WestConnex New M5

CPB CONTRACTORS | DRAGADOS | SAMSUNG C&T

Water Reuse Strategy - Construction Phase

Project Name: WestConnex New M5

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Details of Revision Amendments

Document Control

The Project Director is responsible for ensuring that this Strategy is reviewed and approved. The Support Services Director is responsible for updating this Strategy to reflect changes to the Project, legal and other requirements, as required.

Amendments

Any revisions or amendments must be approved by the Project Director before being distributed or implemented.

Revision Details

Revision	Date	Details
00	08/09/16	Prepared for internal review
01	14/10/16	Updated to address DP&E comments. For DP&E approval
02	24/10/16	Updated to address RMS & SMC comments. For RMS & SMC approval.
03	03/11/16	Updated to address further comments from DP&E.
04	17/11/16	Updated to address further comments from DP&E.
05	09/02/18	Updated to address further comments from DP&E, incorporate findings from ER audit and update outcomes from groundwater reuse investigations.

Contents

1. Introduction

1.1 Project Description

WestConnex is one of the NSW Government's key infrastructure projects which aims to ease congestion, create jobs and connect communities. It is the largest integrated transport and urban revitalisation project in Australia.

The 33 kilometre project was a key recommendation of the State Infrastructure Strategy released in October 2012. It brings together a number of important road projects which together form a vital link in Sydney's Orbital Network. They include a widening of the M4 east of Parramatta, a duplication of the M5 East and new sections of motorway to provide a connection between the two key corridors.

Figure 1 WestConnex project map

WestConnex will support Sydney's long term growth and boost the city's economic productivity. It will:

- Provide quicker, more reliable trips between Western Sydney and the Port Botany/Sydney Airport precinct to support Sydney's urban freight task
- Help distribute traffic across the wider road network, removing bottlenecks and relieving congestion for local trips
- Provide better connections along the M4 and M5 corridors to cater for the forecast growth in employment and population along these routes
- Allow urban revitalisation and increase opportunities for active and public transport along and across Parramatta Road.

The WestConnex project includes a number of stages:

- Stage 1a – M4 Widening
- Stage 1b – M4 East
- Stage 2 – New M5

- Stage 3 – M4-M5 Link

In November 2015, the Sydney Motorway Corporation (SMC) awarded the CPB Contractors Dragados Samsung Joint Venture (CDS JV) the contract for the design and construction of Stage 2 – New M5. The New M5 will run from the existing M5 East corridor at Beverly Hills via a tunnel to St Peters, providing improved access to the airport, south Sydney and Port Botany precincts.

Key features of the New M5 include:

- New twin tunnels which are higher, wider and flatter. These will more than double capacity along the M5 East corridor and provide motorway access to north of Sydney Airport
- A new interchange at an industrial site at St Peters, which reduces the impact on nearby residential areas
- Connections from the interchange to key roads in the area, including Campbell Road/Street, Euston Road and across the canal to Bourke Road
- Widening of Campbell Road/Street and Euston Road through existing road widening reservations
- Western tunnel entry and exit points at Kingsgrove.

1.2 Purpose of this Strategy

CDS-JV has prepared this Water Reuse Strategy in accordance with Condition of Approval (CoA) B30 of the infrastructure Approval for the New M5 Project.

The purpose of the Strategy is to:

- Detail the use of water on the project through the construction phase;
- Investigate and evaluate all feasible reuse options for stormwater and groundwater; and
- Address the requirements of the CoA.

1.3 Scope of this Strategy

This strategy addresses the water use requirements and reuse options for the construction phase of the New M5 tunnel. Water reuse is limited to groundwater and stormwater collected within the project boundaries.

This Strategy addresses and details the following issues:

- Water use requirements for surface works;
- Water use requirements for tunnelling works;
- Stormwater collection, management and discharge during surface works construction activities; and
- Groundwater management throughout the tunnelling works, including treatment, storage and discharge.

This Strategy does not consider the:

- Treatment and reuse of sewerage;
- Treatment and reuse of leachate ‘contaminated groundwater’ from the Alexandria Landfill Treatment Plant; and
- Operational water reuse - an operational phase Water Reuse Strategy will be prepared separately prior to commencement of operation of the project.

1.3.1 Compliance with CoA B30

A Water Reuse Strategy is required by CoA B30. A description of compliance with the requirements of this CoA is provided in

Table 1 below.

Table 1: Compliance with CoA B30

CoA B30 Requirement	Where addressed
The Proponent must prepare a Water Reuse Strategy which sets out feasible and reasonable options for the reuse of collected stormwater and groundwater during construction and operation of the SSI. The Water Reuse Strategy must include, but not be limited to:	This Strategy addresses the construction phase of the project. A separate strategy will be prepared for the operational phase of the project.
(a) evaluation of all feasible and reasonable reuse options;	Section 4
(b) details on the preferred reuse option(s), including volumes of water to be reuse, proposed reuse locations and/or activities, proposed treatment (if required), and any additional licences or approvals that may be required; and	Section 4
(c) a time frame for the implementation of the preferred reuse option(s).	Section 4
Justification must be provided in the event that it is concluded that no feasible or reasonable reuse options prevail.	Section 4
A copy of the Water Reuse Strategy must be submitted to the Secretary for approval prior to commencement of tunnelling works. Nothing in this condition prevents the Proponent from preparing separate Water Reuse Strategies for the construction and operational phases of the SSI. Where a separate Strategy is prepared for the operation of the SSI, this must be submitted to the Secretary for approval at least six months prior to the commencement of operation of the SSI.	This Strategy addresses the construction phase of the project. The operational phase Water Reuse Strategy will be submitted for approval at least 6 months prior to the commencement of operation.

1.3.2 Revised environmental management measures

In addition to the requirements of CoA B30, this Strategy has also been prepared with consideration of the revised environmental management measures (REMMs) listed in the New M5 Submissions and Preferred Infrastructure Report (SPIR).REMMS that relate to this Strategy are provided in Table **2**.

Table 2: Revised environmental management measures identified in the New M5 SPIR that relate to water reuse

Reference	Requirement	Where addressed
REMM GW07	Treated waste water would be stored and re-used for project purposes wherever possible. Groundwater reuse would be in accordance with the policies of sustainable water use of the NSW Office of Water, such as dust suppression and earthworks.	Section 4
REMM WM16	Feasible and reasonable opportunities for wastewater reuse on-site or for construction purposes would be pursued (such as dust suppression both in the tunnels and for surface works).	Section 4

1.4 Objectives and Targets

The water reuse targets in Table 3 relate to the overall targets identified in the New M5 Sustainability Plan (M5N-ES-PLN-PWD-0020). The targets for water reuse were developed with consideration to the particular constraints for each surface site. Constraints for the project include: water quality requirements for plant and equipment and potential for surface water contamination at the St Peters Interchange site.

Table 3: Project sustainability targets for water reuse

Metric / measure	Target	Timeframe	Accountability	Documentation / reporting
Percentage of potable water demand which is sourced from non-potable water sources during construction	15%	Average over construction period	Project Manager	Quarterly Sustainability Report
Percentage of water (rainwater, stormwater, wastewater, groundwater, tunnel inflow water) generated/collected during construction which is reused, recycled or reclaimed.	15%	Average over construction period	Project Manager	Quarterly Sustainability Report

Examples of non-potable replacement of potable demand may include the use of treated groundwater in surface operations, such as dust suppression. Non-potable water may also, in some cases, replace potable water for the flushing of ablution facilities or plant and equipment wash down.

1.5 Environment Protection Licence

The water reuse options identified within this document have been assessed against the current environment protection licences for the project - EPLs No. 20772 and No. 4627.

A variation to the project EPLs No. 20772 and No. 4627 will be sought from the EPA to permit discharge of groundwater from the construction tunnelling water treatment plants. The on-site reuse of water proposed within this strategy does not require an EPL variation, but it will allow for the operation of the construction water treatment plants and subsequently for the utilisation of treated water.

1.6 Alexandria Landfill Leachate Water Treatment Plant

At the St Peters Interchange (SPI) worksite, landfill leachate and/or contaminated stormwater is directed to the Alexandria Landfill Leachate Treatment Plant (LTP). Discharge from the LTP is in accordance with the Trade Waste Agreement with Sydney Water to sewer (Ref: 32539, dated 25 July 2016).

A new Leachate Management System will be installed for the Alexandria Landfill in accordance with the Alexandria Landfill Closure Management Plan, as part of the project. Management of the upgraded Alexandria Landfill LTP during the operational phase will be addressed in the Water Reuse Strategy – Operational Phase.

1.7 Other Approvals

Aquifer Interference approvals have not yet commenced under the *Water Management Act 2000* but may be required to be obtained for the operational phase of the project. Consultation is ongoing with DPI (Water) in regards to ongoing licensing requirements under this Act.

1.8 Associated plans and reference documents

The Water Reuse Strategy has been developed in accordance with the project documents and approvals listed below. This strategy supports, but does not replace or supersede the following documents:

- New M5 Environmental Impact Statement;
- New M5 Submissions Report
- New M5 Construction Environmental Management Plan (M5N-ES-PLN-PWD-0001);
- New M5 Sustainability Plan (M5N-ES-PLN-PWD-0020);
- Water Quality Plan and Monitoring Program (M5N-ES-PLN-PWD-0027);

- Environment Protection Licences No. 20772 and No. 4627;
- Technical Report – Groundwater & Soil Salinity Report (M5N-GOL-TER-100-200-GT-1520);
- Technical Report – Hydrogeological Design Report (M5N-GOL-TER-100-200-GT-1525).

2. Water Requirements

2.1 Construction phase water requirements

The balance of water quality and availability is an essential component of construction. Water, both potable and non-potable, is a vital requirement for the construction of the New M5 project and is required to sustain the health and well-being of the project workforce. All surface water reuse and discharge will be managed in accordance with the Construction Soil and Water Quality Sub-Plan Section 7.5 (M5N-ES-PLN-PWD-0005). Testing and, where necessary, treatment of any construction water or Water Treatment Plant (WTP) water will be undertaken in accordance with Section 5 of the Water Quality Plan and Monitoring Program (M5N-ES-PLN-PWD-0027).

The EIS identifies a series of construction activities that will require water and estimates the total quantity of potable and non-potable water used in the construction of the project at 2,500 megalitres. As detailed design has progressed and construction planning has advanced, the water requirements for both surface and tunnelling works have been refined as outlined in Table 6. CDS-JV has used the detailed design process to assess the potential water saving activities and reuse options available throughout construction.

Water will be utilised for:

- Surface works including western surface works and M5 East Motorway integration works
- St Peters Interchange works and local road upgrade works
- Tunnelling activities
- Alexandria Landfill Closure works
- General construction activities e.g. earthworks, soil compaction, spoil handling, stockpile management, dust suppression.

2.1.1 Surface Works

Several ancillary facility sites will support construction of the Project, eight are required to support construction of the tunnel with two sites also supporting the western surface works. Six sites are required to support the local road upgrade surface works at the eastern end of the project.

Surface works will include activities such as widening and realignment of the existing M5 Motorway, dives into the tunnel, construction of interchanges, surface road improvements, pedestrian and cycling facilities and installation of noise walls.

Table 4: Surface works sites and construction activities

Construction Site	Construction Activity
Kingsgrove North tunnel and civil (C1)	Civil site: cut and cover, spoil management and removal, and surface works support. Tunnel site: shaft excavation and tunnel support site. (Including 484m3 sediment basin at the western surface works site)
Kingsgrove South civil (C2)	Civil site: spoil management and removal, and surface works support.
Commercial Road tunnel (C3)	Tunnel site: shaft excavation and tunnel support site. (Including construction Water Treatment Plant)
Bexley Road North tunnel and civil (C4)	Civil site: declines, spoil management and removal. Tunnel site: shaft excavation and tunnel support site. (Including construction Water Treatment Plant)

Construction Site	Construction Activity
Bexley Road South tunnel and civil (C5)	Civil site: declines, spoil management and removal. Tunnel site: shaft excavation and tunnel support site.
Bexley Road East support (C6)	Support site to Bexley Road North (C4) and Bexley Road South (C5) construction compounds.
Arncliffe tunnel and civil (C7)	Civil site: declines, spoil management and removal, Green and Golden Bell Frog habitat and surface works support. Tunnel site: ventilation shaft excavation and tunnel support site. (Including construction Water Treatment Plant)
Canal Road tunnel and civil (C8)	Civil site: decline, dive structures, cut and cover, spoil management and removal, and surface works support Tunnel site: ventilation shaft excavation and tunnel support site (Including construction Water Treatment Plant)
Campbell Road civil (C9)	Civil site: on and off ramps, bridge structures, tie-ins, carriageways, and surface works support
Landfill Closure civil (C10)	Civil site: enabling and support for landfill closure works, landfill closure works (Including two temporary sediment basins of 900m3 and 1080m3 volumes respectively, to be replaced by a single larger sediment basin of approximately 4000m3 to be built for the construction period at the St Peters Interchange site)
Burrows Road civil (C11)	Civil site: surface works support site
Campbell Road bridge civil (C12)	Civil site: bridge structures, tie-ins, and surface works support
Gardeners Road bridge civil (C13)	Civil site: bridge structures, tie-ins, and surface works support
Sydney Park civil (C14)	Civil site: bridge structures and surface works support
Alexandria Landfill	Alexandria Landfill Closure works (Including new Alexandria Landfill Leachate Water Treatment Plant)
Local road upgrade works	Surface works and spoil management

Surface works will use both potable and non-potable water for the following purposes:

- Dust suppression on exposed surfaces and roads;
- General wash down and wheel wash;
- Compaction;
- Concreting;
- General earthworks;
- Interchange works;
- Conditioning of fill material;

- Site amenities including toilets, showers, cleaning and drinking; and
- Establishment of landscaping.

Surface works generally require a significant volume of water for dust supression and compaction activities. Water carts will distribute the water across the surface sites as required. Water demand from site offices and amenities will depend on the number of personnel based at a particular site and the hours of operation. The amenities at the surface of the tunnelling sites will be operational 24 hours a day, 7 days a week for the duration of the project construction. The civil sites are operational week days between 7am and 6pm, and Saturdays between 8am and 1pm.

2.1.2 Tunnelling Works

Tunnelling works will operate out of six construction compound sites and an additional two office and laydown sites will support the tunnel works. Tunnelling works will utilise both potable and non-potable water from the above ground sites.

Due to the operation of the roadheaders, associated drilling machinery, and benching and shotcreting activities, there is significant demand for water within tunnel operations. Roadheader machines in tunnelling operations on the Project will use a closed loop system for cooling which significantly reduces water demand. Water used in tunnelling operations, such as spraying the cutterhead during excavation and dust suppression, have strict water quality requirements due to the potential for system blockages.

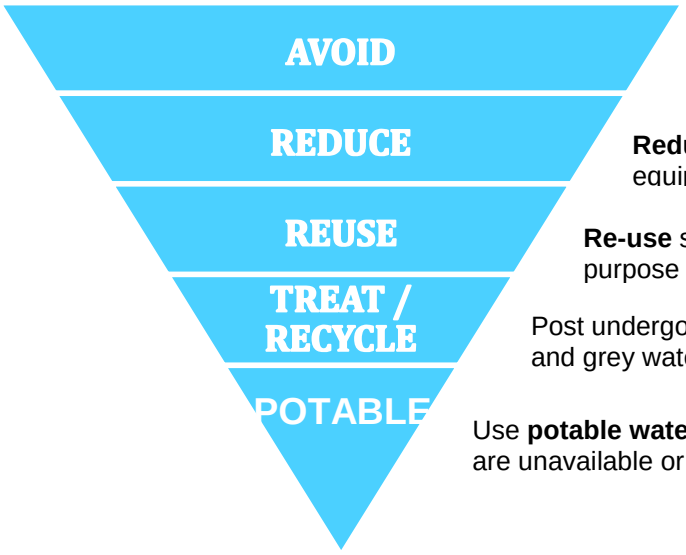
The specific activities within the tunnel construction that require water are:

- Operation of road header machines;
- Operation of bolter machines;
- Surface preparation prior to shotcrete;
- Operation of the shotcrete rig;
- Dust suppression during tunnelling and fit out;
- Rock and concrete cutting during fit out; and
- Drinking water, wash and safety facilities.

Where water is used directly for the operation of the tunnelling machinery it is required to meet strict manufacturer's water quality parameters and pressure requirements. As a result, all roadheader and rockbolting works will be supplied with water from water mains on the surface.

3. Water Sources

Over the course of construction, a number of water sources will be utilised for the purposes described in Section 2. The Sustainability Plan (SP) describes the following strategy which CDS-JV will utilise throughout construction.



Avoid water consumption; prevent and fix leaks

Reduce water consumption by using water efficient equipment and processes

Re-use stormwater without treatment where fit for purpose

Post undergoing **treatment** processes, **recycle** dirty and grey water where fit for purpose

Use **potable water** when non-potable sources are unavailable or not fit for purpose

Figure 2 Water Use and Sourcing Hierarchy

Water will be sourced from the mains supply and a range of non-potable sources including:

- Stormwater harvesting;
- Onsite construction water treatment and reuse; and
- Groundwater.

The use of non-potable water will be preferred over potable water dependent upon workplace health and safety considerations, economic feasibility and any relevant manufacturer's or design specifications, for example.

Treatment and re-use of non-potable water falls into two main categories:

- **Surface water reuse**
    - rainwater harvested from tanks can be stored on site and used to flush toilets, irrigation, wash down, dust suppression and earthworks.
    - after primary treatment (settlement) stormwater can be stored on site and used for dust suppression and earthworks.
- **Groundwater reuse**
    - groundwater collected within the tunnel during construction will be pumped to the surface and treated to meet the discharge specifications of the EPL.
    - treated water will then be used for non-potable uses such as dust suppression on the surface only.

3.1 Water sources for construction phase

Construction activities for both the surface works and tunnelling will make use of all available water sources in line with the necessary specifications.

3.1.1 Surface water

Stormwater harvesting using sediment basins and rainwater collection using tanks will be the preferred method of non-potable water capture on site.

3.1.1.1 Sediment Basins

Sediment basins are proposed at two of the construction compounds, at the western section of road widening works, and at St Peters Interchange works (refer Table **4**). Sediment basins will be designed in accordance with the requirements identified in the CSWQSP. The exact location, size and management of each sediment basin will be in accordance with the applicable erosion and sediment (ERSED) control plan.

Due to the constraints listed in Section 1.4 and further detailed in Table 6, captured surface water in sediment basins may only be re-used at the Kingsgrove and Arncliffe sites.

3.1.1.2 Rainwater harvesting tanks

The Bexley North (C4) and Arncliffe (C7) sites have been assessed as a suitable site for rainwater harvesting through the installation of at least one harvesting tank. The harvested water will be reused for non-potable purposes such as toilet flushing, dust suppression, and wheel-washing.

Other sites, such as the St Peters Interchange, will continue to be assessed for suitability of rainwater collection.

3.1.2 Groundwater and Construction Water

Groundwater is water found below the subsurface which will enter the tunnel from the water table. Once tunnelling commences the groundwater and any residual construction water (from rock bolting activities, for example) will be combined together and pumped to the surface as one stream.

There will be a total of four water treatment plants established to treat the groundwater in line with EPL No. 20772 and No. 4627. These water treatment plants will be used throughout construction of the project. These will be located at the Commercial Road construction compound (C3), the Bexley Road South construction compound (C5), the Arncliffe construction compound (C7) and the Canal Road construction compound (C8).

Water used in tunnelling operations, such as spraying the cutterhead during excavation and dust suppression, have strict water quality requirements. An investigation was conducted to ascertain whether the treated groundwater meets this requirement and can replace the potable demand. Treated groundwater from was found not to be compliant. As a result, treated water from the construction WTPs is not suited for re-use underground. The memo detailing the investigation into the re-use of treated groundwater in tunnelling operations is provided as Appendix B.

The treated groundwater can be reused as further detailed in Section 4.

3.1.3 Potable water

All construction sites will have access to potable water through metered connections to the Sydney Water network. During construction, potable water will supply the site offices and amenities and be used as feedwater to the tunnelling machinery in line with manufacturer's specifications.

4. Evaluation

The CDS-JV design and construction team have undertaken a water reuse assessment for the construction phase of the asset life. This assessment, including the considerations and justifications for site specific water re-use strategies, is detailed below.

Reused water is preferred over potable water on all sites where suitable quality surface water or treated groundwater is available. The supply of re-used water is entirely dependent on rainfall, construction activities, and on the storage capacity of available sediment basins and rainwater tanks.

For any external recycled water reuse options, Third-Party stakeholders such as Councils and Golf Course Operators will be responsible for meeting end-use requirements such as public health requirements and permits and approvals.

4.1 Considerations for Water Reuse

4.1.1 Concrete

All concrete will arrive on site pre-mixed and the use of non-potable water for batching plant production will be encouraged. The primary concrete supplier to the Project, Hanson, will use recycled water wherever possible and report monthly on the non-potable usage.

4.1.2 Green and Golden Bell Frog Plan of Management - Arncliffe

As previously detailed in the Green and Golden Bell Frog Plan of Management (GGBF PoM) (RMS) the reuse of sediment pond water was prohibited to prevent the spread of chytrid fungus. The GGBF PoM specified that only town water should be applied to construction zones for dust suppression. The GGBF PoM was updated by RMS in February 2017 to permit the use of non-potable water for dust suppression at the Arncliffe site. The Department of Planning and Environment approved this change and as a result, treated water from the WTP will now be used to fill the water cart and for dust suppression on the Arncliffe site.

4.1.3 Groundwater reuse in tunnelling operations

WTPs produce water to a standard that is generally suitable for reuse on the surface of worksites, discharge to the environment and for other minor uses. With the consideration of best practice water management in tunnelling operations in NSW and to evaluate all feasible and reasonable reuse options, CDS-JV investigated the potential for re-using treated tunnel water underground. The following conclusions were drawn from the investigation:

- The introduction of tunnel water to the industrial water system (without further treatment) was determined not to be feasible due to the incompatibility of the supply water with the intended uses of the water underground. The treated tunnel water did not meet the specifications as required by major plant suppliers (e.g. Sandvik, Mitsui, and Robodrill).
- Further treatment of tunnel water by RO was assessed with restricted feasibility (waste disposal of brine and space limitations) and not reasonable (excessive cost, energy use and replacement requirements).
- Installation of an additional service line to enable treated ground water to be used selectively underground (i.e. for tunnel wash down, but not supply to plant) was assessed as not reasonable due to significant space issues, hygiene constraints, costs and time delays which significantly outweigh potential benefit.

The investigation is detailed further in the memo provided in Appendix B.

4.2 Reuse Options and Activities

A constant supply of treated groundwater will be available for use at the tunnelling compound sites that can be used both within the tunnelling operations (where specifications permit) and also on the surface. This water will be available as soon as the water treatment plants have been commissioned and will supply the Commercial Road (C3), Bexley North (C4), Arncliffe (C7), Canal Road (C8) tunnel sites. Treated groundwater from water treatment plants will be available from fill points for water carts.

It is anticipated that the treatment plants will be treating water at between 12 and 36 L/s (peak flows) depending on location and the activities being undertaken in the tunnel.

Where possible, available captured surface water and treated groundwater will supply activities as detailed in Table 5**Error! Reference source not found.** below.

Table 5: New M5 Water reuse activities

Construction Phase		
Surface Works (including cut & cover)	**Tunnelling & Fit Out**	**Potential External Third Party Uses**
Dust suppression	Surface preparation	Irrigate and/or supplementary water for public open space
General wash-down	Dust suppression	Watering of retained or regenerated vegetation/landscaping
Wheel wash	Rock saw	
Concrete cutting	Rock breaking	
Fill conditioning	Surface trench excavation	
Compaction		
General earthworks		
Rock sawing		
Concrete batching		
Landscaping		
Non-potable water uses such as toilets		

Table 6 below details and evaluates each the reuse opportunities at each construction site/s, taking into account the specific considerations for this project. The estimated volumes represent the theoretical water consumption for each construction area assuming water quality meets the requirements for each activity and that reused water is available.

Table 6: New M5 water reuse options – Construction Phase

Construction Site/s	NP Water Sources	Est. Potable Water Volume/Day	Est. Available Reused Water Volume/Day	Considerations/ Justification	Implementation Period
Western surface works Kingsgrove North tunnel and civil (C1) Kingsgrove South civil (C2) Commercial Road tunnel (C3)	Construction Water Treatment Plant/s Sediment Basin	93 kL (C1) 90 kL (C2)	Up to 10kL Surface Water when available Up to 200kL WTP	A Water Treatment Plant is located at Commercial Road tunnel site (C3) and treats groundwater and process water for potential reuse at the site or discharge. The potential uses for the treated water under active investigation include supplying the truck wheel wash and for cleaning belt presses and filters. Roadheader machines in tunnelling operations on the Project use two cooling circuits. The cooling system for the main gearbox utilises a closed circuit, with fan assisted cooling and radiators. This greatly reduces the volume of water required for the primary cooling system, which uses an open circuit and requires clean water to be supplied to the machine. The water passes all components on the roadheaders to be cooled and then enters the flat nozzle spaying system. This water is then reused in the tunnel as dust suppression at the cutting face and on the chain conveyor. This cooling system requires clean water to avoid corrosion, blockages and damage to the roadheaders, and treated groundwater from the Kingsgrove WTP does not conform to the water quality requirements. As a result, treated groundwater cannot be re-used for tunnelling operations due to durability, maintenance and warranty risks associated with the water quality requirements of tunnelling machinery. Further details of the investigation into the use of treated	Sediment basins and groundwater treatment plants will be operational in accordance with the Site Environment Plans (and erosion and sediment control plans).

				groundwater for tunnelling operations are provided in Appendix B. A sediment basin is located at the Western Surface Works (WSW) north site (C1) and captures surface water. Due to Licence conditions (sediment basin must be emptied within 5 days of rain to maintain treatment capacity), the potential re-use from this source is limited. The erosion and sediment control strategy at the WSW utilises a number of sediment sumps, which are used to capture water for re-use. The water captured by the sumps is generally pumped into water carts for re-use as dust suppression or during compaction activities. The potential for sharing opportunities between the tunnelling WTP and the adjacent civil site was also investigated. The capacity to get water from the Commercial Road tunneling site (C3) back to the civil site was found to be too limited given that Wolli Creek divides the sites. A pipe bridge was installed for tunnelling operations however the limited surface area available for water storage and cleared area required for truck turnaround meant the opportunity was not reasonable or feasible given the construction timeframes.	
Bexley Road North tunnel and civil (C4) Bexley Road South tunnel and civil (C5) Bexley Road East support (C6)	Construction Water Treatment Plant Rainwater Tanks	214 kL (C4) 116 kL (C5) 17 kL (C6)	Up to 10kL rain water when available Up to 500kL WTP	A rainwater tank has been fitted to the acoustic shed of the Bexley Road North Construction Compound (C4). The rain water is fed to the ablutions facilities on C4 to flush toilets. This water is supplemented, where required, with treated water from the WTP, removing the need for potable water for this service. A dust suppression system utilising this same source of water (rain and treated water) is also in use in the portal of the tunnel at the Bexley Road North Site (C4) to minimise dust	Rainwater tanks are operational in accordance with the Site Environment Plans (and erosion and sediment control plans).

				transmission and generation to the shed, from the shaft and tunnel. Treated groundwater cannot be re-used for tunnelling operations due to durability, maintenance and warranty risks. Further details of the investigation into the use of treated groundwater for tunnelling operations are provided in Appendix B.	
Arncliffe tunnel and civil (C7)	Construction Water Treatment Plant	421 kL (C7)	Up to 500kL WTP	Treated groundwater at the Arncliffe site is used to clean the belt presses and back wash filters of the WTP and for dust suppression on the surface. Treated groundwater cannot be re-used for tunnelling operations due to durability, maintenance and warranty risks associated with the water quality requirements of tunnelling machinery. Further details of the investigation into the use of treated groundwater for tunnelling operations are provided in Appendix B. The Green and Golden Bell Frog Plan of Management (RMS) was updated to permit the use of non-potable water for dust suppression at the Arncliffe site. The Department of Planning and Environment approved this change on 14/02/2017 and since this time, treated water from the WTP has been used to fill the water cart and for dust suppression on the Arncliffe site. Further water reuse opportunities (for both treated water and rain water), such as supply to ablution facilities, will continue to be investigated for feasibility.	Commencement of Construction
St Peters Interchange works Canal Road tunnel and civil (C8)	Construction Water Treatment Plant Sediment Basin/s Rainwater Tanks	504 kL	Up to 622 kL WTP 0 kL Surface Water	SPI is the former Alexandria landfill site. Due to the potential contamination on-site, captured surface water cannot be used for dust suppression and other construction activities. Potable water is required for these activities for H&S reasons.	Sediment basins and groundwater treatment plants will be operational in accordance with the Site

Landfill Closure civil (C10) Burrows Road civil (C11)	Leachate Water Treatment Plant			Leachate cannot be used for wash down facilities and/or used for dust control at the premises. During landfill closure activities, surface water management measures will be implemented to isolate and capture potentially contaminated water. Water will then be transferred to the leachate treatment plant for treatment prior to discharge to sewer under a trade waste agreement with Sydney Water. Treated groundwater at the SPI tunnels site is used to wash the belt press. Reuse of the treated groundwater in tunnelling operations underground is not possible as the WTP discharge exceeds the quality requirements set by plant manufacturers Sandvik and Robodrill, particularly hardness. Further details are provided in Appendix B. CDS-JV will continue to assess opportunities for re-use of treated tunnel water for dust suppression on the SPI civil site. This will examine potential storage locations, water cart filling locations and access across plant operating zones and haul roads.	Environment Plans (and erosion and sediment control plans).
Campbell Road civil (C9) Campbell Road bridge civil (C12) Gardeners Road bridge civil (C13) Sydney Park civil (C14) Local Roads Upgrade Works		80kL	Up to 12kL rain water when available	No sediment basins are installed at these sites given the land size constraints, road design and construction activity requirements. There is not enough land for a sediment basin to be practical, sumps will be too small to recover any water and any large excavations will not be open for extended periods. Water collected in excavations near Sydney Park and Alexandra Canal is generally contaminated, reuse is not an option. Water collected in excavations is also not needed for tasks like dust suppression when it is raining.	Commencement of Construction

				A small water treatment plant is currently being assessed for Campbell Rd construction compound (C9). A 12KL water tank, originally intended for Campbell Rd Bridge construction compound (C12), will be installed at C9 when the compound is established. There was insufficient space at C12 to install a tank of this size adjacent to the site sheds. Gardeners Rd Bridge (Compound 13) will be used as a construction site and location of a bridge spanning Alexandra Canal. There is currently no plan to install sheds from which to capture rainwater. Sydney Park Compound C14 will not be established by CDS-JV. There is no water demand or reuse opportunities at this location.	

5. Monitoring and Reporting

The water reuse targets detailed in Table 3 relate to the overall New M5 project targets identified in the Project Sustainability Plan. To track performance against these targets, a quarterly sustainability report will be produced and provided to SMC. This report will include the monthly volumes of potable water consumed and the volume of water reused on site.

A Permit to Dewater process ((M5N-ES-PER-PWD-0001) has been developed to record the volumes of surface and groundwater reused on, and discharged from, the project sites. This process reinforces the project preference to reuse water that has been captured onsite wherever possible (e.g. for dust control). Prior to any discharge offsite, or reuse onsite, the Environment Team will ensure the water is treated, recorded and reported in accordance with the EPL.

6. Conclusion

This Strategy outlines the water reuse opportunities in the New M5 project construction phase as detailed in Section 4.

The water treatment plants will supply treated water within the site for non-potable water uses in Table 5. At the peak of construction these water treatment plants are estimated to provide up to 2000kL of water per day to the construction works. Sites, such as Kingsgrove, which will have sediment basins on site, will also have the capacity to harvest storm water to supplement the demand for surface activities. This, along with potential opportunities for rainwater harvesting, will ease the pressure placed on potable water demand by making non-potable water available for the construction activities outlined in Table 5.

CDS-JV design and construction teams will continue to work collaboratively to investigate future potential water re-use options for the new M5 project. Such options may include the installation of additional rainwater tanks and the supply of treated groundwater to the local irrigation network at the Kogarah Golf Course. As design, construction and programming progress, these options will be addressed in the Water Re-Use Strategy – Operational Phase.

Appendices

Appendix A: Glossary of Terms

Term / abbreviation	Definition
CAFMP	Construction Ancillary Facilities Management Plan
CCS	Community Communication Strategy
CEMP	Construction Environmental Management Plan
CoA	Condition of Approval
D&C	Design and Construction
Deed	As appropriate to the defined scope of the WestConnex New M5 Main Works D&C Deed.
DP&E	Department of Planning and Environment
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPL	Environment Protection Licence
ER	Environmental Representative
EWMS	Environmental Work Method Statements
CFFSP	Construction Flora and Fauna Sub-plan
IC	Independent Certifier
Infrastructure Approval	Approval under the Environmental Planning & Assessment Act 1979 for SSI 6788 signed by the Minister for Planning on 20 April 2016
ISCA IS Rating Tool	Rating tool developed by the Infrastructure Sustainability Council of Australia (ISCA) to evaluate sustainability across design, construction and operation of infrastructure. The Infrastructure Sustainability rating scheme evaluates the sustainability (including environmental, social, economic and governance aspects) of infrastructure Projects and assets.
CDS-JV	CPB Contractors Dragados Samsung Joint Venture (Contractor)
PMP	Project Management Plan
POEO Act	*Protection of the Environment Operations Act 1997*
Project	WestConnex New M5 Project
Project Company	WCX M5 PT Pty Limited
Project requirements	The project requirements include all CoA (pursuant to Infrastructure Approval), REMMs, EMMs, SWTC and EPL.
REMM	Revised Environmental Management Measure (from the SPIR)

Term / abbreviation	Definition
RMS, Roads and Maritime	Roads and Maritime Services
SMC	Sydney Motorway Corporation
SPIR	Submission [and Preferred Infrastructure] Report
SWTC	As appropriate to the defined scope of the Scope of Works & Technical Criteria defined under the New M5 D&C Deed.
CSWQSP	Construction Soil and Water Quality Sub-plan
WCX	WestConnex
WDA	WestConnex Delivery Authority, now Sydney Motorway Corporation (SMC)
WTP	Water Treatment Plant

Appendix B: Memo – Reuse of Treated Groundwater in Tunnelling Operations

MEMO

To: Steve Fermio

From: Andrew Howcroft

Cc: Travis Butler and Howard Chemney

Date: Wednesday, 31 January 2018

Re: Condition B30 – Groundwater Re-use in Tunnelling Operations

1 Introduction

The use of non-potable water on the Project is preferred over potable water due to the potential economic, environmental and social benefits from reducing the demand on potable water. Consideration of impacts to workplace health and safety, feasibility of treatment to plant and equipment specifications and economic impacts is necessary when assessing the suitability of options for reuse.

Condition B30 of the Instrument of Approval for SSI 6788 defines water reuse requirements:

> *The Proponent must prepare a Water Reuse Strategy which sets out feasible and reasonable options for the reuse of collected stormwater and groundwater during construction and operation of the SSI. The Water Reuse Strategy must include, but not be limited to: (a) evaluation of all feasible and reasonable reuse options; (b) details on the preferred reuse option(s), including volumes of water to be reused, proposed reuse locations and/or activities, proposed treatment (if required), and any additional licenses or approvals that may be required; and (c) a time frame for the implementation of the preferred reuse option(s). Justification must be provided in the event that it is concluded that no feasible or reasonable reuse options prevail.*

The definition of feasible and reasonable is included within the Instrument of Approval as:

> *Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context.*
>
> ***Feasible** relates to engineering considerations and what is practical to build.*
>
> ***Reasonable** relates to the application of judgment in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community expectations and nature and extent of potential improvements.*

The Construction Water Reuse Strategy was prepared in accordance with the Minister's Condition of Approval B30 and conditionally approved by the Department of Planning and Environment in December 2016. Following an audit of the Water Reuse Strategy by the Environmental Representative (ER) in April 2017, further information was requested by the ER to justify the Project's decision to not re-use treated tunnel water underground during tunnel construction. The ER also referred to the Scope of Works and Technical Criteria (SWTC) that apply to Water Efficiency during this audit (as described below). :

CPB Dragados Samsung Joint Venture (ABN 42 484 012 873)
Level 6, Tower B, 197 Coward Street, MASCOT NSW 2020
Telephone +61 2 9381 3700

SWTC Appendix D.5 2.6 Water Efficiency

> *b) The Project Company must demonstrate that opportunities to reduce water use (in particular potable water use) and reuse water (rainwater, stormwater, wastewater, groundwater) during the construction and operational stages have been identified and analysed (costs/benefits must be estimated for each feasible opportunity analysed).*

Table D.5-2 Sustainability Requirements

> *(9) Percentage of potable water demand which is sourced from non-potable water sources during construction – 15%*

2 Scope

This memo has been written in response to the findings of the Environmental Representative in relation to Condition of Approval B30 and to provide further information to support the Project's decision that it is not feasible or reasonable to re-use treated tunnel water underground for tunnel construction. This document will also address the SWTC requirements including D.5-2.

3 Considerations for Water Re-Use

Two sources of non-potable water were identified for potential re-use during construction planning for the Project:

1. Surface water
    - rainwater harvested from hard surfaces (shed rooves);
    - stormwater harvested after preliminary treatment (i.e. settlement).
2. Tunnel water reuse
    - groundwater collected within the tunnel during construction along with process water used during construction, pumped back to the surface and harvested following treatment at a Water Treatment Plant.

Options for re-use of non-potable water during construction were also identified during construction planning and included:

1. Grey water plumbing for flushing toilets and laundry uses,
2. Irrigation (rehabilitation and adjacent land uses),
3. Wash down (tunnel, plant and equipment) and dust suppression.

Surface water is collected and reused as described within the current (approved) Water Reuse Strategy.

Groundwater will enter the tunnel throughout construction and operation. Inflows are predicted to be greater during the construction phase than during the operational phase. During construction, groundwater and process water (water used during construction) are combined and pumped to the surface for treatment. Four water treatment plants (WTPs) have been established to treat tunnel water (groundwater and process water) during construction. Water treatment plant specifications were developed to enable tunnel water to be treated to a standard suitable for discharge to the receiving environment. The discharge of treated tunnel water to the environment was anticipated during

development of the Environmental Impact Statement (EIS) and CDS-JV's tender. The discharge from the WTPs to the environment is regulated under Licence from the EPA (EPLs 20772 and 4627). The WTPs are located at: the Commercial Road construction compound, the Bexley Road North construction compound, the Arncliffe construction compound and the St Peters tunnelling compound.

The Project has collaborated with a range of stakeholders to assess opportunities for re-use of the water treated by the WTP for tunnelling operations. Suppliers including Sandvik, Mitsui Mike and Robodrill have provided advice and support. CDS-JV also partnered with EIC Activities to engage two engineering students from Griffith University to assess opportunities to use non-potable water in tunnel construction, which included seeking evidence from, and consulting with experienced construction and engineering personnel from a range of CPB tunnelling projects (past and present).

These investigations have determined the main risks of water re-use underground are:

- Mechanical – potentially accelerated corrosion of components; restriction and/or blockage of spray valves, valves and pipes, and ;
- Health concerns – potential hygiene requirements associated with the atomisation of non-sterile water particles in restricted atmosphere environment (legionella and other bacterial concerns).

This memo focuses on an assessment of the quality of treated tunnel water for use in mechanical plant and was undertaken with the assistance of Suppliers of the main plant and equipment used underground that require water for construction. Health concerns were considered to be a more reasonably managed risk via chlorination or ozone treatment, and thus do not form part of the detailed investigation.

4 Feasible and Reasonable Assessment

4.1 Water Quality Assessment

Under standard tunnelling conditions, water is distributed underground for a variety of uses including cooling plant, dust suppression, fire/deluge, tunnel and plant wash down, cleaning, and for ablutions (washing hands and flushing toilets). Standard tunnel practice is to install header tanks at surface sites to ensure sufficient storage volume to supply the tunnel length with pumps to provide water at specific design flows and pressure. Water is distributed in tunnels through Victaulic pipes attached to the tunnel walls with service brackets, with manifolds at regular intervals (~40metre) to enable access to the supply. As the water is stored in tanks, fed by pumps and distributed through Victaulic pumps, this water is not potable (cannot be used for drinking) and is referred to as industrial water.

The quality of industrial water must be adequate to enable all of the uses underground (as listed above), otherwise a second supply line specifically for re-use water would require installation (refer to Section 4.3). Based on a review of the variety of uses, the input water quality for re-use in tunnelling plant (i.e. roadheader and drilling rigs) was determined to be the highest risk of non-conformance as these items of plant use significant amounts of industrial water during construction and are subject to warranty and buyback conditions. It is accepted that some other uses (i.e. equipment wash-down) have an inherently lower risk associated with water re-use. This memo therefore focuses on the water quality required to re-use tunnel water in plant.

Water for use directly in tunnel machinery is required to meet strict water quality parameters and pressure requirements as defined by suppliers and listed in OEM documentation. As a result, the current business as usual practice is to supply all roadheaders and associated machinery, e.g. drilling

and shotcreting rigs, with industrial water which is supplied by potable water mains on the surface. Furthermore, warranty arrangements and buyback options are linked to the correct operation and maintenance of the equipment in accordance with the relevant OEMs and specifications. The supply of non-compliant water to this plant and equipment would pose a significant risk to the Project.

To assess if treated tunnel water would comply with plant supply specifications, water was sampled early in the construction phase from the water treatment plants and compared to the quality specifications supplied by the plant suppliers. A water sample was also sent to Germany for analysis by Sandvik in November 2016 to assess for compliance against the plant specifications.

Table 1 illustrates the key parameters and results of a comparison between the supplier water quality specifications and the output quality of the construction water treatment plants (including ranges where appropriate). A copy of the analysis report commissioned by Sandvik is attached in Appendix A. The water quality specifications provided by Robodrill are supplied in Appendix B.

Table 1. Key Parameter Comparison

Key Water Quality Parameter	Unit	Australian Drinking Water Quality Guidelines	Supplier Water Quality Specification			New M5 Water Treatment Plant Discharge Quality
			Sandvik	Mitsui	Robodrill	
pH		6.5-8.5	~7	-	7-9	6.5-8.5
Total hardness	mg/l of $CaCO_3$	200	150	-	60-150	1800-4200
Conductivity	µS/cm	900 (aesthetic value)	28000	<1500	10 - 500	>2500
Filtered substances	mg/l	<1 NTU is the target for effective disinfection (aesthetic value of 5)	Particles must be less than 100µm	<50	<30	<50
Chlorides	mg/l	250	150	-	Above 100°C no chlorides permitted	4650
Sulfate	mg/l	250	-	-	<100	1510
Nitrate	mg/l	50	-	-	<100	16.2
Iron	mg/l	0.3	-	-	<0.2	0.1-0.3

Highlighted cells indicate a conflict between supplier specifications and measured treated tunnel water.

As outlined in Table 1 (and Appendix A), a number of key quality parameters of the treated tunnel water exceeded the specifications required by the plant Suppliers. The treated water, at its current quality, was found not to be suitable for re-use as it was:

- Too hard;
- Too corrosive; and
- With High levels of sodium, Sulfate and chlorides.

4.2 Water Treatment Options

As tunnel water is not currently treated to a standard suitable for re-use, a number of further treatment methods were considered. These included ultra-filtration and reverse osmosis.

Ultra filtration was considered at the tender and early construction phases as a potential method for the treatment of tunnel water on the Project. Treatment using chemical flocculation and coagulation, however, was chosen as the preferred option as a result of past performance assessments on CPB tunnelling projects and due to the very limited space available at the Project's worksites. Further, significant pre-treatment infrastructure is required to enable ultra-filtration (ultrafiltration is used at M4E, however each plant includes large wedge pits and associated infrastructure for pre-treatment). Ultra-filtration was reconsidered for this assessment as it uses fewer chemicals that have the potential to increase hardness and conductivity of water (coagulation and flocculation processes can lead to a slight increase in these levels, particularly where raw water hardness and conductivity is low). Ultrafiltration does not reduce the hardness or conductivity of the source water, however, and given the hard and corrosive nature of the source water (as sampled), this process would not result in a significant reduction in these parameters compared with chemical flocculation and coagulation.

Reverse osmosis (RO) is a process that could potentially reduce conductivity and hardness of the treated water to the specified levels in Table 1. Reverse osmosis utilises a semi permeable membrane and high water pressures to overcome (reverse) osmotic pressures to purify water. Some disadvantages of RO include that it is energy intensive and produces a highly saline waste by-product. Experience from previous projects has demonstrated that the presence of cementitious materials and relatively high levels of suspended solids rapidly degrade membranes leading to increased maintenance and replacement of components, when compared to other applications (i.e. elevated concentrations of ions associated with the use of cement (shotcrete) lead to rapid degradation of the membranes and reduced design life).

Significant pre-treatment is required to remove particulate matter and balance pH for RO systems. A potentially feasible option is to introduce an RO module at the end of the current treatment process to achieve some treated water at the required standard. However, given space constraints (particularly at Bexley and Kingsgrove) and the additional waste stream of highly saline brine, the feasibility of RO on the Project is considered to be limited. Additionally, the establishment of an RO plant on the Project is not considered a reasonable option due to the high costs associated with operation (energy), maintenance and replacement of membranes and disposal of brine waste. The use of RO is therefore not considered to be a reasonable or feasible method to treat groundwater on the Project for potential re-use underground.

4.3 Water Piping Assessment

As treated tunnel water is not suitable for reuse for all required underground uses, the addition of a second water distribution network for treated tunnel water was considered to enable the use of the treated tunnel water in some scenarios (e.g. tunnel wash down). In the current configuration for underground water supply, industrial water is distributed through Victaulic pipes. With the inclusion of regular manifolds, this system allows pipes to be extended as required with minimal water loss and allows ready access to the water for use. This system could be duplicated to enable delivery of treated tunnel water in addition to industrial water as currently supplied.

Industrial water is required for:

- Specialised plant and equipment (roadheaders and drills). The roadheaders use water for cooling circuits and for dust suppression/lubrication at the cutter head and conveyor. Robodrills also use water for cooling and lubrication/flush removal of spoil.
- Amenities. Whilst not used as drinking water, industrial water is used at amenities (underground crib rooms and toilets) for cleaning and other uses.
- Shotcreting. Hydro-scaling is an important activity for some features to ensure adequate shotcrete adhesion. Industrial water is also used to clear product from the shotcreting plant and lines/hoses following use.

Industrial water is also currently used underground for some activities where treated tunnel water would likely to be suitable. These activities include:

- Emergency use (fire system etc.).
- Tunnel and plant wash-down. Dust suppression. Apart from the automatic use of water for dust suppression by plant (e.g. roadheader, drills), the industrial water line is accessed to provide dust suppression for particular activities (e.g. rock hammering, sawing).

An additional service line would need to be labelled and extended, maintained and operated under the same parameters as the industrial water line. A disinfection process for treated tunnel water may also be required (i.e. ozone disinfection unit or chlorination, primarily for legionella sp.).

A separate treated water line would incur additional costs, time/delays and also require additional space. The cost of materials for the additional service line (if implemented from commencement of tunnelling) are detailed in Table 2. Table 2 does not include material costs to enable installation of the treated tunnel water line in the tunnel. The current tunnel service support bracket (Figure 1) does not support the inclusion of another service line. Significant time, materials and design effort would be required to retrofit brackets in the excavated tunnel, and a new tunnel service support bracket would require design and manufacture.

In addition to time and resources incurred during the installation of a secondary line, regardless of whether it is a retro-fit to the system or installed at the beginning of the Project, additional time would be required when advancing the services. Using the Victaulic pipe system, pipes are isolated and advance every 6.5 metres along the tunnel. The additional service line would add approximately 20 minutes of non-production time to every service advance for each drive. Over the tunnel construction period, this would extend the duration of works by approximately 6 weeks.

Storage of the treated water and pumping infrastructure would also be required on the surface sites. Space is highly constrained, particularly for the Bexley and Kingsgrove tunnelling sites, and this assessment does not consider the storage and handling requirements of additional pipework.

In addition to the factors discussed above, the design, procurement and disinfection costs have not been considered in the cost assessment which would result in overall costs significantly exceeding any potential economic savings provided from a reduction in total potable water consumption.

Therefore, the installation of a secondary treated tunnel water line (including tanks, pumps and pipes) to pump treated tunnel water, has some limitations on feasibility, and is not considered a reasonable option given the costs involved and potential delay to completion.

Table 2: Material costs for an additional service line for treated tunnel water

Material	**Unit price**	**Quantity required**	**cost**
6.5 metre Victaulic 4” pipe	$73.95	2750	$203362.50
4” Shouldered clamp and rubber	$11.04	2750	$30360.00
Total cost of materials (excluding supply of header tanks, pumps, t junctions, valves for use etc.)			**$233,722.50**

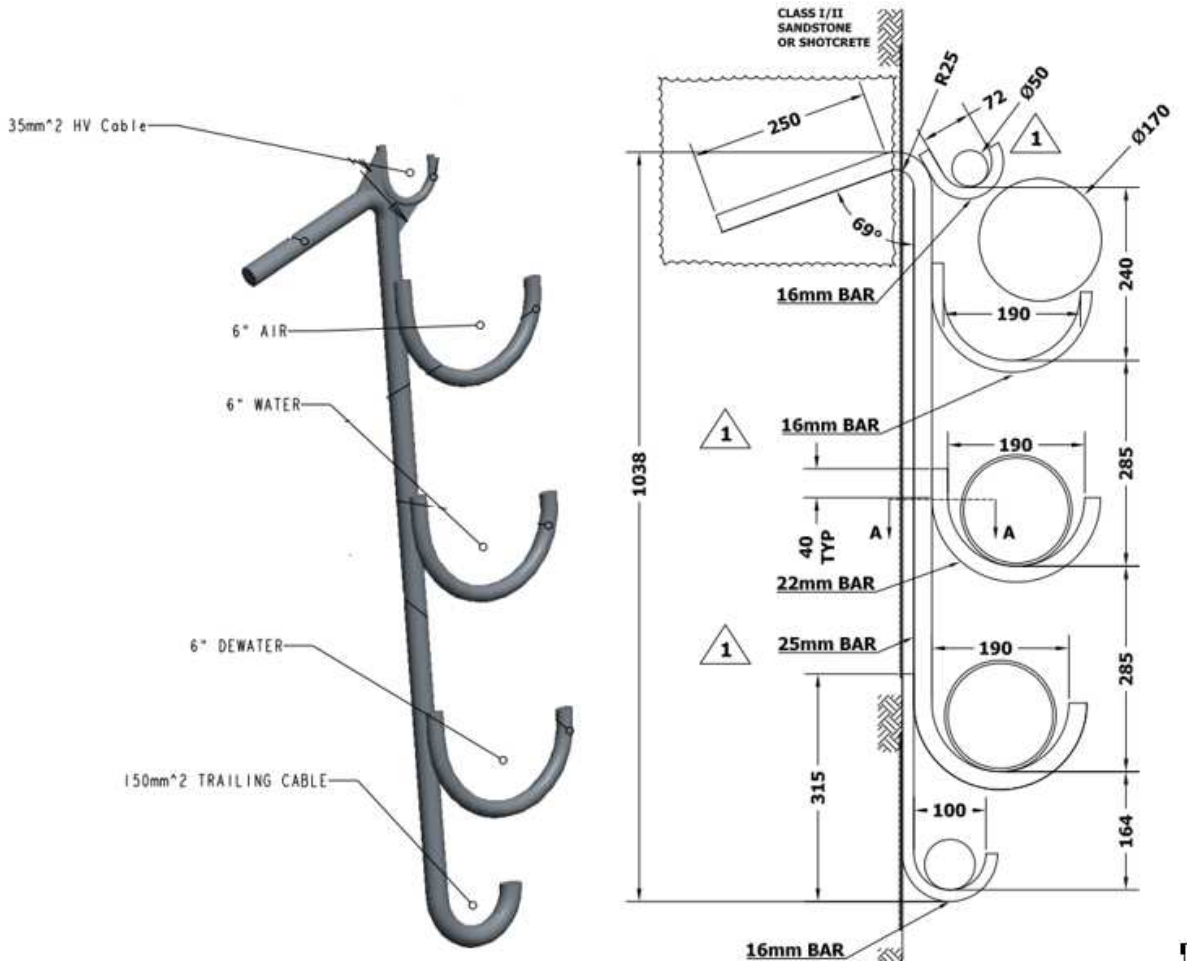


Figure 1: Tunnel service support bracket

5 Conclusion

With the consideration of best practice water management in tunnelling operations in NSW, the Project investigated the potential for re-using treated tunnel water underground. The following conclusions have been drawn from this investigation:

- The introduction of tunnel water to the industrial water system (without further treatment) was determined not to be feasible due to the incompatibility of the supply water with the intended uses of the water underground. The treated tunnel water did not meet the specifications as required by major plant suppliers (e.g. Sandvik, Mitsui, and Robodrill).
- Further treatment of tunnel water by RO was assessed with restricted feasibility (waste disposal of brine and space limitations) and not reasonable (excessive cost, energy use and replacement requirements).
- Installation of an additional service line to enable treated ground water to be used selectively underground (i.e. for tunnel wash down, but not supply to plant) was assessed as not reasonable due to significant space issues, hygiene constraints, costs and time delays which significantly outweigh potential benefit.

In accordance with the Construction Water Reuse Strategy, the Project team will continue to work collaboratively to investigate future potential water re-use options, both below ground and on the surface. In addition, the Project, in partnership with EIC Activities, continues to support the assessment of the potential reuse of treated tunnel water for future projects and has recently received detailed reports from Griffith University engineering students assessing options for reuse on future projects. These reports are currently being assessed by CDS and EIC Activities.

Appendices

Appendix A: Sandvik Water Analyses Report

Bundesstraße 66
8740 Zeltweg
Tel. 03577/758 510
Fax: 03577/758 520
office@gfa.at
www.gfa.at
Gesellschaft für
Analytische Chemie GmbH

Report
2514b129

Water Analyses

Sandvik Mining and Construction G.m.b.H.

This report is a unit; containing 3 Pages. Publishing in parts without written permission is not allowed.
The test result refers exclusively to the mentioned sample.

1. Customer

Sandvik Mining and Construction G.m.b.H.
Alpinestraße 1
8740 Zeltweg

2. Information about Samples

Order	**Water Test - Corrosion**
Name	**ARNCLIFFE**
Sampling	**Sandvik Mining and Construction G.m.b.H.**
Conservation Sample	**SOP Kons 001**
Date of income	**2017-01-11**
No. Sample	**170024**
Preservation Sample	**---**
Time Analyses	**2017-01-11 – 2017-01-23**

3. Results

PHYSIKALISCHE PARAMTER

Parameter	Einheit	Ergebnis	Measurement uncertainty		Method
Water temperature at laboratory entrance	[°C]	**22**	+/-	0,3	ÖNORM M 6616
pH-Value		**6,80**	+/-	0,20	EN ISO 10523
Electrical conductivity at 20 ° C	[µS/cm]	**12700**	+/-	375	EN 27888
Electrical conductivity at 25 ° C	[µS/cm]	**14200**	+/-	418	EN 27888
Filterable substances (0.45 µm)	[mg/L]	**21**	+/-	1	DIN 38409 Teil 2
Dissolved solids (TDS)	[mg/L]	**9700**	+/-	435	DIN 38409 Teil 2

CHEMISCHE STANDARDUNTERSUCHUNG

Parameter	Einheit	Ergebnis	Measurement uncertainty		Method
Oxygen content as O_2	[mg/L]	**7,2**	+/-	0,2	ISO 5814
Oxygen saturation	[%]	**88**	+/-	4	ISO 5814
Acid capacity KS $_{4,3}$	[mmol/L]	**1,28**	+/-	0,13	DIN 38409 Teil 7
Ammonium as NH_4	[mg/L]	**<0,01**	+/-		ÖNORM M 6242
Nitrite as NO_2	[mg/L]	**4,10**	+/-	0,68	EN 26777
Phosphate, ortho as PO_4	[mg/L]	**0,094**	+/-	0,011	EN ISO 6878
Phosphate, total as PO_4	[mg/L]	**0,166**	+/-	0,018	EN ISO 6878
Chloride as Cl	[mg/L]	**4650**	+/-	348	EN ISO 10304 - 1
Nitrate as NO_3	[mg/L]	**16,2**	+/-	1,1	EN ISO 10304 - 1
Sulfate as SO_4	[mg/L]	**1510**	+/-	88	EN ISO 10304 - 1
Fluoride as F	[mg/L]	**<1**	+/-		EN ISO 10304 - 1
Sodium as Na	[mg/L]	**2770**	+/-	223	EN ISO 14911
Potassium as K	[mg/L]	**100**	+/-	8	EN ISO 14911
Magnesium as Mg	[mg/L]	**241**	+/-	20	EN ISO 14911
Calcium as Ca	[mg/L]	**295**	+/-	23	EN ISO 14911

SUMMENPARAMETER

Parameter	Einheit	Ergebnis	Measurement uncertainty		Method
Total org. Carbon as TOC as C	[mg/L]	**13**	+/-	2	EN 1484
Loosened org. Carbon as DOC as C	[mg/L]	**11,8**	+/-	1,6	EN 1484

METALLE

Parameter	Einheit	Ergebnis	Measure-ment uncertainty		Method
Iron, dissolved as Fe	[mg/L]	**0,141**	+/-	0,020	EN ISO 15586
Manganese, dissolved as Mn	[mg/L]	**0,158**	+/-	0,015	EN ISO 15586
Barium	[mg/L]	**0,261**	+/-	0,015	EN ISO 15586
Strontium FA1)	[mg/L]	**1,60**	+/-	0,015	ISO 11885

Measurement uncertainty: k=2
n.u.: not analyzed
1): non-accredited Parameter
FA1) Distribution Wessling Laboratory

4. Remarks

The sample was passed in a PE bottle (500 mLL) from the client. The specifications for the sample are provided by the customer. Sampling took place in the non-accredited area.

On the basis of the above evaluation results and on the basis of our computings the water has the following contents and properties:

- pH-Value **6,8** (lightly acidic)
- Total Hardness 97 [°dH] (very hard)
- On the basis of our calculations in the attachment (DIN EN 12502) the Water is corrosive
- The water contains only small detectable (<5 mg / L) desolved (> 0.45 microns) substances (DOC).
- The water contains very high values from Natrium (Na), Sulfate (SO_4) and Chloride (Cl).
- The water contents nutrients (Nitrogen, Phosphorus), and organic matter (TOC/DOC), but not in high areas.

Christoph Riegler Zeltweg, 2017-01-11

Attachment:
Assessment of the Corrosion Probability

Messunsicherheit: k=2
1): nicht akkreditierter Parameter

Beurteilung der Korrosionswahrscheinlichkeit nach DIN EN 12502		Firma	**GfA GmbH**	
		Strasse	**Bundesstraße 66**	
		PLZ und Ort	**8740 Zeltweg**	
		Telefon	**03577/758-510**	
WinWASI 5.0	**R5.0.1.1**	Fax	**03577/758-520**	

Bezeichnungen	
Client	**Sandvik Mining and Construction G.m.b.H.**
Description of the Water	**ARNCLIFFE**
Description of the Results	170024
Date	23.01.17; 16:57
File name	2514_A170004.xlsx

Water Data for Evaluation		**Raw Water**
Evaluation Temperature (tb)	[°C]	22,0
Oxygen [O2]	[mg/l]	7,20
pHtb (pH-Value bei BeValueungstemperatur)		6,80
m-Value	[mmol/l]	1,192
p-Value	[mmol/l]	-0,284
c(DIC)	[mg/l]	17,7
Buffer intensity	[mmol/l]	0,541
Ionic Strength	[mmol/l]	153
Total Hardness	[°dH]	96,7
Carbonate Hardness	[°dH]	3,3
Calcium [Ca^{2+}]	[mg/l]	295
Magnesium [Mg^{2+}]	[mg/l]	241
Natrium [Na^{+}]	[mg/l]	2770
Kalium [K^{+}]	[mg/l]	100
Ammonium [NH_4^{+}]	[mg/l]	<0,01
Eisen-II [Fe^{2+}]	[mg/l]	0,141
Mangan-II [Mn^{2+}]	[mg/l]	0,158
Barium [Ba^{2+}]	[mg/l]	0,261
Strontium [Sr^{2+}]	[mg/l]	1,600
Chlorid [Cl^{-}]	[mg/l]	2650
Nitrat [NO_3^{-}]	[mg/l]	16,2
Nitrit [NO_2^{-}]	[mg/l]	4,10
Sulfat [SO_4^{2-}]	[mg/l]	1510
Orthophosphat [PO_4^{3-}]	[mg/l]	0,094
P, total as [PO_4^{3-}]	[mg/l]	0,166
Fluorid [F^{-}]	[mg/l]	<1
Kieselsäure [SiO_2]	[mg/l]	13,30
Gelöste Feststoffe [TDS]	[mg/l]	7654

Calcite Saturation Data at the Evaluation Temperature		
pHCtb (Calcitsaturation by Calcit)		7,552
pHA (Calcitsaturation by CO2-exchange)		7,700
pH5mg (pH-Value bei Calcit-Solvency 5 mg/l)		7,342
Delta-pH		-0,752
SI (saturationsindex Calcit)		-0,901
D_C (Calcitlöse-/Abscheidekapazität)	[mg/l]	23,215
related Carbonic Acid	[mg/l]	1,592
excess Carbonic Acid	[mg/l]	11,069
free Carbonic Acid	[mg/l]	12,661

Corrosion Quotients (DIN EN 12502)		
S_1 (Korrosionsquotient)	<0,5	94,297
S_2 (Anionenquotient)	<1 or >3	406,424
S_3 (Kupferquotient)	>1,5	0,072

Saturation Indices		
Bariumsulfat [$BaSO_4$]		
Calciumsulfat [$CaSO_4$]		-0,548
Calciumfluorid [CaF_2]		
Magnesiumhydroxid [$Mg(OH)_2$]		-5,881
SiO_2 (amorph)		
Strontiumsulfat [$SrSO_4$]		

Further Data		
Ionenstärke calculated with Leitfähigkeit	[mmol/l]	
Ionenstärke calculated with Specieskonzentrationen	[mmol/l]	153,295
Leitfähigkeit bei 25°C calculated with Ionenstärke	[mS/m]	950,427
D_{C60} (Calcitlöse-/Abscheidekapazität bei 60°C)	[mg/l]	17,664
Titrationskapazität pH4,3 berechnet bei tb	[mmol/l]	1,259
Kationenquotient		3,561

Cast Iron,Unalloyed and low alloy steel materials (DIN EN 12502-5)

Uniform surface corrosion !

$c(O_2)$	=	0,23	>	0,10 [mmol/l]	
pH-Wert	=	6,80	>	7,00	**not fulfilled !**
$c(HCO_3^{-})$	=	1,19	>	2,00 [mmol/l]	**not fulfilled !**
$c(Ca^{2+})$	=	7,36	>	1,00 [mmol/l]	

The pH-Value is to low for the formation of protective layers!

Caused to the oxygen content and to the pH-Value (>8,5) the corrosion time is raised.

Shallow Pit and Pitting Corrosion !

The danger of shallow pit and pitting corrosion is increased!

Hot galvanised ferrous materials (DIN EN 12502-3)

Uniform surface corrosion ✓

The necessary conditions for the formation of protective outer layers are fulfilled.

The danger of surface corrosion is low.

Shallow Pit and Pitting Corrosion !

$S_1=(Cl^{-}+NO_3^{-}+2\ SO_4^{2-})/\ HCO_3^{-}$	=	94	<	0,50	**not fulfilled !**
$c(HCO_3^{-})$	=	1,19	>	2,00 [mmol/l]	**not fulfilled !**
$c(Ca^{2+})$	=	7,36	>	0,50 [mmol/l]	

The probability of hole corrosion in the presence of oxygen is very high!

S1 higher then 3. The concentration of bicarbonate or calcium ions

Is too low to act in combination as cathodic inhibitors!

Selektive Korrosion ✓

$S_2=(Cl^{-}+2\ SO_4^{2-})/\ NO_3^{-}$	=	406	<	1,00 oder	
$S_2=(Cl^{-}+2\ SO_4^{2-})/\ NO_3^{-}$	=	406	>	3,00	
$c(NO_3^{-})$	=	0,26	<	0,30 [mmol/l]	

The danger of selective corrosion is low.

Copper and copper alloys (DIN EN 12502-2)

Uniform surface corrosion ! ✓

The hydrogen carbonate content is sufficiently high to form adhesive layers ending!

The corrosion rate is increased due to the low pH-Value!

Pitting Corrosion in heating Water !

$S_3= HCO_3^{-}/\ SO_4^{2-}$	=	0,07	>	1,50	**not fulfilled !**
pH-Wert	=	6,80	>	7,00	**not fulfilled !**
$c(HCO_3^{-})$	=	1,19	>	1,50 [mmol/l]	**not fulfilled !**

The danger of pitting corrosion in heated water is low.

Stainless steels (DIN EN 12502-4)

Pitting Corrosion !

The danger of Corrosion is high (caused to the high Chloride Value).

The danger of Corrosion in warm water is low.

Appendix B: Robodrill Water Quality Specifications

En ce qui concerne les éléments contenus dans l'eau ne pas dépasser les valeurs suivantes (1.4404/1.4401 - SA240 316L/SA240 316):

Wasserinhaltsstoff + Kennwerte Water constituent + parameters Composants contenus dans l'eau	Einheit Unit Unité	Plattenwärmetauscher, kupfergelötet Heat Exchanger, copper brazed Echangeurs avec brasure au cuivre	Plattenwärmetauscher, nickelgelötet Heat Exchanger, nickel brazed Echangeurs avec brasure au nickel
pH-Wert pH-value pH		7 - 9 (unter Beachtung SI Index)	6 - 10
Sättigungs-Index SI (delta pH-Wert) Saturation-Index SI (delta pH-value) Indice de saturation SI (valeur delta pH)		-0,2 < 0 < +0,2	Keine Festlegung No specification Pas de recommandation
Gesamthärte Total hardness Dureté totale	°dH	6…15	6…15
Leitfähigkeit Conductivity Conductivité	µS/cm	10...500	Keine Festlegung No specification Pas de recommandation
Abfilterbare Stoffe Filtered substances Substances filtrées	mg/l	<30	<30
Chloride Chlorides Chlorures	mg/l	Siehe Diagramm Seite 9, oberhalb 100°C keine Chloride zulässig See diagram page 9, above 100°C no chlorides permitted Voir diagramme page 9, au-dessus de 100°C pas de chlorures admissibles	
Freies Chlor Free Chlorine Chlore libre	mg/l	<0,5	<0,5
Schwefelwasserstoff (H_2S) Hydrogen sulphide Sulfure d'hydrogène	mg/l	<0,05	Keine Festlegung No specification Pas de recommandation
Ammoniak (NH_3/NH_4^+) Ammonia Ammoniaque	mg/l	<2	Keine Festlegung No specification Pas de recommandation
Sulfat Sulphates Sulfates	mg/l	<100	<300
Hydrogenkarbonat Hydrogen carbonate Hydrogénocarbonate	mg/l	<300	Keine Festlegung No specification Pas de recommandation
Hydrogenkarbonat / Sulfat Hydrogen carbonate / Sulphates Hydrogénocarbonate/ Sulfates	mg/l	>1,0	Keine Festlegung No specification Pas de recommandation
Sulfid Sulphide Sulfures	mg/l	<1	<5
Nitrat Nitrate Nitrates	mg/l	<100	Keine Festlegung No specification Pas de recommandation
Nitrit Nitrite Nitrites	mg/l	<0,1	Keine Festlegung No specification Pas de recommandation
Eisen, gelöst Iron Fer	mg/l	<0,2	Keine Festlegung No specification Pas de recommandation
Mangan Manganese Manganèse	mg/l	<0,1	Keine Festlegung No specification Pas de recommandation
Freie aggressive Kohlensäure Free aggressive carbonic acid Acide carbonique libre	mg/l	<20	Keine Festlegung No specification Pas de recommandation