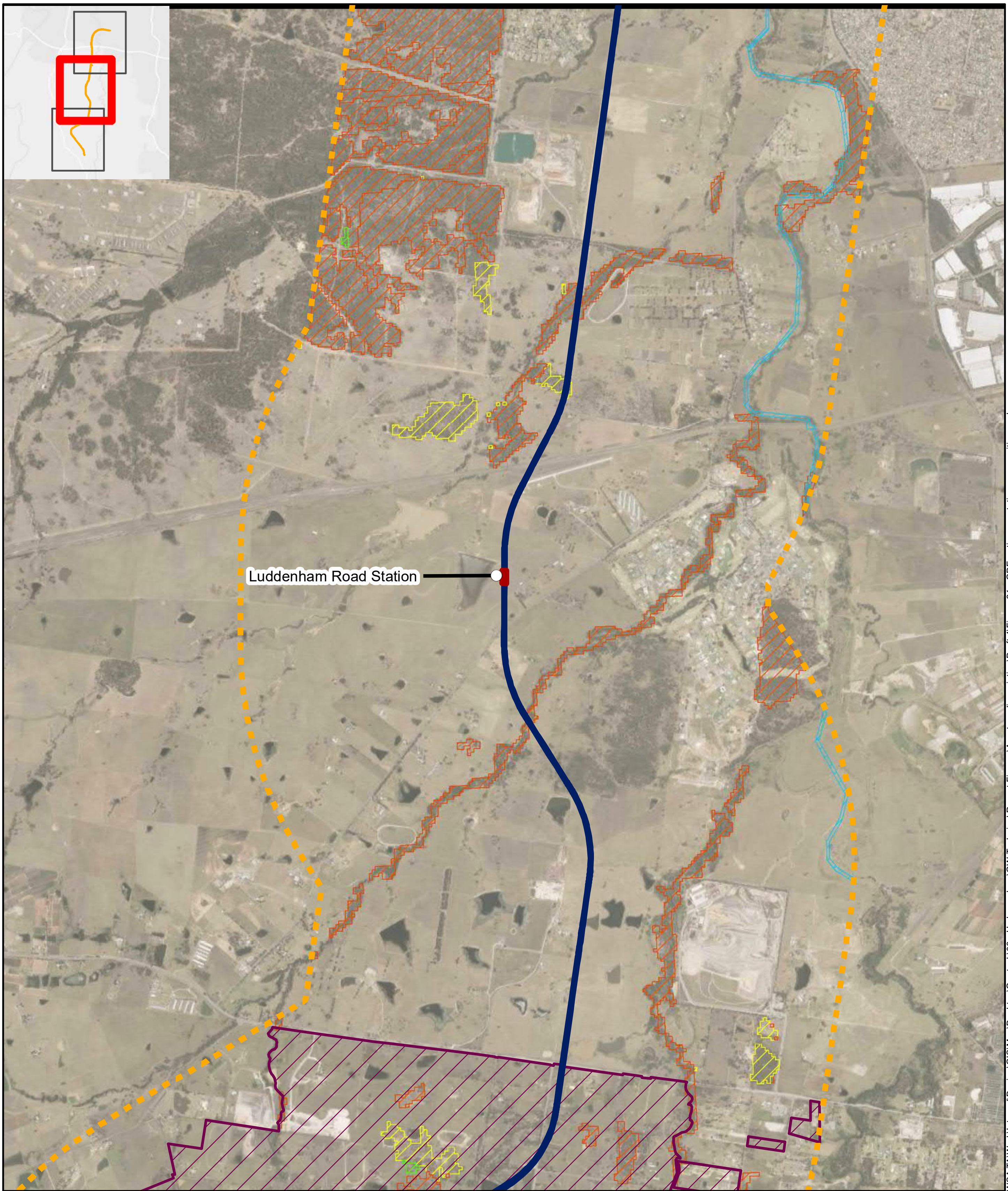

Legend

- Study area
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- Western Sydney International

Groundwater dependent ecosystems (BoM, 2017)

- High potential Terrestrial GDE - from national assessment
- Moderate potential Terrestrial GDE - from national assessment
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- High potential Aquatic GDE - from national assessment

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Groundwater dependent ecosystems

Metres
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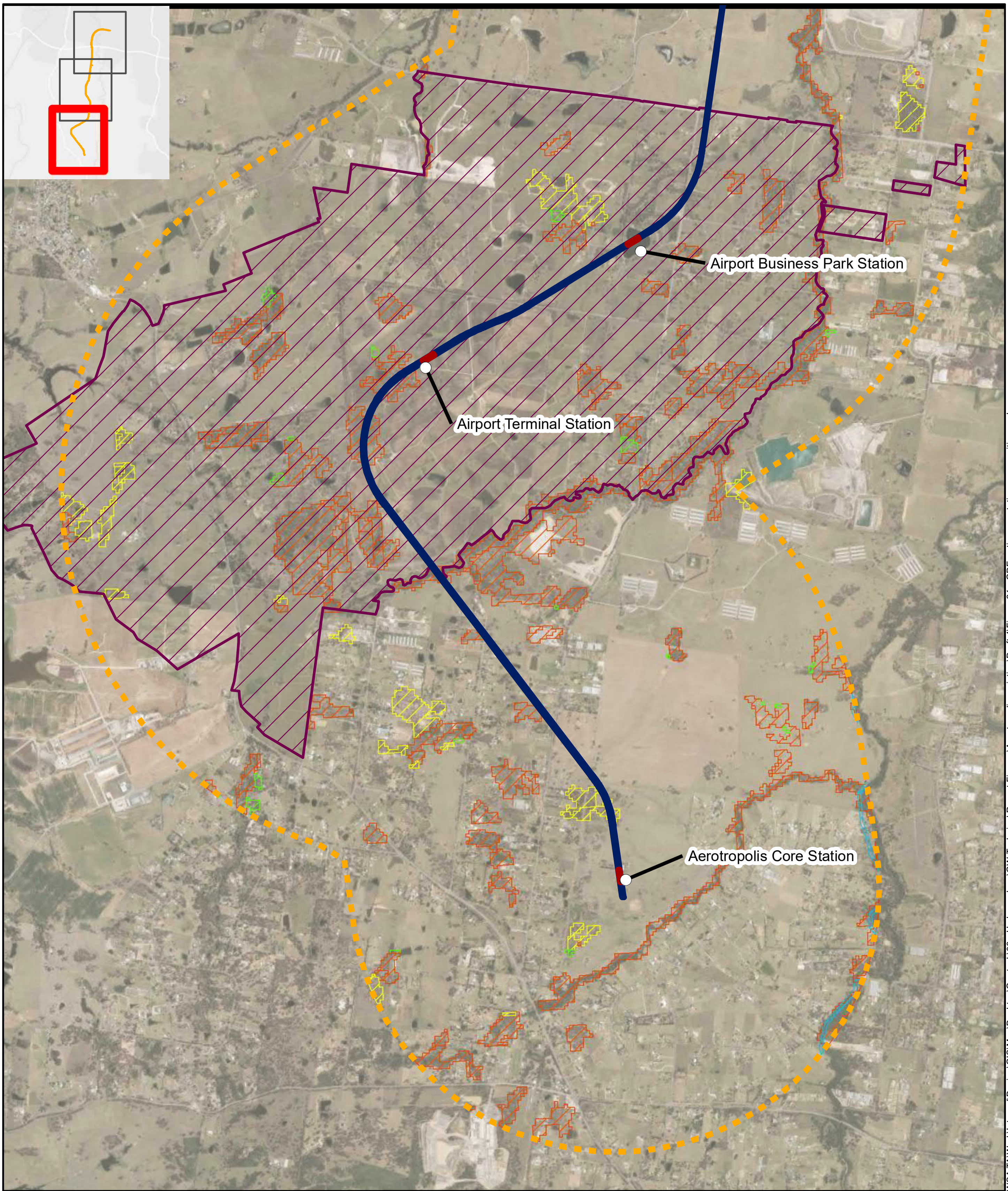

Legend

- Study area
- Project Alignment
- EIS_Construction_footprint
- Western Sydney International

Groundwater dependent ecosystems (BoM, 2017)

- High potential Terrestrial GDE - from national assessment
- Moderate potential Terrestrial GDE - from national assessment
- Low potential Terrestrial GDE - from national assessment
- High potential Aquatic GDE - from national assessment

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Groundwater dependent ecosystems

Metres
0 250 500 750 1,000

D1	19/08/2020	CJ	JL	JL
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265549-00	**021 - Sheet 3**

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4.4 On-airport existing environment

This section provides a summary of the existing on-airport environment. It only considers hydrogeological and environmental data that has been obtained within the Western Sydney International site. For general information relating to the existing environment within the study area, refer to Section 4.2.

4.4.1 Hydrogeology

Hydraulic conductivity

A summary of packer test data from locations on Western Sydney International is presented in Figure 22. The test results indicate hydraulic conductivity values ranging from less than $1x10^{-8}$ m/s to $9x10^{-6}$ m/s. Packer test and slug test data from the airport site generally indicated somewhat higher hydraulic conductivity values than observed from the Bringelly Shale outside of Western Sydney International however no testing was undertaken at depths greater than 40 metres. Testing undertaken close to Badgerys Creek indicated zones of higher hydraulic conductivity within the shale between depths of 20 and 40 metres below ground level.

Groundwater levels

A summary of the groundwater level monitoring data within the airport site (based on pre-existing conditions and FSL) is presented in Table 19**.**

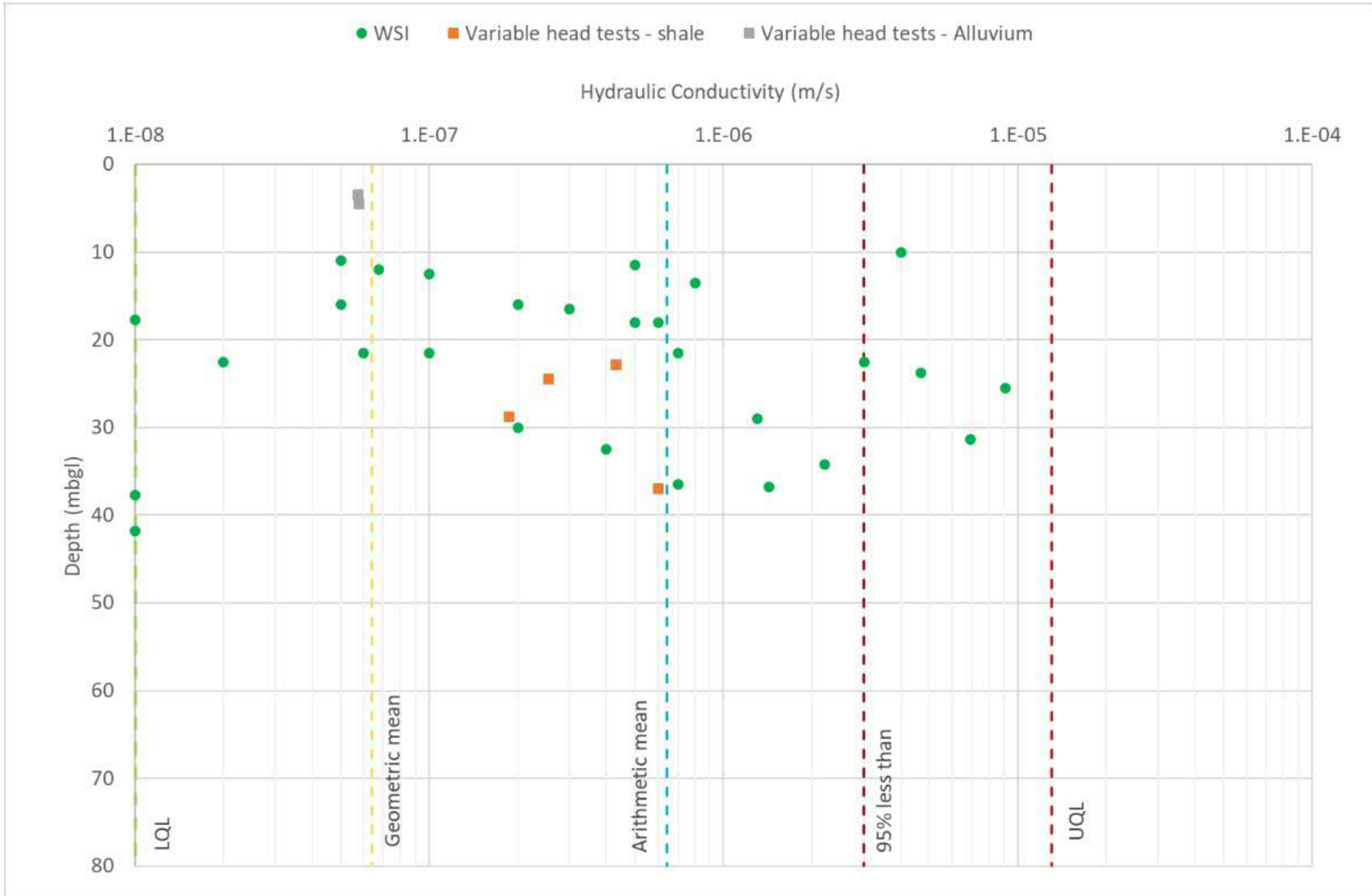
Table 18: Summary groundwater level information – Bringelly Shale

Location	Groundwater elevation (mAHD)	Groundwater level (m below existing ground level)	Groundwater level relative to FSL
Western Sydney International tunnel portal	57 to 67	0.5 to 3	3m below FSL to 2m above FSL [1]
Airport Terminal Station	74 to 76	0.5 to 3.5	8m to 9m below FSL
Airport Rail Tunnels	67 to 80	2 to 9	2m below to 11m below FSL
[1] Areas of cut at Western Sydney International mean that existing groundwater levels are above FSL level			

Table 19 provides details of the groundwater monitoring locations at Western Sydney International with groundwater installed dataloggers and a longer-term monitoring dataset. Groundwater hydrographs at these locations are presented in Appendix C.

Groundwater monitoring hydrographs indicate that there are vertical downward gradients within the Bringelly Shale at Western Sydney International. This may be indicative of vertical recharge within the shale and high anisotropy, which is likely to due to the bedded nature of the shale units.

Figure 22: Hydraulic conductivity summary data – on-airport site (statistics for all project data)



Most groundwater monitoring within the Bringelly Shale showed limited response to rainfall events (see Appendix C). Although much of the data indicated that there was fluctuation in groundwater level within the shale bedrock this did not generally correlate well with the rainfall record. Of those monitoring locations which showed some change, shallow piezometers tended to show greater response.

Figure 24 presents the groundwater hydrograph from VW-R-02 at Western Sydney International. The shallow vibrating wire piezometer installed at 10 metres below ground level showed changes in groundwater level of up to one metre in response to rainfall events where daily rainfall exceeded 15 millimetres. The deeper instrument installed at 22 metres below ground level showed negligible response to individual rainfall events.

A review of maximum and minimum groundwater levels showed that there was some tendency for groundwater levels to be highest between May and September, with several locations having maximum water levels recorded in July. Conversely, groundwater levels showed some tendency to be lowest between November and March. This response is typical for groundwater where recharge takes place during winter periods, although is somewhat contrary to the rainfall patterns which tend to be highest in the summer and lower in the winter months. The cause of this is likely to be that summer rainfall is often intense with large amounts falling over short durations. This is generally not conducive to recharge as most of the water is lost as surface runoff. High evaporation and soil moisture deficits in the summer also contribute, meaning that less rainfall overall is recharged. Longer term monitoring would be required to provide further assessment of the seasonal groundwater response in the Bringelly Shale.

Groundwater level data is reproduced as groundwater contour plan in Figure 23. The contours indicate that groundwater broadly forms a subdued version of the topography which may be as a result of increased recharge in elevated areas.

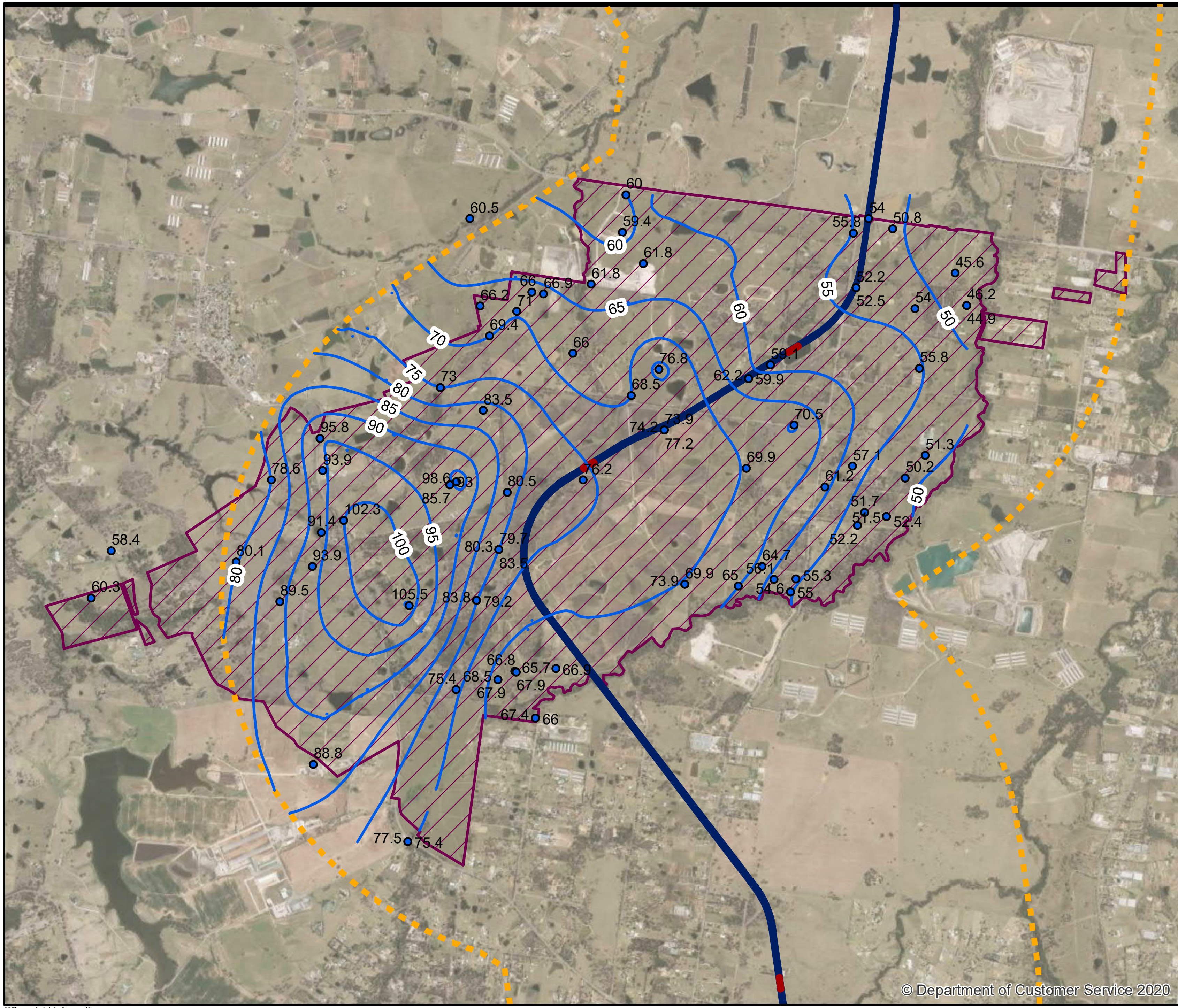
Groundwater gradients within the Bringelly shale appear to be relatively shallow, around 1%. Flow directions are generally in a northerly and easterly direction towards Cosgroves Creek and a southerly and easterly direction towards Badgerys Creek and South Creek. To the west of the surface watershed, groundwater appears to flow westwards towards Duncans Creek.

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

Table 19: Groundwater monitoring well locations (Western Sydney International site)

Bore ID	Ground Elevation (mAHD)	Type	Screened interval or VWP installation depth (mbgl)	Unit	Data available from / to	Groundwater level high		Groundwater level low	
						mbgl	mAHD	mbgl	mAHD
VW-R-01	54.1	Vibrating wire piezometer	20	Bringelly Shale	July-17 – May-19	1.9	52.2	5.2	48.9
			10	Bringelly Shale	July-17 – May-19	1.6	52.5	3.3	50.8
VW-R-02	62.3	Vibrating wire piezometer	22	Bringelly Shale	July-17 – May-19	2.4	59.9	3.6	58.7
			10	Bringelly Shale	July-17 – May-19	0.1	62.2	1.6	60.7
VW-R-03	85.7	Vibrating wire piezometer	30	Bringelly Shale	July-17 – May-19	11.8	73.9	13.9	71.8
			20	Bringelly Shale	July-17 – May-19	11.5	74.2	13.5	72.2
			10	Bringelly Shale	July-17 – May-19	8.5	77.2	11.3	74.4
VW-R-04	80.3	Vibrating wire piezometer	20	Bringelly Shale	July-17 – May-19	10.4	69.9	12.3	68.0
			10	Bringelly Shale	July-17 – May-19	6.4	73.9	9.2	71.1
VW-R-05	91.0	Vibrating wire piezometer	35	Bringelly Shale	July-17 – May-19	11.3	79.7	11.9	79.1
			22	Bringelly Shale	July-17 – May-19	10.7	80.3	11.4	79.6
			10	Bringelly Shale	July-17 – May-19	7.5	83.5	8.4	82.6
VW-R-06	71.0	Vibrating wire piezometer	20	Bringelly Shale	July-17 – May-19	5.3	65.7	13.9	57.1
			10	Bringelly Shale	July-17 – May-19	4.2	66.8	5.8	65.2
BH-D-171	104.2	Vibrating wire piezometer	5	Residual soil	Feb-17 – May-19	Groundwater below piezometer tip			
			12	Bringelly Shale	Feb-17 – May-19	Groundwater below piezometer tip			
			20	Bringelly Shale	Feb-17 – May-19	10.3	93.9	12.4	91.8
BH-D-172	102.7	Vibrating wire piezometer	5	Residual soil	Mar-17 – May-19	Groundwater below piezometer tip			
			12	Bringelly Shale	Mar-17 – May-19	9.7	93.0	11.3	91.4
			25	Bringelly Shale	Mar-17 – May-19	17.0	85.7	18.0	84.7
BH-D-173	96.4		6	Residual soil	Feb-17 – May-19	Groundwater below piezometer tip			

Bore ID	Ground Elevation (mAHD)	Type	Screened interval or VWP installation depth (mbgl)	Unit	Data available from / to	Groundwater level high		Groundwater level low	
						mbgl	mAHD	mbgl	mAHD
		Vibrating wire piezometer	16	Bringelly Shale	Feb-17 – May-19	12.9	83.5	17.4	79.0
BH-D-174	81.6	Vibrating wire piezometer	6	Residual soil	Mar-17 – Dec-18	Groundwater below piezometer tip			
			16	Bringelly Shale	Mar-17 – Dec-18	Groundwater below piezometer tip			
BH-D-175	81.4	Vibrating wire piezometer	4	Residual soil	Feb-17 – May-19	Groundwater below piezometer tip			
			11	Bringelly Shale	Feb-17 – May-19	4.6	76.8	10.0	71.4
BH-R-01	55.7	Standpipe	14 – 20	Bringelly Shale	Jan-18 – May-18	1.7	54.0	2.3	53.4
BH-R-08	61.5	Standpipe	24 – 30	Bringelly Shale	Jan-17 – Jun-18	2.4	59.1	3.1	58.4
BH-R-21	78.6	Standpipe	12.5 – 18.5	Bringelly Shale	Jan-17 – May-19	2.4	76.2	3.7	74.9
BH-R-34	71.1	Standpipe	4 – 10	Bringelly Shale	Jan-17 – May-19	3.2	67.9	4.2	66.8
BH-R-42	81.3	Standpipe	18 – 24	Bringelly Shale	Jan-17 – Mar-18	0.9	80.5	4.7	76.6
WSA GW05	74.0	Standpipe	7 – 10	Bringelly Shale	Jan-17 – Dec-18	5.5	68.5	6.5	67.5
WSA GW06	88.3	Standpipe	17 – 20	Bringelly Shale	Jan-17 – Dec-18	9.1	79.2	10.1	78.2
WSA GW07	88.0	Standpipe	7 – 10	Bringelly Shale	Jan-17 – Dec-18	4.3	83.8	5.9	82.1
WSA GW08	67.8	Standpipe	7 – 10	Bringelly Shale	Jan-17 – Dec-18	0.9	66.9	2.3	65.4
WSA GW17	53.9	Standpipe	17 – 20	Bringelly Shale	Jan-17 – Dec-18	2.4	51.6	3.7	50.3
WSA GW18	53.9	Standpipe	7 – 10	Bringelly Shale	Jan-17 – Dec-18	1.6	52.4	3.0	50.9
WSA GW19	58.3	Standpipe	7 – 10	Bringelly Shale	Jan-17 – Dec-18	4.3	54.1	7.3	51.0
SMGW-BH-C001S	67.0	Standpipe	2 – 4	Alluvium	Jul-19 – Apr-20	1.3	65.7	3.9	63.1
SMGW-BH-C002	66.8	Standpipe	6 - 15	Bringelly Shale	Jul-19 – Apr-20	-0.9	67.7	2.5	64.3



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Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Western Sydney International groundwater elevation map

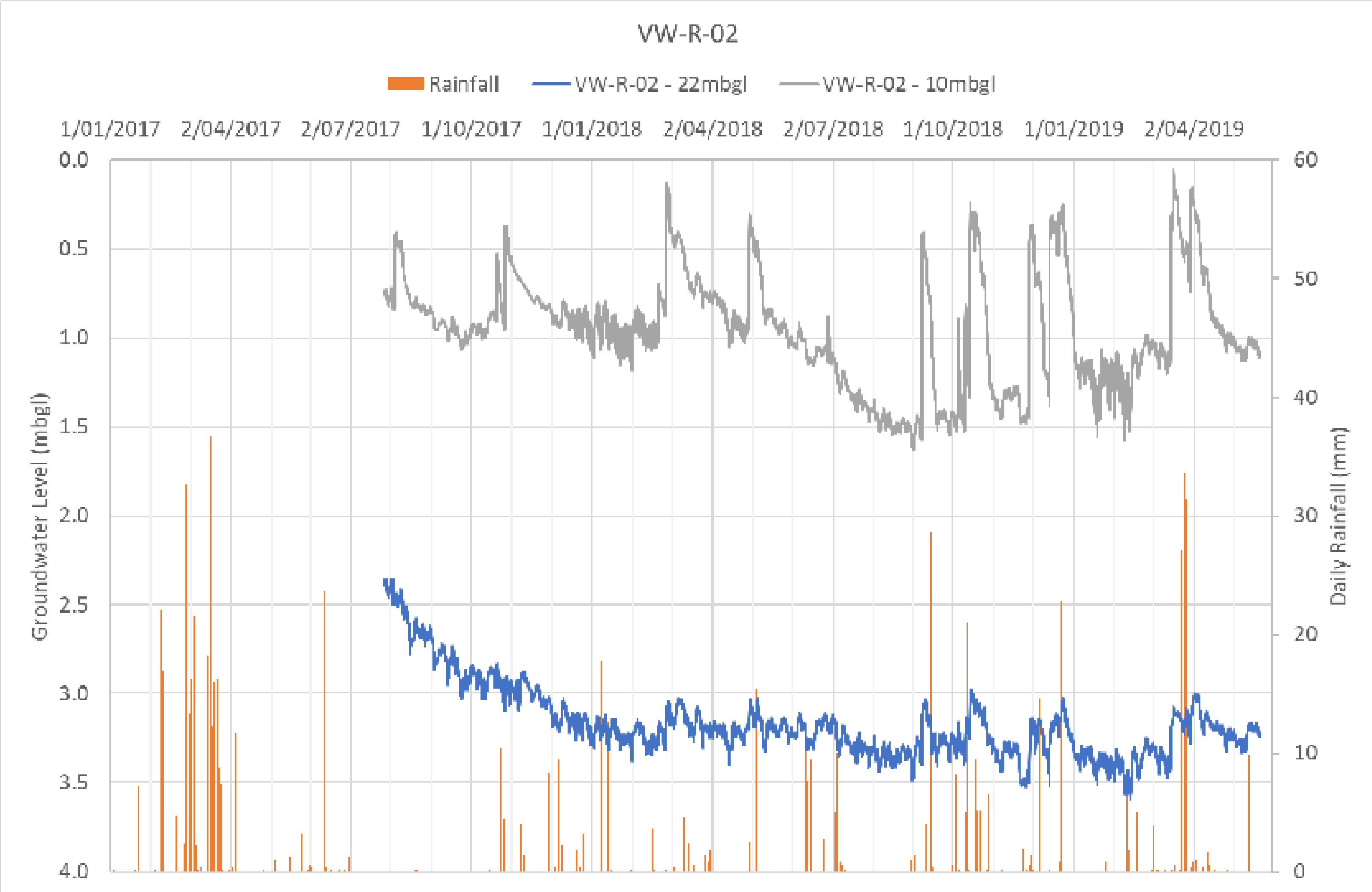
Scale at A4	Figure Status
1:40,000	**Issue**

Coordinate System
GDA 1994 MGA Zone 56

Job No	Figure No
265549-00	**023**

\\global.arup.com\australasia\SYD\Projects\265000\265549-00 SMWSA TA\Work\Internal\Design\GIS\Map\Desktop\Geotech\03 - Hydrogeology\GW Technical Report Figures\Aerotropolis variation\Draft 3\Figure 23 - WSI - groundwater elevation contours.mxd

Figure 24: Groundwater hydrograph – VW-R-02



4.4.2 Groundwater quality

Groundwater contaminant testing was conducted at 15 sampling locations across Western Sydney International between April 2018 and April 2019 (Table 20). None of the groundwater samples collected were located directly within the rail line corridor. Additionally, a total of 13 samples from two project specific boreholes between September-19 and April-20, close to Badgerys Creek have been collected to evaluate groundwater quality. These results are presented in Table 20.

Ongoing groundwater quality testing is being undertaken as part of the CEMP for Western Sydney Airport. Groundwater quality data as part of this program was not available for the purposes of this Techncial Paper but may be available for future phases of design development for the project.

The test results at the aiport included trace metals, nutrients, organic hydrocarbons and pesticides. The results of the testing indicated detections of trace metals, nutrient parameters and minor detections of organic hydrocarbons (total petroleum hydrocarbons – one sample, PAHs – 4 samples and VOCs – 3 samples), however these were not consistently detected across the monitoring period.

Those tests that resulted in exceedances of the ANZECC 95 per cent threshold for freshwater ecosytem guidelines (ANZG, 2018) or the freshwater criteria for NSW lowland rivers are detailed in Table 20. The data showed that the groundwater quallity has background concentrations of copper, lead, nickel and zinc above the 95 per cent ANZECC freshwater criteria.

Groundwater salinity as measured by the electrical conductivity varied from between 600 and 41,000 µS/cm, mostly well above the criteria for lowland rivers. Only a single borehole had a measured salinity within the freshwater range. This appears to be an outlier in comparison to the rest of the groundwater quality data. It is unclear from the available information as to the cause of this better-quality groundwater.

Approximately half of the samples tested for ammonia exceeded the 95 per cent guideline value for freshwater ecosystems. Around half the samples also had concentrations of nitrogen in excess of the threshold for lowland rivers.

Groundwater quality testing from the two project monitoring wells on Western Sydney Airport showed similar exceedances to the Western Sydney Airport monitoring. This included elevated nutrients and heavy metals including Cobalt, Manganese and Zinc. Of those samples, roughly a third to two thirds showed some exceedances above the 95 per cent guideline value for freshwater ecosystems.

Elevated heavy metals, ammonia and nitrogen have been reported in the region in other studies (TfNSW, 2019) and may be because of the predominantly agricultural land use in the study area. It is possible that groundwater may also have naturally elevated concentrations of heavy metals within the groundwater. The results of groundwater quality testing on the airport site are broadly in line with those off airport, as discussed in Section 4.3.2.

Table 20: Groundwater quality (contamination) test results summary from Western Sydney International

Parameter	ANZECC freshwater ecosystem guidelines (95%)	Test Results [1]		
		Minimum	Maximum	No of tests (exceedances)
pH Value [2]	6.5 – 8.5 (lowland rivers – NSW)	5.0	7.5	78 (8)
EC @ 25°C (µS/cm) [2]	125 – 2,200 (lowland rivers – NSW)	590	40,800	80 (79)
Nitrogen	500	< 0.2	2300	16 (7)
Phosphorous	50	20	1,000	70 (45)
Ammonia as N	900	< 10	7,800	71 (39)
Copper	1.4	< 1	87	71 (48)
Lead	1	< 1	8	71 (1)
Nickel	11	< 1	93	73 (20)
Toluene	180	< 2	426	2 (1)
Zinc	8	< 5	90	71 (59)

Notes
[1] Table only includes parameters which exceed the 95% for freshwater ecosystem criteria
[2] Includes recorded field measurements
All units in μg/l unless otherwise stated
< indicates limit of detection of analysis method

Table 21: Groundwater quality test results summary BH-C001S and BH-C002

Parameter	ANZECC freshwater ecosystem guidelines (95%)	Test Results [1]		
		Minimum	Maximum	No of tests (exceedances)
Ammonia	900	30	3,530	12 (8)
Total Phosphorous	50	< 20	750	12 (5)
Aluminium	55	< 10	250	13 (2)
Cobalt	1	< 1	26	13 (4)
Copper	1.4	< 1	8	13 (1)
Manganese	1,900	2	4,550	13 (2)
Zinc	8	< 5	270	13 (4)

Notes
[1] Table only includes parameters which exceed the 95% for freshwater ecosystem criteria
All units in μg/l unless otherwise stated
< indicates limit of detection of analysis method

4.4.3 Groundwater dependent ecosystems

Aquatic GDEs

There are no mapped aquatic GDEs on the airport site.

Terrestrial GDEs

Vegetation mapping indicates that the predominant vegetation communities on the airport site (all of which are noted as high potential GDEs) are Cumberland Plain Woodland and Cumberland River Flat Forest. The River Flat Forest is located adjacent to the main drainage channels of Badgerys Creek as well as other minor creek lines on the site. Reliance on groundwater in these areas is likely to be from alluvial groundwater, connected to creek flow. A small area of Shale Gravel Transition Forest is located to the far east of Western Sydney International. Technical Paper 3 ((Biodiversity Development Assessment Report) presents further information relating to native vegetation communities and mapping showing the location of these communities along the project alignment.

Native vegetation would be cleared from the Stage 1 Construction Impact Zone of the Western Sydney International site.

Subterranean GDEs

There are no known subterranean GDEs on the airport site. The Water Sharing Plan for the Sydney Metropolitan Region Groundwater Sources (NSW, 2015) lists no subterranean GDEs within the water sharing region

Wetlands

There are no Ramsar or nationally important wetland systems on the airport site. The Water Sharing Plan for the Sydney Metropolitan Region Groundwater Sources (OEH, 2011) indicates that there are no high priority wetland GDEs within the study area.

4.5 Baseline conceptual groundwater model

Conceptual models simplify and describe how complex systems work and how components of those systems interact which each other. Conceptual hydrogeological models, which cover the whole project are presented in Figure 25 and Figure 26.

The models assume that conditions are broadly similar across the project alignment. This assumption means that the substantial datasets at Western Sydney International can conceptually be applied under similar settings in locations where there is currently only limited data.

The assumption that similar hydrogeological conditions are likely to be found across the project alignment is based on the following:

- the underlying bedrock geology along the entire alignment is the same

- the overlying soil geology has been derived under the same conditions and by the same processes (i.e. alluvial processes for alluvium and weathering of shale to form residual soils)
- the geomorphology and topographic features along the alignment are broadly repetitive, as a series of broad hills and NE-SW oriented creek lines
- the climatic conditions within the study area are the same
- land use across most of the alignment is similar, in a rural agricultural setting. St Marys to the north which is more developed may have somewhat different recharge dynamics due to the increased paved cover and irrigation practices.

Two separate conceptual models have been produced to describe the following areas:

- the northern part of the alignment (roughly St Marys Station to Luddenham Road Station) which is generally in topographically lower areas associated with the floodplains of the main creek lines (Figure 25)
- the remainder of the alignment (Luddenham Road Station to Aerotropolis Core Station) which traverses creek lines (tributaries of South Creek) and topographically higher areas between them (Figure 26).

Three systems have been considered in the hydrogeological conceptual model for the study area: near-surface residual soils, an alluvial aquifer, and a fractured bedrock aquifer. Surface water (including creeks, lakes and wetlands) is also considered in the conceptual model. The term aquifer is used here in the sense that groundwater is stored and moves through the deposits, albeit likely at a very slow pace, and in relatively small volumes.

1. Surficial deposits made up of residual soils typically comprising clays and silts and which contain localised, perched groundwater. These deposits are highly variable in thickness. Groundwater within these soils is affected by seasonal rainfall and climatic factors and may be unsaturated during dry periods. Horizontal interflow occurs at the interface between units of differing hydraulic conductivity and may locally lead to ponding or minor seepages at the surface. The hydraulic conductivity of the residual soils is generally low. Vertical recharge into the underlying shale occurs through the residual soils via rainfall recharge or from other sources such as agricultural dams.
2. Alluvial deposits comprise of interbedded silt, clay, sand and gravel units with a predominance of finer grained material. The alluvial deposits are confined to creek lines and their floodplains, having been deposited by riverine processes. Groundwater within the alluvial deposits is in direct connection with creek flow and is likely to be recharged during periods of high surface run off. Groundwater flow direction in the alluvial aquifers is locally dictated by the extent of the alluvial deposits but is also broadly to the northeast and north, following the flow direction of the creek. Hydraulic conductivity of the alluvial deposits highly variable, a function of the variability in the material types found within the unit. Groundwater levels are close to ground surface within this aquifer, similar to the level in the

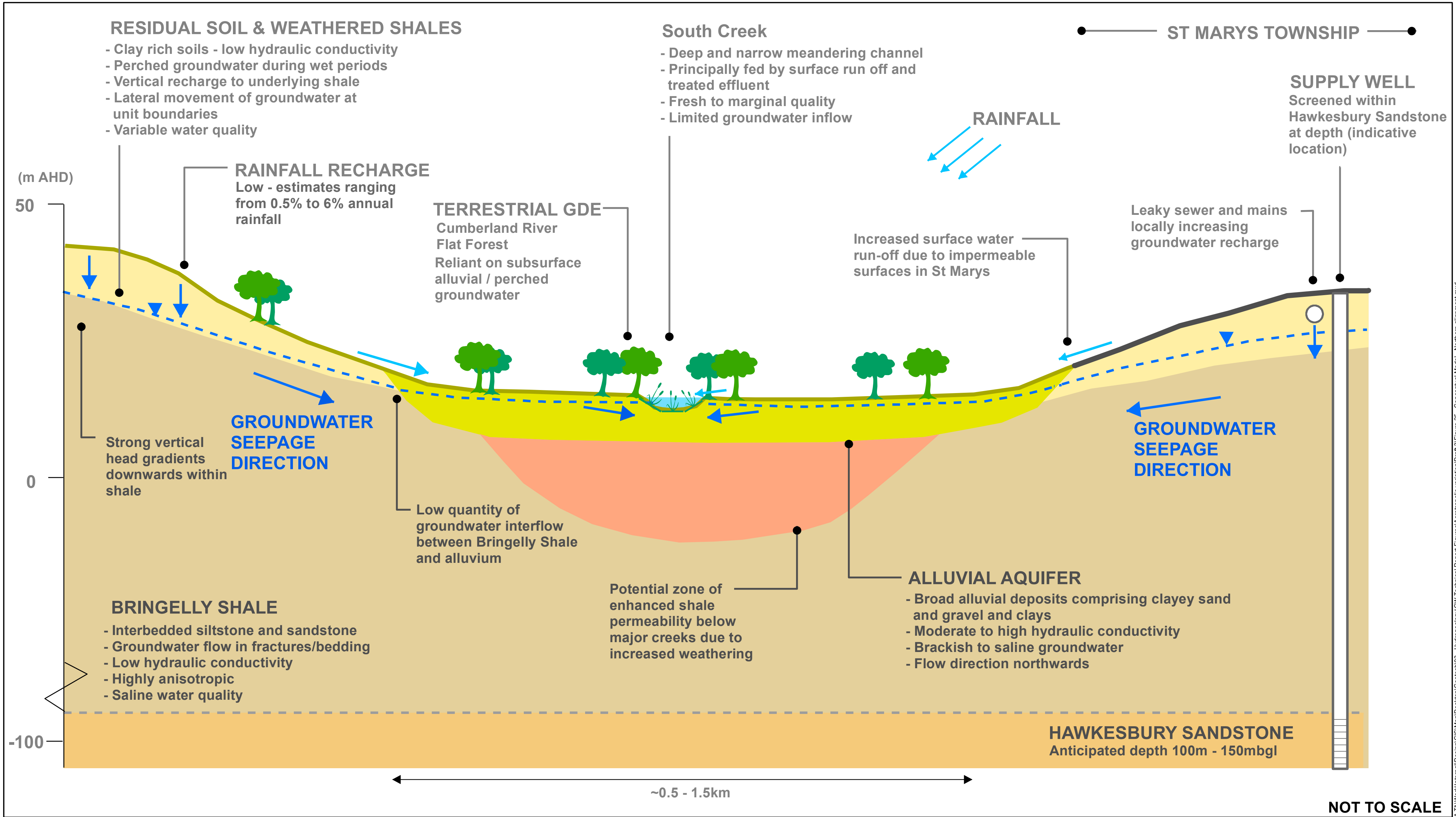
creek lines (many of which are ephemeral/intermittent). Although there is some connectivity between the alluvial deposits and the underlying shale/residual soils, the amount of groundwater interflow between them is likely to be small.

3. A regional fractured bedrock aquifer comprising the Bringelly Shale (a sequence of fractured interbedded siltstones and sandstones). Groundwater in the aquifer is contained within discontinuities such as bedding partings, joint sets and sheared zones. Groundwater flow is slow due to the low hydraulic conductivity of the unit although higher hydraulic conductivity zones may be present below creek lines or along major structural features. The shale is highly anisotropic due to the predominance of horizontally bedded units. The degree of interconnection of the water bearing fractures and bedding planes has a significant bearing on the behaviour and response of groundwater flow within the shale. Within the study area the shale forms a series of small groundwater catchments, the boundaries of which are broadly defined by the NE-SW oriented creeks and the surface watersheds.

Table 22 provides a summary of the groundwater systems in the study area.

Table 22: Project conceptual model groundwater summary

Property	Residual soil/colluvial	Alluvial	Fractured bedrock
Hydraulic conductivity	Low	Low to moderate	Low (may be enhanced below creeks)
Storage / specific yield	Low to moderate (up to 10%)	Moderate to High (up to 30%)	Low (likely less than 1%, possibly up to 10%)
Recharge	Recharge from rainfall at surface	Recharge from rainfall at surface, creek flow, residual soil, limited discharge from shale bedrock	Recharge from overlying residual soils and possibly alluvial deposits
Groundwater levels	Perched groundwater, likely to be variable in response to rainfall events. May be unsaturated during dry periods	Close to surface (within a few metres) along main drainage channel lines. Water levels likely to respond rapidly to rainfall events	Close to surface near creek lines (a few metres) up to 15 to 20 metres below ground level at hill crests. Limited fluctuation in groundwater levels in response to rainfall
Flow direction	Expected to be locally variable. Vertical flow contributing to recharge, lateral flow towards creek lines	Generally northeast to north following creek flow direction	Generally, follows topography towards creek lines
Groundwater quality	Fresh to saline	Fresh to brackish	Generally saline
Groundwater users	None	May be local supplies within region	None
GDEs	May provide water locally to native vegetation where close to the surface	Contribution to creek baseflow and GDEs along creek lines	Unlikely to provide significant contribution to GDEs due to saline groundwater quality



Legend

- Alluvium
- Residual Soil / Colluvium
- Hawkesbury Sandstone
- Bringelly Shale
- Water

Client	Sydney Metro
Job Title	Sydney Metro – Western Sydney Airport
Figure Title	Idealised Local Scale Conceptual Model - Northern alignment sections

Issue	Date	By	Chkd	Appd
D1	2/07/2020	CJ	JL	JL

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Coordinate System: N/A	
Job No: 265549-00	Figure No: 025

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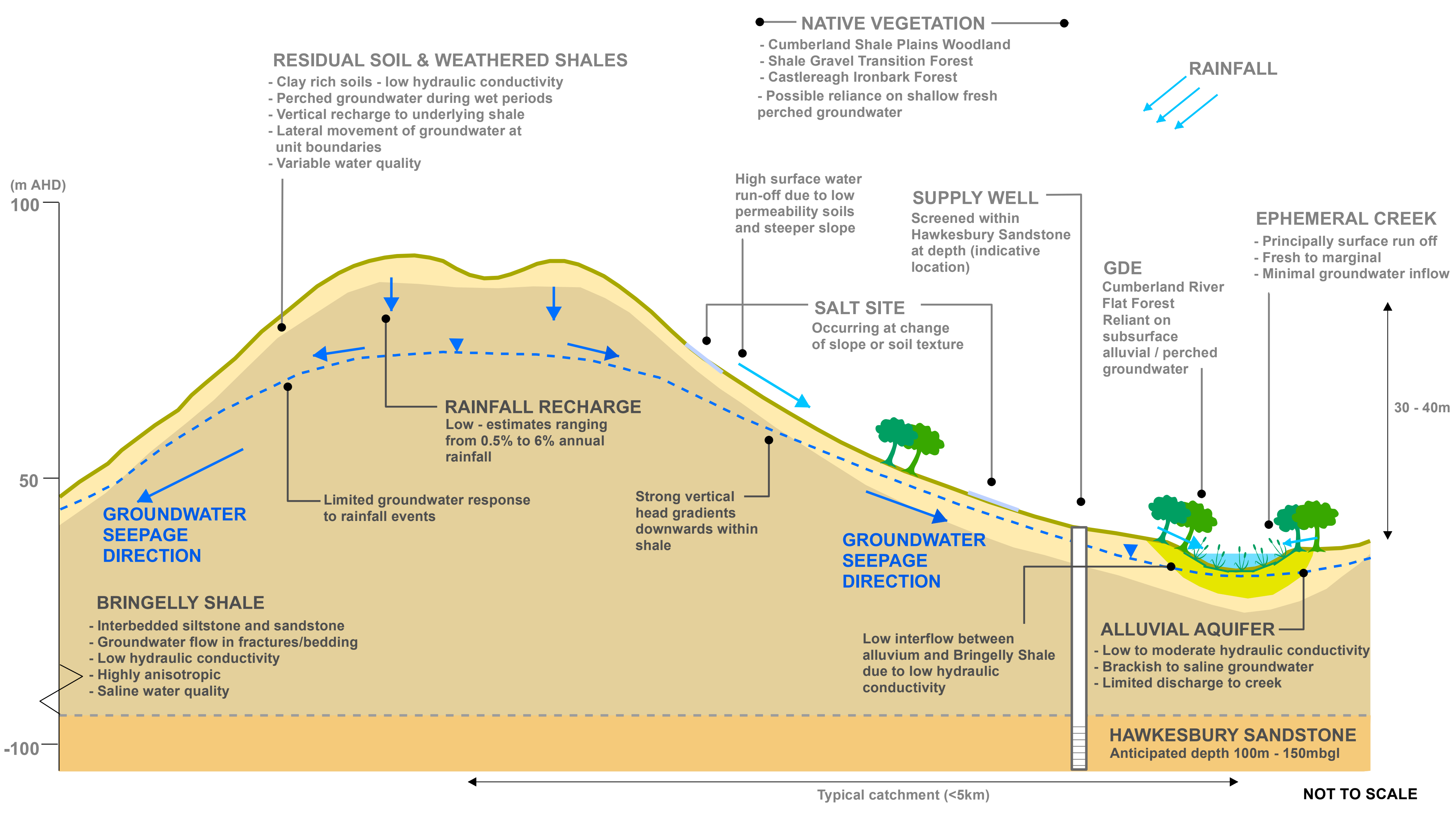

Legend

- Alluvium
- Residual Soil / Colluvium
- Hawkesbury Sandstone
- Bringelly Shale
- Water

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Idealised Local Scale Conceptual Model - Southern alignment sections

Issue	Date	By	Chkd	Appd
D1	2/07/2020	CJ	JL	JL

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5 Assessment of construction impacts

5.1 Background

This section presents the potential impacts of the project on the groundwater environment that may occur during construction, that is, the impact on the surrounding land uses, on groundwater users and on environmental receptors such as GDEs and creek baseflow, because of changes to groundwater level, flow and quality.

The potential impacts upon the groundwater environment during the construction phase are:

- impacts upon GDEs, water supply wells, creeks or other environmental receptors resulting from changes to groundwater level or flow
- impacts upon groundwater quality due to contamination from release of chemicals used during construction activity and potential impacts to other connected environmental receptors
- impacts upon groundwater quality due to exposure, storage and leaching of saline soils along the alignment
- impacts upon buildings and infrastructure from surface settlement related to groundwater drawdown during construction.

Impacts on groundwater resulting from existing contamination, changes to chemistry and mobilisation are discussed in Technical Paper 8 (Contamination).

5.2 Off-airport

Hydrogeological conditions at each of the main off-airport project elements that are likely to interact with the groundwater environment (i.e. below ground infrastructure) are presented in Table 23.

Table 23: Hydrogeological conditions at project elements – off-airport site

Location /structure	Hydrogeological units	Anticipated groundwater level (mbgl)	Approximate maximum depth below groundwater level (m)
St Marys Station and crossover	Residual soil Bringelly Shale	2 – 7	~15
TBM Tunnel (St Marys Station to Orchard Hills Station)	Bringelly Shale	0 – 6 (assumed)	Up to ~25
Claremont Meadows Services Facility	Alluvium Residual soil Bringelly Shale	1 - 2	Up to 15

Location /structure	Hydrogeological units	Anticipated groundwater level (mbgl)	Approximate maximum depth below groundwater level (m)
Orchard Hills tunnel portal and station	Residual soil Bringelly Shale	3 – 5	6 to 8
Cutting south of Orchard Hills Station	Residual soil Bringelly Shale	5 – 6	5 - 6
Western Sydney International to Bringelly tunnel	Bringelly Shale	0 – 6 [1]	Up to ~20
Bringelly Services Facility	Residual soil Bringelly Shale	3 – 4 [1]	~20
Aerotropolis Core Station	Residual soil Bringelly Shale	4 - 5	~15
[1] Limited or no groundwater level data currently available. Geotechnical investigations underway to obtain groundwater level information in these areas			

5.2.1 Sources of changes to groundwater levels

Rail tunnels

Changes to groundwater levels due to construction of the tunnels and cross passages would occur due to short term inflows during excavation. Over the longer term the tunnels would act as a barrier to groundwater flow as they are waterproofed. TBM tunnels would include segmental lining with waterproofing seals between the segments to prevent groundwater inflow into the tunnels.

Groundwater inflow may occur in the short interval of time between excavation at the tunnel face and installation of the tunnel lining. Once the lining is in place, the tunnel is effectively waterproofed and groundwater inflow would be limited. The period during which groundwater can enter the tunnel is short (minutes or a few hours) and groundwater inflows are typically controlled through ground improvement techniques (i.e. grouting to reduce the hydraulic conductivity of the rock mass) or using tunnelling machines which limit inflow.

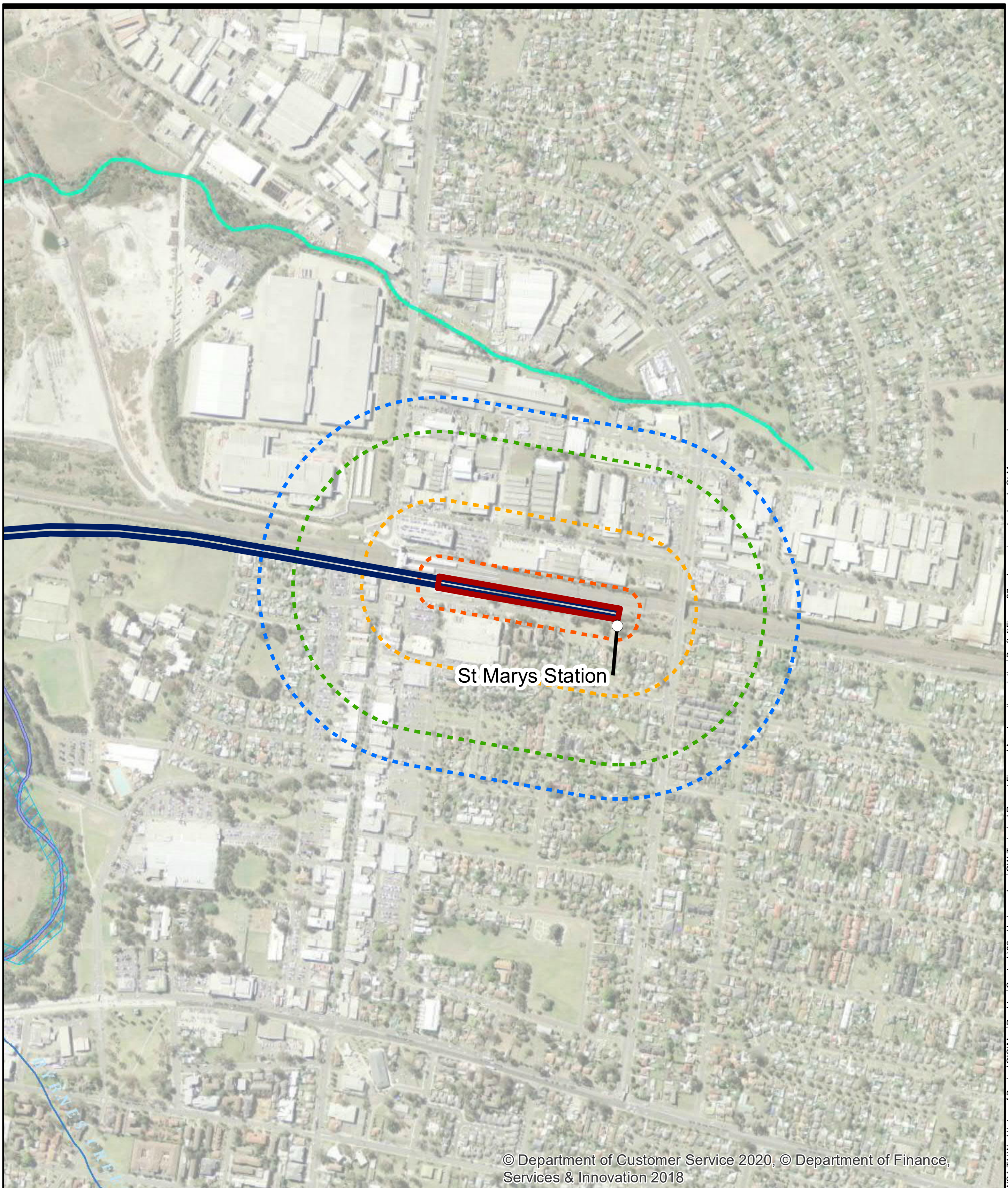
Groundwater inflow to cross passage excavations would occur for longer periods than the TBM tunnel since they are constructed using traditional mining excavation methods which are open for longer. However, efforts to minimise groundwater inflow such as ground improvement are usually undertaken prior to excavation, to minimise the volume of groundwater entering the cross passages.

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

St Marys Station and crossover

Groundwater inflows at St Marys Station and crossover structure would occur during construction as the excavation would take place within a drained (un-tanked) retaining wall. Groundwater flow would be predominantly horizontal into the excavation. Changes to groundwater levels would occur during construction of the cut and cover structure at St Marys Station. These changes would occur for the duration of the excavation period and until the permanent watertight station structure is in place.

The predicted changes to groundwater levels during the construction phase is presented in Figure 27. Groundwater within the residual soils (if saturated) and the Bringelly Shale would be lowered surrounding the excavation. Drawdown at the excavation is expected to be close to the base of the excavation. The assessment indicates that a one metre drawdown (change in groundwater levels of one metre compared with baseline levels) would extend out from the excavation for about 340m over a construction period assumed to last 2 years. Although the contours are shown to extend out uniformly from the excavation, it is likely that there would be variation in the drawdown owing to differences in the hydrogeological conditions away from the station.



Legend

- Stations
- Project Alignment

Groundwater drawdown

- 1m
- 2m
- 5m
- 10m

Groundwater dependent ecosystems (BoM, 2017)

- High potential Terrestrial GDE - from national assessment
- Moderate potential Terrestrial GDE - from national assessment
- Low potential Terrestrial GDE - from national assessment
- High potential Aquatic GDE - from national assessment

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Predicted drawdown during construction - St Marys Station

Metres
0 100 200 300 400

Issue	Date	By	Chkd	Appd
D1	19/08/2020	JL/CJ	JL	JL

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Scale at A4	Figure Status
1:10,000	**Issue**

Coordinate System
GDA 1994 MGA Zone 56

Job No	Figure No
265549-00	**027**

\\global.arup.com\australasia\SYD\Projects\265000\265549-00 SMWSA TA\Work\Internal\Design\GIS\Map\Desktop\Geotech\03 - Hydrogeology\GW Technical Report Figures\Aerotropolis variation\Draft 4\Figure 27 - change in water levels St Marys.mxd

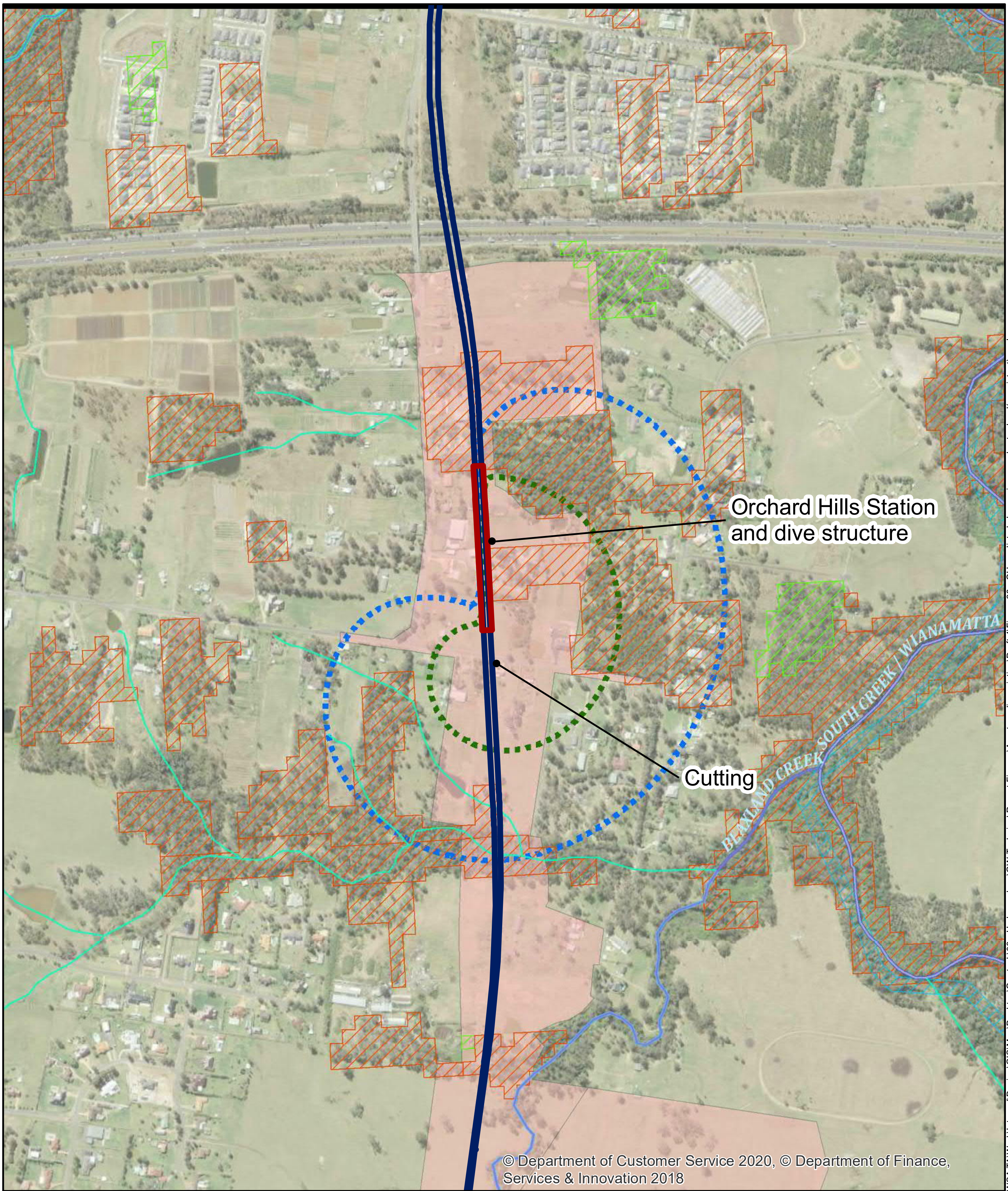
Orchard Hills Station, tunnel portal and cutting

Groundwater inflows during construction of the Orchard Hills Station and tunnel portal are expected to be minor since the structure would be constructed within undrained (tanked) secant piled retaining walls which would prevent horizontal flow of groundwater into the excavation. There may be some minor seepage into the base of the excavation which could lead to some depressurisation outside of the secant pile wall. However, this would only occur temporarily during excavation until the internal concrete structures are installed and waterproofed, when the structure would be undrained (tanked).

Inflow into the drained (un-tanked) cutting south of the station would occur causing a lowering of groundwater levels adjacent to them and progressively into the surrounding shale. Most changes to the groundwater level would develop during construction (as excavation takes place) but could continue to occur into the operational phase of the project depending on the construction sequence and the aquifer properties.

The predicted changes to groundwater level from the undrained (tanked) station box, tunnel portal and drained (un-tanked) cutting south of Orchard Hills Station is presented in Figure 28. The predictions indicate a maximum drawdown of around 4.5 metres adjacent to the deepest part of the cutting, south of the station. The greatest observed drawdown occurs adjacent to the cutting within the construction footprint; the maximum predicted groundwater drawdown outside of the construction footprint is approximately 3.5 metres and occurs approximately 50m to the east of the drained (un-tanked) cutting. Over an assumed construction period of 2 years, drawdown of up to 2m extends to a distance of approximately 230m to the east of the cutting whereas the 1m contour extends to a distance of approximately 440m to the east of the station.

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



Legend

- Study area
- Stations
- Project Alignment
- Construction Footprint

Groundwater Drawdown (m)

- 1m
- 2m

- High potential Aquatic GDE - from national assessment
- High potential Terrestrial GDE - from national assessment
- Moderate potential Terrestrial GDE - from national assessment
- Low potential Terrestrial GDE - from national assessment

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Predicted change in water levels at Orchard Hills Station

Metres
0 100 200 300 400

Issue	Date	By	Chkd	Appd
D1	19/08/2020	CJ	JL	JL

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Scale at A4	Figure Status
1:10,000	Issue

Coordinate System
GDA 1994 MGA Zone 56

Job No	Figure No
265549-00	028

\\global.arup.com\australasia\SYD\Projects\265000\265549-00 SMWSA TA\Work\Internal\Design\GIS\Map\Desktop\Geotech\03 - Hydrogeology\GW Technical Report Figures\Aerotropolis variation\Draft 4\Figure 28 - OH predicted change in groundwater level(consistent).mxd

Claremont Meadows services facility

Inflows during construction of the services facility at Claremont Meadows are expected to be minor since the structure would be constructed within undrained (tanked) secant piled cut-off walls which would prevent horizontal flow of groundwater into the excavation. Changes in groundwater levels during construction are unlikely to occur outside of the excavation during the period of construction.

Bringelly Services Facility

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

The predicted changes to groundwater level during the construction phase is presented in Figure 29. Drawdown at the excavation is expected to be close to the base of the excavation however, due to the depth of the excavation into the Bringelly Shale, the actual drawdown would be controlled by the presence of any water bearing fractures at depth. The assessment indicates that drawdown would extend to approximately 315m from the excavation (given by a change in water levels of 1m from baseline levels).

Aerotropolis Core Station

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

The predicted changes to groundwater level during the construction phase is presented in Figure 29. Drawdown at the excavation is expected to be close to the base of the excavation. The assessment indicates that drawdown would extend away from the excavation a distance of approximately 270m (given by a change in water levels of 1m from baseline levels).

Other cuttings

There are two small cuttings present along the alignment outside of the Western Sydney International site. These are located between Luddenham Road Station and the Western Sydney International site (see Figure 4). These cuts are relatively shallow (a maximum cut depth of between 1 and 4 metres below ground level) through topographically higher spurs, which would be excavated to maintain the grade line of the rail.

No project groundwater monitoring data is available at these cuttings however nearby groundwater information from the Environmental Impact Statement for the future M12 project was reviewed as part of the assessment, which indicated groundwater levels at around 4mbgl. Based on this information and the relatively shallow cut depth, it is anticipated that there would be minimal to no impact on groundwater levels as a result of the construction of these cuttings.

Viaducts

Construction of viaduct piers and abutments would comprise of pile foundation construction and local excavation of the ground in order to construct a cast in situ concrete footing. The total excavation depth is likely to be shallow, although this may vary depending on ground conditions. In locations where shallow groundwater is present above the excavation base, local groundwater control measures may be required in order to maintain dry conditions within the excavation. These measures may comprise of sump pumping of any groundwater ingress, or measures to restrict groundwater ingress into the excavation, such as sheet pile retaining walls.

Pumping of groundwater from the excavation may lead to local changes in water level around the excavation. However, due to the relatively small extent of each excavation and their shallow depth, the amount of groundwater ingress and drawdown at each pier location is anticipated to be small. Low hydraulic conductivity soils which are present across most of the construction footprint would limit the rate of groundwater ingress and extent of groundwater drawdown. Where groundwater levels are below the excavation base, there would be no impact on groundwater levels. The construction of piled foundations, which would extend into the Bringelly Shale bedrock are not anticipated to have an effect on groundwater levels during construction.

Ground conditions at each pier would be evaluated during design development, particularly where critical infrastructure is present, such as the Warragamba to Prospect Water Supply Pipelines. The nearest groundwater monitoring bore to the pipeline crossing (SMGW-BH-B120) indicates groundwater levels approximately 3 mbgl, although long term monitoring is not currently available. If these groundwater levels are consistent with those at the pipeline crossing at the time of construction, it is unlikely that construction of the pier in this location would result in a change to the groundwater level surrounding the excavation. Further work during construction planning and design development would be undertaken to confirm groundwater conditions at the locations of pier and viaduct footings.

Changes to groundwater recharge

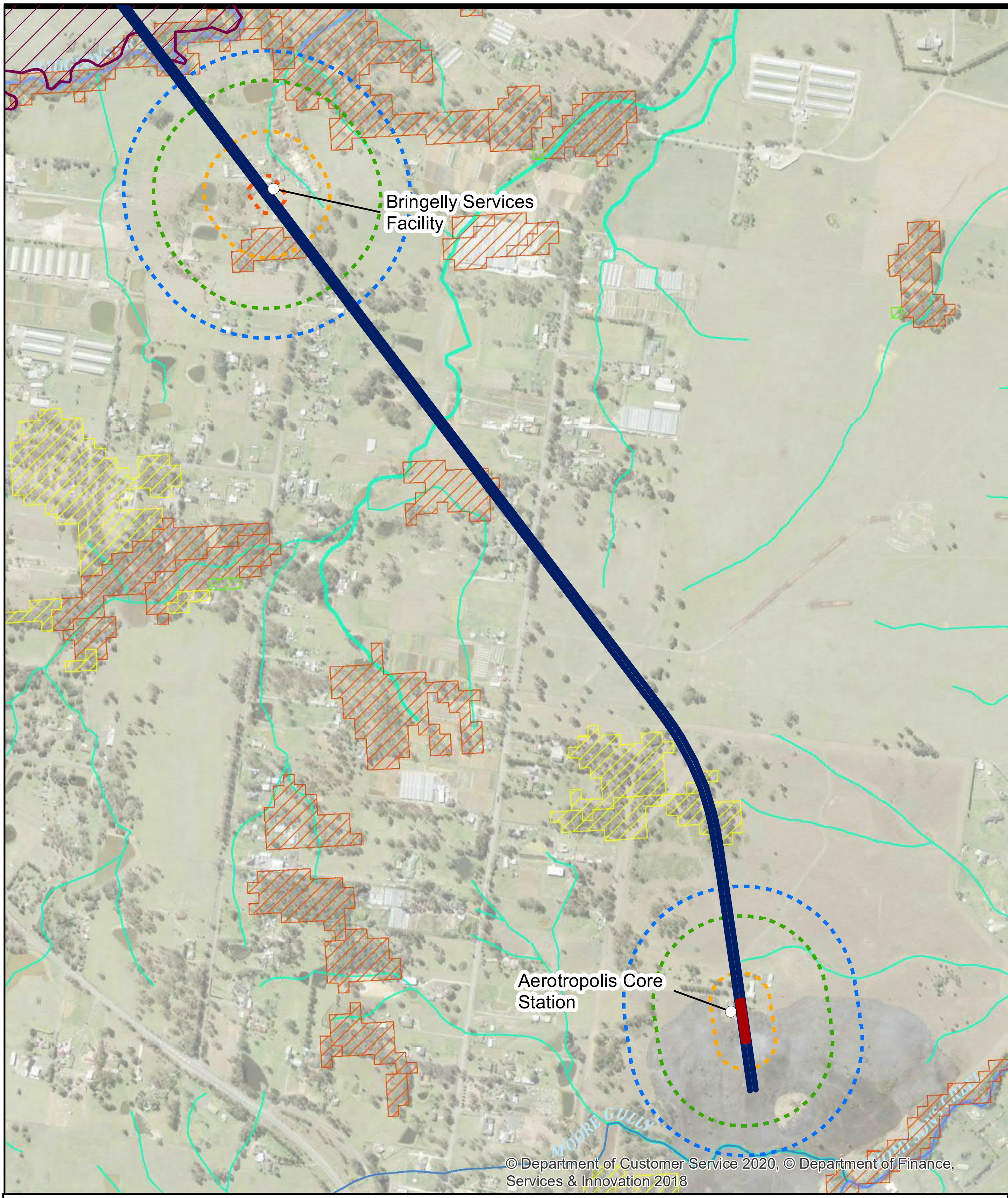
Groundwater recharge (Section 4.2.13) is the proportion of rainfall that makes its way into an aquifer system, because of infiltration through unsaturated soils. Changes to recharge from the surface can cause changes in groundwater level in the underlying system. Changes to recharge during construction are likely to occur principally because of:

- construction of engineered fill, paved surfaces and site facilities preventing rainfall from infiltrating into the ground, leading to a reduction in recharge
- surface run-off on construction areas being captured by drainage systems, as opposed to infiltrating into the ground, leading to a reduction in recharge

- sedimentation basins used during construction locally acting as points of increased recharge

Existing groundwater recharge in the study area is low due to the low hydraulic conductivity of the residual clay soils and Bringelly Shale bedrock (see Section 4.2.13). The construction footprint amounts to a relatively small area within each of the groundwater catchments in which it is located and the total reduction in direct recharge would be a correspondingly small proportion of the total.

The effect of the reduction in direct recharge to groundwater levels across this footprint is anticipated to be small due to the limited scale of the development (compared to the size of the catchments) and the existing low recharge within the study area. Future development of the Western Parkland City and Western Economic Corridor is expected to lead to significant changes in land use. It is expected that the project would be a minor contributor to changes in groundwater recharge conditions in the context of this future development.



Legend

- Stations
- Project
- Western Sydney International

Groundwater drawdown

- 1m
- 2m
- 5m
- 10m

- High potential Aquatic GDE - from national assessment
- High potential Terrestrial GDE - from national assessment
- Moderate potential Terrestrial GDE - from national assessment
- Low potential Terrestrial GDE - from national assessment

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Predicted drawdown during construction - Aerotropolis and Derwent Road ISF

Metres
0 100 200 300 400

Issue	Date	By	Chkd	Appd
D1	13/08/2020	JL/CJ	JL	JL

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Coordinate System
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Job No	Figure No
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5.2.2 Impacts to GDEs

There are several potential GDEs located within the study area. These endangered ecological communities are the Castlereagh Ironbark Forest, Cumberland Shale Plain Woodland, the Shale Gravel Transition Forest and the River Flat Eucalypt Forest.

Mapped native vegetation communities are presented in Figure 27 and Figure 28 the context of the predicted groundwater drawdown at each of the locations above.

The urbanised character surrounding St Marys Station and the disturbed land use (as opposed to natural) in this area mean there are few GDE's and native vegetation communities present. Vegetation associated with South Creek to the north and west are not expected to be affected by any changes in groundwater levels at St Marys.

Several High priority GDEs/native vegetation communities are located close to Orchard Hills Station. These include:

- Cumberland Shale Plains Woodland
- Shale Gravel Transition Forest
- Cumberland Flat River Forest.
- Castlereagh Ironbark Forest

An area of intact Shale Gravel Transition Forest is located to the east of Orchard Hills Station which is within the zone of groundwater drawdown. Figure 28 shows those communities located outside the construction footprint, but within the predicted one metre drawdown contour/zone. Predicted drawdown below the Shale Gravel Forest is mostly less than two metres, except for areas closest to the cutting to the east of the station.

Although native vegetation communities and potential GDE's are present south of Elizabeth Drive, the area has already been assessed as part of the South West Growth Centre. Although areas of Cumberland Shale Plain Woodland are within the zone of drawdown of 2m or more around Bringelly Services Facility, offsets have already been secured for impacts within this area.

The potential impact on native vegetation communities is discussed further in Technical Paper 3 ((Biodiversity Development Assessment Report).

5.2.3 Impacts to existing groundwater supply wells

There are no groundwater supply wells (bores) located within the study area at locations where groundwater levels are affected by the project. No registered supply bores are anticipated to be within the project construction footprint.

There are two supply wells located within 150 metres of the proposed alignment to the south of Patons Lane. The rail alignment at these bore locations is in viaduct and construction activity would comprise principally of foundation construction for the viaduct piers and abutments with minimal impact on the groundwater environment. Additionally, these bores are drilled to depths of 250 metres and 360 metres respectively and the project would not likely have any impact on these supply wells.

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

5.2.4 Impacts to creeks and wetlands

Creeks

Due to the low hydraulic conductivity of the Bringelly Shale and overlying soils, the amount of interflow between the creeks and the groundwater is likely to be small, with creeks being principally surface water run-off fed or supported by baseflow from alluvial deposits. Limited drawdown may occur at South Creek because of the drained (un-tanked) cutting at Orchard Hills however the drawdown is likely to be small and is unlikely to have any observable reduction in creek flow due to the limited connectivity between the units. The potential impact of groundwater drawdown at creek lines as a result is anticipated to be minor.

Direct impacts on alluvial groundwater are unlikely since construction activity would principally occur within residual soil and Bringelly Shale. Alluvial soils are expected to be encountered at each of the main creek crossings where the alignment would either be in viaduct or tunnel well below the alluvial deposits. Investigations indicate that the typical thickness of the alluvial deposits along the alignment is relatively limited, generally on the order of a few metres.

Excavation of the Claremont Meadows services facility may be partly located upon alluvial soils, albeit close to the edge of the mapped deposits. Excavation of the shaft could locally affect groundwater levels within the alluvial deposits however due to its relatively small footprint, the magnitude of potential impact is likely to be minor. Geotechnical investigations at the site would be undertaken to confirm the presence of alluvial soils and groundwater conditions.

Tunnelling below South Creek, Badgerys Creek and other minor creek lines is within Bringelly Shale bedrock at approximately 10 metres below ground level from the tunnel crown. There is a potential for higher hydraulic conductivity within the Bringelly Shale below the creek which could increase the connection between the shale and alluvial deposits. Packer testing at undertaken at South Creek to date has not indicated any above average hydraulic conductivity zones, although at other creek lines (Badgerys Creek), the zones of higher hydraulic conductivity have been observed. Additionally, since the period over which groundwater inflow would occur during tunnelling is short, any impact is unlikely to be long lasting. Construction of the TBM tunnels is considered unlikely to impact on flow within the creek.

Wetlands

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

There are no Ramsar or internationally important wetlands which could be impacted by the project.

5.2.5 Groundwater drawdown settlement

Lowering of groundwater levels within residual soils and alluvial sediments may lead to consolidation of the soil structure and ground settlement at the surface, due to reduced porewater pressure and increased effective stress. The magnitude and extent of groundwater drawdown settlement is dependent on the thickness and stiffness of the soils and the magnitude of and extent of groundwater drawdown. In the context of the project, settlement due to groundwater drawdown is only expected to occur in the residual soil and highly weathered (very low strength) zones in the upper shale.

Ground movement also occurs as a result of ground excavation of tunnels and stations. The total ground movement experienced at the surface would be a combination of both excavation and groundwater drawdown.

An assessment of the potential for settlement from groundwater drawdown has been undertaken based on the current understanding of ground conditions and water levels along the alignment. Undrained (tanked) structures limit the magnitude and extent of drawdown outside an excavation and would generally cause negligible ground movement from drawdown compared to drained (un-tanked) structures.

The maximum predicted magnitude of settlement due to groundwater drawdown is presented in Table 24.

Table 24: Maximum predicted magnitude of settlement from groundwater drawdown

Location	Maximum settlement (mm)
St Marys Station	14
Orchard Hills cutting	8
Bringelly services facility	6
Aerotropolis Station	5

Ground settlement as a result of groundwater drawdown is generally expected to be small as a result of the limited drawdown and generally stiff residual soils present in the area. Where thicker deposits of residual soil are present, such as at St Marys, the maximum predicted drawdown settlement = during construction is estimated to be about14 millimetres.

The zone in which settlement occurs due to groundwater drawdown would be similar to the area of drawdown, as shown in Figure 27, Figure 28 and Figure 29. However, the magnitude of settlement would reduce away from the excavation as the amount of drawdown reduces. Variations in the thickness of the soils, differences in the existing groundwater levels surrounding the excavation and degree of saturation of the soils all contribute to the variability in the magnitude of settlement that occurs.

Groundwater related settlement due to the construction of viaduct and bridge piers is unlikely. If it occurs, the magnitude and extent of settlement would likely to be very small. The excavation depths for these structures are relatively shallow reducing likelihood of drawdown occurring. The short construction period would also serve to limit the potential for groundwater drawdown and subsequent settlement to occur surrounding the excavation.

At critical infrastructure, such as the Warragamba to Prospect Water Supply Pipelines, groundwater drawdown is not expected to occur, based on the nearest groundwater level monitoring information. However, further assessment would be undertaken during construction planning and design development to confirm this, once site specific data becomes available. Although the likelihood of groundwater related settlement occurring is considered unlikely, engagement with WaterNSW would be undertaken to develop appropriate movement criteria, monitoring regimes and mitigation measures during construction to limit the potential for any impacts to the pipelines occurring.

The results of the ground movement impact assessment are presented in Chapter 15 (groundwater and geology) of the Environmental Impact Statement. The potential structures that may be impacted by ground movements because of the project are discussed in this chapter.

5.2.6 Groundwater quality impacts

Groundwater in the study area has limited environmental value and beneficial use due to the high salinity of the water (Section 4.2.20). As a result, the main risks to groundwater quality during construction include:

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

The contamination risk assessment for the project is provided in Technical Paper 8 (Contamination). This assessment found a medium to high risk of a pollutant linkage due to potentially contaminated groundwater being present in certain parts of the study area. These include potentially contaminated groundwater from Gipps

Street landfill and off-site sources up-gradient of St Marys. The report also indicates a medium risk ranking for groundwater contamination entering the rail tunnels between St Marys and Orchard Hills, from various sources. Specific mitigation measures to manage these risks are outlined in Technical Paper 8 (Contamination).

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

Interaction between the Bringelly Shale and Alluvium units naturally occurs, as evidenced by the marginal to saline groundwater quality of the alluvium. Further changes to the quality of the alluvium groundwater are considered unlikely as a result of the project since most of the major below ground construction occurs away from, or well below alluvium deposits. Since most of the below ground infrastructure would, in the longer term, be un-drained (tanked), migration of saline groundwater as a result of drawdown is unlikely.

The risk of impacting groundwater quality is generally anticipated to be low because of the following:

- the limited beneficial use and environmental value of the groundwater in the study area
- the infiltration of saline or contaminated water from stockpiles or at discharge basins would be limited by the low permeability clay soils present in the study area
- mobilisation of large quantities of existing contamination is unlikely due to the low permeability groundwater environment in the study area and the design of the main project elements which would limit groundwater inflow and drawdown during construction
- impacts from spills and leaks would be mitigated by measures identified in Technical Paper 8 (Contamination).

Groundwater ingress into excavations for stations or other cuttings would be captured, treated and then reused for construction activity where possible. Where reuse of the groundwater is not possible, the water would be discharged from the construction sites via construction water quality treatment plants. Water captured during tunnelling would be treated and recirculated to the cutting face or used for dust suppression purposes.

Further information, including the proposed location of water discharge points is provided in Chapter 14 (Flooding, hydrology and water quality). Mitigation measures relating to the monitoring of surface water quality during construction are also included within Chapter 14 (Flooding, hydrology and water quality).

5.3 On-airport

Hydrogeological conditions at each of the main project elements at the Western Sydney International site which are likely to interact with the groundwater environment (i.e. below ground infrastructure) are presented in Table 25.

Table 25: Hydrogeological conditions at project elements

Location /structure	Hydrogeological units	Approximate Groundwater Level (mbgl) [1]	Approximate depth of structure below existing groundwater level (m)
Airport tunnel portal	Residual soil Bringelly Shale	0.5 to 3	0 - 20
Airport Terminal Station	Residual soil Bringelly Shale	0.5 to 3.5	15 - 19
Airport rail tunnels	Bringelly Shale	1 to 9	Up to 28m
[1] Groundwater depths based on existing ground levels			

5.3.1 Sources of changes in groundwater level or flow

Rail tunnels

As described in Section 5.2.1, changes in groundwater level as a result of tunnel and cross passage excavation during construction are likely to be of short duration and unlikely to lead to a significant changes in groundwater levels.

Western Sydney International tunnel portal

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

The predicted changes to groundwater level during the construction phase is presented in Figure 30. Drawdown at the excavation is expected to be close to the base of the excavation. However, since the excavation is deeper to the west, greater drawdown and inflow would be expected in that area. The assessment indicates that the 1m drawdown contour would extend to approximately 285m from the excavation. This extent is unlikely to occur across the entire length of the tunnel portal since there would be less drawdown in shallower areas. However, for the purposes of reporting, it is assumed that this drawdown occurs uniformly across the length of the structure.

Airport Terminal Station

Groundwater inflows at Airport Terminal Station would occur during construction as the excavation would take place within a drained (un-tanked) retaining wall.

This would lead to changes to groundwater levels in the surrounding shale and residual soil. The changes to groundwater level would occur over the course of construction until the permanent watertight station structure is in place.

At Airport Terminal Station, the results of the modelling indicate that that the 1m drawdown contour would extend to approximately 270m from the excavation face, as shown in Figure 30.

Changes to groundwater recharge

The same mechanisms as those described in Section 5.2.1 are expected to result in changes to recharge during construction of the project at Western Sydney International.

In addition, excavated material for the project would be stored within Western Sydney International at the Permanent spoil placement area, which could reduce groundwater recharge into the underlying ground. Further details on the location of this stockpile is provided in Chapter 8 (project description – construction) of the Environmental Impact Statement. As this spoil placement area would be permanent, the effect it has on groundwater recharge would continue to occur into the operational phases of the project. However, given the existing low permeability residual soils and low recharge rates present across the majority of Western Sydney International, it is unlikely that these stockpiles would have an impact on recharge rates and underlying groundwater levels.

Significant landscaping at the airport site is occurring as a result of the Western Sydney International development. It is likely that changes to groundwater recharge would be more significant as a result of this activity compared to the changes caused by the project.

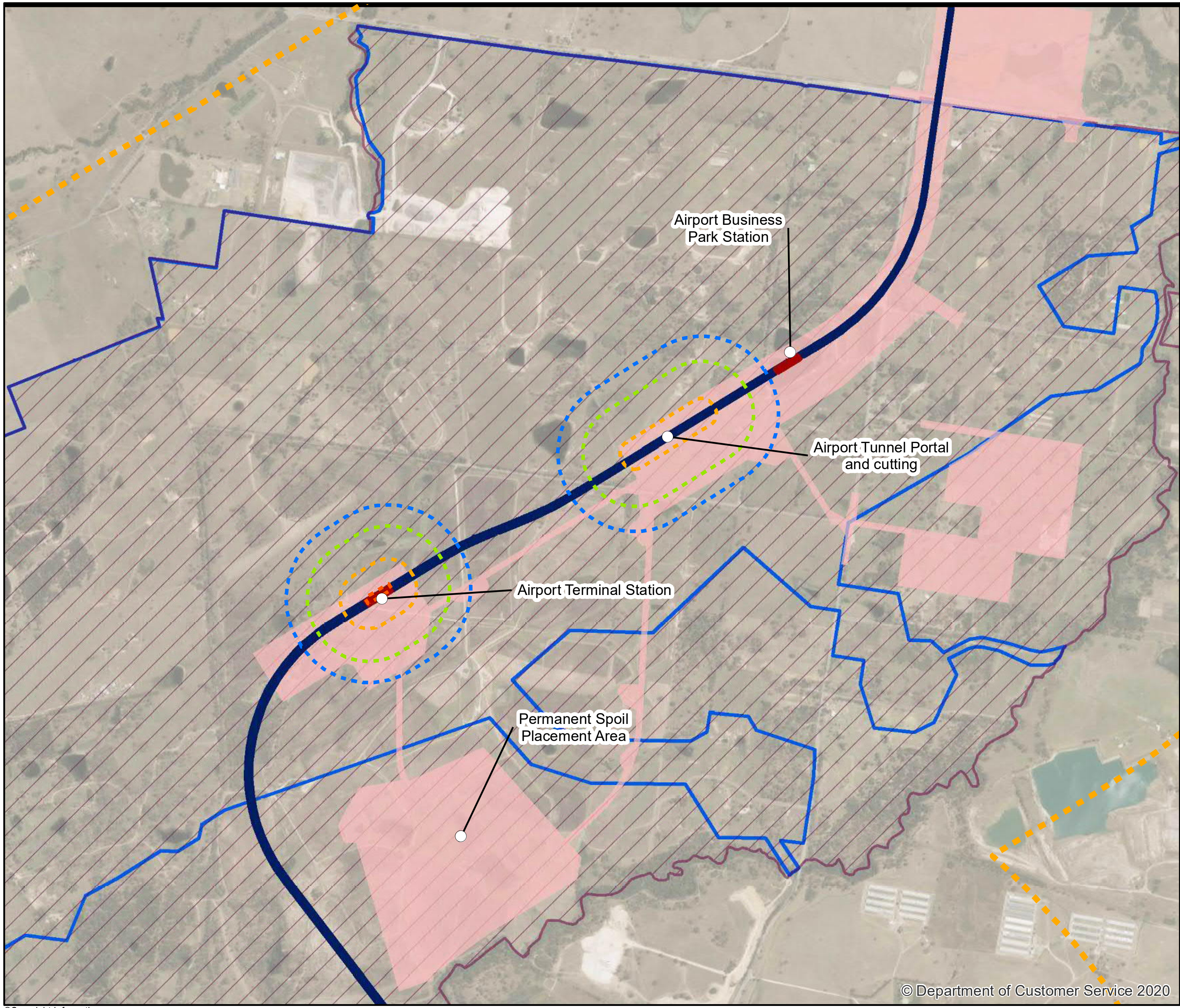
5.3.2 Impacts to GDEs

The Western Sydney International Stage 1 Construction Impact Zone would be cleared as part of the Western Sydney International development. Changes to groundwater level at Western Sydney International during construction are anticipated to occur within the Stage 1Construction Impact Zone. It is considered unlikely that groundwater drawdown would have any impact on GDEs outside this area.

Section 8.4 of the Airport Plan states that groundwater monitoring would be undertaken for the soil and groundwater CEMP which must include monitoring points adjacent to woodlands in areas outside of the Construction Impact Zone (but within the airport). This measure is intended to monitor changes at groundwater dependent vegetation as a result of construction of the airport site.

5.3.3 Impacts to groundwater supply wells

No groundwater supply wells are present at Western Sydney International and no impacts are predicted because of changes to groundwater level or flow at the site.



Legend

- Study area
- Stations
- Project Alignment
- EIS Construction Footprint
- Western Sydney International
- WSI Construction Impact Zone

Groundwater drawdown

- 1m
- 2m
- 5m
- 10m

Issue	Date	By	Chkd	Appd
D1	02/07/2020	CJ	JL	JL

Metres

0 200 400 600 800

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Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Predicted drawdown during construction - Western Sydney International

Scale at A4	Figure Status
1:20,000	**Issue**

Coordinate System
GDA 1994 MGA Zone 56

Job No	Figure No
265549-00	**030**

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5.3.4 Impacts to creeks and wetlands

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

5.3.5 Impacts from groundwater settlement

The mechanisms of settlement due to groundwater drawdown are discussed in Section 5.2.5. The maximum magnitude of settlement due to groundwater drawdown is presented in Table 26.

Table 26: Maximum predicted magnitude of settlement from groundwater drawdown

Location	Maximum settlement (mm)
Western Sydney International tunnel portal	11
Airport Terminal Station	3

The overall risk from groundwater induced settlement at Western Sydney International is anticipated to be low. However, due to the concurrent earthworks and construction operations that would be undertaken at the site, further assessment would need to be undertaken prior to construction to ensure any groundwater induced settlements do not impact the airport infrastructure.

The results of the ground movement impact assessment are presented in Chapter 15 (groundwater and geology) of the Environmental Impact Statement. The potential structures that may be impacted by ground movements as a result of the project are discussed in this chapter.

5.3.6 Impacts due to changes in groundwater quality

Section 5.2.6 presents construction related risks to groundwater quality off airport site which are anticipated to be broadly similar to those on airport. The construction of a permanent spoil placement area at Western Sydney International may lead to an increased risk of generating saline or contaminated runoff and leachate and impact on groundwater, however the overall risk of impacts to the groundwater quality remain low due to:

- the low permeability soil cover, limiting the risk of infiltration of water into the ground
- the limited beneficial use and environmental value of the groundwater at the site
- the low likelihood of existing chemical contamination at Western Sydney Airport (see Technical Paper 8: Contamination)
- standard mitigation measures (outlined in Section 8) that would be used to further limit the risk of potential impacts to the groundwater.

5.4 Estimated construction groundwater take

Groundwater inflows during construction would initially be higher but would reduce as groundwater levels drop in the ground surrounding the excavation. The actual construction inflow rates would depend on the rate at which excavation or tunnelling takes place as this would control the area over which inflow occurs at any given time. The cumulative construction inflows for the entire project would also be dependent on the construction program and where excavations or tunnelling is being undertaken concurrently.

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

Table 27 provides an estimate of the average predicted flow rate and the maximum predicted flow rate at each of the structures. Given the variability of the hydraulic properties of the shale in the project area, and conservative nature of the modelling, it is plausible that the total inflow rates may be substantively lower than predicted.

Groundwater made by the excavations both on and off the airport site would be treated and used in line with the requirements outlined in Chapter 8 (project description – construction) of the Environmental Impact Statement. Groundwater taken as part of the project construction may be utilised across the project as needed, including both at Western Sydney International and off the airport site.

Table 27: Estimated construction groundwater inflows

Project element	Predicted average groundwater inflow (kL/d)	Predicted maximum groundwater inflow (kL/d)
Off-airport		
Rail tunnels (St Marys to Orchard Hills)	5	75
St Marys Station	69	153
Claremont Meadows service facility	5	15
Orchard Hills tunnel portal	2	6
Orchard Hills Station	6	9
Orchard Hills Cutting	13	62
Bringelly service facility	9	18
Rail tunnels (Bringelly to Aerotropolis Station)	4	71
Aerotropolis Station	54	117
Sub-total	166	526
On-airport		
Western Sydney International tunnel portal	30	53
Airport Terminal Station	44	88
Rail tunnels	4	62
Sub-total kL/d	78	203
Project total kL/d **ML/yr**	**240** [1] **89**	**729** [2] **266**
[1] The combined predicted inflow may not occur due to staged construction. [2] The maximum inflow is likely to be of short duration and unlikely to occur concurrently across the project		

6 Assessment of operational impacts

6.1 Overview

This section presents the potential impacts of the project on the groundwater environment that may occur during operation. Additionally, this section addresses the minimum harm criteria as presented in the Aquifer Interference Policy (DPI, 2012) with respect to the predicted impacts from the project.

6.2 Off-airport

6.2.1 Changes to groundwater level and flow

Rail tunnels

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

The undrained (tanked) tunnels, cross passages and stub tunnels would lead to a reduction in the available aquifer transmissivity causing a rise in water levels upgradient (mounding) and a decrease downgradient. The size of the tunnels and cross passages compared to the overall thickness of the Bringelly Shale is small (approximately seven metres diameter compared to many tens of metres) and changes in water levels during the operational phase are expected to be localised around the tunnel structures. These changes in groundwater level are likely to be small and would be unlikely to have a substantial impact on the hydrogeology.

Undrained (tanked) structures

In the operational phase of the project, all stations, services facilities and tunnel portal structures would be undrained (tanked). Groundwater inflow to these structures would be prevented due to waterproofing and groundwater levels that were lowered during construction would recover slowly. In the longer term, these undrained (tanked) structures would present a barrier to the natural groundwater flow, since the shale and residual soils would have been removed and replaced with a largely impermeable barrier. This would lead to an increase in groundwater levels upgradient of any structure and a lowering downgradient. The magnitude and scale of changes would be dictated by the extent of the barrier and the hydraulic conductivity and hydraulic gradients of the aquifer.

The predicted changes in groundwater level as a result of these undrained (tanked) structures is relatively small, and likely within the range of seasonal and long-term groundwater fluctuation. The changes in groundwater level would also be predominantly localised around the structures. At St Marys for instance, which is one of the largest structures, the predicted change in groundwater level is approximately 0.6m upgradient, and 0.5m downgradient. The change in water level reduces away from the station, with a 0.2m change extending to between 250m and 400m upgradient and downgradient.

Similar changes in the magnitude and extent of water level change are expected to occur at Aerotropolis Core Station during the operational phase of the project. The services facilities shafts are unlikely to cause significant changes in water levels during the operational phase due to their small size. Changes to groundwater levels at Orchard Hills Station would be dominated by the drained (un-tanked) cutting to the south a described in Section 5.2.1 and Figure 28.

Viaduct and bridge pier footings would comprise of below ground shallow concrete footings. The footings are supported by piles which will be founded in the Bringelly Shale. Each of these structures would act to impede natural groundwater flow (where water levels are above the base). This would likely lead to some redevelopment of water levels, increasing slight upgradient and decreasing slightly downgradient of the structure.

However, due to the relatively small size of these structures, long-term changes to groundwater level are likely to be very small (within the natural range of groundwater level fluctuation) and localised around the structure. During design development, additional geotechnical investigations would provide geological and groundwater information at each of the viaduct sites, which would allow verification of this assumption.

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

There is not anticipated to be any additional impacts on GDEs, supply works and other receptors during operation than discussed previously in Section 5.2.

6.2.2 Land salinity impacts

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

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

6.2.3 Groundwater quality impacts

Throughout the operational lifetime of the project, groundwater ingress to drained (un-tanked) cuttings would continue to occur into permanent drainage systems. Groundwater seepage would be pumped to permanent water quality treatment plants at St Marys Station and Bringelly Services Facility the where it would be treated in accordance with criteria established in consultation with the Environmental Protection Authority (EPA) and DPIE (Water). Any incidental tunnel inflows would also be conveyed to the water quality treatment plant at St Marys and Bringelly services Facility.

The design of drainage and treatment systems would be undertaken during design development for the project. Groundwater inflow rates would be variable over the operational phase and are likely to be responsive to seasonal and climatic variation in precipitation and recharge. However, the quantity of groundwater captured over the operational life of the project is anticipated to be small owing to the predominantly low permeability groundwater systems in the study area and undrained (tanked) structures which prevent groundwater ingress (see Section 6.4)

During operation, it is unlikely that groundwater would be contaminated by the from unintended release of pollutants such as hydrocarbons. Chemicals used at stabling and maintenance yards which could include petroleum hydrocarbons and fire retardants would be stored in accordance with appropriate standards. Site drainage would also be designed appropriately to capture chemical spills to reduce the risk of environmental release. The generally low permeability of the groundwater system further limits this risk.

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

Groundwater in the study area has limited environmental value and beneficial use and risks to groundwater quality during operation are generally anticipated to be low.

6.3 On-airport

6.3.1 Changes to groundwater level and flow

All tunnels, structures and stations at Western Sydney International are designed as undrained (tanked). Groundwater inflow to these structures would be prevented due to waterproofing and groundwater levels that were lowered during construction would recover slowly. In the longer term, these undrained (tanked) structures would present a barrier to the natural groundwater flow as described in Section 6.2.1.

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

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

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

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

There is not anticipated to be any additional impacts on GDEs, supply works and other receptors during operation than discussed previously.

6.3.2 Land salinity impacts

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

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

6.3.3 Groundwater quality impacts

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

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

The proposed water treatment plants (as discussed in the Technical Paper 10 Hydrology, Flooding and Water Quality) would treat wastewater and groundwater ingress pumped from the stations, tunnels and other below ground facilities. The water treatment plant building would include chemical treatment tanks, water storage tanks, and filters which would collect treated collected water to a standard in line with the performance outcomes prior to discharge from the site (refer to the performance outcomes in Technical Paper 10 Hydrology, Flooding and Water Quality)

The interaction between Western Sydney International operations and the rail alignment would need to be considered in the operational phase of the project. Stormwater treatment systems and the use of other chemicals at Western Sydney International could infiltrate into the groundwater environment and eventually be captured by the rail cutting. Management and mitigation measures implemented by Western Sydney International mean that the risk of this occurring is likely to be low.

6.4 Estimated operational groundwater take

The estimated operational groundwater inflows for the project are presented in Table 28. Groundwater inflow rates at drained (un-tanked) locations would be variable over the operational phase of the project and are likely to be responsive to seasonal and climatic variation in precipitation and recharge. Inflow rates at undrained (tanked) structures have been estimated based on the waterproofing criteria (as discussed in Section 3.6.3). Groundwater ingress at undrained structures such as tunnels would comprise of incidental flows only since waterproofing would be expected to limit ingress to below measurable quantities (accounting for the performance of waterproofing and evaporative losses of any damp that may occur).

Table 28: Estimated long term groundwater inflow rates for project (Arup 2019)

Project element	**Estimated inflow drained structures (kL/d)**	**Estimated inflow undrained structures [1] (kL/d)**
Off-airport		
St Marys Station and crossover	-	1.1
Rail tunnels – St Marys to Orchard Hills	-	8.3
Claremont Meadows Service Facility	-	0.2
Orchard Hills tunnel portal	-	0.2
Orchard Hills Station	-	0.9
Orchard Hills cutting	4	-
Bringelly Service Facility	-	0.2
Aerotropolis Core Station	-	1.2
Sub-total	4 kL/d	12.3 kL/d
On-airport		
Western Sydney International tunnel portal	-	0.8
Airport Terminal Station	-	0.9
Rail tunnels – Western Sydney International to Bringelly	-	10.1
Sub total	0 kL/d	11.7 kL/d
Project Total	**24 kL/d 9 ML/yr**	
[1] Based on waterproofing criteria of 2.0 ml per hour per m2 of concrete lining surfaces		

6.5 Project water take

The total estimated water take for the project during the construction (Section 5.4) and operation phase (Section 6.4) is presented in Table 29, compared to the Long-term average annual extraction limit in the Water Sharing Plan for the Sydney Basin Metropolitan Region Groundwater Sources (NSW, 2015). The operational groundwater inflow rate is based on the long-term steady state prediction however it is likely that operational groundwater inflow rates would be greater than this during the period over which groundwater levels within the Bringelly Shale stabilise.

The results indicate that there is likely to be sufficient groundwater available from a licensing perspective for both the maximum estimated construction inflow and the long-term steady state operational inflow. The water take accounts for between approximately 0.02% and 0.5% of the available water in the WSP.

Table 29: Estimated project water take

Max estimated construction phase water take (ML/yr)	Estimated water take – operation phase, kL/d (ML/yr)	Sydney Basin Metropolitan Groundwater Source long-term average annual extraction limit (ML/yr)
240	9	45,915

6.6 Aquifer interference policy

Potential impacts on the hydrogeological environment are assessed in relation to the requirements of the NSW Aquifer Interference Policy (2012) in Table 30. Further geotechnical investigations and ongoing groundwater data collection has been undertaken during the preparation of this Technical Paper. The additional information would be used in future revisions of any hydrogeological assessment during design development in order to verify or update the conclusions of the assessment.

The Aquifer Interference Policy 2012 provides basis for determining whether a groundwater source should be considered productive or less productive. The definition for a less productive source is:

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

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

The Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against the minimal impact considerations. If the predicted impacts are less than the Level 1 minimal considerations, then the impacts of the project are acceptable.

Table 30: Impact assessment compared to the requirements of the NSW Aquifer Interference Policy

	Water table	Water Pressure	Water Quality
Less productive groundwater sources – porous and fractured rock	Level 1 Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post water sharing plan' variations, 40 metres from any: a) High priority groundwater dependent ecosystem; or b) High priority culturally significant site listed in the schedule of the relevant water sharing plan, or A maximum of a two-metre decline cumulatively at a water supply work Level 2 If more than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any a) High priority groundwater dependent ecosystem; or b) High priority culturally significant site listed in the schedule of the relevant water sharing plan, If appropriate studies demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a two-metre decline cumulatively at any water supply work, then make good provisions should apply.	Level 1 A cumulative pressure head decline of not more than a two-metre decline, at any water supply work Level 2 If the predicted pressure head decline is greater than requirement 1 then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	Level 1 Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity. Level 2 If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply work.
Comment	No water supply work is expected to be affected by a decline in water table. High Priority terrestrial groundwater dependent ecosystems are likely to be within the zone of predicted groundwater change. The current study, based on the relatively conservative estimates of drawdown indicates that changes may be in excess of Level 1, and that further assessment would be required in order to assess whether changes would affect the long-term viability of the groundwater dependent ecosystem. This would need to be undertaken during design development, prior to construction. There is currently insufficient groundwater level information at Orchard Hills Station or Bringelly services Facility to evaluate the natural long-term variability of groundwater levels. Drawdown associated with the drained (un-tanked) cutting south of Orchard Hills Station indicates that there may be lowering of water levels of one to two metres in the Bringelly Shale below Shale Gravel Transition Forest east of the station, outside of the construction footprint. Initial assessment of the groundwater conditions at Orchard Hills Station indicate that the groundwater level is around 5.5 metres below ground level and the groundwater quality is saline. Further geotechnical investigations and a groundwater monitoring program would be undertaken to address data limitations and confirm initial modelling outputs. As part of the proposed management measures additional updates to hydrogeological conceptualisation of the system and drawdown predictions are proposed as part of design development once additional groundwater information is available. Further assessment of the vegetation communities and their reliance on groundwater would also be required to further evaluate the potential effect of changes to the groundwater level at the site. Mitigation measures may be implemented at the site to further reduce the predicted impact on groundwater levels and nearby GDEs.	No water supply work is anticipated to be affected by a decline in pressure head and therefore meets the requirements of level 1	Groundwater in the study area has limited beneficial use owing to its high background salinity. Groundwater quality is unlikely to be impacted because of the project and there would be no change to the beneficial use category. Outstanding risks to groundwater quality would be managed appropriately through standard construction and operational procedures. The impacts therefore are expected to meet the requirements of level 1.

7 Cumulative impacts

7.1 Overview

There is the potential for cumulative groundwater impacts from the project and other proposed developments surrounding the project. The projects that have the potential to have a cumulative impact with the project were considered and screened in Chapter 24 of the Environmental Impact Statement. The projects considered to be relevant for the contamination assessment include:

- Western Sydney International
- Future M12 Motorway
- The Northern Road
- St Marys Intermodal Facility.

A brief description of these projects and qualitative assessment of associated potential cumulative impacts during construction and operation is provided below. This was undertaken by reviewing the predicted impacts on groundwater from those projects and evaluating where, if any there is likely to be overlap with the predicted impacts from the project.

7.2 Western Sydney International

The Western Sydney International is being developed and commenced in September 2018, continuing until opening of the airport in 2026. The development of the Western Sydney International development would include a single 3,700 metre runway, terminal and other relevant facilities for an operational capacity of approximately 10 million passengers annually, as well as freight traffic. Other facilities would include a business park to provide offices for government agencies, service providers and airport-related businesses.

Construction activities for Stage 1 would occur in three major phases:

- site preparation activities including clearing and earthworks
- aviation infrastructure activities such as construction of the runway, internal road network, terminal, air traffic control tower and maintenance facilities
- site commissioning activities involving testing and commissioning of all facilities in readiness for operation.

The project alignment runs through the Stage 1 Construction Impact Zone and areas outside that zone. Any development of Western Sydney International in those areas outside of the Stage 1 Construction Impact Zone would not commence construction until a second runway is required (expected to be around 2050).

The Department of Infrastructure and Regional Development, 2016b. Western Sydney Airport – Environmental Impact Statement (GHD, 2016) indicated that during construction potential impacts on the groundwater were:

- minor potential impacts to creeks and GDEs due to reduced recharge into the groundwater system because of changes to the land surface and site works during construction
- minor potential impacts to groundwater elevations beneath riparian vegetation and inflow to creeks as a result of changes in groundwater level at the site due to significant reprofiling earthworks
- a low risk of impacting water quality at surrounding surface water features and GDEs
- a negligible risk of impacting on groundwater level or quality at registered supply works.

The Western Sydney International development and the project may have some cumulative impacts on the groundwater environment. Potential cumulative impacts during construction may result from:

- decreased water levels at the site resulting from the combination of groundwater seepage into the rail line cuttings and reduced groundwater recharge due to reprofiling activity and construction of pavement and buildings at the airport site. Cumulatively lowered groundwater levels could potentially reduce interflow between the shale groundwater and creek lines
- construction activity being undertaken at the same time on the same site may potentially increase the risk of accidental spillage of chemicals during construction.
- Interaction between operational surface water discharges to the environment from Western Sydney International and the project

Consultation would occur with Western Sydney International to manage the interface of soil, groundwater and contamination management between the two projects. This would be undertaken during design development and when the project construction program is better defined.

Operation of the airport and the on- airport part of project would be undertaken in accordance with the Airports (Environment Protection) Regulations 1997 to prevent pollution to soil, surface water and groundwater.

Mitigation measures to manage cumulative impacts would likely include an ongoing groundwater monitoring program to evaluate the potential changes in groundwater levels at sensitive locations such as along creek lines or at riparian groundwater dependent ecosystems.

7.3 Future M12 Motorway

TfNSW is proposing the construction of a new east–west motorway between the M7 Motorway near Cecil Hills and The Northern Road at Luddenham. The M12 is a new motorway that is being delivered between the M7 Motorway, Cecil Hills and The Northern Road in Luddenham over a distance of about 16 kilometres. Construction of the project is expected to start in 2022 and be open to traffic before the opening of the Western Sydney International Airport in 2026.

The Environmental Impact Statement for the future M12 has been prepared and considers potential impacts to the groundwater environment. The findings indicated that the project has minimal potential to directly impact the groundwater environment. The exception to this is at a single cut at the west of the alignment (approximately 3.5km west of the project alignment) and at locations where bridge footings are below the groundwater table. The proposed interface between the two projects is presented in Chapter 7 (project description – operation) of the Environmental Impact Statement.

The potential for cumulative impacts on the groundwater environment between the project and the future M12 project is limited. Bridge footings that are constructed for the rail alignment over the future M12 may interact with the groundwater environment where they extend below the existing groundwater level. However, given their size, the footings are unlikely to cause any significant impediment to groundwater flow or change in groundwater level. The remainder of both projects would be constructed at or above ground level and interaction and potential cumulative impacts on the groundwater environment are unlikely.

Consultation would occur with the future M12 project to manage the interfaces for management of construction impacts on the groundwater environment relating to spoil and surface water management (treatment and discharge of water, management of spoil run off etc). This would be undertaken during design development and when the project construction program is better defined.

7.4 The Northern Road

TfNSW has nearly completed the upgrade of 35 km of The Northern Road, consisting of upgrade of a 35-kilometre section of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway in Glenmore Park. The Northern Road upgrades are being delivered in stages with some stages completed and the final stages having started construction in 2019.

The upgrade will be delivered in six stages. All stages will be operational by 2021 except Stage 5: Littlefields Road, Mulgoa to Glenmore Parkway, Glenmore Park, which is expected to be operational in 2022. The construction of Stage 5 could possibly occur at the same time as the project. Other stages will be operational when the project construction commences.

The Northern Road Stage 5 is around 4 kilometres west of the project. Due to the substantial distance between the projects, there are not expected to be any interfaces between the two projects that would result in a cumulative impact on the groundwater environment, either during construction or operation.

7.5 St Marys Intermodal Facility

Pacific National is proposing the staged construction and operation of an intermodal terminal (road and rail) and container park near St Marys.

The project is approved. The project is located about 400 metres west of St Marys Station, at Lot 2 Forrester Road St Marys. The container terminal would be located on the east side of the existing Sydney Trains suburban rail network and cover an area of nine hectares. The footprint of the St Mary’s Intermodal construction and the project do not overlap.

The environmental impact statement for the St Mary’s Intermodal project went on exhibition in August 2019. The Environmental Impact Statement indicated that the project was unlikely to have significant impacts on the either the groundwater or groundwater dependent ecosystems (both having a low environmental assessment significance).

Construction of the project is due to be completed in 2020 or early 2021 and the projects are unlikely to have significant construction or operation interfaces. There are unlikely to be any cumulative impacts on the groundwater environment from the two projects.

8 Proposed management and mitigation measures

8.1 Approach to management and mitigation

This chapter describes the environmental management approach and framework for the project for groundwater during construction and operation. Further details on the environmental management approach for the project are provided in Chapter 25 of the Environmental Impact Statement.

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

A Groundwater Management Plan would be developed for the project as identified by Section 7 of the CEMF.

The chapter includes a compilation of the performance outcomes as well as mitigation measures, including those that would be included in the Groundwater Management Plan. This includes mitigation measures as a result of impacts from ground settlements due to groundwater drawdown, tunnelling and excavation. Chapter 15 (Groundwater and geology) of the Environmental Impact Statement presents the results of the ground movement impact assessment, however for the purposes of consistency the mitigation measures are also discussed in this section.

8.2 Performance outcomes

Performance outcomes have been developed consistent with the requirements of the SEARs for the project. The performance outcomes for the project are summarised below in Table 31and identify measurable, performance-based standards for environmental management.

Table 31: Performance outcomes for the project in relation to groundwater

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

8.3 Proposed mitigation measures

In addition to the development and implementation of the management plans described in the CEMF, specific mitigation measures have been identified. These are included in Table 32.

Table 32: Mitigation measures

REF	Mitigation measure	Applicable locations
Construction		
GW1	Further assessment would be undertaken during design development, and prior to construction commencing, to ensure that damage to buildings and structures at risk of ground movement impacts around St Marys, Claremont Meadows, Orchard Hills and Bringelly are avoided or managed Where building damage risk is rated as slight, moderate or high (as per Rankin 1988), a structural assessment of the affected buildings/structures would be carried out and specific measures implemented to address the risk of damage.	St Marys construction site Claremont Meadows services facility construction site Orchard Hills construction site Bringelly services facility construction site
GW2	Further assessment of road and rail infrastructure and utility assets (including the Warragamba to Prospect Water Supply Pipelines) considered to be at risk from ground movement would be undertaken during design development. Consultation would be undertaken with the infrastructure and asset owners in each case to determine appropriate ground movement criteria for the assessment and, if required, to agree management measures to manage potential impacts	St Marys construction site Claremont Meadows services facility construction site Orchard Hills construction site Off-airport construction corridor Bringelly services facility construction site
GW3	Further assessment of potential ground movement impacts on the Goods Shed building at St Marys Station, including a building condition survey, would be carried out during design development and prior to the commencement of construction. The assessment would be carried out in consultation with a suitably qualified heritage architect and would identify acceptable ground movement criteria and, if required, feasible measures to reduce or mitigate the effects of ground movement on this structure Ground movement in the vicinity of the Goods Shed and the condition of the Goods Shed building would be monitored during construction A dilapidation survey of the Goods Shed would be carried out prior to work commencing in the vicinity of the building. At the completion of construction, should there be any damage to the building which is determined to be as a result of the project construction works, the building would be repaired in consultation with a suitably qualified heritage architect.	St Marys construction site
GW4	Consultation with Western Sydney Airport will be on-going in respect to the construction programs for both	On-airport

REF	Mitigation measure	Applicable locations
	projects to understand the potential for ground movement impacts to proposed buildings and structures.	
GW5	Detailed hydrogeological and geotechnical models for the project would be developed and progressively updated during design and construction These models would: • be informed by the results of groundwater monitoring undertaken before and during construction • identify predicted changes to groundwater levels, including at nearby water supply works and at groundwater dependent ecosystems or other sensitive groundwater receptors. Where changes to groundwater levels are predicted at nearby water supply works, groundwater dependent ecosystems or other sensitive groundwater receivers, an appropriate groundwater monitoring program would be developed and implemented Where changes to groundwater level are close to the ground surface, dryland salinity monitoring would be implemented to allow for management of any identified impacts The groundwater monitoring program would aim to confirm no adverse impacts on the receiver during construction or to effectively manage any impacts with the implementation of appropriate mitigation measures. Monitoring at any specific location would be subject to the status of the water supply work and agreement with the landowner.	All
GW6	A Groundwater Management Plan would be prepared and implemented. The plan must include the following trigger-action-response measures in relation to groundwater levels in areas identified as subject to potential drawdown (at groundwater dependent ecosystems or other sensitive receivers) but outside the construction footprint and Western Sydney International Stage 1 Construction Impact Zone: a. target criteria, set with reference to relevant standards and site-specific parameters; b. trigger values and corresponding corrective actions to prevent recurring or long-term exceedance of the target criteria described in (a); and c. corrective actions to compensate for any recurring or long-term exceedance of the target criteria described in (a) Response measures may include: • targeted ground improvement and grouting to limit groundwater inflows into station excavations,	All

REF	Mitigation measure	Applicable locations
	tunnels and cross-passage to reduce groundwater drawdown • design of undrained temporary retention systems to minimise groundwater inflow into station excavations and reduce groundwater drawdown • supplementing groundwater supply at affected groundwater dependent ecosystems or watercourses • make good provisions for groundwater supply wells impacted by changes in groundwater level or quality.	
Operation		
GW7	Ongoing groundwater inflows from drained project elements (or incidental flows) would be treated and tested before discharge to comply with any relevant Environmental Protection Licence or agreed discharge criteria.	St Marys Station Bringelly services facility

9 Conclusions

This technical Paper has documented the potential impacts of the project to the groundwater environment. The risks to groundwater are generally considered to be low due to the nature of the hydrogeology in the study area, and the following attributes in particular:

- low hydraulic conductivity deposits including Bringelly Shale bedrock, clay-dominated residual soils and alluvial deposits. These deposits are generally low yielding and are not relied upon as a groundwater source
- brackish or saline groundwater which has limited beneficial use. The quality of the water is such that it is not considered acceptable for drinking water, irrigation water or stock supply
- limited exchange of water between the creeks and the underlying shale bedrock, again due to the low permeability system. Riparian groundwater-dependent vegetation is likely to be partly reliant on groundwater within alluvial deposits, however these but these are likely to be connected directly to water in the creek with limited inflow from the underlying bedrock system.

The hydrogeological assessment indicates that the largest alteration in the groundwater condition due to the project is likely to be drawdown resulting from seepage of groundwater into drained (un-tanked) cuttings and stations during construction. Specifically, lowering of the groundwater level within the shale bedrock system is predicted to occur at St Marys Station, in the vicinity of the drained (un-tanked) cuttings and at Orchard Hills Station, Western Sydney International tunnel portal and terminal station, Bringelly Services Facility and at Aerotropolis Core Station.

Groundwater drawdown would occur at these locations during the construction phase of the project. During the operational phase, groundwater levels are expected to recover and there would likely be only minor changes to the water levels surrounding the structures, which are predominantly undrained (tanked) and would act to impede groundwater flow.

Changes to groundwater level are also likely to occur at St Marys Station, adjacent to the running tunnels between Orchard Hills Station and St Marys Station and between Western Sydney International tunnel portal and Aerotropolis Core Station as these structures would create a barrier to the natural groundwater flow, although these changes are expected to be minor.

Based on the predicted changes to groundwater level due to the project, the following conclusions can be drawn:

- it is unlikely there would be any impact on groundwater supply wells
- the potential for impacts to surface water in creeks or wetlands along the alignment is low
- the potential for impacts to riparian GDEs is low
- the magnitude of groundwater drawdown related settlement is likely to be small

- there is potential for minor impacts to soil salinity due to raised groundwater levels at locations where structures below ground may impede groundwater flow
- the maximum groundwater level drawdown predicted for the shale bedrock below terrestrial (non-riparian) native vegetation outside of the construction footprint at Orchard Hills is around two metres.

Groundwater quality is unlikely to be significantly affected by the project, either during construction or operation and there is limited beneficial use of the groundwater in the area such that the impact of any change is likely to be minimal.

Performance outcomes relating to groundwater include the requirement for groundwater availability and quality for water supply and environmental benefit not to be affected beyond the requirements described in the NSW Aquifer Interference Policy.

A detailed project geotechnical investigation and groundwater monitoring exercise would be carried out to supplement the existing baseline groundwater monitoring data that forms the basis of the assessment in this Technical Paper. This includes ongoing groundwater level monitoring and groundwater sampling of existing wells.

Mitigation measures include the development of detailed geological and hydrogeological models for the project during future design development phases, as additional geological and hydrogeological information is obtained. These would be used to refine predicted groundwater level changes at groundwater dependent ecosystems or other sensitive groundwater receptors.

Where changes to groundwater levels are predicted at locations where groundwater dependent ecosystems or other sensitive groundwater receivers are present, an appropriate groundwater monitoring program would be developed and implemented during construction as part of the Groundwater Management Plan. Trigger levels for monitoring changes in groundwater levels would be developed for monitoring during construction in order to manage potential groundwater impacts. The monitoring program would aim to confirm no adverse impacts on the receiver during construction, or to effectively manage any impacts with the implementation of appropriate corrective actions.

Risks associated with impacts to groundwater quality during construction would be managed through the implementation of construction environmental management plans. The management plans would also be developed in accordance with the Construction Environmental Management Framework and would include requirements for appropriate handling of fuels and chemicals, surface drainage to manage clean and dirty water and water treatment to minimise the risks from infiltration to groundwater.

During operation, ongoing groundwater inflows from drained project elements (or incidental flows) would be treated and tested before discharge to comply with any relevant Environmental Protection Licence or agreed discharge criteria.

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Appendix A

Groundwater Monitoring Summary

A1 Data table

Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
VW-R-01 (20m)	Western Sydney International	291293	6249134	54.1	-	-	20	28/07/2017	21/05/2019	662	52.2	1.9	48.9	5.2	3.3
VW-R-01 (10m)	Western Sydney International	291293	6249134	54.1			10	28/07/2017	21/05/2019	662	52.5	1.6	50.8	3.3	1.7
VW-R-02 (22m)	Western Sydney International	290475	6248446	62.3	-	-	22	28/07/2017	21/05/2019	662	59.9	2.4	58.7	3.6	1.2
VW-R-02 (10m)	Western Sydney International	290475	6248446	62.3			10	28/07/2017	21/05/2019	662	62.2	0.1	60.7	1.6	1.5
VW-R-03 (30m)	Western Sydney International	289836	6248054	85.7	-	-	30	28/07/2017	21/05/2019	662	73.9	11.8	71.8	13.9	2.1
VW-R-03 (20m)	Western Sydney International	289836	6248054	85.7			20	28/07/2017	21/05/2019	662	74.2	11.5	72.2	13.5	2
VW-R-03 (10m)	Western Sydney International	289836	6248054	85.7			10	28/07/2017	21/05/2019	662	77.2	8.5	74.4	11.3	2.8
VW-R-04 (20m)	Western Sydney International	289992	6246884	80.3	-	-	20	28/07/2017	21/05/2019	662	69.9	10.4	68.0	12.3	1.9
VW-R-04 (10m)	Western Sydney International	289992	6246884	80.3			10	28/07/2017	21/05/2019	662	73.9	6.4	71.1	9.2	2.8
VW-R-05 (35m)	Western Sydney International	288582	6247147	91.0	-	-	35	28/07/2017	21/05/2019	662	79.7	11.3	79.1	11.9	0.6
VW-R-05 (22m)	Western Sydney International	288582	6247147	91.0			22	28/07/2017	21/05/2019	662	80.3	10.7	79.6	11.4	0.7
VW-R-05 (10m)	Western Sydney International	288582	6247147	91.0			10	28/07/2017	21/05/2019	662	83.5	7.5	82.6	8.4	0.9
VW-R-06 (20m)	Western Sydney International	288704	6246225	71.0	-	-	20	28/07/2017	21/05/2019	662	65.7	5.3	57.1	13.9	8.6
VW-R-06 (10m)	Western Sydney International	288704	6246225	71.0			10	28/07/2017	21/05/2019	662	66.8	4.2	65.2	5.8	1.6
BH-D-171 (5m)	Western Sydney International	287246	6247747	104.2	-	-	5	12/02/2018	28/05/2019	470	Dry	Dry	Dry	Dry	Dry
BH-D-171 (12m)	Western Sydney International	287246	6247747	104.2			12	12/02/2018	28/05/2019	470	Dry	Dry	Dry	Dry	Dry
BH-D-171 (20m)	Western Sydney International	287246	6247747	104.2			20	12/02/2018	28/05/2019	470	93.9	10.3	91.8	12.4	2.1
BH-D-172 (5m)	Western Sydney International	288210	6247638	102.7	-	-	5	23/03/2018	28/05/2019	431	Dry	Dry	Dry	Dry	Dry
BH-D-172 (12m)	Western Sydney International	288210	6247638	102.7			12	23/03/2018	28/05/2019	431	93.0	9.7	91.4	11.3	1.6
BH-D-172 (25m)	Western Sydney International	288210	6247638	102.7			25	23/03/2018	28/05/2019	431	85.7	17.0	84.7	18.0	1
BH-D-173 (6m)	Western Sydney International	288462	6248204	96.4	-	-	6	12/02/2018	28/05/2019	470	Dry	Dry	Dry	Dry	Dry
BH-D-173 (16m)	Western Sydney International	288462	6248204	96.4			16	12/02/2018	28/05/2019	470	83.5	12.9	79.0	17.4	4.5

Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
BH-D-174 (6m)	Western Sydney International	290297	6249365	81.6	-	-	6	19/03/2018	7/12/2018	263	Dry	Dry	Dry	Dry	Dry
BH-D-174 (16m)	Western Sydney International	290297	6249365	81.6			16	19/03/2018	7/12/2018	263	Dry	Dry	Dry	Dry	Dry
BH-D-175 (4m)	Western Sydney International	289796	6248515	81.4	-	-	4	12/02/2018	28/05/2019	470	Dry	Dry	Dry	Dry	Dry
BH-D-175 (11m)	Western Sydney International	289796	6248515	81.4			11	12/02/2018	28/05/2019	470	76.8	4.6	71.4	10.0	5.4
BH-R-01	Western Sydney International	291387	6249658	55.7	14	20	-	19/01/2017	15/05/2018	481	54.0	1.7	53.4	2.3	0.56
BH-R-08	Western Sydney International	290643	6248549	61.5	24	30	-	19/01/2017	18/06/2018	515	59.1	2.4	58.4	3.1	0.7
BH-R-21	Western Sydney International	289222	6247676	78.6	12.5	18.5	-	19/01/2017	28/05/2019	859	76.2	2.4	74.9	3.7	1.3
BH-R-34	Western Sydney International	288713	6246218	71.1	4	10	-	19/01/2017	28/05/2019	859	67.9	3.2	66.8	4.2	1.06
BH-R-42	Western Sydney International	289880	6247019	81.3	18	24	-	19/01/2017	21/03/2018	426	80.5	0.9	76.6	4.7	3.85
WSA GW04	Western Sydney International	288574	6246161	74.3	17	20	-	12/01/2017	13/12/2018	700	67.9	6.4	67.2	7.1	0.705
WSA GW05	Western Sydney International	288574	6246161	74.0	7	10	-	12/01/2017	13/12/2018	700	68.5	5.5	67.5	6.5	0.98
WSA GW06	Western Sydney International	288413	6246761	88.3	17	20	-	12/01/2017	13/12/2018	700	79.2	9.1	78.2	10.1	1.03
WSA GW07	Western Sydney International	288413	6246761	88.0	7	10	-	12/01/2017	13/12/2018	700	83.8	4.3	82.1	5.9	1.61
WSA GW08	Western Sydney International	289013	6246245	67.8	7	10	-	12/01/2017	13/12/2018	700	66.9	0.9	65.4	2.3	1.46
WSA GW14	Western Sydney International	290400	6246870	73.9	7	10	-	12/01/2017	13/12/2018	700	65.0	9.0	64.3	9.7	0.69
WSA GW16	Western Sydney International	290461	6247764	78.1	7	10	-	12/01/2017	13/12/2018	700	69.9	8.3	69.2	9.0	0.701
WSA GW17	Western Sydney International	291523	6247399	53.9	17	20	-	15/02/2017	13/12/2018	666	51.6	2.4	50.3	3.7	1.27
WSA GW18	Western Sydney International	291523	6247399	53.9	7	10	-	12/01/2017	13/12/2018	700	52.4	1.6	50.9	3.0	1.44
WSA GW19	Western Sydney International	291738	6248976	58.3	7	10	-	12/01/2017	13/12/2018	700	54.1	4.3	51.0	7.3	3.02
WSA GW20	Western Sydney International	292130	6249000	48.1	17	20	-	12/01/2017	13/12/2018	700	46.2	1.9	42.0	6.1	4.203
WSA GW21	Western Sydney International	292130	6249000	48.1	7	10	-	12/01/2017	13/12/2018	700	44.9	3.2	43.4	4.7	1.476
WSA GW22	Western Sydney International	289283	6249162	62.8	7	10	-	12/01/2017	13/12/2018	700	61.8	1.0	59.5	3.3	2.236

Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
WSA GW23	Western Sydney International	291265	6247780	59.0	7	10	-	12/01/2017	13/12/2018	700	57.1	1.9	55.2	3.7	1.867
BH-C-01	Western Sydney International	287923	6247697	54.2	0.5	5	-	-	-	-	52.1	2.2	-	-	-
BH-C-03	Western Sydney International	291056	6247622	65.0	3	12	-	-	-	-	61.2	3.8	-	-	-
BH-C-04	Western Sydney International	291664	6247691	54.1	1	6	-	-	-	-	50.2	3.9	-	-	-
BH-C-05	Western Sydney International	291773	6248524	59.3	5	12	-	-	-	-	55.8	3.5	-	-	-
BH-C-08	Western Sydney International	291569	6249582	57.6	4	12	-	-	-	-	50.8	6.8	-	-	-
BHC-09	Western Sydney International	288919	6249087	72.1	6	12	-	-	-	-	66.9	5.2	-	-	-
BH-C-10	Western Sydney International	287235	6247278	96.8	4	12	-	-	-	-	91.4	5.4	-	-	-
BH-C-11	Western Sydney International	290577	6247020	68.0	3	12	-	-	-	-	64.7	3.3	-	-	-
BH-C-12	Western Sydney International	290835	6246926	58.8	2.5	5.5	-	-	-	-	55.3	3.5	-	-	-
BH-C-14	Western Sydney International	287173	6245519	93.5	4	12	-	-	-	-	88.8	4.7	-	-	-
BH-C-17	Western Sydney International	287923	6248536	93.5	3	12	-	-	-	-	90.5	3.0	-	-	-
BH-C-19	Western Sydney International	286920	6246753	94.6	3	12	-	-	-	-	89.5	5.2	-	-	-
BH-C-21	Western Sydney International	291816	6247861	52.7	1	4	-	-	-	-	51.3	1.4	-	-	-
BH-C-22	Western Sydney International	289520	6249555	69.6	4	12	-	-	-	-	59.4	10.2	-	-	-
BH-GN-338	Western Sydney International	288003	6248043	78.2	2	5	-	-	-	-	75.8	2.4	-	-	-
A	Aerotropolis	288242	6244147	92.9	24.3	27.3	-	-	-	-	81.3	11.7	-	-	-
B	Western Sydney International	289679	6249318	71.2	35.5	38.5	-	-	-	-	61.8	9.4	-	-	-
E Deep	Western Sydney International	287890	6244931	78.2	8.3	11.3	-	-	-	-	75.4	2.9	-	-	-
E Shallow	Western Sydney International	287890	6244931	78.2	2	5	-	-	-	-	77.5	0.7	-	-	-
F Deep	Western Sydney International	288859	6245870	69.9	27.3	30.3	-	-	-	-	66.0	3.9	-	-	-
F Shallow	Western Sydney International	288859	6245870	69.9	3	6	-	-	-	-	67.4	2.5	-	-	-

Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
G Deep	Western Sydney International	290793	6246826	59.6	21.3	24.3	-	-	-	-	54.6	5.0	-	-	-
G Shallow	Western Sydney International	290793	6246826	59.7	2	5	-	-	-	-	55.0	4.7	-	-	-
H Deep	Aerotropolis	289197	6244454	84.1	9.3	12.3	-	-	-	-	81.1	3.0	-	-	-
H Shallow	Aerotropolis	289197	6244454	84.0	1.5	4.5	-	-	-	-	81.6	2.4	-	-	-
J Deep	Aerotropolis	290078	6242951	70.9	39.3	42.3	-	-	-	-	65.2	5.6	-	-	-
J Shallow	Aerotropolis	290078	6242951	70.9	1.5	4.5	-	-	-	-	67.2	3.6	-	-	-
K	Western Sydney International	289587	6248317	72.0	29.3	32.3	-	-	-	-	68.5	3.5	-	-	-
1990_Coff_D1	Western Sydney International	286946	6246079	104.2	-	-	-	-	-	-	96.3	7.9	-	-	-
1990_Coff_D2	Western Sydney International	287166	6247020	97.6	-	-	-	-	-	-	93.9	3.7	-	-	-
1990_Coff_D3	Western Sydney International	287405	6247369	105.7	-	-	-	-	-	-	102.3	3.4	-	-	-
1990_Coff_D4	Western Sydney International	287223	6247992	98.8	-	-	-	-	-	-	95.8	3.0	-	-	-
1990_Coff_D5	Western Sydney International	288261	6247663	102.5	-	-	-	-	-	-	98.6	3.9	-	-	-
1990_Coff_D6	Western Sydney International	287900	6246723	112.9	-	-	-	-	-	-	105.5	7.4	-	-	-
1990_Coff_D7	Western Sydney International	288258	6246085	79.4	-	-	-	-	-	-	75.4	4.0	-	-	-
1990_Coff_D9	Western Sydney International	289591	6247340	87.5	-	-	-	-	-	-	83.3	4.2	-	-	-
1990_Coff_D10	Western Sydney International	289886	6248066	88.0	-	-	-	-	-	-	83.3	4.7	-	-	-
1990_Coff_D12	Western Sydney International	291270	6249548	59.0	-	-	-	-	-	-	55.8	3.2	-	-	-
1990_Coff_D13	Western Sydney International	290822	6248092	73.5	-	-	-	-	-	-	70.5	3.0	-	-	-
2018_JK_BH-D-161	Western Sydney International	292042	6249246	48.2	5	10	-	-	-	-	45.6	2.6	-	-	-
2018_JK_BH-D-162	Western Sydney International	291356	6247430	54.9	7	10	-	-	-	-	51.7	3.2	-	-	-
2018_JK_BH-D-163	Western Sydney International	291300	6247330	55.9	7	10	-	-	-	-	52.2	3.7	-	-	-
2018_JK_BH-D-164	Western Sydney International	290668	6246921	61.2	6	10	-	-	-	-	56.1	5.1	-	-	-
2018_JK_BH-D-165	Western Sydney International	289547	6249840	61.0	4	10	-	-	-	-	60.0	1.0	-	-	-

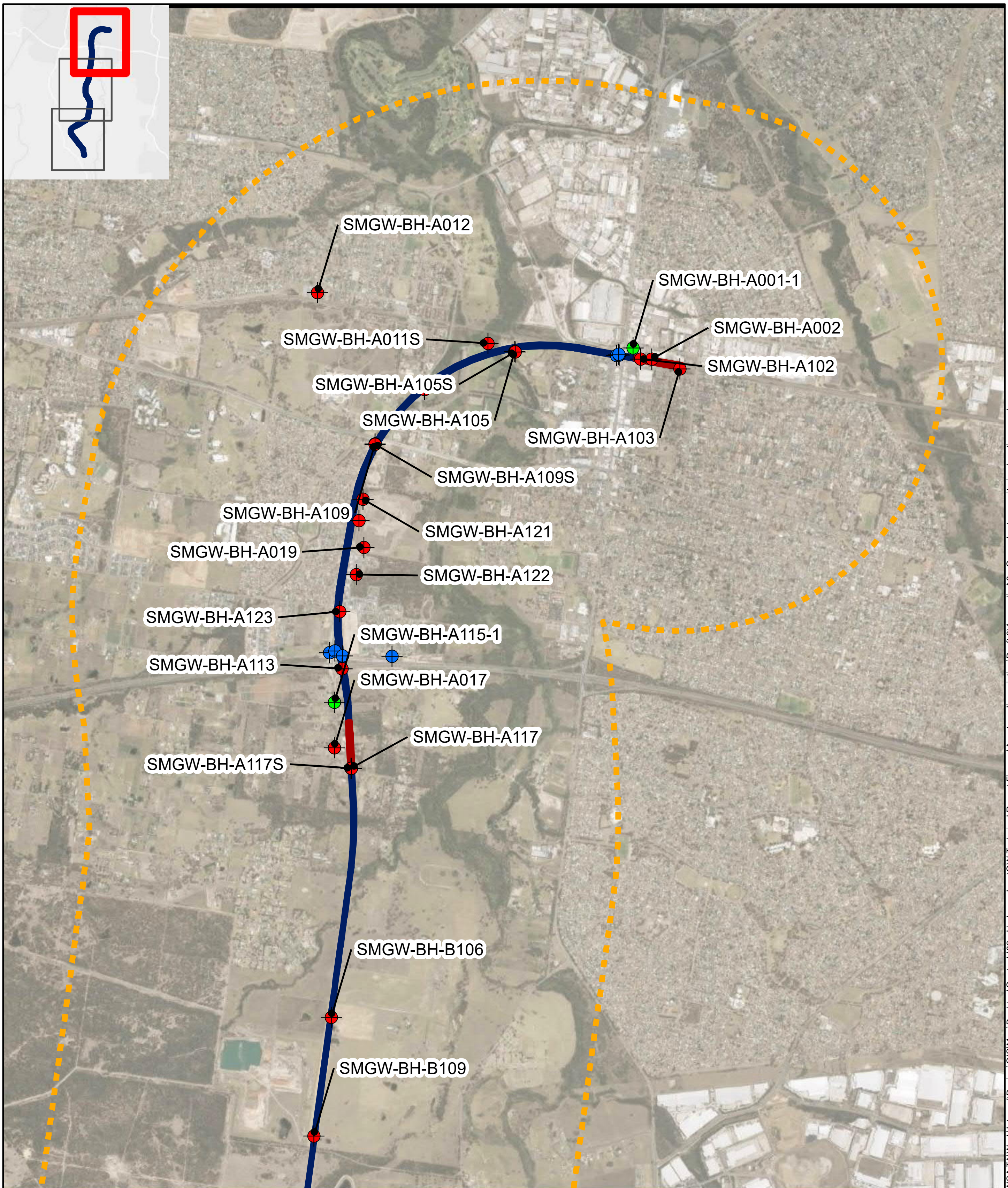
Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
2018_JK_BH-D-166	Western Sydney International	288509	6248769	77.5	6	12	-	-	-	-	69.4	8.1	-	-	-
2018_JK_BH-D-167	Western Sydney International	286854	6247676	84.4	5	10	-	-	-	-	78.6	5.8	-	-	-
2018_JK_BH-D-200	Western Sydney International	286587	6247055	85.1	4	10	-	-	-	-	80.1	5.0	-	-	-
2018_JK_BH-FF-005	Western Sydney International	288831	6249103	74.0	4	10	-	-	-	-	66.0	8.0	-	-	-
2018_JK_BH-FF-007	Western Sydney International	288438	6248995	67.4	4	10	-	-	-	-	66.2	1.2	-	-	-
2018_JK_BH-FF-010	Western Sydney International	288715	6248955	75.6	4	10	-	-	-	-	71.0	4.6	-	-	-
GW105054	Luddenham Rd - OHE	291424	6256068	-	-	210	-	-	-	-	-	-	-	-	-
GW105382	Luddenham Rd - OHE	291651	6255672	-	-	252	-	-	-	-	-	-	-	-	-
GW110454	Luddenham Rd - OHE	290961	6256815	-	-	30.3	-	-	-	-	-	-	-	-	-
GW110455	Luddenham Rd - OHE	291628	6256774	42.2	-	44.4	-	-	-	-	-	-	-	-	-
BH1	St Marys	293870	6261971	35.5	3	6	-	-	-	-	29.7	5.8	-	-	-
MW1	St Marys	293889	6261976	-	4.3	7.3	-	-	-	-	-	2.6	-	-	-
MW2	St Marys	293887	6261983	-	4.3	7.3	-	-	-	-	-	2.7	-	-	-
BH05	OHE - St Marys	291691	6259715	56.6	6	9	-	-	-	-	-	2.6	-	-	-
BH09	OHE - St Marys	291732	6259731	54.6	3	12	-	-	-	-	-	2.3	-	-	-
BH14	OHE - St Marys	291788	6259692	49.6	6	9	-	-	-	-	49.0	7.6	-	-	-
BH17	OHE - St Marys	292165	6259690	50.9	6	9	-	-	-	-	46.5	8.1	-	-	-
BH117	M12	291107	6251013	65.1	6.4	12.4	-	-	-	-	40.8	8.8	-	-	-
BH119	M12	291372	6249710	54.0	6.1	12.1	-	-	-	-	45.0	5.9	-	-	-
BH202	M12	290090	6251218	49.5	6	18	-	-	-	-	48.23	1.3	-	-	-
BH204	M12	290177	6251195	50.2	16.4	15.4	-	-	-	-	49.21	1.0	-	-	-
BH207	M12	292342	6251217	40.0	5.9	17.9	-	-	-	-	36	4.0	-	-	-
BH209	M12	292587	6251246	39.4	0.5	18.2	-	-	-	-	36.46	2.9	-	-	-
BH211	M12	293340	6251097	37.7	6	18	-	-	-	-	35.62	2.1	-	-	-

Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
BH215	M12	293615	6251030	37.8	6.4	18.4	-	-	-	-	34.77	3.0	-	-	-
BH301	M12	292746	6251171	43.0	0.5	10.5	-	-	-	-	39.48	3.5	-	-	-
BH302	M12	292935	6251154	40.5	0.5	10.5	-	-	-	-	-	-	-	-	-
MW01	Aerotropolis	290928	6244381	68.1	3	6	-	-	-	-	64.221	3.84	-	-	-
MW02	Aerotropolis	291241	6243734	61.5	3	6	-	-	-	-	57.6	3.93	-	-	-
BB01	Aerotropolis	290737	6243959	71.8	6	12	-	-	-	-	67.32	4.47	-	-	-
BB02	Aerotropolis	290753	6243957	71.7	6	12	-	-	-	-	67.23	4.42	-	-	-
BB03	Aerotropolis	290750	6243952	71.9	6	12	-	-	-	-	67.07	4.85	-	-	-
BB114	Aerotropolis	290808	6244063	67.7	6	12	-	-	-	-	65.86	1.84	-	-	-
BB116	Aerotropolis	291171	6244247	63.3	3	6	-	-	-	-	58.36	4.91	-	-	-
SMGW-BH-A001-1	St Marys	293993	6262029	34.4	-	-	8	Jul-19	-	-	36.1	-1.7	32	2.4	4.1
SMGW-BH-A001-2	St Marys	293993	6262029	34.4	-	-	18	Jul-19	-	-	33.3	1.1	31.5	2.9	1.8
SMGW-BH-A001-3	St Marys	293993	6262029	34.4	-	-	26	Jul-19	-	-	31	3.4	28.1	6.3	2.9
SMGW-BH-A001-4	St Marys	293993	6262029	34.4	-	-	31	Jul-19	-	-	27.8	6.6	26.7	7.7	1.1
SMGW-BH-A002	St Marys	294138	6261944	36.2	21.7	27.7	-	Aug-19	-	-	32.5	3.7	32.3	3.9	0.2
SMGW-BH-A011-1	South Creek	292889	292889	20.1	-	-	5.5	Jul-19	-	-	21.6	-1.5	17.8	2.0	3.5
SMGW-BH-A011-2	South Creek	292889	292889	20.1	-	-	10.5	Jul-19	-	-	18.3	1.8	18.1	2.2	0.4
SMGW-BH-A011-3	South Creek	292889	292889	20.1	-	-	23.5	Jul-19	-	-	23	-2.9	20	0.0	2.9
SMGW-BH-A011-4	South Creek	292889	292889	20.1	-	-	30	Jul-19	-	-	23.5	-3.4	20.5	-0.4	3.0
SMGW-BH-A011S	South Creek	292892	6262062	20.0	1.8	4.8	-	Jul-19	-	-	20.4	-0.4	17.6	2.3	2.7
SMGW-BH-A012	Werrington	291601	6262451	29.4	25	34	-	Jul-19	-	-	64.9	5.5	23.8	2.2	0.1
SMGW-BH-A017	Orchards Hill	291728	6258996	43.6	15	24	-	Jul-19	-	-	38.1	5.5	37.9	5.7	0.2
SMGW-BH-A019	Gipps Street	291953	6260516	42.2	28	34	-	Jul-19	-	-	38	4.2	37	5.2	1.0
SMGW-BH-C002	Badgerys Creek	288852	6246085	66.8	6	15	-	Jul-19	-	-	64.5	2.5	63.14	3.9	1.4
SMGW-BH-C001S	Badgerys Creek	288970	6246102	67.0	2	4	-	Jul-19	-	-	67.7	-0.9	64.4	2.4	3.3
SMGW-BH-A102	St Marys Station	294051	6261946	36.8	3	8		Feb-20	-	-	32.6	4.2	32.3	4.5	0.3

Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
SMGW-BH-A103	TBM tunnel - St Marys	294351	6261870	46.4	15	24		Jan-20	-	-	25.2	5.8	24.5	6.5	0.7
SMGW-BH-A105	TBM Tunnel - South Creek	293098	6262002	22.6	15	28		Dec-19	-	-	20.9	1.7	20.6	2.0	0.3
SMGW-BH-A105S	TBM Tunnel - South Creek	293100	6261999	22.6	2	8		Feb-20	-	-	19.2	3.4	19	3.6	0.2
SMGW-BH-A107	TBM Tunnel - South Creek	292413	6261713	22.5	19	26		Dec-19	-	-	21.2	1.3	20.7	1.8	0.5
SMGW-BH-A107S	TBM Tunnel - South Creek	292413	6261713	22.5	3	5		Dec-19	-	-	22.1	0.4	20	2.5	2.1
SMGW-BH-A109	Claremont Meadows services facility	292038	6261300	27.1	16	25		Dec-19	-	-	25.6	1.5	25.3	1.8	0.3
SMGW-BH-A109S	Claremont Meadows services facility	292037	6261297	27.4	3.5	5		Jan-2	-	-	25.31	2.1	24.9	2.5	0.4
SMGW-BH-A111	TBM Tunnel - Gipps Street	291915	6260719	41.7	29	38		Jan-20	-	-	31.0	10.7	30.6	11.1	0.4
SMGW-BH-A113	TBM tunnel M4	291786	6259594	43.4	20	29		Feb-20	-	-	-	-	-	-	-
SMGW-BH-A115-1	Orchard Hills tunnel portal	291729	6259341	40.4	-	-	7	Jan-20	-	-	37.1	3.3	36.8	3.6	0.3
SMGW-BH-A115-2	Orchard Hills tunnel portal	291729	6259341	40.4	-	-	18	Jan-20	-	-	36.6	3.8	36.2	4.2	0.4
SMGW-BH-A115-3	Orchard Hills tunnel portal	291729	6259341	40.4	-	-	21	Jan-20	-	-	36.6	3.8	36.3	4.1	0.3
SMGW-BH-A117	Orchards Hill Station	291855	6258838	38.9	10	16	-	Dec-19	-	-	35.4	3.4	34.7	4.1	0.7
SMGW-BH-A117S	Orchards Hill Station	291857	6258838	38.8	2	4	-	Dec-19	-	-	36.5	2.2	36	2.8	0.6
SMGW-BH-A121	Claremont Meadows	291944	6260883	38.6	15	21	-	Dec-19	-	-	33.2	5.4	31.3	7.3	1.9
SMGW-BH-A122	Claremont Meadows	291893	6260308	41.4	25	35	-	Feb-20	-	-	36.2	5.2	35.7	5.6	0.5
SMGW-BH-A123	TBM Tunnel - Orchard Hills	291769	6260026	49.0	30	39	-	Feb-20	-	-	27.5	21.5	27.2	21.8	0.3
SMGW-BH-B106	Luddenham Road	291703	6256950	39.4	1	4		Apr-20	-	-	37.7	1.8	37.2	2.3	0.5
SMGW-BH-B109	Luddenham Road	291572	6256049	41.5	9	13		Mar-20	-	-	38.7	2.8	38.3	3.2	0.4
SMGW-BH-B120	Luddenham Road Station	290964	6253779	52.6	5	14	-	Mar-20	-	-	49.7	2.8	49.5	3.1	0.3
SMGW-BH-B121	Luddenham Road Station	290940	6253451	56.6	2	3	-	Mar-20	-	-	53.5	3.1	53.0	3.6	0.4

Bore ID	Location	Easting	Northing	Ground elevation mAHD	Top of screen (mbgl)	Base of screen (mbgl)	VWP Install Depth (mbgl)	Start logger monitoring	End logger monitoring	Period (days)	GW level high (mAHD)	GW level high (mbgl)	GW level high (mAHD)	GW level low (mbgl)	Range (m)
SMGW-BH-B122-1	Luddenham Road Station	290940	6253280	59.0	-	-	4	Jan-20	-	-	55.3	3.7	55.1	3.9	0.2
SMGW-BH-B122-2	Luddenham Road Station	290940	6253280	59.0	-	-	20	Jan-20	-	-	-	-	-	-	
SMGW-BH-B123	Luddenham Road	290939	6253035	57.2	5	14	-	Mar-20	-	-	-	-	-	-	-
SMGW-BH-B130	Elizabeth Drive	291379	6250043	60.3	5	14	-	Mar-20	-	-	57.0	3.3	57.7	2.6	-0.7
SMGW-BH-D103	Derwent Road	289676	6245697	74.7			10	Feb-20	-	-	69.0	5.7	68.6	6.1	0.4
SMGW-BH-D103	Derwent Road	289676	6245697	74.7			25	Feb-20	-	-	67.6	7.2	67.4	7.3	0.2
SMGW-BH-D103	Derwent Road	289676	6245697	74.7			40	Feb-20	-	-	67.1	7.6	66.9	7.8	0.1
SMGW-BH-D109	Aerotropolis	290714.9	6243825.3	72.6	11	20	-	-	-	-	-	-	-	-	-
SMGW-BH-D109S	Aerotropolis	290715.8	6243821.2	72.4	5.95	8.95	-	-	-	-	-	-	-	-	-
SMGW-BH-C111	Western Sydney Airport	289291.8	6246220.6	65.8	-	-	6.4	-	-	-	-	-	-	-	-
SMGW-BH-C111	Western Sydney Airport	289291.8	6246220.6	65.8	-	-	13.9	-	-	-	-	-	-	-	-
SMGW-BH-C111	Western Sydney Airport	289291.8	6246220.6	65.8	-	-	21.9	-	-	-	-	-	-	-	-

A2 Groundwater monitoring locations



Legend

- Study area
- Stations
- Project Alignment
- Western Sydney International

SMGW Groundwater

- Vibrating Wire Piezometer
- Standpipe

Other Projects

- Groundwater monitoring (other projects)

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Groundwater monitoring locations

Metres
0 250 500 750 1,000

D1	1/07/2020	CJ	JL	JL
Issue	Date	By	Chkd	Appd

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Coordinate System
GDA 1994 MGA Zone 56

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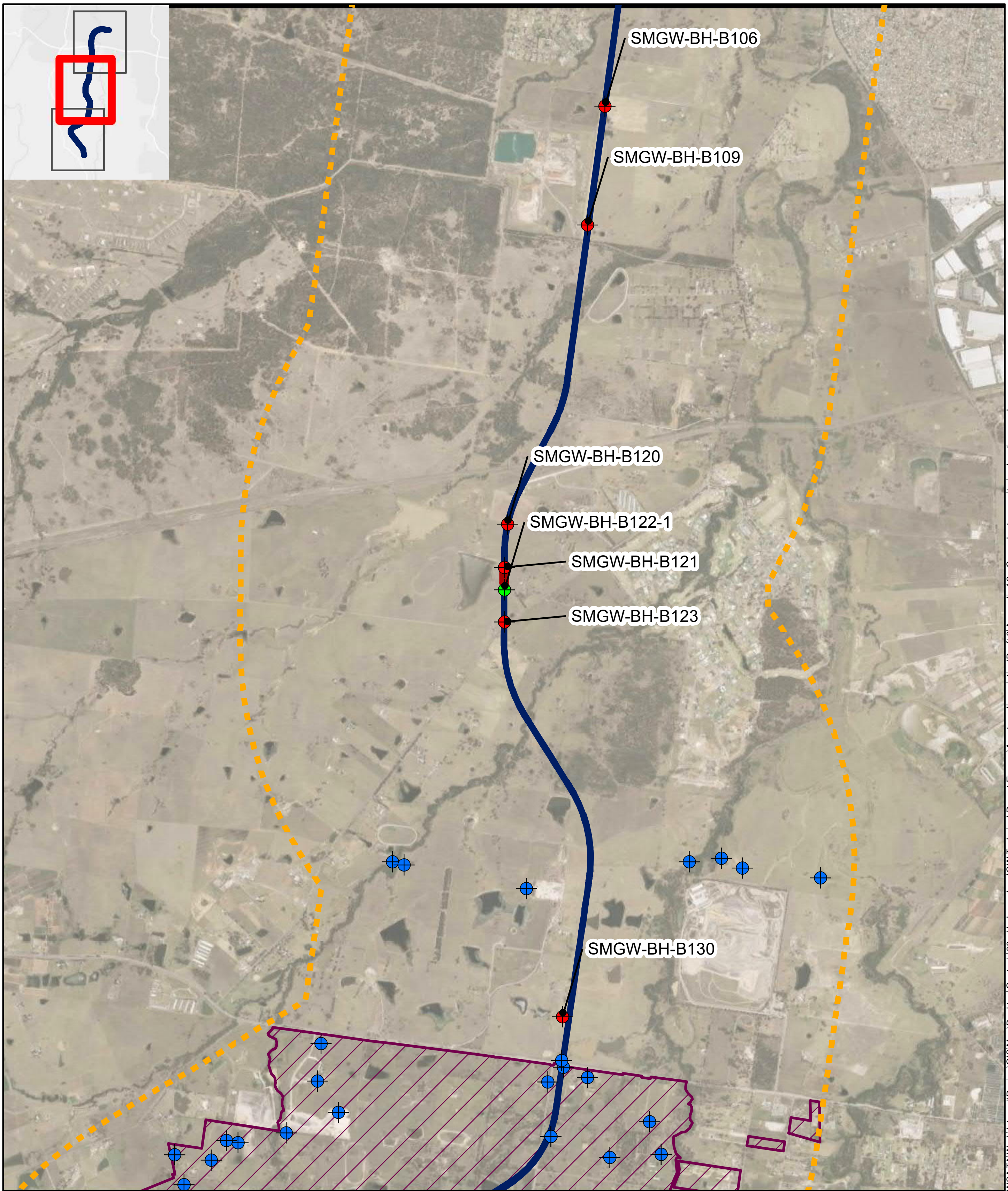

Legend

- Study area
- Stations
- Project Alignment
- Western Sydney International

SMGW Groundwater

- Vibrating Wire Piezometer
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Client
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Job Title
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Figure Title
Groundwater monitoring locations

Metres
0 250 500 750 1,000

D1	1/07/2020	CJ	JL	JL
Issue	Date	By	Chkd	Appd

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Job No	Figure No
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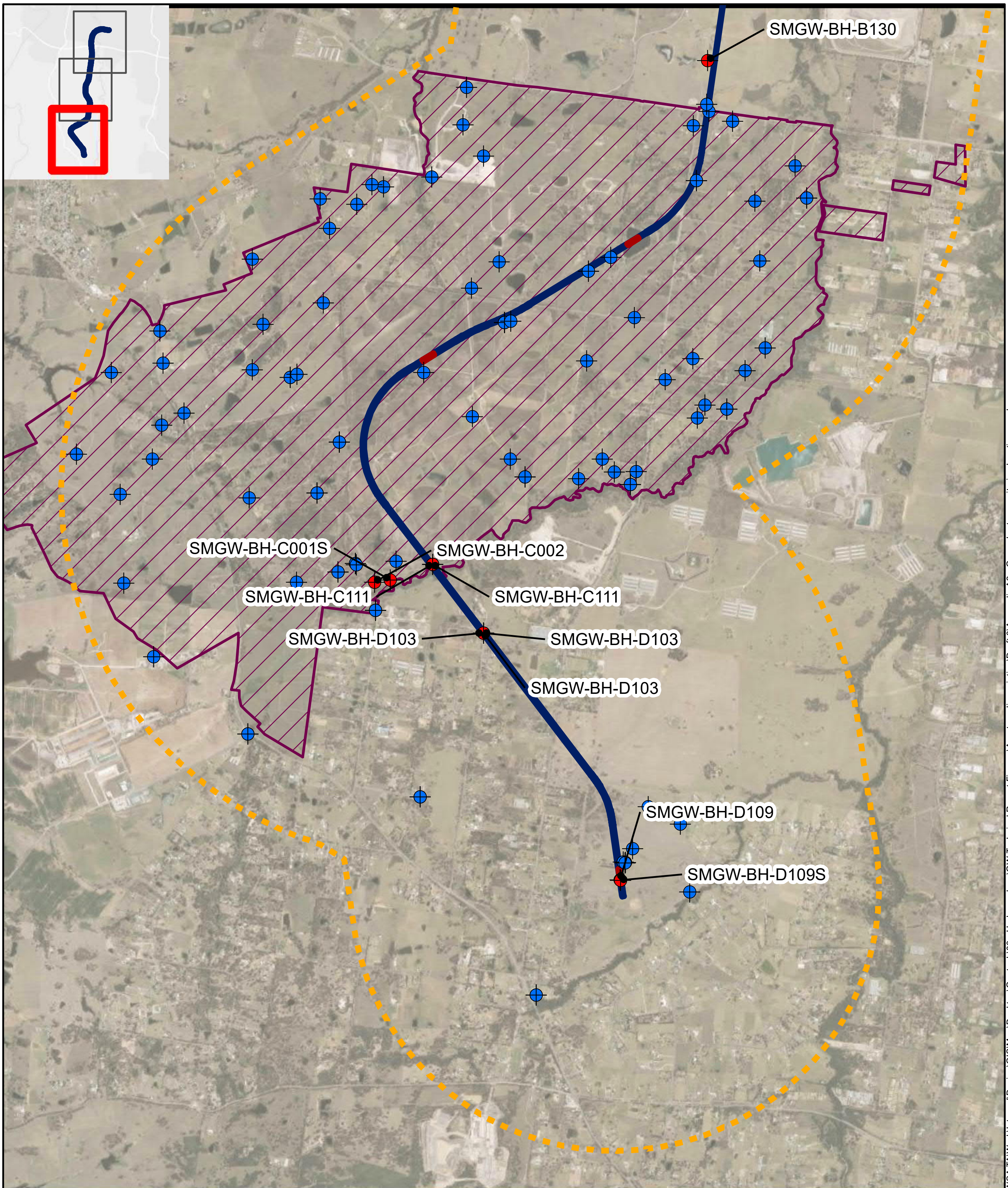

Legend

- Study area
- Stations
- Project Alignment
- Western Sydney International

SMGW Groundwater

- Vibrating Wire Piezometer
- Standpipe

Other Projects

- Groundwater monitoring (other projects)

Client
Sydney Metro

Job Title
Sydney Metro – Western Sydney Airport

Figure Title
Groundwater monitoring locations

Metres
0 250 500 750 1,000

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Coordinate System
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Appendix B

Groundwater analysis and modelling summary

B1 Numerical modelling assessment

Simplified local scale groundwater models were developed as two dimensional (2-D) cross-sections oriented perpendicular to the rail alignment. The models were set up and run using the modelling package SEEP/W.

Models were set up and run for the following locations:

- St Marys Station
- Claremont Meadows Services Facility
- Orchard Hills tunnel portal, station and cutting
- Airport tunnel portal
- Airport terminal station
- Bringelly Services Facility
- Aerotropolis Core Station

A summary of the modelling locations is presented in Table B.1.

Table B.1: Summary of numerical model locations

Location	Total Length (m)	Final excavation level (mAHD)	Assumed Baseline groundwater level (mAHD)	Depth of cutting below groundwater level (m)
St Marys	348	19	34	15
Claremont Meadows Services Facility	47	5	30 [3]	25
Orchard Hills tunnel portal	87	25	37	12
Orchard Hills Station	225	28	37	9
Airport tunnel portal	180 [1]	51 [2]	68	17
Airport Terminal Station	263	56	74	18
Bringelly Services Facility	32	44	72	28
Aerotropolis Core Station	366	54	70	16

Notes

[1] Additional ~120m of shallow cut assumed to be below groundwater level prior to tunnel portal structure

[2] At deepest point

3 Assumed to be at ground level

Individual models were set up at each of the locations using a simplified geometry and geological profile based on interpreted profiles from available borehole information undertaken for the project.

The modelling was carried out to predict:

- the potential inflows associated with drained (un-tanked) below-ground stations and cuttings structures during construction
- the potential magnitude of drawdown in groundwater level associated with drained (un-tanked) below-ground stations and cuttings structures

The approach to numerical modelling comprised the following stages:

- model design and construction – based on the available data and understanding of the hydrogeological environment
- predictive modelling and interpretation of results to evaluate changes in groundwater level and potential inflow rates.
- Sensitivity assessment based on likely range of hydraulic conductivity values observed during geotechnical investigations

Setup and hydrogeological parameters

Each model was developed based on the geotechnical classification derived from interpretation of geological logging of cores along the alignment. The breakdown of geological units within the model comprised of:

- Alluvium (Claremont Meadows Services Facility only)
- Residual soil
- Bringelly Shale Class V and IV
- Bringelly Shale Class III
- Bringelly Shale Class II.

Hydrogeological testing undertaken on the Bringelly Shale showed some, but generally limited variation by shale class. Class II and Class III bedrock generally had a higher proportion of testing below the quantitation limit of $1x10^{-8}$ m/s (30 to 35%) compared to the Class IV/V material (approximately 10%). However, the proportion of higher permeability tests in all classes (10^{-6} and higher) only varied between 6% and 16% (with Class I/II having the highest proportion). It should be noted that there were substantially less tests undertaken on the Class IV/V shale due to seating issues with the packers and because of the generally thinner nature of the units.

The range of parameters used for the modelling for each unit is presented in Table B.2. Storage parameters were based on the advised parameters for Sydney Shales in Pells (2019). The range of hydraulic conductivities used in the assessment was typically based on:

- Site specific testing data
- Average hydraulic conductivity values for all packer test data

- Upper bound based on 90th percentile of packer test data

Table 33: Parameter ranges

Material	Hydraulic conductivity (m/s)	Anisotropy	Specific yield [1]	Specific storage m^{-1} [2]
Alluvium [3]	$1x10^{-6}$ to $1x10^{-5}$	0.5	0.25	$5x10^{-4}$
Residual Clay	$1x10^{-7}$ to $2x10^{-6}$	0.5	0.05	$5x10^{-4}$
Class V Shale	$4x10^{-8}$ to $2x10^{-6}$	0.05 - 0.1	0.03	$2x10^{-4}$
Class IV Shale	$4x10^{-8}$ to $2x10^{-6}$	0.05 – 0.1	0.03	$8x10^{-5}$
Class III Shale	$4x10^{-8}$ to $2x10^{-6}$	0.01 – 0.05	0.04	$3x10^{-5}$
Class II or better Shale	$2x10^{-8}$ to $1x10^{-6}$	0.01 – 0.05	0.02	$3x10^{-5}$
Notes [1] Based on literature values, where available, specific to Sydney shales [2] Estimated based on available stiffness/compressibility data [3] Clay alluvium present at Claremont Meadows Service Facility only				

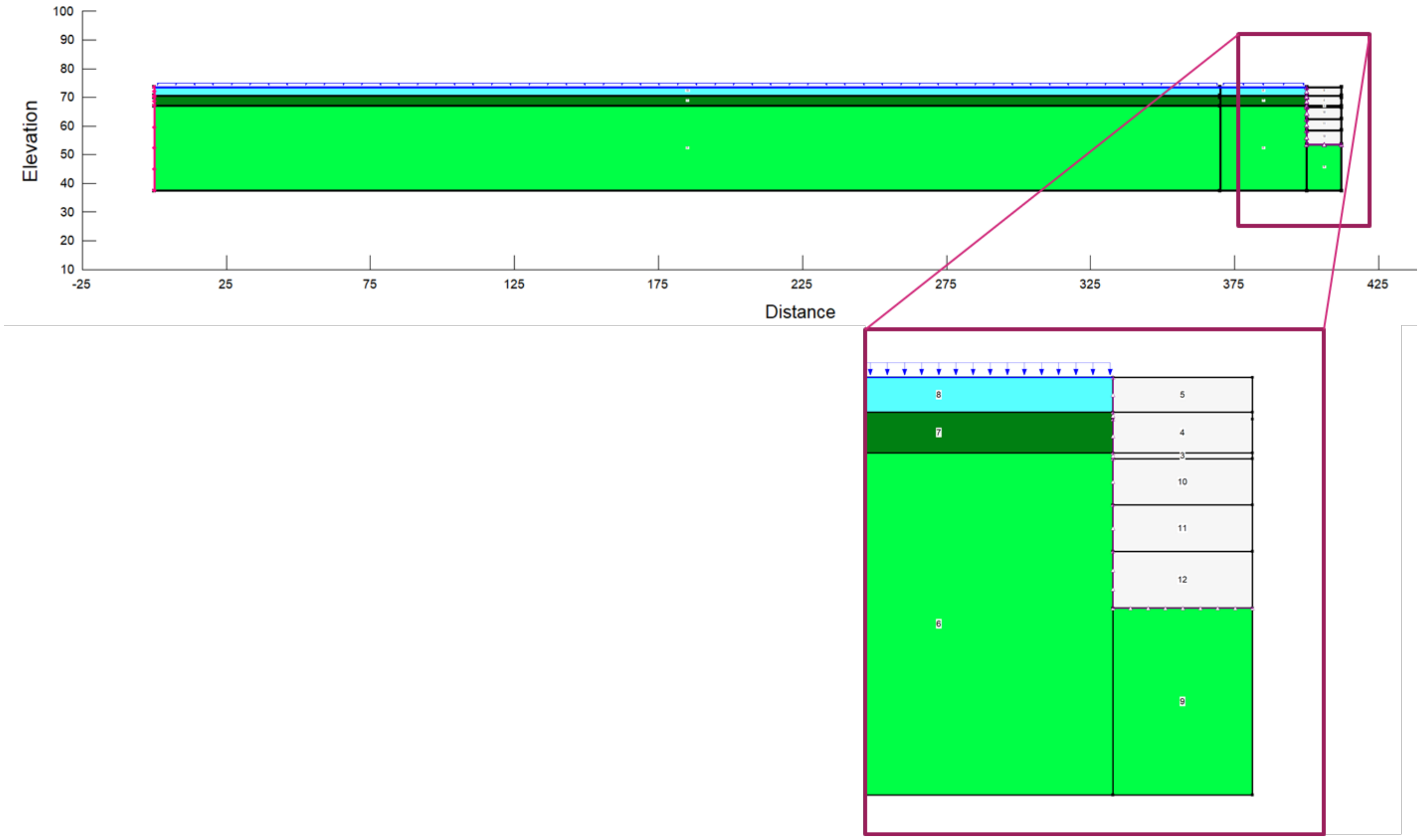
For those structures which are designed as undrained (tanked) during construction, (Claremont Meadows Service Facility, Orchard Hills East Dive and Station), a low permeability wall cut-off was included in the model. This was based on the toe level from Concept Design and was typically 2 – 3 metres below the final excavation level. The ground conditions modelled at each of the locations is presented in Table B.3. Figure B.1 shows the simplified setup and geometry used at each of the structure locations

Table B.3 Ground models

	St Marys		Claremont Meadows Services Facility		Orchard Hills tunnel Portal		Orchard Hills Station	
	Top elevation (mAHD)	**Thickness (m)**	**Top elevation (mAHD)**	**Thickness (m)**	**Top elevation (mAHD)**	**Thickness (m)**	**Top elevation (mAHD)**	**Thickness (m)**
Existing Ground surface	36.6	-	30	-	40	-	41.3	-
Alluvium	-	-	30	4.2	-	-	-	-
Residual soil	36.6	9	25.8	3.6	40	6.2	41.3	5.7
Shale Class V/IV	27.6	6	22.2	8.2	33.2	3.2	35.6	4.2
Shale Class III	21.6	22	14	13	30	5.7	31.4	6.5
Shale Class II/I	-	-	1	5	24.3	25	24.9	8.3
Excavation level	19	-	4.5	-	24.8	-	27.4	-

	Airport tunnel portal		Airport Terminal Station		Bringelly Services Facility		Aerotropolis Core Station	
	Top elevation (mAHD)	**Thickness (m)**	**Top elevation (mAHD)**	**Thickness (m)**	**Top elevation (mAHD)**	**Thickness (m)**	**Top elevation (mAHD)**	**Thickness (m)**
Existing Ground surface	69	-	75	-	73	-	73.5	-
Alluvium		-	-	-	-	-	-	-
Residual soil	69	3.5	75	3	73	3.5	73.5	3
Shale Class V/IV	65.5	1	72	3	69.5	3	70.5	2.5
Shale Class III	64.5	5.5	69	30	64.5	8.5	67	30
Shale Class II/I	58	25	-	-	56	30	-	-
Excavation level	51	-	56	-	43.5	-	54	-

Figure B.1: Simplified model geometry (Aerotropolis Core Station)



Predictive modelling

Predictive modelling was undertaken based on the average hydraulic conductivity values from the geotechnical investigation data and the proposed cutting geometry. Drainage boundaries were placed at the cutting surface and the recharge boundary removed from the extent of the cutting. Models were run as transient analyses to evaluate the potential inflow and drawdown over a two-year construction period.

Sensitivity assessment around the hydraulic conductivity was used to evaluate the potential effect on groundwater seepage. The average hydraulic conductivity conditions were used to assess the drawdown, noting that for most structures, the packer testing information at most of the structures were generally below the average hydraulic conductivity values for the entire project.

The results of the numerical modelling were used to estimate the groundwater seepage rate into the cuttings. To obtain seepage rates for the entire length of the excavations, the total perimeter length of the excavation was multiplied by the predicted seepage rate, which is provided in a discharge per m length. This is probably an overestimate for the tunnel portal and cut structures because the models are undertaken at the deepest part of the cut, with groundwater level and cut elevations being higher along the remainder of the cut section. Average inflow and maximum inflow rates are obtained from the results.

Groundwater drawdown from the models is observed by obtaining the change in groundwater level over the 2-year period from the initial baseline groundwater level.

Modelling assumptions and uncertainty

Numerical hydrogeological models are designed as simplifications of complex, real world systems that are governed by physical and human processes. The purpose of any numerical modelling is to replicate conditions in enough detail to allow predictions to be made and to inform decision making. However, model predictions are uncertain, because they are built on limited information and many assumptions. Simplifying assumptions for the modelling included:

- Uniform thickness and horizontal boundaries between model layers.
- Groundwater flow within the bedrock modelled as a mass continuum with equivalent properties (i.e. hydraulic conductivity and storage parameters) which assumes that flow occurs through the entire layer, rather than along discrete bedding and fracture planes
- Recharge (where applied) is uniform and constant at a rate of 2% annual average recharge
- Excavation takes place instantaneously every four weeks until final excavation level is reached. Each excavation lift approximately 3 – 4m, based on information provided by design TA.

- Groundwater ingress into excavation face modelled as a drainage boundary, allowing the model to compute the groundwater inflow over time across that boundary
- Constant head boundary condition set at a distance from the excavation coinciding with a nearby creek line or another feature.
- Initial baseline groundwater level is uniform across the model domain and hydrostatic from that level.
- the simplification of a 3D groundwater flow pattern into a 2D model.

The key assumption used in the modelling that flow within the Shale is an equivalent soil mass permeability is unlikely to be wholly valid. Groundwater flow within the Bringelly Shale is within secondary features such as bedding planes and joints. The amount of these features and their connectivity with the overlying soils dictate the true extent of groundwater drawdown in the Bringelly Shale caused by drained (un-tanked) structures. At a catchment scale it is unlikely that groundwater within the shale would be fully interconnected and therefore, drawdown predicted by the numerical model, is likely to be an overestimate.

The 2D simplification of a complex 3D flow pattern is also considered to be an oversimplification. The baseline groundwater conditions are not aligned with the likely 3D conditions (i.e. there is a component of groundwater flow which is oblique to the models). This flow component occurs because of recharge to the west of the catchment moving towards the northeast. It is anticipated that this would serve to reduce the potential drawdown predicted by the models, in this respect, making them conservative.

The numerical modelling is based on available groundwater monitoring data collected from the investigations close to the structures. The availability of groundwater data away from the project alignment is limited, and the simplification of a flat-water table, although unrealistic, is considered reasonable for the purposes of evaluating inflow and drawdown over the construction period. Refinement of these assumptions would be appropriate once additional monitoring data is available.

Based on the Australian groundwater modelling guidelines (Barnett et al, 2012) the modelling classification is between Class 1, for the specific attributes below:

- data – Class 1 – Groundwater head observations are available close to the project but do not generally provide adequate coverage throughout the domain. Additionally, there is limited data available near to potentially sensitive receivers (alluvial aquifers and GDEs)
- calibration – Class 1 – Calibration was not undertaken for the purposes of these models.

B2 Analytical modelling assessment

B2.1 Approach

AnAqSim analytical assessment software was used to estimate potential changes to groundwater levels from at Orchard Hills Station, tunnel portal and cutting. AnAqSim uses the "analytical element method" (AEM), based on superposition of analytic functions, to yield a solution for groundwater heads and flow based on aquifer properties and boundary conditions. The software was used to evaluate potential changes to groundwater level in three-dimensional space at Orchard Hills station, tunnel portal and cutting which except for the cutting at Orchard Hills, are designed as undrained (tanked) structures. This approach was undertaken at Orchard Hills due to the proximity of the potential GDE vegetation to the east of the station, to provide an assessment of the potential drawdown in 3D space.

The method has limitations compared with numerical solution software and can only be used for relatively simple assessments. However, given the limited datasets currently available, this methodology was considered appropriate for assessment of potential long-term changes in groundwater level at this location, where there is likely to be influence of drained (un-tanked) and undrained (tanked) structures during construction and operation phases of the project.

Hydrogeological data at Orchard Hills Station is limited to a few groundwater monitoring points with only a short period of monitoring data. Calibration of the analytical models was not possible, except to two locations (BH-A017 and BH-A115). As an alternative approach, similar groundwater flow dynamics to those at Western Sydney International were used to replicate similar gradients and flow directions (i.e. shallow gradients and flow towards the main drainage channels).

A simple unconfined single layer model was set up bounded by creek lines (South Creek and Claremont Creek). Constant head boundary conditions were assigned to the models at the main creek lines based on the ground elevations, assuming that groundwater is close to the surface and that creek and alluvial deposits acts as a source of water into the model). Hydraulic parameters were assigned using available testing data from the study area and where available, site specific data.

The analytical assessment undertaken in this section is Class 1 in terms of the Australian groundwater modelling guidelines (Barnett et al, 2012). There is a large degree of uncertainty associated within these assessments due to the limited site-specific monitoring or calibration. The results of the assessment are an indicative prediction and only used to broadly evaluate potential magnitude of the long-term groundwater level change.

B2.2 Orchards Hill Station

At Orchards Hill groundwater levels around the station area are approximately 5 to 6 metres below ground level within the Bringelly Shale. Constant head boundaries were included in the model at the approximate locations of South Creek to the east, and Claremont Creek to the north and Blaxland Creek to the south. The constant head boundaries decreased in a northerly direction in line with the topographic slope of the drainage channels.

Hydraulic conductivity within the model was set at a value of 6 $x10^{-7}$ m/s based on the estimated average hydraulic conductivity from site-specific data. Recharge was varied to achieve hydraulic gradients across the proposed station locations of between 1% and 2%, along with achieving a reasonable water level match to the limited groundwater level data available at the site locations. A recharge value of 2.1% ($4.5x10^{-10}$ $m/s/m^2$) of annual average recharge achieved a reasonable fit for the gradient and water level.

The predicted hydraulic gradient across the station is approximately 1.5% in an easterly direction towards South Creek. The station and tunnel portal structures are aligned in a N-S direction, which is roughly perpendicular to the inferred groundwater flow direction.

To model the effect of the underground undrained (tanked) structures at Orchard Hills, a zone of lower hydraulic conductivity was placed in the model domain at the location of the structures. This zone occurs across the full depth of the model thickness. The hydraulic conductivity was reduced to model a full cut-off however in reality it is possible that some flow would continue to occur below the structures.

At Orchard Hills the drained (un-tanked) cutting south of the station was modelled using a constant head boundary set at the lower rail level (29 metres AHD to 31 metres AHD) at locations where the cutting is below the baseline groundwater levels.

The baseline model and model with project structures were run in steady state and the difference between the groundwater heads of the two models were calculated. This difference represents the potential long-term change in groundwater level (under the specific conditions set up in the model).

The model setup and baseline results are presented in Figure B.3 and the predictive model and results are presented in Figure B.4

Figure B.3: Orchard Hills AnAqSim model - baseline setup and results

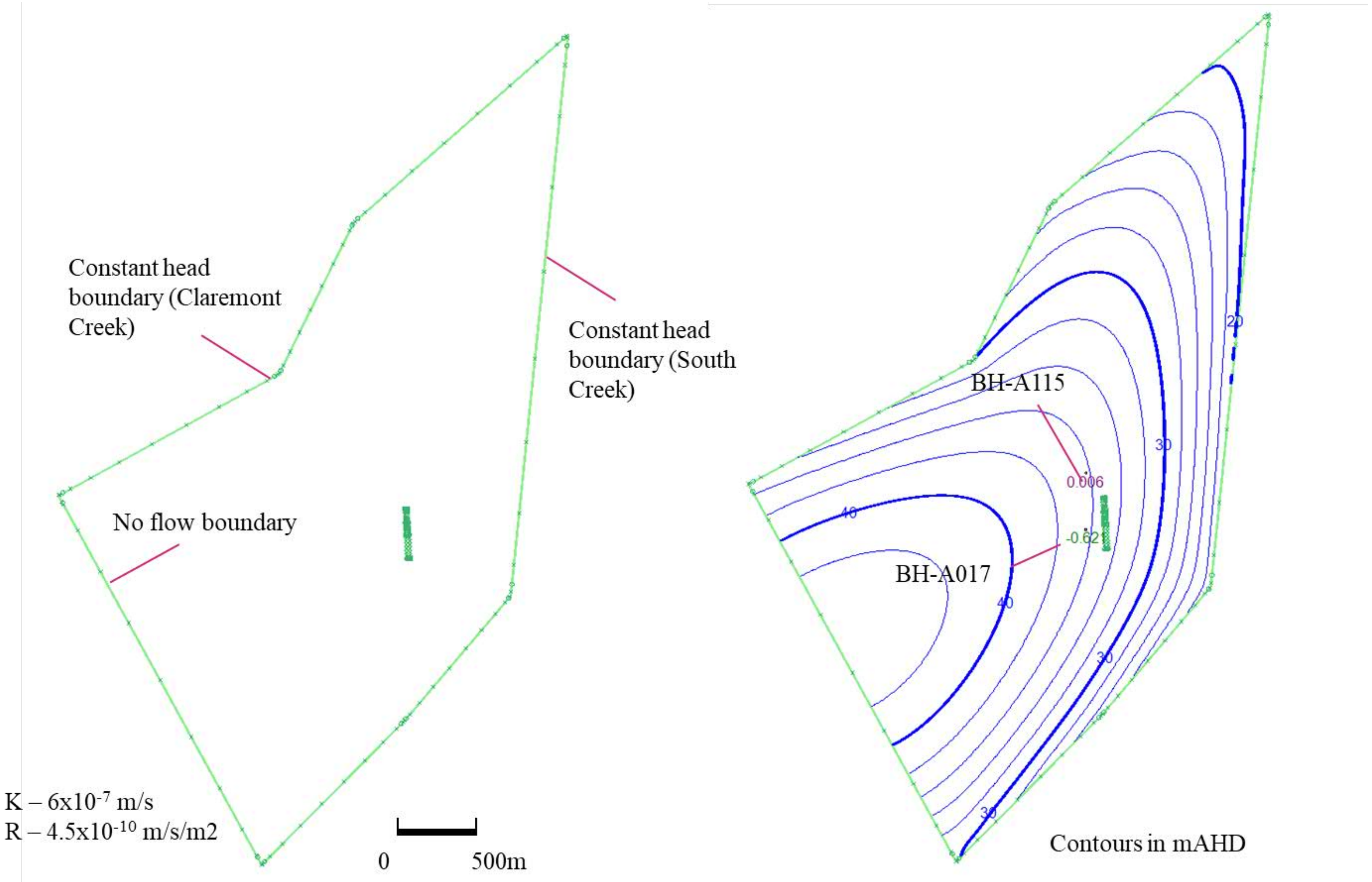
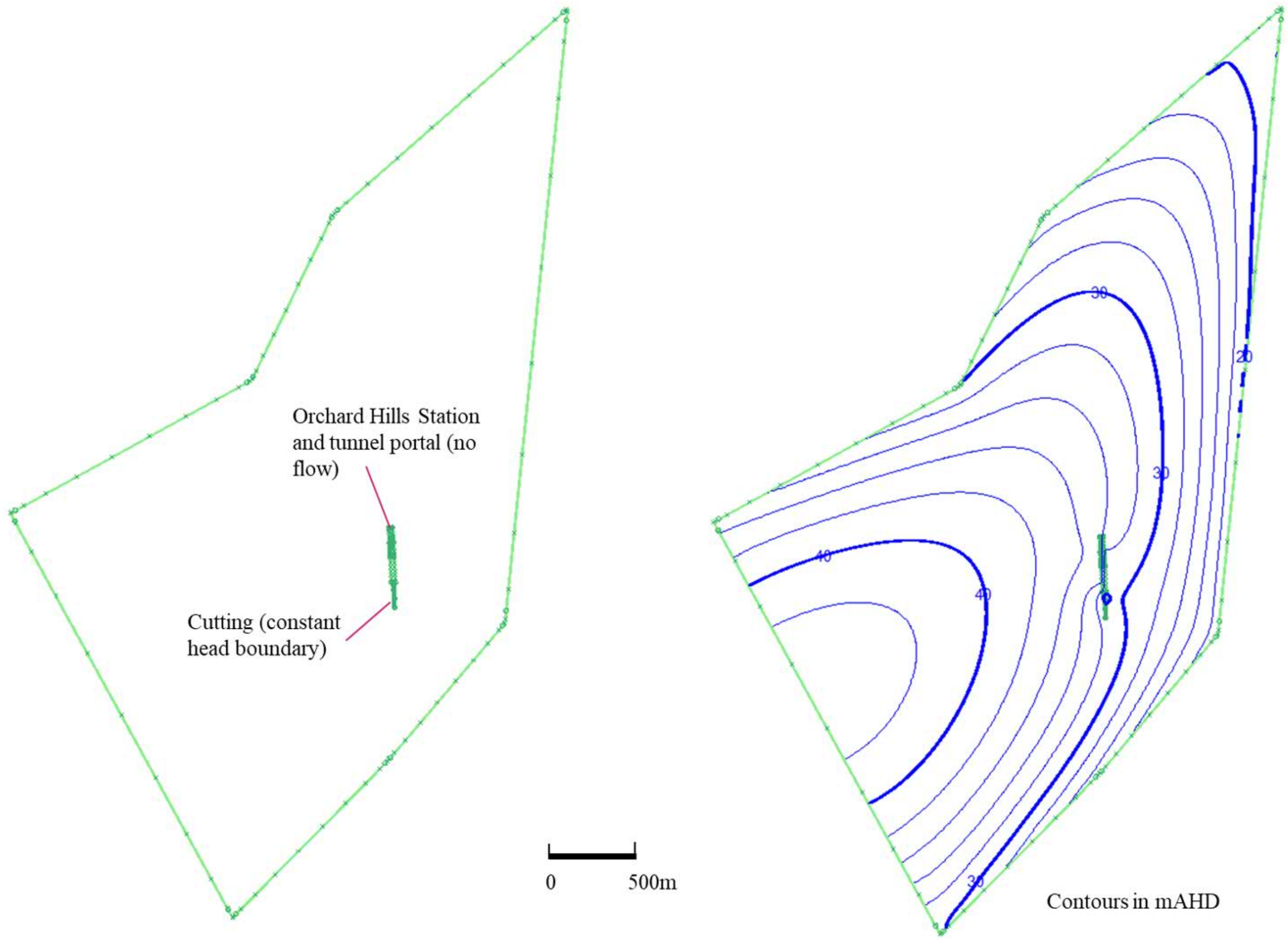


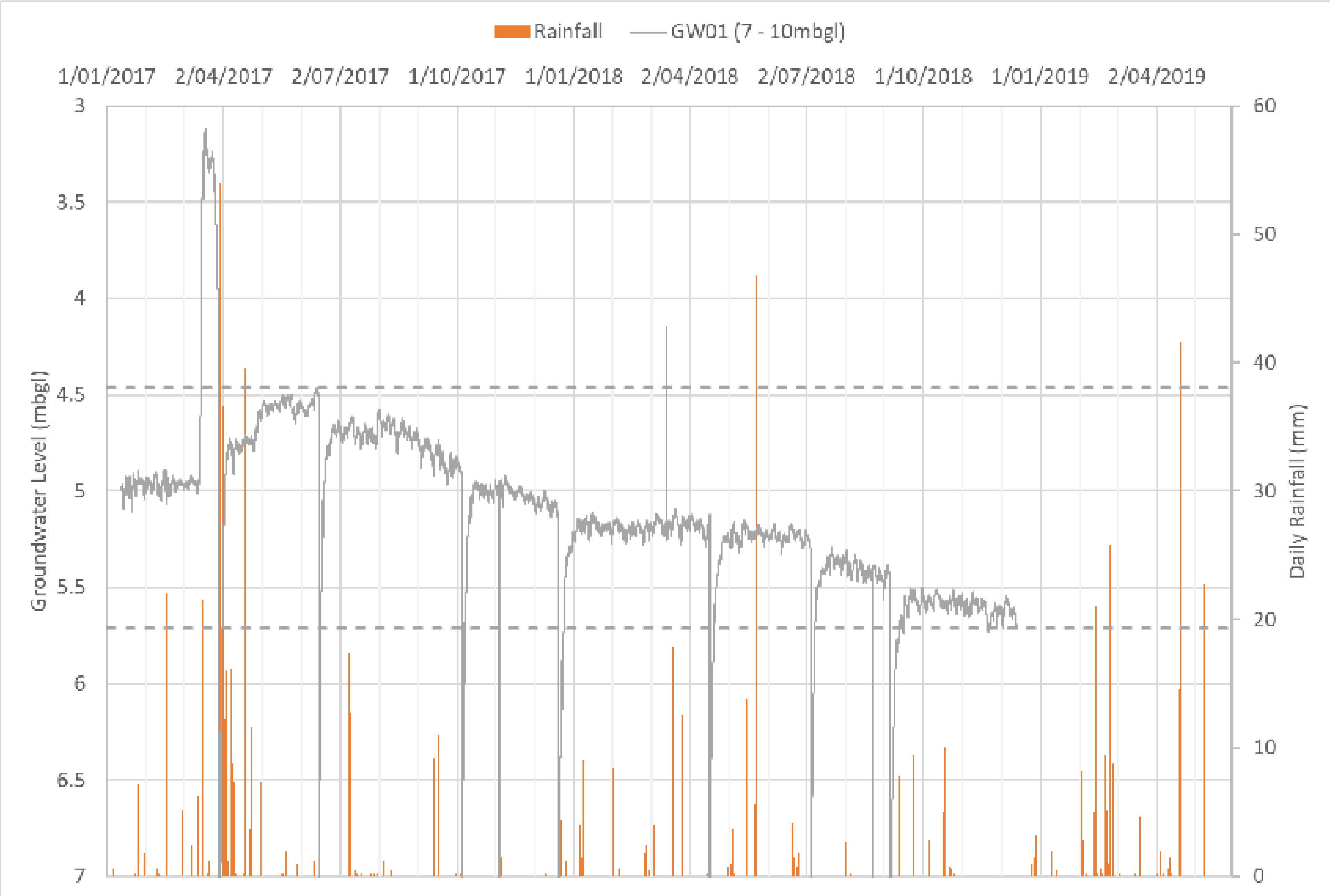
Figure B.4: Orchard Hills AnAqSim model - predictive setup and results

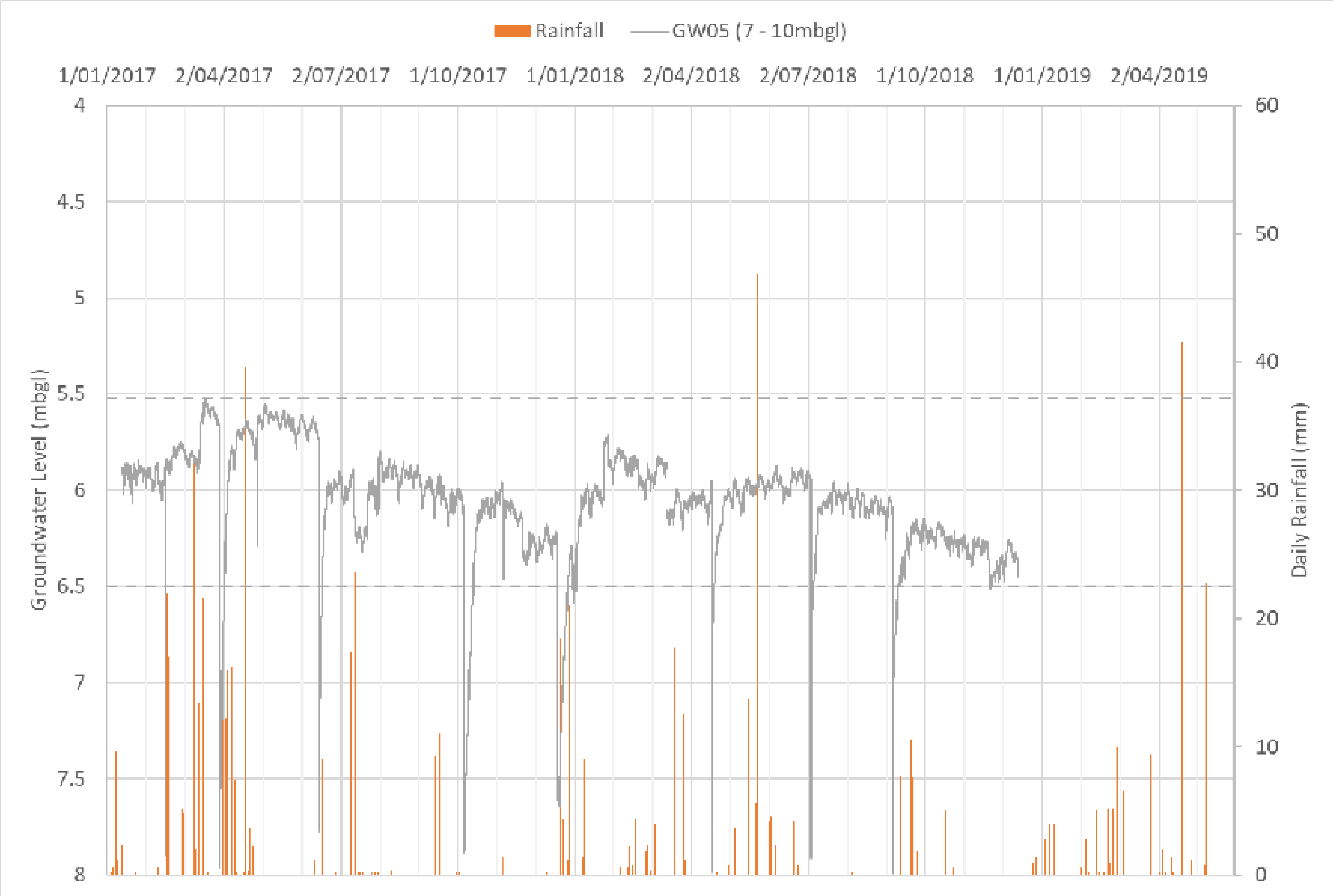


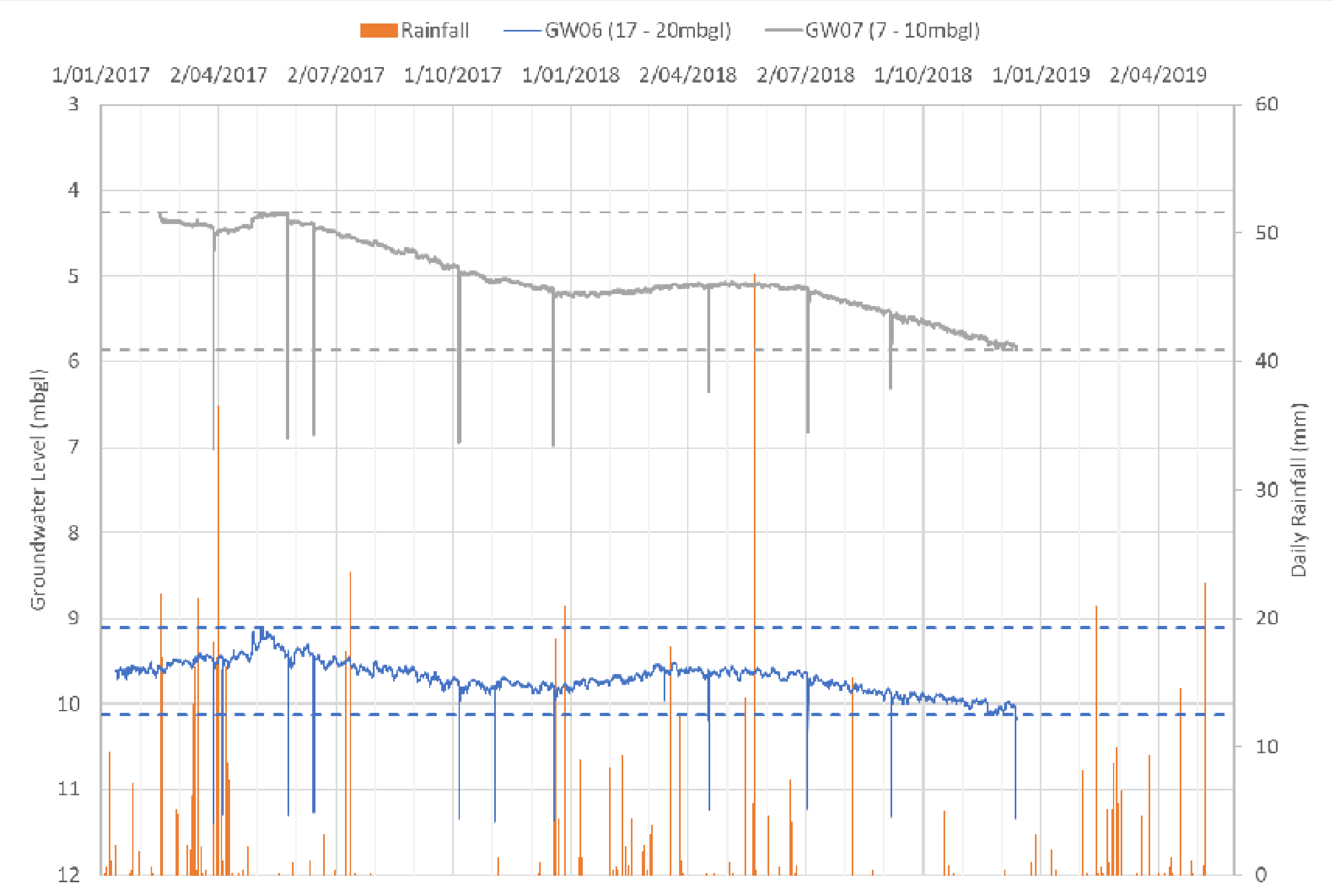
Appendix C

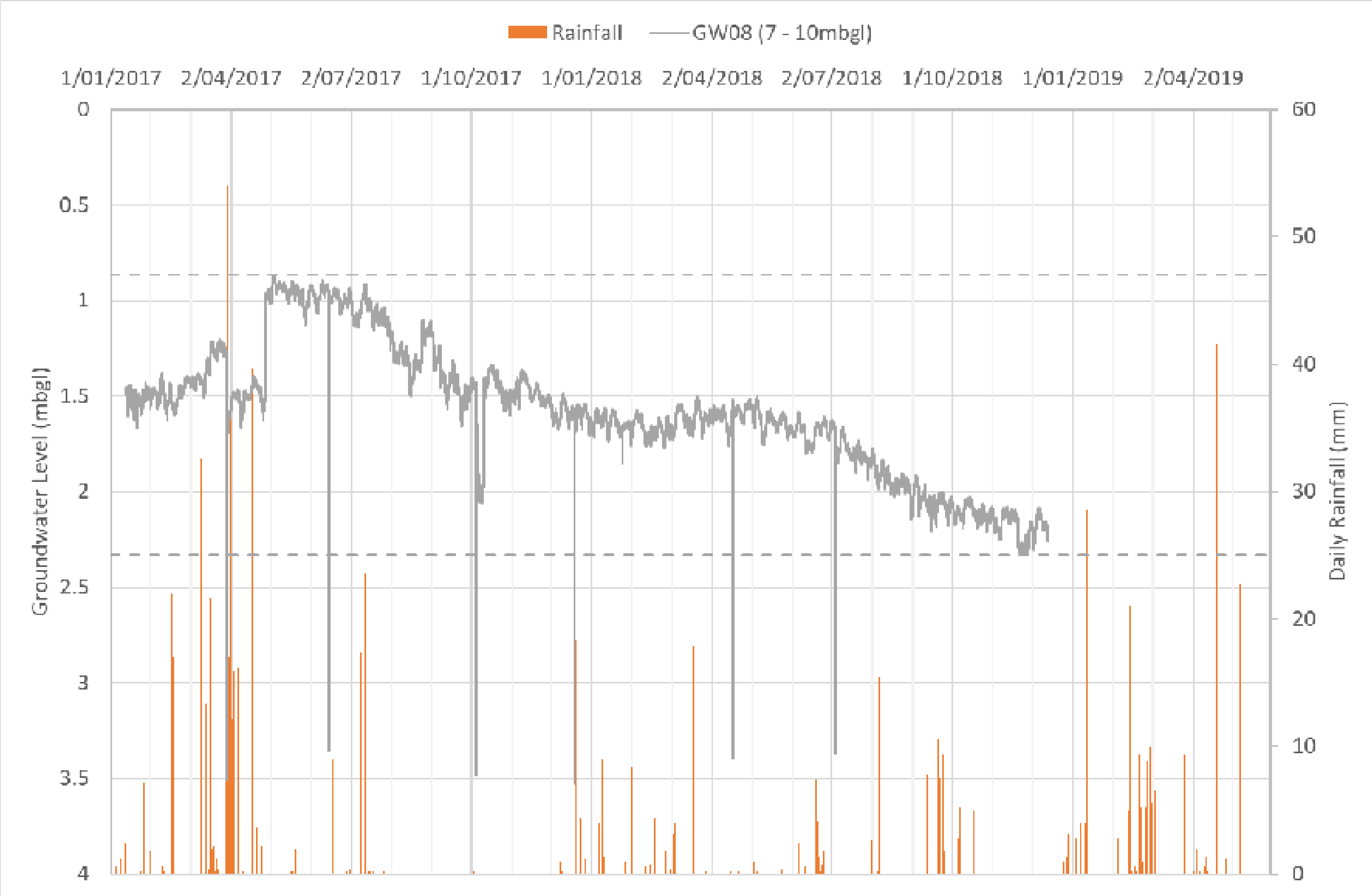
Groundwater Hydrographs

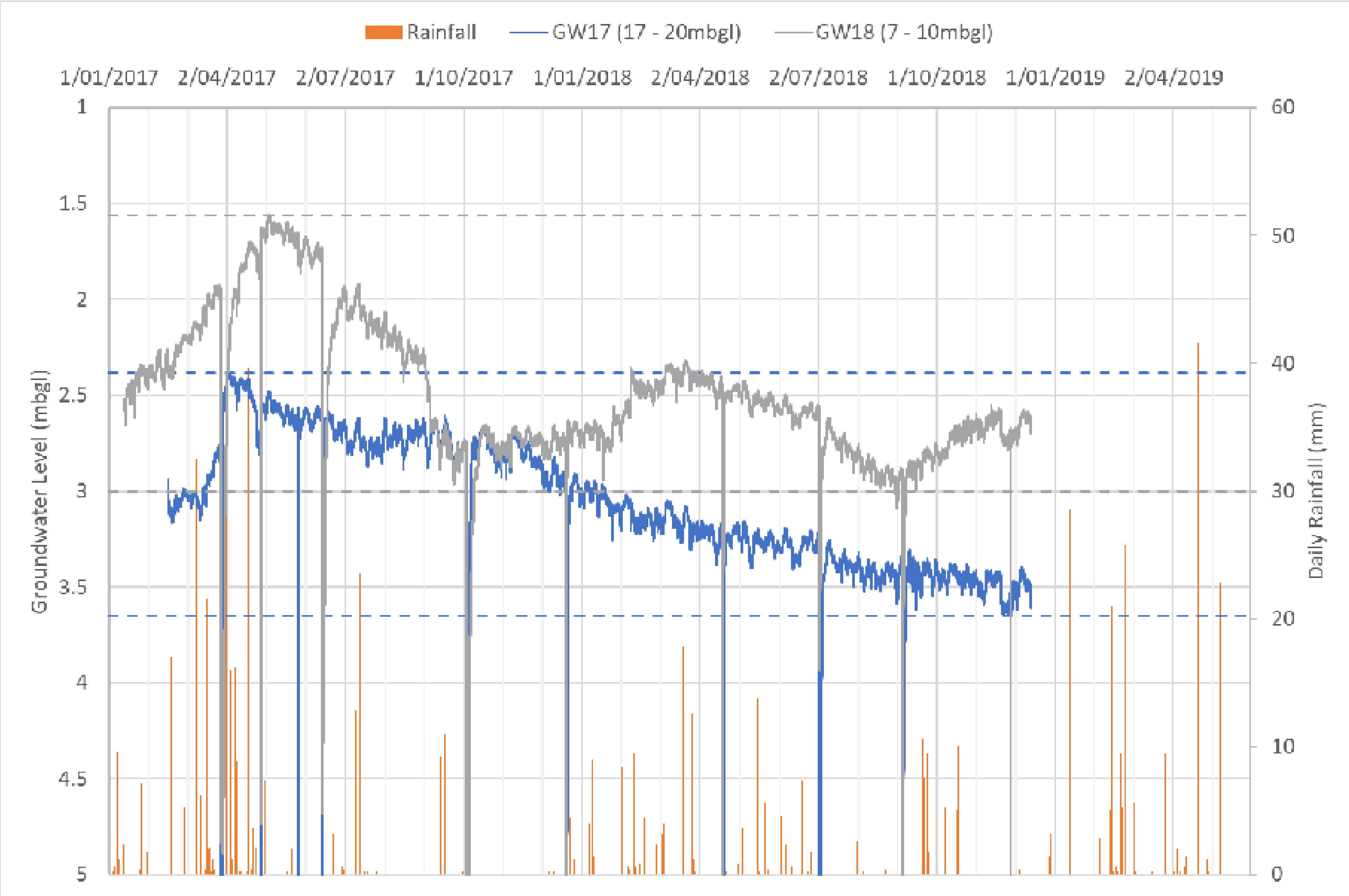
C1 On-airport

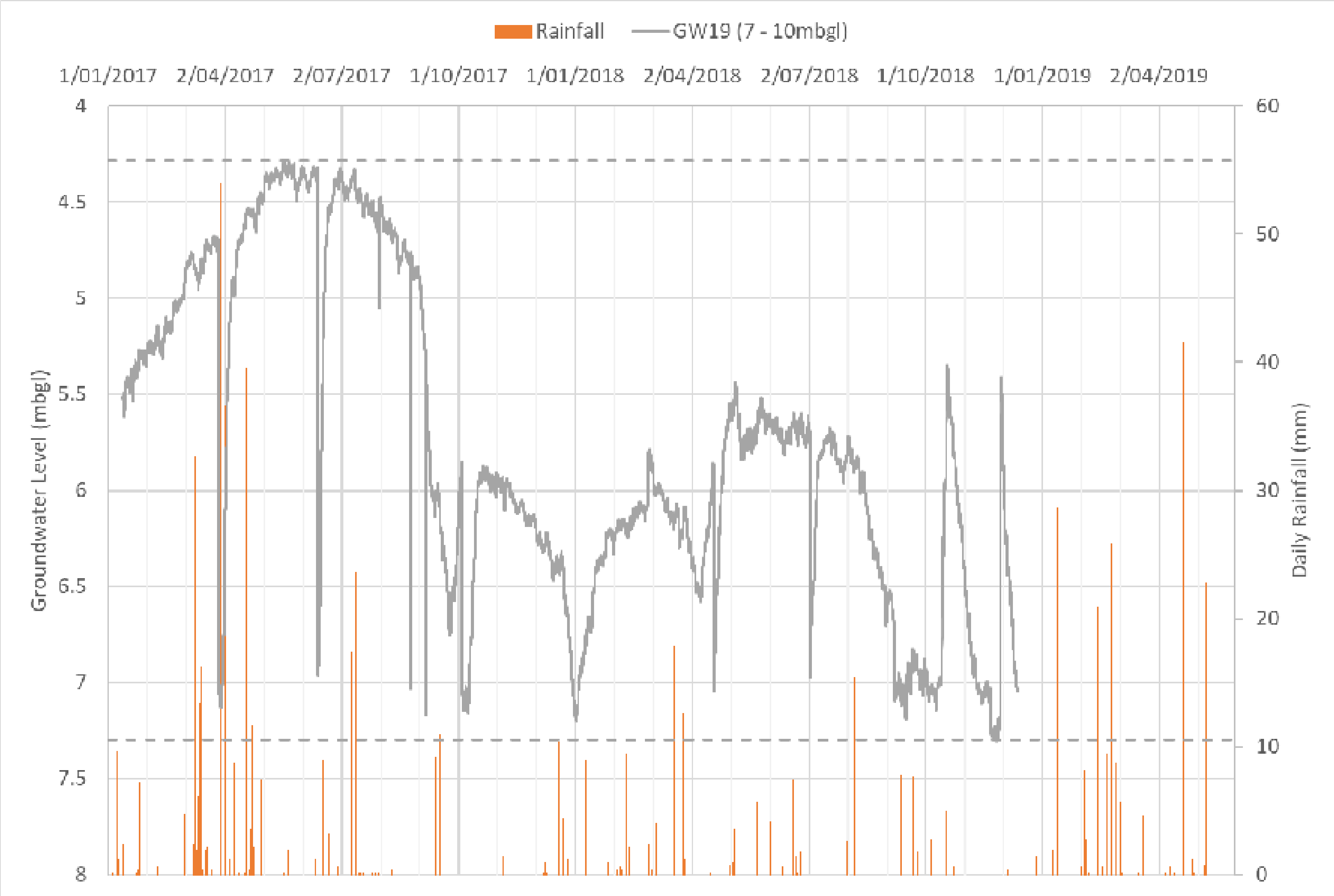

Rainfall
GW01 (7 - 10mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
3
3.5
4
4.5
5
5.5
6
6.5
7
Daily Rainfall (mm)
60
50
40
30
20
10
0

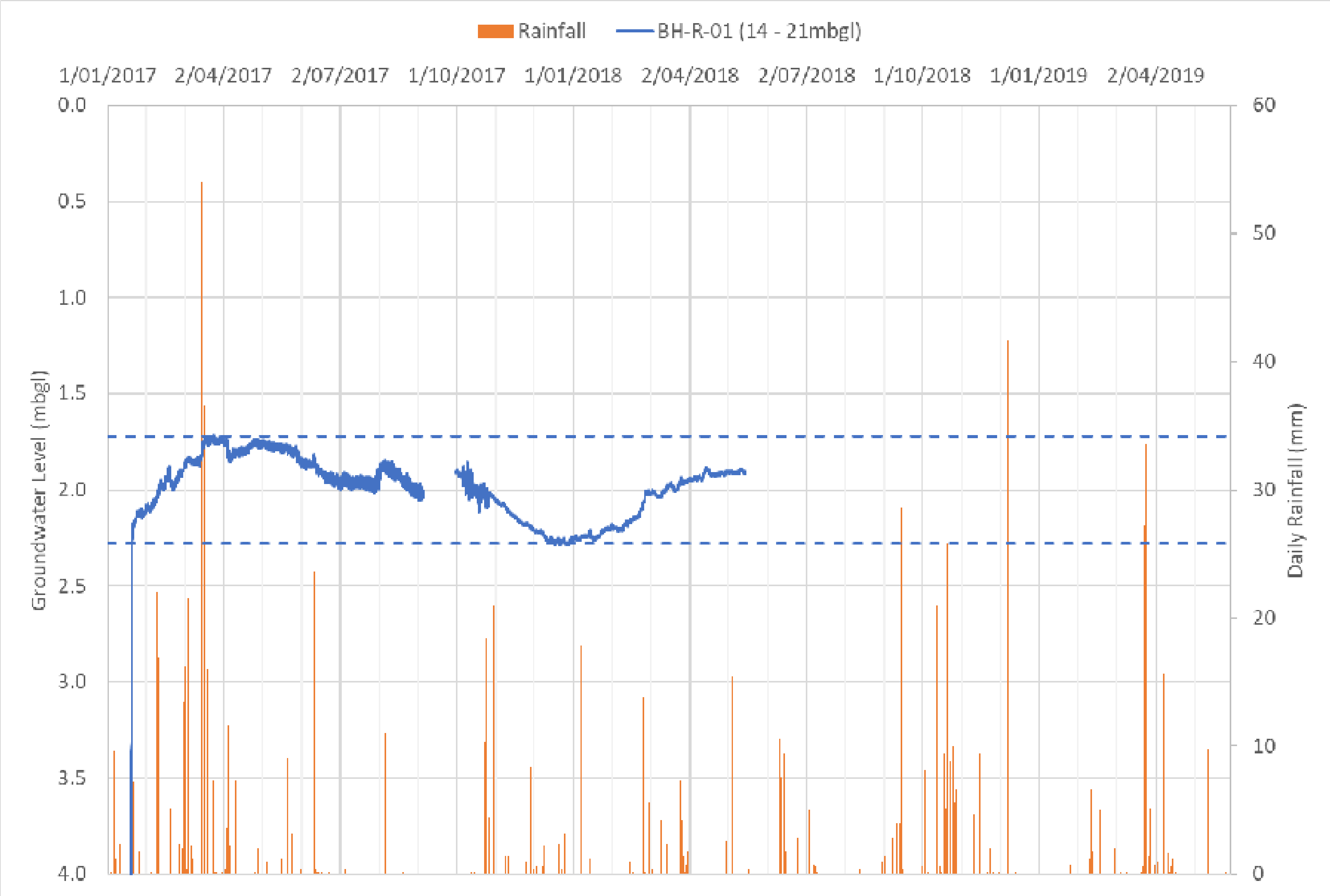

Rainfall
GW05 (7 - 10mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
4
4.5
5
5.5
6
6.5
7
7.5
8
Daily Rainfall (mm)
60
50
40
30
20
10
0

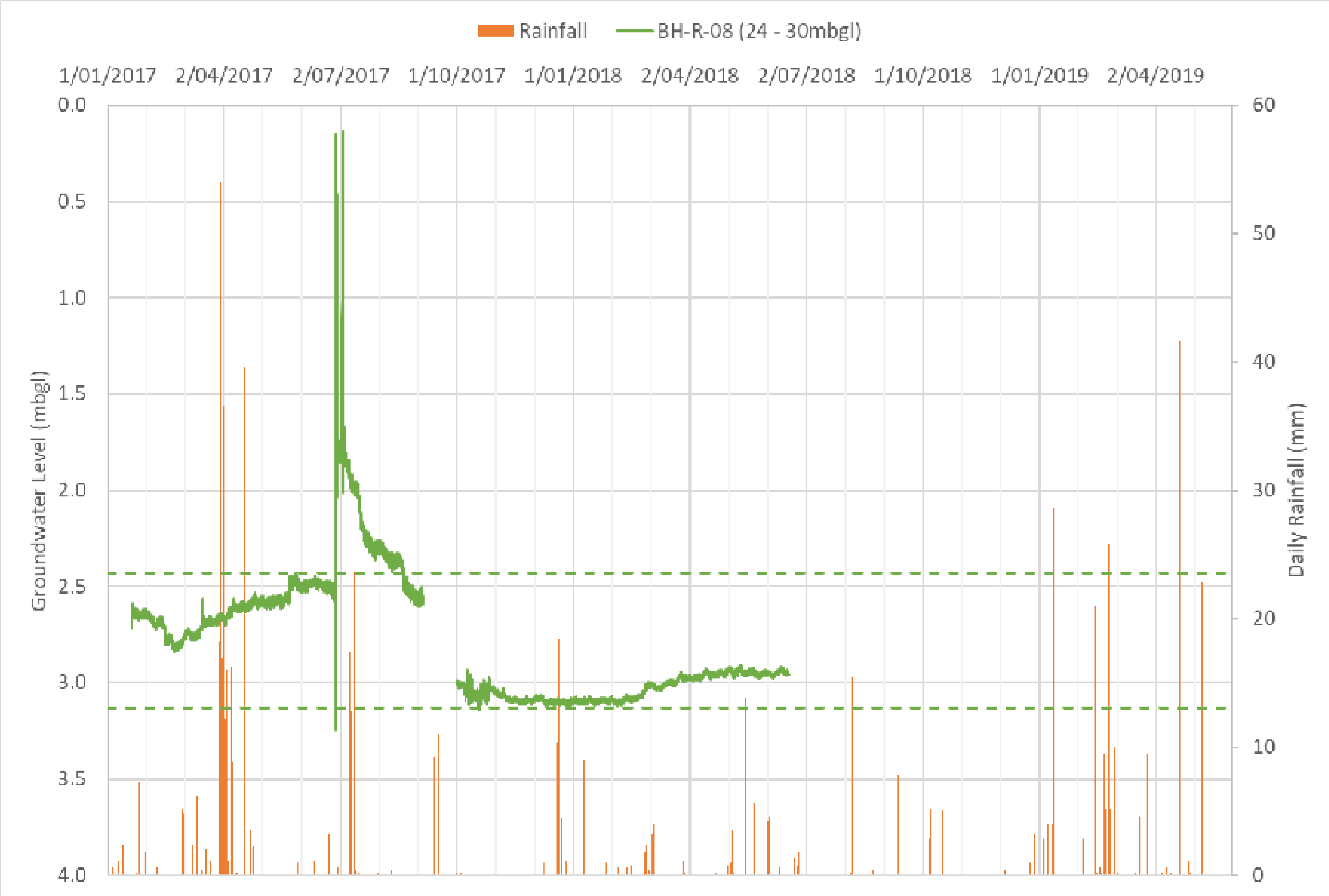

Rainfall
GW06 (17 - 20mbgl)
GW07 (7 - 10mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
Daily Rainfall (mm)
3
4
5
6
7
8
9
10
11
12
60
50
40
30
20
10
0

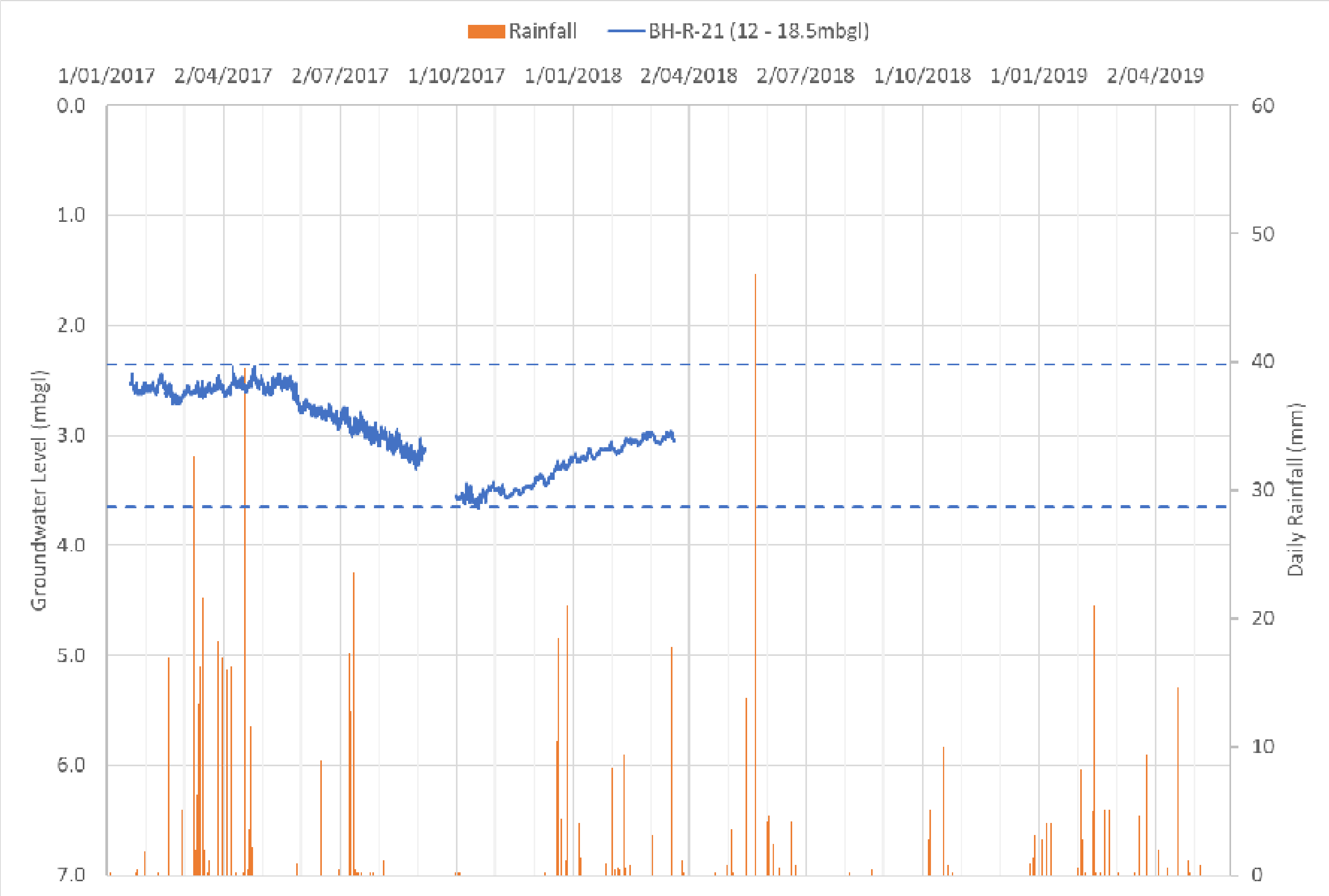

Rainfall
GW08 (7 - 10mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
0
0.5
1
1.5
2
2.5
3
3.5
4
Daily Rainfall (mm)
60
50
40
30
20
10
0

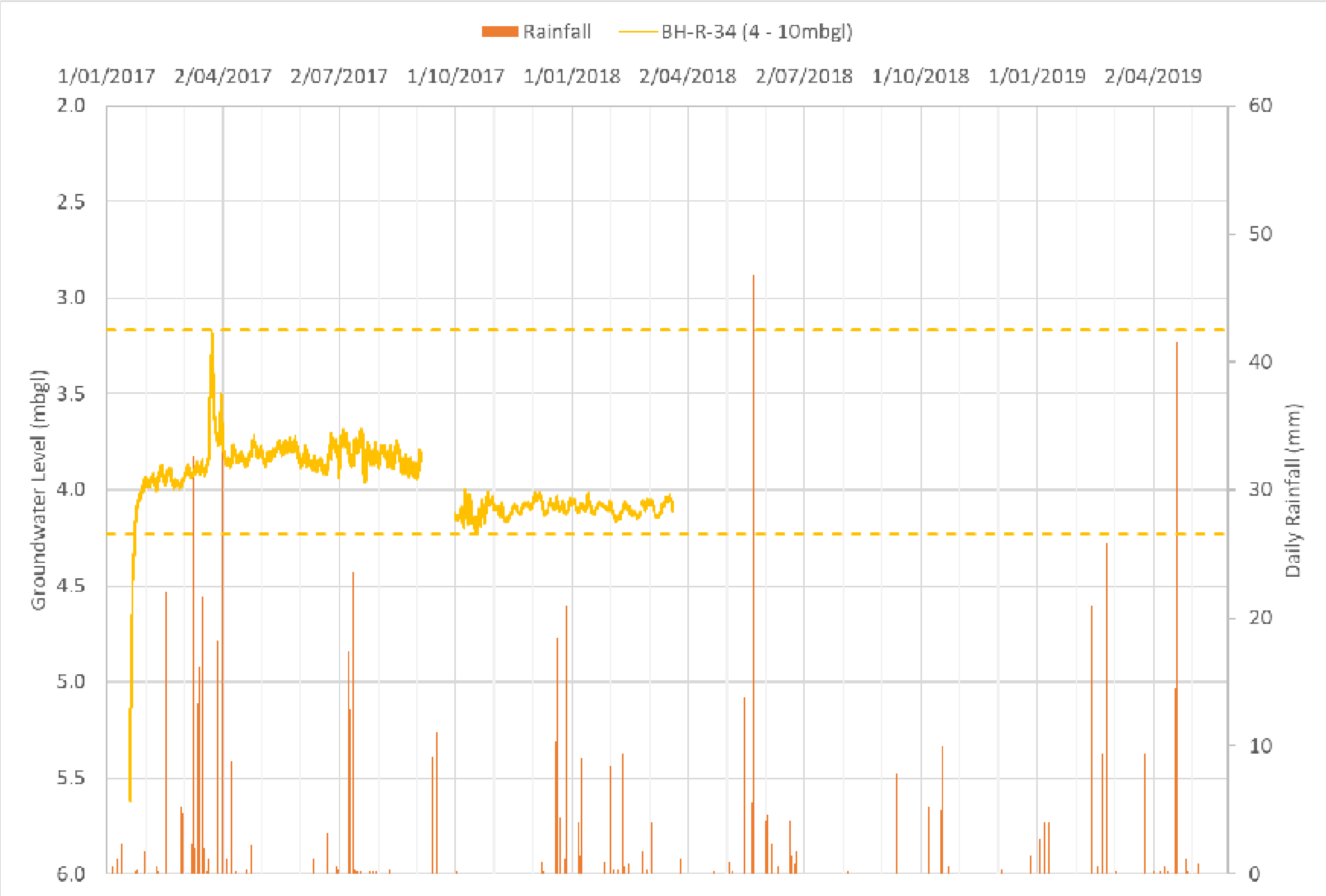

Rainfall
GW17 (17 - 20mbgl)
GW18 (7 - 10mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
1
1.5
2
2.5
3
3.5
4
4.5
5
Daily Rainfall (mm)
60
50
40
30
20
10
0


Rainfall
GW19 (7 - 10mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
4
4.5
5
5.5
6
6.5
7
7.5
8
Daily Rainfall (mm)
60
50
40
30
20
10
0

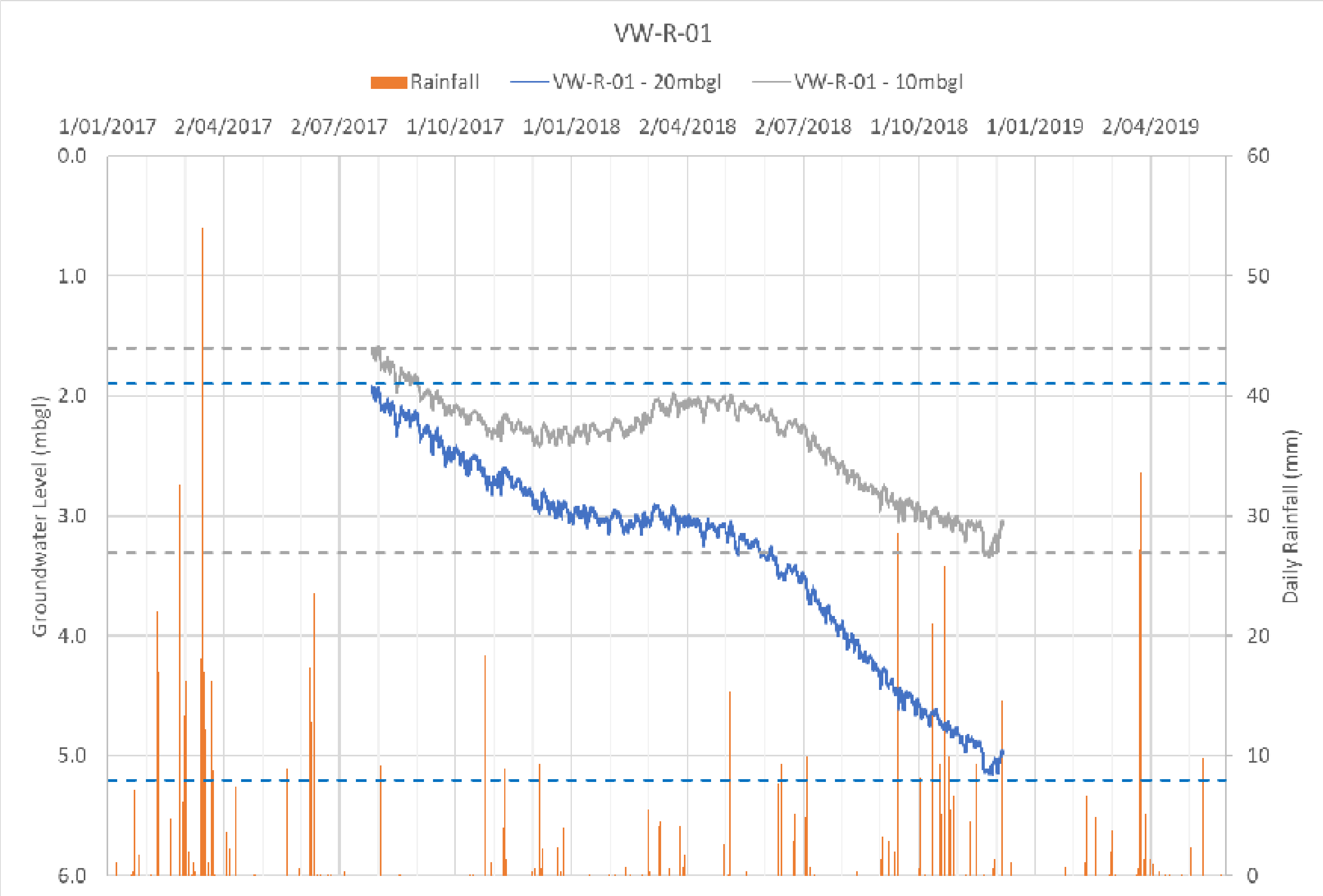

Rainfall
BH-R-01 (14 - 21mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Daily Rainfall (mm)
60
50
40
30
20
10
0

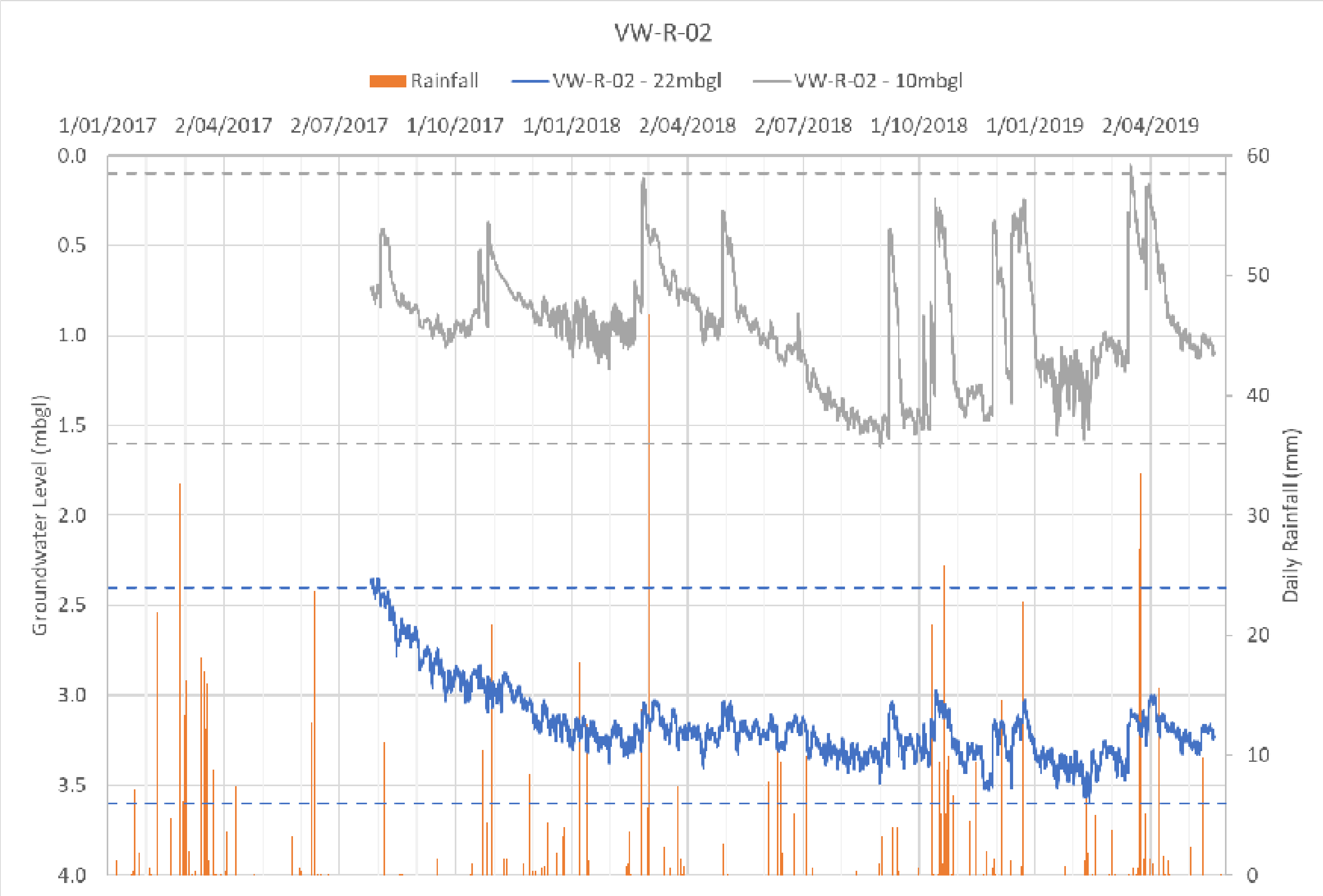

Rainfall
BH-R-08 (24 - 30mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)

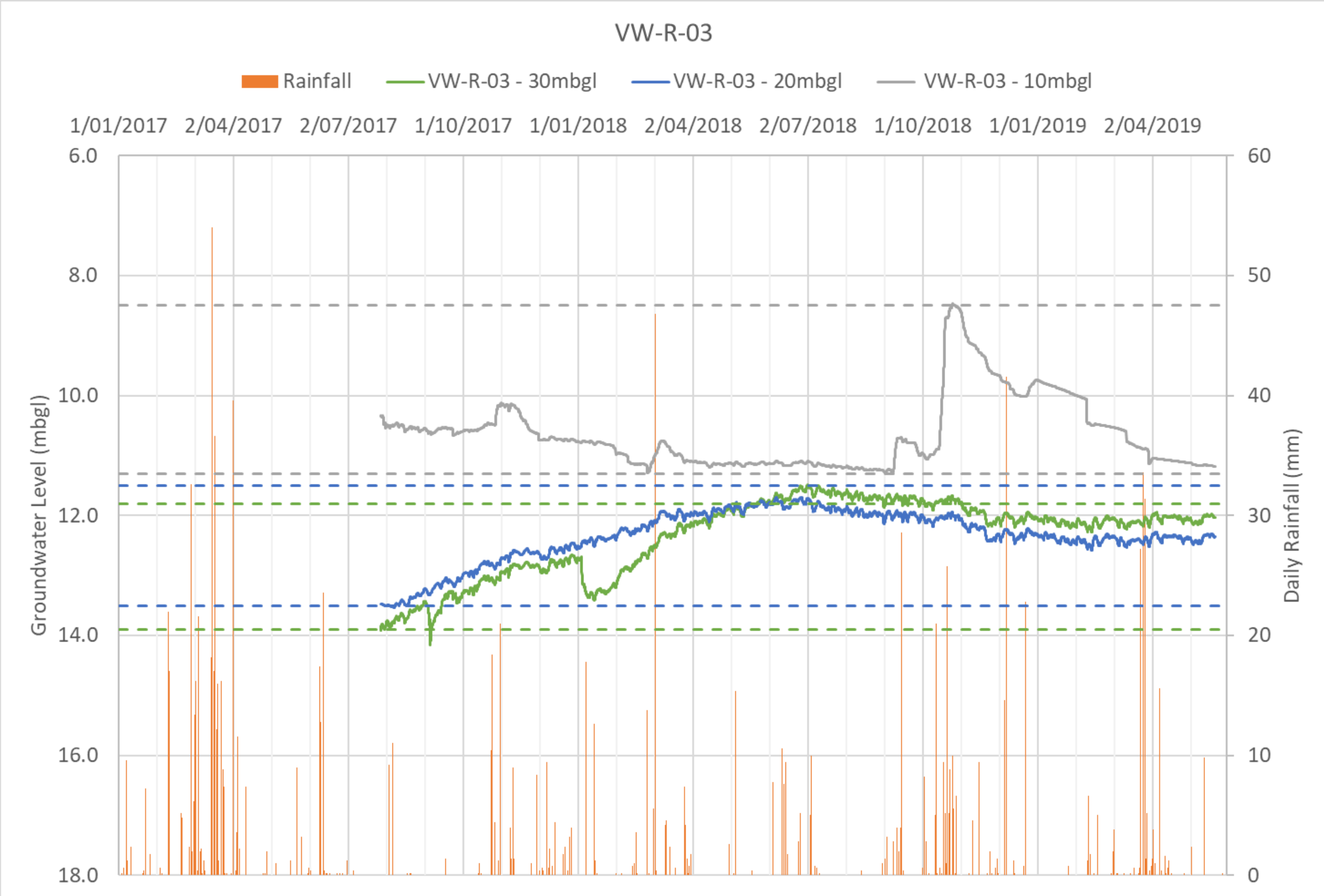

Rainfall
BH-R-21 (12 - 18.5mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Daily Rainfall (mm)
60
50
40
30
20
10
0

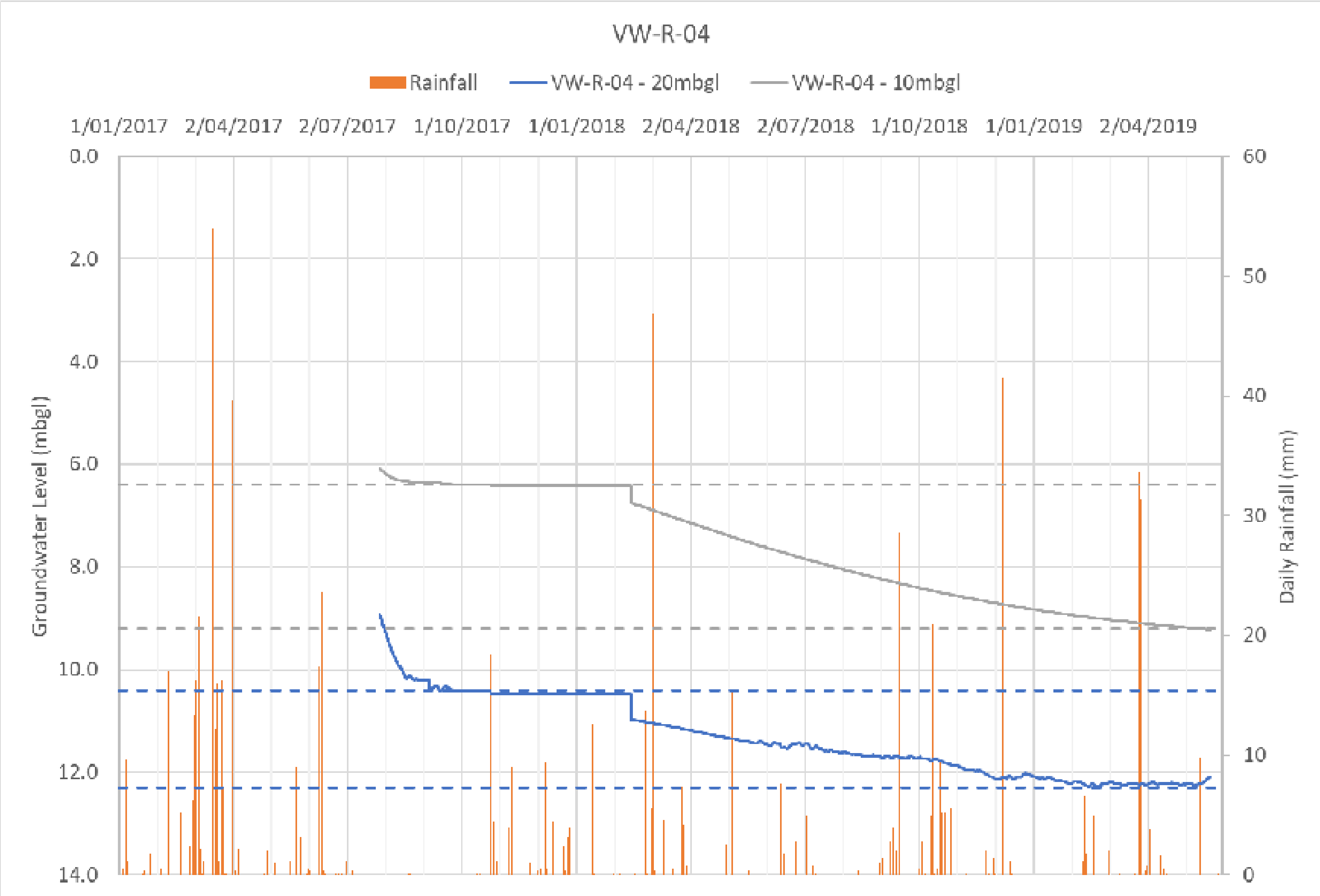

Rainfall
BH-R-34 (4 - 10mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
Daily Rainfall (mm)
60
50
40
30
20
10
0

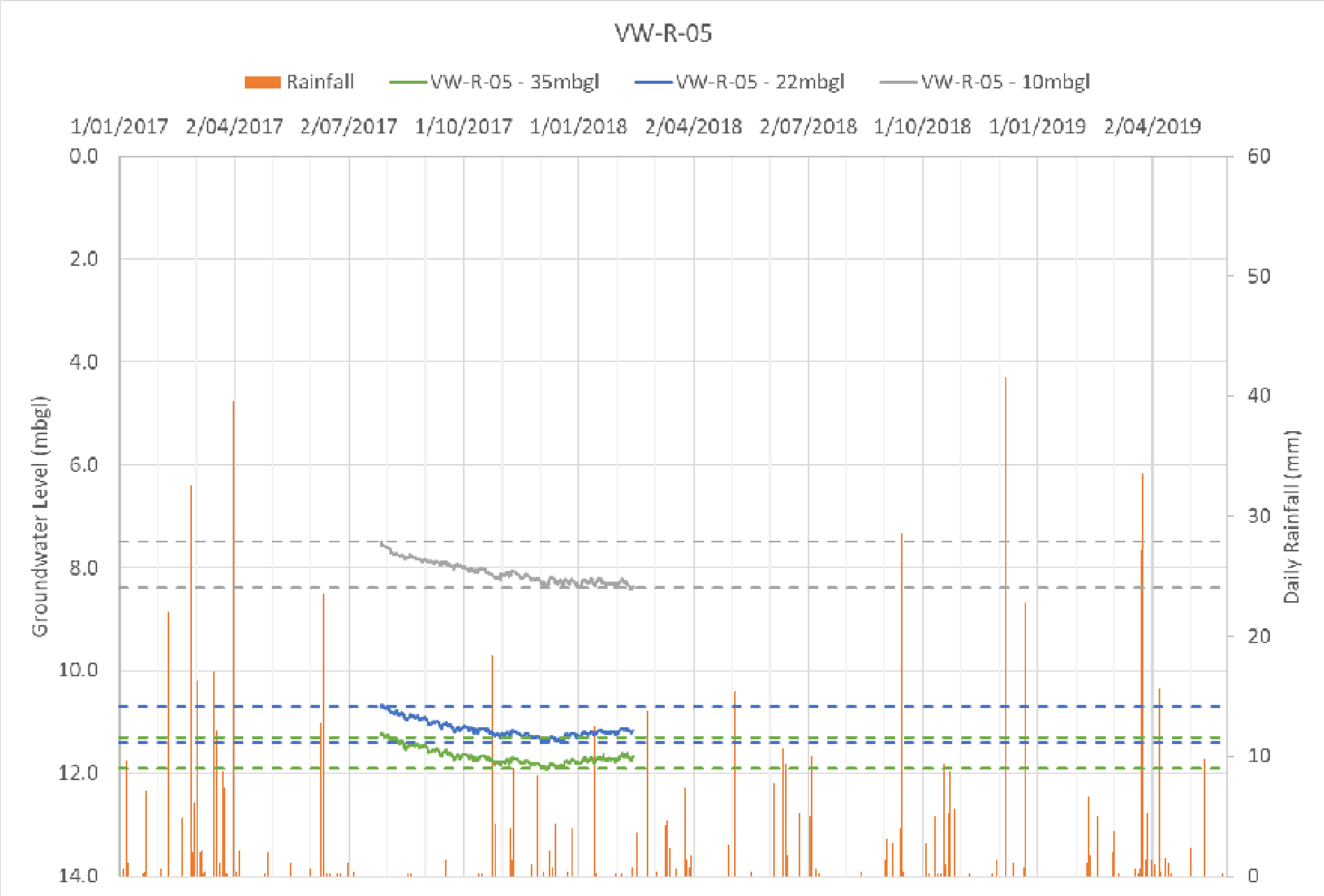

Rainfall
BH-R-42 (18 - 24mbgl)
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)

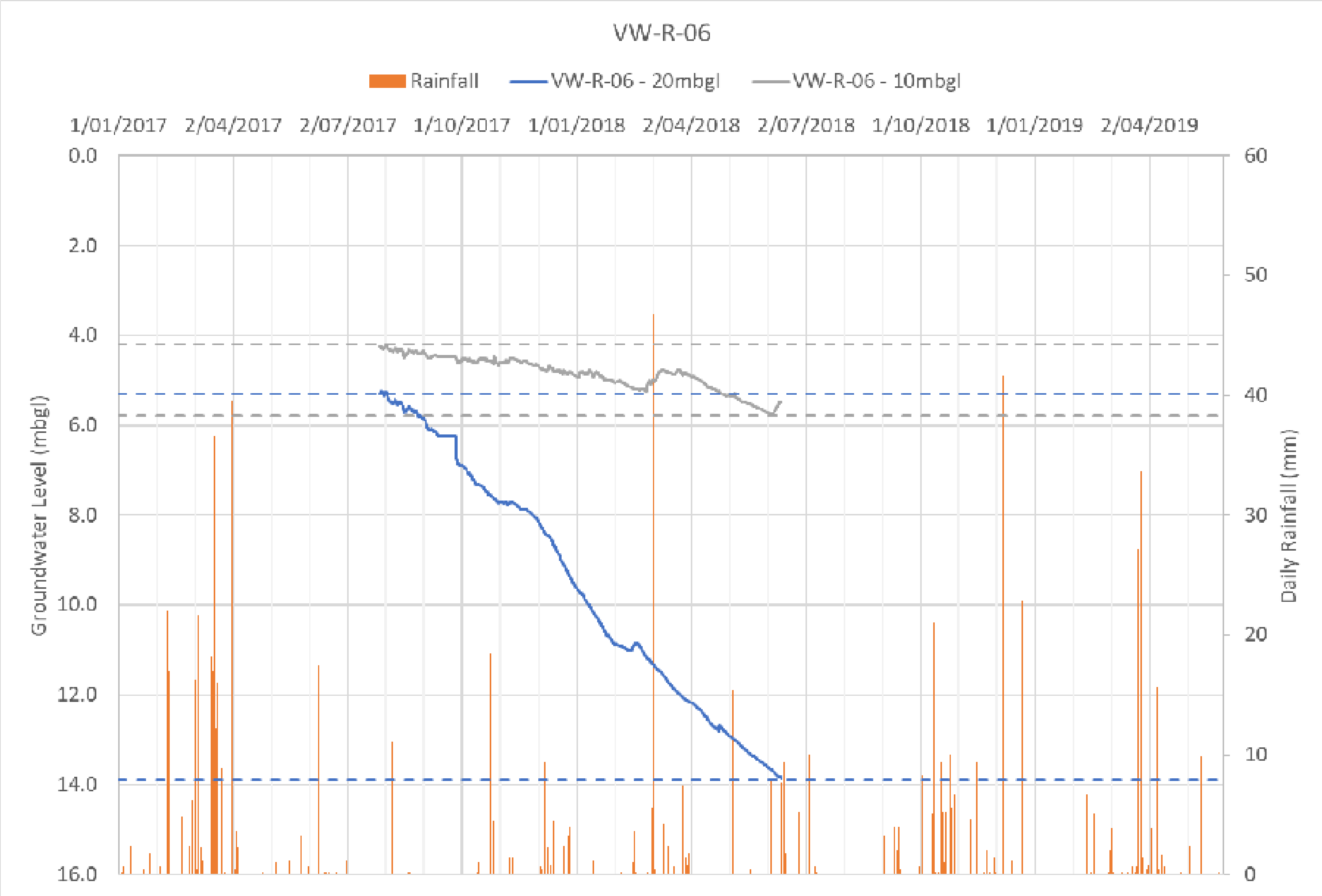

VW-R-01
Rainfall
VW-R-01 - 20mbgl
VW-R-01 - 10mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)

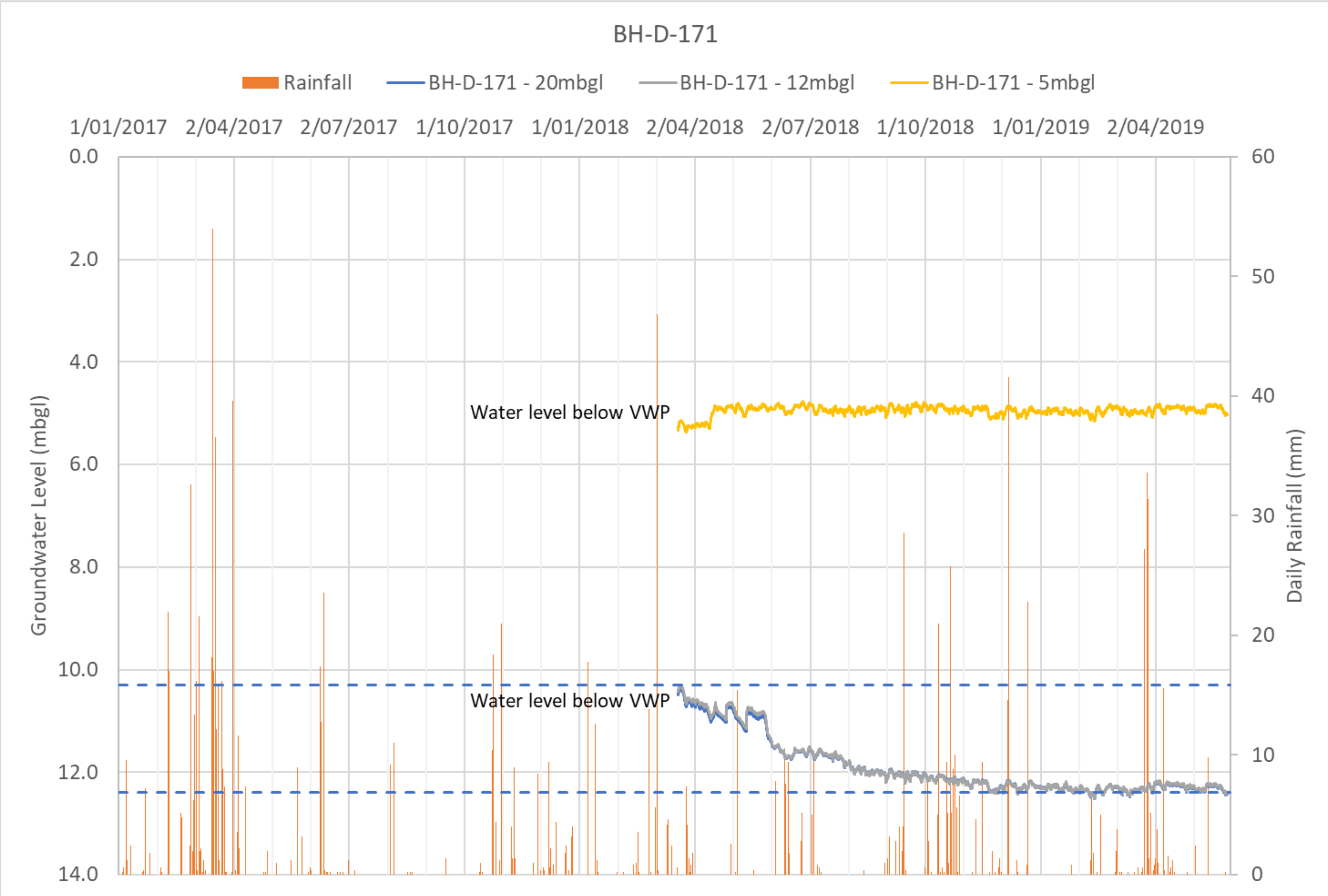

VW-R-02
Rainfall
VW-R-02 - 22mbgl
VW-R-02 - 10mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Daily Rainfall (mm)
60
50
40
30
20
10
0

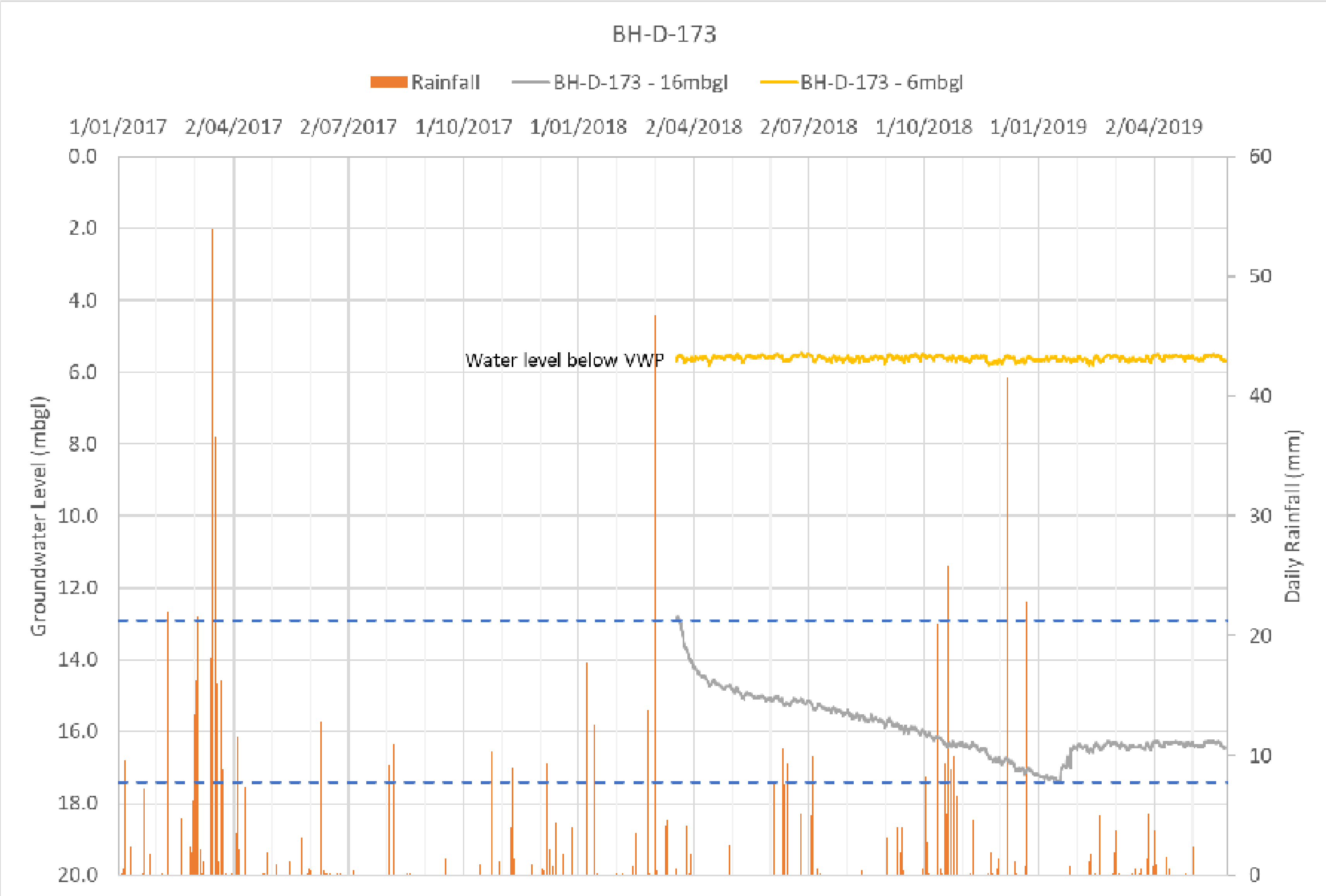

VW-R-03
Rainfall
VW-R-03 - 30mbgl
VW-R-03 - 20mbgl
VW-R-03 - 10mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
6.0
8.0
10.0
12.0
14.0
16.0
18.0
60
50
40
30
20
10
0
Groundwater Level (mbgl)
Daily Rainfall (mm)

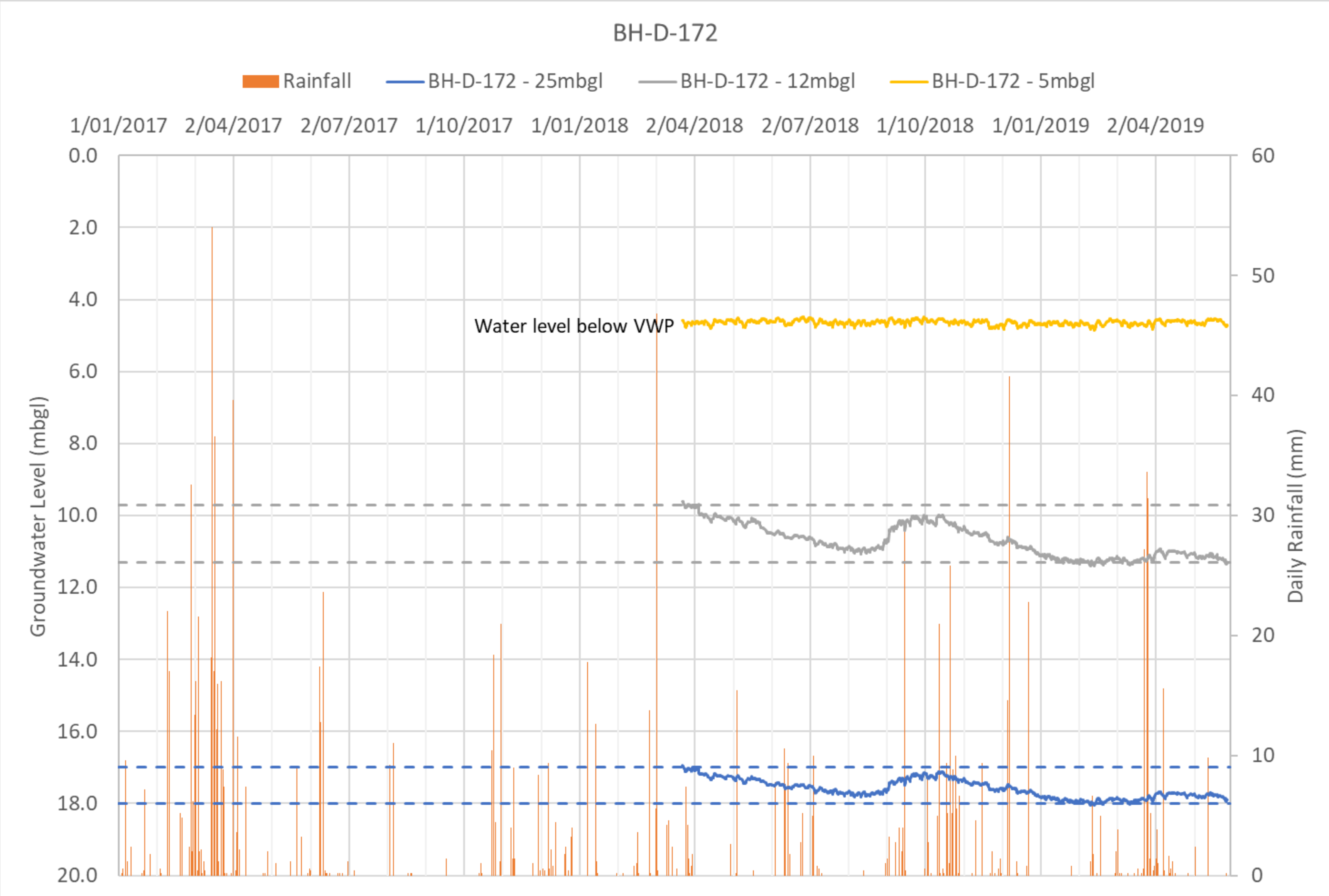

VW-R-04
Rainfall
VW-R-04 - 20mbgl
VW-R-04 - 10mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)

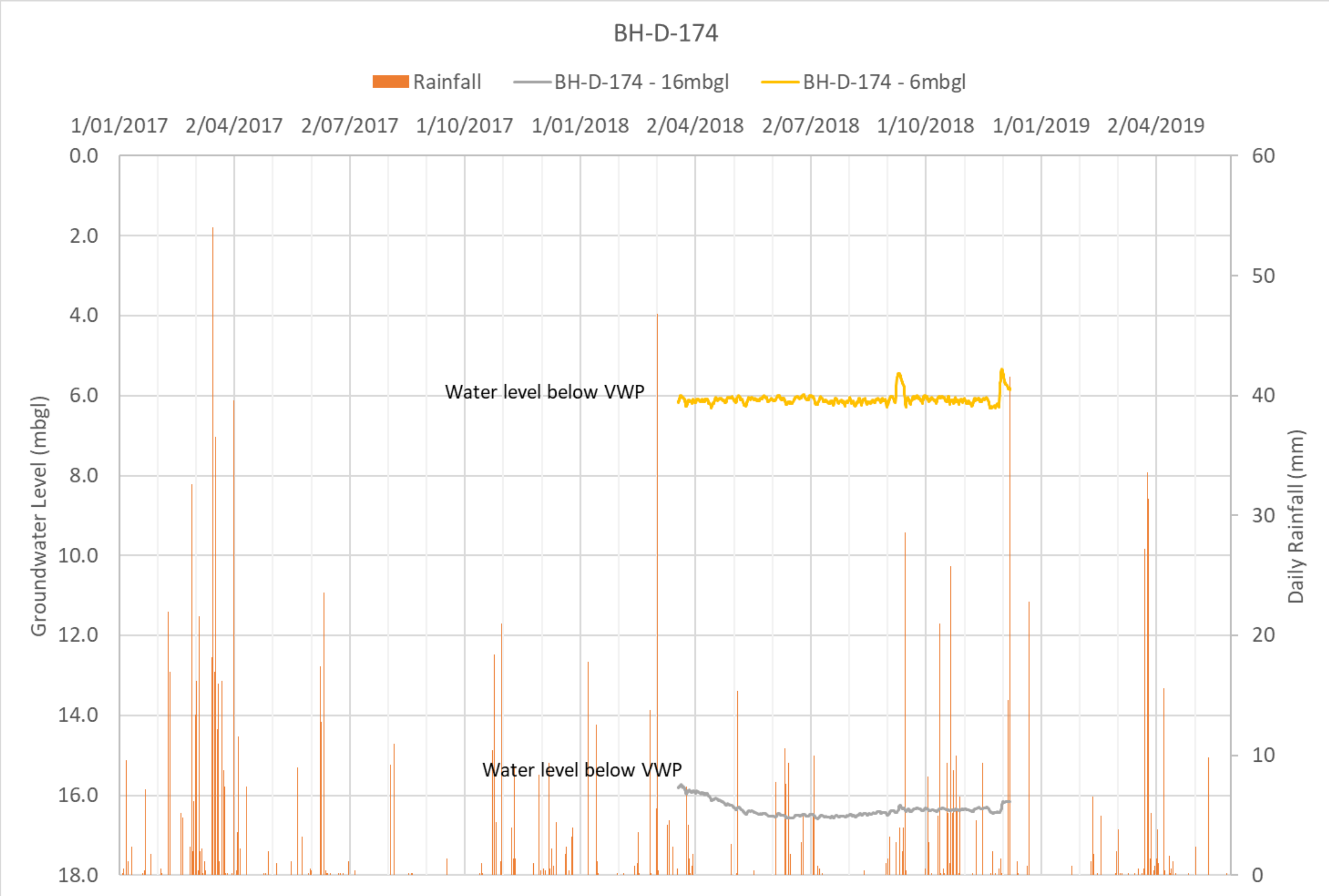

VW-R-05
Rainfall
VW-R-05 - 35mbgl
VW-R-05 - 22mbgl
VW-R-05 - 10mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)

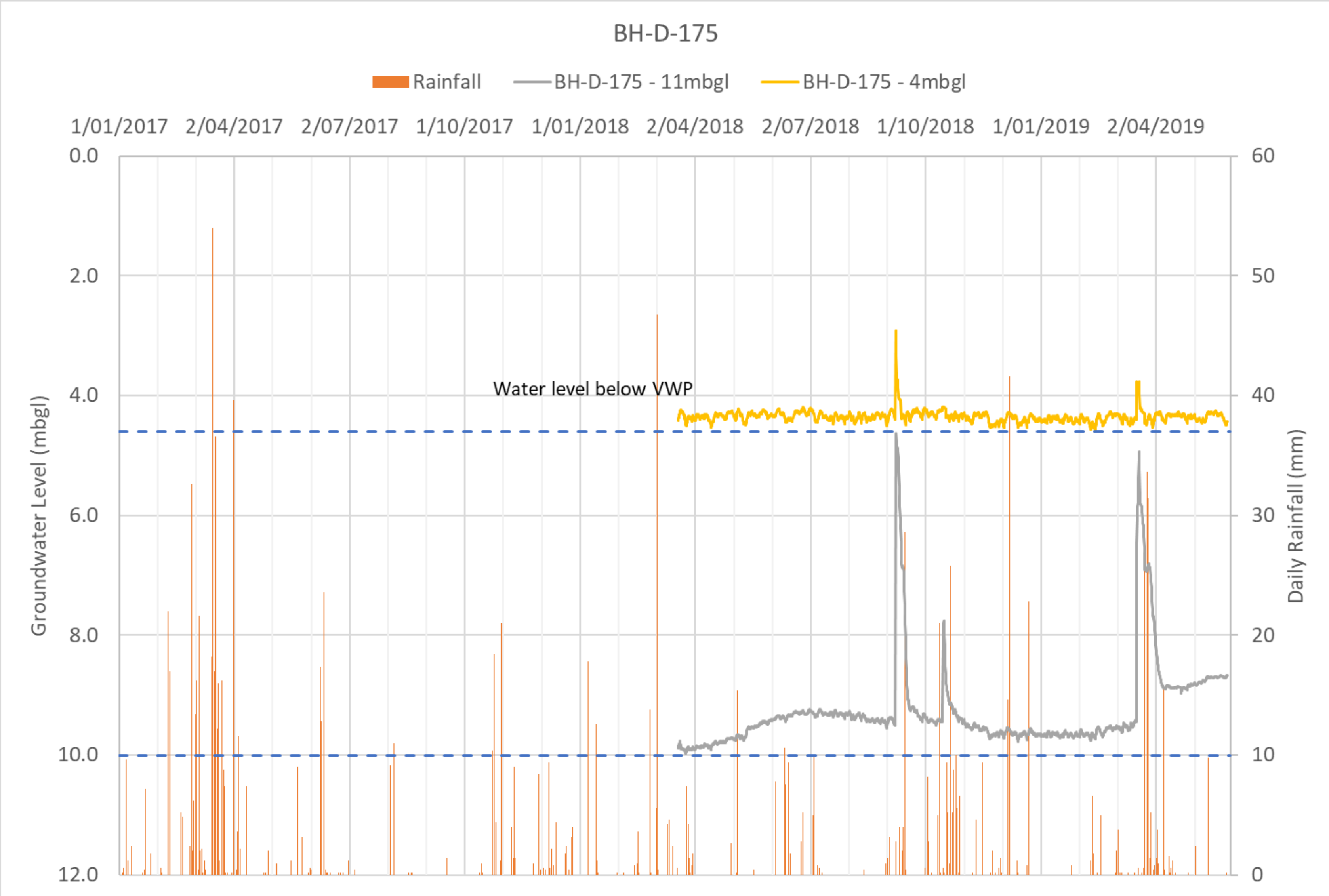

VW-R-06
Rainfall
VW-R-06 - 20mbgl
VW-R-06 - 10mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)


BH-D-171
Rainfall
BH-D-171 - 20mbgl
BH-D-171 - 12mbgl
BH-D-171 - 5mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)
Water level below VWP
Water level below VWP


BH-D-173
Rainfall
BH-D-173 - 16mbgl
BH-D-173 - 6mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Groundwater Level (mbgl)
60
50
40
30
20
10
0
Daily Rainfall (mm)
Water level below VWP

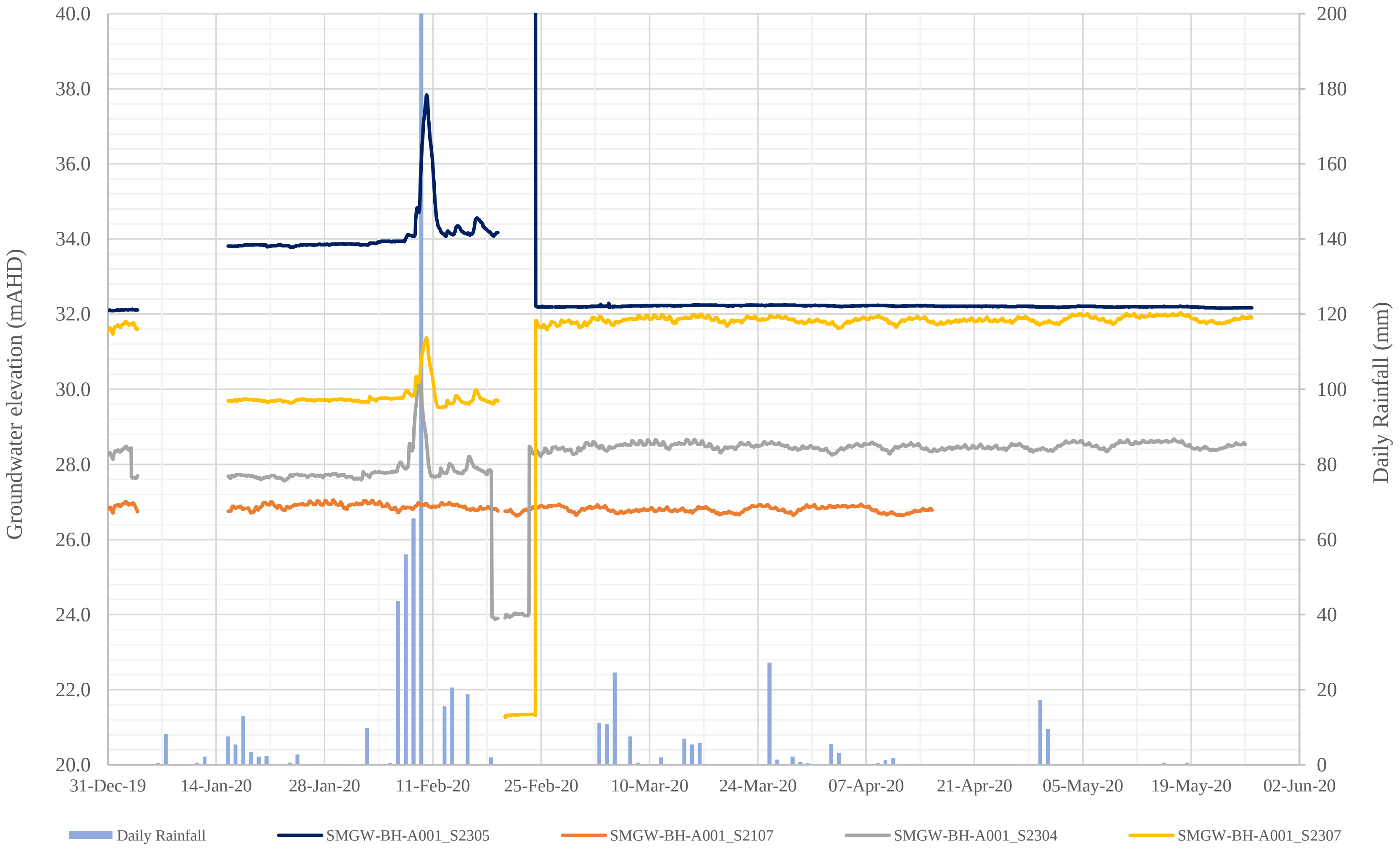

BH-D-172
Rainfall
BH-D-172 - 25mbgl
BH-D-172 - 12mbgl
BH-D-172 - 5mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
Groundwater Level (mbgl)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Daily Rainfall (mm)
60
50
40
30
20
10
0
Water level below VWP


BH-D-174
Rainfall
BH-D-174 - 16mbgl
BH-D-174 - 6mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
60
50
40
30
20
10
0
Groundwater Level (mbgl)
Daily Rainfall (mm)
Water level below VWP
Water level below VWP

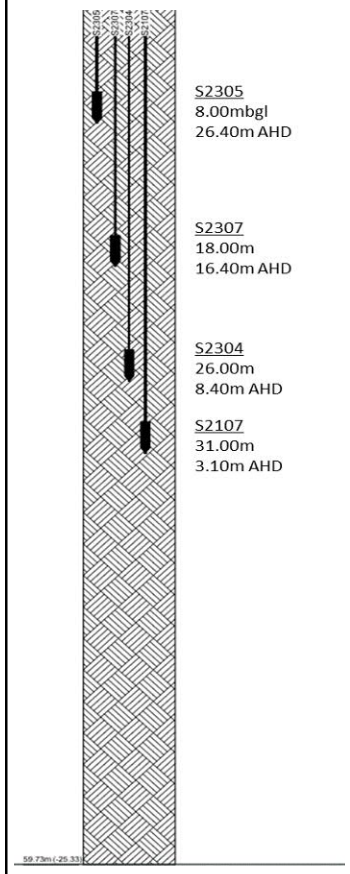

BH-D-175
Rainfall
BH-D-175 - 11mbgl
BH-D-175 - 4mbgl
1/01/2017
2/04/2017
2/07/2017
1/10/2017
1/01/2018
2/04/2018
2/07/2018
1/10/2018
1/01/2019
2/04/2019
0.0
2.0
4.0
6.0
8.0
10.0
12.0
60
50
40
30
20
10
0
Water level below VWP
Groundwater Level (mbgl)
Daily Rainfall (mm)

C2 Off-airport

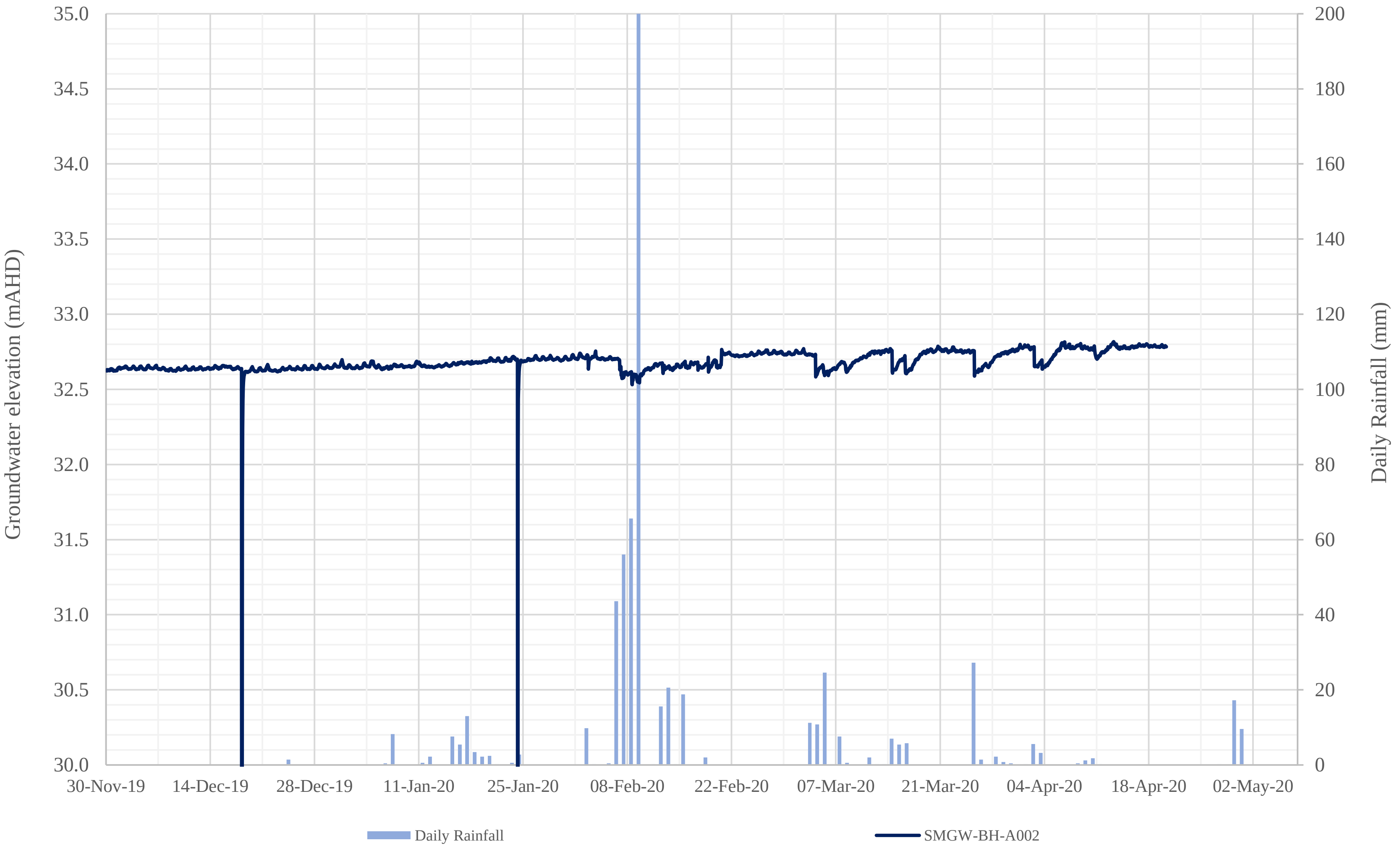
ARUP	SMGW-BH-A001	Prep	Chk	App
		FC / GY	JL	JH
		Job Number: 272467		
		Printed on: 11-Jun-20		



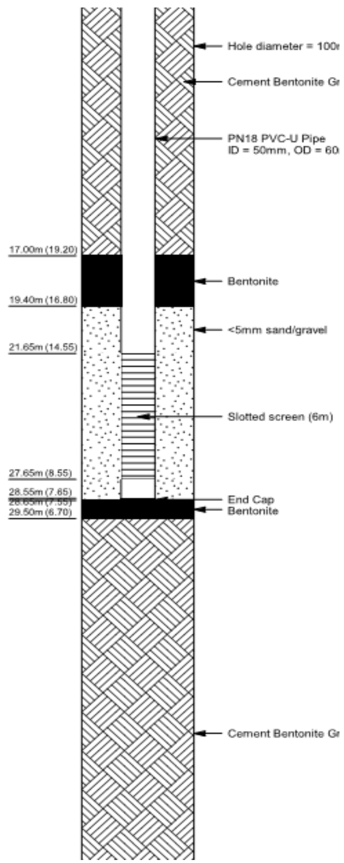
VWP



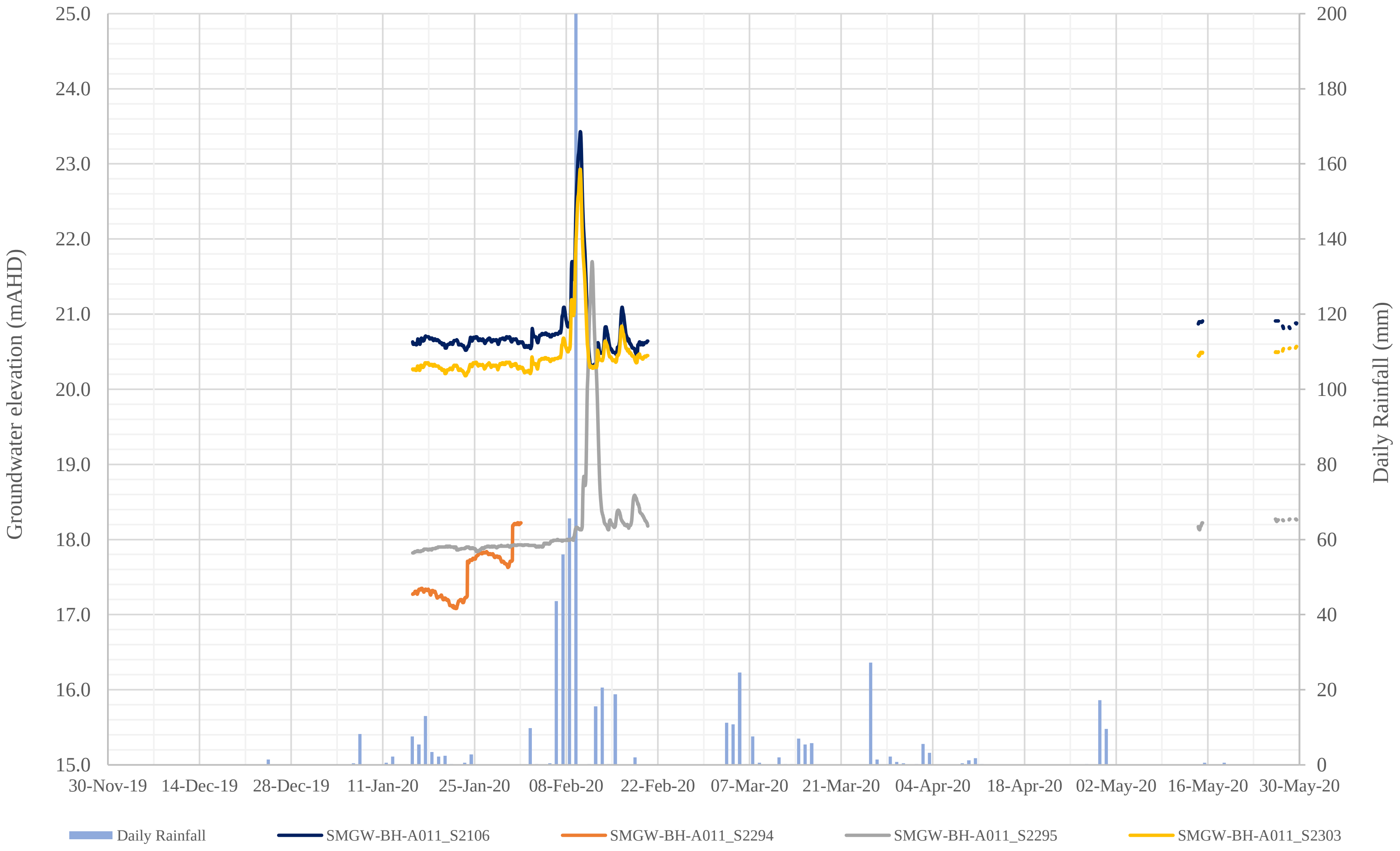
ARUP	SMGW-BH-A002	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 29-May-20		

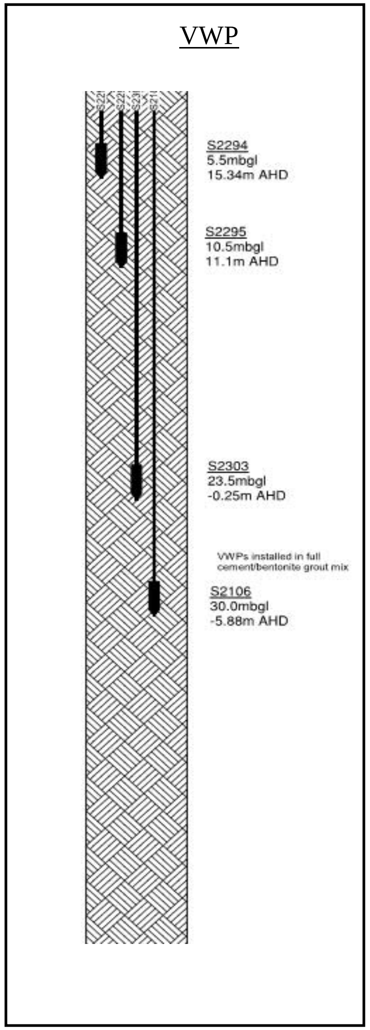


Piezometer

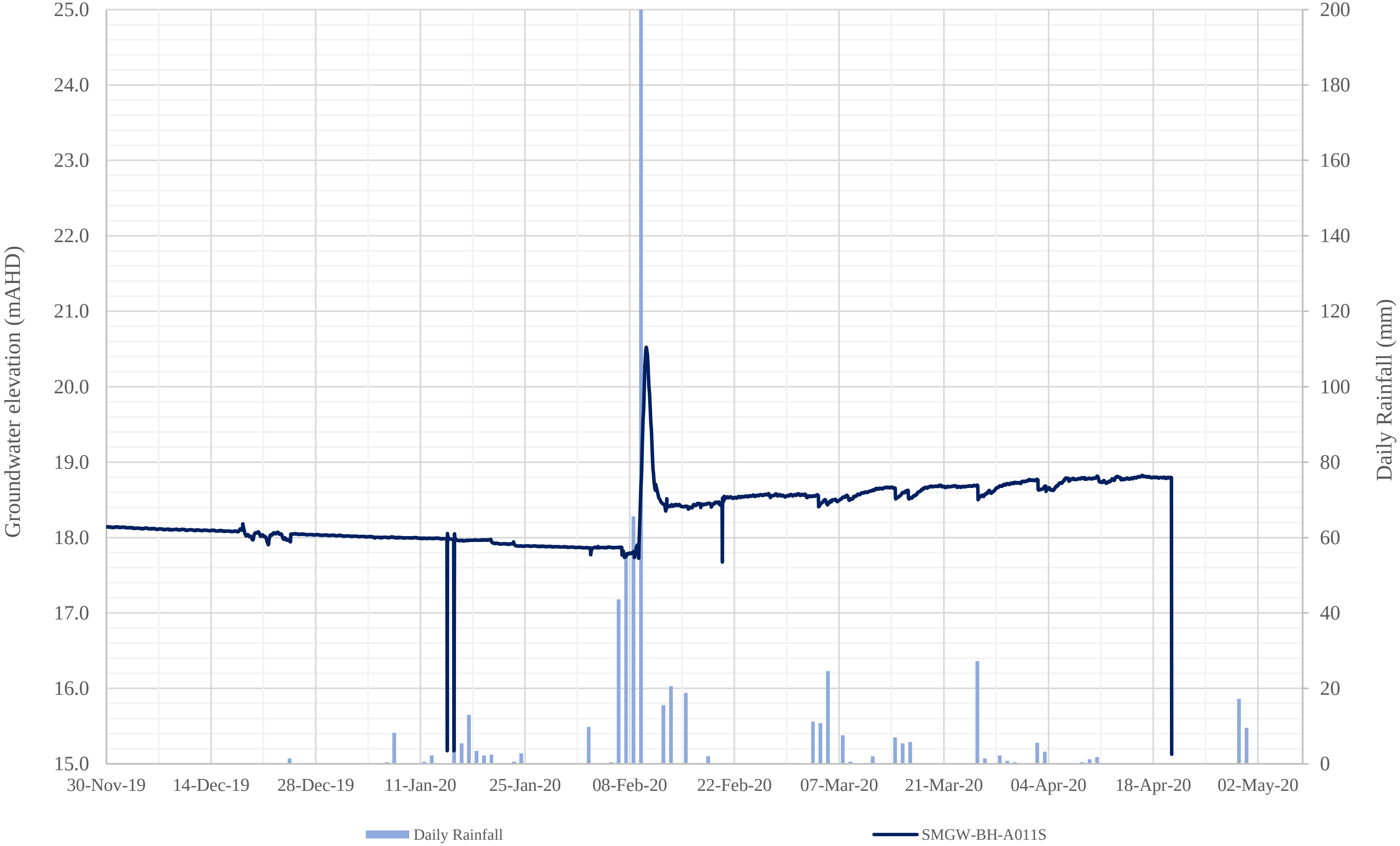


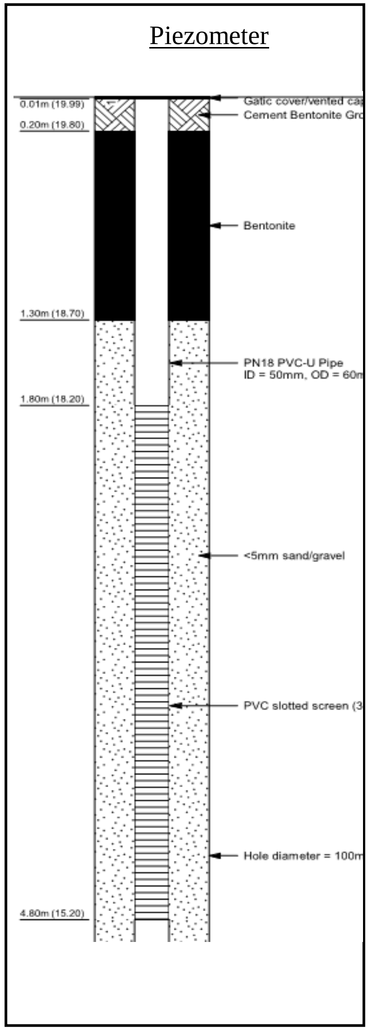
ARUP	SMGW-BH-A011	Prep: FC / GY	Chk: JL	App: JH
		Job Number: 272467		
		Printed on: 11-Jun-20		



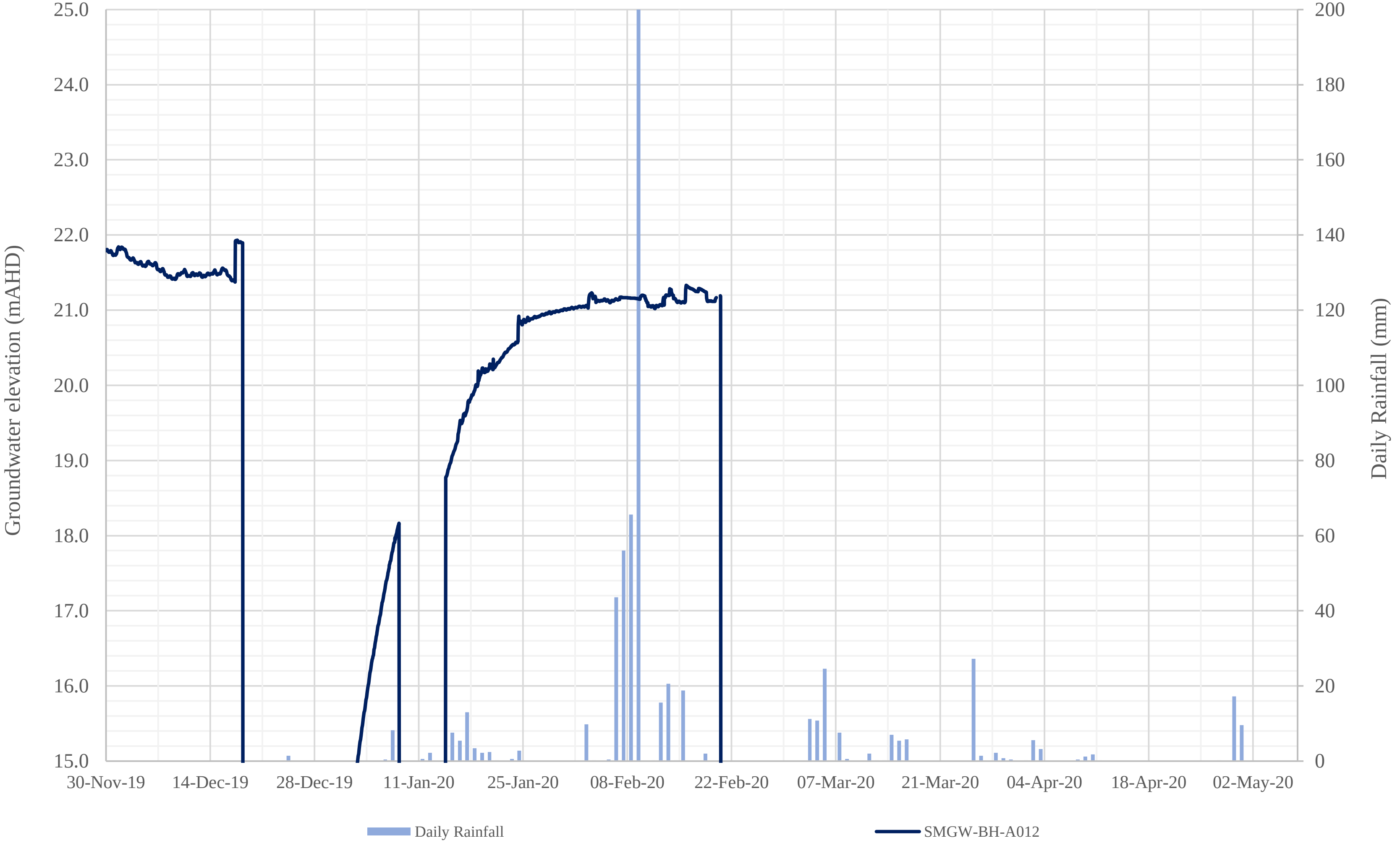


ARUP	SMGW-BH-A011S	Prep: FC / GY	Chk: JL	App: JH
		Job Number: 272467		
		Printed on: 29-May-20		

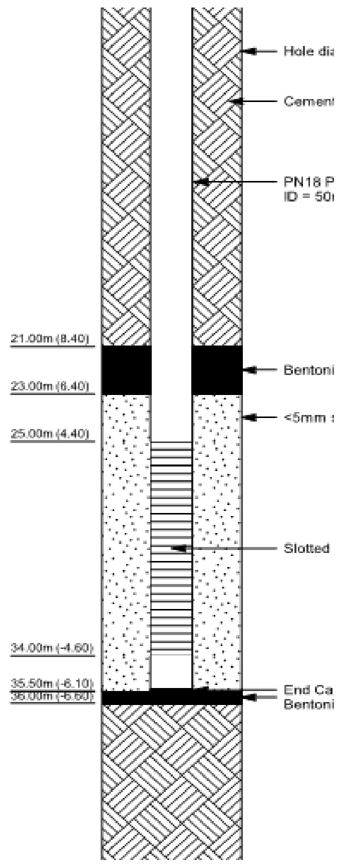




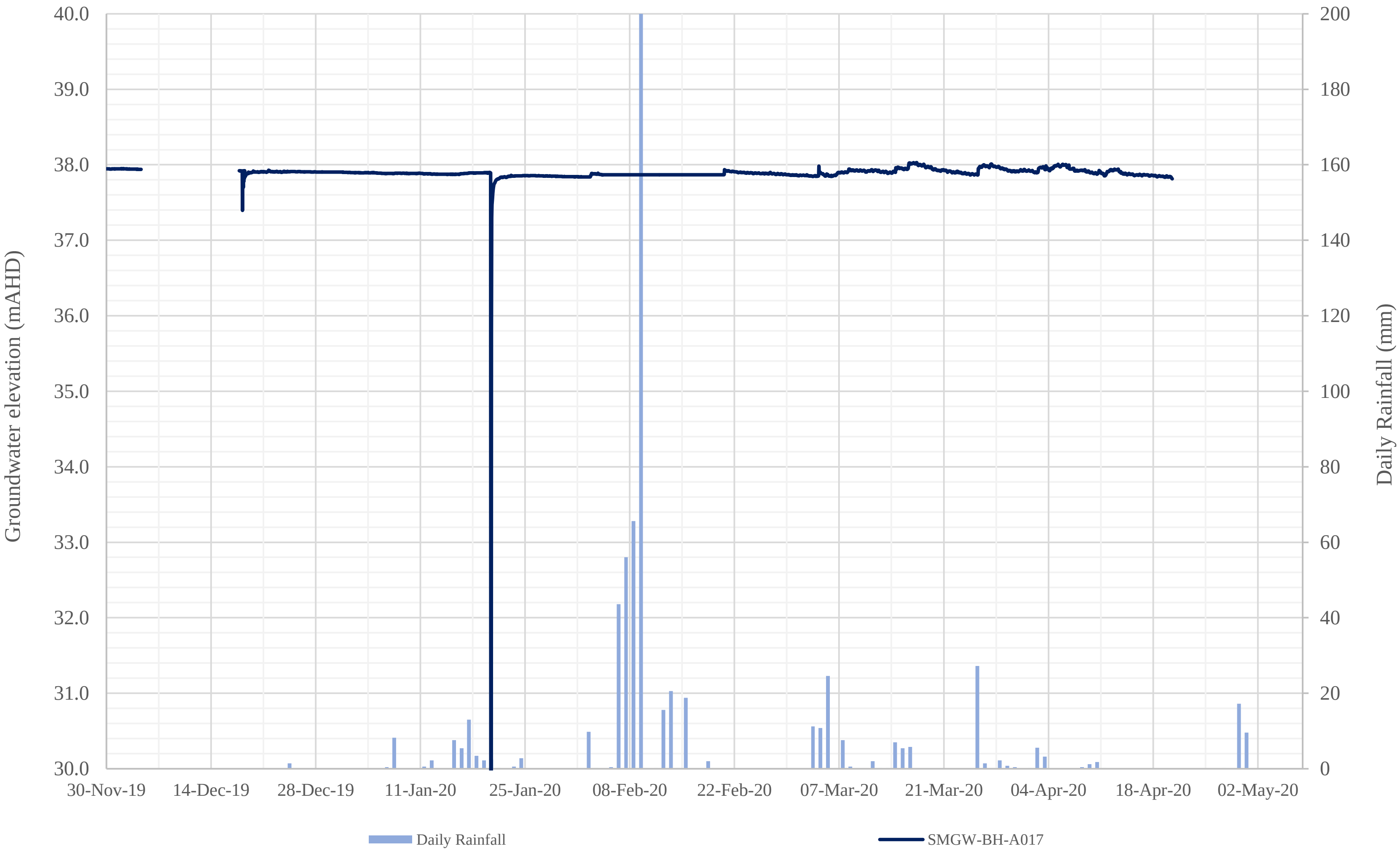
ARUP	SMGW-BH-A012	Prep: FC / GY	Chk: JL	App: JH
		Job Number: 272467		
		Printed on: 22-May-20		



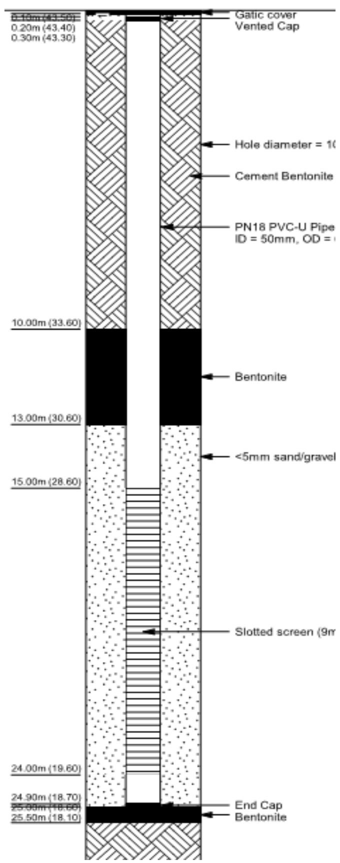
Piezometer



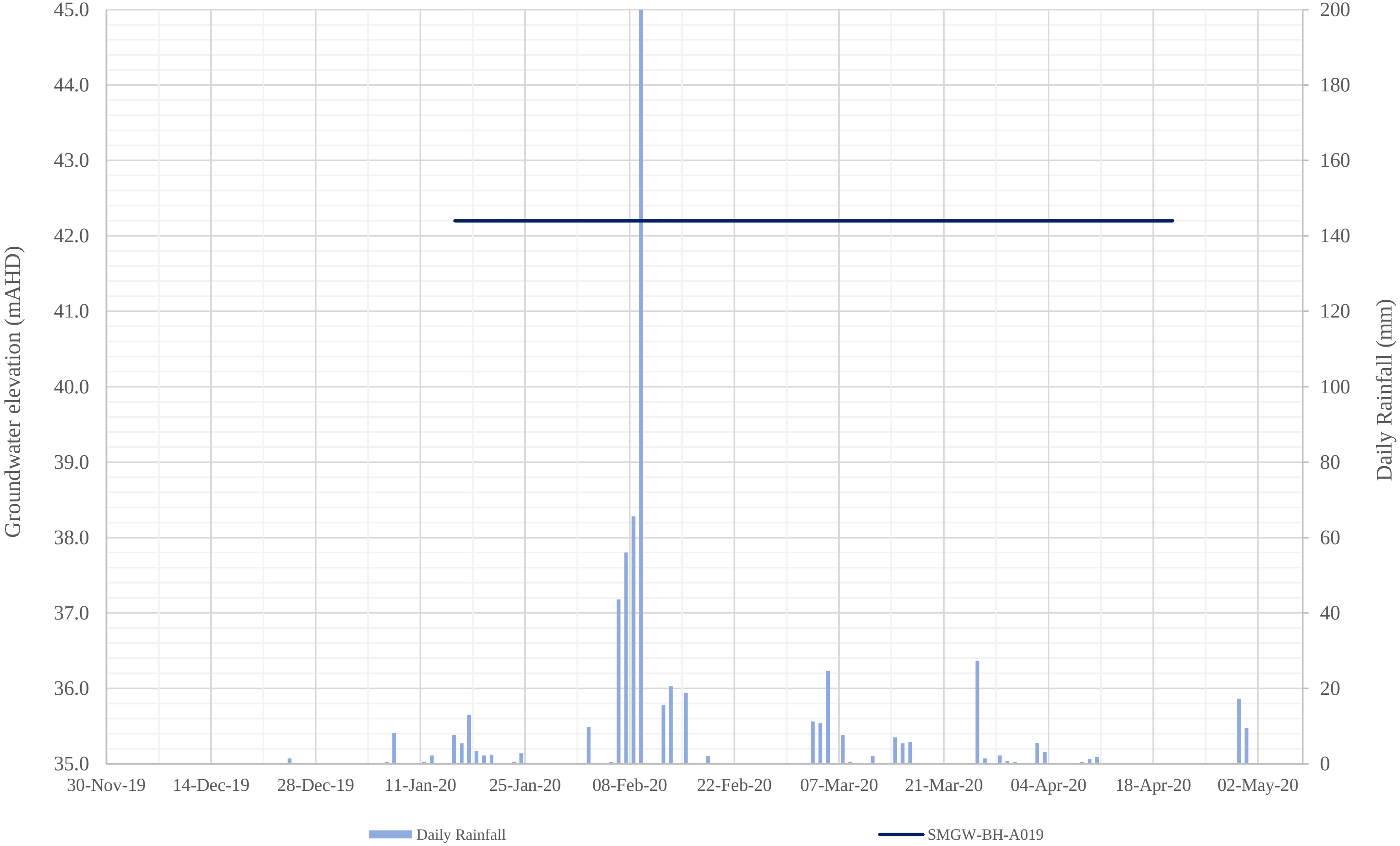
ARUP	SMGW-BH-A017	Prep	Chk	App
		FC / GY	JL	JH
		Job Number: 272467		
		Printed on: 29-May-20		



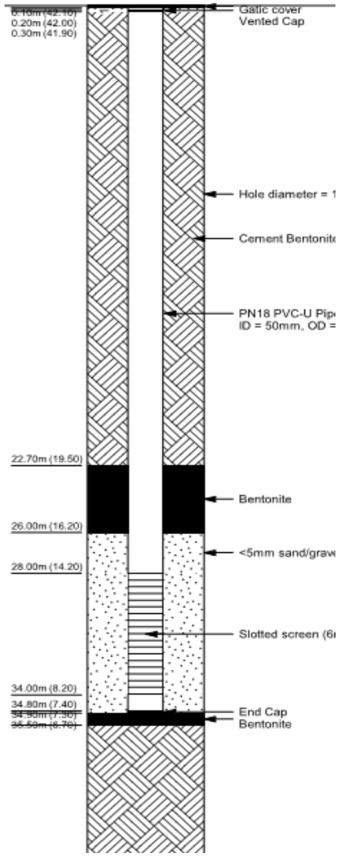
Piezometer



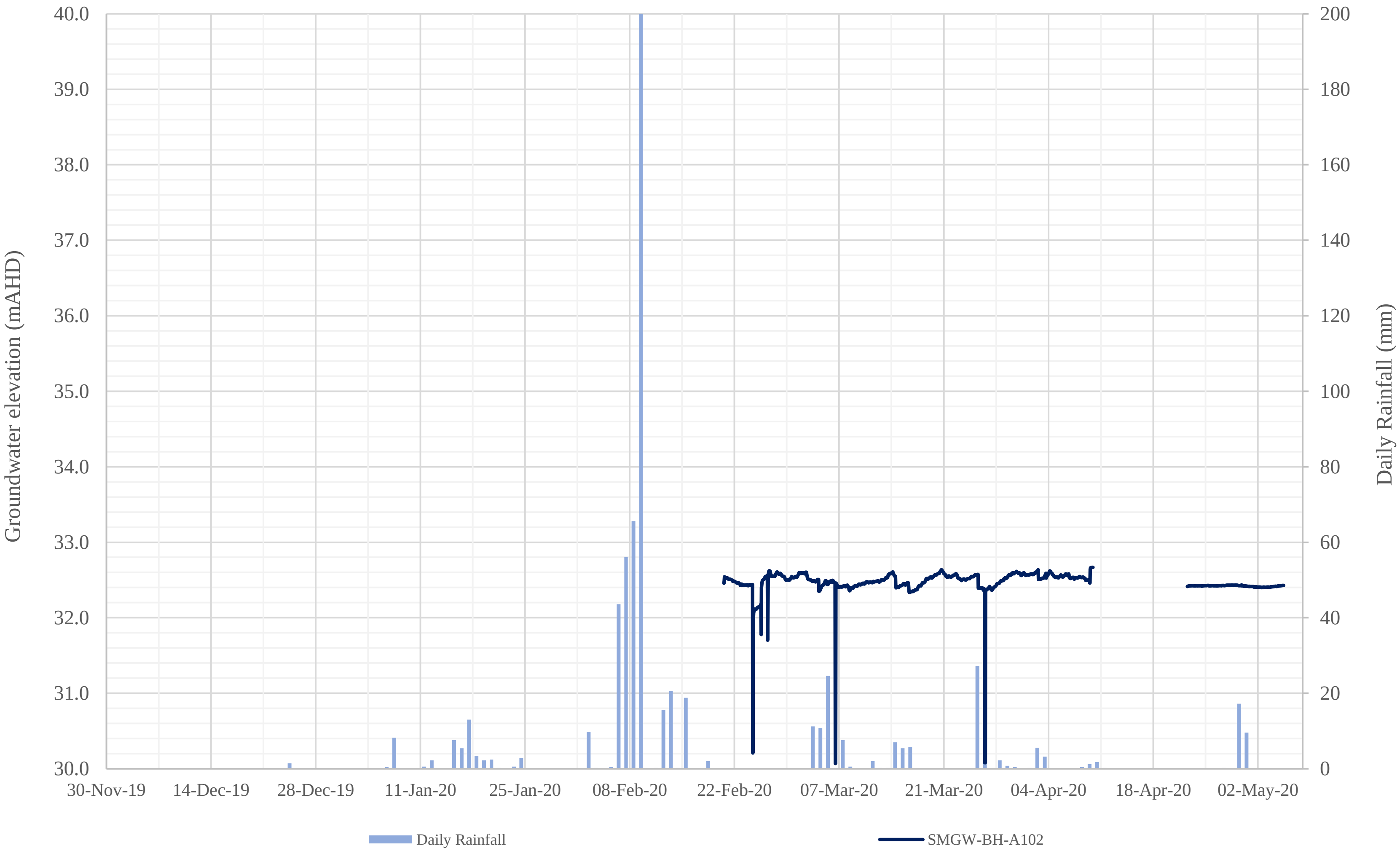
ARUP	SMGW-BH-A019	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



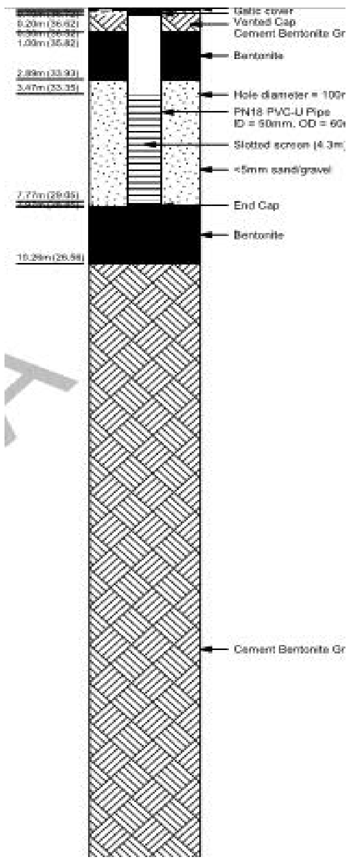
Piezometer



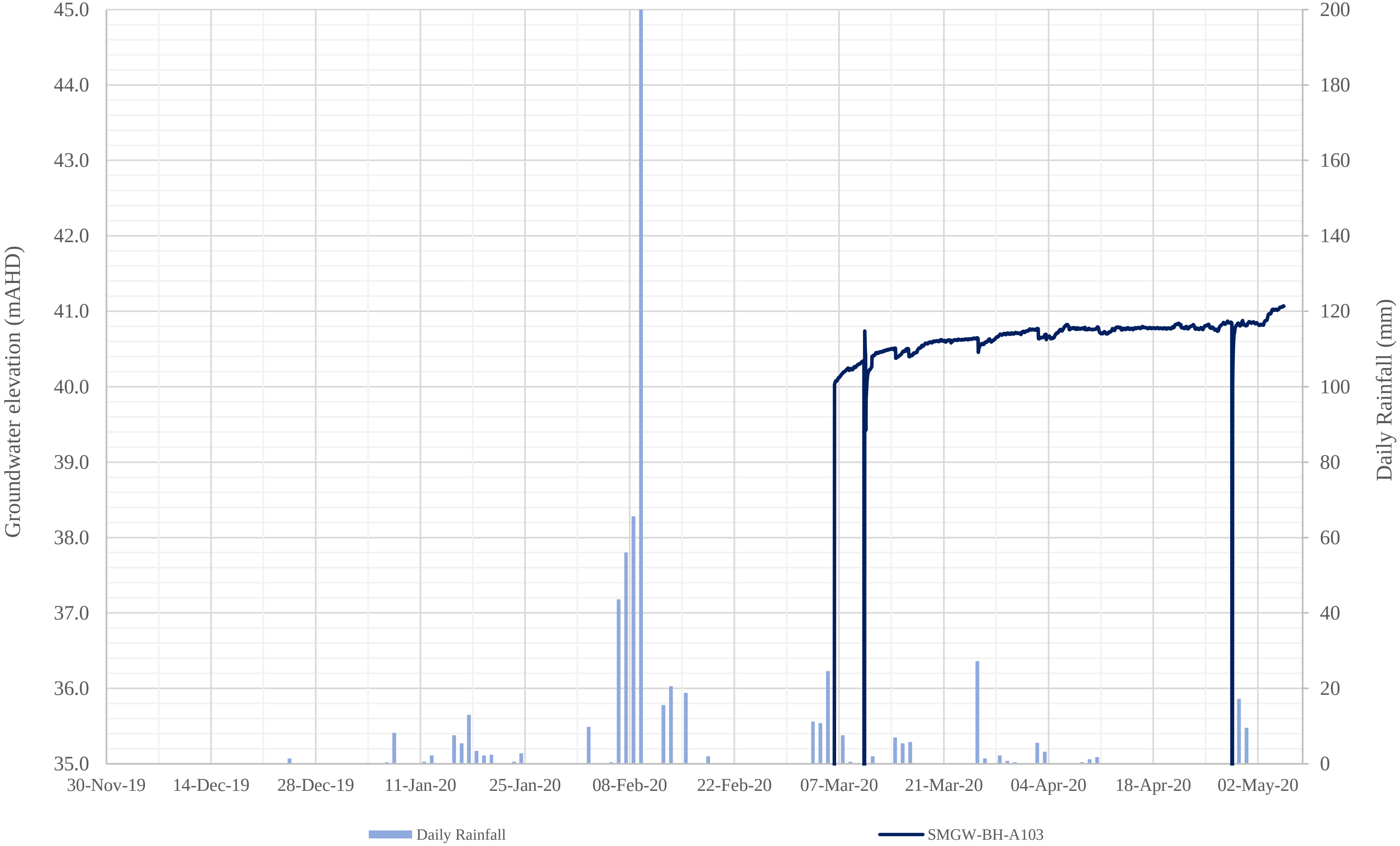
ARUP	SMGW-BH-A102	Prep FC / GY	Chk JL	App JH
		Job Number: 272467		
		Printed on: 22-May-20		



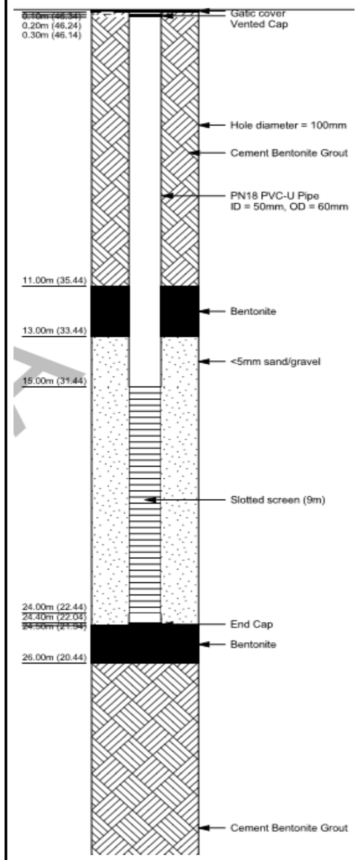
Piezometer



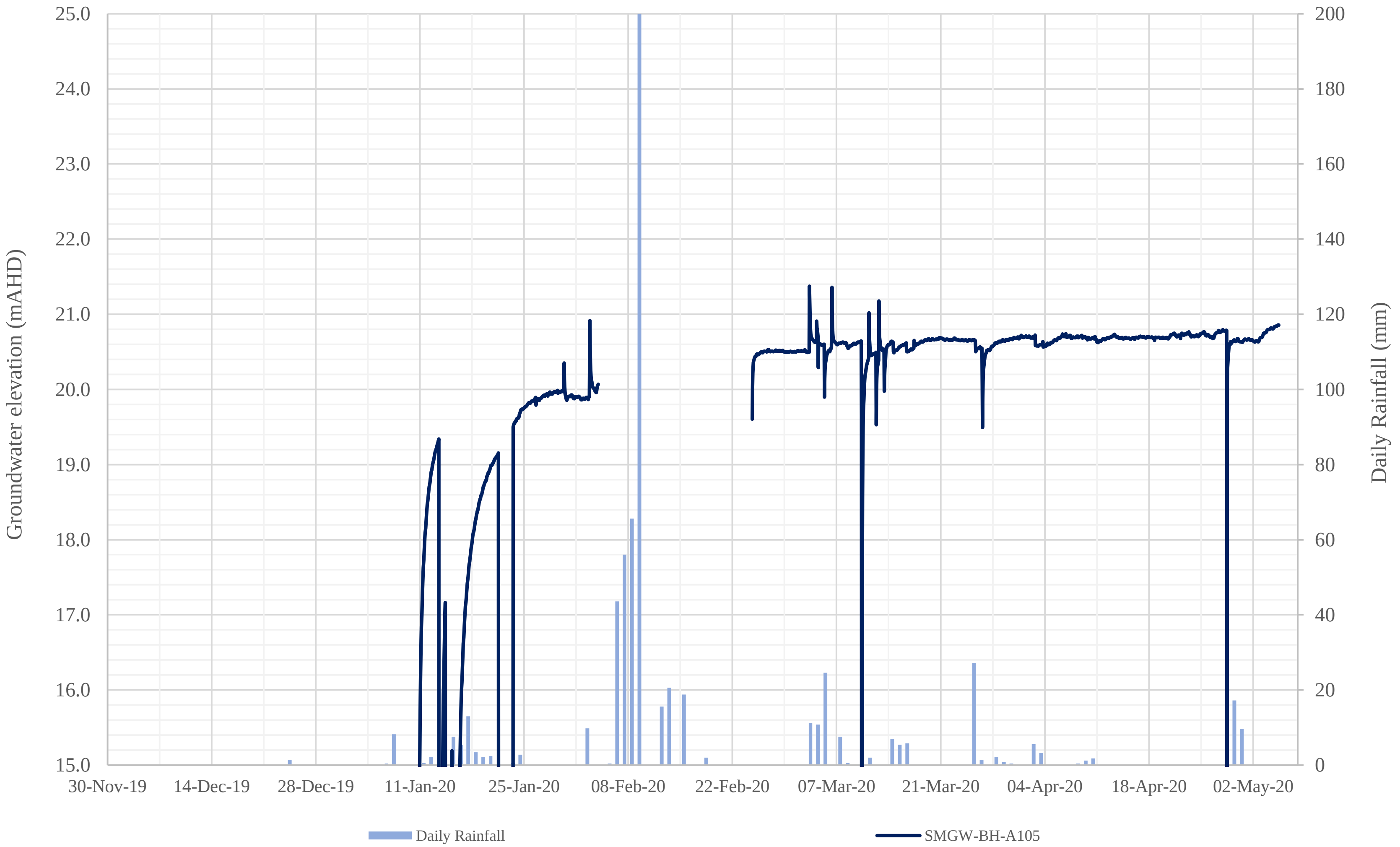
ARUP	SMGW-BH-A103	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



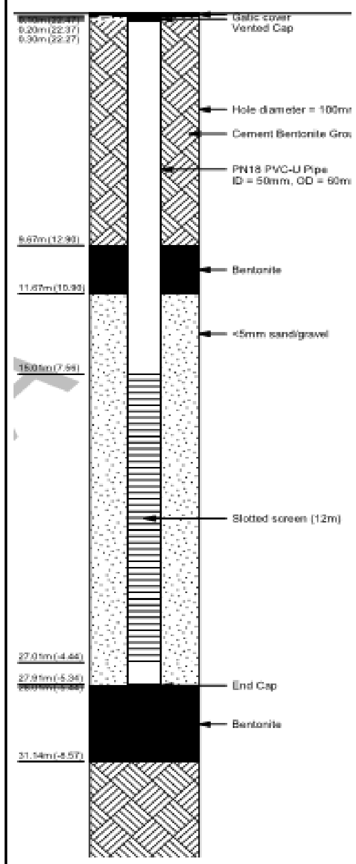
Piezometer



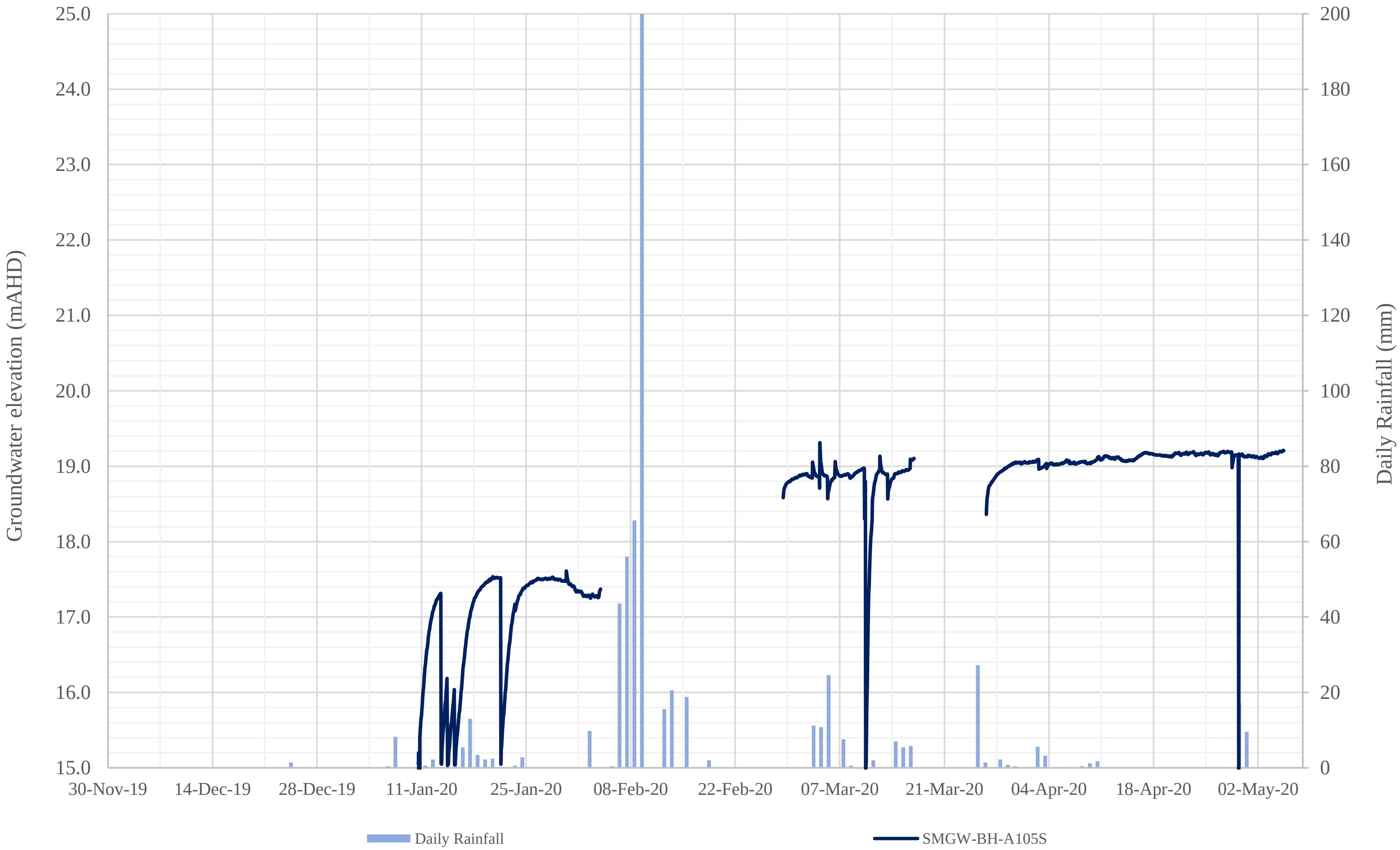
ARUP	SMGW-BH-A105	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



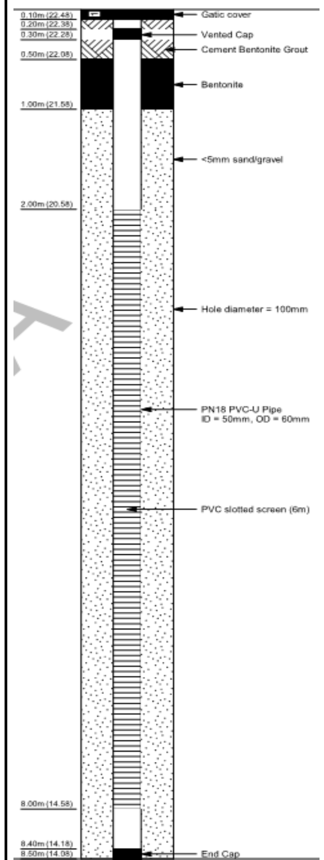
Piezometer



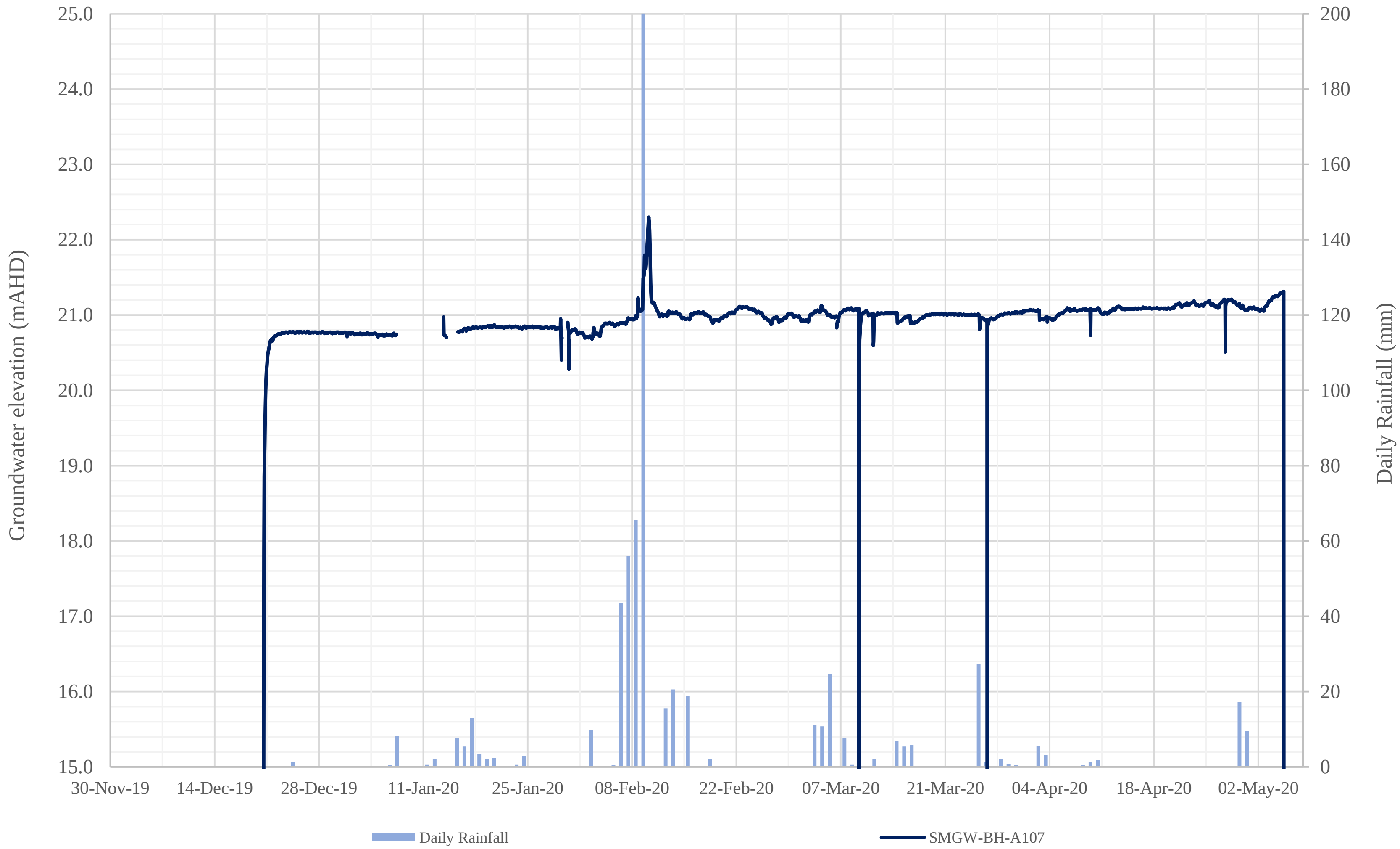
		Prep	Chk	App
ARUP	**SMGW-BH-A105S**	FC / GY	JL	JH
		Job Number: 272467		
		Printed on: 22-May-20		



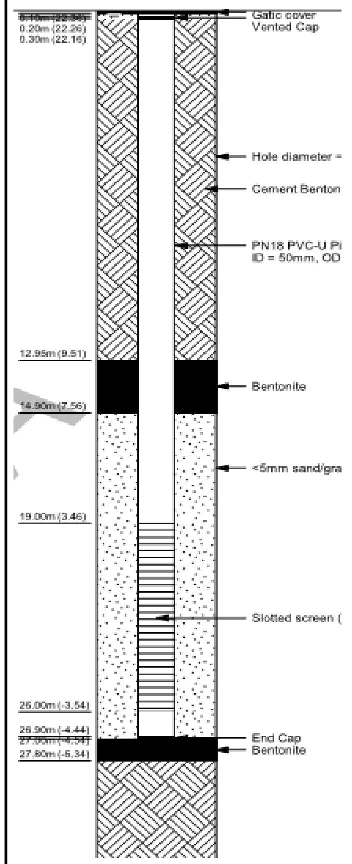
Piezometer



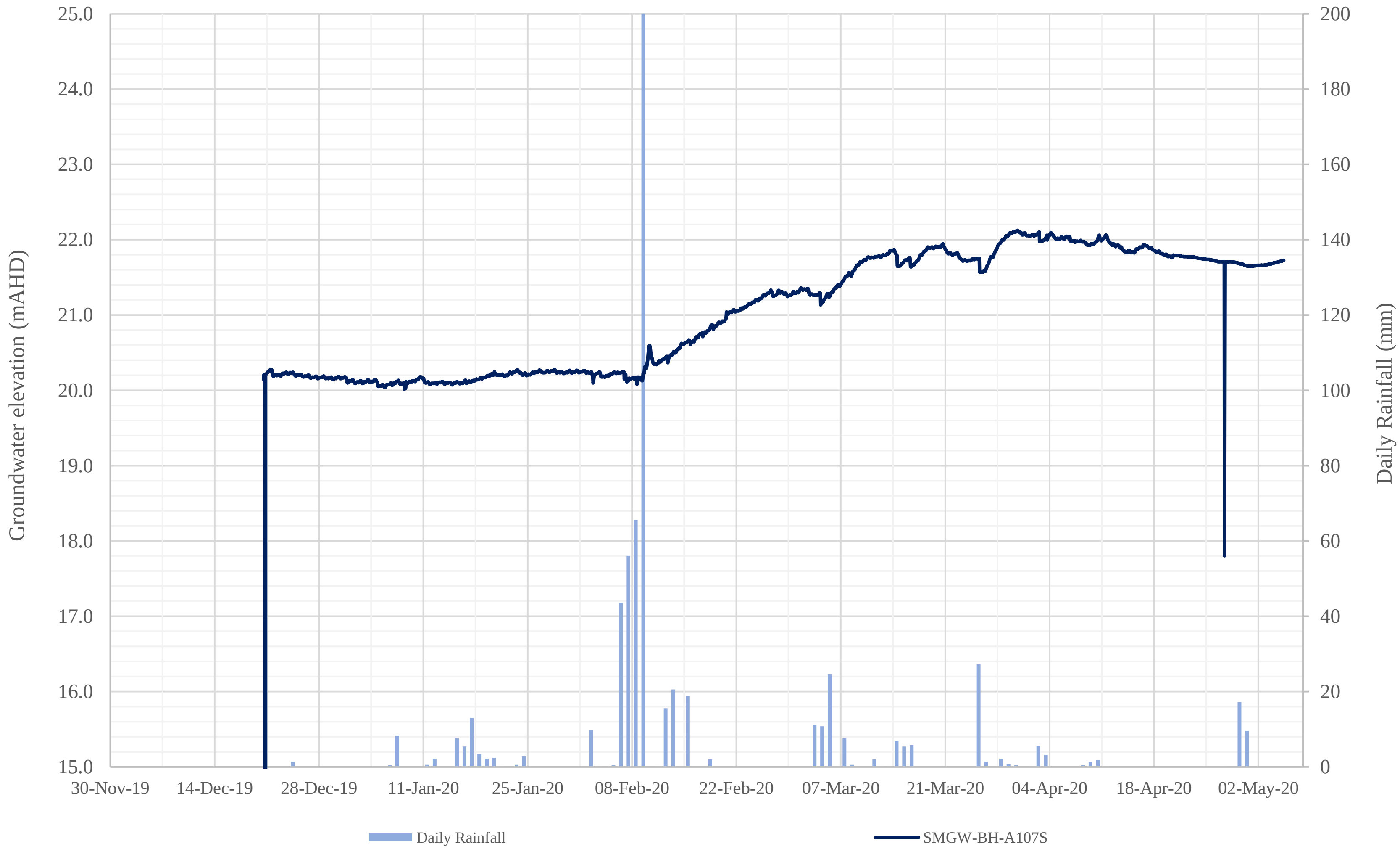
ARUP	SMGW-BH-A107	Prep	Chk	App
		FC / GY	JL	JH
		Job Number: 272467		
		Printed on: 22-May-20		

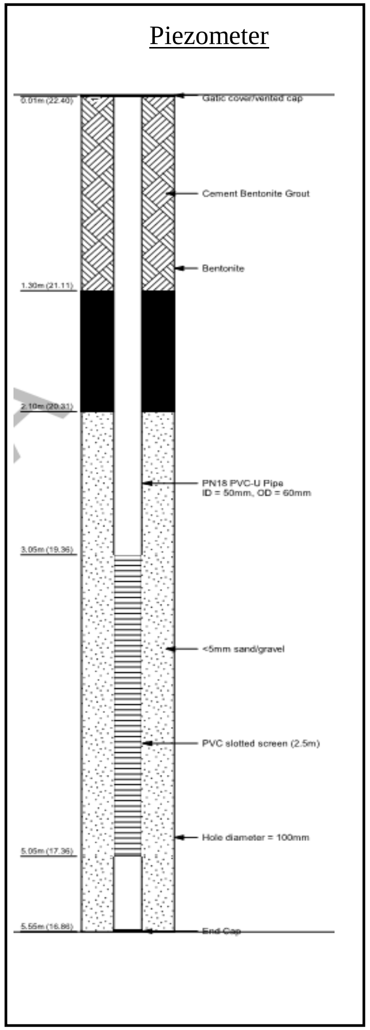


Piezometer

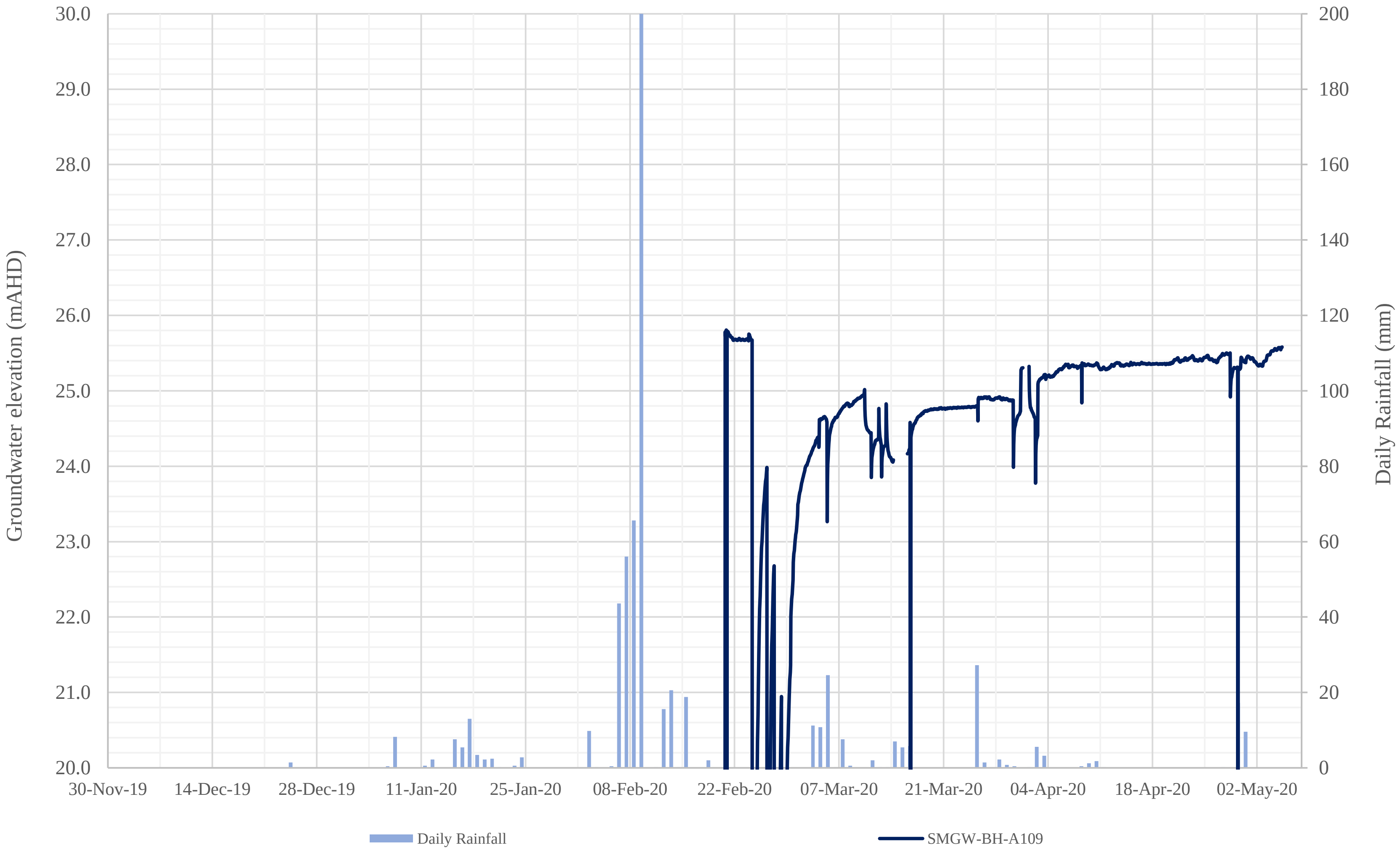


ARUP	SMGW-BH-A107S	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		

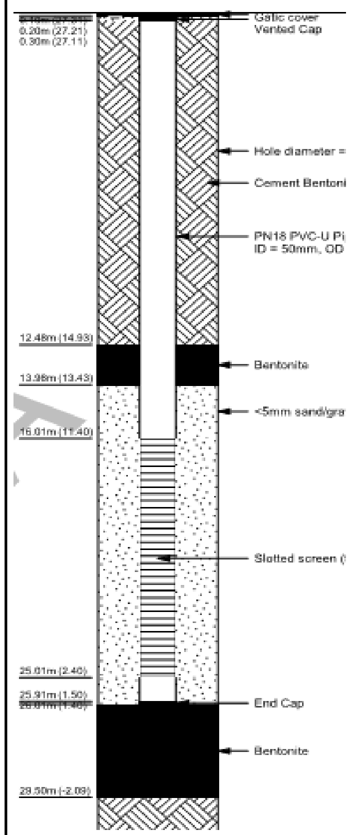




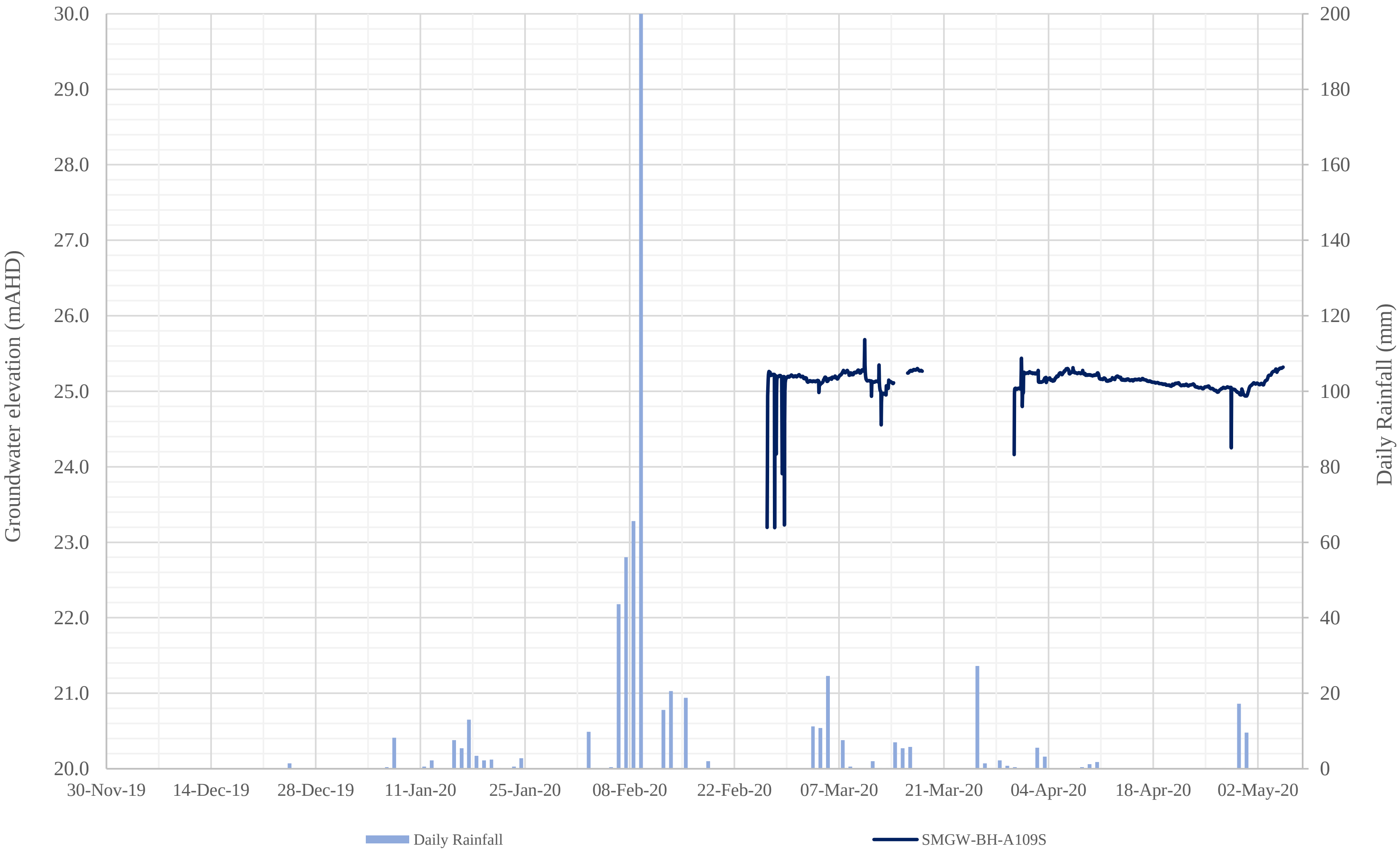
ARUP	SMGW-BH-A109	Prep	Chk	App
		FC / GY	JL	JH
		Job Number: 272467		
		Printed on: 22-May-20		



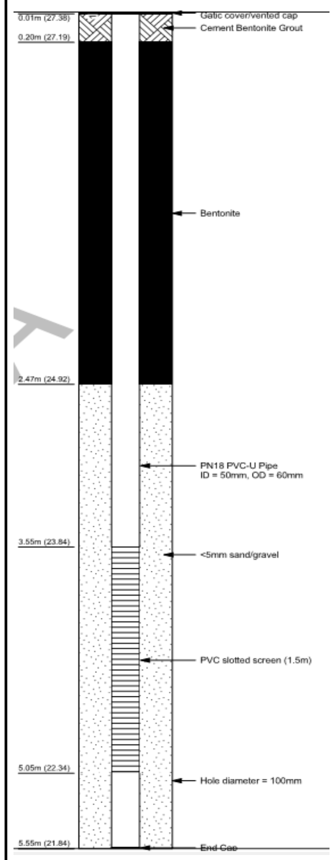
Piezometer



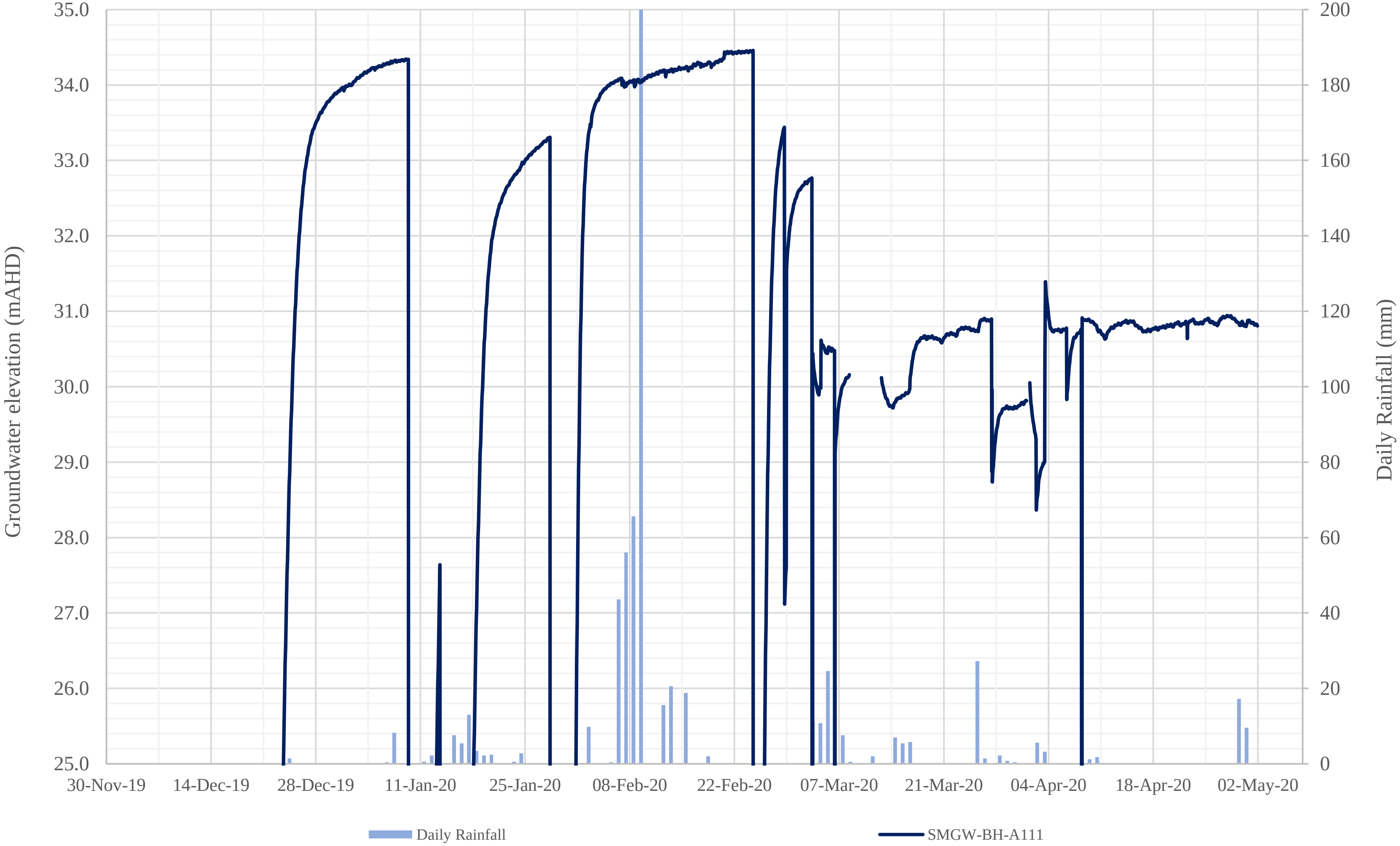
ARUP	SMGW-BH-A109S	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



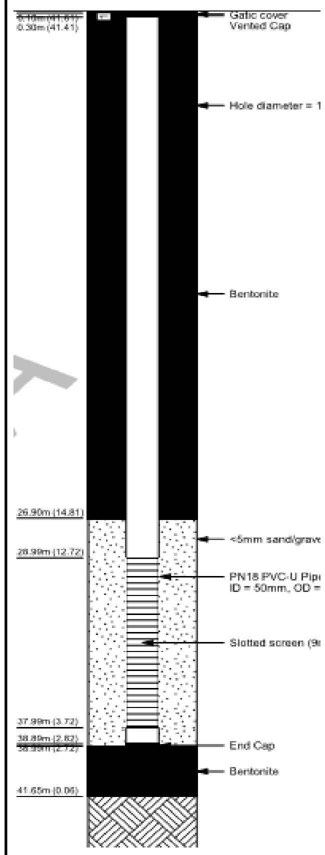
Piezometer



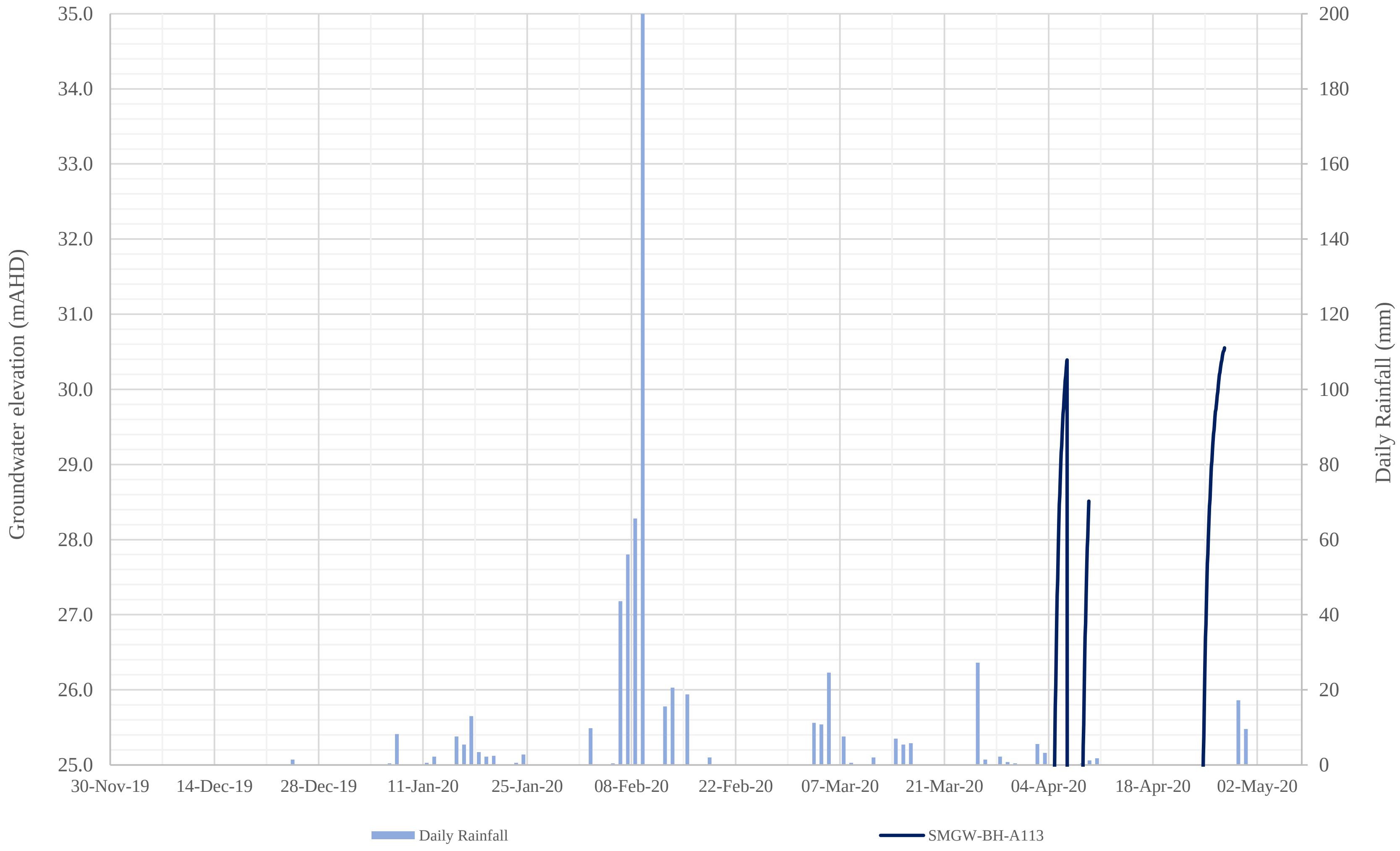
ARUP	SMGW-BH-A111	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



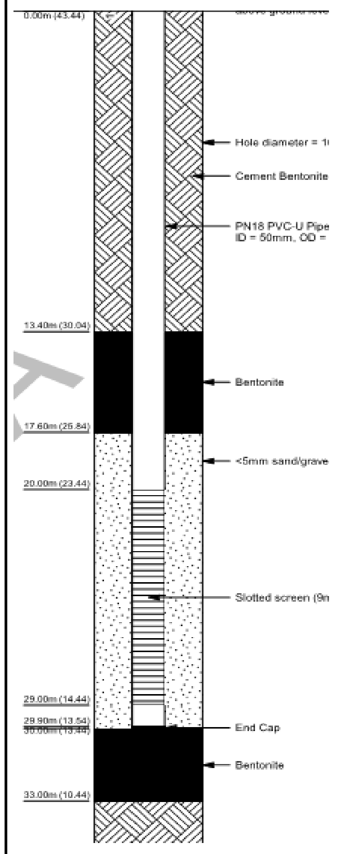
Piezometer



ARUP	SMGW-BH-A113	Prep FC / GY	Chk JL	App JH
		Job Number: 272467		
		Printed on: 22-May-20		



Piezometer



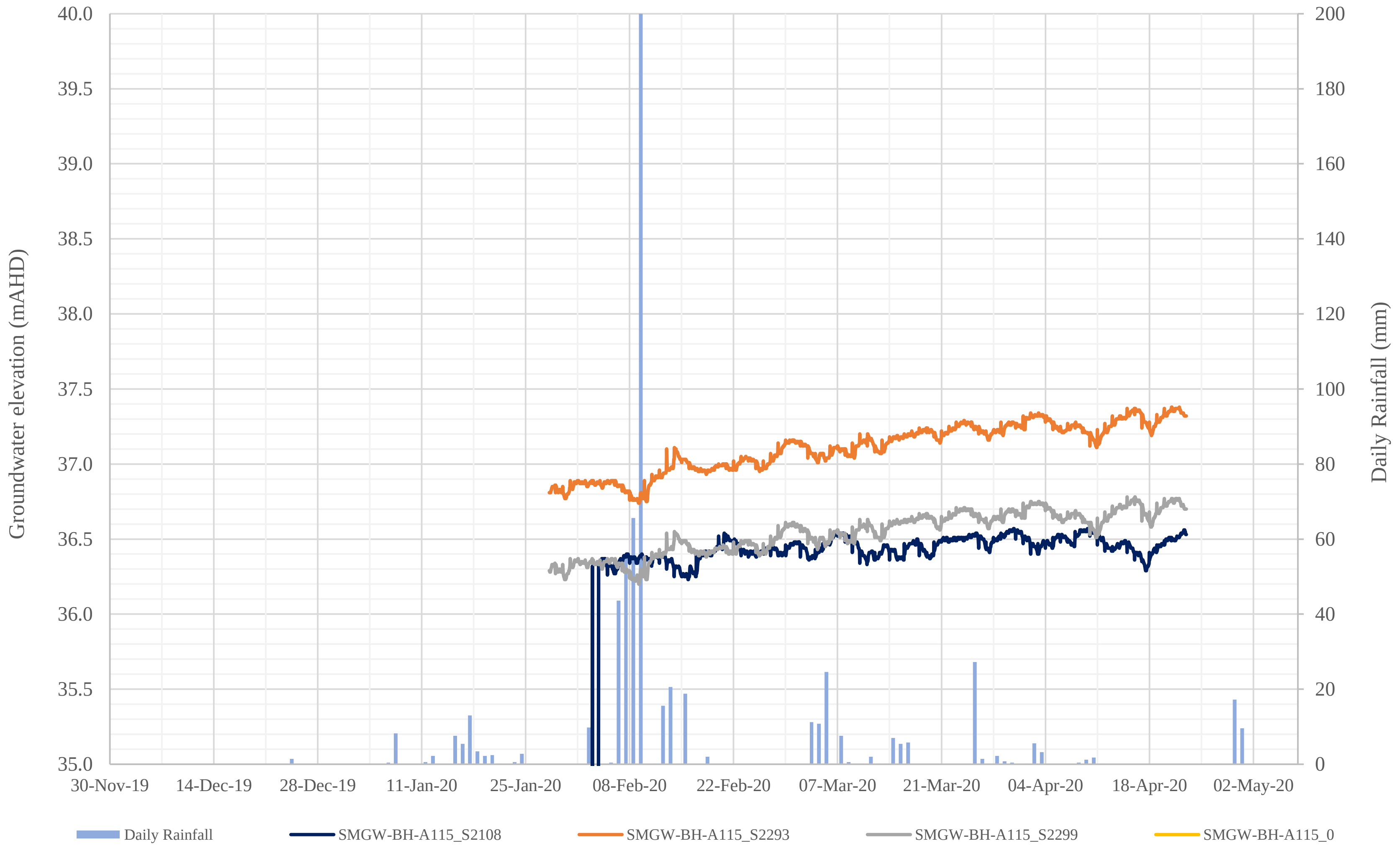
ARUP

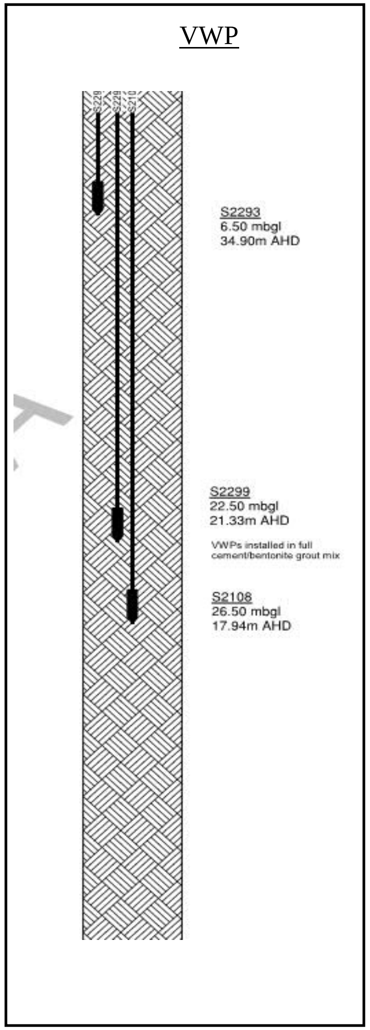
SMGW-BH-A115

Prep	Chk	App
FC / GY	JL	JH

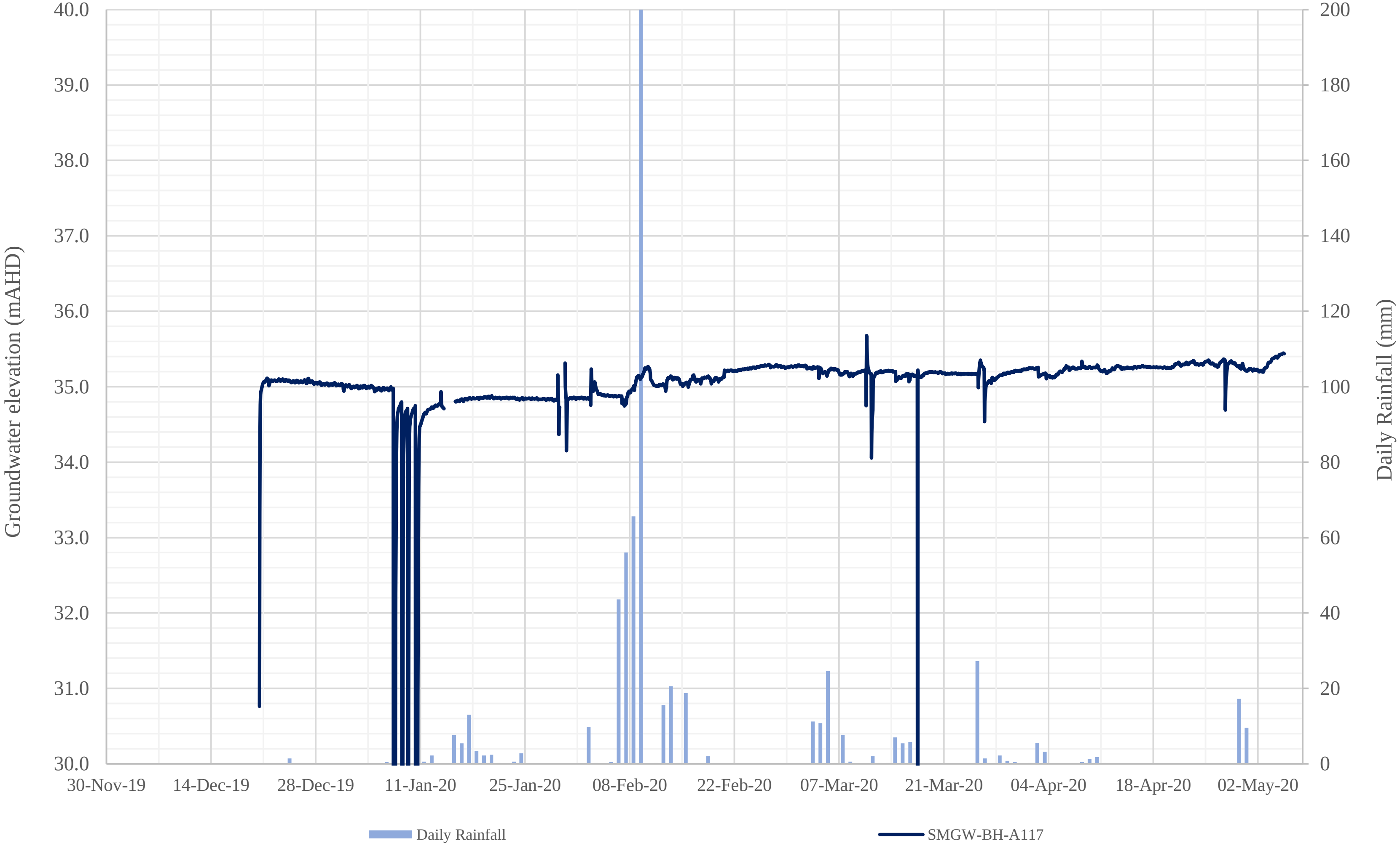
Job Number: 272467

Printed on: 22-May-20

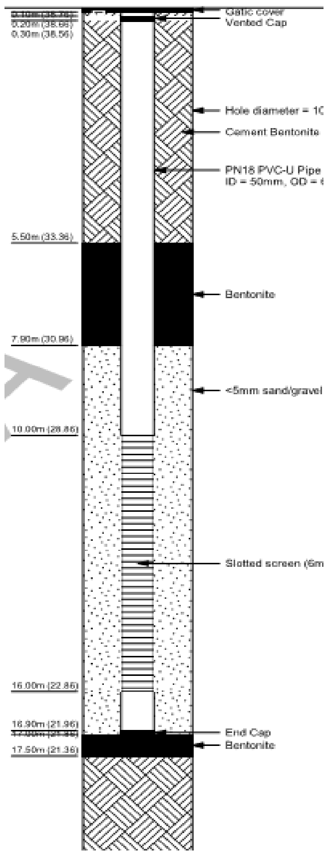




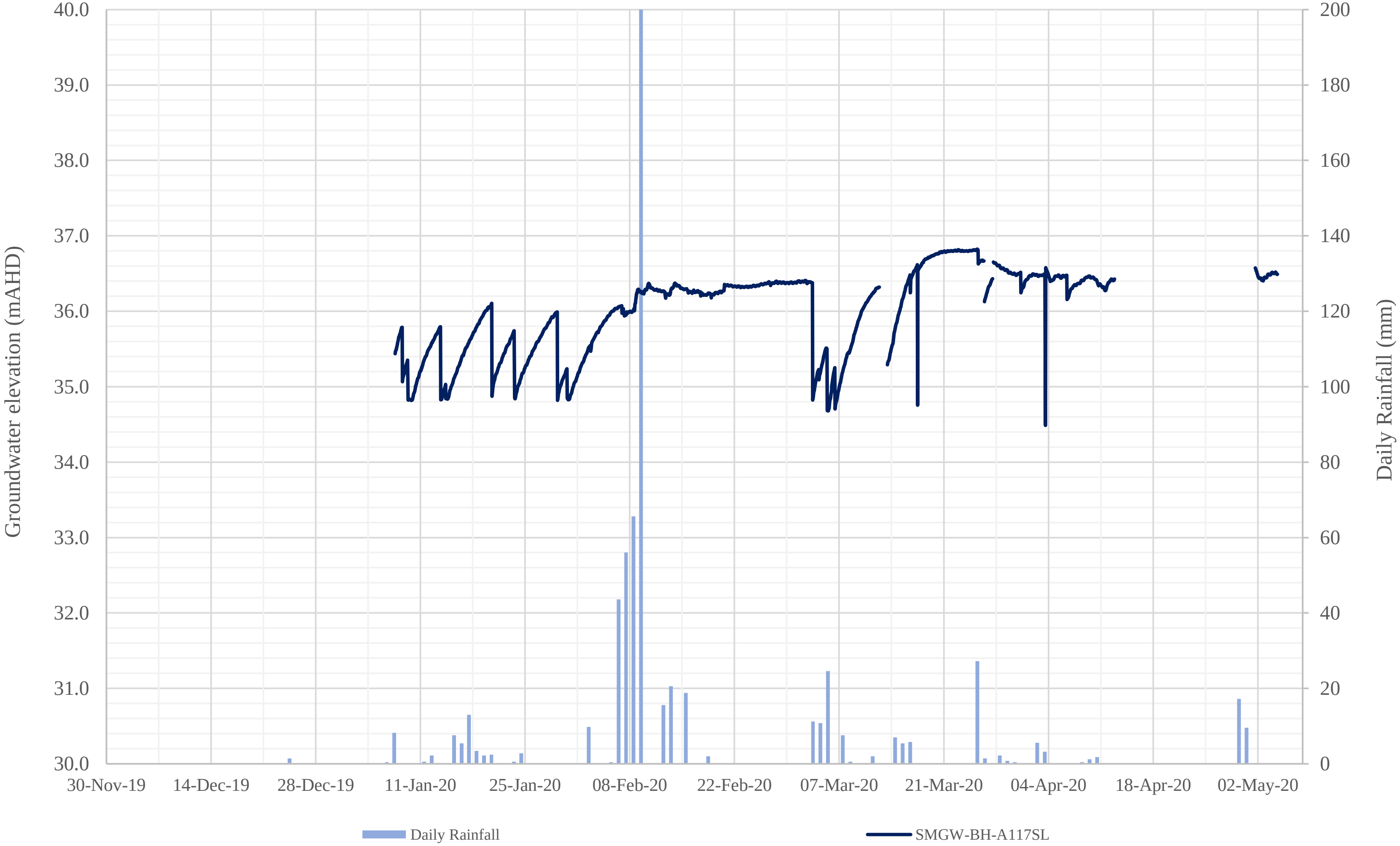
ARUP	SMGW-BH-A117	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



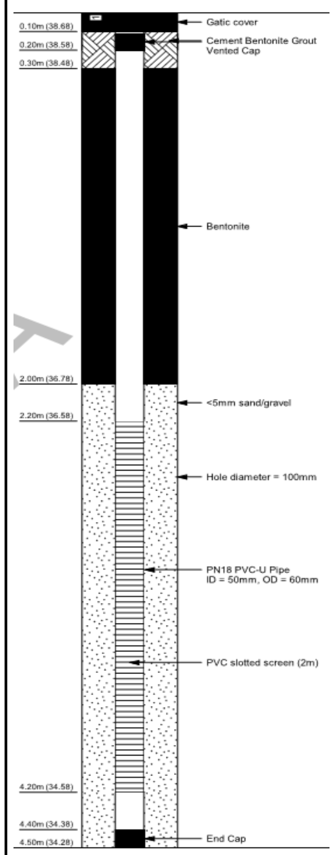
Piezometer



ARUP	SMGW-BH-A117SL	Prep: FC / GY	Chk: JL	App: JH
		Job Number: 272467		
		Printed on: 22-May-20		



Piezometer



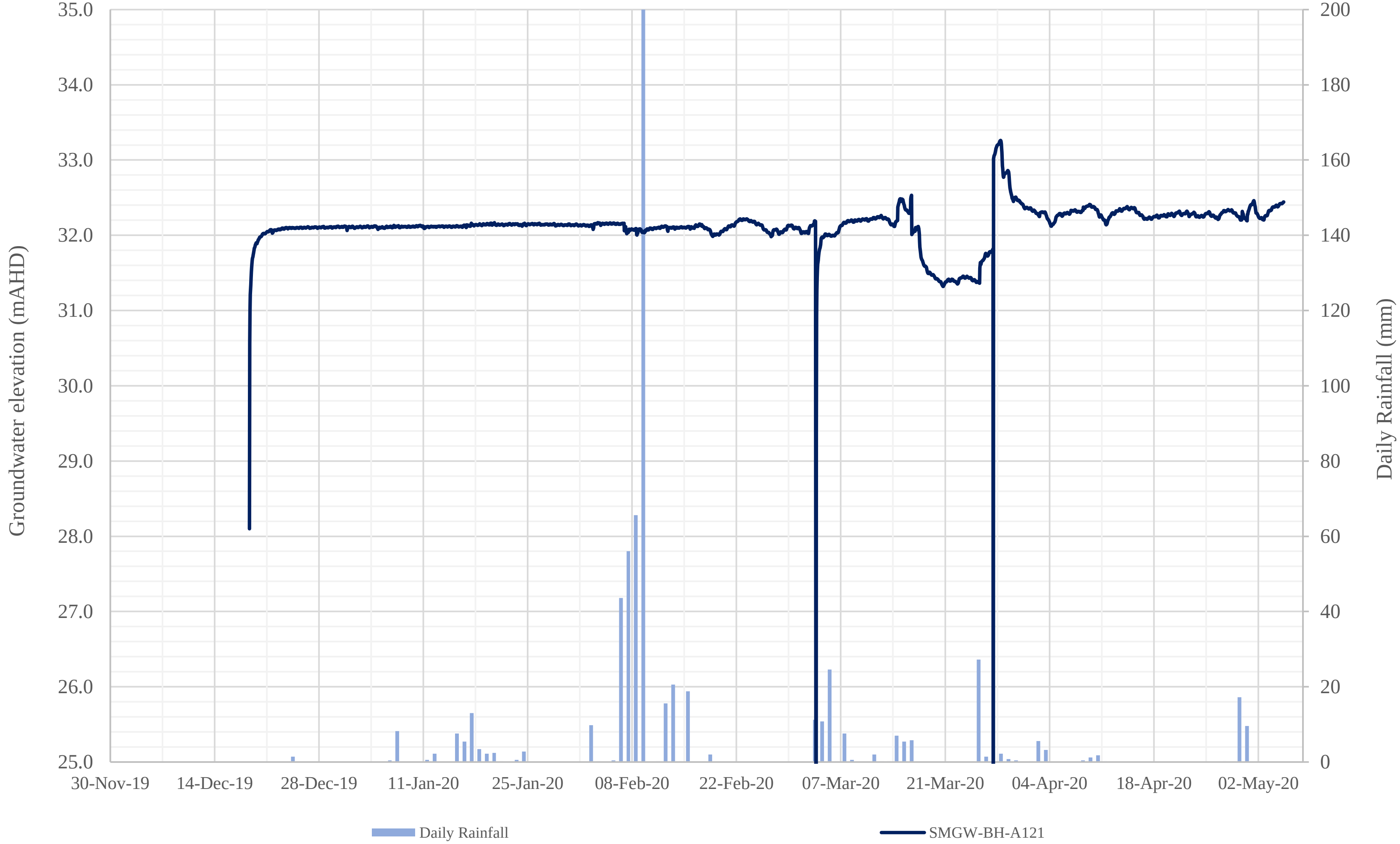
ARUP

SMGW-BH-A121

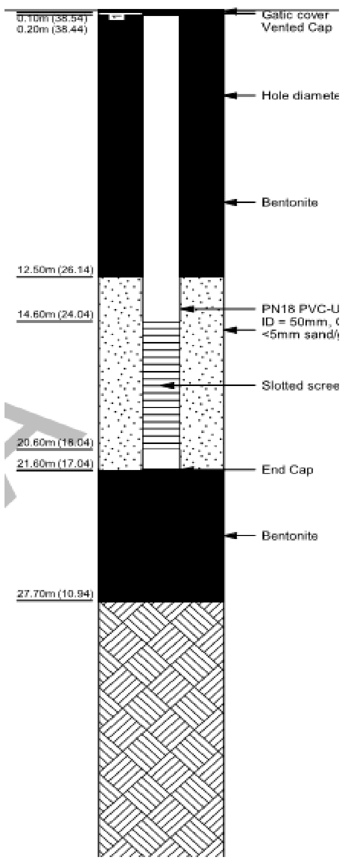
Prep	Chk	App
FC / GY	JL	JH

Job Number: 272467

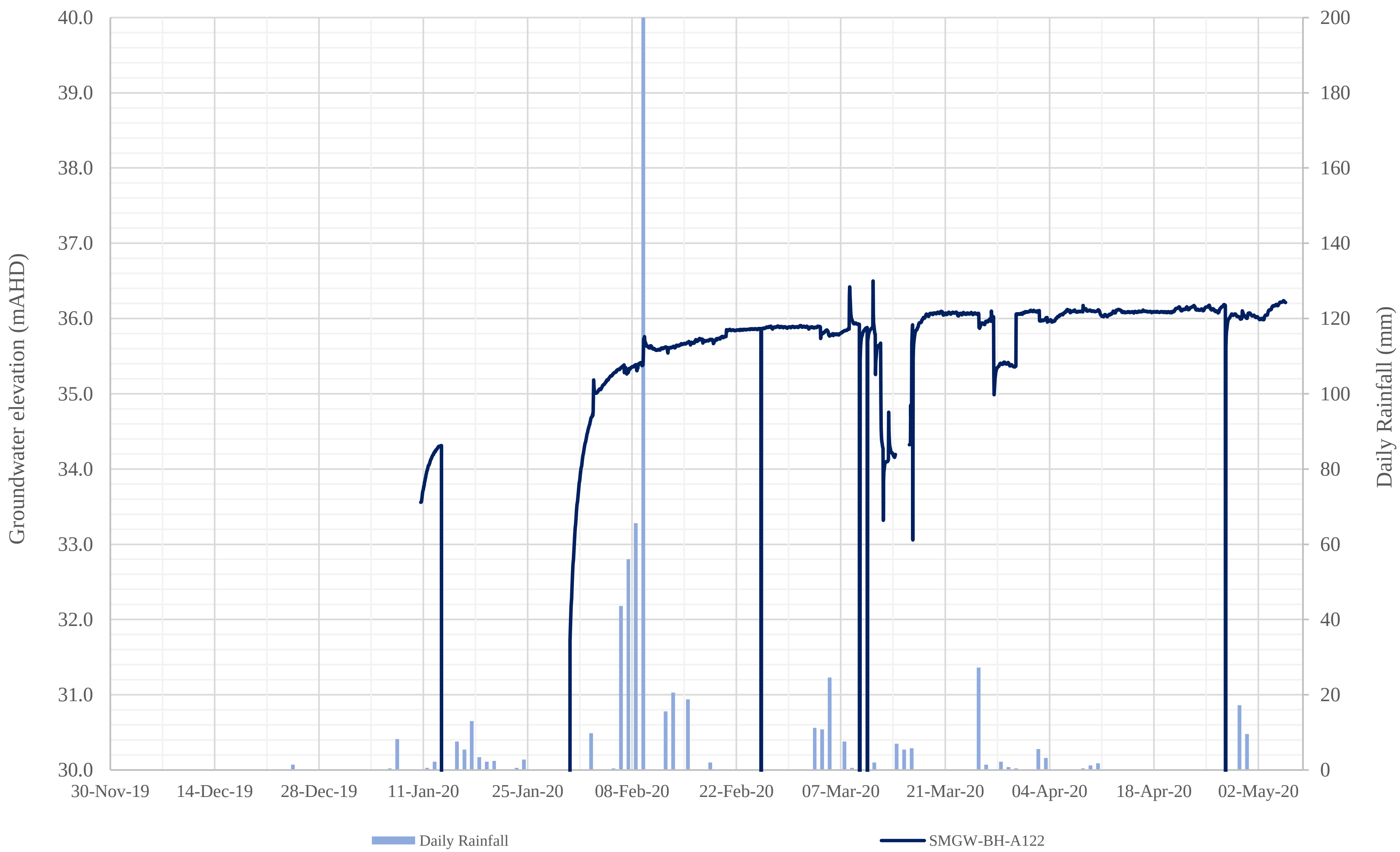
Printed on: 22-May-20



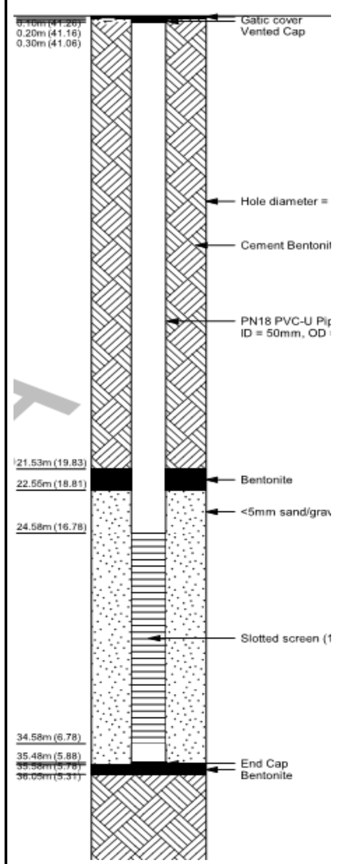
Piezometer



ARUP	SMGW-BH-A122	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



Piezometer



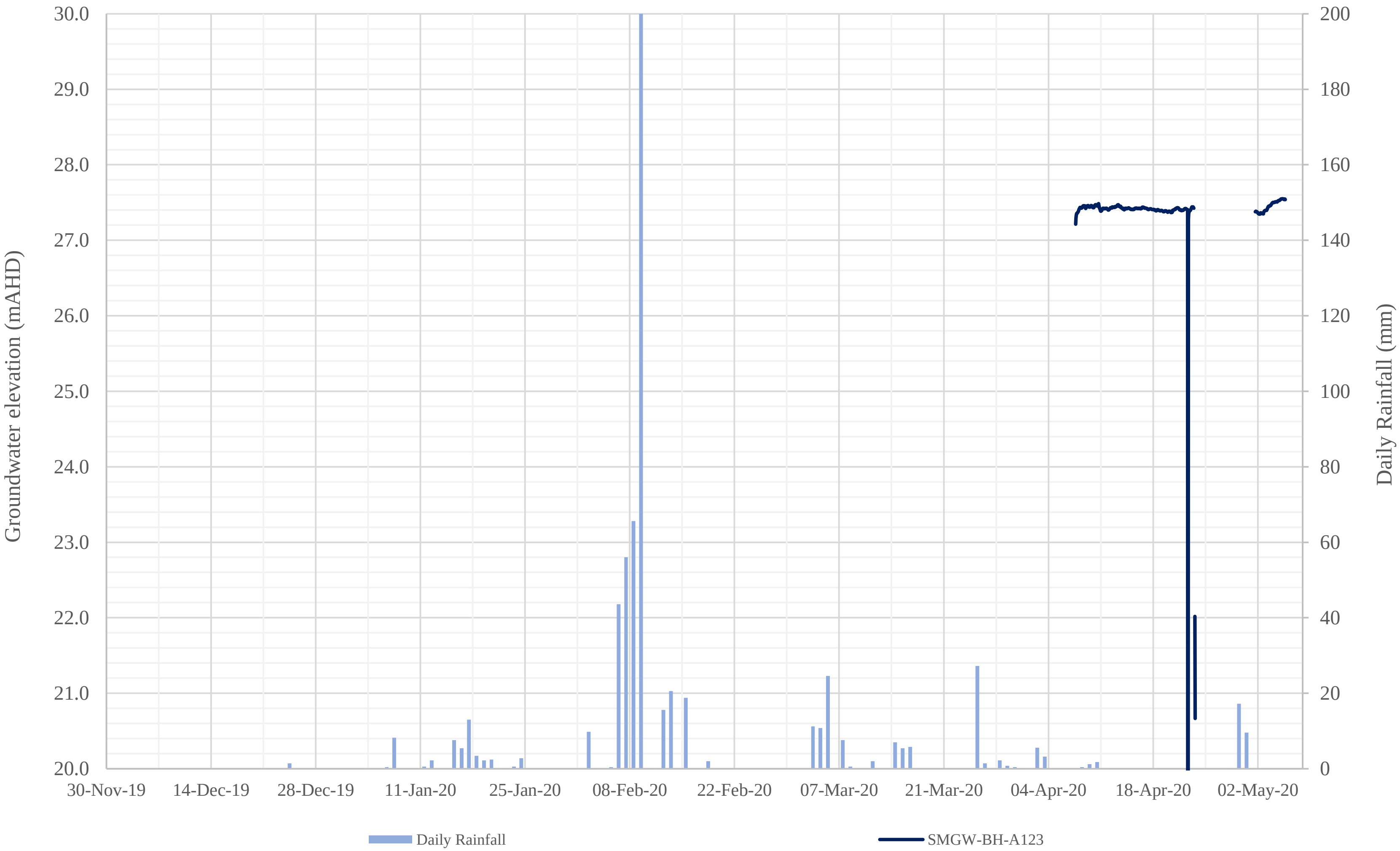
ARUP

SMGW-BH-A123

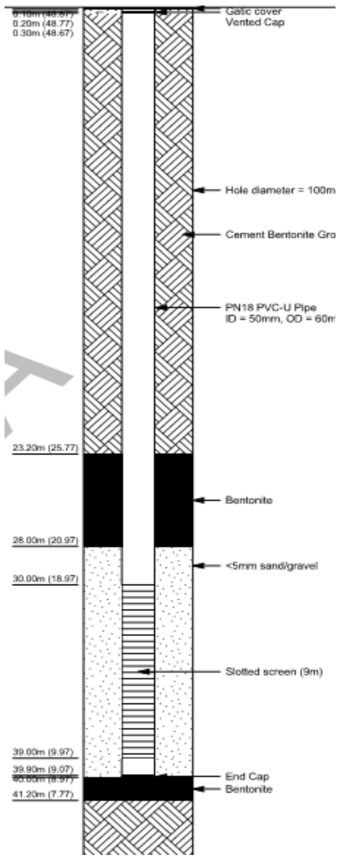
Prep	Chk	App
FC / GY	JL	JH

Job Number: 272467

Printed on: 22-May-20



Piezometer



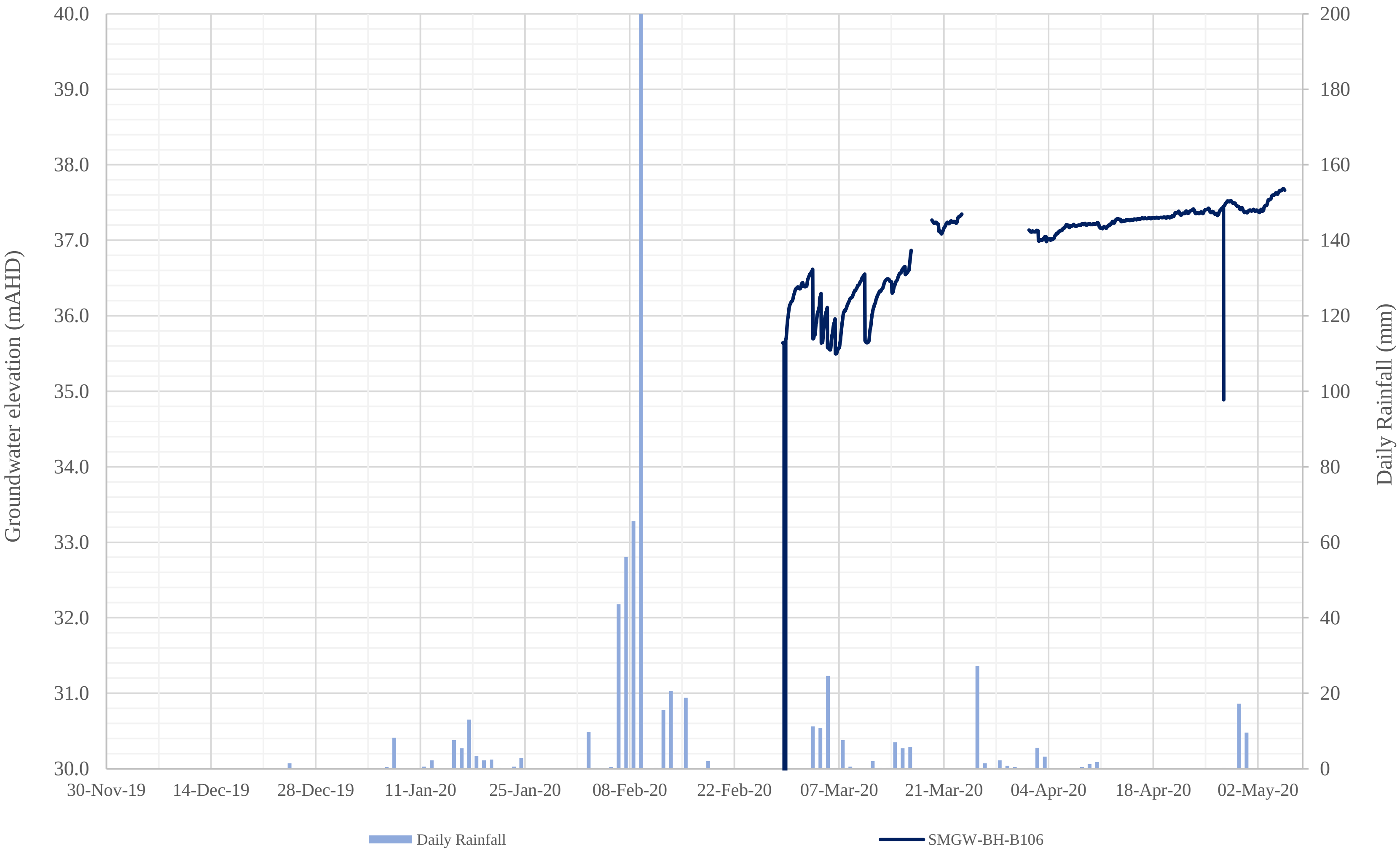
ARUP

SMGW-BH-B106

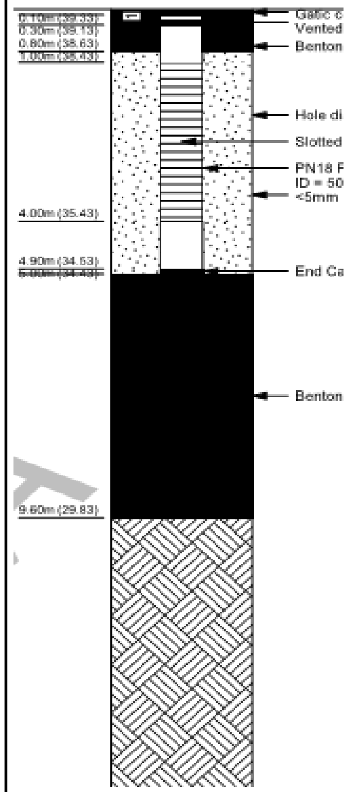
Prep	Chk	App
FC / GY	JL	JH

Job Number: 272467

Printed on: 22-May-20



Piezometer



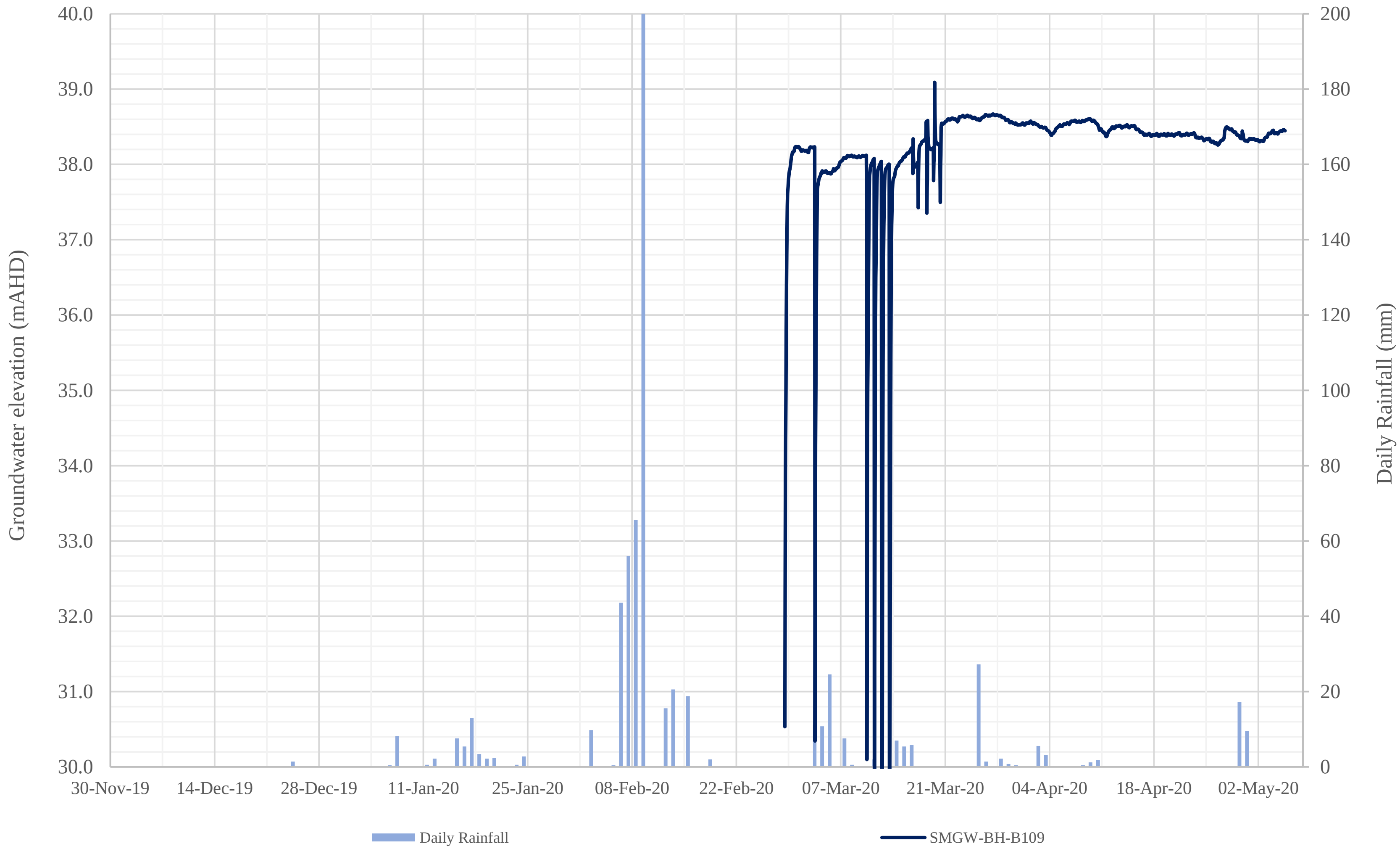
ARUP

SMGW-BH-B109

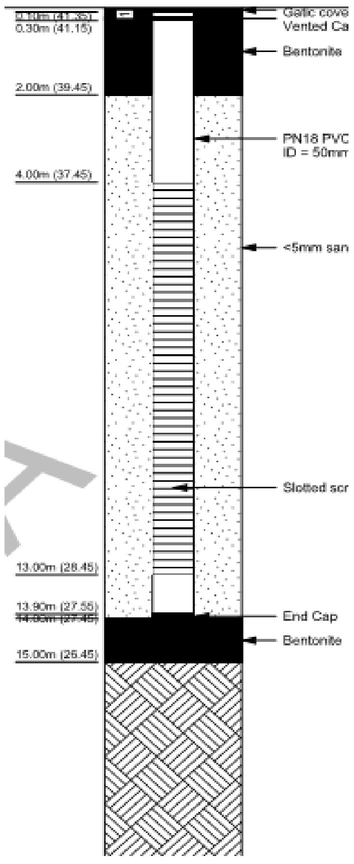
Prep	Chk	App
FC / GY	JL	JH

Job Number: 272467

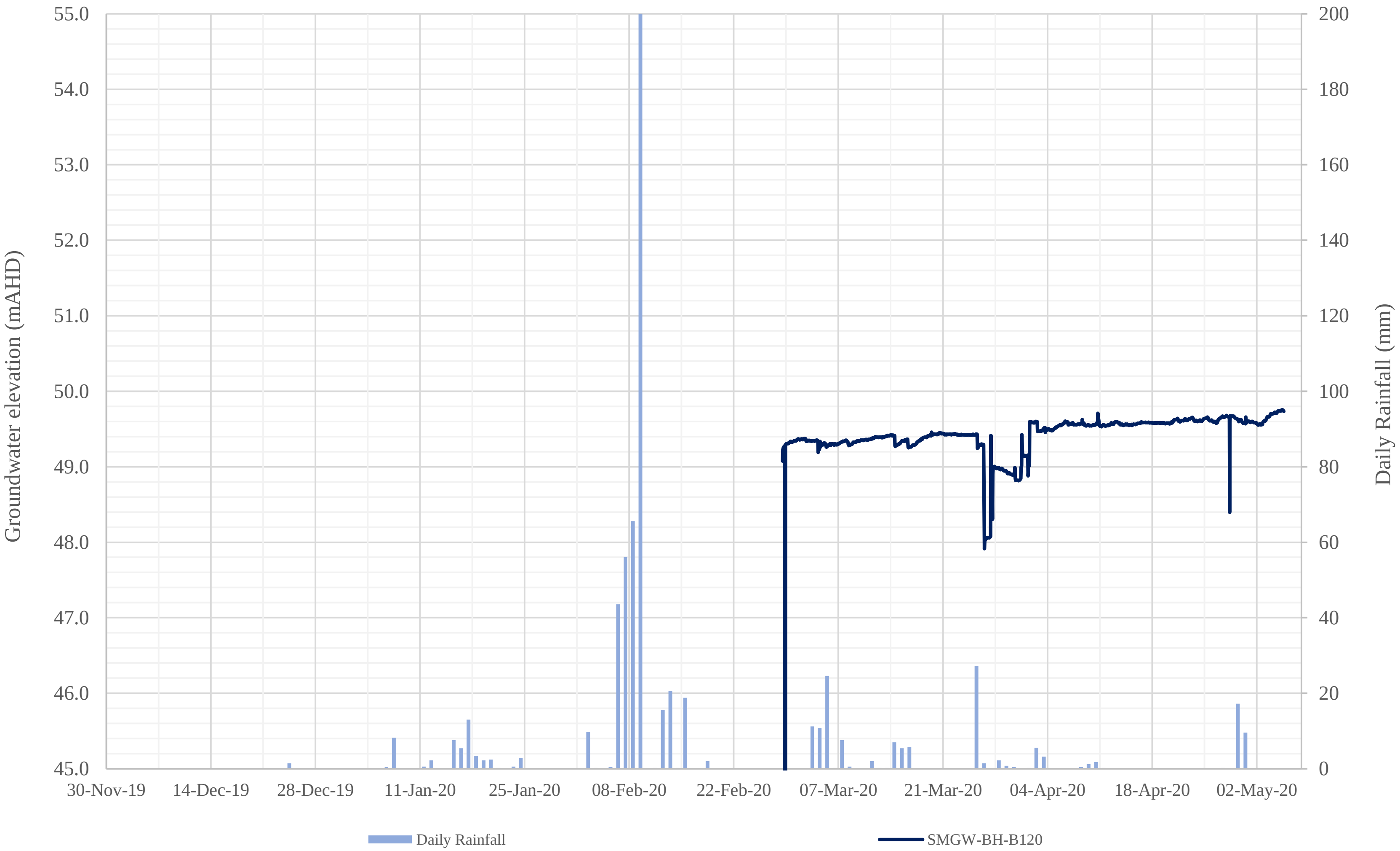
Printed on: 22-May-20



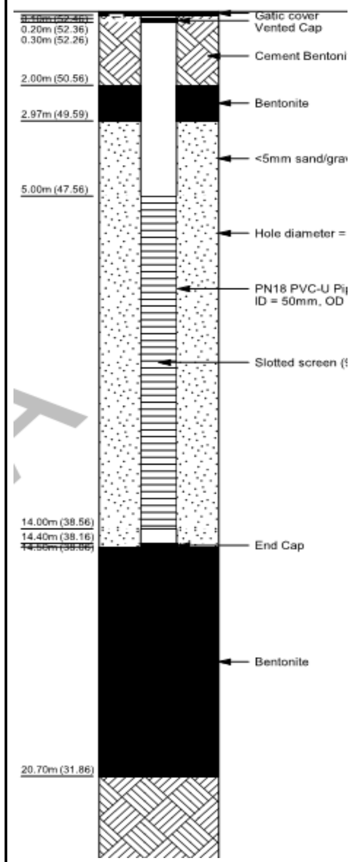
Piezometer



ARUP	SMGW-BH-B120	Prep	Chk	App
		FC / GY	JL	JH
		Job Number: 272467		
		Printed on: 22-May-20		



Piezometer



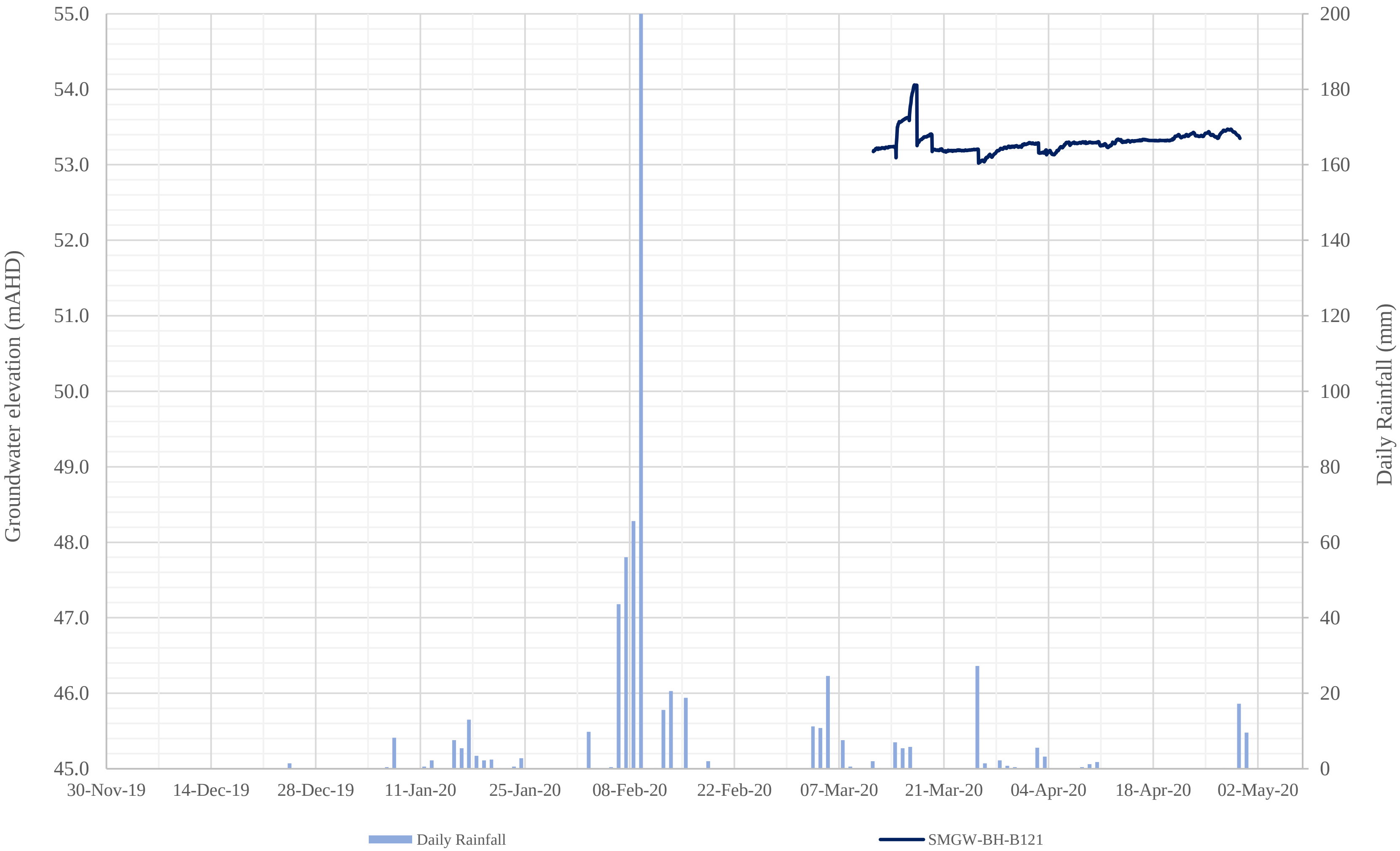
ARUP

SMGW-BH-B121

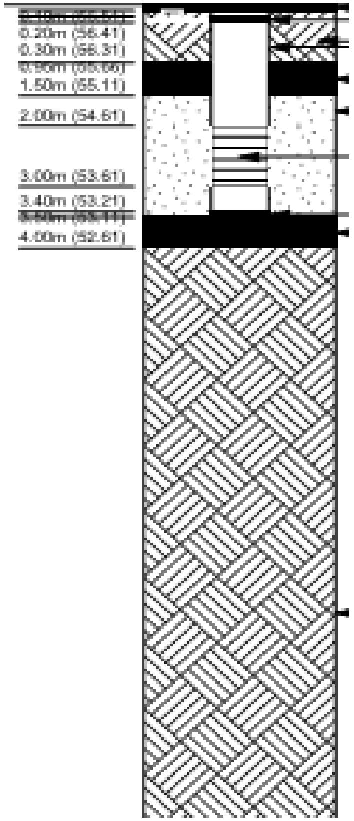
Prep	Chk	App
FC / GY	JL	JH

Job Number: 272467

Printed on: 22-May-20



Piezometer



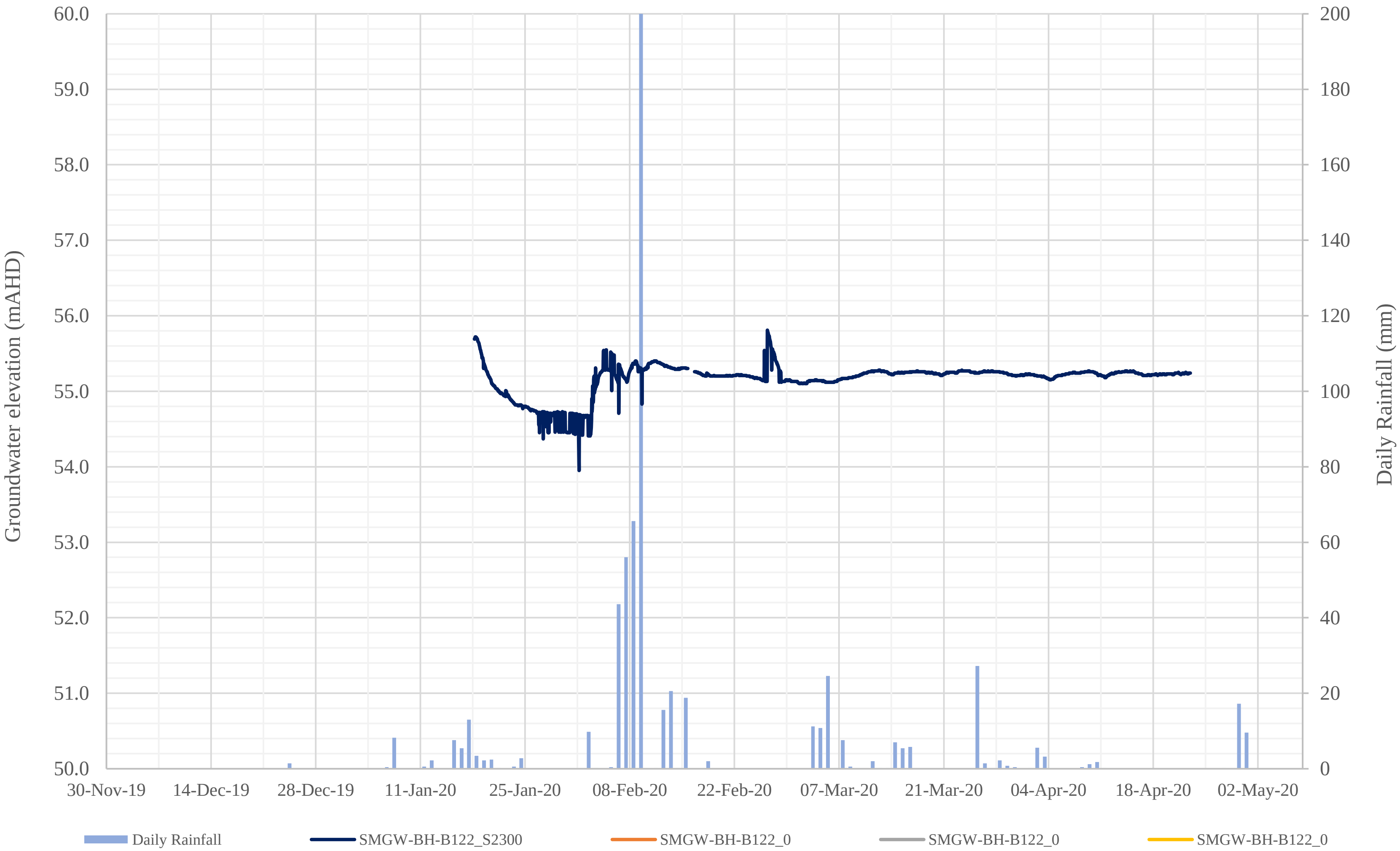
ARUP

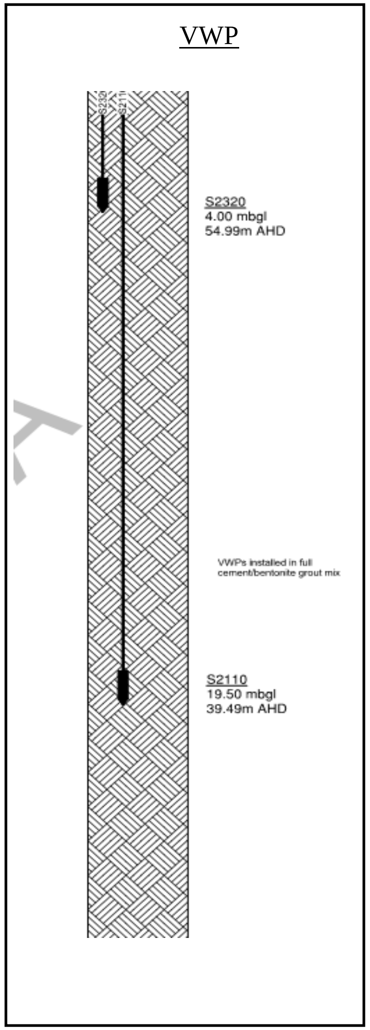
SMGW-BH-B122

Prep	Chk	App
FC / GY	JL	JH

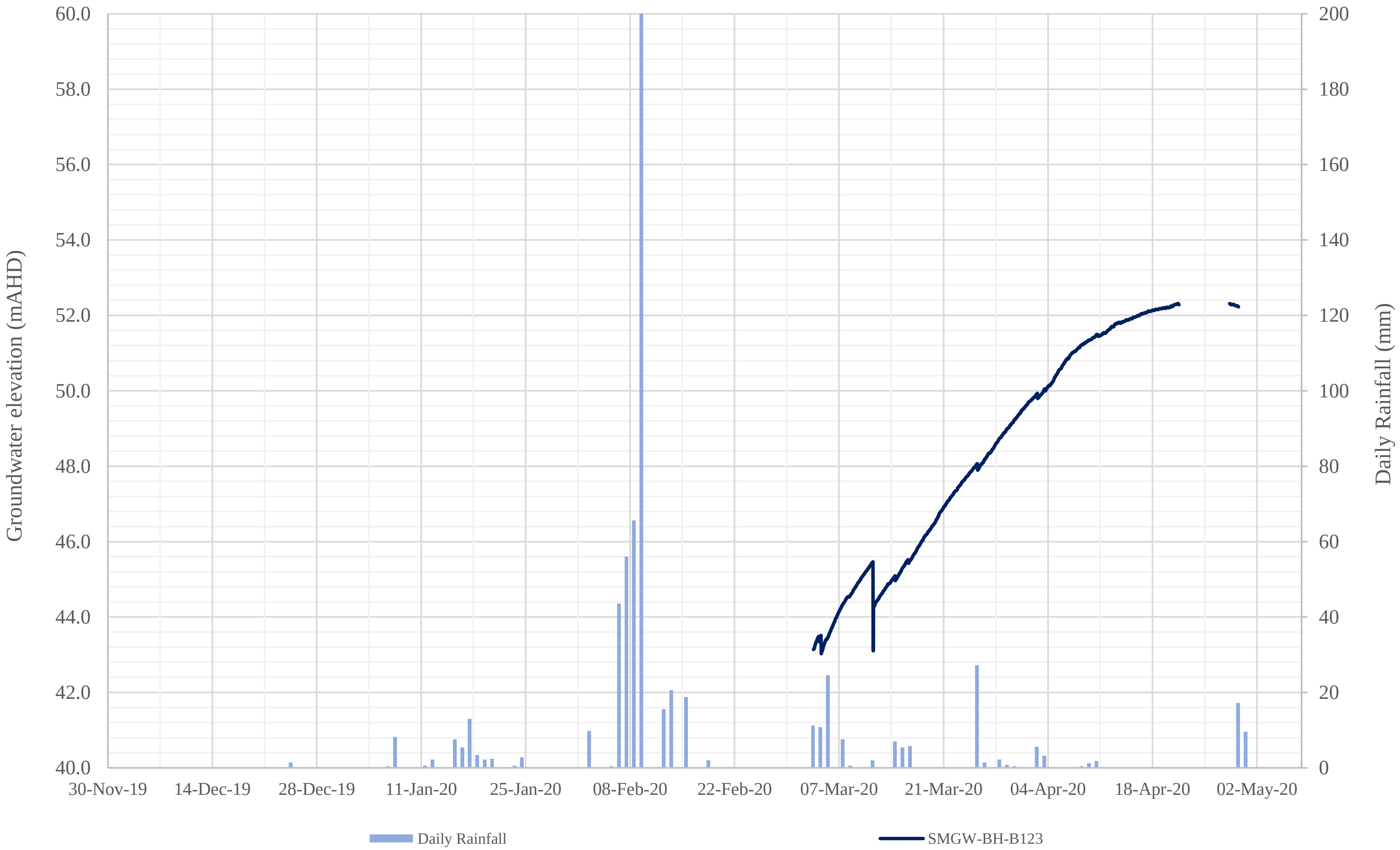
Job Number: 272467

Printed on: 22-May-20

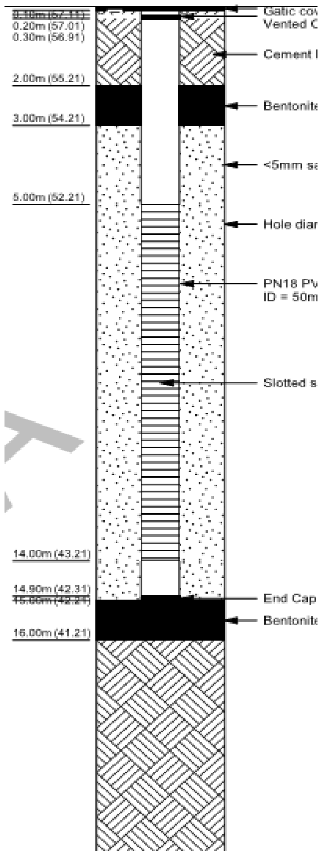




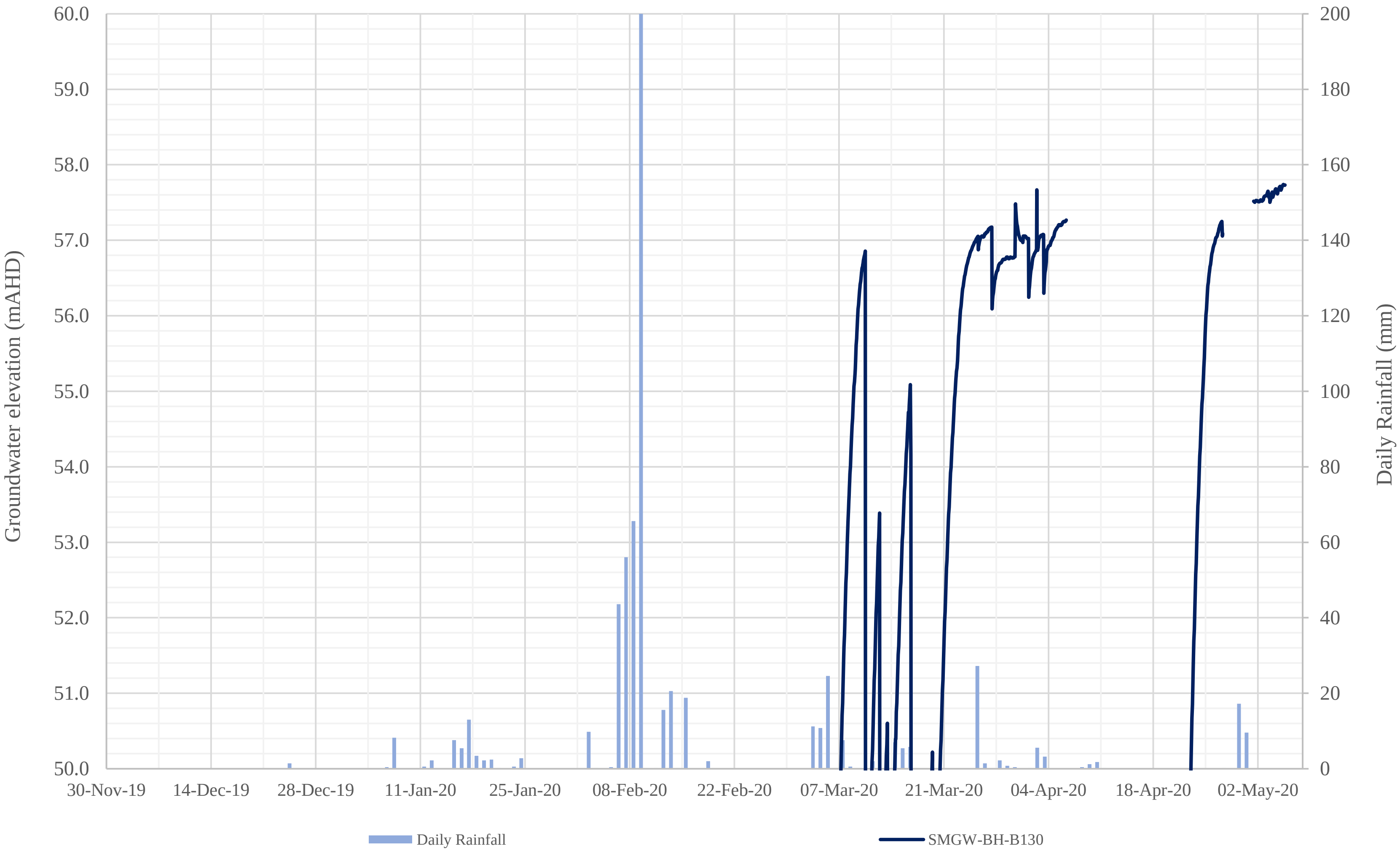
ARUP	SMGW-BH-B123	Prep FC / GY	Chk JL	App JH
		Job Number: 272467 Printed on: 22-May-20		



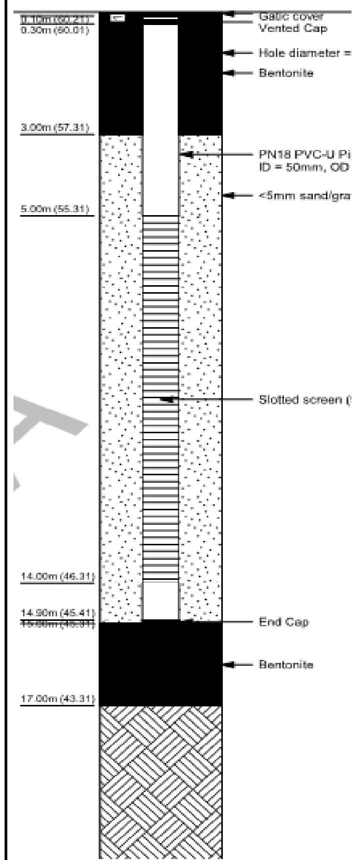
Piezometer



ARUP	# SMGW-BH-B130	Prep FC / GY	Chk JL	App JH
		Job Number: 272467		
		Printed on: 22-May-20		



Piezometer



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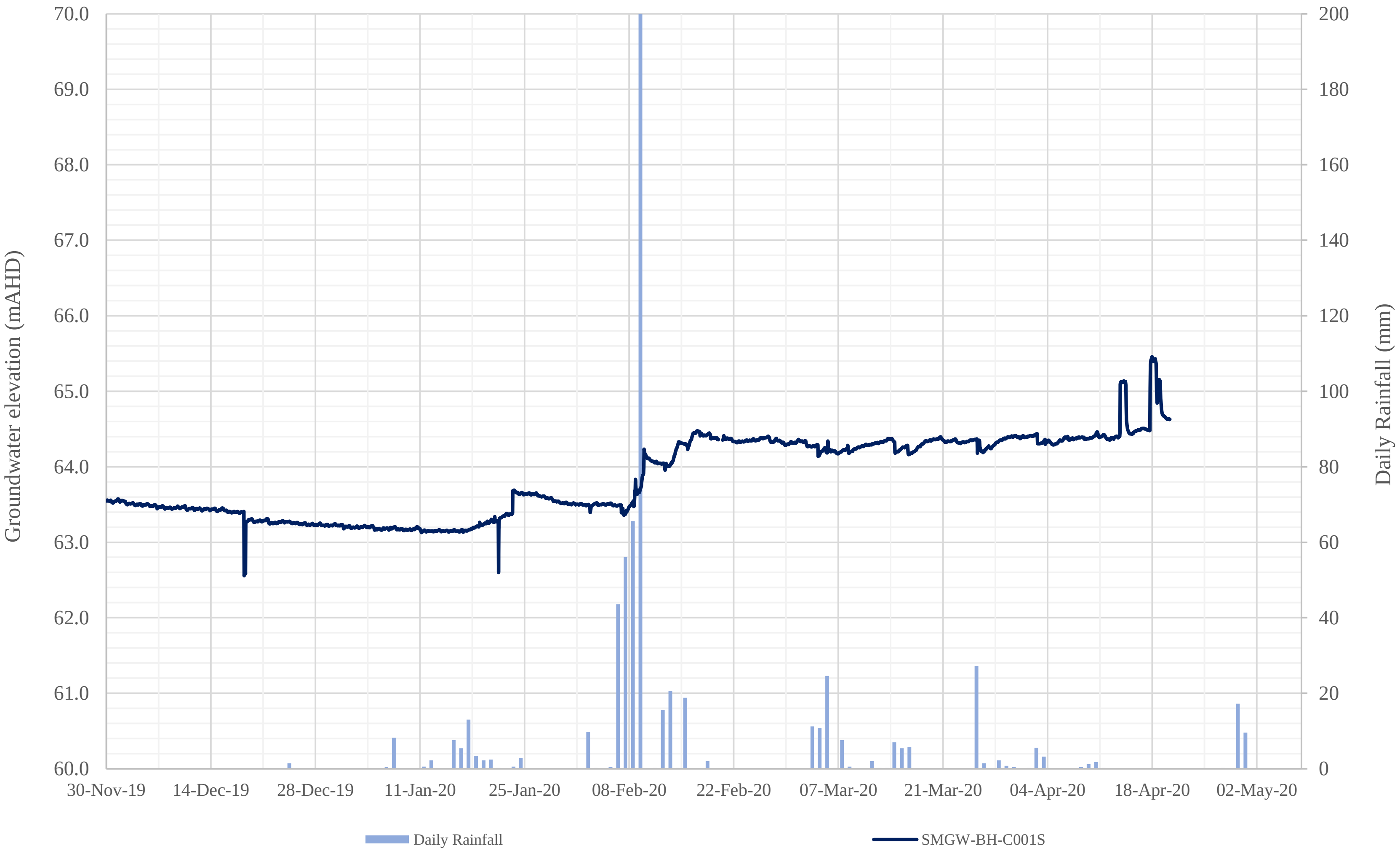
		Job Number: 272467		
		Printed on: 29-May-20		



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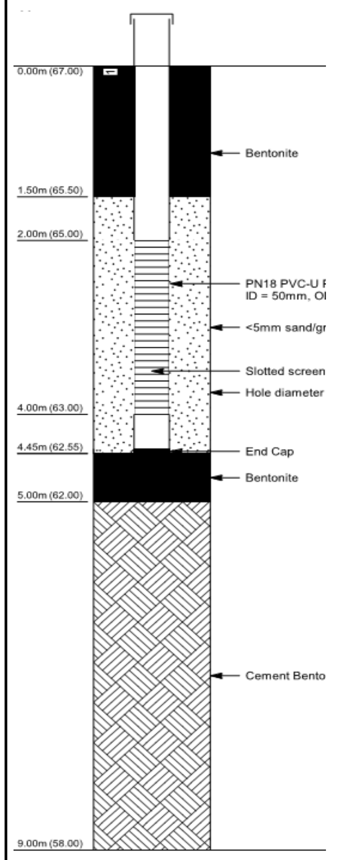

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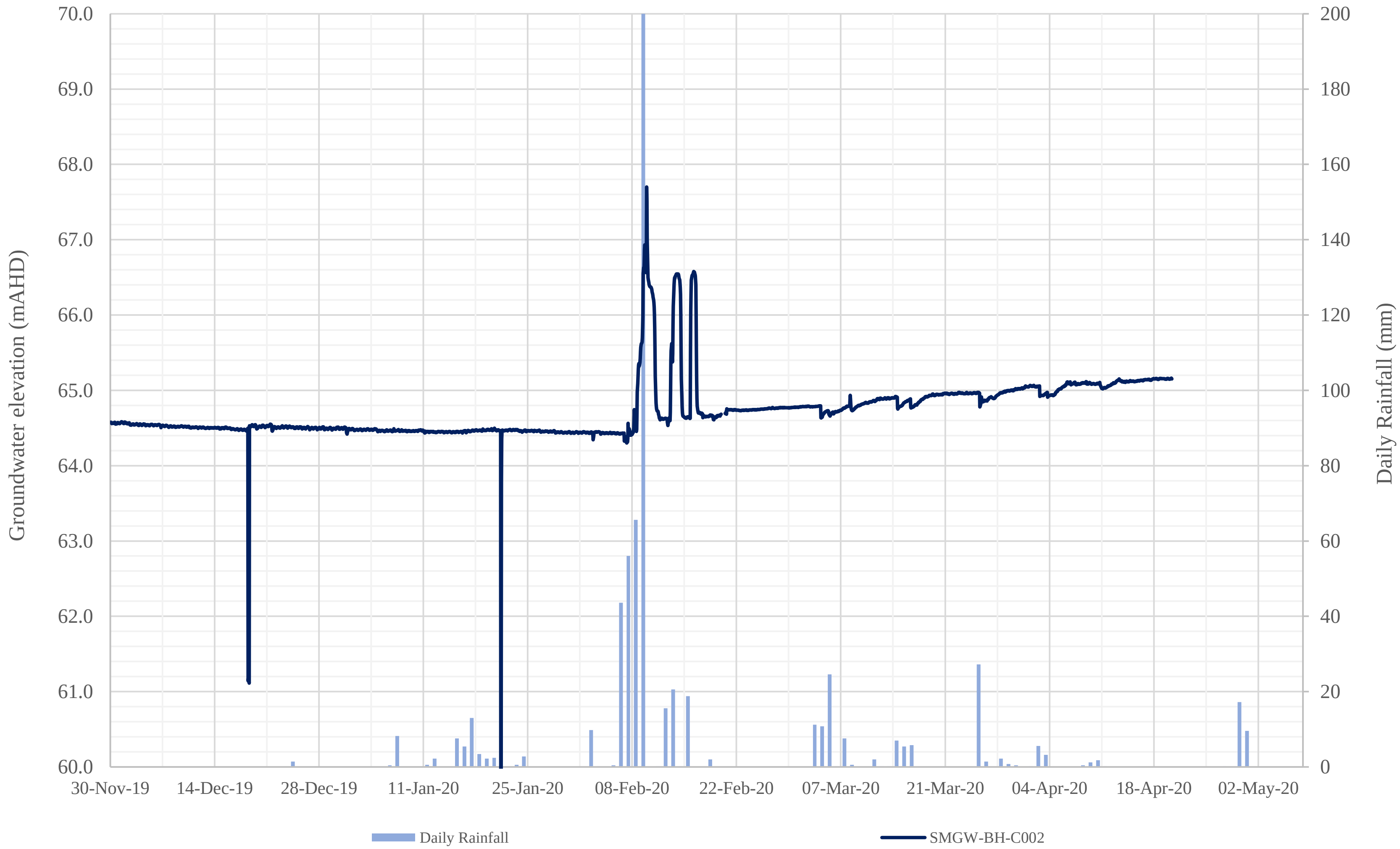

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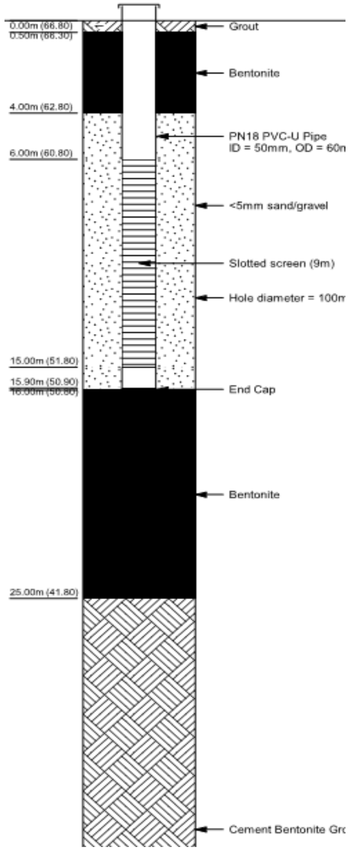

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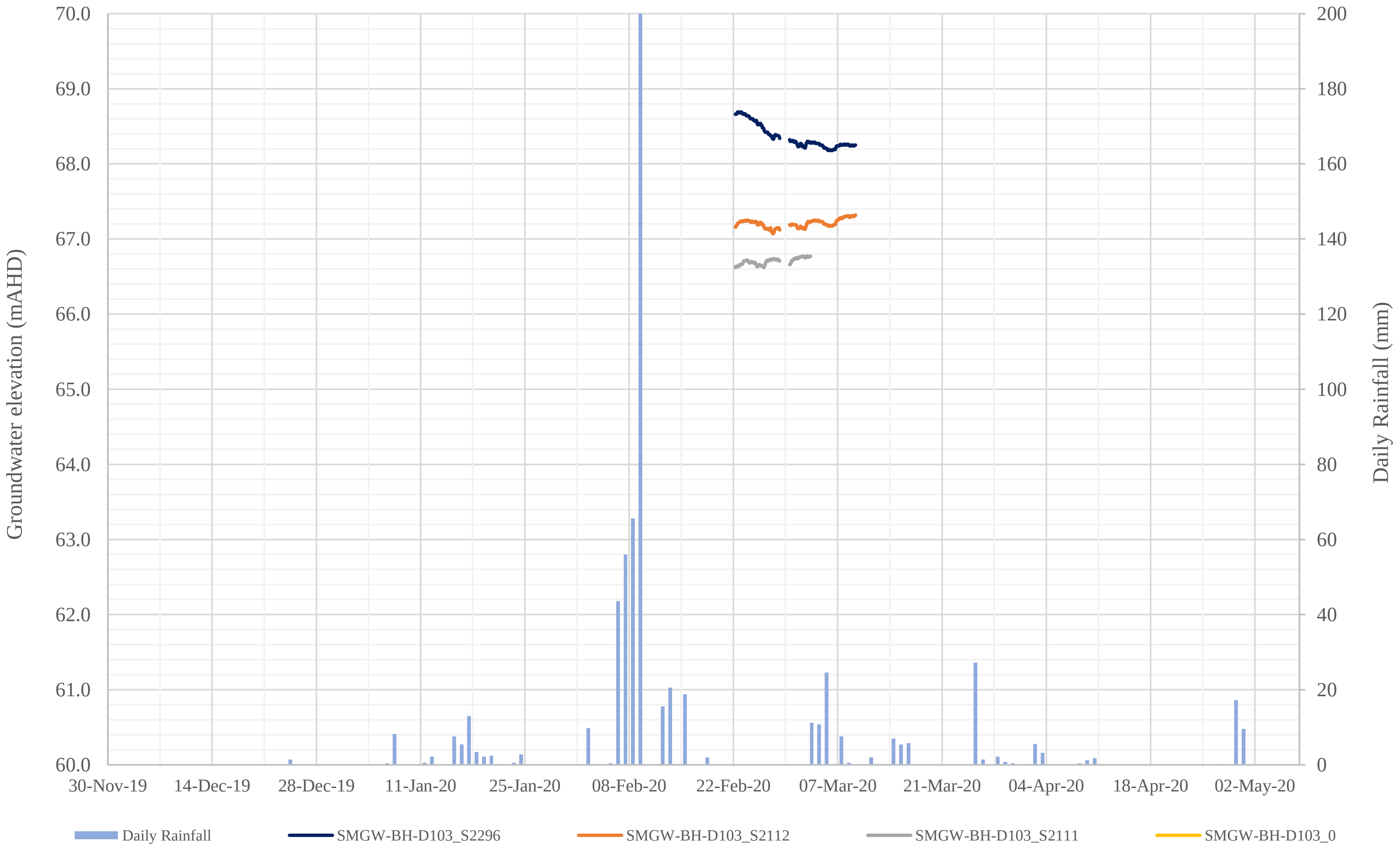
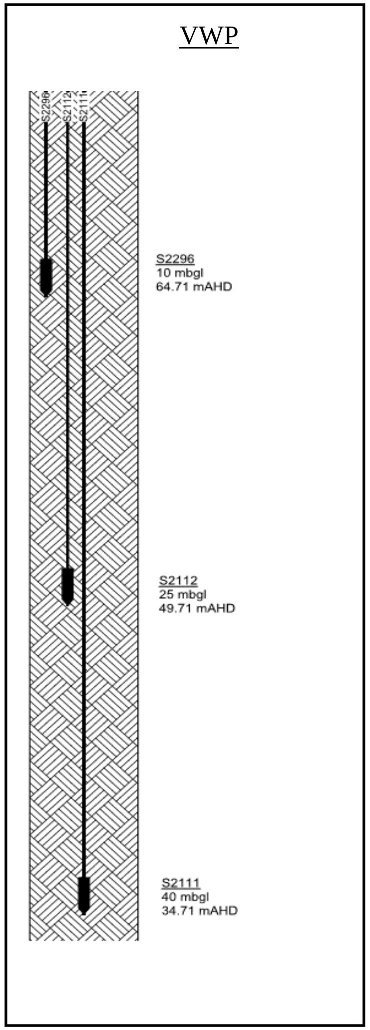
		Job Number: 272467 Printed on: 05-Jun-20		





Appendix D

Groundwater Quality Data

D1 SMGW groundwater quality data

ChemName	Units	LOD	SMW 95% Protection of Species ANZG 2018 (Freshwater)	SMW ADWG 2011 Health	SMW ADWG 2011 Health (x10) (Recreational)	SMW NEPM 2013 Comm/Ind HSL D GW for Vapour Intrusion, Sand 2 - 4m	A011S South Creek 06/09/2019	A011S South Creek 18/12/2019	A011S South Creek 20/01/2020	A011S South Creek 20/04/2020	A002 St Marys 06/09/2019	A002 St Marys 18/12/2019	A002 St Marys 06/03/2020	A002 St Marys 24/01/2020
Quality Parameters														
pH Value	pH unit	0.01						6.62	6.18	6.45		7.38	6.76	7.42
Electrical Conductivity @ 25°C	µS/cm	1						2420	2430	3450		29000	13000	23800
Total Dissolved Solids @ 180°C	mg/L	10						1430	1550	2310		19500	8310	15500
Suspended Soilds (SS)	mg/L	5						195	44	58		37		36
Major Anions														
Hyrdroxide Alkalinity as CaCO3	mg/L	1					<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1					<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1					80	83	74	101	408	547	223	314
Total Alkalinity as CaCO3	mg/L	1					80	83	74	101	408	547	223	314
Sulfate as SO4 - Turbidimetric	mg/L	1		500	5000		11	10	10	8	352	961	587	672
Chloride	mg/L	1					782	754	776	988	8920	9920	4200	7670
Major Cations														
Calcium	mg/L	1					37	34	32	57	628	594	124	570
Magnesium	mg/L	1					69	68	69	109	812	1060	251	913
Sodium	mg/L	1					318	321	333	395	3440	4160	2230	3880
Potassium	mg/L	1					1	1	1	4	40	35	3	34
Total Hardness as CaCO3	mg/L	1						365	364			5850	1304	5180
Dissolved Metals														
Aluminium	mg/L	0.01	0.055				0.02	<0.01	<0.01	<0.01	0.01	<0.01	0.02	<0.01
Arsenic	mg/L	0.001	0.024	0.01	0.1		0.001	<0.001	0.001	0.002	<0.001	0.001	0.002	<0.001
Beryllium	mg/L	0.001						<0.001	<0.001	<0.001		<0.001	0.002	<0.001
Barium	mg/L	0.001						2.15	2.18	3.1		0.122	0.099	0.152
Cadmium	mg/L	0.0001	0.0002	0.002	0.02		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0001
Chromium	mg/L	0.001	0.001	0.05	0.5		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	0.001				0.149	0.102	0.094	0.114	0.02	0.016	0.102	0.037
Copper	mg/L	0.001	0.0014	2	20		<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.001	0.002
Lead	mg/L	0.001	0.0034	0.01	0.1		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Manganese	mg/L	0.001	1.9	0.5	5		6.41	3.34	2.84	7.92	1.53	1.52	1.87	2.85
Molybdenum	mg/L	0.001						<0.001	<0.001	<0.001	-	0.002	0.007	0.001
Nickel	mg/L	0.001	0.011	0.02	0.2		0.007	0.006	0.006	0.006	0.009	0.006	0.029	0.022
Selenium	mg/L	0.01	0.005	0.01	0.1		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001						0.827	0.822	1.41		15.2	1.82	15.2
Vanadium	mg/L	0.01	0.008					<0.01	<0.01	<0.01		<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.008				<0.005	<0.005	<0.005	0.008	0.026	<0.005	0.011	0.055
Boron	mg/L	0.05						<0.05	<0.05	<0.05		0.06	0.05	0.05
Iron	mg/L	0.05					9.37	4.78	4.34	21	0.08	1.25	18.5	<0.05
Dissolved Mercury	mg/L	0.0001						<0.0001	<0.0001	<0.0001		<0.0001		<0.0001
Total Metals														
Aluminium	mg/L	0.01	0.055				-	2.19	0.83	0.95	-	0.56	3.06	0.83
Arsenic	mg/L	0.001	0.024	0.01	0.1		-	<0.001	0.002	0.002	-	0.002	0.003	0.002
Beryllium	mg/L	0.001					-	<0.001	<0.001	<0.001	-	<0.001	0.003	<0.001
Barium	mg/L	0.001					-	2.18	2.16	3.21	-	1.29	0.1	0.449
Cadmium	mg/L	0.0001	0.0002	0.002	0.02		-	<0.0001	<0.0001	<0.0001	-	<0.0001	0.0001	0.0001
Chromium	mg/L	0.001	0.001	0.05	0.5		-	<0.001	0.001	0.001	-	0.002	<0.001	0.002
Cobalt	mg/L	0.001	0.001				-	0.102	0.098	0.122	-	0.015	0.104	0.042
Copper	mg/L	0.001	0.0014	2	20		-	<0.001	<0.001	0.004	-	0.007	0.002	0.014
Lead	mg/L	0.001	0.0034	0.01	0.1		-	<0.001	0.002	0.001	-	0.002	0.002	0.002
Manganese	mg/L	0.001	1.9	0.5	5		-	2.94	2.95	7.84	-	1.38	1.85	2.87
Molybdenum	mg/L	0.001					-	<0.001	<0.001	<0.001	-	0.002	0.009	0.002
Nickel	mg/L	0.001	0.011	0.02	0.2		-	0.006	0.006	0.007	-	0.005	0.03	0.024
Selenium	mg/L	0.01	0.005	0.01	0.1		-	<0.01	<0.01	<0.01	-	<0.01	0.01	<0.01
Strontium	mg/L	0.001					-	0.848	0.85	1.42	-	15.4	1.79	13.7
Vanadium	mg/L	0.01					-	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.008				-	0.019	0.009	0.012	-	0.025	0.013	0.074
Boron	mg/L	0.05					-	<0.05	<0.05	<0.05	-	<0.05	0.05	<0.05
Iron	mg/L	0.05					-	4.02	6	23.1	-	1.9	19.8	2.13
Total Mercury	mg/L	0.0001	0.0006	0.001	0.01		-	<0.0001	<0.0001	<0.0001	-	<0.0001		<0.0001
Fluoride	mg/L	0.1		0.0015	0.015		-	0.2	<0.1	<0.1	-	0.3		0.3
Nutrients														
Ammonia as N	mg/L	0.01	0.9				0.09	0.04	0.05	0.42	2.96	2.14	0.03	0.76
Nitrite as N	mg/L	0.01					<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Nitrate as N	mg/L	0.01	0.5				<0.01	<0.01	<0.01	<0.01	0.03	<0.01	0.01	0.27
Nitrite + Nitrate as N	mg/L	0.01						<0.01	<0.01			<0.01	0.01	
Total Phosphorus as P	mg/L	0.01	0.05				0.68	0.07	0.03	0.32	<0.05	<0.05	0.04	0.13
Reactive Phosphorus as P	mg/L	0.01	0.02				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ionic Balance														
Total Anions	meq/L	0.01					23.9	23.1	23.6	30	267	311	135	237
Total Cations	meq/L	0.01					21.4	21.3	21.8	29.1	249	299	124	273
Ionic Balance	%	0.01					5.53	4.18	3.95	1.62	3.54	1.98	4.34	7.18
Total Petroleum Hydrocarbons														
C6 - C9 Fraction	mg/L	20					<0.02	-	-	-	<0.02	-		-
Total Recoverable Hydrocarbons														
C6 - C10 Fraction	mg/L	0.02					<0.02	-	-	-	<0.02	-		-
C6 - C10 Fraction minus BTEX (F1)	mg/L	0.02		1.3	13	6	<0.02	-	-	-	<0.02	-		-
BTEX														
Benzene	µg/L	1	950	1	10	5000	<1	-	-	-	<1	-		-
Toluene	µg/L	2	180	800	8000	NL	<2	-	-	-	<2	-		-
Ethylbenzene	µg/L	2	80	300	3000	NL	<2	-	-	-	<2	-		-
meta- & para-Xylene	µg/L	2	75				<2	-	-	-	<2	-		-
ortho-Xylene	µg/L	2	350				<2	-	-	-	<2	-		-
Total Xylenes	µg/L	2		600	6000	NL	<2	-	-	-	<2	-		-
Sum of BTEX	µg/L	1					<1	-	-	-	<1	-		-
Naphthalene	µg/L	5	16				<1	-	-	-	<1	-	-	-
TPH(V)/BTEX Surrogates														
1.2-Dichloroethane-D4	%	0.1					-	-	-	-	-	-	-	-
Toluene-D8	%	0.1					-	-	-	-	-	-		-
4-Bromofluorobenzene	%	0.1					-	-	-	-	-	-		-
Bacteria														
Sulphate Reducing Bacteria Population Estimate	CFU/mL	1					-	1400	115000		-	6000	500000	

ChemName	Units	LOD	SMW 95% Protection of Species ANZG 2018 (Freshwater)	SMW ADWG 2011 Health	SMW ADWG 2011 Health (x10) (Recreational)	SMW NEPM 2013 Comm/Ind HSL D GW for Vapour Intrusion, Sand 2 - 4m	A002 St Marys 20/04/2020	A011 South Creek 20/01/2020	A012 Werrington 05/09/2019	A017 OHE 05/09/2019	A017 OHE 18/12/2019	A017 OHE 20/01/2020	A017 OHE 20/04/2020	A019 Gipps Street 06/09/2019
Quality Parameters														
pH Value	pH unit	0.01					**7.08**	**6.18**			**7.39**	**7.29**	**6.8**	
Electrical Conductivity @ 25°C	µS/cm	1					**27200**	**2430**			**23000**	**23800**	**1580**	
Total Dissolved Solids @ 180°C	mg/L	10					**20700**	**1550**			**14700**	**17300**	**875**	
Suspended Soilds (SS)	mg/L	5					**12**	**44**			**133**	**9**	**18**	
Major Anions														
Hyrdroxide Alkalinity as CaCO3	mg/L	1					<1	<1		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1					<1	<1		<1	<1	<1	<1	**2290**
Bicarbonate Alkalinity as CaCO3	mg/L	1					**534**	**74**		**607**	**494**	**565**	**92**	**198**
Total Alkalinity as CaCO3	mg/L	1					**534**	**74**		**607**	**494**	**565**	**92**	**2490**
Sulfate as SO4 - Turbidimetric	mg/L	1		500	5000		**667**	**10**		**532**	**951**	**936**	**95**	<1
Chloride	mg/L	1					**8900**	**776**		**8440**	**7840**	**8510**	**390**	**2030**
Major Cations														
Calcium	mg/L	1					**578**	**32**	**826**	**360**	**366**	**335**	**40**	**478**
Magnesium	mg/L	1					**991**	**69**	**94**	**361**	**665**	**681**	**35**	**1**
Sodium	mg/L	1					**3960**	**333**	**3320**	**3870**	**3900**	**4230**	**210**	**1650**
Potassium	mg/L	1					**35**	**1**	**51**	**27**	**27**	**25**	**3**	**94**
Total Hardness as CaCO3	mg/L	1						**364**			**3650**	**3640**		
Dissolved Metals														
Aluminium	mg/L	0.01	0.055				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.12**	**0.24**
Arsenic	mg/L	0.001	0.024	0.01	0.1		**0.002**	**0.001**	<0.001	**0.002**	**0.004**	**0.005**	**0.001**	<0.001
Beryllium	mg/L	0.001					<0.001	<0.001			<0.001	<0.001	<0.001	
Barium	mg/L	0.001					**0.115**	**2.18**			**0.198**	**0.123**	**0.038**	
Cadmium	mg/L	0.0001	0.0002	0.002	0.02		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	0.05	0.5		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	0.001				**0.026**	**0.094**	<0.001	**0.028**	**0.045**	**0.029**	**0.005**	<0.001
Copper	mg/L	0.001	0.0014	2	20		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.003**	<0.001
Lead	mg/L	0.001	0.0034	0.01	0.1		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	1.9	0.5	5		**1.76**	**2.84**	<0.001	**0.596**	**1.09**	**0.803**	**0.109**	**0.002**
Molybdenum	mg/L	0.001					**0.001**	<0.001			**0.002**	**0.002**	**0.003**	
Nickel	mg/L	0.001	0.011	0.02	0.2		**0.008**	**0.006**	**0.001**	**0.026**	**0.024**	**0.014**	**0.007**	**0.007**
Selenium	mg/L	0.01	0.005	0.01	0.1		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.01**
Strontium	mg/L	0.001					**16.8**	**0.822**			**12.4**	**10.3**	**0.339**	
Vanadium	mg/L	0.01	0.008				<0.01	<0.01			<0.01	<0.01	<0.01	
Zinc	mg/L	0.005	0.008				**0.006**	<0.005	<0.005	**0.011**	<0.005	<0.005	**0.008**	<0.005
Boron	mg/L	0.05					<0.05	<0.05			**0.06**	**0.07**	<0.05	
Iron	mg/L	0.05					**1.53**	**4.34**	<0.05	**0.29**	**2.15**	**2.29**	**0.63**	<0.05
Dissolved Mercury	mg/L	0.0001					<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	
Total Metals														
Aluminium	mg/L	0.01	0.055				**0.15**	**0.83**	-	-	**0.7**	**0.08**	**0.51**	-
Arsenic	mg/L	0.001	0.024	0.01	0.1		**0.002**	**0.002**	-	-	**0.004**	**0.003**	**0.001**	-
Beryllium	mg/L	0.001					<0.001	<0.001	-	-	<0.001	<0.001	<0.001	-
Barium	mg/L	0.001					**0.212**	**2.16**	-	-	**0.202**	**0.115**	**0.05**	-
Cadmium	mg/L	0.0001	0.0002	0.002	0.02		<0.0001	<0.0001	-	-	<0.0001	<0.0001	<0.0001	-
Chromium	mg/L	0.001	0.001	0.05	0.5		<0.001	**0.001**	-	-	**0.001**	<0.001	**0.001**	-
Cobalt	mg/L	0.001	0.001				**0.03**	**0.098**	-	-	**0.046**	**0.027**	**0.006**	-
Copper	mg/L	0.001	0.0014	2	20		**0.005**	<0.001	-	-	**0.005**	<0.001	**0.006**	-
Lead	mg/L	0.001	0.0034	0.01	0.1		<0.001	**0.002**	-	-	<0.001	**0.002**	<0.001	-
Manganese	mg/L	0.001	1.9	0.5	5		**1.8**	**2.95**	-	-	**1.08**	**0.787**	**0.124**	-
Molybdenum	mg/L	0.001					**0.002**	<0.001	-	-	**0.003**	**0.002**	**0.003**	-
Nickel	mg/L	0.001	0.011	0.02	0.2		**0.01**	**0.006**	-	-	**0.025**	**0.015**	**0.008**	-
Selenium	mg/L	0.01	0.005	0.01	0.1		<0.01	<0.01	-	-	<0.01	<0.01	<0.01	-
Strontium	mg/L	0.001					**16.8**	**0.85**	-	-	**11.3**	**10.5**	**0.362**	-
Vanadium	mg/L	0.01					<0.01	<0.01	-	-	<0.01	<0.01	<0.01	-
Zinc	mg/L	0.005	0.008				**0.012**	**0.009**	-	-	**0.007**	<0.005	**0.015**	-
Boron	mg/L	0.05					**0.06**	<0.05	-	-	<0.05	**0.06**	<0.05	-
Iron	mg/L	0.05					**1.78**	**6**	-	-	**2.49**	**1.93**	**0.96**	-
Total Mercury	mg/L	0.0001	0.0006	0.001	0.01		<0.0001	<0.0001	-	-	<0.0001	<0.0001	<0.0001	-
Fluoride	mg/L	0.1		0.0015	0.015		**0.3**	<0.1	-	-	**0.2**	**0.4**	**0.1**	-
Nutrients														
Ammonia as N	mg/L	0.01	0.9				**2.12**	**0.05**	**12.5**	**2.96**	**2.1**	**2.2**	**0.23**	<0.01
Nitrite as N	mg/L	0.01					<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	**0.02**
Nitrate as N	mg/L	0.01	0.5				<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	**0.02**
Nitrite + Nitrate as N	mg/L	0.01									<0.01	<0.01		
Total Phosphorus as P	mg/L	0.01	0.05				<0.02[#1]	**0.03**	**0.08**	<0.05	<0.05	<0.05	**0.18**	**0.08**
Reactive Phosphorus as P	mg/L	0.01	0.02				<0.01	<0.01		<0.01	<0.01	<0.01	**0.07**	<0.05
Ionic Balance														
Total Anions	meq/L	0.01					276	23.6	-	261	251	271	14.8	107
Total Cations	meq/L	0.01					284	21.8	-	239	243	257	14.1	98.1
Ionic Balance	%	0.01					1.42	3.95	-	4.47	1.52	2.54	2.52	4.34
Total Petroleum Hydrocarbons														
C6 - C9 Fraction	mg/L	20					-	-	<0.02	**0.1**	-	-	-	<0.02
Total Recoverable Hydrocarbons														
C6 - C10 Fraction	mg/L	0.02					-	-	<0.02	**0.09**	-	-	-	<0.02
C6 - C10 Fraction minus BTEX (F1)	mg/L	0.02		1.3	13	6	-	-	<0.02	**0.03**	-	-	-	<0.02
BTEX														
Benzene	µg/L	1	950	1	10	5000	-	-	<1	<1	-	-	-	<1
Toluene	µg/L	2	180	800	8000	NL	-	-	<2	51-56	-	-	-	<2
Ethylbenzene	µg/L	2	80	300	3000	NL	-	-	<2	<2	-	-	-	<2
meta- & para-Xylene	µg/L	2	75				-	-	<2	<2	-	-	-	<2
ortho-Xylene	µg/L	2	350				-	-	<2	<2	-	-	-	<2
Total Xylenes	µg/L	2		600	6000	NL	-	-	<2	<2	-	-	-	<2
Sum of BTEX	µg/L	1					-	-	<1	**56**	-	-	-	<1
Naphthalene	µg/L	5	16				-	-	<1	<1	-	-	-	<1
TPH(V)/BTEX Surrogates														
1.2-Dichloroethane-D4	%	0.1					-	-	-	-	-	-	-	-
Toluene-D8	%	0.1					-	-	-	-	-	-	-	-
4-Bromofluorobenzene	%	0.1					-	-	-	-	-	-	-	-
Bacteria														
Sulphate Reducing Bacteria Population Estimate	CFU/mL	1							-	-	**6000**	-		-

ChemName	Units	LOD	SMW 95% Protection of Species ANZG 2018 (Freshwater)	SMW ADWG 2011 Health	SMW ADWG 2011 Health (x10) (Recreational)	SMW NEPM 2013 Comm/Ind HSL D GW for Vapour Intrusion, Sand 2 - 4m	A102 St Marys 06/03/2020
Quality Parameters							
pH Value	pH unit	0.01					**6.76**
Electrical Conductivity @ 25°C	µS/cm	1					**13000**
Total Dissolved Solids @ 180°C	mg/L	10					**8310**
Suspended Soilds (SS)	mg/L	5					
Major Anions							
Hyrdroxide Alkalinity as CaCO3	mg/L	1					<1
Carbonate Alkalinity as CaCO3	mg/L	1					<1
Bicarbonate Alkalinity as CaCO3	mg/L	1					**223**
Total Alkalinity as CaCO3	mg/L	1					**223**
Sulfate as SO4 - Turbidimetric	mg/L	1		500	5000		**587**
Chloride	mg/L	1					**4200**
Major Cations							
Calcium	mg/L	1					**124**
Magnesium	mg/L	1					**251**
Sodium	mg/L	1					**2230**
Potassium	mg/L	1					**3**
Total Hardness as CaCO3	mg/L	1					**1340**
Dissolved Metals							
Aluminium	mg/L	0.01	0.055				**0.02**
Arsenic	mg/L	0.001	0.024	0.01	0.1		**0.002**
Beryllium	mg/L	0.001					**0.002**
Barium	mg/L	0.001					**0.099**
Cadmium	mg/L	0.0001	0.0002	0.002	0.02		<0.0001
Chromium	mg/L	0.001	0.001	0.05	0.5		<0.001
Cobalt	mg/L	0.001	0.001				**0.102**
Copper	mg/L	0.001	0.0014	2	20		<0.001
Lead	mg/L	0.001	0.0034	0.01	0.1		<0.001
Manganese	mg/L	0.001	1.9	0.5	5		**1.87**
Molybdenum	mg/L	0.001					**0.007**
Nickel	mg/L	0.001	0.011	0.02	0.2		**0.029**
Selenium	mg/L	0.01	0.005	0.01	0.1		<0.01
Strontium	mg/L	0.001					**1.82**
Vanadium	mg/L	0.01	0.008				<0.01
Zinc	mg/L	0.005	0.008				**0.011**
Boron	mg/L	0.05					<0.05
Iron	mg/L	0.05					**18.5**
Dissolved Mercury	mg/L	0.0001					<0.0001
Total Metals							
Aluminium	mg/L	0.01	0.055				**3.06**
Arsenic	mg/L	0.001	0.024	0.01	0.1		**0.003**
Beryllium	mg/L	0.001					**0.003**
Barium	mg/L	0.001					**0.1**
Cadmium	mg/L	0.0001	0.0002	0.002	0.02		<0.0001
Chromium	mg/L	0.001	0.001	0.05	0.5		**0.003**
Cobalt	mg/L	0.001	0.001				**0.104**
Copper	mg/L	0.001	0.0014	2	20		**0.002**
Lead	mg/L	0.001	0.0034	0.01	0.1		**0.002**
Manganese	mg/L	0.001	1.9	0.5	5		**1.85**
Molybdenum	mg/L	0.001					**0.009**
Nickel	mg/L	0.001	0.011	0.02	0.2		**0.03**
Selenium	mg/L	0.01	0.005	0.01	0.1		<0.01
Strontium	mg/L	0.001					**1.79**
Vanadium	mg/L	0.01					<0.01
Zinc	mg/L	0.005	0.008				**0.013**
Boron	mg/L	0.05					<0.05
Iron	mg/L	0.05					**19.8**
Total Mercury	mg/L	0.0001	0.0006	0.001	0.01		<0.0001
Fluoride	mg/L	0.1		0.0015	0.015		**0.3**
Nutrients							
Ammonia as N	mg/L	0.01	0.9				**0.03**
Nitrite as N	mg/L	0.01					<0.01
Nitrate as N	mg/L	0.01	0.5				**0.01**
Nitrite + Nitrate as N	mg/L	0.01					
Total Phosphorus as P	mg/L	0.01	0.05				**0.04**
Reactive Phosphorus as P	mg/L	0.01	0.02				<0.01
Ionic Balance							
Total Anions	meq/L	0.01					135
Total Cations	meq/L	0.01					124
Ionic Balance	%	0.01					4.34
Total Petroleum Hydrocarbons							
C6 - C9 Fraction	mg/L	20					-
Total Recoverable Hydrocarbons							
C6 - C10 Fraction	mg/L	0.02					-
C6 - C10 Fraction minus BTEX (F1)	mg/L	0.02		1.3	13	6	-
BTEX							
Benzene	µg/L	1	950	1	10	5000	-
Toluene	µg/L	2	180	800	8000	NL	-
Ethylbenzene	µg/L	2	80	300	3000	NL	-
meta- & para-Xylene	µg/L	2	75				-
ortho-Xylene	µg/L	2	350				-
Total Xylenes	µg/L	2		600	6000	NL	-
Sum of BTEX	µg/L	1					-
Naphthalene	µg/L	5	16				
TPH(V)/BTEX Surrogates							
1.2-Dichloroethane-D4	%	0.1					-
Toluene-D8	%	0.1					-
4-Bromofluorobenzene	%	0.1					-
Bacteria							
Sulphate Reducing Bacteria Population Estimate	CFU/mL	1					

D2 Western Sydney International groundwater quality and contamination data

					Field Parameters							Nutrients									Metals								BTEXN								TRH - NEPM			
Location Code	Date	Field ID	Sample Type	Matrix Type	PURGE VOLUME	pH (Field)	Electrical conductivity (field)	Purge SWL (mbTOC) (field)	Dissolved Oxygen (Field) (filtered)	Redox (Field)	Temperature (Field)	Ammonia as N	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised) (as N)	Nitrogen (Total)	Phosphate total (P)	Kjeldahl Nitrogen Total	Nitrogen (Organic)	Phosphorus (Total)	Arsenic (filtered)	Cadmium (filtered)	Chromium (III+VI) (filtered)	Copper (filtered)	Lead (filtered)	Mercury (filtered)	Nickel (filtered)	Zinc (filtered)	Benzene	Toluene	Ethylbenzene	Xylene (o)	Xylene (m & p)	Xylene Total	Naphthalene (BTEXN)	BTEX (Sum of Total) - Lab Calc	F1 (C6-C10 minus BTEX)	C6-C10 Fraction	F2 (>C10-C16 minus Naphthalene)	>C10-C16 Fraction
					L	pH Units	µS/cm	mbTOC	mg/L	mV	°C	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
WSA GW01	17/04/2018	WSA GW01	Normal	water	3.5	6.71	5,036	7.99	0.81	-34.1	19.9																													
WSA GW01	5/07/2018	WSA_GW01	Normal	water								<0.01	0.13	<0.02	0.13	<0.2	60	<0.2			<0.001	<0.0002	<0.001	0.024	0.002	<0.0001	0.005	0.043							<10		<20	<20	<50	<50
WSA GW01	5/07/2018	WSA GW01	Normal	water	3.5	6.69	6,288	8.264	0.43	-41.7	19.5																													
WSA GW01	5/09/2018	FD01_180905	Field_D	water								<0.01	0.23	<0.02	0.24	<0.2	60	<0.2			<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.002	0.009	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW01	5/09/2018	WSA GW01	Normal	water	3.2	6.79	5,439	8.321	2.23	54.5	16.9																													
WSA GW01	5/09/2018	WSA GW01	Normal	water								<0.01	0.34	<0.02	0.34	0.34	120	<0.2			<0.001	<0.0002	<0.001	0.026	0.002	<0.0001	0.007	0.035	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW01	13/12/2018	WSA GW01	Normal	water								0.04	0.31	<0.02	0.31	0.3	140	<0.2			<0.001	<0.0002	<0.001	0.028	0.002	<0.0001	0.006	0.061	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW01	5/04/2019	WSA GW01	Normal	water								0.03	0.07	<0.02	0.07	0.4	40	0.3	0.3		<0.001	<0.0002	<0.001	0.049	0.003	<0.0001	0.009	0.087	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW04	18/04/2018	WSA GW04	Normal	water	2	6.34	15,224	15.327	0.61	-127.2	20																													
WSA GW04	4/07/2018	FD02_180704	Field_D	water								5.5	<0.02	<0.02	<0.05	5.3	510	5.3			0.003	<0.0002	<0.001	0.020	0.002	<0.0001	0.10	0.070												
WSA GW04	4/07/2018	WSA_GW04	Normal	water								5.5	<0.02	<0.02	<0.05	5.4	470	5.4			0.003	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.093	0.026	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW04	4/07/2018	WSA GW04	Normal	water	2.2	6.43	14,372	15.16	0.62	-127	18.1																													
WSA GW04	6/09/2018	WSA GW04	Normal	water	2.8	6.93	15,029	16.135	6.4	-65.5	18.6																													
WSA GW04	6/09/2018	WSA GW04	Normal	water								5	<0.02	<0.02	<0.05	4.6	90	4.6			0.003	<0.0002	<0.001	0.005	<0.001	<0.0001	0.010	0.038	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW04	12/12/2018	WSA GW04	Normal	water								5.8	<0.02	<0.02	<0.05	7.2	890	7.2			0.004	<0.0002	<0.001	0.008	0.001	<0.0001	0.007	0.028	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW04	4/04/2019	WSA GW04	Normal	water								5	<0.02	<0.02	<0.05	5.5	100	5.5	<0.2		0.004	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.016	0.059	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW05	18/04/2018	WSA GW05	Normal	water	2	6.63	16,716	8.13	0.34	-52.1	19																													
WSA GW05	4/07/2018	WSA_GW05	Normal	water								0.35	0.03	<0.02	<0.05	0.5	190	0.5			0.002	<0.0002	<0.001	0.037	0.003	<0.0001	0.014	0.078							<10		<20	<20	<50	<50
WSA GW05	4/07/2018	WSA GW05	Normal	water	1.7	6.62	16,814	8.142	0.43	-69.5	18.3																													
WSA GW05	6/09/2018	WSA GW05	Normal	water	2.2	6.67	17,977	8.341	1.07	-80.2	18.4																													
WSA GW05	6/09/2018	WSA GW05	Normal	water								0.25	0.08	<0.02	0.09	0.5	<50	0.4			0.002	<0.0002	<0.001	0.024	0.002	<0.0001	0.015	0.062	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW05	13/12/2018	WSA GW05	Normal	water								0.05	0.17	<0.02	0.17	0.2	360	<0.2			<0.001	<0.0002	<0.001	0.019	0.002	<0.0001	0.013	0.035	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW05	4/04/2019	FD02	Interlab_D	water									0.12	<0.01	0.12	0.6		0.5		0.09	<0.001	<0.0001	<0.001	0.002	<0.001	<0.0001	0.011	0.025	<1	<2	<2	<2	<2	<2		<1	<20	<20	<100	<100
WSA GW05	4/04/2019	WSA GW05	Normal	water								0.18	0.03	<0.02	<0.05	0.5	120	0.5	0.3		<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.009	0.018	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW06	18/04/2018	WSA GW06	Normal	water	3.7	6.78	17,933	12.17	0.39	-153.7	18.8																													
WSA GW06	4/07/2018	WSA_GW06	Normal	water								7.1	<0.02	<0.02	<0.05	7.3	1,000	7.3			<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.010	0.027	3	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW06	4/07/2018	WSA GW06	Normal	water	2	6.86	17,220	11.53	0.42	-103.8	17																													
WSA GW06	6/09/2018	WSA GW06	Normal	water	3	6.91	19,013	12.242	0.66	-10.1	18.6																													
WSA GW06	6/09/2018	WSA GW06	Normal	water								6.4	<0.02	<0.02	<0.05	5.8	70	5.8			<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	0.010	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW06	6/09/2018	WSA GW06-M	Normal	water																																				
WSA GW06	12/12/2018	WSA GW06	Normal	water								7.7	<0.02	<0.02	<0.05	7.7	520	7.7			<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.010	0.076	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW06	4/04/2019	WSA GW06	Normal	water								7.8	<0.02	<0.02	<0.05	8.6	150	8.6	0.8		<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.004	0.038	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW07	18/04/2018	WSA GW07	Normal	water	3.4	6.59	18,099	7.38	0.56	-70.3	18.5																													
WSA GW07	4/07/2018	WSA_GW07	Normal	water								0.05	0.18	<0.02	0.18	<0.2	70	<0.2			<0.001	<0.0002	<0.001	0.024	0.002	<0.0001	0.012	0.081	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW07	4/07/2018	WSA GW07	Normal	water	1.9	6.59	17,677	7.541	0.46	-51.2	16.5																													
WSA GW07	6/09/2018	WSA GW07	Normal	water	2	6.65	19,869	7.57	1.41	28.1	18.9																													
WSA GW07	6/09/2018	WSA GW07	Normal	water								0.08	<0.02	<0.02	<0.05	0.3	80	0.3			<0.001	<0.0002	<0.001	0.027	0.002	<0.0001	0.006	0.29	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW07	13/12/2018	WSA GW07	Normal	water								0.16	0.03	<0.02	<0.05	<0.2	340	<0.2			<0.001	<0.0002	<0.001	0.016	<0.001	<0.0001	0.005	0.033	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW07	4/04/2019	WSA GW07	Normal	water								0.06	2.4	0.05	2.5	2.9	160	0.4	0.4		<0.001	0.0002	<0.001	0.031	0.002	<0.0001	0.010	0.13	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW08	18/04/2018	WSA GW08	Normal	water	7.5	6.84	20,497	3.957	0.42	-337.1	19.5																													
WSA GW08	4/07/2018	WSA_GW08	Normal	water								2.4	<0.02	<0.02	<0.05	2.3	70	2.3			<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.004	<0.005	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW08	4/07/2018	WSA GW08	Normal	water	4	6.86	17,981	3.965	0.5	-331.1	19.5																													
WSA GW08	6/09/2018	WSA GW08	Normal	water	2.6	6.91	18,230	4.191	0.42	-281.3	18																													
WSA GW08	6/09/2018	WSA GW08	Normal	water								2.5	<1	<1	<2.5	1.5	50	1.5			<0.001	<0.0002	<0.001	0.004	<0.001	<0.0001	0.005	0.011							<10		<20	<20	<50	<50
WSA GW08	6/09/2018	WSA GW08-B	Normal	water																																				
WSA GW08	13/12/2018	WSA GW08	Normal	water								2.2	<0.02	<0.02	<0.05	2.6	320	2.6			<0.001	<0.0002	<0.001	<0.001	<0.001	0.0003	0.005	<0.005	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW08	4/04/2019	FD01	Field_D	water								2.2	<0.02	<0.02	<0.05	2.5	50	2.5	0.2		<0.001	<0.0002	<0.001	<0.001	<0.001	0.0001	0.002	0.008	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW08	4/04/2019	WSA GW08	Normal	water								2.3	<0.02	<0.02	<0.05	2.5	40	2.5	<0.2		<0.001	<0.0002	<0.001	<0.001	<0.001	0.0002	<0.001	0.005	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW14	19/04/2018	WSA GW14	Normal	water	1.1	6.61	9,494		1.66	-9.2	20.6																													
WSA GW14	5/07/2018	WSA_GW14	Normal	water								<0.01	0.03	<0.02	<0.05	<0.2	360	<0.2			<0.001	<0.0002	<0.001	0.013	<0.001	<0.0001	0.013	0.053							<10		<20	<20	<50	<50
WSA GW14	5/07/2018	WSA GW14	Normal	water	0.1	6.86	8,756		1.04	-67.4	18.8																													
WSA GW14	6/09/2018	WSA GW14	Normal	water								0.02	<0.02	<0.02	<0.05	1.5	<50	1.5			<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.004	0.007							<10		<20	<20	<50	<50
WSA GW14	12/12/2018	WSA GW14	Normal	water								0.03	<0.02	<0.02	<0.05	7.9	110	7.9																						
WSA GW14	3/04/2019	WSA GW14	Normal	water																																				
WSA GW16	17/04/2018	WSA GW16	Normal	water	1.2	6.69	18,652	9.53	0.63	41.2	20.1																													
WSA GW16	5/07/2018	WSA_GW16	Normal	water								1.2	1.9	0.29	2.2	3.7	180	1.5			0.002	<0.0002	<0.001	0.002	<0.001	<0.0001	0.030	0.029							<10		<20	<20	<50	<50
WSA GW16	5/07/2018	WSA GW16	Normal	water	3.1	6.7	23,086	9.91	0.39	-106.5	18																													
WSA GW16	7/09/2018	WSA GW16	Normal	water								1.9	0.97	<0.02	0.97	3.1	270	2.1			0.002	<0.0002	<0.001	0.002	<0.001	<0.0001	0.025	0.038							<10		<20	<20	<50	<50
WSA GW16	12/12/2018	WSA GW16	Normal	water								1.9	0.59	<0.02	0.6	4.4	940	3.8			<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.006	<0.005	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW16	3/04/2019	WSA GW16	Normal	water								1.8	0.24	0.07	0.31	3.5	830	3.2	1.4		<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.018	0.014	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW17	19/04/2018	WSA GW17	Normal	water	4	6.77	20,062	6.595	1.44	-146.9	20.3																													
WSA GW17	3/07/2018	WSA_GW17	Normal	water								3.5	0.02	<0.02	<0.05	3.5	200	3.5			0.003	<0.0002	<0.001	0.003	<0.001	<0.0001	0.081	0.046	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW17	3/07/2018	WSA GW17	Normal	water	3.7	6.71	17,998	6.527	0.2	-156.5	18.1																													
WSA GW17	5/09/2018	WSA GW17	Normal	water	2.7	6.75	18,754	6.118	0.26	55.6	17.6																													
WSA GW17	5/09/2018	WSA GW17	Normal	water								2.8	<0.02	<0.02	<0.05	3.1	<50	3.1			0.001	<0.0002	<0.001	0.024	0.002	<0.0001	0.020	0.032	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW17	13/12/2018	WSA GW17	Normal	water								3.8	<0.02	<0.02	<0.05	5.1	130	5.1			0.003	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.006	0.012	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW17	3/04/2019	WSA GW17	Normal	water								3.6	0.03	0.26	0.28	4	50	3.7	<0.2		0.002	<0.0002	<0.001	0.009	<0.001	<0.0001	0.009	0.065	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW18	19/04/2018	WSA GW18	Normal	water	5	6.66	21,807	5.781	1.42	-157	19.9																													
WSA GW18	3/07/2018	WSA_GW18	Normal	water								4	<0.02	<0.02	<0.05	4.3	350	4.3			0.015	<0.0002	<0.001	0.005	<0.001	<0.0001	0.007	0.036	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50

					Field Parameters							Nutrients									Metals								BTEXN								TRH - NEPM			
					PURGE VOLUME	pH (Field)	Electrical conductivity (field)	Purge SWL (mbTOC) (field)	Dissolved Oxygen (Field) (filtered)	Redox (Field)	Temperature (Field)	Ammonia as N	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised) (as N)	Nitrogen (Total)	Phosphate total (P)	Kjeldahl Nitrogen Total	Nitrogen (Organic)	Phosphorus (Total)	Arsenic (filtered)	Cadmium (filtered)	Chromium (III+VI) (filtered)	Copper (filtered)	Lead (filtered)	Mercury (filtered)	Nickel (filtered)	Zinc (filtered)	Benzene	Toluene	Ethylbenzene	Xylene (o)	Xylene (m & p)	Xylene Total	Naphthalene (BTEXN)	BTEX (Sum of Total) - Lab Calc	F1 (C6-C10 minus BTEX)	C6-C10 Fraction	F2 (>C10-C16 minus Naphthalene)	>C10-C16 Fraction
					L	pH Units	µS/cm	mbTOC	mg/L	mV	°C	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
WSA GW18	3/07/2018	WSA GW18	Normal	water	2	6.69	19,941	5.205	0.23	-154	18.2																													
WSA GW18	5/09/2018	FD02_180905	Field_D	water								0.5	1.3	1.3	2.6	2.9	110	0.3			0.007	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.005	0.045							<10		<20	<20	<50	<50
WSA GW18	5/09/2018	WSA GW18	Normal	water	3.3	6.89	20,771	6.081	0.7	-43.3	17.4																													
WSA GW18	5/09/2018	WSA GW18	Normal	water								0.56	1.2	1.3	2.5	3.2	<50	0.7			0.004	<0.0002	<0.001	0.020	0.001	<0.0001	0.010	0.088							<10		<20	<20	<50	<50
WSA GW18	13/12/2018	WSA GW18	Normal	water								2	<0.02	<0.02	<0.05	3.1	20	3.1			0.009	<0.0002	<0.001	0.012	<0.001	<0.0001	0.005	0.031	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW18	3/04/2019	WSA GW18	Normal	water								2	<0.02	0.05	0.05	2	180	2	<0.2		0.011	<0.0002	<0.001	0.002	<0.001	<0.0001	0.008	0.090	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW19	19/04/2018	WSA GW19	Normal	water	3.4	6.3	33,709	8.42	2.28	71.2	20																													
WSA GW19	3/07/2018	WSA_GW19	Normal	water								0.93	0.03	<0.02	<0.05	0.9	80	0.9			<0.001	<0.0002	<0.001	0.023	0.002	<0.0001	0.12	0.11	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW19	3/07/2018	WSA GW19	Normal	water	1.8	6.22	31,571	8.115	0.44	107.5	17.2																													
WSA GW19	7/09/2018	WSA GW19	Normal	water	1.6	6.42	34,701	8.727	2.07	61.5	18.7																													
WSA GW19	7/09/2018	WSA GW19	Normal	water								0.57	0.6	<0.02	0.6	1	110	0.4			<0.001	<0.0002	<0.001	0.087	0.008	<0.0001	0.11	0.14							<10		<20	<20	<50	<50
WSA GW19	14/12/2018	WSA GW19	Normal	water								0.4	0.46	<0.02	0.46	1.1	20	0.7			<0.001	0.0003	<0.001	0.013	0.001	<0.0001	0.19	0.14	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW20	18/04/2018	WSA GW20	Normal	water	3.8	7.02	11,665	6.69	1.15	-76.8	19.2																													
WSA GW20	3/07/2018	WSA_GW20	Normal	water								1.8	0.05	<0.02	0.05	1.8	140	1.8																						
WSA GW20	3/07/2018	WSA_GW20	Normal	water																	<0.001	<0.0002	<0.001	0.015	0.001	<0.0001	0.014	0.040												
WSA GW20	3/07/2018	WSA GW20	Normal	water	4.3	6.93	11,630	7.287	0.41	48.3	17.1																													
WSA GW20	5/09/2018	WSA GW20	Normal	water	2.8	6.93	14,009	7.138	0.45	32.3	17.7																													
WSA GW20	5/09/2018	WSA GW20	Normal	water								1.9	<0.02	<0.02	<0.05	1.6	<50	1.6			0.002	<0.0002	<0.001	0.020	0.001	<0.0001	0.025	0.036	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW20	14/12/2018	WSA GW20	Normal	water								2.5	<0.02	<0.02	<0.05	2.7	20	2.7			0.004	<0.0002	<0.001	0.022	0.002	<0.0001	0.019	0.033	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW20	3/04/2019	WSA GW20	Normal	water								3	0.03	<0.02	<0.05	3	20	3	<0.2		0.005	<0.0002	<0.001	0.010	<0.001	<0.0001	0.015	0.033	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW21	18/04/2018	WSA GW21	Normal	water	8.5	6.52	24,172	4.78	0.78	-84.6	18																													
WSA GW21	3/07/2018	FD01_180703	Field_D	water								0.85	<0.02	<0.02	<0.05	0.8	<50	0.8			<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	<0.001	<0.005	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW21	3/07/2018	WSA_GW21	Normal	water								1.4	<0.02	<0.02	<0.05	0.8	<50	0.8			<0.001	<0.0002	<0.001	0.023	0.002	<0.0001	0.005	0.037	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW21	3/07/2018	WSA GW21	Normal	water	4	6.51	21,380	4.972	0.2	2.5	16.8																													
WSA GW21	5/09/2018	WSA GW21	Normal	water	3.7	6.47	21,682	5.336	0.22	21.9	17.1																													
WSA GW21	5/09/2018	WSA GW21	Normal	water								0.76	<0.02	<0.02	<0.05	1.2	60	1.2			<0.001	<0.0002	<0.001	0.021	0.002	<0.0001	0.006	0.027	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW21	14/12/2018	WSA GW21	Normal	water								0.86	<0.02	<0.02	<0.05	1.2	50	1.1			0.001	<0.0002	<0.001	0.018	0.002	<0.0001	0.009	0.030	<1	<1	<1	<1	<2	<3	<10		<20	<20	250	250
WSA GW21	3/04/2019	WSA GW21	Normal	water								0.97	<0.02	<0.02	<0.05	1	30	1	<0.2		0.001	<0.0002	<0.001	0.026	0.002	<0.0001	0.008	0.045	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW22	17/04/2018	WSA GW22	Normal	water	4	6.77	19,816	4.82	0.3	-209.2	19.1																													
WSA GW22	5/07/2018	WSA_GW22	Normal	water								0.55	<0.02	<0.02	<0.05	0.6	100	0.6			<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.004	0.022							<10		<80	<80	<50	<50
WSA GW22	5/07/2018	WSA GW22	Normal	water	2.3	6.78	20,423	4.485	0.23	-186.9	17.2																													
WSA GW22	7/09/2018	WSA GW22	Normal	water	1.7	6.77	24,580	4.938	0.38	-67.9	17.9																													
WSA GW22	7/09/2018	WSA GW22	Normal	water								0.78	<0.02	<0.02	<0.05	0.9	100	0.9			0.002	<0.0002	<0.001	0.006	<0.001	<0.0001	0.006	0.026							<10		<20	<20	<50	<50
WSA GW22	12/12/2018	WSA GW22	Normal	water								1.1	<0.02	<0.02	<0.05	1.2	270	1.2			0.003	<0.0002	<0.001	0.004	<0.001	<0.0001	0.007	0.045	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW22	13/12/2018	FD01_121218	Field_D	water								0.83	<0.02	<0.02	<0.05	0.9	260	0.9			0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.007	0.032	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW22	13/12/2018	FD02_121218	Interlab_D	water								1.02			0.02	0.9		0.9		0.02	0.003	<0.0001	<0.001	<0.001	<0.001	<0.0001	0.008	0.034	<1	<2	<2	<2	<2	<2		<1	<20	<20	<100	<100
WSA GW22	5/04/2019	WSA GW22	Normal	water								0.9	<0.02	<0.02	<0.05	0.9	30	0.9	<0.2		0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.009	0.071	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW23	19/04/2018	WSA GW23	Normal	water	6	6.64	17,677	3.925	2.26	-5.4	20.2																													
WSA GW23	3/07/2018	WSA_GW23	Normal	water								0.23	<0.02	<0.02	<0.05	0.2	<50	0.2			<0.001	<0.0002	<0.001	0.022	0.002	<0.0001	0.006	0.039	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW23	3/07/2018	WSA GW23	Normal	water	2	6.66	15,809	4.075	0.27	23	19.7																													
WSA GW23	5/09/2018	WSA GW23	Normal	water	4.1	6.7	16,379	4.87	1.33	58.8	18.7																													
WSA GW23	5/09/2018	WSA GW23	Normal	water								0.66	<0.02	<0.02	<0.05	<0.2	<50	<0.2			<0.001	<0.0002	<0.001	0.039	0.002	<0.0001	0.007	0.041	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW23	13/12/2018	WSA GW23	Normal	water								0.26	0.08	<0.02	0.08	0.4	180	0.3			<0.001	<0.0002	0.001	0.016	<0.001	<0.0001	0.005	0.032	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50
WSA GW23	3/04/2019	WSA GW23	Normal	water								0.3	<0.02	<0.02	<0.05	0.3	20	0.3	<0.2		<0.001	<0.0002	<0.001	0.010	<0.001	<0.0001	0.004	0.039	<1	<1	<1	<1	<2	<3	<10		<20	<20	<50	<50

Source of data

GHD 2019

					M 2013			TRH - NEPM 1999					PAHs																		Phenols														
					F3 (>C16-C34 Fraction)	F4 (>C34-C40 Fraction)	>C10-C40 (Sum of Total)	C6-C9 Fraction	C10-C14 Fraction	C15-C28 Fraction	C29-C36 Fraction	C10-C36 (Sum of Total)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a) pyrene	Benzo[b+j]fluoranthene	Benzo(k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Naphthalene	Fluorene	Indeno(1,2,3-c,d)pyrene	Naphthalene-PAH	Phenanthrene	Pyrene	PAHs (Sum of total) - Lab calc	3,4-Methylphenol (m,p-cresol)	2,4,5-trichlorophenol #	2,4,6-trichlorophenol	2,4-dichlorophenol #	2,4-dimethylphenol	2,4-dinitrophenol	2,6-dichlorophenol	2-chlorophenol	2-methylphenol	2-nitrophenol	4,6-Dinitro-2-methylphenol	4,6-Dinitro-o-cyclohexyl phenol	4-chloro-3-methylphenol	4-nitrophenol	Pentachlorophenol #
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Location Code	Date	Field ID	Sample Type	Matrix Type																																									
WSA GW01	17/04/2018	WSA GW01	Normal	water																																									
WSA GW01	5/07/2018	WSA_GW01	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW01	5/07/2018	WSA GW01	Normal	water																																									
WSA GW01	5/09/2018	FD01_180905	Field_D	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW01	5/09/2018	WSA GW01	Normal	water																																									
WSA GW01	5/09/2018	WSA GW01	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW01	13/12/2018	WSA GW01	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW01	5/04/2019	WSA GW01	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW04	18/04/2018	WSA GW04	Normal	water																																									
WSA GW04	4/07/2018	FD02_180704	Field_D	water																																									
WSA GW04	4/07/2018	WSA_GW04	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW04	4/07/2018	WSA GW04	Normal	water																																									
WSA GW04	6/09/2018	WSA GW04	Normal	water																																									
WSA GW04	6/09/2018	WSA GW04	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW04	12/12/2018	WSA GW04	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW04	4/04/2019	WSA GW04	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW05	18/04/2018	WSA GW05	Normal	water																																									
WSA GW05	4/07/2018	WSA_GW05	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW05	4/07/2018	WSA GW05	Normal	water																																									
WSA GW05	6/09/2018	WSA GW05	Normal	water																																									
WSA GW05	6/09/2018	WSA GW05	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW05	13/12/2018	WSA GW05	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW05	4/04/2019	FD02	Interlab_D	water	<100	<100	<100	<20	<50	<100	<50	<50												<5																					
WSA GW05	4/04/2019	WSA GW05	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW06	18/04/2018	WSA GW06	Normal	water																																									
WSA GW06	4/07/2018	WSA_GW06	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW06	4/07/2018	WSA GW06	Normal	water																																									
WSA GW06	6/09/2018	WSA GW06	Normal	water																																									
WSA GW06	6/09/2018	WSA GW06	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	0.02	<0.01	<0.01	0.02	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW06	6/09/2018	WSA GW06-M	Normal	water																																									
WSA GW06	12/12/2018	WSA GW06	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW06	4/04/2019	WSA GW06	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW07	18/04/2018	WSA GW07	Normal	water																																									
WSA GW07	4/07/2018	WSA_GW07	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW07	4/07/2018	WSA GW07	Normal	water																																									
WSA GW07	6/09/2018	WSA GW07	Normal	water																																									
WSA GW07	6/09/2018	WSA GW07	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW07	13/12/2018	WSA GW07	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW07	4/04/2019	WSA GW07	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW08	18/04/2018	WSA GW08	Normal	water																																									
WSA GW08	4/07/2018	WSA_GW08	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW08	4/07/2018	WSA GW08	Normal	water																																									
WSA GW08	6/09/2018	WSA GW08	Normal	water																																									
WSA GW08	6/09/2018	WSA GW08	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW08	6/09/2018	WSA GW08-B	Normal	water																																									
WSA GW08	13/12/2018	WSA GW08	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW08	4/04/2019	FD01	Field_D	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW08	4/04/2019	WSA GW08	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW14	19/04/2018	WSA GW14	Normal	water																																									
WSA GW14	5/07/2018	WSA_GW14	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW14	5/07/2018	WSA GW14	Normal	water																																									
WSA GW14	6/09/2018	WSA GW14	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW14	12/12/2018	WSA GW14	Normal	water									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW14	3/04/2019	WSA GW14	Normal	water									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW16	17/04/2018	WSA GW16	Normal	water																																									
WSA GW16	5/07/2018	WSA_GW16	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW16	5/07/2018	WSA GW16	Normal	water																																									
WSA GW16	7/09/2018	WSA GW16	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																			<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW16	12/12/2018	WSA GW16	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW16	3/04/2019	WSA GW16	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW17	19/04/2018	WSA GW17	Normal	water																																									
WSA GW17	3/07/2018	WSA_GW17	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW17	3/07/2018	WSA GW17	Normal	water																																									
WSA GW17	5/09/2018	WSA GW17	Normal	water																																									
WSA GW17	5/09/2018	WSA GW17	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	0.04	<0.01	<0.01	0.04	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW17	13/12/2018	WSA GW17	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW17	3/04/2019	WSA GW17	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW18	19/04/2018	WSA GW18	Normal	water																																									
WSA GW18	3/07/2018	WSA_GW18	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2

					M 2013			TRH - NEPM 1999					PAHs																		Phenols														
					F3 (>C16-C34 Fraction)	F4 (>C34-C40 Fraction)	>C10-C40 (Sum of Total)	C6-C9 Fraction	C10-C14 Fraction	C15-C28 Fraction	C29-C36 Fraction	C10-C36 (Sum of Total)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a) pyrene	Benzo[b+j]fluoranthene	Benzo(k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Naphthalene	Fluorene	Indeno(1,2,3-c,d)pyrene	Naphthalene-PAH	Phenanthrene	Pyrene	PAHs (Sum of total) - Lab calc	3,4-Methylphenol (m,p-cresol)	2,4,5-trichlorophenol #	2,4,6-trichlorophenol	2,4-dichlorophenol #	2,4-dimethylphenol	2,4-dinitrophenol	2,6-dichlorophenol	2-chlorophenol	2-methylphenol	2-nitrophenol	4,6-Dinitro-2-methylphenol	4,6-Dinitro-o-cyclohexyl phenol	4-chloro-3-methylphenol	4-nitrophenol	Pentachlorophenol #
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
WSA GW18	3/07/2018	WSA GW18	Normal	water																																									
WSA GW18	5/09/2018	FD02_180905	Field_D	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW18	5/09/2018	WSA GW18	Normal	water																																									
WSA GW18	5/09/2018	WSA GW18	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW18	13/12/2018	WSA GW18	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW18	3/04/2019	WSA GW18	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW19	19/04/2018	WSA GW19	Normal	water																																									
WSA GW19	3/07/2018	WSA_GW19	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW19	3/07/2018	WSA GW19	Normal	water																																									
WSA GW19	7/09/2018	WSA GW19	Normal	water																																									
WSA GW19	7/09/2018	WSA GW19	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																			<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW19	14/12/2018	WSA GW19	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW20	18/04/2018	WSA GW20	Normal	water																																									
WSA GW20	3/07/2018	WSA_GW20	Normal	water									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.02	<0.01	<0.01	0.08	<0.01	0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW20	3/07/2018	WSA_GW20	Normal	water																																									
WSA GW20	3/07/2018	WSA GW20	Normal	water																																									
WSA GW20	5/09/2018	WSA GW20	Normal	water																																									
WSA GW20	5/09/2018	WSA GW20	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW20	14/12/2018	WSA GW20	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW20	3/04/2019	WSA GW20	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW21	18/04/2018	WSA GW21	Normal	water																																									
WSA GW21	3/07/2018	FD01_180703	Field_D	water	<100	<100		<20	<50	<100	<100	<100																																	
WSA GW21	3/07/2018	WSA_GW21	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW21	3/07/2018	WSA GW21	Normal	water																																									
WSA GW21	5/09/2018	WSA GW21	Normal	water																																									
WSA GW21	5/09/2018	WSA GW21	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW21	14/12/2018	WSA GW21	Normal	water	800	<100	1,050	<20	200	800	100	1,100																																	
WSA GW21	3/04/2019	WSA GW21	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW22	17/04/2018	WSA GW22	Normal	water																																									
WSA GW22	5/07/2018	WSA_GW22	Normal	water	<100	<100		<80	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW22	5/07/2018	WSA GW22	Normal	water																																									
WSA GW22	7/09/2018	WSA GW22	Normal	water																																									
WSA GW22	7/09/2018	WSA GW22	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																			<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW22	12/12/2018	WSA GW22	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW22	13/12/2018	FD01_121218	Field_D	water	<100	<100	<100	<20	<50	<100	<100	<100																																	
WSA GW22	13/12/2018	FD02_121218	Interlab_D	water	<100	<100	<100	<20	<50	<100	<50	<50												<5																					
WSA GW22	5/04/2019	WSA GW22	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW23	19/04/2018	WSA GW23	Normal	water																																									
WSA GW23	3/07/2018	WSA_GW23	Normal	water	<100	<100		<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	<0.2	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.2	<1	<100	<0.2	<0.1	<2
WSA GW23	3/07/2018	WSA GW23	Normal	water																																									
WSA GW23	5/09/2018	WSA GW23	Normal	water																																									
WSA GW23	5/09/2018	WSA GW23	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.5	<10	<0.1	<0.5	<1
WSA GW23	13/12/2018	WSA GW23	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<6	<10	<10	<3	<3	<30	<3	<3	<3	<10	<30	<100	<10	<30	<10
WSA GW23	3/04/2019	WSA GW23	Normal	water	<100	<100	<100	<20	<50	<100	<100	<100																																	

Source of data
GHD 2019

									VOCs																				
					Phenol	tetrachlorophenols	Phenols (Total Halogenated)	Phenols (Total Non Halogenated)	1,1-dichloroethane	1,2,3-trichloropropane	1,2-dibromoethane	1,3-dichlorobenzene	2-butanone (MEK)	4-methyl-2-pentanone (MIBK)	Acetone	Allyl chloride	Bromodichloromethane	Bromoform	Carbon disulfide	Chlorodibromomethane	Chloroethane	cis-1,3-dichloropropene	Dibromomethane	Iodomethane	Trichloroethene	Tetrachloroethene	trans-1,3-dichloropropene	trans-1,2-dichloroethene	Trichlorofluoromethane
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Location Code	Date	Field ID	Sample Type	Matrix Type																									
WSA GW01	17/04/2018	WSA GW01	Normal	water																									
WSA GW01	5/07/2018	WSA_GW01	Normal	water	<3	<30	<10	<100																					
WSA GW01	5/07/2018	WSA GW01	Normal	water																									
WSA GW01	5/09/2018	FD01_180905	Field_D	water																									
WSA GW01	5/09/2018	WSA GW01	Normal	water																									
WSA GW01	5/09/2018	WSA GW01	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW01	13/12/2018	WSA GW01	Normal	water	<3	<30	<10	<100																					
WSA GW01	5/04/2019	WSA GW01	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW04	18/04/2018	WSA GW04	Normal	water																									
WSA GW04	4/07/2018	FD02_180704	Field_D	water																									
WSA GW04	4/07/2018	WSA_GW04	Normal	water	<0.1	<0.2	<2	<100	<1	<1	<1	<1	<1	<1	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW04	4/07/2018	WSA GW04	Normal	water																									
WSA GW04	6/09/2018	WSA GW04	Normal	water																									
WSA GW04	6/09/2018	WSA GW04	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW04	12/12/2018	WSA GW04	Normal	water																									
WSA GW04	4/04/2019	WSA GW04	Normal	water																									
WSA GW05	18/04/2018	WSA GW05	Normal	water																									
WSA GW05	4/07/2018	WSA_GW05	Normal	water	<0.1	<0.2	<2	<100																					
WSA GW05	4/07/2018	WSA GW05	Normal	water																									
WSA GW05	6/09/2018	WSA GW05	Normal	water																									
WSA GW05	6/09/2018	WSA GW05	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW05	13/12/2018	WSA GW05	Normal	water	<3	<30	<10	<100																					
WSA GW05	4/04/2019	FD02	Interlab_D	water																									
WSA GW05	4/04/2019	WSA GW05	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW06	18/04/2018	WSA GW06	Normal	water																									
WSA GW06	4/07/2018	WSA_GW06	Normal	water	<0.1	<0.2	<2	<100																					
WSA GW06	4/07/2018	WSA GW06	Normal	water																									
WSA GW06	6/09/2018	WSA GW06	Normal	water																									
WSA GW06	6/09/2018	WSA GW06	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW06	6/09/2018	WSA GW06-M	Normal	water																									
WSA GW06	12/12/2018	WSA GW06	Normal	water	<3	<30	<10	<100	<1	<1	<1	<1	<1	<1	16	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW06	4/04/2019	WSA GW06	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW07	18/04/2018	WSA GW07	Normal	water																									
WSA GW07	4/07/2018	WSA_GW07	Normal	water	<0.1	<0.2	<2	<100	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW07	4/07/2018	WSA GW07	Normal	water																									
WSA GW07	6/09/2018	WSA GW07	Normal	water																									
WSA GW07	6/09/2018	WSA GW07	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW07	13/12/2018	WSA GW07	Normal	water					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW07	4/04/2019	WSA GW07	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW08	18/04/2018	WSA GW08	Normal	water																									
WSA GW08	4/07/2018	WSA_GW08	Normal	water	<0.1	<0.2	<2	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW08	4/07/2018	WSA GW08	Normal	water																									
WSA GW08	6/09/2018	WSA GW08	Normal	water																									
WSA GW08	6/09/2018	WSA GW08	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW08	6/09/2018	WSA GW08-B	Normal	water																									
WSA GW08	13/12/2018	WSA GW08	Normal	water	<3	<30	<10	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW08	4/04/2019	FD01	Field_D	water																									
WSA GW08	4/04/2019	WSA GW08	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW14	19/04/2018	WSA GW14	Normal	water																									
WSA GW14	5/07/2018	WSA_GW14	Normal	water	<3	<30	<10	<100																					
WSA GW14	5/07/2018	WSA GW14	Normal	water																									
WSA GW14	6/09/2018	WSA GW14	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW14	12/12/2018	WSA GW14	Normal	water	<3	<30	<10	<100																					
WSA GW14	3/04/2019	WSA GW14	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW16	17/04/2018	WSA GW16	Normal	water																									
WSA GW16	5/07/2018	WSA_GW16	Normal	water	<3	<30	<10	<100																					
WSA GW16	5/07/2018	WSA GW16	Normal	water																									
WSA GW16	7/09/2018	WSA GW16	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW16	12/12/2018	WSA GW16	Normal	water					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW16	3/04/2019	WSA GW16	Normal	water	<0.05	<0.5	<1	<10																					
WSA GW17	19/04/2018	WSA GW17	Normal	water																									
WSA GW17	3/07/2018	WSA_GW17	Normal	water	<0.1	<0.2	<2	<100																					
WSA GW17	3/07/2018	WSA GW17	Normal	water																									
WSA GW17	5/09/2018	WSA GW17	Normal	water																									
WSA GW17	5/09/2018	WSA GW17	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW17	13/12/2018	WSA GW17	Normal	water	<3	<30	<10	<100																					
WSA GW17	3/04/2019	WSA GW17	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
WSA GW18	19/04/2018	WSA GW18	Normal	water																									
WSA GW18	3/07/2018	WSA_GW18	Normal	water	<0.1	<0.2	<2	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

					OC Pesticides																
					Organochlorine pesticides EPAVic	Other organochlorine pesticides EPAVic	4,4'-DDE	a-BHC	Aldrin #	Aldrin + Dieldrin	b-BHC	Chlordane #	d-BHC	4,4 DDD	4,4 DDT #	DDT+DDE+DDD - Lab Calc	Dieldrin #	Endosulfan I (alpha)	Endosulfan II (beta)	Endosulfan Sulfate	Endrin #
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Location Code	Date	Field ID	Sample Type	Matrix Type																	
WSA GW01	17/04/2018	WSA GW01	Normal	water																	
WSA GW01	5/07/2018	WSA_GW01	Normal	water																	
WSA GW01	5/07/2018	WSA GW01	Normal	water																	
WSA GW01	5/09/2018	FD01_180905	Field_D	water																	
WSA GW01	5/09/2018	WSA GW01	Normal	water																	
WSA GW01	5/09/2018	WSA GW01	Normal	water																	
WSA GW01	13/12/2018	WSA GW01	Normal	water																	
WSA GW01	5/04/2019	WSA GW01	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WSA GW04	18/04/2018	WSA GW04	Normal	water																	
WSA GW04	4/07/2018	FD02_180704	Field_D	water																	
WSA GW04	4/07/2018	WSA_GW04	Normal	water																	
WSA GW04	4/07/2018	WSA GW04	Normal	water																	
WSA GW04	6/09/2018	WSA GW04	Normal	water																	
WSA GW04	6/09/2018	WSA GW04	Normal	water																	
WSA GW04	12/12/2018	WSA GW04	Normal	water																	
WSA GW04	4/04/2019	WSA GW04	Normal	water																	
WSA GW05	18/04/2018	WSA GW05	Normal	water																	
WSA GW05	4/07/2018	WSA_GW05	Normal	water																	
WSA GW05	4/07/2018	WSA GW05	Normal	water																	
WSA GW05	6/09/2018	WSA GW05	Normal	water																	
WSA GW05	6/09/2018	WSA GW05	Normal	water																	
WSA GW05	13/12/2018	WSA GW05	Normal	water																	
WSA GW05	4/04/2019	FD02	Interlab_D	water																	
WSA GW05	4/04/2019	WSA GW05	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WSA GW06	18/04/2018	WSA GW06	Normal	water																	
WSA GW06	4/07/2018	WSA_GW06	Normal	water																	
WSA GW06	4/07/2018	WSA GW06	Normal	water																	
WSA GW06	6/09/2018	WSA GW06	Normal	water																	
WSA GW06	6/09/2018	WSA GW06	Normal	water	<1	<1	<0.05	<0.05	<0.05	<0.1	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05
WSA GW06	6/09/2018	WSA GW06-M	Normal	water																	
WSA GW06	12/12/2018	WSA GW06	Normal	water																	
WSA GW06	4/04/2019	WSA GW06	Normal	water																	
WSA GW07	18/04/2018	WSA GW07	Normal	water																	
WSA GW07	4/07/2018	WSA_GW07	Normal	water																	
WSA GW07	4/07/2018	WSA GW07	Normal	water																	
WSA GW07	6/09/2018	WSA GW07	Normal	water																	
WSA GW07	6/09/2018	WSA GW07	Normal	water	<1	<1	<0.05	<0.05	<0.05	<0.1	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05
WSA GW07	13/12/2018	WSA GW07	Normal	water	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
WSA GW07	4/04/2019	WSA GW07	Normal	water																	
WSA GW08	18/04/2018	WSA GW08	Normal	water																	
WSA GW08	4/07/2018	WSA_GW08	Normal	water																	
WSA GW08	4/07/2018	WSA GW08	Normal	water																	
WSA GW08	6/09/2018	WSA GW08	Normal	water																	
WSA GW08	6/09/2018	WSA GW08	Normal	water																	
WSA GW08	6/09/2018	WSA GW08-B	Normal	water																	
WSA GW08	13/12/2018	WSA GW08	Normal	water																	
WSA GW08	4/04/2019	FD01	Field_D	water																	
WSA GW08	4/04/2019	WSA GW08	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WSA GW14	19/04/2018	WSA GW14	Normal	water																	
WSA GW14	5/07/2018	WSA_GW14	Normal	water																	
WSA GW14	5/07/2018	WSA GW14	Normal	water																	
WSA GW14	6/09/2018	WSA GW14	Normal	water	<1	<1	<0.05	<0.05	<0.05	<0.1	<0.05	<0.5	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05
WSA GW14	12/12/2018	WSA GW14	Normal	water	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
WSA GW14	3/04/2019	WSA GW14	Normal	water																	
WSA GW16	17/04/2018	WSA GW16	Normal	water																	
WSA GW16	5/07/2018	WSA_GW16	Normal	water																	
WSA GW16	5/07/2018	WSA GW16	Normal	water																	
WSA GW16	7/09/2018	WSA GW16	Normal	water	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
WSA GW16	12/12/2018	WSA GW16	Normal	water	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
WSA GW16	3/04/2019	WSA GW16	Normal	water																	
WSA GW17	19/04/2018	WSA GW17	Normal	water																	
WSA GW17	3/07/2018	WSA_GW17	Normal	water																	
WSA GW17	3/07/2018	WSA GW17	Normal	water																	
WSA GW17	5/09/2018	WSA GW17	Normal	water																	
WSA GW17	5/09/2018	WSA GW17	Normal	water																	
WSA GW17	13/12/2018	WSA GW17	Normal	water																	
WSA GW17	3/04/2019	WSA GW17	Normal	water																	
WSA GW18	19/04/2018	WSA GW18	Normal	water																	
WSA GW18	3/07/2018	WSA_GW18	Normal	water																	

									VOCs																					OC Pesticides																
					Phenol	tetrachlorophenols	Phenols (Total Halogenated)	Phenols (Total Non Halogenated)	1,1-dichloroethane	1,2,3-trichloropropane	1,2-dibromoethane	1,3-dichlorobenzene	2-butanone (MEK)	4-methyl-2-pentanone (MIBK)	Acetone	Allyl chloride	Bromodichloromethane	Bromoform	Carbon disulfide	Chlorodibromomethane	Chloroethane	cis-1,3-dichloropropene	Dibromomethane	Iodomethane	Trichloroethene	Tetrachloroethene	trans-1,3-dichloropropene	trans-1,2-dichloroethene	Trichlorofluoromethane	Organochlorine pesticides EPAVic	Other organochlorine pesticides EPAVic	4,4'-DDE	a-BHC	Aldrin #	Aldrin + Dieldrin	b-BHC	Chlordane #	d-BHC	4,4 DDD	4,4 DDT #	DDT+DDE+DDD - Lab Calc	Dieldrin #	Endosulfan I (alpha)	Endosulfan II (beta)	Endosulfan Sulfate	Endrin #
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
WSA GW18	3/07/2018	WSA GW18	Normal	water																																										
WSA GW18	5/09/2018	FD02_180905	Field_D	water																																										
WSA GW18	5/09/2018	WSA GW18	Normal	water																																										
WSA GW18	5/09/2018	WSA GW18	Normal	water	<0.05	<0.5	<1	<10																																						
WSA GW18	13/12/2018	WSA GW18	Normal	water					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
WSA GW18	3/04/2019	WSA GW18	Normal	water																										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WSA GW19	19/04/2018	WSA GW19	Normal	water																																										
WSA GW19	3/07/2018	WSA_GW19	Normal	water	<0.1	<0.2	<2	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
WSA GW19	3/07/2018	WSA GW19	Normal	water																																										
WSA GW19	7/09/2018	WSA GW19	Normal	water																																										
WSA GW19	7/09/2018	WSA GW19	Normal	water	<0.05	<0.5	<1	<10																						<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
WSA GW19	14/12/2018	WSA GW19	Normal	water																										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WSA GW20	18/04/2018	WSA GW20	Normal	water																																										
WSA GW20	3/07/2018	WSA_GW20	Normal	water	<0.1	<0.2	<2	<100																																						
WSA GW20	3/07/2018	WSA_GW20	Normal	water																																										
WSA GW20	3/07/2018	WSA GW20	Normal	water																																										
WSA GW20	5/09/2018	WSA GW20	Normal	water																																										
WSA GW20	5/09/2018	WSA GW20	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
WSA GW20	14/12/2018	WSA GW20	Normal	water																																										
WSA GW20	3/04/2019	WSA GW20	Normal	water																										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WSA GW21	18/04/2018	WSA GW21	Normal	water																																										
WSA GW21	3/07/2018	FD01_180703	Field_D	water																																										
WSA GW21	3/07/2018	WSA_GW21	Normal	water	<0.1	<0.2	<2	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
WSA GW21	3/07/2018	WSA GW21	Normal	water																																										
WSA GW21	5/09/2018	WSA GW21	Normal	water																																										
WSA GW21	5/09/2018	WSA GW21	Normal	water	<0.05	<0.5	<1	<10																																						
WSA GW21	14/12/2018	WSA GW21	Normal	water																																										
WSA GW21	3/04/2019	WSA GW21	Normal	water					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
WSA GW22	17/04/2018	WSA GW22	Normal	water																																										
WSA GW22	5/07/2018	WSA_GW22	Normal	water	<3	<30	<10	<100																																						
WSA GW22	5/07/2018	WSA GW22	Normal	water																																										
WSA GW22	7/09/2018	WSA GW22	Normal	water																																										
WSA GW22	7/09/2018	WSA GW22	Normal	water	<0.05	<0.5	<1	<10																						<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
WSA GW22	12/12/2018	WSA GW22	Normal	water	<3	<30	<10	<100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
WSA GW22	13/12/2018	FD01_121218	Field_D	water																																										
WSA GW22	13/12/2018	FD02_121218	Interlab_D	water																																										
WSA GW22	5/04/2019	WSA GW22	Normal	water	<0.05	<0.5	<1	<10																																						
WSA GW23	19/04/2018	WSA GW23	Normal	water																																										
WSA GW23	3/07/2018	WSA_GW23	Normal	water	<0.1	<0.2	<2	<100																																						
WSA GW23	3/07/2018	WSA GW23	Normal	water																																										
WSA GW23	5/09/2018	WSA GW23	Normal	water																																										
WSA GW23	5/09/2018	WSA GW23	Normal	water	<0.05	<0.5	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
WSA GW23	13/12/2018	WSA GW23	Normal	water	<3	<30	<10	<100																						<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
WSA GW23	3/04/2019	WSA GW23	Normal	water					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																					

Source of data
GHD 2019

													OP Pesticides																																		
					Endrin aldehyde	Endrin ketone	g-BHC (Lindane) #	Heptachlor #	Heptachlor epoxide	Hexachlorobenzene #	Methoxychlor #	Toxaphene #	Tokuthion	Azinphos methyl #	Bolstar (Sulprofos)	Chlorfenvinphos	Chlorpyrifos #	Chlorpyrifos-methyl	Coumaphos	Demeton-O	Demeton-S	Diazinon #	Dichlorvos	Dimethoate #	Disulfoton	EPN	Ethion	Ethoprop	Fenitrothion #	Fensulfothion	Fenthion	Malathion #	Merphos	Methyl parathion	Mevinphos (Phosdrin)	Monocrotophos	Naled (Dibrom)	Omethoate	Parathion #	Phorate	Pirimiphos-methyl	Pyrazophos	Ronnel	Terbufos	Trichloronate	Tetrachlorvinphos
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Location Code	Date	Field ID	Sample Type	Matrix Type																																										
WSA GW01	17/04/2018	WSA GW01	Normal	water																																										
WSA GW01	5/07/2018	WSA_GW01	Normal	water																																										
WSA GW01	5/07/2018	WSA GW01	Normal	water																																										
WSA GW01	5/09/2018	FD01_180905	Field_D	water																																										
WSA GW01	5/09/2018	WSA GW01	Normal	water																																										
WSA GW01	5/09/2018	WSA GW01	Normal	water																																										
WSA GW01	13/12/2018	WSA GW01	Normal	water																																										
WSA GW01	5/04/2019	WSA GW01	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<1	<1	<1	<10	<1	<10	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1
WSA GW04	18/04/2018	WSA GW04	Normal	water																																										
WSA GW04	4/07/2018	FD02_180704	Field_D	water																																										
WSA GW04	4/07/2018	WSA_GW04	Normal	water																																										
WSA GW04	4/07/2018	WSA GW04	Normal	water																																										
WSA GW04	6/09/2018	WSA GW04	Normal	water																																										
WSA GW04	6/09/2018	WSA GW04	Normal	water																																										
WSA GW04	12/12/2018	WSA GW04	Normal	water																																										
WSA GW04	4/04/2019	WSA GW04	Normal	water																																										
WSA GW05	18/04/2018	WSA GW05	Normal	water																																										
WSA GW05	4/07/2018	WSA_GW05	Normal	water																																										
WSA GW05	4/07/2018	WSA GW05	Normal	water																																										
WSA GW05	6/09/2018	WSA GW05	Normal	water																																										
WSA GW05	6/09/2018	WSA GW05	Normal	water																																										
WSA GW05	13/12/2018	WSA GW05	Normal	water																																										
WSA GW05	4/04/2019	FD02	Interlab_D	water																																										
WSA GW05	4/04/2019	WSA GW05	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<1	<1	<1	<10	<1	<10	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1
WSA GW06	18/04/2018	WSA GW06	Normal	water																																										
WSA GW06	4/07/2018	WSA_GW06	Normal	water																																										
WSA GW06	4/07/2018	WSA GW06	Normal	water																																										
WSA GW06	6/09/2018	WSA GW06	Normal	water																																										
WSA GW06	6/09/2018	WSA GW06	Normal	water	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<0.2	<0.2	<0.2	<2	<0.2	<2	<20	<0.2	<20	<0.2	<0.2	<2	<0.2	<2	<0.2	<0.2	<0.2	<0.2	<0.2	<2	<0.2	<0.2	<0.2	<2	<0.2	<2	<2	<0.2	<20	<2	<0.2	<2	<0.2	<2
WSA GW06	6/09/2018	WSA GW06-M	Normal	water																																										
WSA GW06	12/12/2018	WSA GW06	Normal	water																																										
WSA GW06	4/04/2019	WSA GW06	Normal	water																																										
WSA GW07	18/04/2018	WSA GW07	Normal	water																																										
WSA GW07	4/07/2018	WSA_GW07	Normal	water																																										
WSA GW07	4/07/2018	WSA GW07	Normal	water																																										
WSA GW07	6/09/2018	WSA GW07	Normal	water																																										
WSA GW07	6/09/2018	WSA GW07	Normal	water	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<0.2	<0.2	<0.2	<2	<0.2	<2	<20	<0.2	<20	<0.2	<0.2	<2	<0.2	<2	<0.2	<0.2	<0.2	<0.2	<0.2	<2	<0.2	<0.2	<0.2	<2	<0.2	<2	<2	<0.2	<20	<2	<0.2	<2	<0.2	<2
WSA GW07	13/12/2018	WSA GW07	Normal	water	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<10	<2	<2	<2	<2	<20	<2	<20	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<20	<2	<2	<2	<2	<2
WSA GW07	4/04/2019	WSA GW07	Normal	water																																										
WSA GW08	18/04/2018	WSA GW08	Normal	water																																										
WSA GW08	4/07/2018	WSA_GW08	Normal	water																																										
WSA GW08	4/07/2018	WSA GW08	Normal	water																																										
WSA GW08	6/09/2018	WSA GW08	Normal	water																																										
WSA GW08	6/09/2018	WSA GW08	Normal	water																																										
WSA GW08	6/09/2018	WSA GW08-B	Normal	water																																										
WSA GW08	13/12/2018	WSA GW08	Normal	water																																										
WSA GW08	4/04/2019	FD01	Field_D	water																																										
WSA GW08	4/04/2019	WSA GW08	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<1	<1	<1	<10	<1	<10	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1
WSA GW14	19/04/2018	WSA GW14	Normal	water																																										
WSA GW14	5/07/2018	WSA_GW14	Normal	water																																										
WSA GW14	5/07/2018	WSA GW14	Normal	water																																										
WSA GW14	6/09/2018	WSA GW14	Normal	water	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<0.2	<0.2	<0.2	<2	<0.2	<2	<20	<0.2	<20	<0.2	<0.2	<2	<0.2	<2	<0.2	<0.2	<0.2	<0.2	<0.2	<2	<0.2	<0.2	<0.2	<2	<0.2	<2	<2	<0.2	<20	<2	<0.2	<2	<0.2	<2
WSA GW14	12/12/2018	WSA GW14	Normal	water	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<10	<2	<2	<2	<2	<20	<2	<20	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<20	<2	<2	<2	<2	<2
WSA GW14	3/04/2019	WSA GW14	Normal	water																																										
WSA GW16	17/04/2018	WSA GW16	Normal	water																																										
WSA GW16	5/07/2018	WSA_GW16	Normal	water																																										
WSA GW16	5/07/2018	WSA GW16	Normal	water																																										
WSA GW16	7/09/2018	WSA GW16	Normal	water	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<10	<2	<2	<2	<2	<20	<2	<20	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<20	<2	<2	<2	<2	<2
WSA GW16	12/12/2018	WSA GW16	Normal	water	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<10	<2	<2	<2	<2	<20	<2	<20	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<20	<2	<2	<2	<2	<2
WSA GW16	3/04/2019	WSA GW16	Normal	water																																										
WSA GW17	19/04/2018	WSA GW17	Normal	water																																										
WSA GW17	3/07/2018	WSA_GW17	Normal	water																																										
WSA GW17	3/07/2018	WSA GW17	Normal	water																																										
WSA GW17	5/09/2018	WSA GW17	Normal	water																																										
WSA GW17	5/09/2018	WSA GW17	Normal	water																																										
WSA GW17	13/12/2018	WSA GW17	Normal	water																																										
WSA GW17	3/04/2019	WSA GW17	Normal	water																																										
WSA GW18	19/04/2018	WSA GW18	Normal	water																																										
WSA GW18	3/07/2018	WSA_GW18	Normal	water																																										

														OP Pesticides																																
					Endrin aldehyde	Endrin ketone	g-BHC (Lindane) #	Heptachlor #	Heptachlor epoxide	Hexachlorobenzene #	Methoxychlor #	Toxaphene #	Tokuthion	Azinphos methyl #	Bolstar (Sulprofos)	Chlorfenvinphos	Chlorpyrifos #	Chlorpyrifos-methyl	Coumaphos	Demeton-O	Demeton-S	Diazinon #	Dichlorvos	Dimethoate #	Disulfoton	EPN	Ethion	Ethoprop	Fenitrothion #	Fensulfothion	Fenthion	Malathion #	Merphos	Methyl parathion	Mevinphos (Phosdrin)	Monocrotophos	Naled (Dibrom)	Omethoate	Parathion #	Phorate	Pirimiphos-methyl	Pyrazophos	Ronnel	Terbufos	Trichloronate	Tetrachlorvinphos
					μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
WSA GW18	3/07/2018	WSA GW18	Normal	water																																										
WSA GW18	5/09/2018	FD02_180905	Field_D	water																																										
WSA GW18	5/09/2018	WSA GW18	Normal	water																																										
WSA GW18	5/09/2018	WSA GW18	Normal	water																																										
WSA GW18	13/12/2018	WSA GW18	Normal	water																																										
WSA GW18	3/04/2019	WSA GW18	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<1	<1	<1	<10	<1	<10	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1
WSA GW19	19/04/2018	WSA GW19	Normal	water																																										
WSA GW19	3/07/2018	WSA_GW19	Normal	water																																										
WSA GW19	3/07/2018	WSA GW19	Normal	water																																										
WSA GW19	7/09/2018	WSA GW19	Normal	water																																										
WSA GW19	7/09/2018	WSA GW19	Normal	water	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<10	<2	<2	<2	<2	<20	<2	<20	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<20	<2	<2	<2	<2	<2
WSA GW19	14/12/2018	WSA GW19	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<1	<1	<1	<10	<1	<10	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1
WSA GW20	18/04/2018	WSA GW20	Normal	water																																										
WSA GW20	3/07/2018	WSA_GW20	Normal	water																																										
WSA GW20	3/07/2018	WSA_GW20	Normal	water																																										
WSA GW20	3/07/2018	WSA GW20	Normal	water																																										
WSA GW20	5/09/2018	WSA GW20	Normal	water																																										
WSA GW20	5/09/2018	WSA GW20	Normal	water																																										
WSA GW20	14/12/2018	WSA GW20	Normal	water																																										
WSA GW20	3/04/2019	WSA GW20	Normal	water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<1	<1	<1	<10	<1	<10	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1
WSA GW21	18/04/2018	WSA GW21	Normal	water																																										
WSA GW21	3/07/2018	FD01_180703	Field_D	water																																										
WSA GW21	3/07/2018	WSA_GW21	Normal	water																																										
WSA GW21	3/07/2018	WSA GW21	Normal	water																																										
WSA GW21	5/09/2018	WSA GW21	Normal	water																																										
WSA GW21	5/09/2018	WSA GW21	Normal	water																																										
WSA GW21	14/12/2018	WSA GW21	Normal	water																																										
WSA GW21	3/04/2019	WSA GW21	Normal	water																																										
WSA GW22	17/04/2018	WSA GW22	Normal	water																																										
WSA GW22	5/07/2018	WSA_GW22	Normal	water																																										
WSA GW22	5/07/2018	WSA GW22	Normal	water																																										
WSA GW22	7/09/2018	WSA GW22	Normal	water																																										
WSA GW22	7/09/2018	WSA GW22	Normal	water	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<10	<2	<2	<2	<2	<20	<2	<20	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<20	<2	<2	<2	<2	<2
WSA GW22	12/12/2018	WSA GW22	Normal	water																																										
WSA GW22	13/12/2018	FD01_121218	Field_D	water																																										
WSA GW22	13/12/2018	FD02_121218	Interlab_D	water																																										
WSA GW22	5/04/2019	WSA GW22	Normal	water																																										
WSA GW23	19/04/2018	WSA GW23	Normal	water																																										
WSA GW23	3/07/2018	WSA_GW23	Normal	water																																										
WSA GW23	3/07/2018	WSA GW23	Normal	water																																										
WSA GW23	5/09/2018	WSA GW23	Normal	water																																										
WSA GW23	5/09/2018	WSA GW23	Normal	water																																										
WSA GW23	13/12/2018	WSA GW23	Normal	water	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<10	<2	<2	<2	<2	<20	<2	<20	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<20	<2	<2	<2	<2	<2
WSA GW23	3/04/2019	WSA GW23	Normal	water																																										

Source of data
GHD 2019

					MAH					Halogenate		Herbicides	PFAS																										
					1,2,4-trimethylbenzene	1,3,5-trimethylbenzene	Isopropylbenzene	Styrene	Total MAH	Bromomethane	Dichlorodifluoromethane	Dinoseb	Perfluoropropanesulfonic acid (PFPrS)	Perfluorobutane sulfonic acid (PFBS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorobutanoic acid (PFBA)	Perfluoropentanoic acid (PFPeA)	Perfluorohexanoic acid (PFHxA)	Perfluoroheptanoic acid (PFHpA)	Perfluorooctanoic acid (PFOA)	Perfluorononanoic acid (PFNA)	Perfluorodecanoic acid (PFDA)	Perfluoroundecanoic acid (PFUnDA)	Perfluorododecanoic acid (PFDoDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorooctane sulfonamide (FOSA)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	UG/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Location Code	Date	Field ID	Sample Type	Matrix Type																																			
WSA GW01	17/04/2018	WSA GW01	Normal	water																																			
WSA GW01	5/07/2018	WSA_GW01	Normal	water								<100																											
WSA GW01	5/07/2018	WSA GW01	Normal	water																																			
WSA GW01	5/09/2018	FD01_180905	Field_D	water										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW01	5/09/2018	WSA GW01	Normal	water																																			
WSA GW01	5/09/2018	WSA GW01	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW01	13/12/2018	WSA GW01	Normal	water								<100		<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	0.09
WSA GW01	5/04/2019	WSA GW01	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW04	18/04/2018	WSA GW04	Normal	water																																			
WSA GW04	4/07/2018	FD02_180704	Field_D	water																																			
WSA GW04	4/07/2018	WSA_GW04	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											
WSA GW04	4/07/2018	WSA GW04	Normal	water																																			
WSA GW04	6/09/2018	WSA GW04	Normal	water																																			
WSA GW04	6/09/2018	WSA GW04	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW04	12/12/2018	WSA GW04	Normal	water																																			
WSA GW04	4/04/2019	WSA GW04	Normal	water																																			
WSA GW05	18/04/2018	WSA GW05	Normal	water																																			
WSA GW05	4/07/2018	WSA_GW05	Normal	water								<100																											
WSA GW05	4/07/2018	WSA GW05	Normal	water																																			
WSA GW05	6/09/2018	WSA GW05	Normal	water																																			
WSA GW05	6/09/2018	WSA GW05	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW05	13/12/2018	WSA GW05	Normal	water								<100		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW05	4/04/2019	FD02	Interlab_D	water																																			
WSA GW05	4/04/2019	WSA GW05	Normal	water								<10																											
WSA GW06	18/04/2018	WSA GW06	Normal	water																																			
WSA GW06	4/07/2018	WSA_GW06	Normal	water								<100																											
WSA GW06	4/07/2018	WSA GW06	Normal	water																																			
WSA GW06	6/09/2018	WSA GW06	Normal	water																																			
WSA GW06	6/09/2018	WSA GW06	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW06	6/09/2018	WSA GW06-M	Normal	water										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW06	12/12/2018	WSA GW06	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											
WSA GW06	4/04/2019	WSA GW06	Normal	water								<10																											
WSA GW07	18/04/2018	WSA GW07	Normal	water																																			
WSA GW07	4/07/2018	WSA_GW07	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											
WSA GW07	4/07/2018	WSA GW07	Normal	water																																			
WSA GW07	6/09/2018	WSA GW07	Normal	water																																			
WSA GW07	6/09/2018	WSA GW07	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW07	13/12/2018	WSA GW07	Normal	water	<1	<1	<1	<1	<3	<1	<1			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW07	4/04/2019	WSA GW07	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10																											
WSA GW08	18/04/2018	WSA GW08	Normal	water																																			
WSA GW08	4/07/2018	WSA_GW08	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											
WSA GW08	4/07/2018	WSA GW08	Normal	water																																			
WSA GW08	6/09/2018	WSA GW08	Normal	water																																			
WSA GW08	6/09/2018	WSA GW08	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW08	6/09/2018	WSA GW08-B	Normal	water										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW08	13/12/2018	WSA GW08	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW08	4/04/2019	FD01	Field_D	water																																			
WSA GW08	4/04/2019	WSA GW08	Normal	water								<10																											
WSA GW14	19/04/2018	WSA GW14	Normal	water																																			
WSA GW14	5/07/2018	WSA_GW14	Normal	water								<100																											
WSA GW14	5/07/2018	WSA GW14	Normal	water																																			
WSA GW14	6/09/2018	WSA GW14	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW14	12/12/2018	WSA GW14	Normal	water								<100																											
WSA GW14	3/04/2019	WSA GW14	Normal	water								<10																											
WSA GW16	17/04/2018	WSA GW16	Normal	water																																			
WSA GW16	5/07/2018	WSA_GW16	Normal	water								<100																											
WSA GW16	5/07/2018	WSA GW16	Normal	water																																			
WSA GW16	7/09/2018	WSA GW16	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW16	12/12/2018	WSA GW16	Normal	water	<1	<1	<1	<1	<3	<1	<1																												
WSA GW16	3/04/2019	WSA GW16	Normal	water								<10																											
WSA GW17	19/04/2018	WSA GW17	Normal	water																																			
WSA GW17	3/07/2018	WSA_GW17	Normal	water								<100																											
WSA GW17	3/07/2018	WSA GW17	Normal	water																																			
WSA GW17	5/09/2018	WSA GW17	Normal	water																																			
WSA GW17	5/09/2018	WSA GW17	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW17	13/12/2018	WSA GW17	Normal	water								<100		<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW17	3/04/2019	WSA GW17	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW18	19/04/2018	WSA GW18	Normal	water																																			
WSA GW18	3/07/2018	WSA_GW18	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											

					MAH					Halogenate		Herbicides	PFAS																										
					1,2,4-trimethylbenzene	1,3,5-trimethylbenzene	Isopropylbenzene	Styrene	Total MAH	Bromomethane	Dichlorodifluoromethane	Dinoseb	Perfluoropropanesulfonic acid (PFPrS)	Perfluorobutane sulfonic acid (PFBS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorobutanoic acid (PFBA)	Perfluoropentanoic acid (PFPeA)	Perfluorohexanoic acid (PFHxA)	Perfluoroheptanoic acid (PFHpA)	Perfluorooctanoic acid (PFOA)	Perfluorononanoic acid (PFNA)	Perfluorodecanoic acid (PFDA)	Perfluoroundecanoic acid (PFUnDA)	Perfluorododecanoic acid (PFDoDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorooctane sulfonamide (FOSA)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	UG/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
WSA GW18	3/07/2018	WSA GW18	Normal	water																																			
WSA GW18	5/09/2018	FD02_180905	Field_D	water										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW18	5/09/2018	WSA GW18	Normal	water																																			
WSA GW18	5/09/2018	WSA GW18	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW18	13/12/2018	WSA GW18	Normal	water	<1	<1	<1	<1	<3	<1	<1			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW18	3/04/2019	WSA GW18	Normal	water																																			
WSA GW19	19/04/2018	WSA GW19	Normal	water																																			
WSA GW19	3/07/2018	WSA_GW19	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											
WSA GW19	3/07/2018	WSA GW19	Normal	water																																			
WSA GW19	7/09/2018	WSA GW19	Normal	water																																			
WSA GW19	7/09/2018	WSA GW19	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW19	14/12/2018	WSA GW19	Normal	water										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	0.07
WSA GW20	18/04/2018	WSA GW20	Normal	water																																			
WSA GW20	3/07/2018	WSA_GW20	Normal	water								<100																											
WSA GW20	3/07/2018	WSA_GW20	Normal	water																																			
WSA GW20	3/07/2018	WSA GW20	Normal	water																																			
WSA GW20	5/09/2018	WSA GW20	Normal	water																																			
WSA GW20	5/09/2018	WSA GW20	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW20	14/12/2018	WSA GW20	Normal	water										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	0.40
WSA GW20	3/04/2019	WSA GW20	Normal	water									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW21	18/04/2018	WSA GW21	Normal	water																																			
WSA GW21	3/07/2018	FD01_180703	Field_D	water																																			
WSA GW21	3/07/2018	WSA_GW21	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											
WSA GW21	3/07/2018	WSA GW21	Normal	water																																			
WSA GW21	5/09/2018	WSA GW21	Normal	water																																			
WSA GW21	5/09/2018	WSA GW21	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW21	14/12/2018	WSA GW21	Normal	water										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW21	3/04/2019	WSA GW21	Normal	water	<1	<1	<1	<1	<3	<1	<1																												
WSA GW22	17/04/2018	WSA GW22	Normal	water																																			
WSA GW22	5/07/2018	WSA_GW22	Normal	water								<100																											
WSA GW22	5/07/2018	WSA GW22	Normal	water																																			
WSA GW22	7/09/2018	WSA GW22	Normal	water																																			
WSA GW22	7/09/2018	WSA GW22	Normal	water								<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW22	12/12/2018	WSA GW22	Normal	water	<1	<1	<1	<1	<3	<1	<1	<100																											
WSA GW22	13/12/2018	FD01_121218	Field_D	water																																			
WSA GW22	13/12/2018	FD02_121218	Interlab_D	water																																			
WSA GW22	5/04/2019	WSA GW22	Normal	water								<10																											
WSA GW23	19/04/2018	WSA GW23	Normal	water																																			
WSA GW23	3/07/2018	WSA_GW23	Normal	water								<100																											
WSA GW23	3/07/2018	WSA GW23	Normal	water																																			
WSA GW23	5/09/2018	WSA GW23	Normal	water																																			
WSA GW23	5/09/2018	WSA GW23	Normal	water	<1	<1	<1	<1	<3	<1	<1	<10		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05
WSA GW23	13/12/2018	WSA GW23	Normal	water								<100		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	0.10
WSA GW23	3/04/2019	WSA GW23	Normal	water	<1	<1	<1	<1	<3	<1	<1		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05

Source of data
GHD 2019

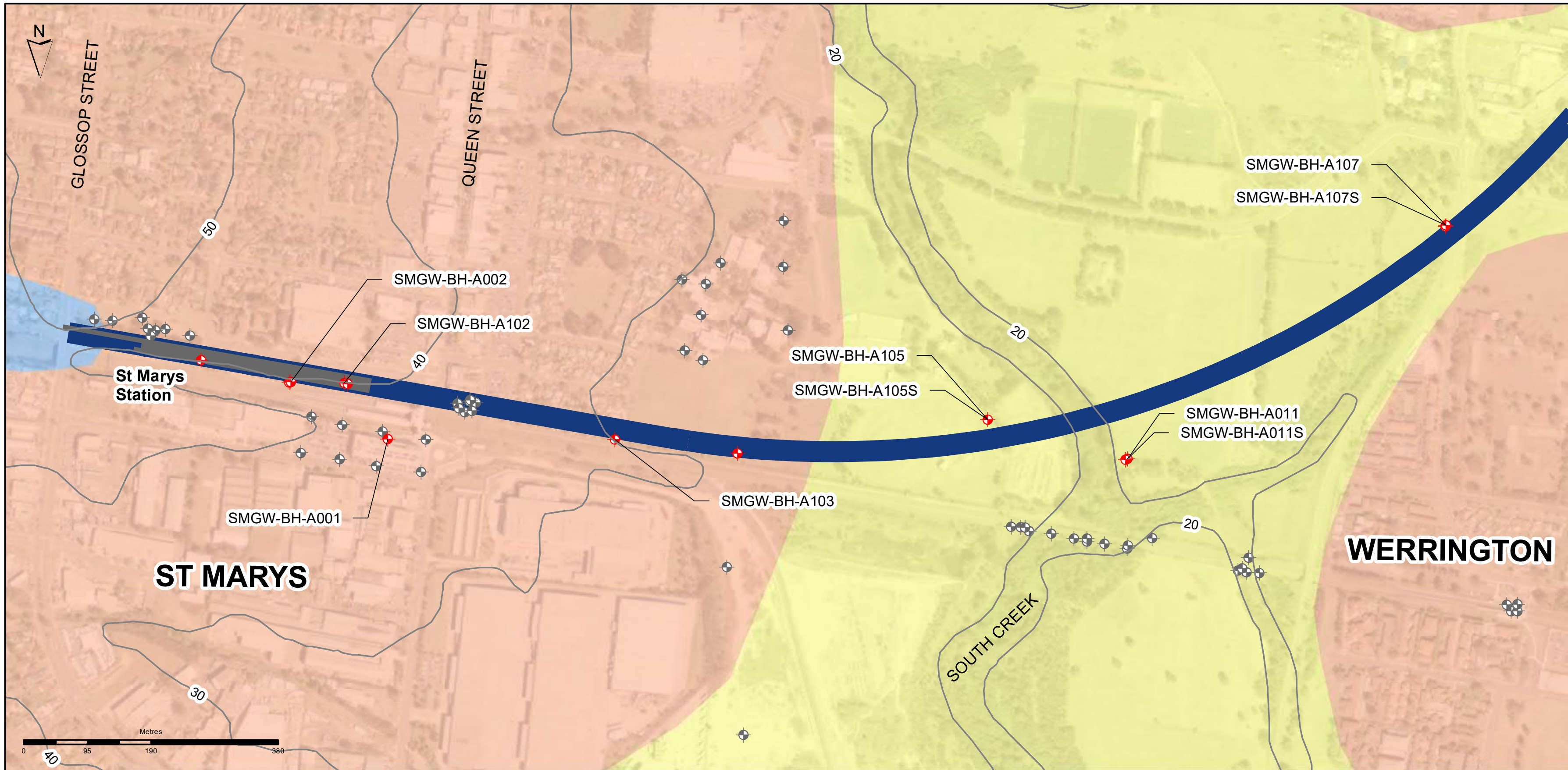
													Chlorinated Hydrocarbons																					
					8:2 Fluorotelomer sulfonic acid (8:2 FTS)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	PFAS (Sum of Total)	Sum of PFHxS and PFOS	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*	Perfluorononane sulfonate (PFNS)	Chlorinated hydrocarbons EPAVic	Other chlorinated hydrocarbons (Total)	1,1,1,2-tetrachloroethane	1,1,1-trichloroethane	1,1,2,2-tetrachloroethane	1,1,2-trichloroethane	1,1-dichloroethene	1,2-dichlorobenzene	1,2-dichloroethane	1,2-dichloropropane	1,3-dichloropropane	1,4-dichlorobenzene	4-chlorotoluene	Bromobenzene	Bromochloromethane	Carbon tetrachloride	Chlorobenzene	Chloroform	Chloromethane	cis-1,2-dichloroethene	Methylene chloride	Vinyl chloride
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Location Code	Date	Field ID	Sample Type	Matrix Type																														
WSA GW01	17/04/2018	WSA GW01	Normal	water																														
WSA GW01	5/07/2018	WSA_GW01	Normal	water																														
WSA GW01	5/07/2018	WSA GW01	Normal	water																														
WSA GW01	5/09/2018	FD01_180905	Field_D	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW01	5/09/2018	WSA GW01	Normal	water																														
WSA GW01	5/09/2018	WSA GW01	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW01	13/12/2018	WSA GW01	Normal	water	<0.01	<0.01	0.1	0.01	0.1	0.01	0.01																							
WSA GW01	5/04/2019	WSA GW01	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01	<0.01	<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW04	18/04/2018	WSA GW04	Normal	water																														
WSA GW04	4/07/2018	FD02_180704	Field_D	water																														
WSA GW04	4/07/2018	WSA_GW04	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW04	4/07/2018	WSA GW04	Normal	water																														
WSA GW04	6/09/2018	WSA GW04	Normal	water																														
WSA GW04	6/09/2018	WSA GW04	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW04	12/12/2018	WSA GW04	Normal	water																														
WSA GW04	4/04/2019	WSA GW04	Normal	water																														
WSA GW05	18/04/2018	WSA GW05	Normal	water																														
WSA GW05	4/07/2018	WSA_GW05	Normal	water																														
WSA GW05	4/07/2018	WSA GW05	Normal	water																														
WSA GW05	6/09/2018	WSA GW05	Normal	water																														
WSA GW05	6/09/2018	WSA GW05	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW05	13/12/2018	WSA GW05	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW05	4/04/2019	FD02	Interlab_D	water																														
WSA GW05	4/04/2019	WSA GW05	Normal	water																														
WSA GW06	18/04/2018	WSA GW06	Normal	water																														
WSA GW06	4/07/2018	WSA_GW06	Normal	water																														
WSA GW06	4/07/2018	WSA GW06	Normal	water																														
WSA GW06	6/09/2018	WSA GW06	Normal	water																														
WSA GW06	6/09/2018	WSA GW06	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW06	6/09/2018	WSA GW06-M	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW06	12/12/2018	WSA GW06	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW06	4/04/2019	WSA GW06	Normal	water																														
WSA GW07	18/04/2018	WSA GW07	Normal	water																														
WSA GW07	4/07/2018	WSA_GW07	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW07	4/07/2018	WSA GW07	Normal	water																														
WSA GW07	6/09/2018	WSA GW07	Normal	water																														
WSA GW07	6/09/2018	WSA GW07	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW07	13/12/2018	WSA GW07	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW07	4/04/2019	WSA GW07	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW08	18/04/2018	WSA GW08	Normal	water																														
WSA GW08	4/07/2018	WSA_GW08	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW08	4/07/2018	WSA GW08	Normal	water																														
WSA GW08	6/09/2018	WSA GW08	Normal	water																														
WSA GW08	6/09/2018	WSA GW08	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW08	6/09/2018	WSA GW08-B	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW08	13/12/2018	WSA GW08	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW08	4/04/2019	FD01	Field_D	water																														
WSA GW08	4/04/2019	WSA GW08	Normal	water																														
WSA GW14	19/04/2018	WSA GW14	Normal	water																														
WSA GW14	5/07/2018	WSA_GW14	Normal	water																														
WSA GW14	5/07/2018	WSA GW14	Normal	water																														
WSA GW14	6/09/2018	WSA GW14	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW14	12/12/2018	WSA GW14	Normal	water																														
WSA GW14	3/04/2019	WSA GW14	Normal	water																														
WSA GW16	17/04/2018	WSA GW16	Normal	water																														
WSA GW16	5/07/2018	WSA_GW16	Normal	water																														
WSA GW16	5/07/2018	WSA GW16	Normal	water																														
WSA GW16	7/09/2018	WSA GW16	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW16	12/12/2018	WSA GW16	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW16	3/04/2019	WSA GW16	Normal	water																														
WSA GW17	19/04/2018	WSA GW17	Normal	water																														
WSA GW17	3/07/2018	WSA_GW17	Normal	water																														
WSA GW17	3/07/2018	WSA GW17	Normal	water																														
WSA GW17	5/09/2018	WSA GW17	Normal	water																														
WSA GW17	5/09/2018	WSA GW17	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW17	13/12/2018	WSA GW17	Normal	water	<0.01	<0.01	<0.1	0.01	<0.05	0.01	0.01																							
WSA GW17	3/04/2019	WSA GW17	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01	<0.01	<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW18	19/04/2018	WSA GW18	Normal	water																														
WSA GW18	3/07/2018	WSA_GW18	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1

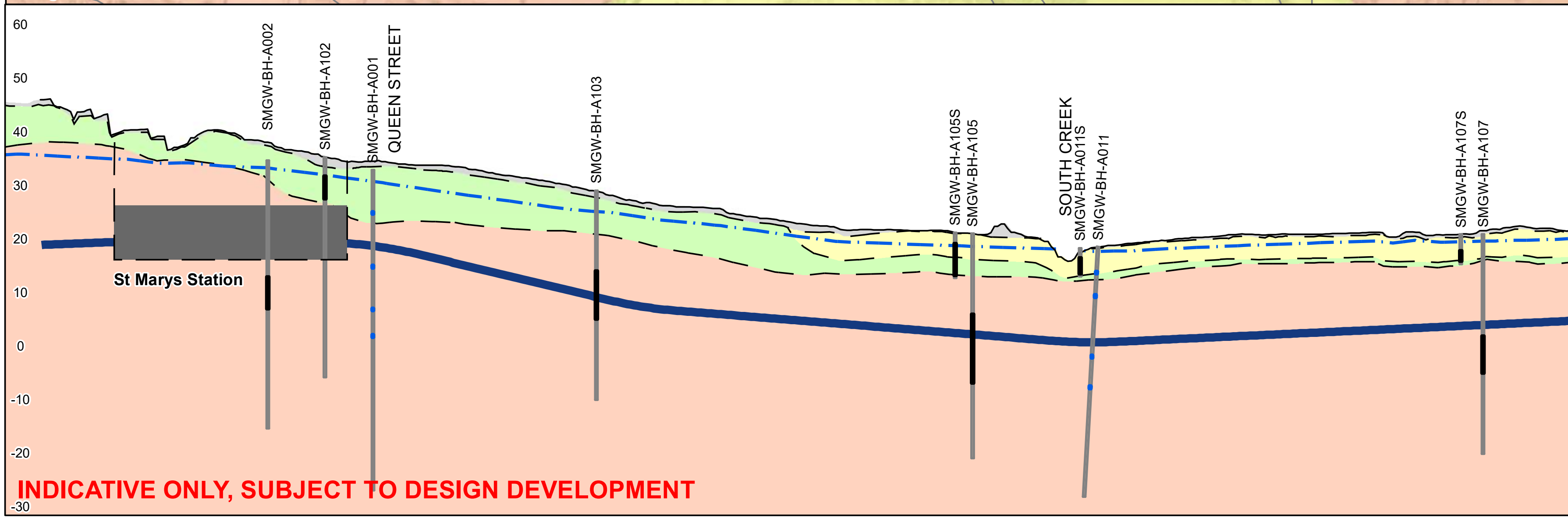
													Chlorinated Hydrocarbons																					
					8:2 Fluorotelomer sulfonic acid (8:2 FTS)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	PFAS (Sum of Total)	Sum of PFHxS and PFOS	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*	Perfluorononane sulfonate (PFNS)	Chlorinated hydrocarbons EPAVic	Other chlorinated hydrocarbons (Total)	1,1,1,2-tetrachloroethane	1,1,1-trichloroethane	1,1,2,2-tetrachloroethane	1,1,2-trichloroethane	1,1-dichloroethene	1,2-dichlorobenzene	1,2-dichloroethane	1,2-dichloropropane	1,3-dichloropropane	1,4-dichlorobenzene	4-chlorotoluene	Bromobenzene	Bromochloromethane	Carbon tetrachloride	Chlorobenzene	Chloroform	Chloromethane	cis-1,2-dichloroethene	Methylene chloride	Vinyl chloride
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
WSA GW18	3/07/2018	WSA GW18	Normal	water																														
WSA GW18	5/09/2018	FD02_180905	Field_D	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW18	5/09/2018	WSA GW18	Normal	water																														
WSA GW18	5/09/2018	WSA GW18	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW18	13/12/2018	WSA GW18	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW18	3/04/2019	WSA GW18	Normal	water																														
WSA GW19	19/04/2018	WSA GW19	Normal	water																														
WSA GW19	3/07/2018	WSA_GW19	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW19	3/07/2018	WSA GW19	Normal	water																														
WSA GW19	7/09/2018	WSA GW19	Normal	water																														
WSA GW19	7/09/2018	WSA GW19	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW19	14/12/2018	WSA GW19	Normal	water	<0.01	<0.01	<0.1	<0.01	0.07	<0.01	<0.01																							
WSA GW20	18/04/2018	WSA GW20	Normal	water																														
WSA GW20	3/07/2018	WSA_GW20	Normal	water																														
WSA GW20	3/07/2018	WSA_GW20	Normal	water																														
WSA GW20	3/07/2018	WSA GW20	Normal	water																														
WSA GW20	5/09/2018	WSA GW20	Normal	water																														
WSA GW20	5/09/2018	WSA GW20	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW20	14/12/2018	WSA GW20	Normal	water	<0.01	<0.01	0.4	<0.01	0.4	<0.01	<0.01																							
WSA GW20	3/04/2019	WSA GW20	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01	<0.01																						
WSA GW21	18/04/2018	WSA GW21	Normal	water																														
WSA GW21	3/07/2018	FD01_180703	Field_D	water																														
WSA GW21	3/07/2018	WSA_GW21	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW21	3/07/2018	WSA_GW21	Normal	water																														
WSA GW21	5/09/2018	WSA GW21	Normal	water																														
WSA GW21	5/09/2018	WSA GW21	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW21	14/12/2018	WSA GW21	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW21	3/04/2019	WSA GW21	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW22	17/04/2018	WSA GW22	Normal	water																														
WSA GW22	5/07/2018	WSA_GW22	Normal	water																														
WSA GW22	5/07/2018	WSA GW22	Normal	water																														
WSA GW22	7/09/2018	WSA GW22	Normal	water																														
WSA GW22	7/09/2018	WSA GW22	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01																							
WSA GW22	12/12/2018	WSA GW22	Normal	water									<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW22	13/12/2018	FD01_121218	Field_D	water																														
WSA GW22	13/12/2018	FD02_121218	Interlab_D	water																														
WSA GW22	5/04/2019	WSA GW22	Normal	water																														
WSA GW23	19/04/2018	WSA GW23	Normal	water																														
WSA GW23	3/07/2018	WSA_GW23	Normal	water																														
WSA GW23	3/07/2018	WSA GW23	Normal	water																														
WSA GW23	5/09/2018	WSA GW23	Normal	water																														
WSA GW23	5/09/2018	WSA GW23	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01		<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1
WSA GW23	13/12/2018	WSA GW23	Normal	water	<0.01	<0.01	0.1	<0.01	0.1	<0.01	<0.01																							
WSA GW23	3/04/2019	WSA GW23	Normal	water	<0.01	<0.01	<0.1	<0.01	<0.05	<0.01	<0.01	<0.01	<5	<5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<1	<1

Source of data
GHD 2019

Appendix E

Geological Long Section





Plan Legend

- Ground Surface Elevation (10m AHD)
- Indicative Alignment (V8.5)
- Station Box
- Project Specific Boreholes
- Historical Boreholes
- Quaternary Alluvium
- Bringelly Shale Formation
- St Marys Formation

*Only boreholes with groudwater monitoring are labelled on plan.

Section Legend

- Indicative Alignment (V8.5)
- Station Box
- Indicative Groundwater Level
- Geological Boundary
- Fill / Top Soil
- Quaternary Alluvium
- Residual Soil
- Bringelly Shale Formation

Groundwater Monitoring Installation

- Standpipe Screened Section
- Vibrating Wire Piezometer

Notes:

1) Aerial Imagery from SixMap, Spatial Services, NSW Department of Finance and Services (accessed on 2020). Geological mapping (plan) based on the NSW Seamless Geology Data Package (version 2) released by Geological Survey of NSW in 2020.
2) Locations of historical geotechnical investigation and project specific geotechnical investigation are shown on the plan. Only groundwater monitoring locations used to develop the hydrogeological model are presented on the section line.
3) Indicative groundwater level is provided based on the available groundwater monitoring data up to May 2020.
4) For monitoring instrumentation details please refer to Appendix A of the Groundwater Technical Paper.

Issue	Date	By	Chkd	Appd
D1	2020-08-27	LJ	FC	JH

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Job Title
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Drawing Title
Geological Long Section - St Marys to Orchard Hills (Sheet 1)

Section Scale at A3	Plan Scale at A3
1:7000 (H) 1:875 (V)	1:7000

Job No	Drawing Status
272467	Preliminary

Drawing No	Issue
Figure E1.1	D1

16/09/2020 9:44:18 AM

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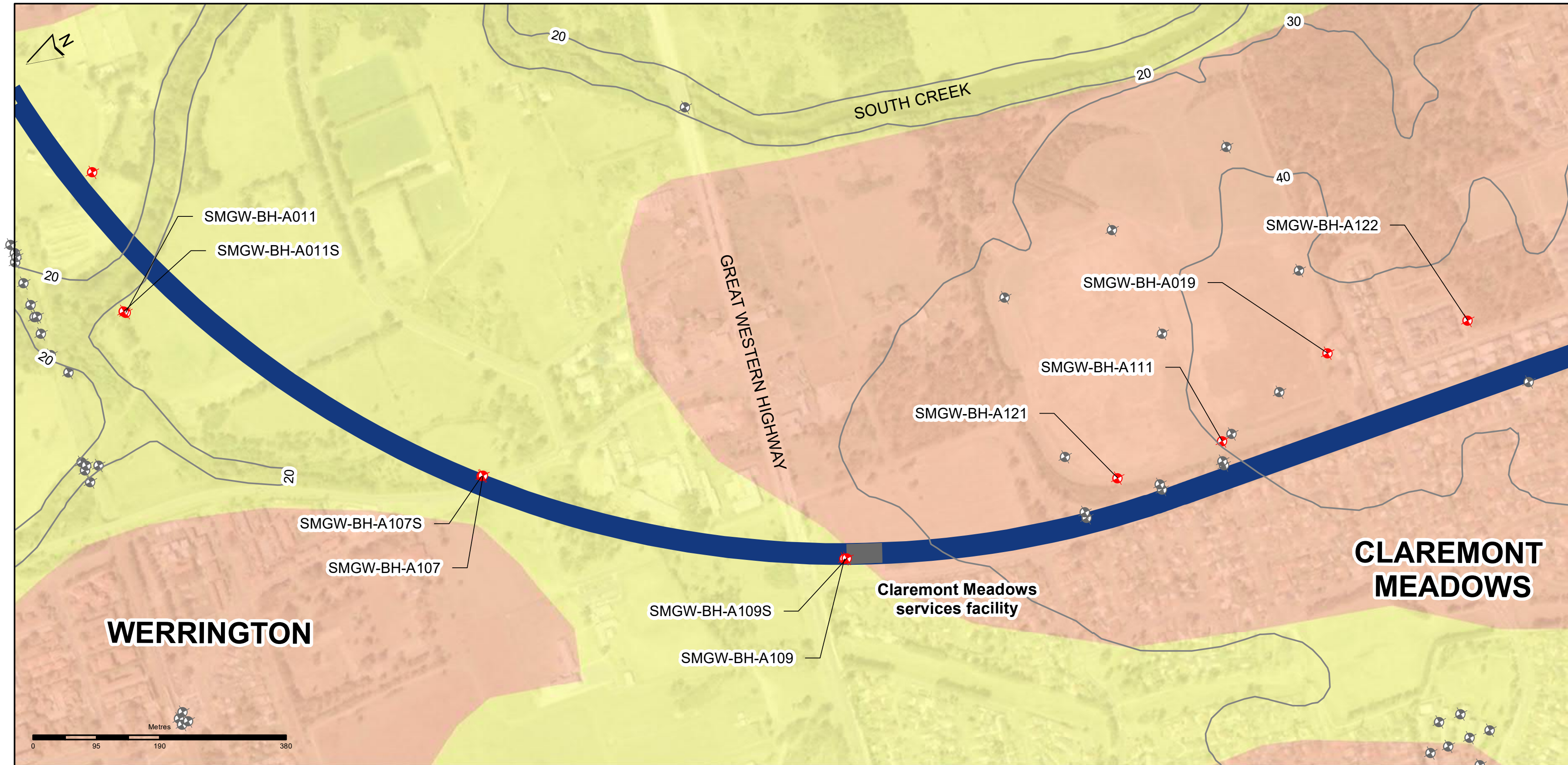

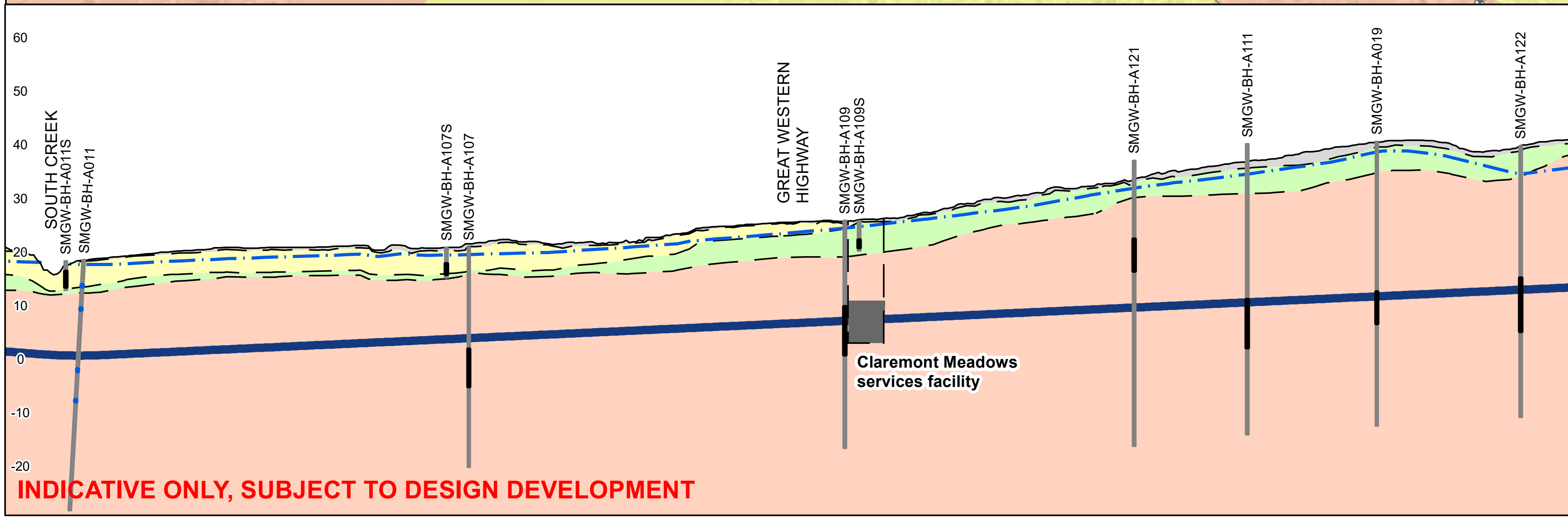

Plan Legend

- Ground Surface Elevation (10m AHD)
- Indicative Alignment (V8.5)
- Station Box
- Project Specific Boreholes
- Historical Boreholes
- Quaternary Alluvium
- Bringelly Shale Formation

*Only boreholes with groudwater monitoring are labelled on plan.

Section Legend

- Indicative Alignment (V8.5)
- Station Box
- Indicative Groundwater Level
- Geological Boundary
- Fill / Top Soil
- Quaternary Alluvium
- Residual Soil
- Bringelly Shale Formation

Groundwater Monitoring Installation

- Standpipe Screened Section
- Vibrating Wire Piezometer

Notes:

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4) For monitoring instrumentation details please refer to Appendix A of the Groundwater Technical Paper.

Issue	Date	By	Chkd	Appd
P0	2020-08-27	LJ	FC	JH

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Drawing Title
Geological Long Section - St Marys to Orchard Hills (Sheet 2)

Section Scale at A3
1:7000 (H) 1:875 (V)

Plan Scale at A3
1:7000

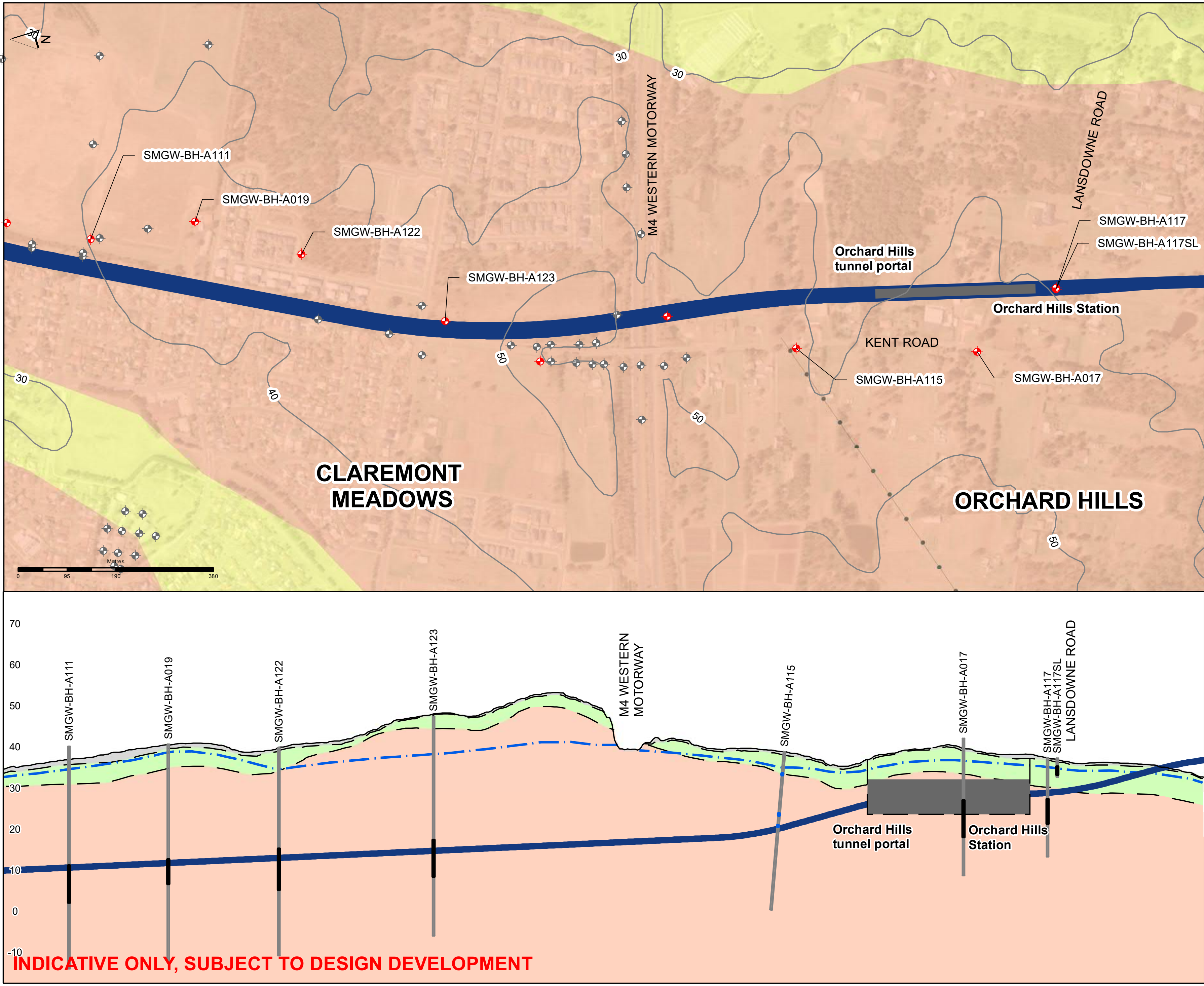
Job No
272467

Drawing Status
Preliminary

Drawing No
Figure E1.2

Issue
P0

16/09/2020 9:43:29 AM



Plan Legend

- Ground Surface Elevation (10m AHD)
- Indicative Alignment (V8.5)
- Station Box
- Project Specific Boreholes
- Historical Boreholes
- Dykes
- Quaternary Alluvium
- Bringelly Shale Formation

*Only boreholes with groudwater monitoring are labelled on plan.

Section Legend

- Indicative Alignment (V8.5)
- Station Box
- Indicative Groundwater Level
- Geological Boundary
- Fill / Top Soil
- Residual Soil
- Bringelly Shale Formation

Groundwater Monitoring Installation

- Standpipe Screened Section
- Vibrating Wire Piezometer

Notes:

1) Aerial Imagery from SixMap, Spatial Services, NSW Department of Finance and Services (accessed on 2020). Geological mapping (plan) based on the NSW Seamless Geology Data Package (version 2) released by Geological Survey of NSW in 2020.
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Issue	Date	By	Chkd	Appd
P0	2020-08-27	LJ	FC	JH

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Drawing Title
Geological Long Section - St Marys to Orchard Hills (Sheet 3)

Section Scale at A3: **1:7000 (H) 1:875 (V)**
Plan Scale at A3: **1:7000**

Job No: **272467**
Drawing Status: **Preliminary**

Drawing No: **Figure E1.3**
Issue: **P0**

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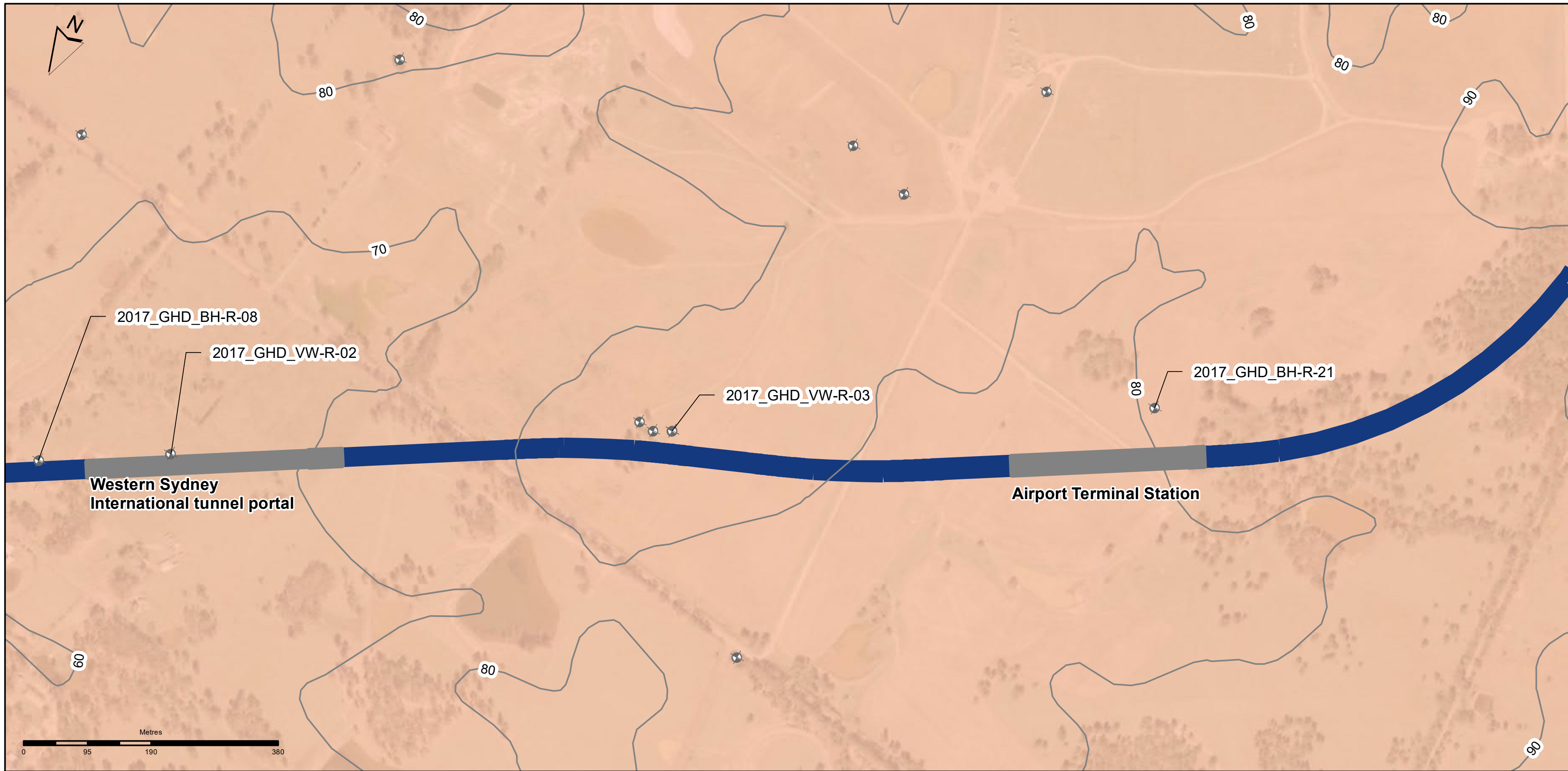

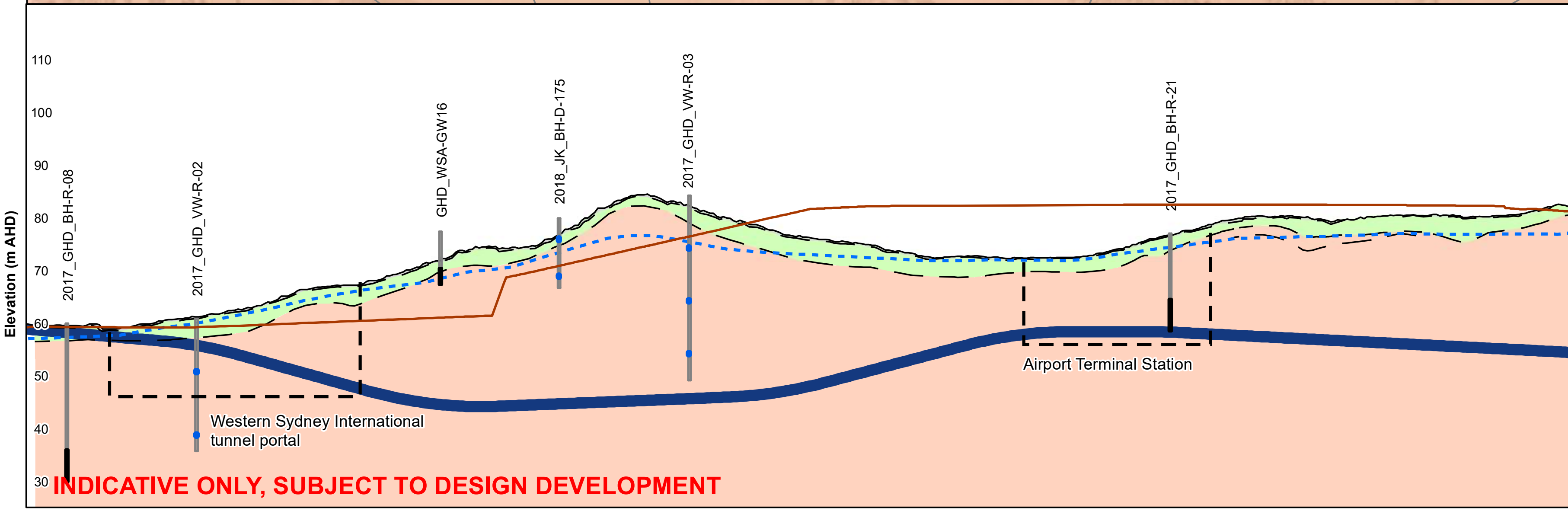

Plan Legend

- Ground Surface Elevation (10m AHD)
- Indicative Alignment (V8.5)
- Historical Boreholes
- Bringelly Shale Formation

*Only boreholes with groudwater monitoring are labelled on plan.

Section Legend

- Finished Surface Level
- Indicative Alignment (V8.5)
- Excavation_Extent
- Indicative GW Level
- Geological Boundary
- Fill / Topsoil
- Residual Soil
- Bringelly Shale Formation

Groundwater Monitoring Installation

- Standpipe Screened Section
- Vibrating Wire Piezometer

Notes:

1) Aerial Imagery from SixMap, Spatial Services, NSW Department of Finance and Services (accessed on 2020). Geological mapping (plan) based on the NSW Seamless Geology Data Package (version 2) released by Geological Survey of NSW in 2020.
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3) Indicative groundwater level is provided based on the available groundwater monitoring data up to May 2020.
4) For monitoring instrumentation details please refer to Appendix A of the Groundwater Technical Paper.
5) Some groundwater monitoring installations shown on the section are significantly offset from the alignment and are outside the extent of plan.

Issue	Date	By	Chkd	Appd
P0	2020-08-28	LJ	FC	JH

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Client
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Job Title
Sydney Metro - Western Sydney Airport

Drawing Title
Geological Long Section – Western Sydney International to Aerotropolis Core Station (Sheet 1)

Section Scale at A3	Plan Scale at A3
1:7000 (H) 1:875 (V)	1:7000

Job No	Drawing Status
272467	Preliminary

Drawing No	Issue
Figure E2.1	P0

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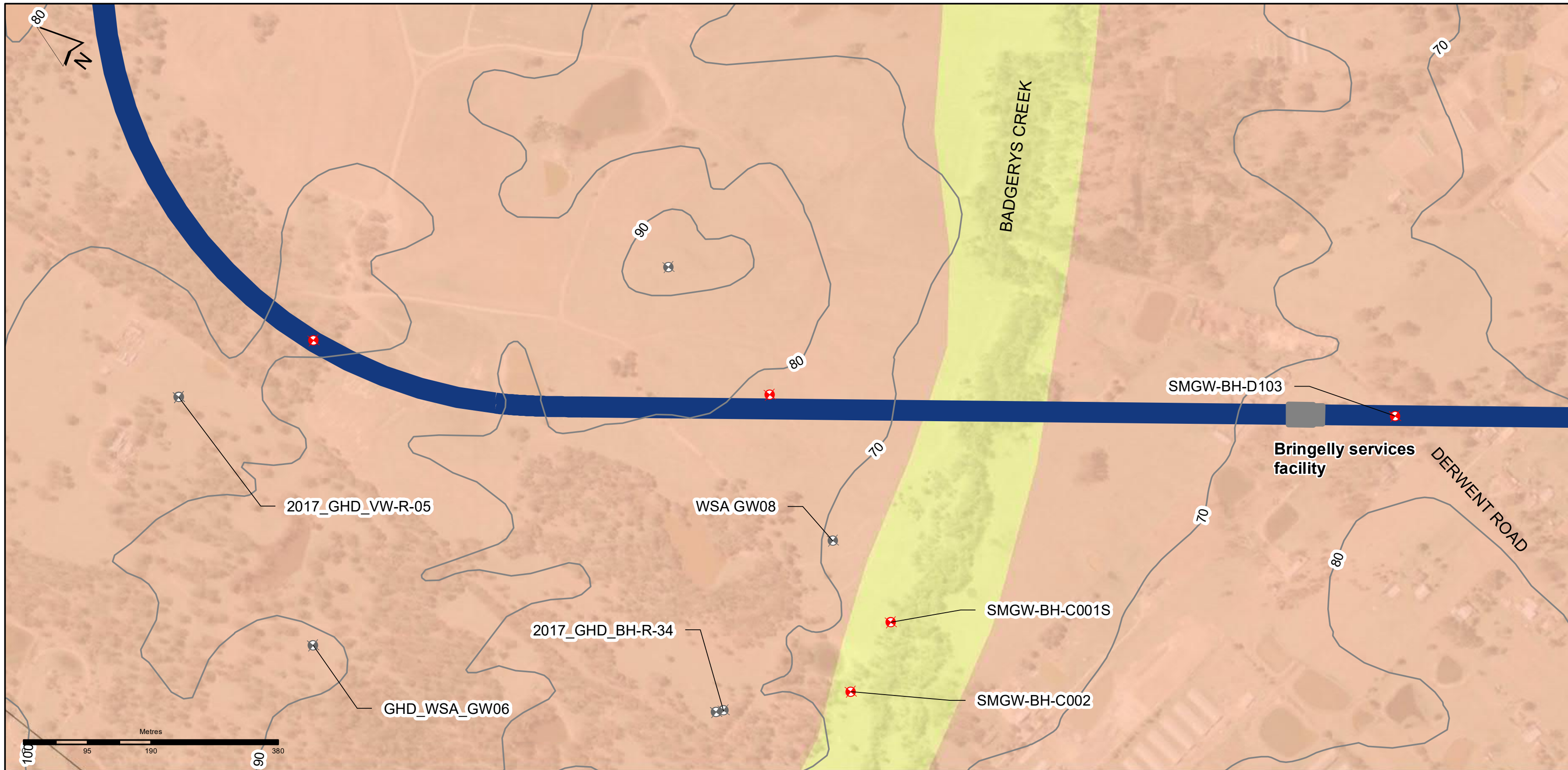

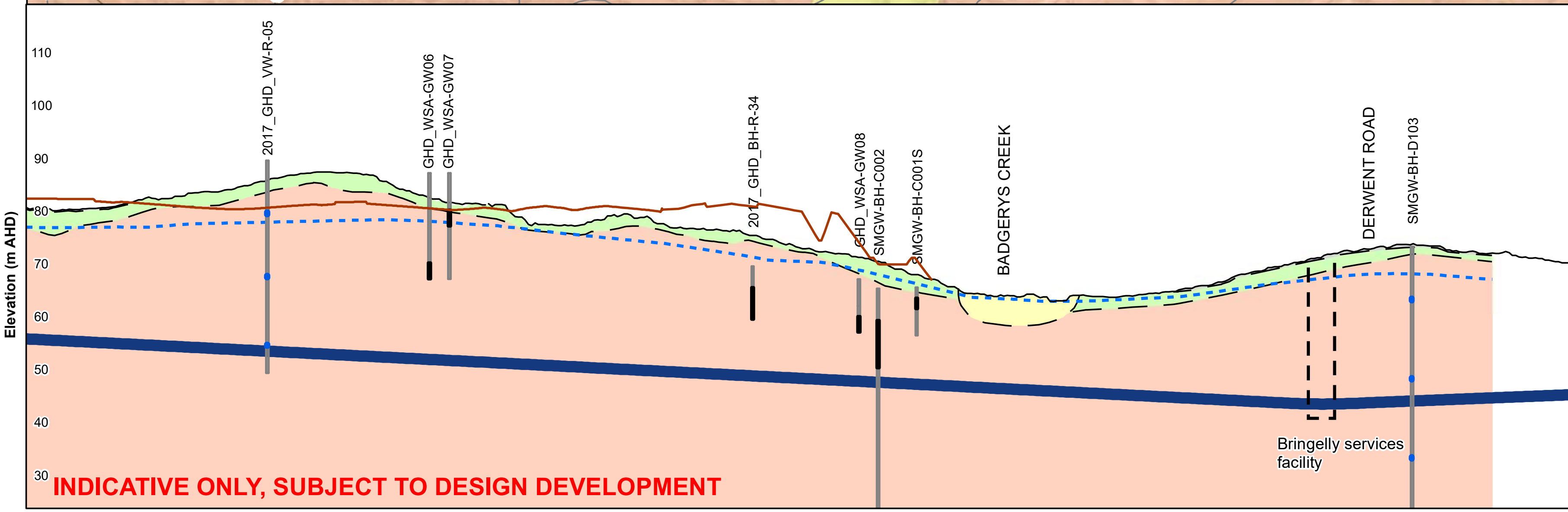

Plan Legend

- Ground Surface Elevation (10m AHD)
- Indicative Alignment (V8.5)
- Project Specific Boreholes
- Historical Boreholes
- Quaternary Alluvium
- Bringelly Shale Formation

*Only boreholes with groudwater monitoring are labelled on plan.

Section Legend

- Finished Surface Level
- Indicative Alignment (V8.5)
- Excavation_Extent
- Indicative GW Level
- Geological Boundary
- Fill / Topsoil
- Quaternary Alluvium
- Residual Soil
- Bringelly Shale Formation

Groundwater Monitoring Installation

- Standpipe Screened Section
- Vibrating Wire Piezometer

Notes:

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Issue	Date	By	Chkd	Appd
P0	2020-08-28	LJ	FC	JH

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Client
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Job Title
Sydney Metro - Western Sydney Airport

Drawing Title
Geological Long Section – Western Sydney International to Aerotropolis Core Station (Sheet 2)

Section Scale at A3	Plan Scale at A3
1:7000 (H) 1:875 (V)	1:7000

Job No	Drawing Status
272467	Preliminary

Drawing No	Issue
Figure E2.2	P0

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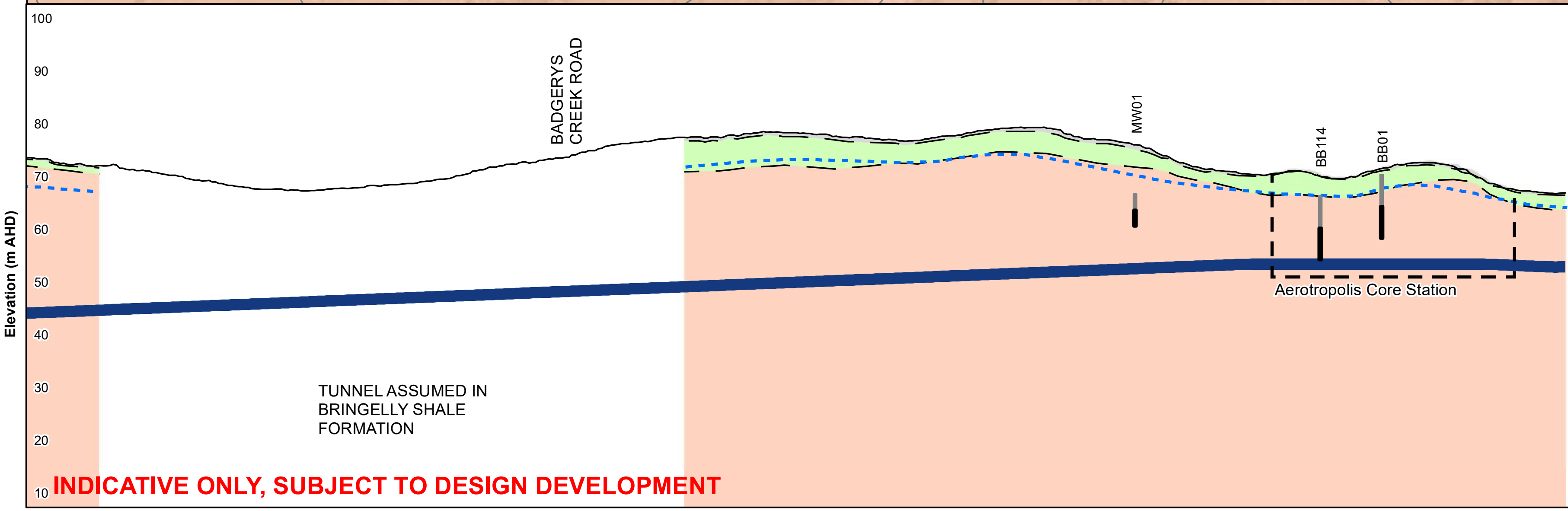

Plan Legend

- Ground Surface Elevation (10m AHD)
- Indicative Alignment (V8.5)
- Station Box
- Historical Boreholes
- Quaternary Alluvium
- Bringelly Shale Formation

*Only boreholes with groundwater monitoring are labelled on plan.

Section Legend

- Indicative Alignment (V8.5)
- Excavation_Extent
- Indicative GW Level
- Geological Boundary
- Fill / Topsoil
- Residual Soil
- Bringelly Shale Formation

Groundwater Monitoring Installation

- Standpipe Screened Section
- Vibrating Wire Piezometer

Notes:

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Issue	Date	By	Chkd	Appd
P0	2020-08-28	LJ	FC	JH

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Drawing Title
Geological Long Section – Western Sydney International to Aerotropolis Core Station (Sheet 3)

Section Scale at A3
1:7000 (H) 1:875 (V)

Plan Scale at A3
1:7000

Job No
272467

Drawing Status
Preliminary

Drawing No
Figure E2.3

Issue
P0

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