GOOGONG

Googong Integrated Water Cycle Project Stage D

Review of Environmental Factors

Water Recycling Plant and Permanent Reservoirs

Volume Two: Appendices A – E

June 2020

APPENDICES

Appendix A EP&A Regulation Clause 228 and Matters of National Environmental Significance checklists

Clause 228(2) Checklist

Factor	Consideration	Impact
a. Any environmental impact on a community?	The Proposal would have temporary traffic, noise, surface water, air quality and visual impacts as a result of construction activities.	Minor short term negative impacts
b. Any transformation of a locality?	The local area is currently undergoing major development with the establishment of the Googong township. The Proposal is an augmentation of the existing WRP and Hill 800 sites thus is a minor component in the wider changes to the area. As such, the areas will not be transformed by the Proposal as is it is considered characteristic of the existing use for the WRP and Hill 800 sites.	Nil
c. Any environmental impact on the ecosystems of the locality?	The Proposal does not require the removal of any vegetation, and would not impact the habitat of threatened species, population or community. Stage D will discharge excess recycled water, on occasion off-specification recycled water and very rarely emergency releases. The quality and quantity of the discharges have been assessed and it has been determined that no long term negative impacts are expected. It has been noticed that increased water to be discharged into Googong Creek is likely to improve aquatic and riparian ecology.	Minor positive impact
d. Any reduction of the aesthetic, recreational, scientific, or other environmental quality or value of a locality?	The Proposal would not negatively impact the aesthetic, recreational, scientific or other environmental quality or value of a locality. Stage D allows for the sustainable use of water in Googong township. Any minor impacts attributed to Stage D are offset against the long term advantages of reusing water within the township and reducing the resource requirements of the community. The Proposal would have permanent long term visual impacts to the community as the new permanent reservoir site would be visible form the surrounding residential and community areas. However, given that the area is currently semi-rural and would be built up to an urban area, these impacts are expected to be moderate and they would play a crucial part in the ongoing infrastructure for the township	Nil Moderate long term visual impacts
e. Any effect on a locality, place, or building have aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific, or social significance or other special value for present or future generations?	The Proposal would not negatively impact on the locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations.	Nil
f. Any impact on the habitat of protected fauna (within the meaning of the *National parks and Wildlife Act 1974*)?	The Proposal will not require impact to or removal of any habitat for fauna species such as hollow bearing trees, logs and vegetation. As such, there will be no impact to fauna.	Nil

Factor	Consideration	Impact
g. Any endangering of any species of animal, plant, or other form of life, whether living on land, in water or in the air?	The Proposal is unlikely to endanger any species within the Proposal area as a result of construction or operation activities. An Aquatic Ecology assessment was undertaken for the Proposal and identified that the development of the Googong township and commencement of recycled water reticulation would alter the flows of downstream waterways, such as Googong Creek. However, the impacts are expected to be minor and Stage D is not expected to endanger any aquatic animal or plant species or other forms of life.	Nil Minor long term impacts
h. Any long-term effects on the environment?	The Proposal would provide for long-term benefits by providing an important part of the infrastructure for the sustainable management of recycled water supplying the township, reducing the population demand on potable water supply by up to 60 per cent.	Positive long term benefits
i. Any degradation of the quality of the environment?	The Proposal is unlikely to degrade the environment due to the minor scale of works. There is potential for minor erosion to ephemeral watercourses through discharges however mitigation measures are proposed to counter or manage geomorphologic impacts. Ongoing monitoring is also proposed to ensure any issues can be addressed as they arise.	Nil Minor long term impacts
j. Any risk to the safety of the environment?	The construction management measures identified in the REF would manage and mitigate potential risks to the environment. The Water Management Plan implemented for the IWC Project addresses and manages ongoing risks and their corresponding mitigation measures.	Minor short term negative impacts Minor long term impacts
k. Any reduction in the range of beneficial uses of the environment?	The Proposal would not reduce the beneficial uses of the environment. The Stage D WRP and Hill 800 are an expansion of the existing sites, therefore not alienating further land from public use or enjoyment. Furthermore, the use of recycled water supports the principles of ecologically sustainable by providing a more sustainable water supply for the Googong township.	Positive long term benefits
l. Any pollution of the environment?	During construction, there is potential that the Proposal may cause minor air and water pollution to the local environment. However, the construction management measures identified in the REF would manage and mitigate potential risks to the environment. The Proposal would result in discharge of water to the environment. Ongoing monitoring of both surface water and groundwater has been implemented under the Water Management Plan for the IWC Project. Protocols are in place should any discharges not meet water quality guidelines.	Minor short term negative impacts Potential minor impacts
m. Any environmental problems associated with the disposal of waste?	The Proposal would require the disposal of waste during construction. It is anticipated that spoil from earthworks can be predominantly utilised on site. The WRP does require the disposal of waste from screening and de-gritting as well as biosolids produced as part of the water treatment process. This waste will be disposed in line with relevant standards and management measures.	Minor short term impacts Potential minor impacts
n. Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply?	The Proposal is unlikely to increase the demands on any resources that are, or are likely to become, in short supply. The Proposal provides for the efficient management of resources in water by the Googong township development.	Positive long term impacts
o. Any cumulative environmental effect with other existing or likely future activities?	The Proposal is part of the wider IWC Project. Stage AB and C is currently in operation. The IWC project will provide recycled water for Googong township and reduce the overall water requirements for the development. As such, the IWC Project reduces the ongoing impact of the new development.	Minor negative impacts

Factor	Consideration	Impact
p. Any impact on coastal processes and coastal hazards, including those under projected climate change conditions?	The Proposal is not expected to impact on any coastal processes and coastal hazards.	Nil

Matters of National Environmental Significance

Under the environmental assessment provisions of the E*nvironment Protection and Biodiversity Conservation Act 1999*, the following matters of national environmental significance and impacts on Commonwealth land are required to be considered to assist in determining whether the proposal should be referred to the Australian Government Department of the Environment.

Factor	Impact
Any impact on a World Heritage property? There are no World Heritage properties in the vicinity of the Proposal.	Nil
Any impact on a National Heritage place? There are no National Heritage places in the vicinity of the Proposal.	Nil
Any impact on a wetland of international importance? There are no wetlands of international importance in the vicinity of the Proposal.	Nil
Any impact on a listed threatened species or communities? Approval under the EPBC Act has been obtained for the Googong township and IWC Project and included an assessment of threatened species and communities. Of note is the Pink-tailed Worm-lizard and the requirement to establish a protection area and implement a plan of management (CoA 1) and the Hoary Sunray which must be fenced when working in the vicinity (CoA 4). These conditions would continue to be implemented throughout Stage D to protect threatened species however works for the Proposal would not impact on areas associated with the Pink-tailed Worm-lizard and Hoary Sunray. No additional threatened species or communities have been identified as part this assessment for Stage D. The Proposal area is cleared and provides minimal habitat.	Nil
Any impacts on listed migratory species? It is unlikely that the development of the Proposal would significantly affect any listed migratory species.	Nil
Does the proposal involve a nuclear action (including uranium mining)? The Proposal does not involve a nuclear action.	Nil
Any impact on a Commonwealth marine area? There are no Commonwealth marine areas in the vicinity of the Proposal	Nil
Does the Proposal involve development of coal seam gas and/or large coal mine that has the potential to impact on water resources? The Proposal is not related to coal seam gas or mining.	Nil
Additionally, any impact (direct or indirect) on Commonwealth land? The Googong Foreshores is located east of the Proposal areas and comprises Commonwealth land. The potential impacts of the Googong township (including the IWC Project) on the foreshores has previously been assessed as part of the EPBC process, and was subsequently approved by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now Department of Agriculture, Water and the Environment) on 19 May 2011. CoA 2 and CoA 3 of the EPBC Approval required GTPL to prepare and implement a Googong Foreshores Interface Management Strategy. This Strategy would continue to be implemented through Stage D. No additional impacts to Commonwealth land have been identified as part this assessment for Stage D.	Nil

Appendix B EP&A Act Part 3A Conditions of Approval checklist

CoA #	Condition	Response
2.1	Pursuant to section 75P(2)(c) of the EP&A Act, the following environmental assessment requirements apply with respect to any future development that is subject to Part 4 of Part 5 of the EP&A Act (which are not exempt or complying development), for the subsequent project stages:	
2.1 (a)	A detailed project description, including the design and location of ancillary infrastructure (including access roads and temporary construction compounds) and its relationship to the approved concept and approved project stages.	Section 3 outlines a detailed description of the Proposal and all ancillary facilities including temporary compound sites.
2.1 (b)	An assessment of relevant statutory matters including land zoning, permissibility and consistency with the objects of the EP&A Act.	An assessment of relevant statutory matters is outlined in Section 4.
2.1 (c)	A demonstration that the project is consistent with the requirements of this Concept Plan approval and generally consistent with the scope and intent of the Concept Plan and environmental impacts outlined in the documents under condition 1.1 of this approval.	A demonstration that the Proposal is consistent with the Concept Plan approval is outlined in Section 2. Consideration of the environmental impacts of the Proposal are outlined in Section 6.
2.1 (d)	A risk assessment of the potential environmental impacts of the project, identifying the key issues for further assessment.	A risk assessment has been considered for the Proposal and is included in Section 6.1 and Appendix J.
2.1 (e)	A description of the measures that would be implemented to avoid, minimise and, if necessary, offset the potential impacts of the project, and ensure that the project is in the public interest.	Section 6 identifies the management measures that would be implemented to avoid, minimise or offset the potential impacts of the Proposal on the local environment. Section 2 identifies the justification of the Proposal that it is in the public interest to ensure sufficient potable water and recycled water supply to the growing Googong township.
2.1 (f)	An assessment of the consistency of the potential impacts and proposed mitigation measures with the management plans approved under Stage 1 Project and subsequent stages.	A demonstration that the Proposal is consistent with the Concept Plan approval is outlined in Section 2. All potential impacts of the Proposal have been considered in Section 6.
2.1 (g)	A detailed project specific statement of commitments	Section 7 provides an outline of the specific statement of commitments for the Proposal. These commitments summarise the proposed management measures for the Proposal to avoid, minimise or offset the potential impacts.
2.1 (h)	Assessment of the following key issues considering all components of the project (including temporary construction facilities) and cumulative impacts from other projects associated with the Concept Plan:	
	Surface Water – including potential water quality impacts on local creeks and rivers and impacts on surface water flows, as a result of construction and operation of the project;	The potential impacts of the Proposal to surface water quality have been considered in Section 6.2.
	Soils and landscape – including potential soil contamination, erosion risks, irrigations and rehabilitation;	The potential impacts of the Proposal to soils and landscape have been considered in Section 6.5.

CoA #	Condition	Response
	Groundwater – including potential impacts on local recharge levels, contamination risks, groundwater mounding, isolated waterlogging of soils and impacts on groundwater quality.	The potential impacts of the Proposal to groundwater during have been considered in Section 6.3.
	Flora and fauna – including terrestrial riparian and aquatic, with accurate estimates of vegetation disturbance associated with the project;	The potential impacts of the Proposal to terrestrial, riparian and aquatic biodiversity have been considered in Section 6.4.
	Heritage – both Aboriginal and non-Aboriginal, including an assessment of Aboriginal sites affected by the proposed development, their cultural value and the significance of these values for Aboriginal people;	The potential impacts of the Proposal to Aboriginal and non-Aboriginal heritage have been considered in Section 6.10 and 6.11, respectively.
	Human Health – inducing impacts arising from the application of recycled water and discharges of wastewater and recycled water.	The potential impacts of the Proposal to human health have been considered in Section 6.14.
	Waste Management – including the likely waste quantities and qualities generated during the construction (including spoil generation) and operation of the project.	Waste assessment and management for the Proposal has been considered in Section 6.12.
	Hazards and risk – including details of hazardous materials used or kept on the premises during the construction and operation phases of the project	Hazards and risks for the Proposal have been considered in Section 6.13. Bushfire risk for the Proposal has been considered in Section 6.14.
	Air quality – including dust and odour impacts.	The potential air quality impacts of the Proposal have been considered in Section 6.7.
	Noise and vibration – including construction and operation noise impacts in the context of planned urban development in the area;	The potential noise and vibration impacts of the Proposal have been considered in Section 6.6.
	Visual amenity – an assessment of the impact of the project on visual amenity, including future sensitive receptor areas, including residential;	The potential visual amenity impacts of the Proposal have been considered in Section 6.8.
	Traffic and access – including details of transport routes to and from construction and operation sites and associated impacts to existing activities, including safety impacts;	The potential impacts of the Proposal on traffic and access, including transport routes and peak construction numbers, have been considered in Section 6.9.
2.1 (i)	Evidence of an appropriate level of consultation with (but not necessarily limited to) the following parties, including identification of the issues raised and how these have been addressed in the assessment: • Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now referred to as the Department of the Environment) (now referred to as the Department of Agriculture, Water and the Environment); • Office of Environment and Heritage (including its Heritage Branch) (now referred to as NSW Energy, Environment and Science); • Department of Trade and Investment, Regional Infrastructure and Services (including its Primary Industries Division) (now referred to as Department of Primary Industries); • Roads and Traffic Authority (now referred to as Roads and Maritime Services); • Queanbeyan City Council (now Queanbeyan-Palerang Regional Council); • Palerang Council (now Queanbeyan-Palerang Regional Council); • Relevant services providers; and • Property owners and the local community.	All consultation that has been undertaken for this Proposal, the issues raised in response to this consultation and GTPL's responses are described in Section 5.

CoA #	Condition	Response
2.1 (j)	The environmental assessment of the project must take into account relevant State Government guidelines, policies and plans	All relevant State Government guidelines, policies and plans have been considered and referenced where required and have been considered in Section 4 and Section 6 under the relevant environmental issues.
2.1 (k)	The assessments of the subsequent project stages shall take into account, but not limited to the following guidelines, as relevant; • *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000).* • *National Water Quality Management Strategy – Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and Australian Health Ministers Conference 2006)* • *NSW Industrial Noise Policy (EPA, 2000)* • *Interim Construction Noise Guidelines (DECC, 2009)* • *Environmental Noise Management –Assessing Vibration: a Technical Guideline (DECC, 2006)* • *Environment Criteria for Road Traffic Noise (EPA, 1999)* • *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005)*	These water guidelines have been considered as part of the design of the Proposal and assessment outlined in Section 6.2 and Section 6.3. The Noise and Vibration Assessment (Section 6.6) has been prepared with reference to: • *Construction Noise and Vibration Guideline* (Transport Roads and Maritime Services, 2016) • *Interim Construction Noise Guideline* (DECC, 2009) • *Noise Policy for Industry* (EPA, 2017) • *Assessing Vibration: a technical guideline* (DEC, 2006) • Australian/New Zealand Standard 2107:2016 • British Standard 7385 The air pollutant guidelines have been considered as part of the air quality assessment outlined in Section 6.7.
3.1	Subject to confidentiality, the Proponent shall make all documents required under this approval available for public inspection on request.	All planning documents for the Googong IWC Project have been made publicly available by GTPL on the project website www.compliance.googong.net.
3.2	Prior to the commencement of construction of any projects associated with this Concept Plan approval, the Proponent shall establish a dedicated website or maintain dedicated pages within its existing website for the provision of electronic information associated with the project. The Proponent shall publish and maintain up-to-date information on this website or dedicated pages including, but not necessarily limited to: (a) the status of the project; (b) a copy of each relevant environmental approval, licence or permit required and obtained in relation to the project; (c) a copy of each approved plan, report, or monitoring program required by this approval and associated project approvals; (d) a summary of the monitoring result of the project, which have been reported in accordance with the various plans and programs approved under this approval and associated project approvals; (e) a summary of the monitoring results of the project, which have been reported in accordance with the various plans and programs approved under this approval and associated project approvals; (f) details of the outcomes of compliance reviews and audits of the project, to the satisfaction of the Director-General.	GTPL has established the IWC Project website to inform the community of progress on the planning and construction of the project. This website is www.compliance.googong.net. In addition, GTPL provides quarterly updates delivered via email to all residents, property owners and any other listed on the Googong stakeholder list. Contact information is made available for all residents to report any issues with construction activities and records are kept of any reports and how these were addressed.

Appendix C EP&A Act Part 4.15 Matters for consideration checklist

Matters for consideration – general	Response
a. The provisions of:	
(i) any environmental planning instrument,	Section 4.3.1 considers the environmental planning instruments relevant to the proposed temporary construction access.
(ii) any proposed instrument that is or has been the subject of public consultation under this Act and that has been notified to the consent authority (unless the Planning Secretary has notified the consent authority that the making of the proposed instrument has bene deferred indefinitely or has not been approved),	Not relevant to the proposed temporary construction access.
(iii) any development control plan,	Section 2.3.4 considers the application of the Googong Development Control Plan on the proposed temporary construction access.
(iiia) any planning agreement that has been entered into under section 7.4, or any draft planning agreement that a developer has offered to enter into under section 7.4, and	The Googong Development Corporation entered into the Googong Urban Development Local Planning Agreement with QCC for the provision of infrastructure, public amenities, and open space on behalf of Council. Stage 1 and part of stage 2 (Stage C) of the IWC Project has already been transferred to QPRC under this agreement and it is agreed that Stage D components would also be transferred following completion and verification.
(iv) the regulations (to the extent that they prescribe matters for the purposes of this paragraph).	The provisions of the regulations would be considered during the development application process for the temporary construction access.
b. The likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality	Section 6 considers the likely environmental, social and economic impacts of the proposed temporary construction access. Likely impacts of the temporary construction access relate to soil erosion and air quality (dust).
c. The suitable of the site for the development	Section 3.3.2 considers the suitability and justification of the site for the proposed temporary construction access.
d. Any submissions made in accordance with this Act or the regulations	Submissions would be made to QPRC following the public display of this REF.
e. The public interest	The proposed temporary construction access would support the construction of Stage D

Appendix D Surface water assessment

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Surface Water Assessment

Googong Integrated Water Cycle Project Stage D WRP and Permanent Reservoirs

Reference No. AU212000166
Prepared for RPS Manidis Roberts Pty Ltd
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List of Abbreviations and Acronyms

Abbreviation/ Acronym	Description
ACT	Australian Capital Territory
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AGWR	Australian Guidelines for Water Recycling
BOM	Bureau of Meteorology
COA	Conditions of Approval
CRMRM	Cumulative Residual Monthly Rainfall Mass – calculated in the method described by Ferdowsian et al (2001)
CEMP	Construction Environmental Management Plan - A site or project specific plan designed to ensure appropriate environmental management practices are applied through the construction phases of the project
DO	Dissolved Oxygen
DEC	Department of Environment and Conservation
EC	Electrical Conductivity
EDT	Emergency Detention Tank
EP	Equivalent Population - Term used to describe sewage generation based on the average person in a residential development
EP&A Act	Environmental Planning and Assessment Act
EPL	Environmental Protection Licence
EQL	Lowest level that can be reliably achieved within the specified limits of precision and accuracy during routine laboratory operating conditions
GTPL	Googong Township Propriety Limited
IMP	Irrigation Management Plan
IWC	Integrated Water Cycle
ha	hectares
ID	Identification – refers to name of element
kL	Kilo litre
LLD	Low Level Detection
L/s	Litres per second
m	Metres
mAHD	Meters (Above) Australian Height Datum
mBGL	Meters Below Ground Level

Abbreviation/ Acronym	Description
MBR	Membrane Bioreactor
MCC	Motor Control Centre
mg/L	Milligrams per litre
ML	Mega litres
mTOC	Meters below Top of Casing
NA	Not Assessed
NH	Neighbourhood (of Googong Township)
NRMMC	Natural Resource Management Ministry Council
OEMP	Operational Environmental Management Plan
NS	No Sample – refers to not enough for sample collection
PLC	Programmable Logic Controller
PTWL	Pink Tailed Wormed Lizard
PVC	polymerization of vinyl chloride – a type of pipe
PW	Potable Water
µg/L	Micrograms per litre
QPRC	Queanbeyan-Palerang Regional Council
RAH	Rotary Air Blast
REF	Review of Environmental Factors
ReW	Recycled Water
RPD	Relative Percent Difference
RWRP	Recycled Water Flow Release Protocol
RWQMP	Recycled Water Quality Management Plan
RL	Relative Level, generally referenced to mAHD
SOC	Statement of Commitments
SCADA	Supervisory Control and Data Acquisition
SGRP	Surface and Groundwater Response Plan
SMEC	Snowy Mountains Engineering Company – SMEC Australia Pty Ltd
SPS	Sewage Pumping Station
STP	Sewage Treatment Plant
SWAEMP	Surface Water and Aquatic Ecology Monitoring Program
SWL	Standing Water Level
TOR	Terms of Reference

Abbreviation/ Acronym	Description
UTM	Universal Transverse Mercator – coordinate system
WMP	Water Management Plan
WRP	Water Recycling Plant
WSG	World Survey Grid 1984
WTP	Water Treatment Plant

1 Introduction

Googong Township is located approximately 8 km south of Queanbeyan and 14 km south-east of Canberra, near Googong Reservoir in New South Wales (Figure 1 and Figure 2). SMEC Australia Pty Ltd (SMEC) was engaged by RPS Manidis Roberts (RPS) on behalf of Googong Township Pty Ltd (GTPL) to prepare a Surface Water Assessment for the Stage D Water Recycling Plant (WRP) (the site) the final component of the Googong Integrated Water Cycle (IWC) Project.

The Googong Township is a planned housing development for about 18,850 people and is being developed over the next 25 years. The township is designed around an integrated water cycle (IWC), with a dedicated Water Recycling Plant (WRP) that will reduce the consumption of potable water in the community by around 60 per cent and recycle the township's water for non-potable use. The Googong IWC Project is being constructed and operated in stages to ensure the infrastructure is appropriately sized to meet the incremental level of demand as development of the Googong township progresses.

The stages of development are summarised as:

- Stage 1 which was completed in Late 2016 for WRP Stage AB and designed for 4,700 EP;
- Stage C which was completed in November 2019 and included the Stage C WRP for 9,400 EP; and
- Stage D the ultimate capacity of the project which has been planned for 18,850 EP.

The Stage D IWC Project components assessed in this review of environmental factors (REF) contains three parts:

- the upgrade of the existing WRP (construction and operation);
- the upgrade of Permanent Reservoirs located on Hill 800 (construction and operation); and
- the application of recycled water on public space (including sports fields) and on residential and other properties within the Googong Township.

Concept Approval for the ultimate development has been granted, subject to future environmental assessment requirements, and was granted by the Minister for Planning under Part 3A (now repealed) of the *Environment Planning and Assessment Act 1979* (EP&A Act). Stage D requires a surface water assessment to address the requirements of the Part 3A Concept Approval and requirements for the project approval under the EP&A Act. It incorporates all neighbourhoods, sporting grounds and open spaces for irrigation both current and planned.

1.1 Part 3A Concept Plan Approval Requirement

The Stage D WRP outlined requires a surface water assessment that considered Section 2.1 of the Part 3A Concept Plan Approval:

- *Surface Water – including potential water quality impacts on local creeks and rivers and impacts on surface water flows as a result of construction and operation of the project*

The assessment of the subsequent project stages shall take into account, but not limited to the following guidelines as relevant;

  - *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000);*
  - *National Water Quality Management Strategy – Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (NRMMC, 2006); and*
  - *Environmental Guidelines: Use of Effluent by Irrigation (DEC, 2004).*

1.2 Data Sources

The following data sources and reports were used for this surface water assessment:

- Stage C WRP Surface Water Assessment (Hydrobiology, September 2016) – provided by RPS;
- Googong Township Water Management Plan – provided by RPS;
- SMEC 2017 Annual Monitoring Report and SMEC 2018 Annual Factual Monitoring Report;
- QPRC 2019 monitoring data in the SMEC 2019 Annual Factual Monitoring Report; and
- Stage D WRP construction methodology and operational details – provided by RPS.

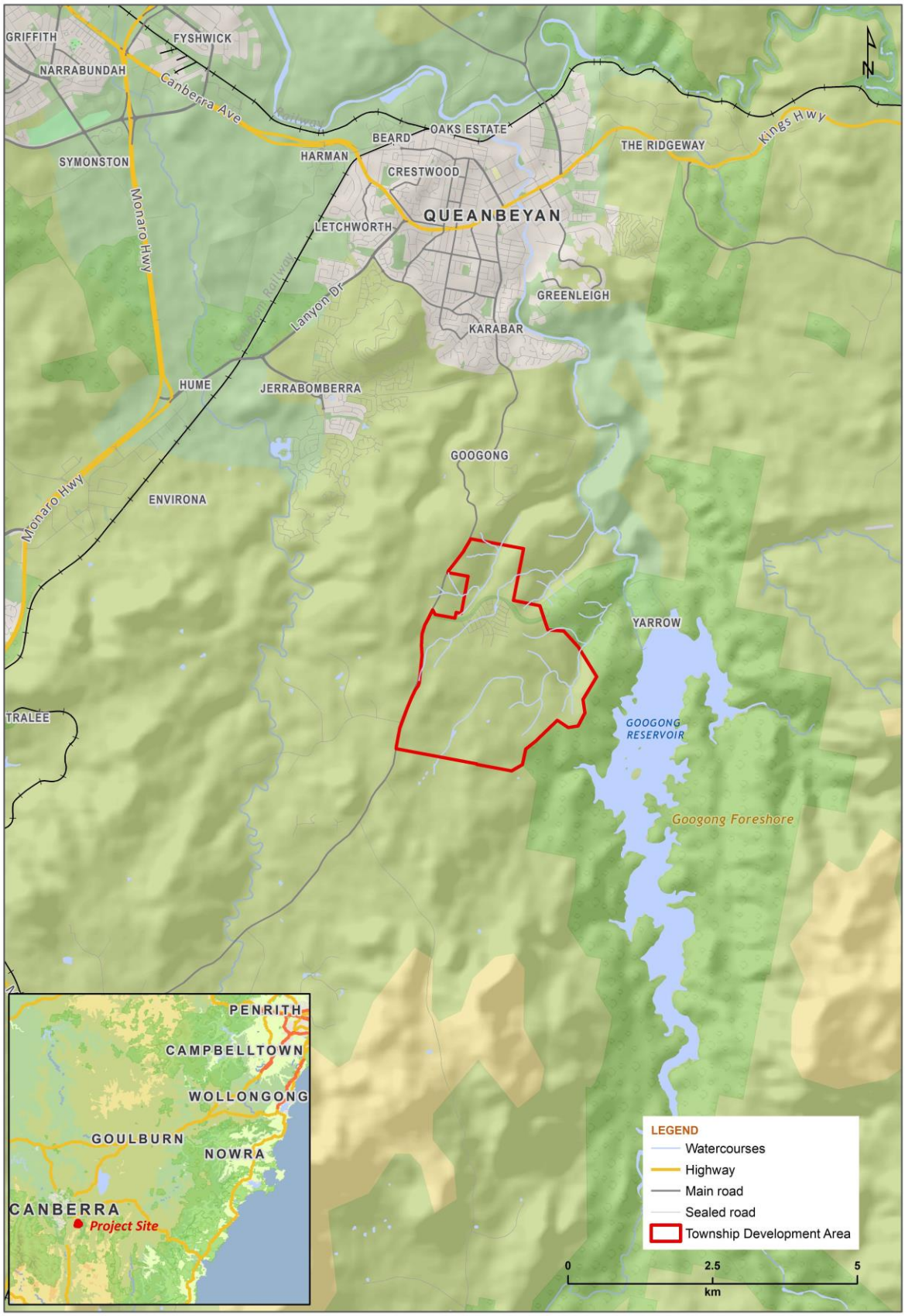


Figure 1: Googong Township Regional Location

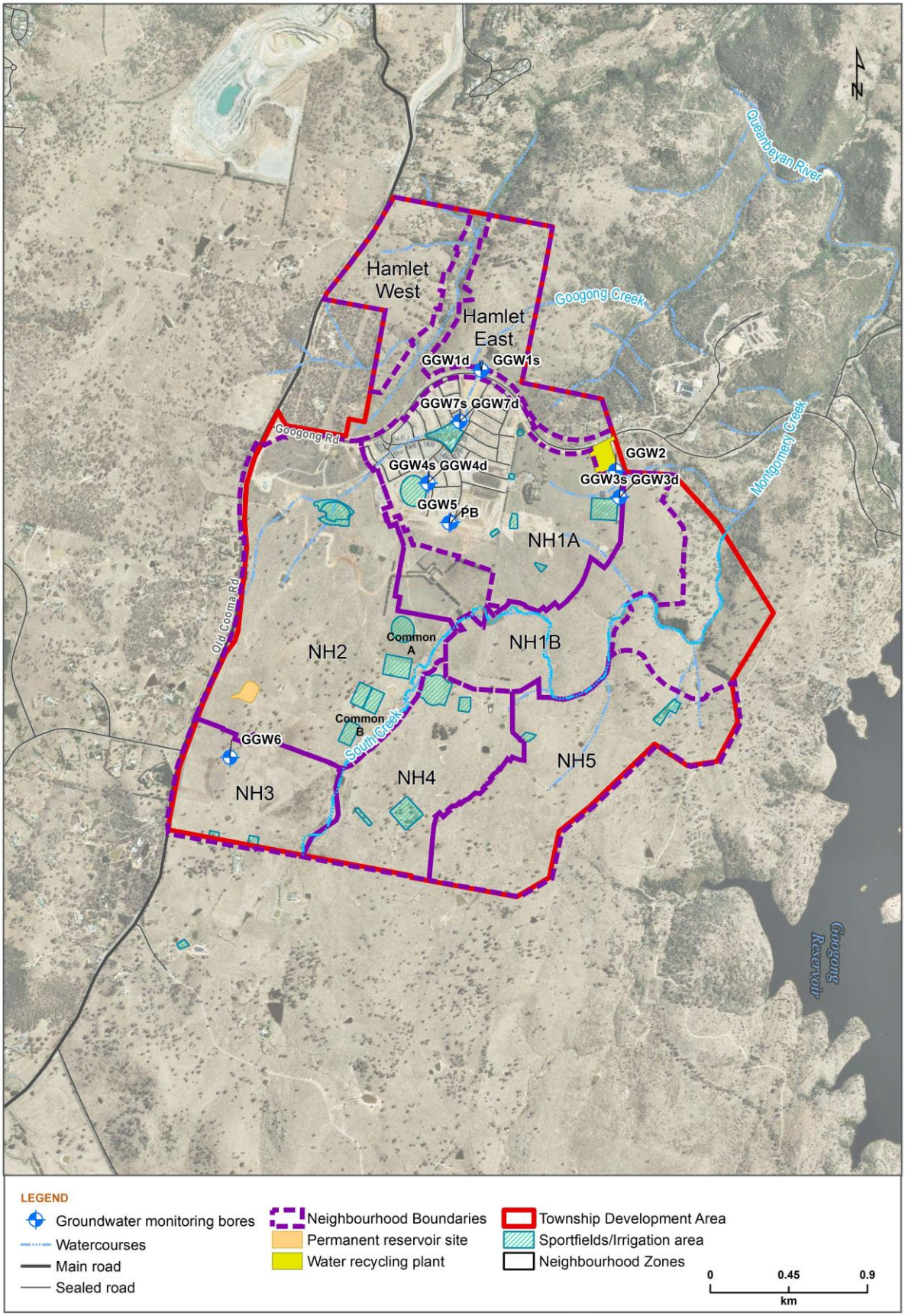


Figure 2: Googong IWC Project Stage D works and Neighbourhood Boundaries

2 Regional Setting

2.1 Googong Township

Googong Township is located approximately 8 km south of Queanbeyan, in NSW at the intersection of Old Cooma Road and Googong Road. Googong Reservoir is located approximately 600 m to the east of the eastern boundary of the township.

2.2 Climate

Climatic data is available from:

- Queanbeyan Bowling Club for rainfall from station no. 070072 to 31 October 2015;
- Tuggeranong (in the ACT) station no. 703390 from 1996; and
- Canberra Airport (in the ACT) evaporation from station no. 070014.

These are the closest stations with long term records held by the Bureau of Meteorology. On-site a weather station records data which is available from September 2013 for rainfall, wind speed, wind direction, minimum and maximum temperature, solar radiation and minimum and maximum relative humidity. There is no on-site evaporation data and some months have incomplete records. The baseline hydrogeological data was collected during a period of below average rainfall conditions and subsequent monitoring data has been collected during both above average and below average rainfall conditions. This should be considered during any interpretation of results and trends.

Average annual rainfall at the Googong Township, from the township weather station between 2014 and 2019 is approximately 590 mm compared to the 595mm annual average for the region. Rainfall is variable and can be subject to prolonged periods of above or below average rainfall with the winter months generally being slightly drier. The Googong climate is temperate and characterised by warm dry summers and cold winters.

Climate statistics from Canberra Airport show the mean temperatures range from -0.1°C to 12°C in winter to 13 °C to 34.5° C. Mean temperatures at Queanbeyan are within the range of 13-27° C during summer and 0.5-12° C in winter. The Googong township weather station shows since September 2019 the mean temperature ranges from 6-30° C in summer and 0.4-20°C in winter.

The nearest active Bureau of Meteorology (BOM) weather station is Tuggeranong (station number 70339) in the Australian Capital Territory (ACT), which has records from 1996. Figure 3 and Table 1 present a summary of the monthly mean and median rainfall totals at the Tuggeranong weather station with those from the Googong Township weather station. It should be noted that the Googong Township weather station has a limited dataset for statistical analysis and this should be considered when comparing results. Canberra Airport, also in the ACT, is the only BOM weather station with evaporation records. Table 2 presents a compilation summary of available climate statistic data from Canberra Airport, Tuggeranong and Googong Township weather station for evaporation, temperature, wind speed, relative humidity and solar radiation.

The cumulative residual monthly rainfall mass (CRMRM) compares the cumulative monthly rainfall with the long-term average. The CRMRM is calculated for both Queanbeyan Bowling Club weather station and Tuggeranong weather station, the two closest rainfall stations with significant data records, as shown on Figure 4. It was not calculated for Canberra Airport or Googong Township weather station as they have only been in operation for a shorter period. The CRMRM is most effective where more than 50 years of continuous records exist. On Figure 4 and other figures within this report showing the CRMRM it is the slope of the line that is important not a numerical value.

Figure 4 shows for both Queanbeyan and Tuggeranong the same trends for periods of above or below average rainfall, with a prolonged period of below average conditions occurring between 2002 and 2010. The Queanbeyan Bowling Club weather station was taken offline in 2015. The CRMRM for Tuggeranong only is shown, where practicable, on subsequent figures within this report. From 2010 to 2017, the trend at Tuggeranong shows generally above average rainfall conditions, with short periods of below average conditions before the start of another period of below average rainfall from 2017 to 2019. The baseline surface water data was collected during a period of below average rainfall conditions and subsequent monitoring data has been collected during both above average and below average rainfall conditions. This should be considered during any interpretation of results and trends.

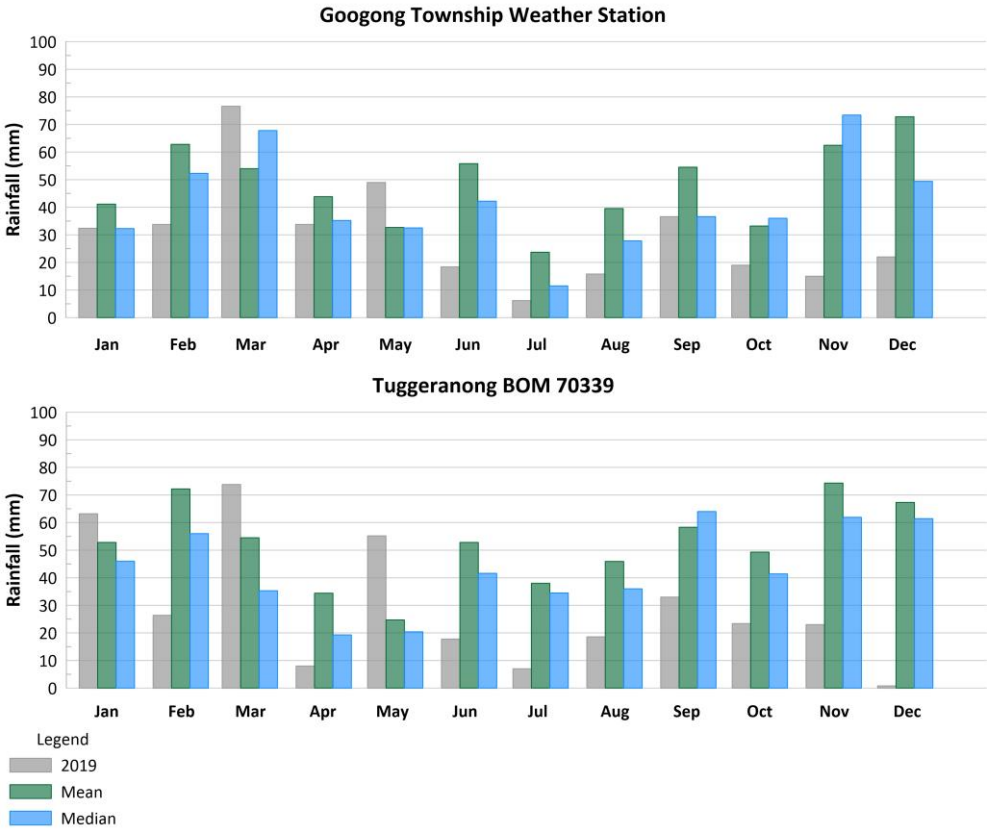


Figure 3: Googong Township Weather Station and BOM Weather Station Tuggeranong for monthly rainfall summary with mean and median results

Table 1: Rainfall data from Googong Weather Station (Sep 2013 to May 2020) and Tuggeranong (BOM 70339 for all years to February 2020)

Statistic	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Googong Mean rainfall (mm)	41.1	62.8	54.0	43.8	32.7	55.8	23.7	39.5	54.5	33.2	62.5	72.8	590
Tuggeranong Mean rainfall	52.8	72.2	52.5	32.4	24.8	52.8	38.0	45.9	58.3	49.3	74.3	67.3	620
Googong Median rainfall (mm)	32.3	52.3	67.8	35.2	32.5	42.2	11.5	27.8	36.6	36.0	73.4	49.4	497
Tuggeranong Median rainfall (mm)	46.0	56.0	34.2	17.2	19.4	41.6	34.5	36.0	64.0	41.4	61.9	61.4	513
Googong Highest Daily (mm), day and year	27.4, 12th 2015	47.2, 11th 2020	44.2, 5th 2020	43.0, 8th 2015	22.6, 9th 2016	89, 6th 2016	12.8, 6th 2016	36.0, 3rd 2015	55.8, 18th 2013	21.2, 15th 2014	34.2, 7th 2017	58.6, 14th 2018	
Tuggeranong Highest Daily (mm), day and year	65.2, 27th 2013	83.6, 3rd 2011	87.6, 4th 2012	65.0, 8th 2015	52.2, 20th 2017	81.8, 6th 2016	51.0, 9th 2005	47.0, 18th 2011	76.2, 17th 2013	60.0, 19th 2000	91.6, 26th 2011	93.0, 9th 2010	

Table 2: Climate data compilation from Googong Township weather station, Canberra Airport and Tuggeranong

Statistic	January	February	March	April	May	June	July	August	September	October	November	December
Average daily PAN Evaporation (mm) (Canberra Airport)	7.4	6.0	4.3	2.9	1.7	1.2	1.6	2.3	3.4	5.1	7.1	8.1
Googong Average Minimum Relative Humidity (%)	30.0	32.9	38.9	43.8	48.7	56.8	52.0	44.8	39.5	33.8	30.2	28.8
Canberra Airport Average Minimum Relative Humidity (%)	28.7	28.9	35.3	38.8	48.9	51.4	49.7	41.1	32.2	23.9	19.6	16.6
Googong Average Maximum Relative Humidity (%)	87.6	88.5	90.9	92.4	93.8	94.7	93.9	92.2	90.8	89.0	87.5	87.3
Canberra Airport Average Maximum Relative Humidity (%)	87.8	88.5	91.7	94.4	94.5	98.4	96.7	93.7	92.7	88.3	74.1	73.7
Googong Average Windspeed (m/sec)	3.5	3.5	3.2	3.0	3.2	3.3	3.4	3.6	3.5	3.5	3.7	3.5
Canberra Airport Average Windspeed (m/sec)	3.9	4.0	3.8	2.7	3.2	2.6	4.0	4.1	4.0	4.0	5.4	4.8
Canberra Airport Average daily solar radiation (MJ/sq m)	25.6	23.0	16.0	14.1	10.3	9.3	10.0	12.8	16.4	22.2	25.9	26.8
Googong Mean minimum temperature (°C)	14.1	13.1	11.6	7.9	3.6	1.9	0.4	0.9	3.1	6.7	8.9	12.3
Tuggeranong Mean minimum temperature (°C)	14.5	14.2	11.4	7.0	2.5	1.2	-0.1	0.9	3.7	6.4	9.8	12.4
Googong Mean maximum temperature (°C)	30.2	28.3	24.9	20.5	15.6	12.1	11.2	12.6	16.4	21.4	24.3	28.0
Tuggeranong Mean maximum temperature (°C)	29.8	28.1	25.3	21.0	16.6	13.1	12.4	14.1	17.7	21.1	24.4	27.4

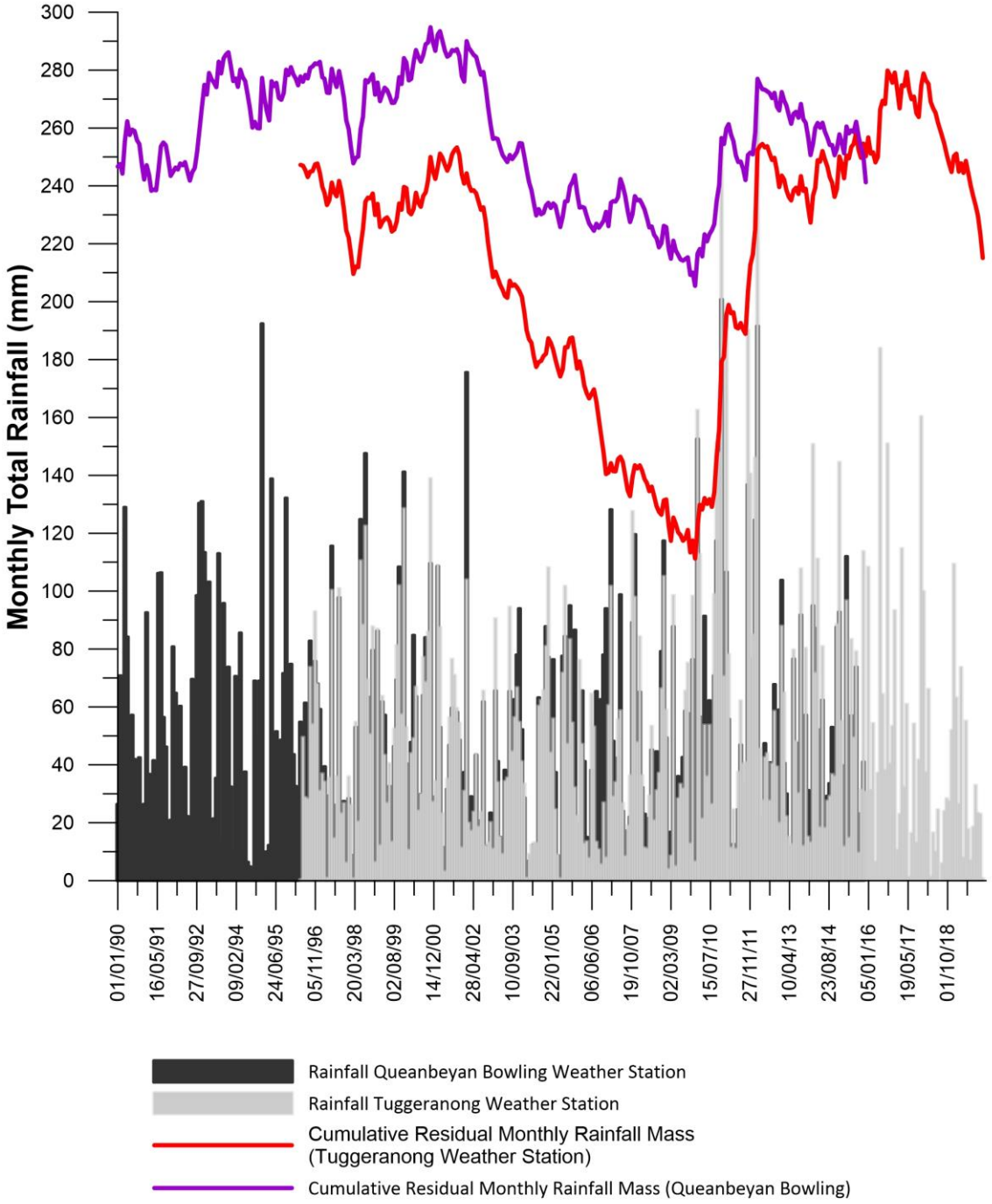


Figure 4: Monthly rainfall and cumulative residual rainfall mass from 1990 to 2019

2.3 Regional Geological Setting

General information sourced from Geological Survey of New South Wales and Bureau of Mineral resources shows the region is underlain by the Colinton Volcanics, a late Silurian aged volcanic unit within the Canberra block, part of the Lachlan Fold Belt (Figure 5). The Lachlan Fold Belt (LFB) is a 700-kilometre-wide belt of deformed, Palaeozoic, deep and shallow marine sedimentary rocks, cherts and mafic volcanic rocks. Surface structural elements suggest that it was formed by massive telescoping and strike-slip translation within a continental margin sediment prism along the former eastern margin of Gondwanaland during the mid-Palaeozoic.

During the Devonian (and to a lesser degree the Carboniferous) the introduction of granites and associated batholiths – such as the Ellenden, Gibraltar and Rossi Granites of the Bega Batholith to the east and south-east of the study area – marked the LFB's transition from an immature depositional basin comprising poorly sorted volcanoclastic sediments and airfall tuffs, towards a mature continental margin with the development of complex sedimentary deposits and explosive volcanic events. As a result of the numerous tectonic movements throughout the LFB's 'active' duration, the geological units throughout most of the fold belt have undergone multiple deformation events. In general, a strong regional tectonic inclination – from north-north-west to south-south-east – dominates the alignment of structures and geological units, particularly in the central and northern portions of the fold belt. In the Googong–Queanbeyan districts, however, the dominant tectonic inclination is north north-east–south-south-west (Figure 5).

The site (Figure 6) is underlain by the Colinton Volcanics, a unit of Silurian age. The Colinton Volcanics typically comprise limestone and dolomitic limestone, dark green dacitic ignimbrite and minor volcaniclastic sediments. The Stage AB field investigation encountered shale and dacite during the monitoring bore drilling program. A reef of igneous rock is exposed at the surface outside the south-eastern corner of the site and runs on about the line of the north-eastern boundary of the site.

The north-eastern corner of the township, where the WRP is situated, is underlain by the Googong Adamellite, a locally significant intrusive body that is described as a medium to coarse-grained, moderately weathered, buff-coloured porphyritic adamellite. It is the youngest unit in the area, having been intruded into the surrounding Colinton Volcanics, and appears to have faulted boundaries. Hill 800 reservoirs are located on the Colinton Volcanics in the south-west of the site. Drilling of GGW6, located nearby, encountered a thin layer of shale over dacite.

2.4 Hydrogeology

Groundwater is hosted in a regionally extensive fractured-rock aquifer. Minor alluvial aquifers are located along the alignments of locally significant waterways but are expected to have minimal storage and not to be of significance to this assessment. The depth to bedrock across much of the Googong Township is between about 0.5 m and 2 m, with fresh bedrock encountered at shallower depths at higher elevations, commonly marked by changes in slope. At the Googong Township groundwater is hosted in unconfined to semi confined fractured rock aquifers. Groundwater recharge is via infiltration of rainfall and infiltration of slope run-off and discharge is through springs, both perennial and ephemeral, and as baseflow to perennial watercourses.

Shallow groundwater is expected to migrate along the interface between the soil horizons and relatively fresh bedrock, and to discharge to surface water drainage lines and creeks. The regional groundwater flow direction is north-east towards the Queanbeyan River. The dedicated groundwater monitoring network (Figure 6) has been established on the site since August 2013. The groundwater monitoring network consists of 11 monitoring bores at seven different locations. At four locations nested shallow and deep monitoring bores have been installed.

2.5 Surface Water Catchments

Part of the township is located within the Googong Reservoir Water supply catchment. Topographically the township's surface water catchment is bounded by Old Cooma Road to the west, Googong Dam to the east and elevated area between Wells Place and Burra Road to the south of the site. Within the township catchment area are three water courses:

- South Creek / Montgomery Creek,
- North Creek, and
- Googong Creek

All join the Queanbeyan River north of the township and their catchment boundaries are shown on Figure 7 with the Stages AB and Stage C surface water monitoring locations.

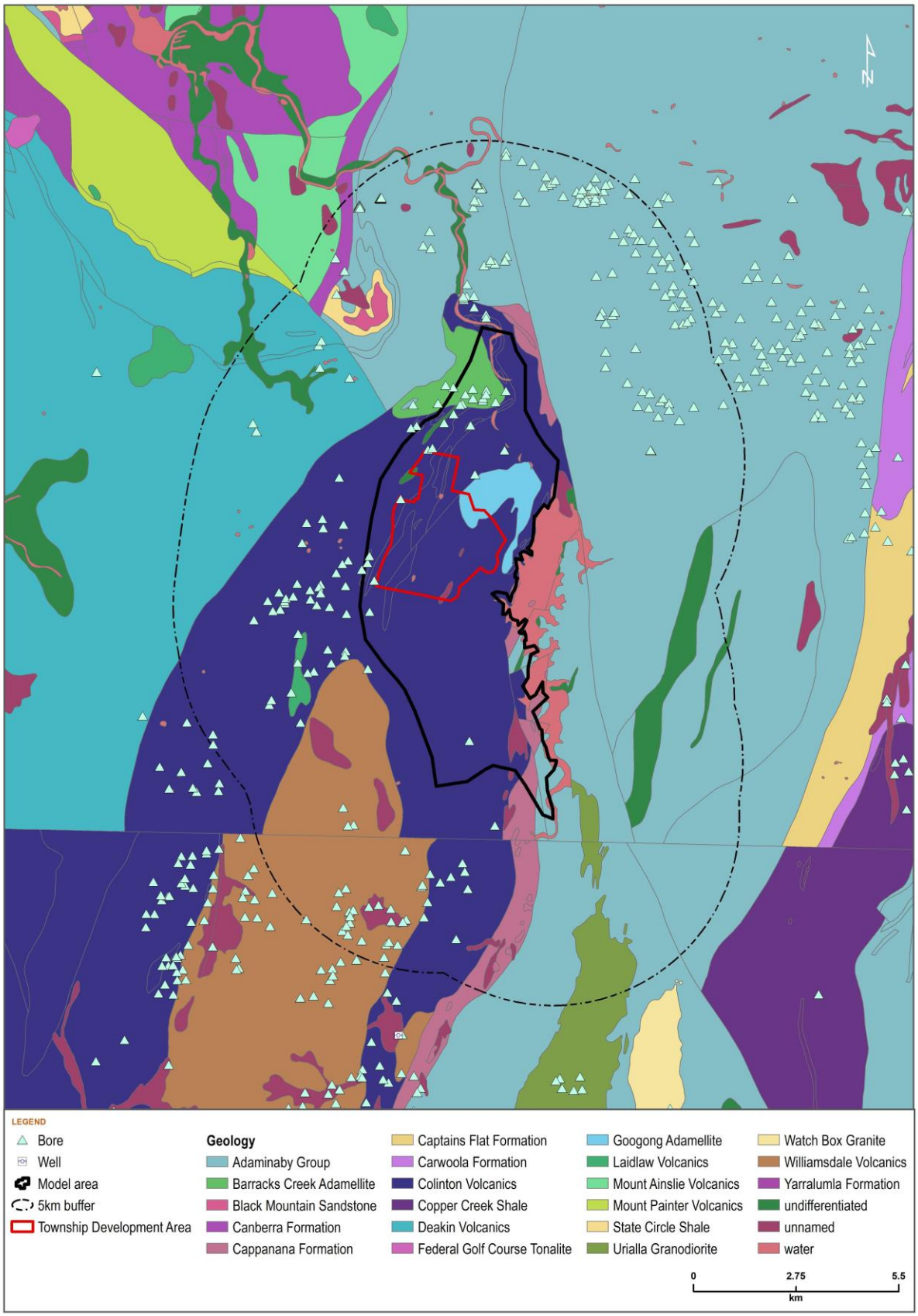


Figure 5: Regional Geology Map

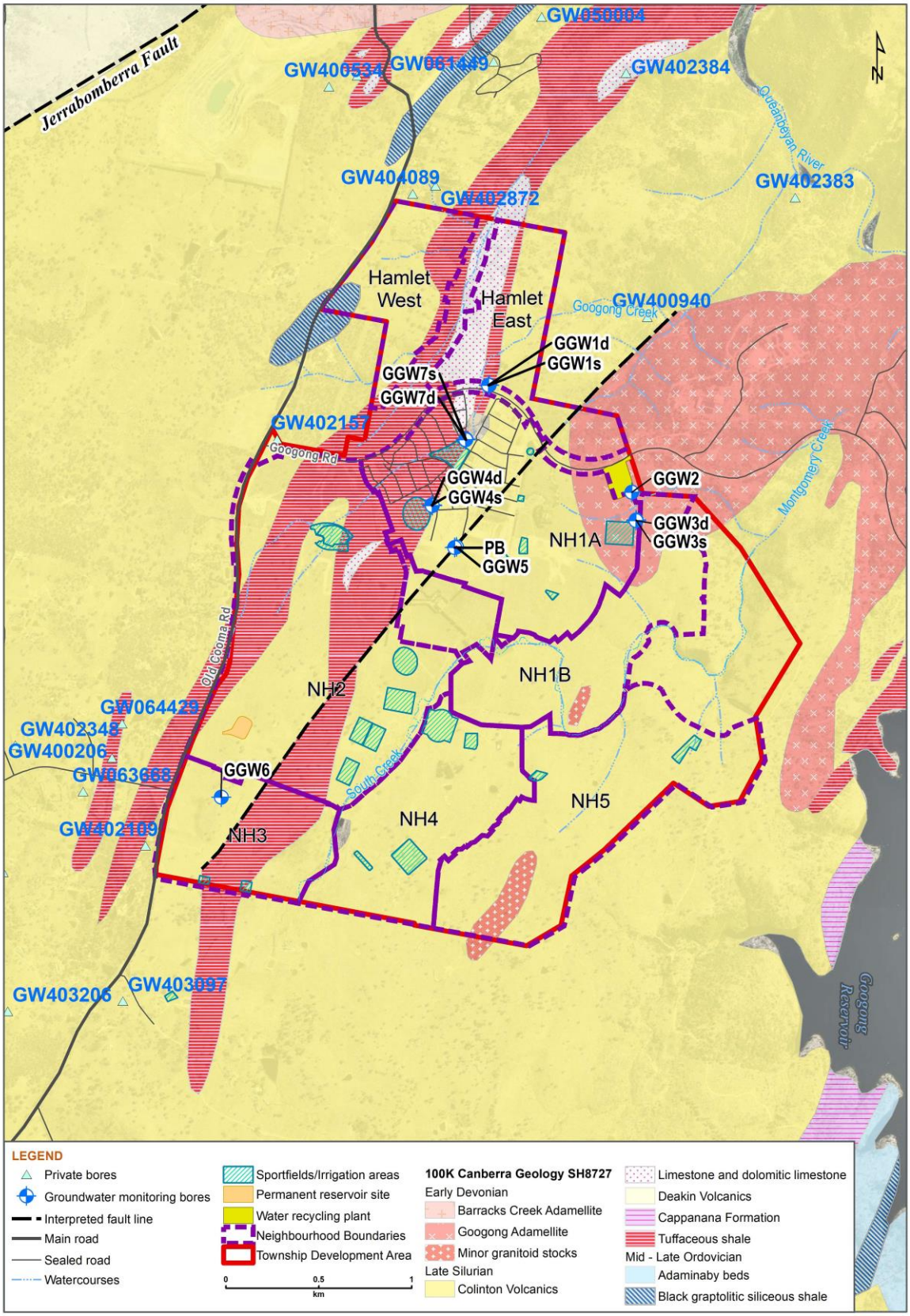


Figure 6: Googong Township Geological Map and Monitoring Bore Locations

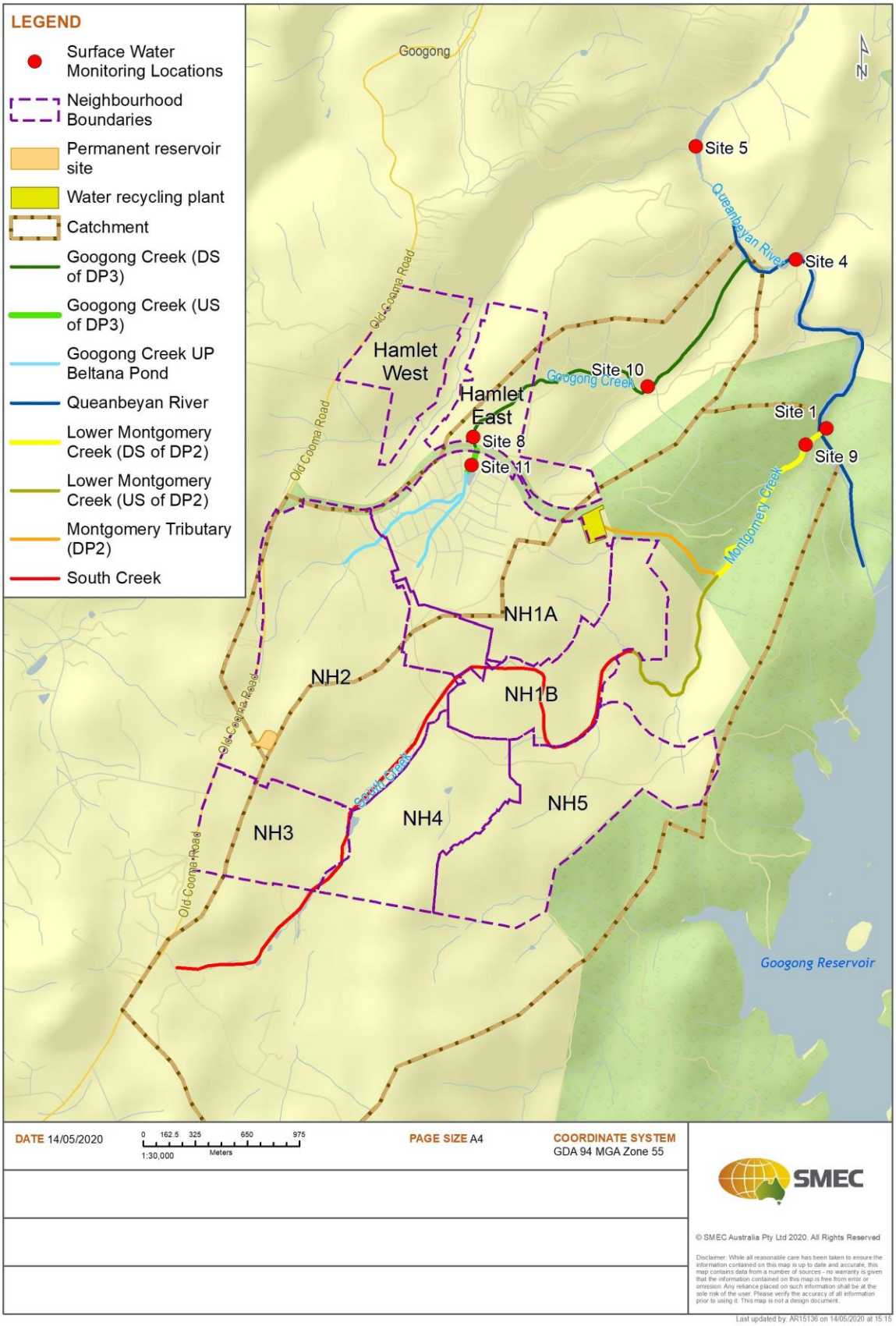


Figure 7: Googong IWC Project Stage D works and Neighbourhood Boundaries with Surface Water Catchment Boundaries and Monitoring Locations

The catchment area is characterised by the ongoing Googong Township development of low-intensity grazing land, natural bushland, and rural residential land uses. Stage C WRP development saw the commissioning of the WRP and the start of discharge of excess recycled water to Googong Creek. To date, there has been no recycled water irrigation or domestic use of recycled water, and no emergency discharges of recycled water down Montgomery Creek.

The Stage C surface water assessment report (Hydrobiology 2016), WMP and other earlier reports may have differing nomenclature for the creeks. Montgomery Creek has been divided into South Creek for the upper reach and Montgomery for the lower reach on the recent master Irrigation Plan provided by RPS. The previously unnamed creek west of Googong Creek has been named North Creek. Its catchment starts at the junction of Old Cooma Road and Googong Dam Road and is contained to Hamlet West with Old Cooma Road as the west boundary and the Googong Creek as the eastern boundary. Of these water courses, Googong Creek and Montgomery Creek will receive flows of excess recycled water as part of the IWC.

Figure 8 presents a longitudinal elevation profile, with vertical exaggeration, of Googong Creek and South Creek / Montgomery Creek into the Queanbeyan River with the location of the discharge points. These creeks show significant changes in elevation (noting a vertical exaggeration of about 8:1) over a relatively short distance.

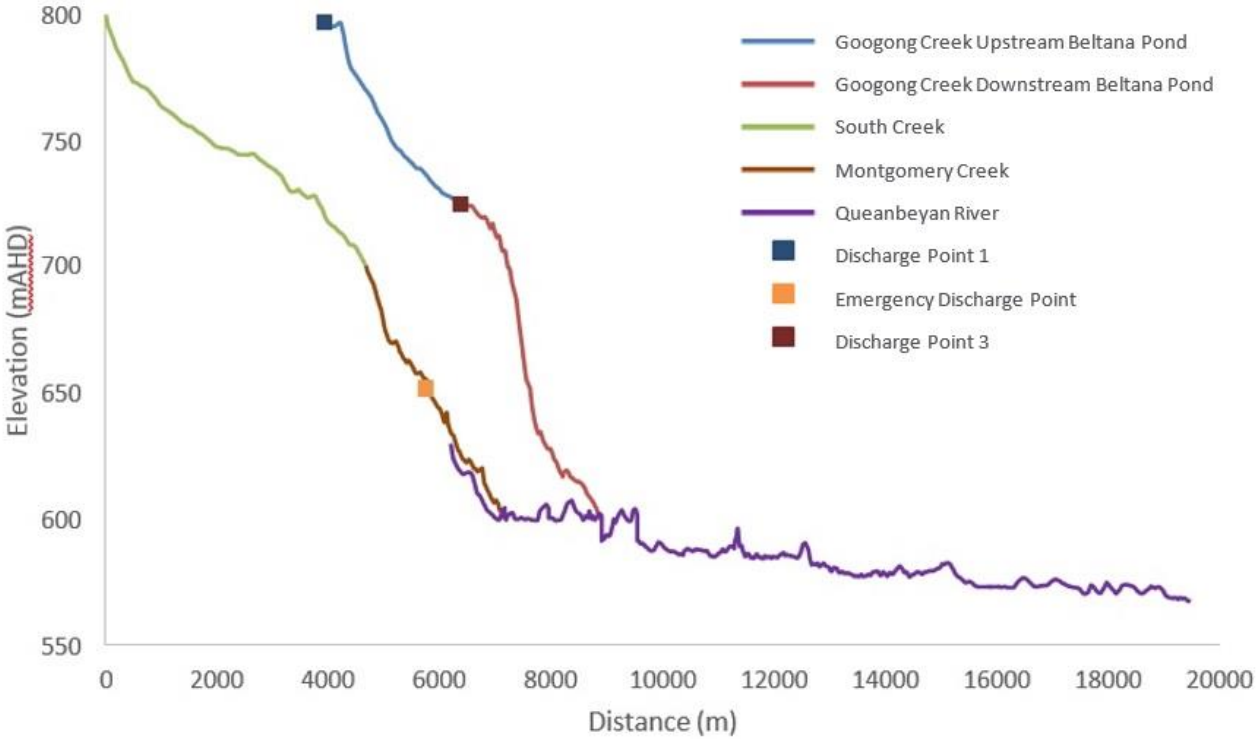


Figure 8: Longitudinal profile of the waterways change in elevation and location of recycled water discharge points (Note: sudden spikes in elevation on the Queanbeyan River are a result of the resolution of the DEM – Adapted from Hydrobiology, 2016)

2.5.1 Googong Creek

Googong Creek is a small ephemeral system that is divided into two different reaches:

- the upper reach now forms part of the stormwater system of Googong Township to Beltana Pond, and
- the lower reach that connects to the Queanbeyan River.

The creek flows in a north-easterly direction. The upper reach [previously] comprised moderately sloped grassy swales with poorly defined bed and banks and a number of farm dams. Between Old Cooma Road and NH1A the system still comprises a series of farm dams, terminating with a large dam that will be transformed into the Town Lake. From there to Beltana Pond, the creek is a stormwater system than runs beneath Rockley Oval and discharged into vegetated bio-swales at the corner of Rockley Parade and Alchin Street that flow north into Beltana Pond.

From Googong Dam Road, Googong Creek is unaltered by the township development and passes through open farmland into a dam. It then becomes a more constrained waterway as a result of the steepening topography. The channel slope markedly increases within this reach until near the confluence with the Queanbeyan River. The Stage C surface water assessment by Hydrobiology (2016) defined this section of the creek as narrow, less than 10 m wide and shallow, with less than 1 m of water, characterised by a rock base. It has coarse bed and bank material with cobbles and boulders,

and limited opportunities for lateral or vertical channel movement under current conditions. The riparian vegetation is generally good providing stability to channel margins, with isolated erosion likely due to livestock access.

Googong Creek has two surface water monitoring locations: Site 8 and Site 10. Continuous recycled water discharge to Googong Creek commenced in July 2016, after the initial trial of discharge in December 2015 and is shown on Figure 9. The volume of excess recycled water increases from around 200 kL/day in July 2017 to 400 kL/day by December 2017 to 700 kL/day by December 2019. Several peak discharge events of 1300 kL/day and 1900 kL/day occurred in November 2017 and December 2018 respectively.

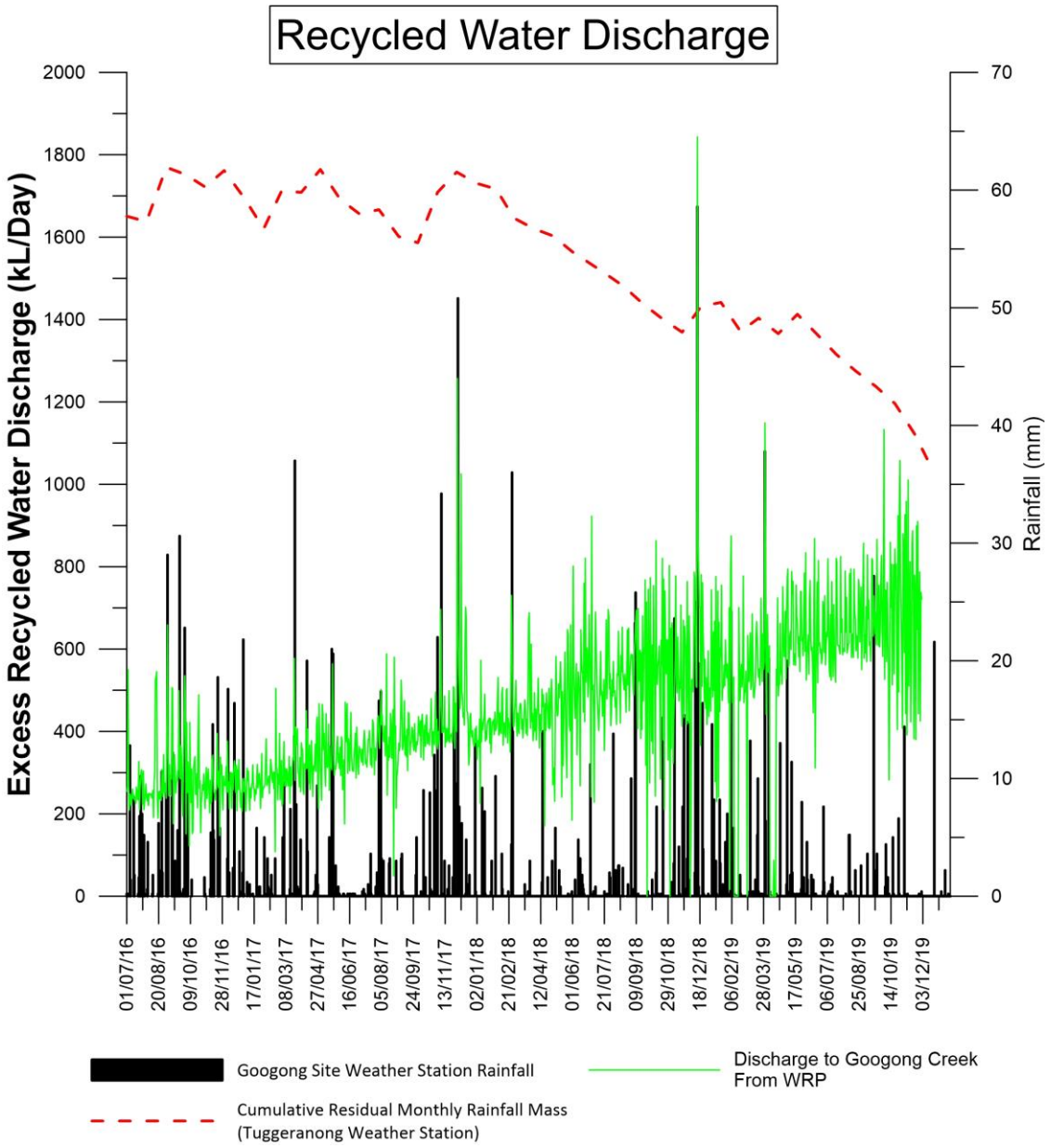


Figure 9: Excess recycled water discharge to Googong Creek from July 2016 to December 2019

2.5.2 North Creek

North Creek, which runs almost parallel to Googong Creek has its headwaters at Googong Dam Road, approximately 440 m west of Old Cooma Road. The channel is steeply incised and vegetated with outcrops of rock observed in the hill slopes and likely forming the base. The surface catchment for North Creek encompasses Hamlet East and West.

2.5.3 South Creek

South Creek forms the upper reaches of Montgomery Creek. It is mainly a drainage line as opposed to a defined channel, is discontinuous, confined by moderately sloped valley sides (15 – 25 %), and has been intercepted by numerous farm dams. It is currently unaffected by the township development in NH3 and NH4, where Common A and Common B sports

grounds are planned, and has been confined within NH1A to the eastern township boundary. At the eastern township boundary, near soil sampling Site 7, South Creek becomes Montgomery Creek.

Within NH1A the creek is characterised by a small discontinuous channel set within a wide and flat floodplain with moderately sloped sides and a series of dams. The channel slope reduces, before becoming narrower and constrained towards the eastern boundary of the township where Montgomery Creek commences.

2.5.4 Montgomery Creek

The creek is characterised by a steep channel and valley slopes. The Stage C surface water assessment (Hydrobiology, 2016) describes the channel slope as up to 25 %, with very little capacity for lateral movement and rock in the bed of the waterway under current conditions. The waterway is ephemeral with several small rock pools that appear to hold water. The banks and valley sides are sparsely vegetated. The development of NH1A has increased the amount of impervious areas to the north of the creek.

At the WRP two small drainage lines, which appear spring feed, flow to the east and converge into a dam in the Googong Foreshore Protected Zone. From this dam a small creek joins Montgomery Creek around 750 m downstream. The spring provides constant discharge to this creek, which is more vegetated than the upper reaches of Montgomery Creek. This 'spring' creek line is the location for the emergency discharge of the WRP. Montgomery Creek joins the Queanbeyan River approximately 570 m downstream of Googong Dam.

2.5.5 Queanbeyan River

The Queanbeyan River downstream of Googong Dam receives surface water from Googong Creek and Montgomery Creek. Its catchment area covers around 873 km^2 and primarily consists of rural land uses. The town's sewage treatment plant (operated by ACTEW) is located within the Queanbeyan River Catchment. The Stage C surface water assessment report (Hydrobiology, 2016) describes the river as perennial, draining in a general northerly direction towards Queanbeyan and the Molonglo River. Flows have been significantly altered by the construction of Googong Dam, and environmental flow releases and discharge from power generation at the dam influence the river flow. The nearest river gauge is Wickerslack located, located approximately 3.1 km downstream and to the north of Googong Dam. Information on levels at Googong Reservoir are available through Water Data Online (BOM website) Station number 41078.

Between Googong Dam and Queanbeyan, the river is characterised by high valley confinement though a series of narrow gorges, with coarse bed and bank material and good riparian vegetation. Apart from in the narrow gorges, slopes are mostly moderate, with the river depth being in the order of several meters. The degree of constraint of the channel decreases significantly at Queanbeyan, where channel accessibility is increased and, consequently, the riparian vegetation becomes sparser, with more invasive species present and a decrease in habitat condition. Construction of Googong Dam in 1977 resulted in considerable hydrological changes within the Queanbeyan River downstream of the dam. Flows were substantially reduced, and increased demand for water for Queanbeyan and Canberra decreased the frequency of spill events at the dam. The Stage C surface water assessment report (Hydrobiology, 2016) estimated that the regulation of the system resulted in a reduction of baseflow from about 1 m^3/s to 0.1 m^3/s, as shown on Figure 10. Googong Creek and Montgomery Creek flow in a north-easterly direction and join the Queanbeyan River north of the township.

The commencement of recycled water discharge to Googong Creek occurred in July 2016. Figure 10 presents the Queanbeyan River flow at the Wickerslack Gauge, downstream of the junction of Googong Creek. The volume of recycled water being discharged is slowly increasing, and in 2019 was approaching 0.01 m^3/s. This flow rate is significantly lower than the discharge release from Googong Reservoir per day from the Mini Hydro plant (0.3 to 0.7 m^3/sec – Source Icon Water Website). Cumulatively, these two sources of discharge assist in maintaining baseflow levels but are a very small contribution to the overall flow in the river.

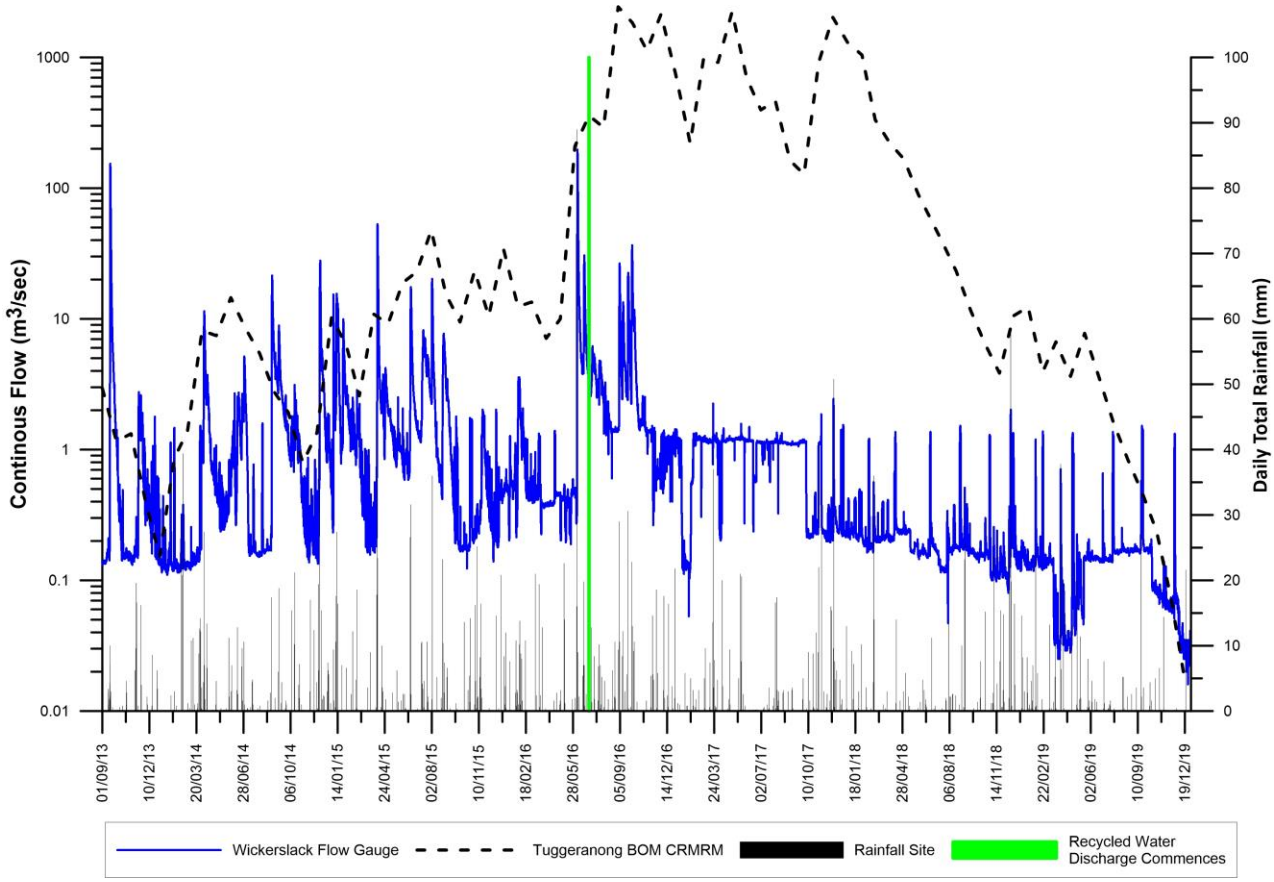


Figure 10: Queanbeyan River flow at Wickerslack Gauge September 2013 to December 2019

2.6 Surrounding Land Use and Potential Receptors

The Googong Township is being developed on former rural farmland. The nearest surface water body is Googong Dam, located 600 m east of the township and is the primary potable water source for Queanbeyan. A quarry is located 950 m north-west of the northern boundary.

The nearest major river is the Queanbeyan River which flows in a north-westerly direction. Googong Creek located north-east of the site flows north-east into the Queanbeyan River. North Creek, west of Googong Creek, flows north into the Queanbeyan River. East of the township is Montgomery Creek which flows east into the Queanbeyan River. South Creek flows through the eastern portion of the township into Montgomery Creek. The private bore survey (SMEC, 2014) identified two bores along Googong Creek, north of the township which are potential groundwater beneficial users. GTPL also indicated there are some potential surface water users who draw water directly from the Queanbeyan River which have been observed by SMEC.

2.7 Surface Water Monitoring Locations

The township has dedicated surface water monitoring at nine locations as required for Stages AB and C project approvals (Figure 7), with monitoring activities occurring in accordance with the Water Management Plan (WMP). The baseline surface water quality monitoring, between November 2013 and December 2014, is discussed with the WMP and it is noted that some of the monitoring locations have been relocated or removed following completion of the baseline period. Two baseline monitoring locations, known as Site 2 and Site 3 shown on Figure 11, both located on the Queanbeyan River immediately downstream of Googong Dam Road and 1 km further downstream, were removed due to access difficulties. Site 8 on Googong Creek was move upstream towards Beltana pond due to low flows being observed. Following the outcome of the Stage C WRP hydrogeological assessment recommendations, a second surface water location was added to Googong Creek, known as Site 10, which is near the former Site 8 location. In December 2017, at the request of QPRC, Site 11 in Beltana Pond was added to assess the quality of surface water quality entering Googong Creek upstream of the excess recycled water Discharge Point 3. A dedicated soil and geophysical monitoring locations required for the project approvals of Stages AB and C is shown on Figure 12).

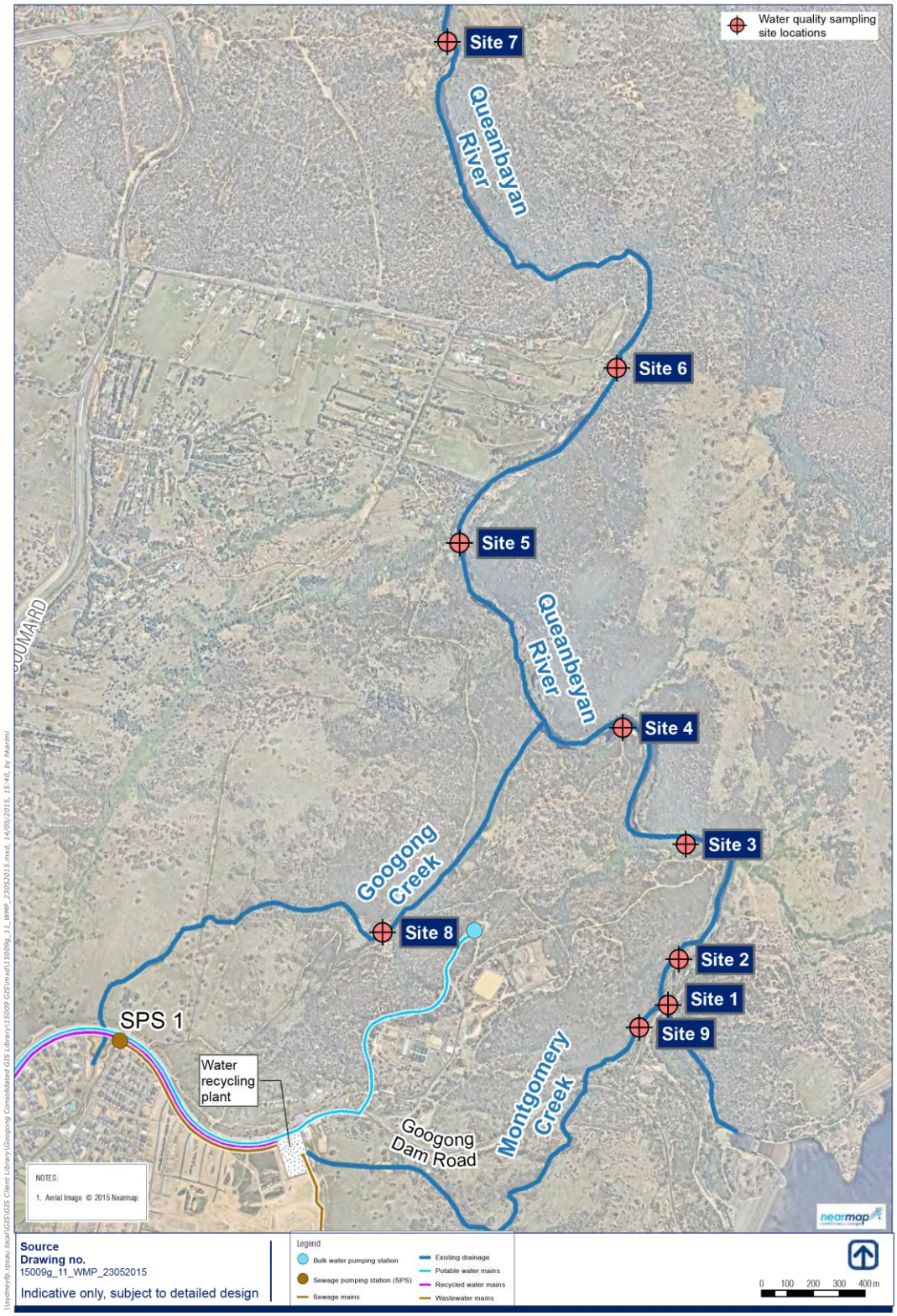


Figure 11: Original baseline surface water monitoring locations (Source: WMP)

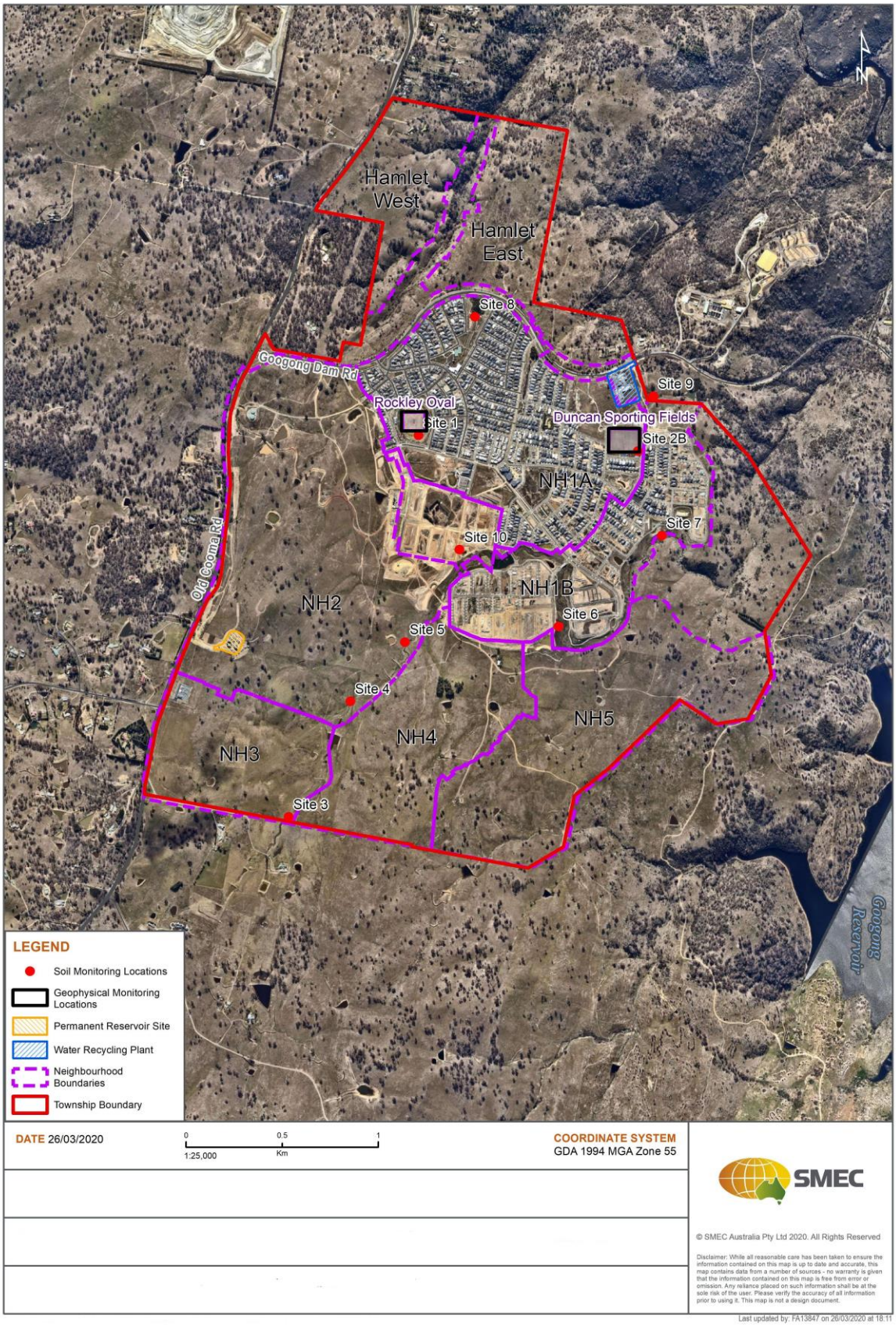


Figure 12: Googong Township soil and geophysical monitoring locations

2.8 Legislative Framework

The Water Quality and River Objectives form part of the State Water Management Outcomes Plan (SWMOP) under the Water Management Act 2000. The SWMOP provides direction for addressing:

- water sharing;
- water use;
- drainage management;
- floodplain management;
- controlled activities and aquifer interference; and
- environmental protection.

The township falls within the Murrumbidgee River and Lake George Catchment for NSW Water Quality and River Flow Objectives with the Queanbeyan River below Googong Dam considered a Controlled river with reduced flow.

The Water Quality Objectives (WQOs) under the SWMOP are:

- aquatic ecosystems
- visual amenity
- secondary contact recreations
- primary contact recreations
- livestock water supply; and
- homesteads water supply.

The river flow objectives (ROFs) under the SWMOP are:

- protect pools in dry times;
- protect natural low flows;
- protect important rises in water levels;
- maintain natural flow variability;
- maintain natural rates of change in water levels;
- minimise effects of weirs and other structures;
- minimise effects of dams on water quality; and
- make water available for unforeseen events.

3 Proposed Works and Existing Environment– WRP, Permanent Reservoirs and Stage D Irrigation Areas

This section of the surface water assessment details the existing environment at the WRP site, Permanent Reservoir Site at Hill 800 and Stage D irrigation areas. The Stage D WRP and Permanent Reservoir works are summarised in Table 3 and in Table 4 for the Permanent Reservoir works and shown on Figure 13 and Figure 14. Figure 15 presents the township development plan with neighbourhood layout and open spaces consisting of parks, sporting fields and protected areas.

Table 3: Summary of Stage D works at the WRP

Infrastructure element	Equipment / component	Stage D scope of works
Bioreactor	Bioreactor and membrane tanks	Construction of one larger Bioreactor tank
	Diffused aeration system	Install the single Bioreactor trains with Fine Bubble Diffused Aeration systems
	Mixed liquor return / Membrane Feed Pumps	Install one set of larger mixed liquor pumps and larger Membrane Feed Pumps
	Aeration Blowers	Replace the existing blowers with three new larger units
Membrane Bioreactor (MBR) Membranes	Membrane tank	Construction of three MBR membrane tanks
	MBR Membranes	Install two sets of MBR membranes Install one additional set of MBR membranes when required (nominally 2032)
	Membrane Blowers	Replace existing blowers with three new larger units
Tertiary Feed System	Filtrate Storage Tank	Filtrate Storage Tanks installed were for ultimate capacity – no further upgrade required at Stage D
	Tertiary Feed Pumps	Replace two existing smaller pumps with new larger pumps (identical model to existing larger pumps)
	Tertiary Filters	Install a new Tertiary Filter skid complete with 56 modules to enable duty/assist/standby trains
	UV Disinfection Units	UV Disinfection Units installed at Stage C were for ultimate capacity – no further upgrade works expected at Stage D provided feed water UV Transmissivity (UVT) remains above 60%
	Chlorine Disinfection System	Chlorine Disinfection Units installed at Stages AB and C were for ultimate capacity - no further upgrade required at Stage D
Recycled Water Storage and Transfer	Recycled water storage tank	Recycled Water Storage Tanks installed at Stage C were for ultimate capacity – no further upgrade required at Stage D
	Recycled water transfer pump station	Replace one existing smaller transfer pump with a new larger pump identical to the units installed at Stage C
Aerobic Digester	Aerobic digester tank	Construct new Aerobic Digester tank adjacent to the Stage C digester – hydraulic connection to be via concrete weir cut-out Install Fine Bubble Diffused Aeration system in the new tank as per the existing digesters
	Aerobic digester blowers	Existing digester blowers installed at Stages AB and C were sufficient to meet ultimate aeration demand - no further upgrade required at Stage D.
	Rotating drum thickener (RDT)	Relocate and recommission the RDT to the top of the new Stage D Aerobic Digester tank

Infrastructure element	Equipment / component	Stage D scope of works
Biosolids Dewatering and Storage	Dewatering centrifuge unit	Install one new larger dewatering centrifuge (4 L/s capacity) Install an additional centrifuge feed pump to enable feed flow to both smaller and larger centrifuges (up to 7.5 L/s)
	Biosolids outloading conveyor system	Install a new biosolids outloading conveyor system to allow for transfer of dewatered biosolids from the new centrifuge unit to a new biosolids bin area north of the centrifuge building
	Biosolids bins	Install a new bin weighing system on the north side of the centrifuge building for 10 kL bins to enable duty/standby bins operation
Chemical storage and dosing	Chemical storage tanks	Chemical Storage Tanks installed at Stages AB and C were for ultimate capacity – no further upgrade required at Stage D
	Chemical dosing system	Install new sodium hydroxide dosing line from Dosing Skid 3 to the new Bioreactor(s) Install new ferric sulphate dosing line from the Dosing Skid 3 to the new Bioreactor(s) Reconfigure and extend the acetic acid dosing line from south-west corner of Bioreactor No. 2 to the new Bioreactor(s) Reconfigure and extend the sodium hypochlorite dosing line from south-west corner of Bioreactor No. 2 to the new Bioreactor(s) and Membrane Tanks Reconfigure and extend the citric acid dosing line from south-west corner of Bioreactor No. 2 to the new Membrane Tanks
Emergency Detention Tank (EDT)	EDT tank	The existing EDT storage volume is considered sufficient to cater for wet weather attenuation for Stage D flows. Interconnecting pipework to potential additional EDT storage south of the Neutralisation Pit has been installed at Stage C.
	EDT return pumps	No further upgrade required to the existing EDT Return Pumps
Off-Spec / Effluent transfer system	Off-Spec Water Tank	Off-Spec Water Tanks installed at Stages AB and C were for ultimate capacity – no further upgrade required at Stage D
	Effluent Transfer Pumps	Install one (1) new Off-Spec/Effluent Transfer Pump with an identical unit to the existing set to operate in Duty / Assist / Standby configuration (175 L/s total capacity)
Compressed Air System	Air compressors	Replace the existing air compressors with two larger capacity units
Odour control	Odour extraction network	Install odour covers for the new Bioreactor and Aerobic Digester tanks Expand odour extraction network to service the new Bioreactor, Aerobic Digester, centrifuge and biosolids conveyor system. This includes fit-out of odour covers and ductwork for the empty membrane tanks Replace existing odour discharge stack efflux cone with larger diameter cone
	Activated carbon units	No further upgrade required to the Activated Carbon Units at Stage D
Yard piping	Yard piping	Yard piping to suit the new Stage D assets
Electrical and control systems	Motor Control Centre (MCC) and electrical systems	Install MCC No. 4 and drives associated with new Stage D assets Upgrade Uninterrupted Power Supply (UPS) to meet requirements of Stage D assets

Infrastructure element	Equipment / component	Stage D scope of works
	Programmable Logic Controller (PLC) and Supervisory Control And Data Acquisition (SCADA) systems	Upgrade PLC and SCADA as required to reflect new Stage D assets
	Generator	No further upgrade required to the standby generator system at Stage D

Table 4: Summary of Stage D works at the Permanent Reservoirs on Hill 800

Infrastructure element	Equipment / component	Stage D scope of works
Recycled Water Reservoir	New 9 ML Recycled Water (ReW) Reservoir	Decommission of the existing Stage C sedimentation bund. Construct a new 9 ML ReW reservoir (nominally bolted steel panel type, but TBC during concept design phase) and associated pipework Piped connections to the new 9 ML ReW reservoir extended sufficiently far from the Stage C services terminating in direct buried isolation valves have all been included in Stage C
	Existing 4 ML ReW Reservoir	Convert the existing 4.0 ML ReW Reservoir into a Potable Water (PW) Reservoir (5.9 ML total potable water capacity). This includes emptying and cleaning (super-chlorination) of the existing reservoir for it to be repurposed for PW use
	Potable Water Booster Pumps	Decommission the existing Stage C PW Booster Pump Station Install a new Stage D PW Booster Pump Station and associated pipework to cater to flows for the higher elevation development areas
	Sodium Metabisulfite Dosing	Modify sodium metabisulfite dosing pipework to dose into the new Stage D chemical dosing chamber which will receive overflow stream from the new RW Reservoir
	Sodium Hypochlorite Dosing	Replace the existing recycled water sodium hypochlorite dosing pumps with new larger units (40 L/hr), if required
	Electrical and Control Systems	Upgrade the existing MCC, drives, PLC and SCADA systems to accommodate the new Stage D assets

Existing reports covering the surface water environment for the township are:

- Groundwater Assessment – Googong NSW, September 2010. (C.M Jewell and Associates; J0991.10R-rev4);
- Googong Hydrogeological Services: Annual Groundwater Monitoring Report – December 2014 (SMEC Australia, 30011525-AF);
- Surface Water and Aquatic Ecology Monitoring Program – October 2015 (RPS Manidis Roberts);
- Stage C WRP Surface water assessment (Hydrobiology, 2016);
- Googong Hydrogeological Services: Annual Monitoring Report – October 2017 (SMEC Australia, 30012126 – AR01); and
- Googong Hydrogeological Services: Annual Factual Monitoring Report – May 2019 (SMEC Australia, 30012126 – AR02.

These reports have been used to inform, along with the 2019 monitoring data from QPRC, this surface water assessment.

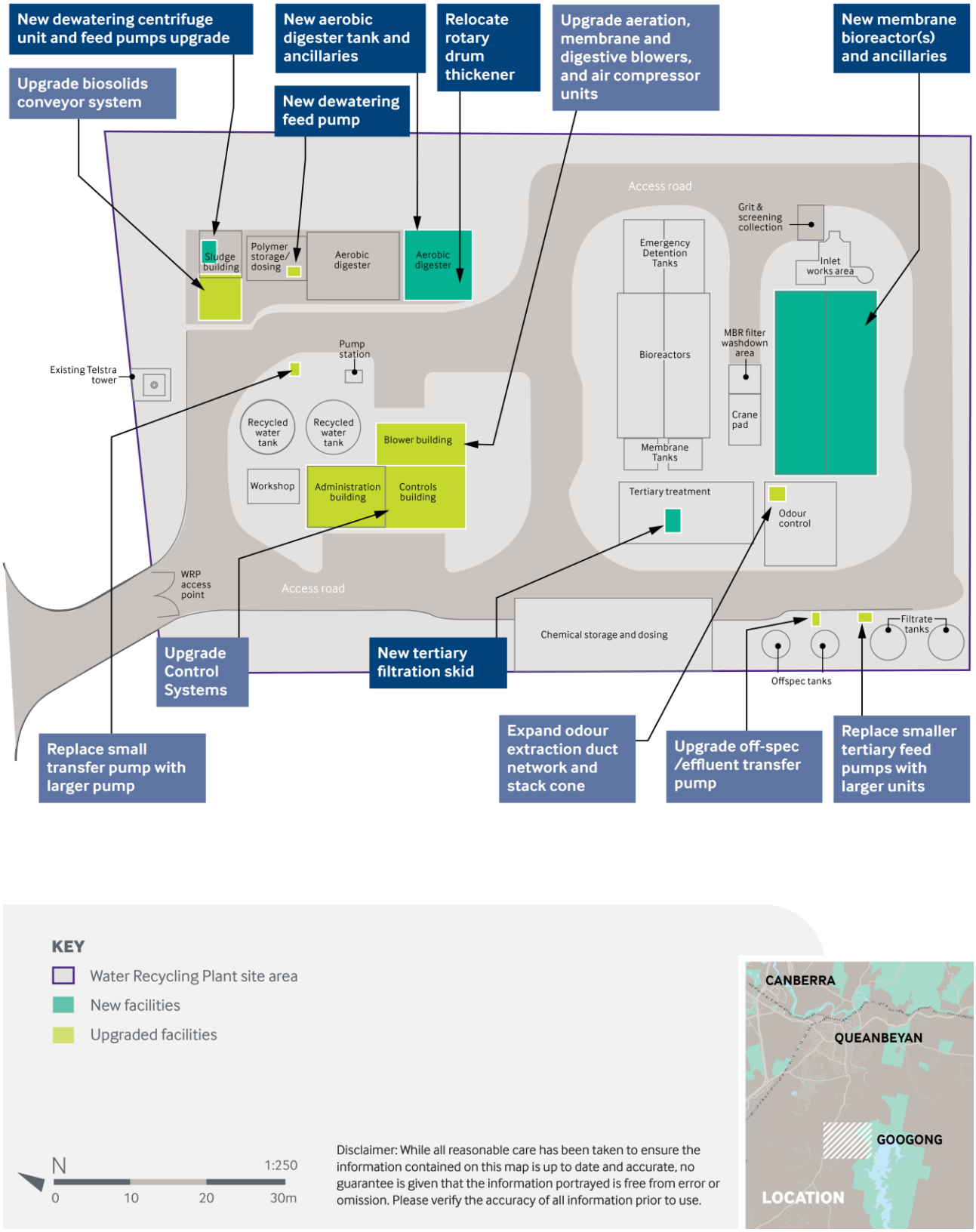


Figure 13: Stage D Infrastructure upgrades and works within the WRP (provided by RPS)

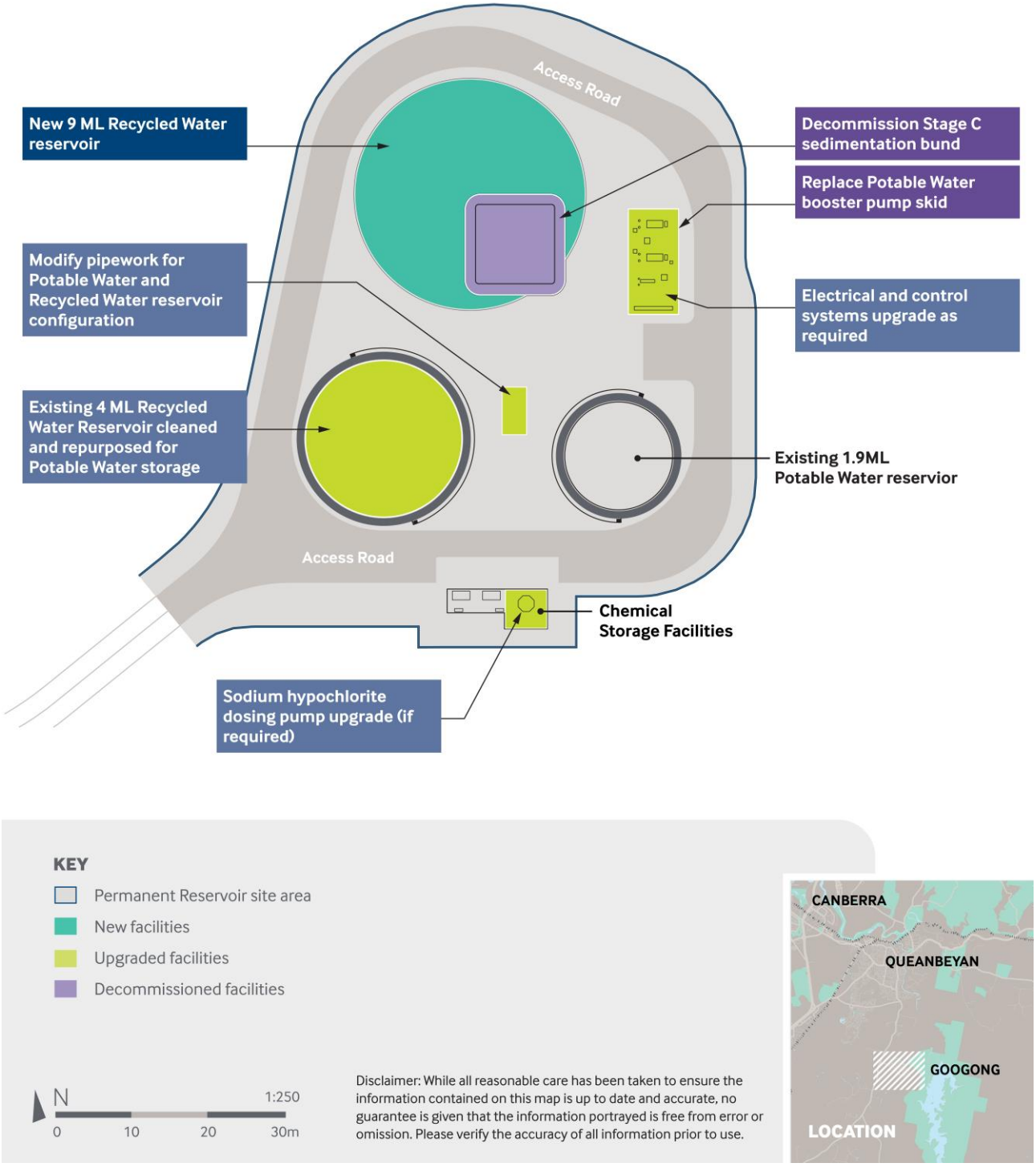


Figure 14 Permanent Reservoirs at Hill 800 Reservoir Stage D design (provided by RPS)

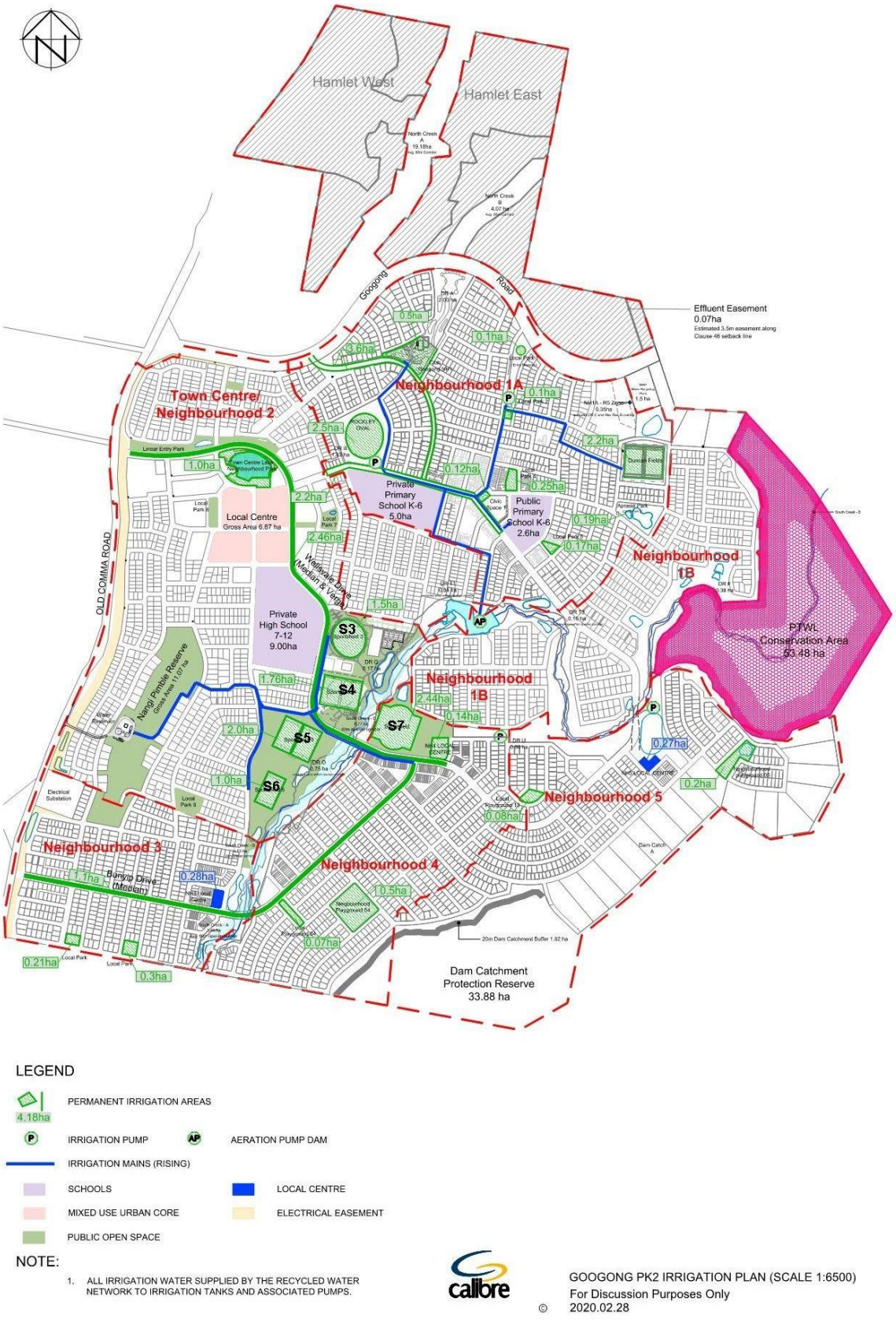


Figure 15: Googong Township Master Plan (provided by RPS) showing proposed neighbourhoods and irrigation areas and open spaces

3.1 Site Location

The Googong Township development is located approximately 8 km south of Queanbeyan, New South Wales, located off Old Cooma Road and covering an area of around 723 hectares.

3.1.1 WRP

The WRP is located within the north-eastern boundary of the Googong Township off Googong Road (Figure 7Figure 6) and covers an area of approximately three hectares. Expansion of the WRP is to the south and east of the existing structures, within the existing WRP site footprint.

3.1.2 Permanent Reservoirs

The Stage D Hill 800 reservoirs are located in NH2 in the south-west of the site, approximately 200 m from Old Cooma Road (Figure 7). The existing environment consists of a 4.0 ML reservoir, consisting of two storage tanks constructed as part of the Stage C works, within a hardstand compound in the saddle of the hill.

3.1.3 Recycled Water Discharge locations

The recycled water discharge locations for Stage D of the IWC project are located at the permanent reservoir (Discharge Point 1 and at the Beltana Park Outlet Structure (Discharge Point 3) and are shown on Figure 16. Presently only Discharge Point 3 is used.

The following discharges will occur at these locations:

- Discharge Point 1 – EPA-licenced discharge point where recycled water in excess of township demand will discharge via a series of overland flow stormwater ponds in NH2 and the NH2 stormwater management system and flow into Beltana Pond. This discharge point is anticipated to come online in May 2020;
- Discharge Point 3 – EPA-licenced discharge point where recycled water that doesn't meet the *Essential Sewage and Recycled Water Quality Management Plan* (RWQMP) criteria but meets discharge criteria detailed in an operational Environmental Protection Licence is discharged. Discharge has been occurring at this location since 2016.

The emergency discharge point (EDP) is located at the WRP (Figure 16) and in the event of an emergency discharge is directed to Montgomery Creek. Discharge Point 3 is currently used for discharge of recycled water in excess of the township demand as there is no use in the township. QPRC propose a change to the designation of the discharge locations such at Point 1 is used on occasion for operational purposes and Point 3 remains as the primary discharge point for any excess recycled water after township demand

3.1.4 Stage D Public Space Irrigation Areas

Once Stage D is completed, recycled water from the WRP will be used on public spaces (including sports fields) and residential and other properties across all neighbourhoods within the Googong Township. These include both current and future public spaces and properties. Figure 15 presents the township development plan with neighbourhood layout and open spaces consisting of parks, sporting fields and protected areas. NH1A and NH1B have been constructed, NH2 has commenced development in the norther portion. Residential development will be ongoing over the next 25 years.

Existing open spaces as part of the Stages AB and C works are:

- Beltana Pond;
- NH1 Local Parks 2 and 3;
- Sportsfield 1 (Rockley Oval);
- Sportsfield 2 (Duncan Sporting Fields);
- NH1 Local Park 4 (Dog walking park); and
- NH1 Local Parks 5, 6 and 7.

Future planned open spaces within the Stage D development are:

- NH2 Park 2 – September 2020;
- NH2 Town Centre – September 2025;
- NH2 local Park 8;
- NH3 Local Park 3;

- NH3 civic space;
- NH3 Local Park 10;
- Common A: Sportsfield 3 – December 2020;
- Common A: Sportsfield 4 – June 2023;
- Common B: Sportsfield 5 – April 2026;
- Common B: Indoor Sport Centre – January 2027;
- Neighbourhood 4 Civic Space;
- NH4 local Park 11;
- NH4 local Park 12;
- NH5 local Park 5 – August 2028;
- Neighbourhood 5 Civic Space;
- NH5 local Park 13;
- Common B: Sportsfield 6 – November 2028;
- NH4 Sportsfield 7 – September 2031;
- Googong Common Drainage Reserve;
- NH5 Dam Foreshore protection reserve; and
- NH5 Pink tailed worm lizard conservation area.

The Stage C WRP Surface Water Assessment by Hydrobiology (2016) assessed irrigation areas in NH1AB and part of NH2 and the impacts of discharge of recycled water to the environment.

The Stage D IWC Project works incorporate irrigation of recycled water on public spaces for the whole of the township. The township consists of a total of 705 hectares (ha) of which 325 ha are hardstand and 380 ha are open space. Of the open space 27 ha are irrigated sporting fields, 180 ha is open space for reserves and parklands and 200 ha is domestic lots that will not be built on as provided by Stantec under the assumption of 500 m^2 average lot size with max coverage of 50%.

There is a total of 9.8 ha of open space for irrigation already constructed in NH1AB. Currently the existing irrigation areas use potable water. Stantec have estimated for the IWC Project at completion (i.e. the ultimate project including all stages, A-D) the total recycled water generation of the township is around 3,960 kL/day (118,755 kL/month). The monthly break down of the volume for irrigation, domestic consumption and excess recycled water discharge is shown in Table 5.

Table 5: Summary of ultimate IWC Project monthly recycled water average, minimum and maximum volumes to irrigation and domestic consumption and predicted excess discharge for environmental flow in kL

Month	Monthly and	Volume to Domestic	Irrigation Consumption	Monthly Environmental	Predicted Discharge	Excess for
	Average	Minimum	Maximum	Average	Minimum	Maximum
Jan	3,004.9	237.4	5837.6	297.8	0.0	4,283.3
Feb	2,833.8	254.5	6051.7	351.6	0.0	3,496.9
Mar	2,320.3	254.7	5123.9	489.0	0.0	5,477.4
Apr	1,538.3	146.5	4222.7	899.5	0.0	3,771.8
May	943.2	88.7	3779.2	1,373.0	0.0	3,942.3
Jun	469.7	49.4	2663.0	1,818.4	0.0	3,773.6
Jul	370.1	9.4	931.4	1,922.9	1,226.8	3,640.0
Aug	492.4	0.0	1869.5	1,797.8	188.4	4,766.8
Sep	821.7	44.5	3343.8	1,478.9	0.0	3,288.2

Month	Monthly and	Volume to Domestic	Irrigation Consumption	Monthly Environmental	Predicted Discharge	Excess for
Oct	1,554.3	103.8	4236.8	903.5	0.0	4,485.1
Nov	2,036.1	117.5	5219.0	687.3	0.0	4,445.6
Dec	2,881.0	254.5	5546.3	295.3	0.0	3,202.3

The predicted excess recycled water, to be discharged to the environment shows seasonal variability with the winter months generating the most excess. Township consumption of recycled water has a slight seasonal variability, likely related to garden watering.

3.2 Surface Drainage

3.2.1 WRP

Surface water drainage in the vicinity of the WRP is predominantly east to south-east towards the foreshore boundary and drainage lines which feed into Montgomery Creek (Figure 16). Within the WRP compound surface drainage is contained within the IWC.

The WRP is designed with three types of surface water drainage systems:

1. First Flush – all the areas which are considered 'dirty' and likely to have had raw sewage/dirty water contact the surface drains to a first flush tank. This has been designed to capture the first 10 mm rainfall across all of the dirty areas – this water is put back to the head of works as soon as possible;
2. Chemical drainage – all areas that could be contaminated with chemicals drain to the neutralisation pit which is then treated and put back to head of works; and
3. Stormwater – all other areas drain to stormwater and are discharged directly to the Montgomery creek outlet.

Access to the WRP will involve reopening and utilise the Stage C temporary access road on the eastern site boundary for which surface drainage is east towards Montgomery Creek.

3.2.2 Permanent Reservoirs

The surface water within the permanent reservoirs compound, outside of the chemical areas, follows the site profile for overland drainage to surrounding areas. Chemical areas are bunded. Around the compound, surface water drainage follows topography and is generally to the north-west and west. Discharge Point 1 is located north-west of the reservoir and forms the start of the overland flow system for excess recycled water. On the eastern side surface water may also flow east towards South Creek (Figure 16).

Access is from Old Cooma Road on a sealed road for which surface drainage is towards the west and northwest.

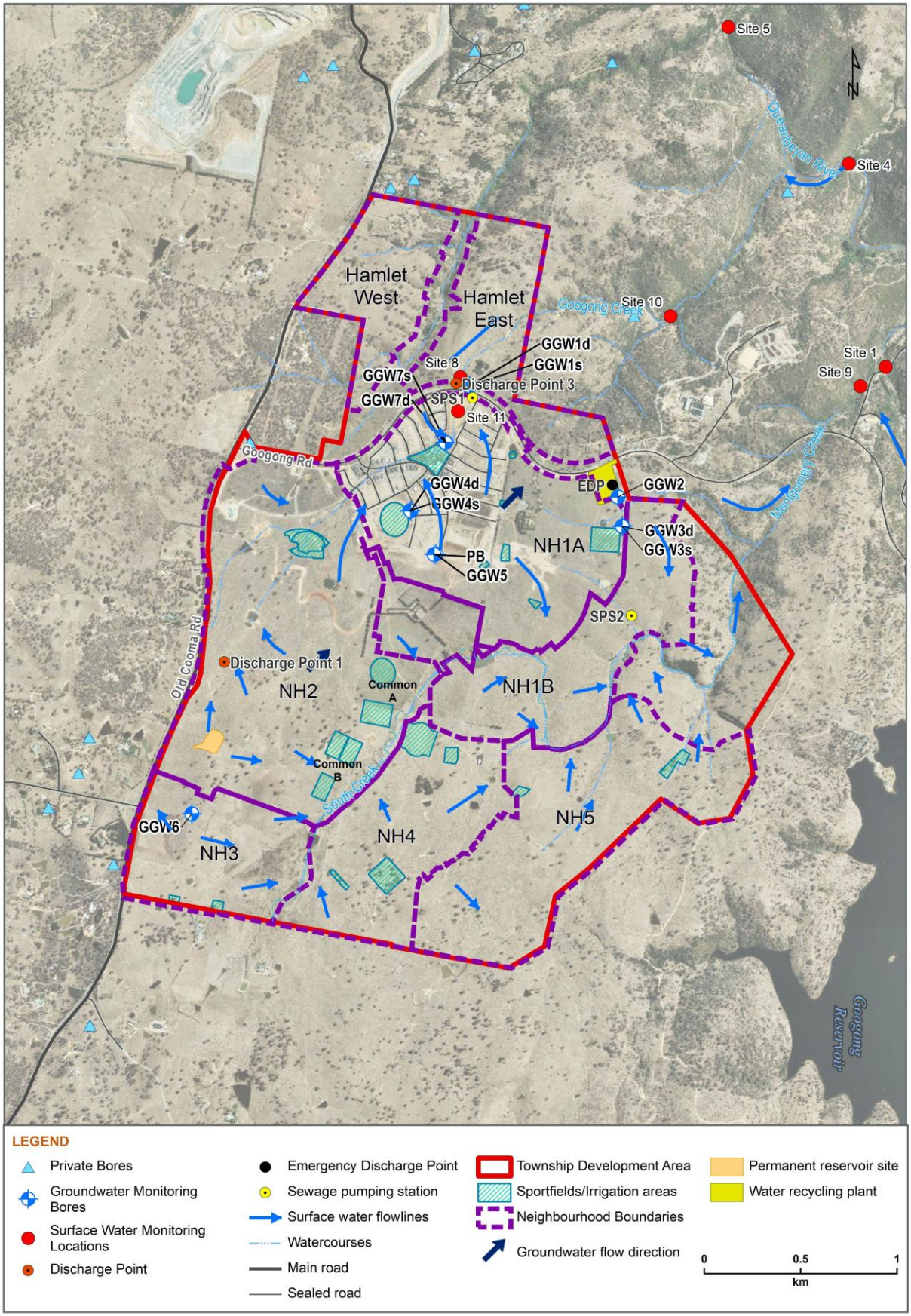


Figure 16: Location of WRP, sewage pumping stations and recycled water discharge locations with inferred surface water drainage

3.2.3 Township Development

Surface water within the township development areas is controlled by the topography of the environment, either existing (i.e. natural slopes) or developed (i.e. residential). In the developed neighbourhoods surface water is directed through the IWC stormwater system. In areas under development surface water is controlled through the CEMP. In the natural areas surface water flow direction follows topography flowing from elevated areas to lower lying areas and drainage lines. Post development the surface drainage at several key locations is inferred as:

- Common A and Common B: sports fields – surface drainage from the sports field surfaces would be captured by the township's stormwater system;
- Common A and Common B area – surface drainage east to north east towards South Creek;
- NH2: Nangi Pimble Reserve - surface drainage would be towards the north and be contained within the township's stormwater system;
- NH4: Sporting Field 7- surface drainage form the sporting field surface would be captured by the township's stormwater system, areas surrounding the sporting field would drain toward the north towards South Creek;
- Dam Foreshore Protection Zone: surface drainage is to east towards Googong Reservoir;
- PTWL Conservation Zone: surface drainage is north towards Montgomery Creek.

Other small parks and open spaces would have surface drainage contained within the township's stormwater system. Flooding is generally not considered to be of concern for Common A and B and Sporting Field 7, but some localised inundation of low lying land may occur along South Creek.

3.3 Soils

The township constitutes former grazing land with a generally shallow residual soil profile that reflects the geology of the area. In areas that have been developed by the township as neighbourhoods the soil has been reworked and domestic residences may have imported soil materials.

3.3.1 WRP

The WRP is constructed on residual ground and reworked spoil. No exotic fill has been imported to the site. Significant hardstand areas are present with limited vegetation. Rip-rap has been installed for erosion control at the emergency discharge point and spring seep.

3.3.2 Permanent Reservoirs

The permanent reservoirs are constructed on bedrock with some reworked spoil. No exotic fill has been imported to the site. Significant hardstand areas are present with limited vegetation. Outside the compound, shale bedrock outcrops at the surface. Around the compound, surface water drainage is to the north-west and west.

3.4 Surrounding Land Use and Potential Receptors

Land use surrounding the township development to the west, north and south is farmland and rural residential and to the east the water supply catchment of Googong Reservoir.

3.4.1 WRP

To the west of the WRP are residential houses; to the south is Duncan Fields; to the north is Googong Road and farmland; and to the east is the Googong Foreshores protection area surrounding Googong Reservoir. The nearest receiving surface water environment is the ephemeral Montgomery Creek flows which flows into the Queanbeyan River, followed by Googong Reservoir.

3.4.2 Permanent Reservoirs

The area surrounding the reservoirs site is currently farmland but will be developed as open space (Nangi Pimble Reserve) and residential areas within NH2 and NH3. Around 280 m south-west is an electricity substation. To the north is the start of development for NH2. Approximately 3.5 km to the east is the Googong Foreshore protection area surrounding Googong Reservoir. The nearest receiving surface water environment is the ephemeral South Creek, located approximately 650 m to the east.

3.5 Geophysics

In 2009 Agsol undertook surface geophysical mapping (Figure 17) using EM-31 and EM-38 ground conductivity meters which showed area of low to moderate conductivity responses (green to yellow colours). The conductivity results reflect the soil composition (e.g. clays), soil moisture, soil salinity and shallow groundwater. Moderate to high conductivity values do not necessarily indicate high soil salinity. Higher values along waterways and drainage lines may indicate shallow groundwater and mobile salt discharge in these areas. The ground electromagnetic survey showed in general moderate conductivity values (greens to yellow) in the areas reflecting the surface water drainage pathways of South Creek and the upper reaches of Googong Creek.

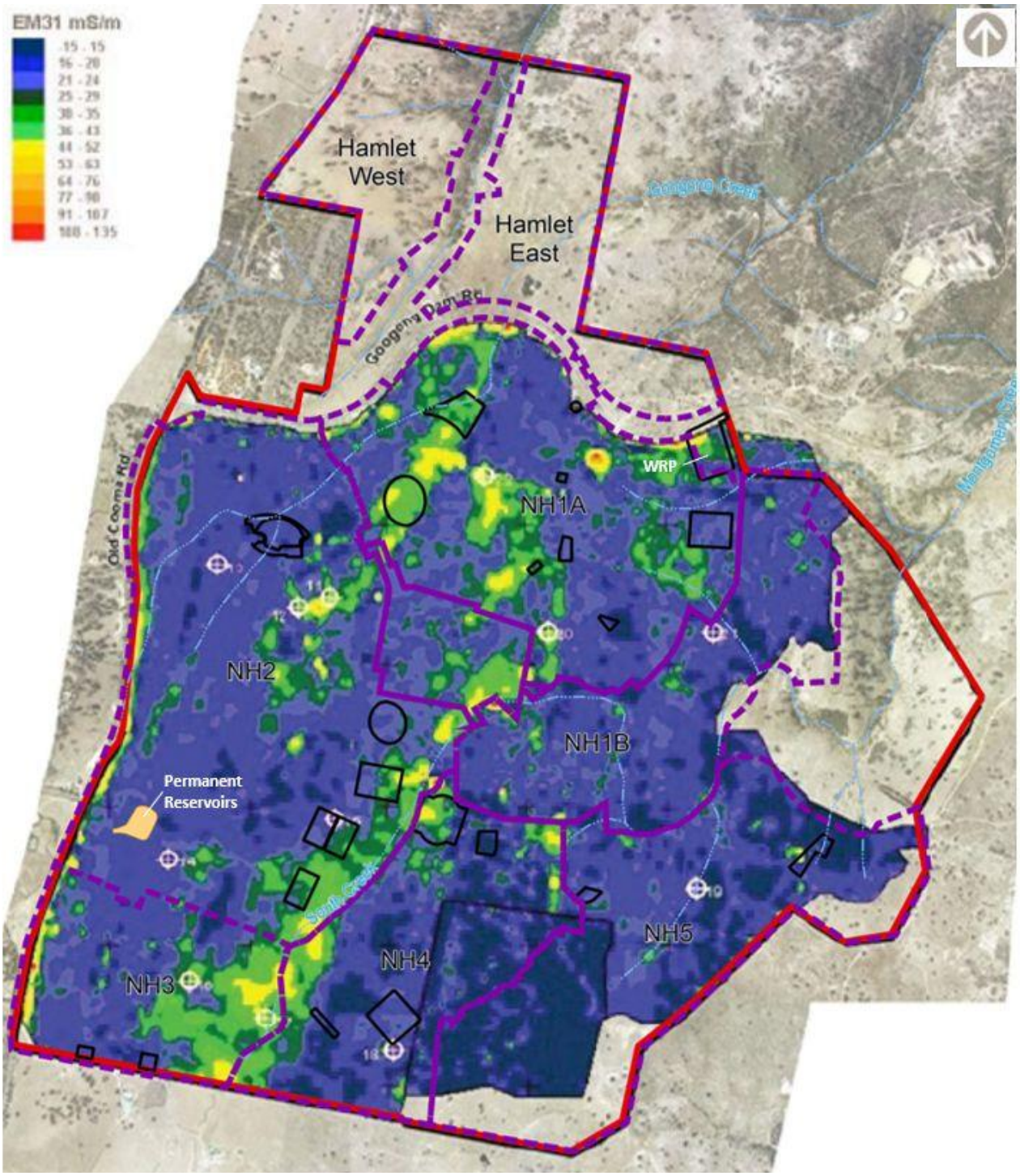


Figure 17: Agsol electromagnetic survey conductivity map (adapted from the WMP) with current and proposed sporting fields and irrigated open space outlined in black, permanent reservoirs (pale orange) and WRP

In NH2, NH3 and NH1B the higher conductivity area (green to yellow colours) correlates with the drainage path and low-lying areas and of South Creek. NH1A shows a higher conductivity zone extending from the boundary with NH1B north towards Beltana Pond and a second higher conductivity zone west of that also joining near Beltana Pond. These are likely the former upper reaches of Googong Creek. In NH5 there appears limited response around the drainage lines that feed Montgomery Creek.

It is important to note that these results will not be comparable with post-construction results within the township due to the significant landform changes, paving, buried services and buildings. Areas not significantly altered by the township development, such as parts of South Creek, are likely to be difficult to survey. Geophysical surveying is proposed for Rockley Oval and Duncan Sporting Fields post irrigation with recycled water under the Irrigation Management Plan (IMP).

3.5.1 WRP

The Figure 17 surface conductivity map shows area of low to moderate conductivity responses (green to yellow colours) with some more conductive responses likely reflecting shallow groundwater and drainage lines which are seen in as green colours around the WRP. The shallow nature of the Googong Adamellite likely influences the conductivity seen pre-development by both the Agsol survey and the survey undertaken by in 2014 (SMEC, 2014), shown on Figure 18. Higher conductivities (green colours) observed within the drainage lines and area that is now a spring. Post development of the WRP area not been surveyed. Further surveying of these areas around the WRP is not practical due to the power lines and fences introducing significant geophysical interference.

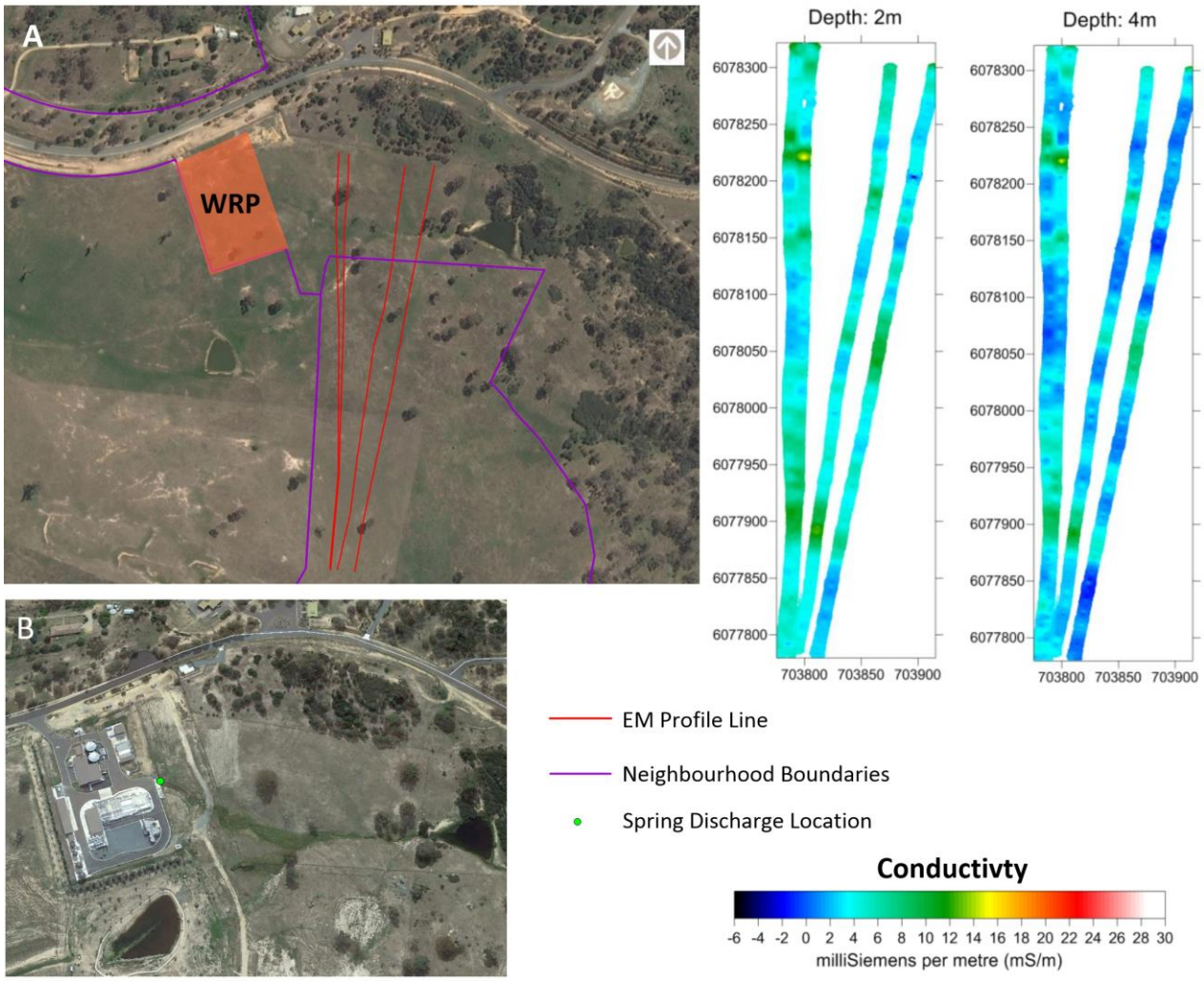


Figure 18: SMEC 2014 electromagnetic survey conductivity results at WRP to approximate depth of 2m and 4m with a) pre-development view and b) current WRP with spring discharge location

3.5.2 Permanent Reservoirs

The Figure 17 surface conductivity map shows low conductivity responses (blue colours) for the area where the permanent reservoirs are at Hill 800. To the northwest of the site the linear feature of moderate conductivity (green colours) represents an existing natural drainage line where Stage D overland flow of excess recycled water is planned. No further geophysical surveys have been done in this area.

3.6 Surface Water Quality

The surface water quality of the Queanbeyan River is monitored by QPRC and as part of the townships WMP. Googong Creek, Montgomery Creek, and Beltana Pond are monitored as part of the WMP under the SWAEMP. The surface water monitoring parameters are described the SWAEMP of the WMP and include:

- field measurements of pH, electrical conductivity, dissolved oxygen, temperature, and total chlorine;
- laboratory analysis of major ions, total and suspended solids, oil and grease, ammonia, nitrate, nitrite, oxides of nitrogen, total nitrogen, total phosphorus, total kjeldahl nitrogen, faecal coliforms and algae (summer and spring months); and
- photographs of channel and bank for habitat and stability.

Site specific trigger values are outlined in the WMP for selected parameters and are shown on relevant figures within this report. Refer to the SWAEMP or Appendix A for the associated trigger values. Several changes have been made to the SWEAMP including being in an interim phase of monitoring pending the commencement of recycled water consumption. A summary is as follows:

- QPRC approved interim phase surface water program with a reduction in frequency to quarterly from December 2017 and no monitoring of diatoms or macroinvertebrates;
- QPRC approved the recommendation of the addition of major ion analysis following the 2018 Annual Monitoring Report (SMEC, 2018);
- QPRC approved the removal of the annual fish survey from the monitoring program;
- SWEAMP trigger levels were revised in August 2018;
- QPRC removed Site 6 from the sampling program due to ongoing access issues with the private landholder in September 2019; and
- SWAEMP monitoring program frequency revised in 2019.

The SWAEMP revised the trigger levels were to better account for the natural variation seen in the additional baseline (pre-irrigation) data. The annual fish survey was removed as it had shown no changes to the aquatic health of the Queanbeyan River after two years of recycled water discharge to Googong Creek.

This surface water assessment focuses on the data collected from August 2016 to January 2020. The reader is referred to the Stage C Surface Water Assessment Report (Hydrobiology, 2016) or the WMP for historical sample information. Appendix A of this report presents a summary of the surface water monitoring results for each monitoring location, and Appendix B presents individual location Piper plots with time series plots of major ions and time series plots of field and laboratory pH with field electrical conductivity, total and dissolved solids, total nitrogen and oxides of nitrogen, total phosphorus and ammonia. The majority of these figures provide the SWAEMP trigger level, where applicable, and show rainfall with the cumulative residual rainfall mass (CRMRM) or just the CRMRM.

Montgomery Creek is the nearest surface water body to the WRP with a monitoring location (Site 9) and the receiver of any emergency discharge water. Site 9 has at times been dry. There are no surface water sampling sites established in South Creek, noting that it does flow through Site 9 on Montgomery Creek. There are no surface water sampling sites established near Discharge Point 1, which is in the upper reaches of Googong Creek, as it is not yet operational. There is no surface water monitoring location near the permanent reservoirs at Hill 800. Googong Creek receives excess recycled water discharge and overflow from Beltana Pond and has two surface water monitoring sites, Site 8 and Site 10. A monitoring site is also in Beltana Pond (Site 11).

Figure 19 and Figure 20 present the Piper and Durov plots of the surface water monitoring data from 2016 to 2019. The monitoring data indicates that on Googong Creek, Site 8 and Site 10 have a wide spread of results and that likely represent the mixing between the recycled water discharge and surface water. Site 10 shows some affinity with GGW3D and GGW1D groundwater samples. The other monitoring locations show very similar water chemistry for both the Queanbeyan River (Site 1, 4, 5, 6 and 7) and Montgomery Creek (Site 9). Beltana pond (Site 11) shows variability in TDS, reflecting the townships' surface water run-off, and slightly high calcium and lower chloride than the Queanbeyan River.

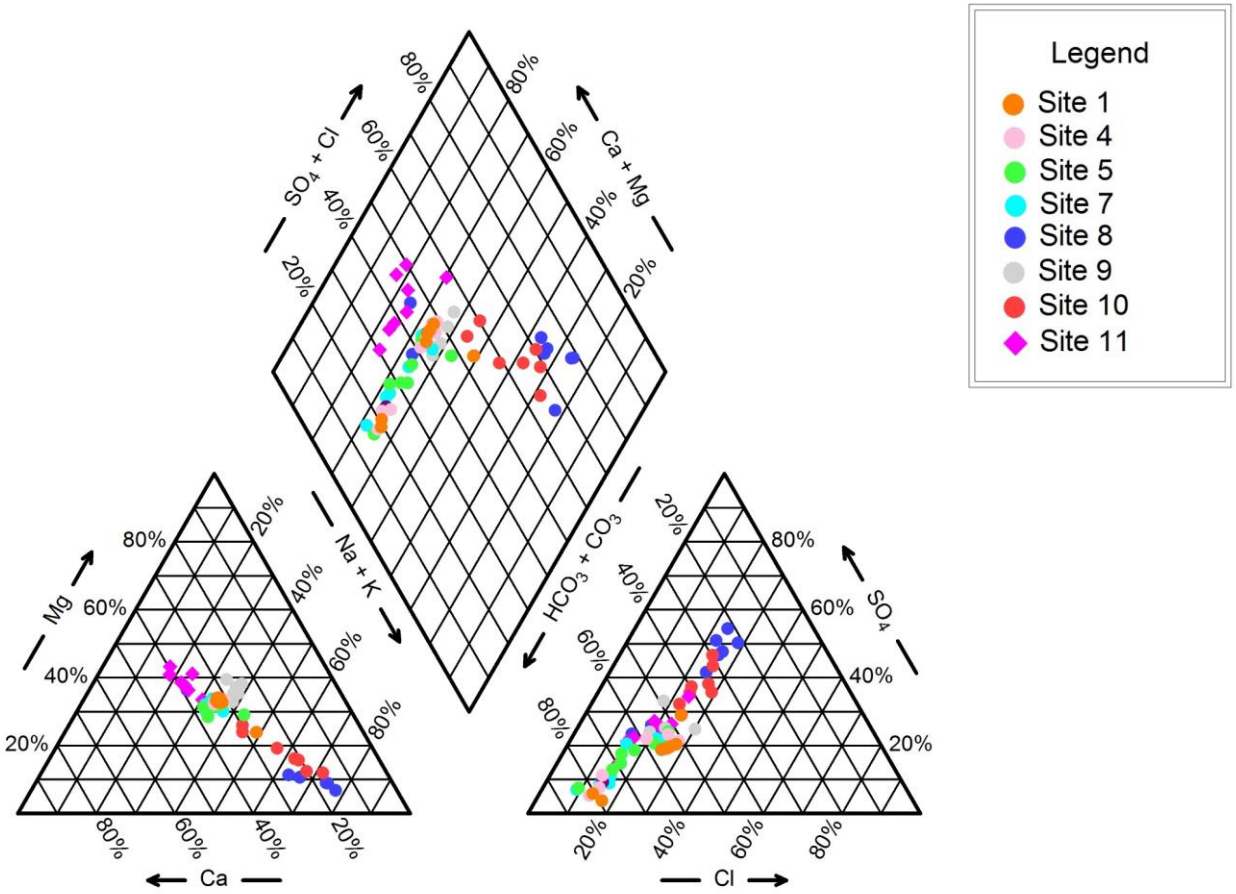


Figure 19: Piper diagram plot of surface water quality from August 2016 to January 2020

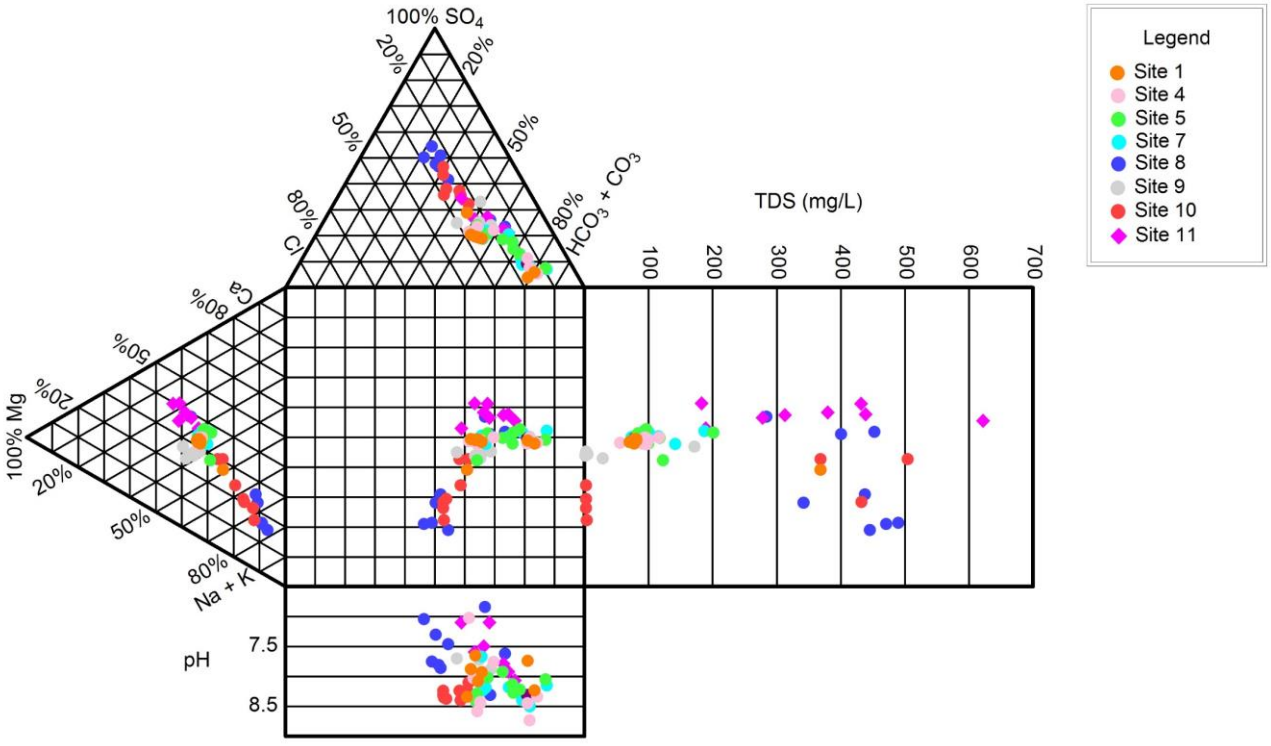


Figure 20: Durov diagram plot of surface water locations from August 2016 to January 2020

Figure 21 and Figure 22 present the time series plots to total nitrogen and oxides of nitrogen for Beltana Pond (Site 11) with Googong Creek (Site 8 and Site 10) and Montgomery Creek (Site 9) with the Queanbeyan River (Sites 1, 4, 5, 6 and 7). Refer to Appendix B for individual location time series plots of total nitrogen and oxides of nitrogen.

Site 8 shows increasing concentration of total nitrogen and oxides of nitrogen in response to recycled water discharge, for which the quality of the recycled water discharge also shows increasing total nitrogen concentration (Figure 21). The EPL limit for total nitrogen for discharge of recycled water is 10 mg/L and all results fall below this value. However, the Site 8 assessment criteria is much lower at 0.25 mg/L. At Site 10, approximately 1.2 km downstream of Site 8 on Googong Creek, total nitrogen is also above the site assessment criteria and follow a similar trend of increase and decrease with Site 8, except in January 2020. In January 2020, a very high result of total nitrogen was reported at Site 10, located on Googong Creek, and Site 4 on the Queanbeyan River. Concentrations of total nitrogen appear to decrease following significant rainfall events.

At Montgomery Creek (Site 9) and along the Queanbeyan River Figure 22 shows the total nitrogen is very similar across all locations and concentrations appear to follow the long-term climate trend of increase during above average rainfall and decrease during below average rainfall. In general concentrations appear to increase between sites in a downstream direction. From July 2019 there is a trend for increasing concentrations, during below average rainfall conditions, which is not observed at Site 8 and 10 on Googong Creek though Site 10 reported a very high total nitrogen result in January 2020. Site 4 also recorded a very high total nitrogen in January 2020. Site 1 and 9 were unable to be accessed due to the extreme bushfire risk during that monitoring round. September 2019 concentrations at Site 7, the furthest downstream, are higher than Site 1,9 and 5 upstream. The Stage C surface water assessment noted that total nitrogen in the baseline study were above the environmental protection guideline of ANZECC (2000). Elevated total nitrogen may be a result of the 2019 summer period of bushfires dropping ash into the surface water catchment.

Refer to Appendix B for time series plots of total phosphorus and ammonia. Total phosphorus is also variable at Site 10, with very high results reported between January 2017 and June 2017. These correspond to the period of increase oxides of nitrogen during a period of below average rainfall. Ammonia has not been detected above the laboratory limit of detection (LLD) since December 2018.

Biochemical Oxygen Demand (BOD) has remained below the LLD, with the exception the January 2020 result at Site 7 and the April 2017 result at Site 8. Suspended solids are variable and appear to increase following significant rainfall events, and total dissolved solids range in concentration from 200 mg/L to 600 mg/L at Site 8, Site 10 and Site 11 on Googong Creek, and Site 9 on Montgomery Creek. Concentrations on the Queanbeyan River sites are generally below 200 mg/L and do not exceed the guidelines for water supply.

Faecal coliforms are generally detected a low levels and levels below the assessment criteria, except for:

- Site 9: in December 2016
- Site 6 and Site 8: in February 2017;
- Site 8, Site 9 and Site 10: in March 2017;
- Site 4, Site 5, Site 8, Site 9 and Site 10: in April 2017
- Site 1, Site 8 and Site 10: in March 2018
- Site 10: in September and December 2018
- Site 11: in December 2018
- Site 10 and Site 11: March 2019, and
- Site 8 and Site 10: January 2020.

The recycled discharge water quality provided by QPRC shows no detections of faecal coliforms in the recycled water that was discharged. Sources may be attributed to livestock grazing within the surface water catchments and the township development (e.g. pets and sewage systems).

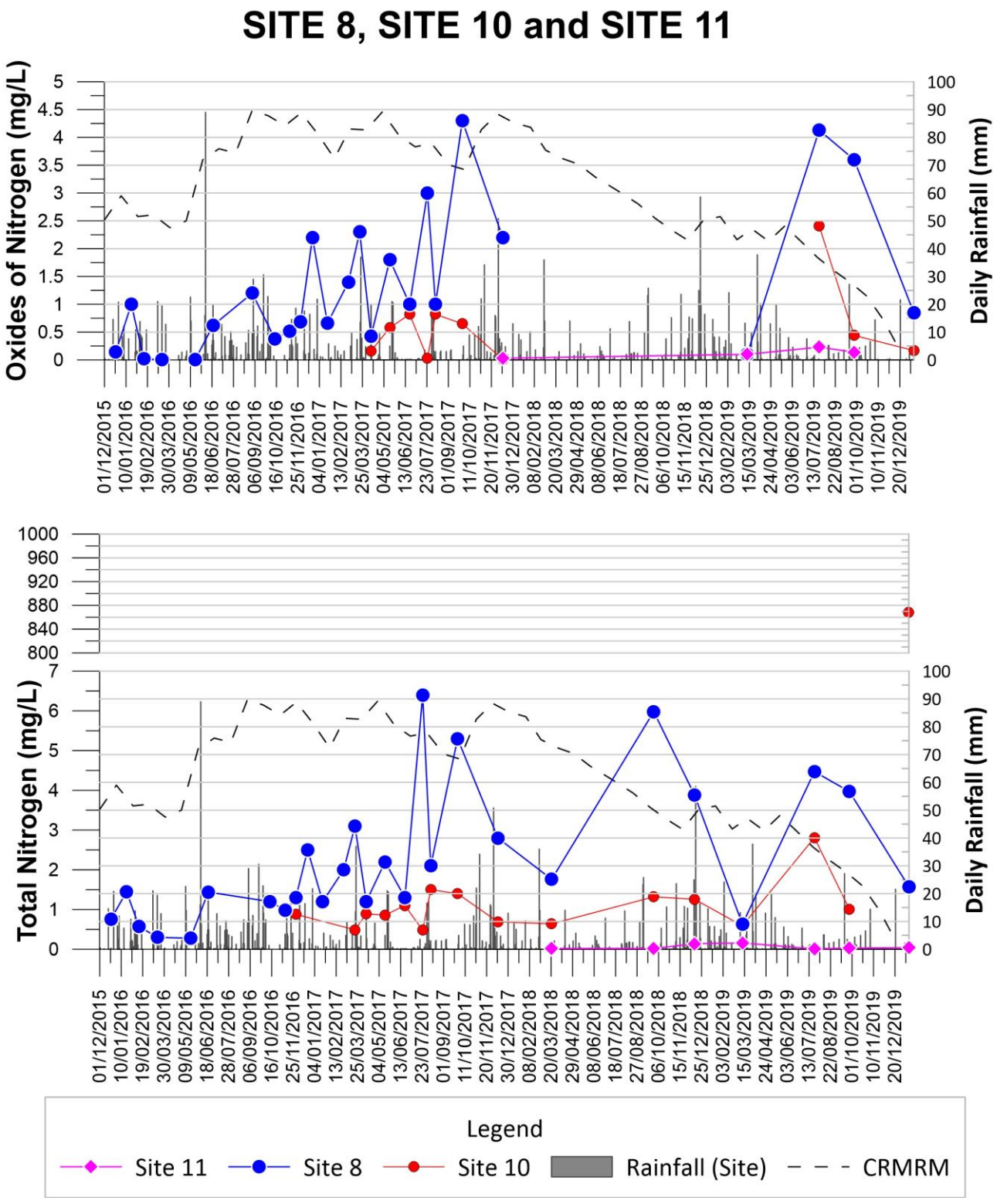


Figure 21: Time series plot of total nitrogen and oxides of nitrogen at Beltana Pond (Site 11) and surface water sites on Googong Creek (Site 8 and Site 10) with rainfall and cumulative residual rainfall mass (CRMRM)

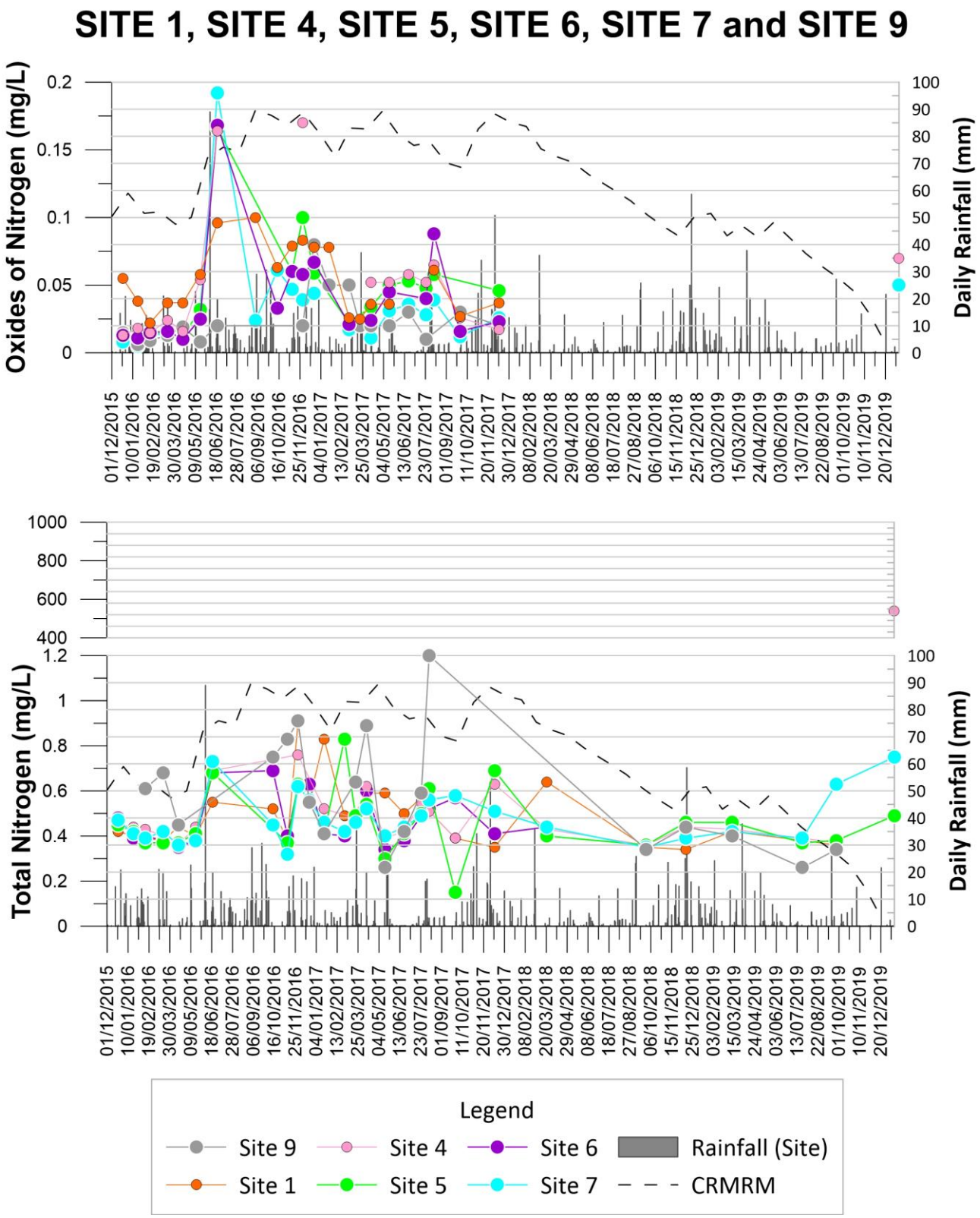


Figure 22: Time series plot of total nitrogen and oxides of nitrogen at Montgomery Creek and surface water sites on the Queanbeyan River with rainfall and cumulative residual rainfall mass (CRMRM)

The monitoring data shows cyanobacteria and total algae below the assessment criteria except for one result each at Site 4 in March 2017, Site 8 in April 2017, and Site 11 in March 2018. Oil and grease was not detected above the LLD in the recycled water or at the surface water locations except for:

- Site 1: in June, July and August 2017;
- Site 4: in April, June and August 2017;
- Site 5: in June 2017;
- Site 6: in June 2017;
- Site 7: in June, August and December 2017;
- Site 8: in May and June 2017; and
- Site 10: between May 2017 and August 2017.

Refer to Appendix B for time series plots of field and laboratory pH with field electrical conductivity and total and dissolved solids. Field measurements of pH and electrical conductivity at the surface water monitoring sites shows generally consistent results, with variability in response to rainfall events and long term climatic trends. pH ranges from 6.1 to 8.9 and EC ranges from 53 µS/cm to 1037 µS/cm. Sites 8, 9, 10 and 11 generally have higher EC than the other surface water sites. Field measurements of total chlorine using a field chlorine test kit reported results at all locations over the monitoring period. Tests were also undertaken in GGW2A, the groundwater monitoring bore at the WRP, after a strong chlorine odour was noted during a sampling round. Site 11 [on Beltana Pond] also reported field chlorine results which may be attributed to the swimming pool within the park complex and the use of potable water for irrigation.

Since the commencement of recycled water discharge, the test of December 2015, and continuous discharge since May 2016, the surface water quality at Site 8 has been impacted with the increase of nitrogen species. Faecal coliforms are unlikely attributed to the discharge of recycled water, however are more likely to reflect the activities within the catchment such as livestock grazing, the presence of domestic pets or potentially leaking sewage pipes. It is noted that the ACTEW sewage treatment plant also has a licenced discharge point into the Queanbeyan River.

There has been no surface water monitoring in South Creek or the upper reaches of Montgomery Creek, and earthworks upstream and township activities contribute to the water quality at Site 9. The quality of the spring discharge at the WRP has not been assess and this may contribute to the results observed at Site 9.

No monitoring of water quality has occurred on North Creek, which runs parallel to Googong Creek. Discharges from Googong Dam contribute freshwater inputs to the Queanbeyan River and the surface water quality shows there is seasonal variability in concentrations of chemical species and relationships with long term climate patterns. There are no significant changes to the Queanbeyan River water quality since the start of recycled water discharge. Photography, reported in the 2018 Annual Factual Monitoring Report (SMEC, 2018) of the monitoring sites shows no significant changes to habitat or bank stability.

3.7 Recycled Water Discharge Points

The excess recycled water discharge locations for Stage D of the IWC project are located at the permanent reservoir of Hill 800 (Discharge Point 1) and at the Beltana Park Outlet Structure (Discharge Point 3) and are as shown on Figure 16. Presently only Discharge Point 3 is used.

For Stage C discharges will occur at the following locations:

- Discharge Point 1 – an EPA-licenced discharge point where recycled water in excess of township demand is discharged via a series of overland flow stormwater ponds, with flow into Googong Creek through the stormwater management system (including Beltana Pond). This discharge point is anticipated to come online in May 2020;
- Discharge Point 3 – an EPA-licenced discharge point where recycled water that doesn't meet the *Essential Sewage and Recycled Water Quality Management Plan* (RWQMP) criteria, but meets discharge criteria detailed in an operational EPL, is discharged. Discharge has been occurring at this location since 2016.

The emergency discharge point (EDP) is located at the WRP (Figure 16) and in the event of an emergency discharge is directed to Montgomery Creek. Discharge Point 3 is currently used for discharge of recycled water as there is no use in the township. QPRC propose a change to the designation of the discharge locations such at Point 1 is used on occasion for operational purposes and Point 3 remains as the discharge point for any excess recycled water after township demand.

3.8 Recycled Water Quality

The quality of the ReW is influenced by is sources, pathways of travel and treatment process. The WRP process adds to the water quality chlorine and other treatment chemicals.

Discharge of excess recycled water must meet the EPL conditions before it can be discharged. Quality samples are taken each month (or multiple times a month) from the treatment plant in accordance with the EPL. Figure 23 presents a piper diagram plot of the recycled water chemistry and selected surface and groundwater locations. It shows the recycled water, which has varied slightly each year, appears distinctly different to the surface water and groundwater quality. Prior to recycled water quality discharge, Site 8 on Googong had a chemistry similar to the groundwater at GGW1S and GGW1D but now shows the same signature as the recycled water. Site 10, downstream from Site 8 on Googong Creek, shows there is mixing zone between the groundwater and recycled water. Site 11 in Beltana Pond, which is upstream from the recycled water discharge in Beltana pond, shows a similar chemistry to the groundwater.

Figure 24 presents the time series plot of recycled water quality results from QPRC. It shows as discharge has increased over time pH has generally remained consistent along with the concentrations of major ions and ammonia and total phosphorus. Sulphate concentration shows some variability which may be related to seasonal variability. Total nitrogen shows a significant increase in concentration from May 2017 to September 2017 to around 5 mg/L. The TDS of the water ranges from 288 mg/L to 586 mg/L.

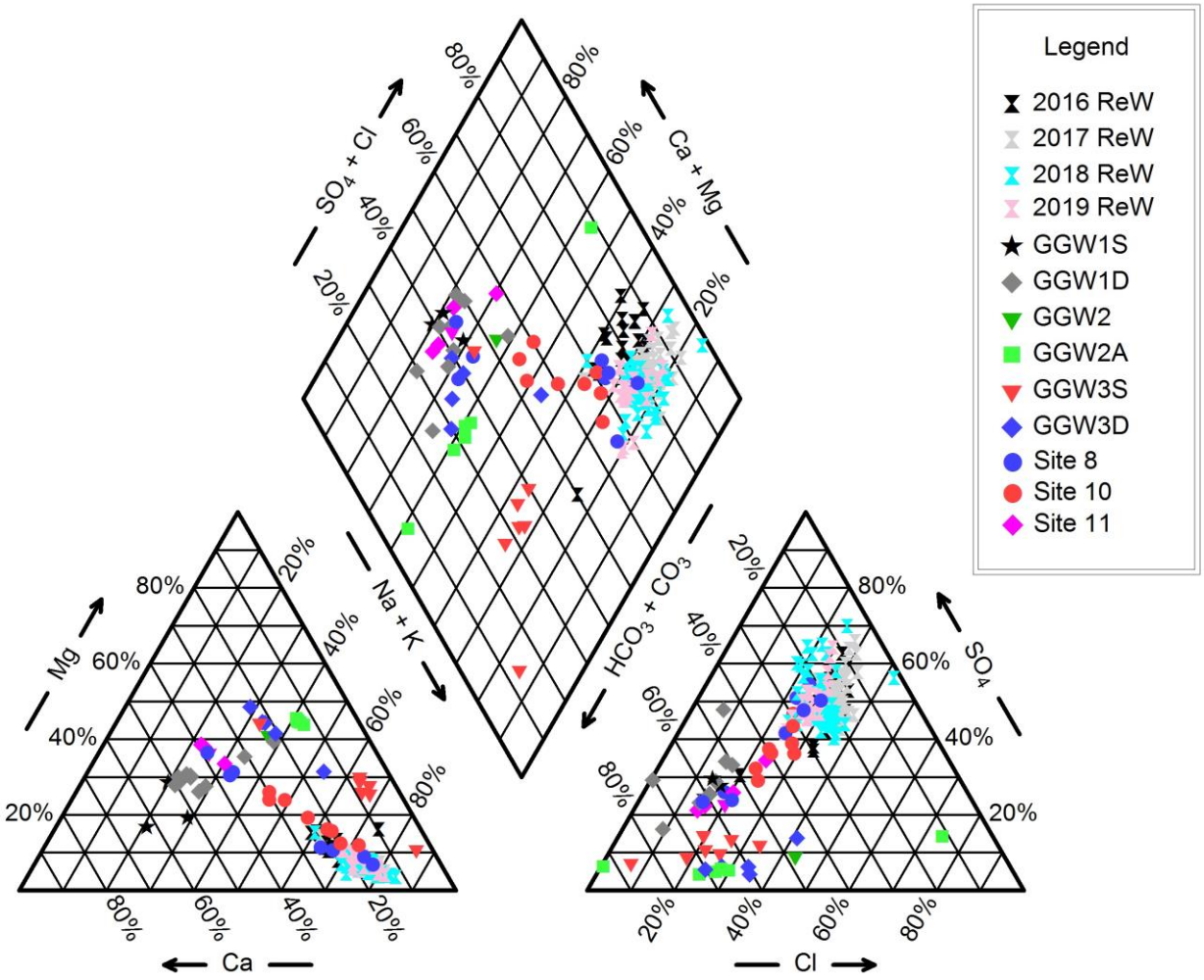


Figure 23: Piper diagram plot of recycled water quality with selected surface and groundwater sampling locations

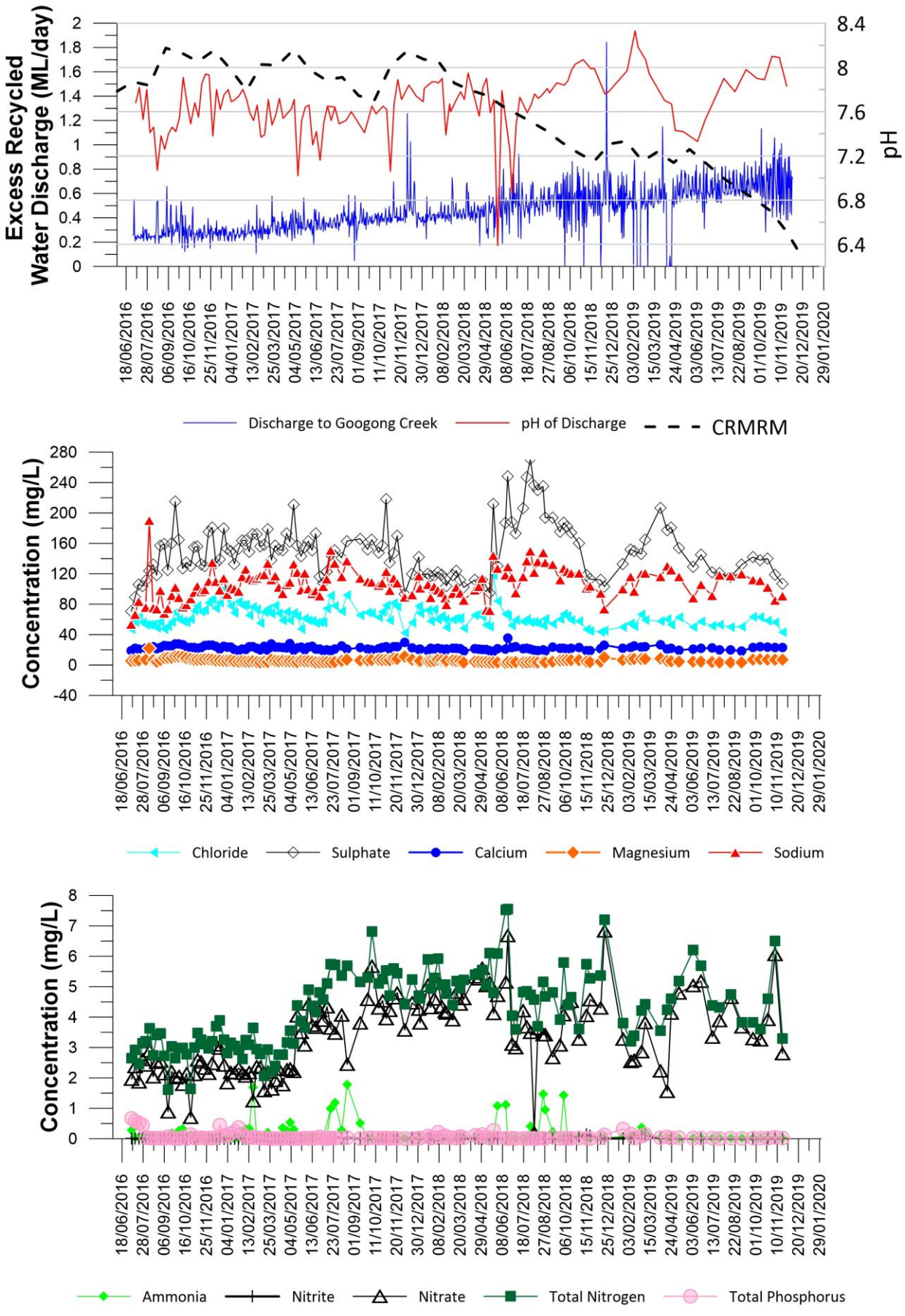


Figure 24: Time series plot of recycled water quality

4 Potential Construction and Operation Impacts

4.1 Construction Activities and Potential Impacts

4.1.1 WRP

The WRP site layout in Stage C included provision for Stage D infrastructure. Construction activities within the WRP will result in the temporary reopening of the access road to the east of the WRP (within its existing footprint) and will later be rehabilitated for the operational phase of the development. The opening of the access road is likely to result in topsoil stripping, placement and compaction of materials. There will be excavation works for foundations of new structures which will likely expose the shallow rock profile and any placed material. Potential impacts include:

- degradation and erosion of the temporary access track;
- sediment discharge to the drainage line from the road construction;
- spills of chemicals from decommissioned and disassembled plant; and
- contaminated surface run off.

Construction works associated with the WRP works are anticipated to be completed by end of 2024.

4.1.2 Hill 800 Reservoirs

The Hill 800 reservoir site layout in Stage C included provision for Stage D infrastructure. The main access to the site is from Old Cooma Road by way of a sealed access road. Potential impacts include:

- sediment discharge during the removal of the earth bund;
- spills of chemicals from decommissioned and disassembled plant;
- contaminated surface run off.

Construction works associated with the WRP works are anticipated to be completed by the end of 2024.

4.2 Mitigation and Monitoring of Construction Impacts

Construction activities for Stage D WRP and Permanent Reservoirs are not anticipated to require extensive earthworks and as such potential impacts are minimal. Any impact of flows into receiving waterways resulting from construction of Stage D WRP and Hill 800 Reservoirs are likely to be negligible and measures in place within the CEMP are considered sufficient.

Around the WRP site monitoring for construction impacts should include:

- Site 9 on Montgomery Creek and
- Spring discharge at the WRP.

Around the Permanent Reservoirs of Hill 800 there are no established surface water monitoring locations and surface water run off should be contained within the IWC. A surface water monitoring location should be established on South Creek, downgradient of Common A and Sporting Field 7.

Impacts may be identified by comparing current monitoring data to baseline monitoring criteria, where available or requirements outlined in the CEMP. Increases in parameters such as pH, EC, TDS, heavy metals and nutrients may indicate a potential impact to the surface water system.

It is noted mobilisation of sediment may increase heavy metals within the surface water which are not currently assessed in the surface water monitoring analysis suite. Monitoring should include selected metals, such as those with bio-accumulated toxicity, included in future rounds.

Construction will likely have an impact, however monitoring conducted on site since 2013 indicates construction related impacts, where observed, are typically short lived.

4.3 Operational Impacts of Stage D

The potential operational impacts of the WRP and Hill 800 Reservoirs relate to:

- spills of dosing chemicals, leaking pipes and tanks and emergency discharge releases;
- overall reduction of surface water flow due to township development.

Operational impacts are considered relatively unlikely and should be contained within the IWC, excluding emergency discharge releases. Emergency discharge of water down Montgomery Creek may be visually unsightly but short lived. Potential impacts may include erosion of the upper creek channel and a potential decrease in water quality. There is no further practical mitigation with respect to emergency discharge.

The potential operation impacts of open space irrigation relate to:

- overapplication of water leading to surface ponding or run-off; and
- spray drift;
- pipe failure leading to flow of excess water.

These impacts are considered minor. The irrigated areas are unlikely to contribute significant volumes of water to the surface water system as volumes and times [of irrigation] are controlled within the IMP. Run-off from these irrigated areas would be managed within the stormwater infrastructure.

The development of the township increases surface water run-off as storm water increases in areas of hardstand over the natural environment, and the IWC directs this to specific locations which report to Googong Creek and Montgomery Creek. The Stage C WRP surface water assessment by Hydrobiology (2016) noted that for Googong Creek, on the basis of MUSIC modelling, there would be some impacts from reduced flow, but for the Queanbeyan River the impacts would be less pronounced as flows from other downstream sub-catchments would mask or buffer the impacts of the development. No updated MUSIC modelling has been provided for the Stage D assessment.

The spring seepage under the WRP should also be considered in terms of the quality of water it contributes to Montgomery Creek. This location should be included within the townships WMP and be sampled in under the GWMP and SWEAMP criteria.

4.4 Operational Impacts of Discharge of Excess Recycled Water

The township development Stages AB and C proposed that excess recycled water is to be discharged from Discharge Point 1 in NH2. However excess recycled water has been discharged from Discharge Point 3 on Googong Creek just below Beltana Pond pending approval for QPRC to reticulate recycled water for use in the township. Any water that is discharged must meet the effluent criteria listed in the RWQMP and be in accordance the EPA licences conditions under EPL Licence Number 20188.

The Stage D development proposes to retain the location of excess recycled water discharge as Discharge Point 3 on Googong Creek. QPRC considers that pumping excess recycled water up hill to the permanent reservoirs at Discharge Point 1 is not as efficient as release from Discharge Point 3. Discharge Point 1 would be retained to allow discharge of recycled water as required to meet operational requirements.

This change would mean that the bio-retention basins, vegetated swales and wetland element of the townships stormwater management system would not receive excess recycled water. The bio-retention basins, vegetated swales, and wetland elements are designed to capture, reduce, and in some instances, remove excess nitrogen and phosphorous. Beltana Pond has been designed with passive water flow to ensure water is regularly passed through the wetland and a recirculation pump to provide increased oxygenation. It would also mean that less recycled water would recharge the shallow groundwater system from this process and more surface flow reaching the Queanbeyan River.

Stantec have estimated for the ultimate IWC Project the average excess recycled water to discharge to the environment is 1029 kL/day to a maximum of 5477 kL/day. This equates to around 11 L/sec (0.01 m^3/s) to 63 L/sec (0.06 m^3/sec) of discharge to Googong Creek compared to the 2019 discharge which was around 700 kL/day which equates to around 8 L/sec (or 0.008m^3/s.)

The potential impacts of increased recycled water discharge include: waterlogging of soils, erosion of creek bed and banks, and elevated nutrient load to the Queanbeyan River.

Potential impacts of discharge of excess recycled water may include:

- increased surface flow in Googong Creek reporting to the Queanbeyan River during wet periods;
- increased TSS / TDS, nutrient and metals load to surface water; and
- erosion in Googong Creek from increased flow.

Discharge of excess recycled water must meet the EPL conditions and is not considered likely to have a significant impact on the quality of surface water. Monitoring results to date show the receiving waters of the Queanbeyan River do not appear to be adversely impacted by the recycled water discharge.

Figure 25a presents the predicted excess recycled water discharge as a monthly summary of average, minimum and maximum discharge as kL/day with the result of discharge from 2019. Figure 25b presents the seasonal average daily discharge with results from 2017 and 2019.

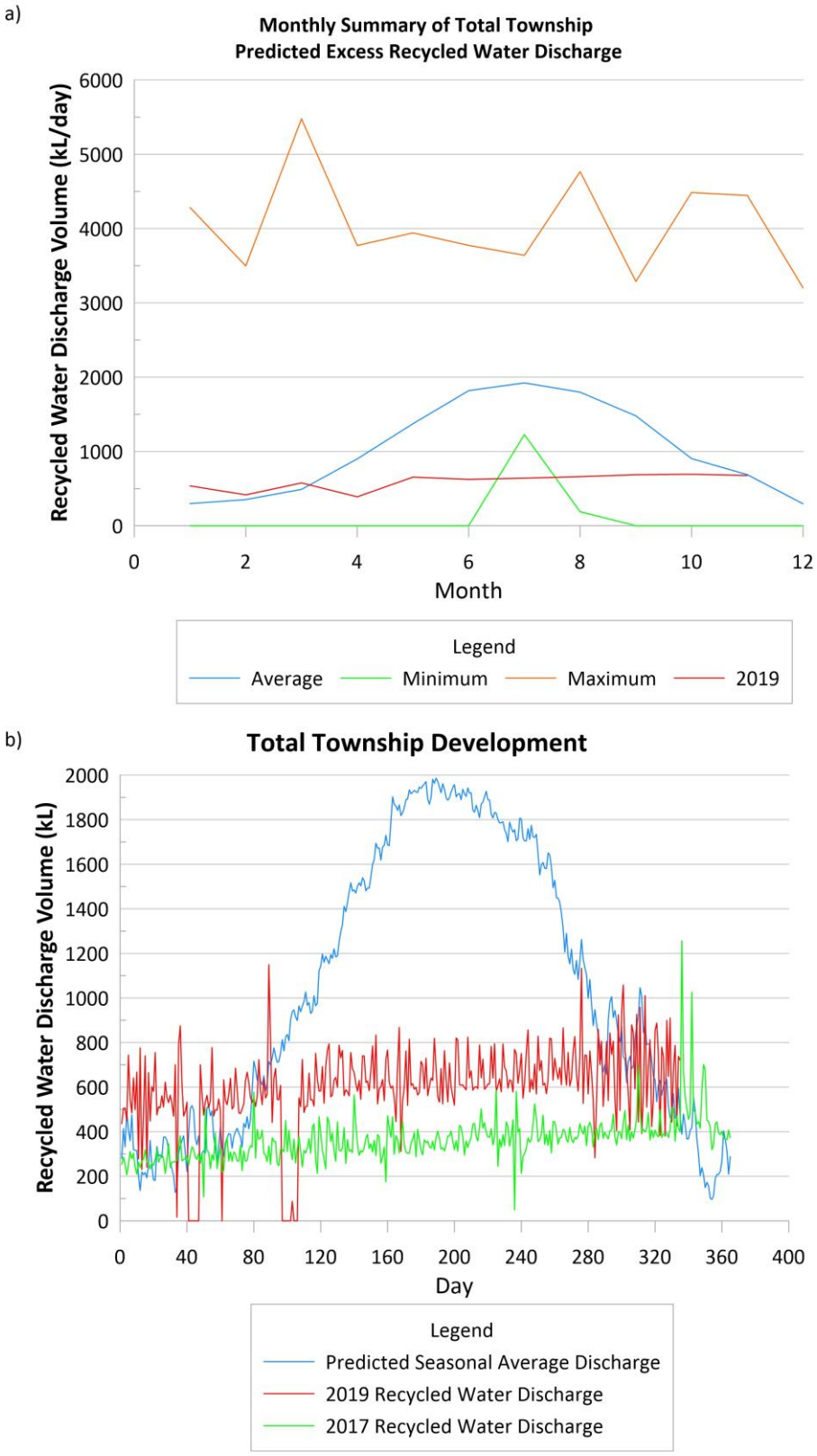


Figure 25: Predicted Excess recycled water discharge to Googong Creek a) month summary with predicted minimum, average and maximum and 2019 results and b) daily summary of average predicted discharge with 2017 and 2017 results

For assess the potential impacts to Googong Creek for the ultimate IWC project the overall it is important to understand how the volume of discharge will change from the current situation. As there has been no consumption of recycled water the recycled water has been discharged and the volume increased over time. When this is compared to the ultimate IWC project estimated discharge it can been see that seasonal disparity in volume will occur. That is, more discharge in winter months and less to none in summer, spring and autumn months. The winter months discharge will be higher than what has been discharged to date. There will be a return to the 2017 discharge volumes for the summer period in the ultimate IWC and for the winter months the assessed increase is 174% on the 2019 discharge volumes.

The 2019 discharge to Googong Creek is higher than the ultimate IWC project predicted average excess for summer months but lower compared to the winter months. When the 10th and 90th percentile of excess flow are considered (Figure 26), then excess recycled water greater than current volume is predicted for the winter months as a 142% and 214% increase respectively. It is likely that the start of reticulation of recycled water in the third quarter of 2020 would result in minimal to no excess discharged as environmental flow to Googong Creek in the summer months and reduced volumes in the winter months of the following year. The would be a significant change from the current conditions, returning Googong Creek to a more ephemeral state. This would lead to a shift in macroinvertebrate and diatom aquatic characteristics, potentially similar to those observed in the baseline study.

The increase in winter discharge to Googong Creek at the ultimate township IWC project appears a similar volume as the very low flow in the Queanbeyan River observed in 2019. During years of above average rainfall conditions the township consumption of recycled water is likely to decrease, resulting in the increased likelihood of excess recycled water above the 50th percentile and closer to the 90th percentile in winter months.

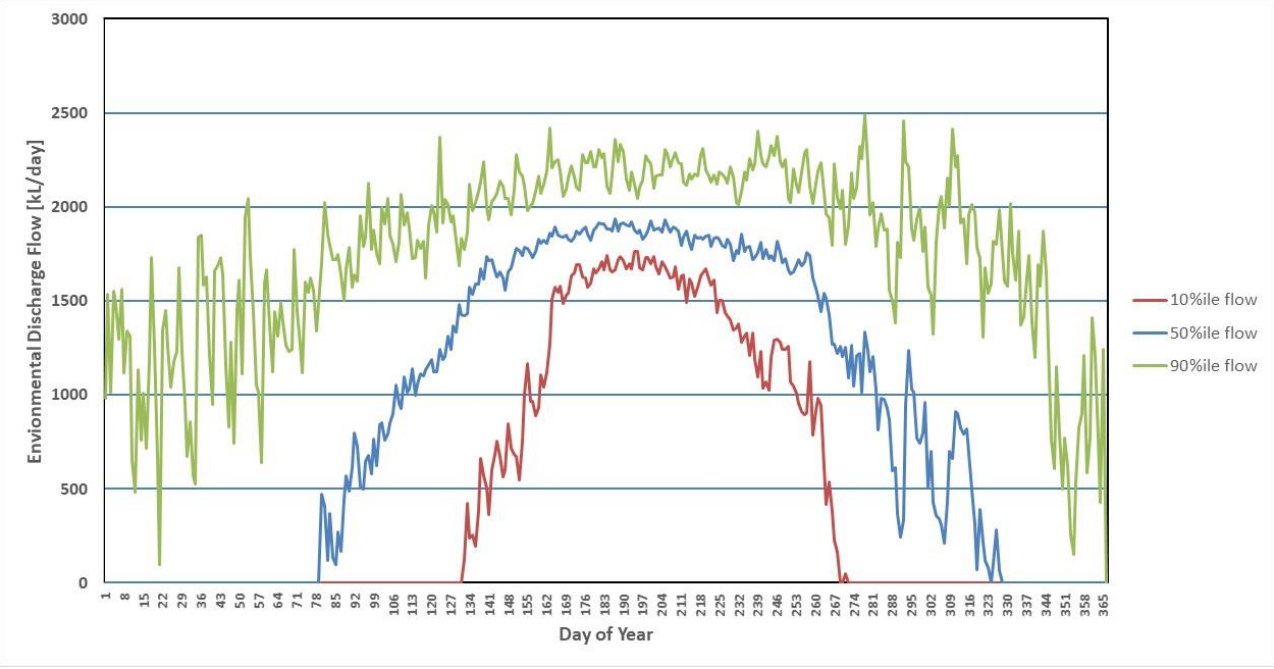


Figure 26: Summary of percentile daily environmental discharge (Stantec)

4.5 Monitoring and Mitigation of Operational Impacts

Surface water monitoring for the operational impacts of the WRP and Permanent Reservoirs is unlikely to be necessary. In the event of a spills that are not captured by the IWC system an event-based surface water monitoring of the nearest receiving water body may be considered and should target relevant parameters. The permanent reservoirs do not have a down-gradient surface water monitoring point as flows are contained within the IWC system. Beltana Pond (Site 11) is the nearest water body monitoring location. Monitoring should be considered in NH2 Town Lake as this flows to Beltana Pond via the stormwater system. NH2 Town Lake receives discharge from Discharge Point 1.

Surface water monitoring for the operational impacts of irrigation with recycled water is difficult. Within the catchment there are many activities associated with township development and residential living that contribute to the overall surface water quality in Googong Creek and Montgomery Creek. Some of these residential activities, such as gardens and pets, are outside the control of the WMP. In parts of the township yet to be develop animals are being grazed and

native wildlife such as kangaroos and wombats are observed in the Foreshore Protection Area and feral animals such as pigs in the areas around the lower reaches of Googong Creek and Montgomery Creek. Surface water results in Googong Creek and the Queanbeyan River may also be impacted by discharge from the ICON Water sewage treatment plant (operated by ACTEW) which is located just north of the township. Long-term changes in surface water quality may be better assessed with a quarterly monitoring frequency though changes directly associated with Stage D activities may still be difficult to discern over other impacts and long-term climate trends.

Monitoring of the potential operational impacts of excess recycled water discharge under the SWAEMP should continue for at least the first year of irrigation with recycled water with the removal of Site 6 and Site 7 from the program and the addition of heavy metals testing at all sites. Monitoring at Site 11 should continue compare the quality of the water in Beltana Pond with the recycled water discharge. The SWAEMP trigger levels for total nitrogen at Site 8 will continue to exceed with the discharge of recycled water and should be revised to the EPL limit.

As the quality of recycled water discharge must meet the EPL the monitoring undertaken by QPRC as part of the EPL conditions is considered acceptable for monitoring of impacts and the mitigation is the water meeting the EPL criteria. The other mitigation measures should focus on preventing erosion or localised flooding as the volume of discharge increases over time. The temporary sediment fence and reeds, Figure 27 at Surface Water Site 8 should be replaced with a more permanent series of gabion walls and smaller bio-swales / wetlands with the aim of minimising pooled water areas whilst achieving some of the benefits of improved water quality that come from wetlands with vegetation. Erosion is not considered a major issue given the steep and incised nature of Googong Creek in the lower reaches however a series of gabion walls would assist with reducing flow velocity and minimise erosion in the plateau area between Beltana Pond and the existing dam on Googong Creek. This would be in accordance with the Water Quality Objective ‘minimise effects of weirs and other structures’.

The frequency and locations of surface water monitoring should be reviewed after the first year’s irrigation with recycled water. Site 7 should only be considered if significant impacts were observed at Site 5 that may be attributed to the discharge of excess recycled water.



Figure 27: Site 8 on Googong Creek with reed bed

Consideration is given to the practicality of installing flow monitoring on Googong Creek and Montgomery Creek. The volume of excess recycled water discharged to Googong Creek is known but the discharge from Beltana Pond is not. Adding flume weirs or v-notch weirs to the culvert structure may be possible and this would monitor the total flow entering Googong Creek. It is unlikely that flow monitoring on South Creek or Montgomery Creek is practical to install.

A re-run of the MUSIC model should be considered during the update of the groundwater model after one year of irrigation with recycled water. Once those data have been collected, the model can be further developed to include the integration of the IWC system and water quality assessment.

Impacts of emergency discharges to Montgomery Creek may be more noticeable but they are likely to be of short duration, very infrequent, and heavily diluted upon mixing with the Queanbeyan River flows.

5 Discussion

5.1 Stage D Construction

The surface water assessment of the Stage D WRP and Permanent Reservoirs at Hill 800 outlines that construction related impacts to the surface water are likely to be minor and would be contained within the existing IWC infrastructure. Earthworks will disturb the soil profile and may cause additional sediment load to surface water however mitigation measures undertaken as part of construction management plans and the construction methodology are considered sufficient. Any impacts are likely short lived and are not anticipated to have significant long-term impacts on the water quality of the Queanbeyan River and are not anticipated to impact on the water quality of the Googong Reservoir.

5.2 Stage D Operation

The operation of Stage D is considered unlikely to contribute impacts to surface water from the WRP, Permanent Reservoirs and irrigation with recycled water. Any impacts would be difficult to distinguish over the impacts from township runoff. The township development has likely reduced both baseflow and surface flows to Googong Creek and Montgomery Creek which are normally both ephemeral with some natural baseflow from groundwater discharge, particularly in the lower reaches. The discharge of excess recycled water to Googong Creek has offset some of this loss, though the quality is different. Hydrobiology (2016) noted in the Stage C Surface Water Assessment that with the addition of recycled water to the system the water quality appeared to improve. Googong Creek has changed from an ephemeral creek to one that permanently flows and as the total township development is achieved may return to a more ephemeral creek.

It is likely that when recycled water reticulation and irrigations commences in the third quarter of 2020 that discharge of excess recycled water will decrease or cease in the summer months. Long term the volume of excess recycled water discharged to Googong Creek will be higher than it presently is in the winter months only. Discharge Point 3 is a more suitable location than Discharge Point 1 primarily as water doesn't need to be pumped up hill. Localising the discharge down stream of Beltana Pond reduces the potential for flooding issues within the township and may return more surface water to the Queanbeyan River as less is lost through shallow groundwater recharge in the township.

The results from the first few years of recycled water discharge to the environment found no significant changes were able to be assessed outside of the variations associated with long term climatic variability and other catchment activities. Provided the recycled water meets the EPL criteria, impacts associated with the release are considered acceptable. Moving the release to Discharge Point 1 is unlikely to improve the overall water quality. A benefit of continuing to discharge excess recycled water at Discharge Point 3 is that it may assist in diluting groundwater baseflow that is predicted around Site 10, where elevated salts may occur as a result of irrigation with recycled water.

To continue releasing at Discharge Point 3 the recycled water and surface water monitoring should add selected heavy metals to the analysis. Metals such as zinc, copper and nickel may be harmful to aquatic life and bio-accumulate. The annual fish survey in the WMP has been discontinued as it showed no significant changes to the aquatic health of the Queanbeyan River which was dominated by exotic fish species. The macroinvertebrate results appeared to showed improvements in the Queanbeyan River post recycled water discharge but may also have been due to the prevailing above average rainfall conditions. The two ephemeral creeks (Googong and Montgomery) the results show little change and had communities indicating moderate to severe pollution or ephemeral conditions. The macroinvertebrate survey is not currently being undertaken (SMEC, 2017 Annual Monitoring Report) at the request of QPRC until there is commencement or irrigation with recycled water. Whilst this and diatoms are considered a more suitable indicator of river health, than a fish survey, it will be difficult to assess if the changes are due to the operation of Stage D or the township development and alterations to the catchments. It is recommended these surveys be reviewed after the first two years of irrigation.

The pre-WRP baseline data is not considered representative of background conditions given construction activities within the township had commenced and influenced this data. Revision of the surface water site specific assessment criteria should be undertaken to give single trigger values across the sites rather than individual values for Total Nitrogen and oxides of nitrogen. The site-specific data of Site 7 would be suitable, noting that the Queanbeyan River quality for total nitrogen is higher than the ANZECC (2000) derived guideline.

Under the current irrigation program, using potable water, there appears to be no significant impact to the surface water system when compared to the impact of the overall construction and development of the township. The surface water monitoring locations on the Queanbeyan River reflect a wider source and changes in the quality may not be

directly attributable to the IWC Project. Review of surface water monitoring should occur after the first two years of recycled water irrigation.

6 Conclusions and Recommendations

On this basis of the assessment documented in this report, and previous water quality monitoring rounds, SMEC offers the following conclusions. With regards to construction of Stage D WRP and Permanent Reservoirs:

- mitigation measures during construction in the CEMP are considered sufficient;
- construction impacts to the surface water system may occur, but should be minimal and short lived and be contained within the IWC;
- primary impact of construction is an increase in sediment load;
- impacts are unlikely to Googong Reservoir.

With regards to operation of Stage D:

- impacts of irrigation with recycled water to the surface water system are considered unlikely;
- impacts of discharge of recycled water to the surface water system are likely to be minimal and may be beneficial;
- impacts from the operation of the WRP and Permanent Reservoirs to the surface water system are unlikely;
- the new permanent flow regime in Googong Creek may decrease when consumption of recycled water commences;
- unlikely to be any impact to Googong Reservoir;
- Discharge Point 3 considered more suitable than Discharge Point 1 for excess recycled water release;
- the ultimate IWC Project would see an average 174% increase in recycled water excess discharged to Googong Creek over the next 25 years (compared to 2019 discharge volumes) during winter months, summer months may be the same or less; and
- surface water monitoring locations on the Queanbeyan River reflect a wider source and changes in the quality may not be directly attributable to the IWC.

The monitoring conducted to date has highlighted the issue of surface water monitoring for impacts associated with the use of recycled water downstream of a township development. Runoff from the township, both during construction and during ongoing occupation is not able to be distinguished from recycled water use impacts. This is especially evident during rainfall events where runoff contamination (hydrocarbons, nutrients, chemicals) often peak. It is the opinion of SMEC that as long as the recycled water meets the discharge quality potential for impacts to the receiving environment are likely to be low and may in fact (in some instances) be beneficial.

SMEC makes the following recommendations:

- addition of surface water monitoring point in NH2 Town Lake;
- removal of Site 6 and Site 7 from the surface water monitoring program;
- addition of heavy metals analysis to the surface water monitoring program;
- diatoms and macroinvertebrates surveys be reviewed after two years of irrigation with recycled water;
- revision of the surface water program to quarterly monitoring frequency;
- revision of total nitrogen and oxides of nitrogen criteria to the values of Site 7 and revise Site 8 to the value of the EPL;
- update of the MUSIC model for whole of township development stages and irrigation after one year of irrigation with recycled water (i.e. May 2021); and
- update of the WMP to ensure the above recommendations are implemented.

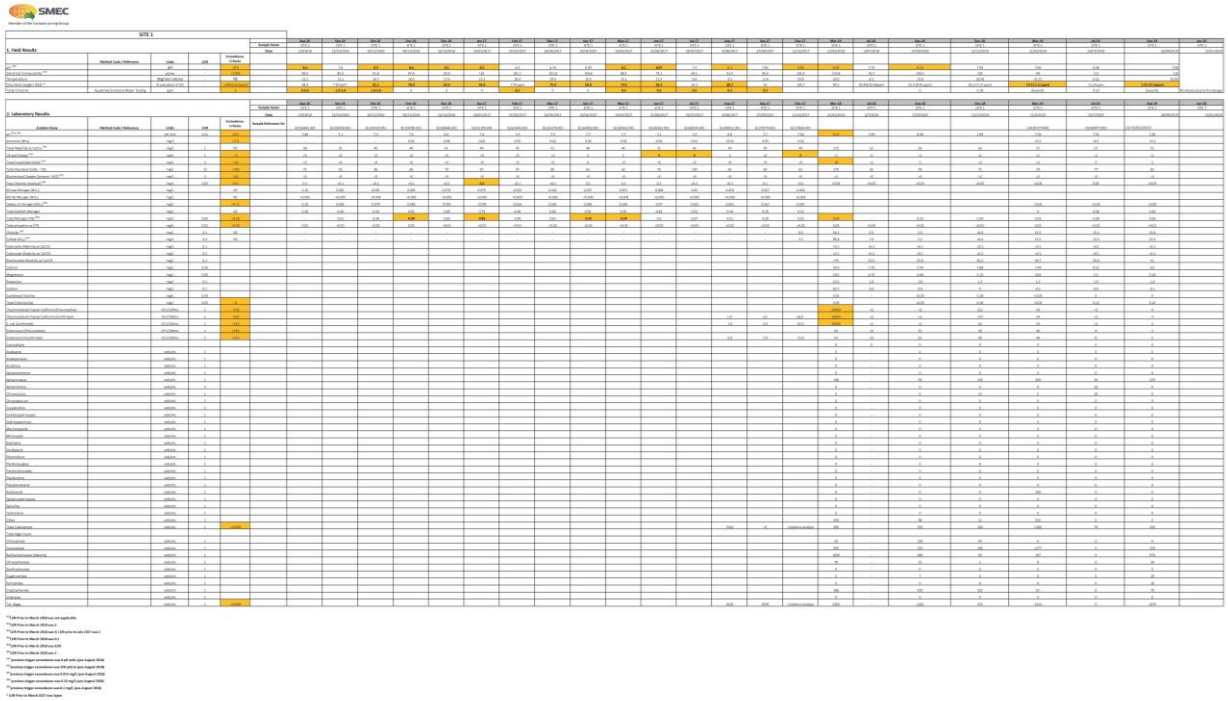
7 References

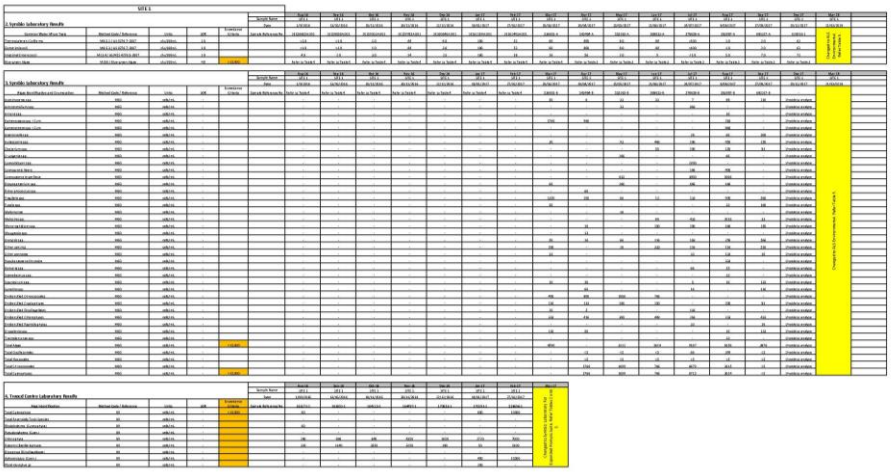
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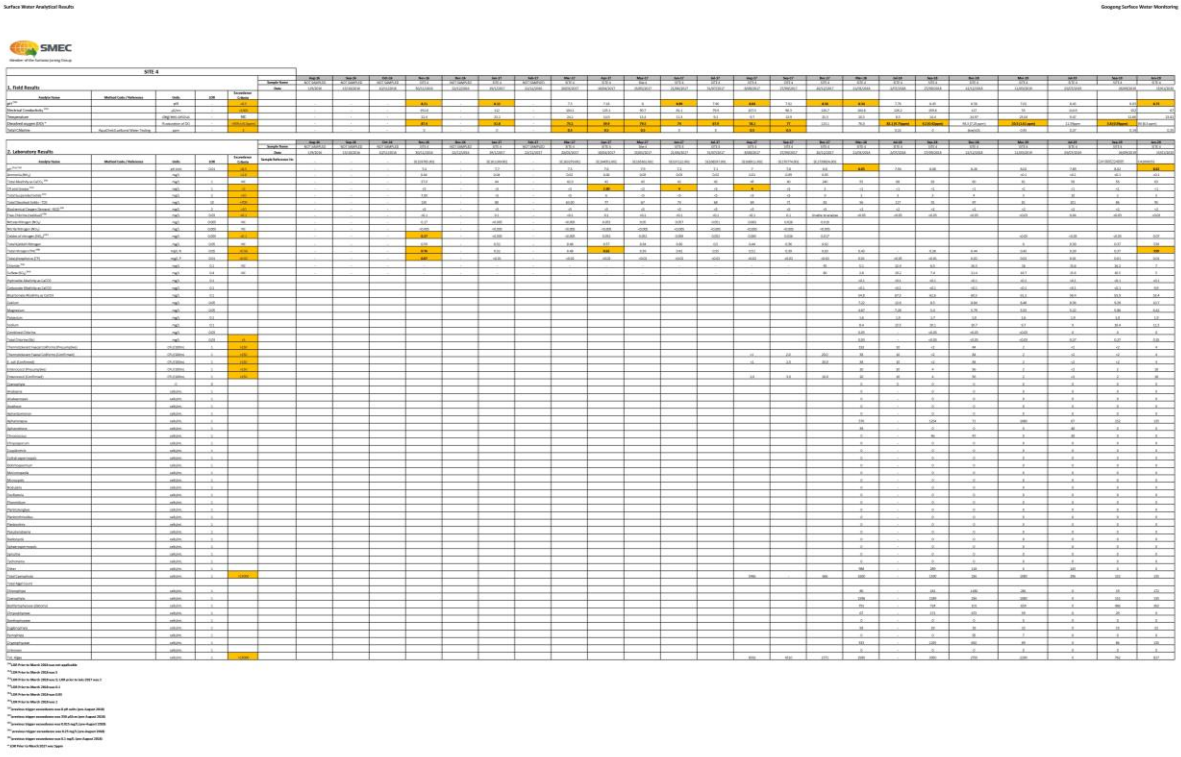
APPENDIX A: Surface Water Chemistry Results

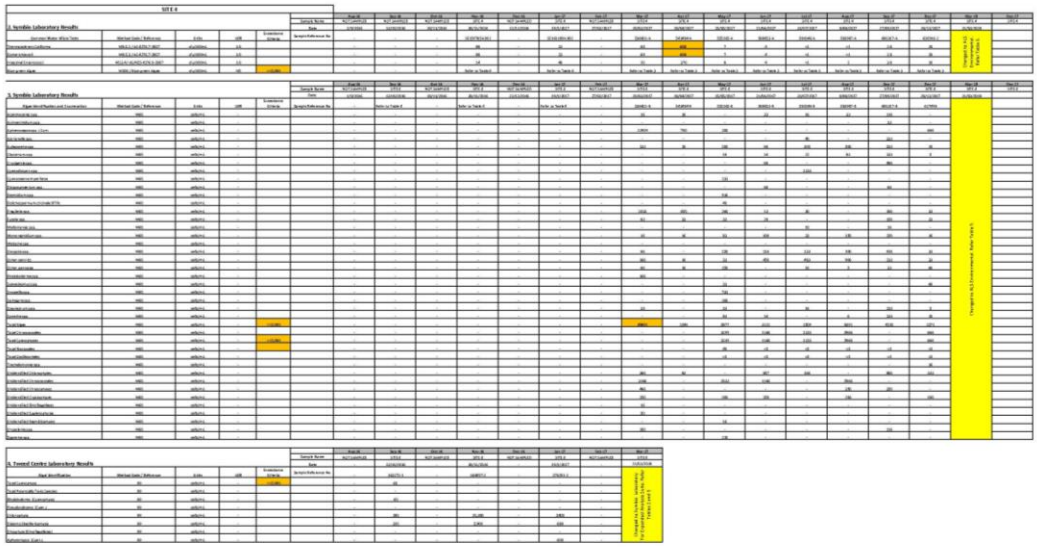
Surface Water Analytical Results

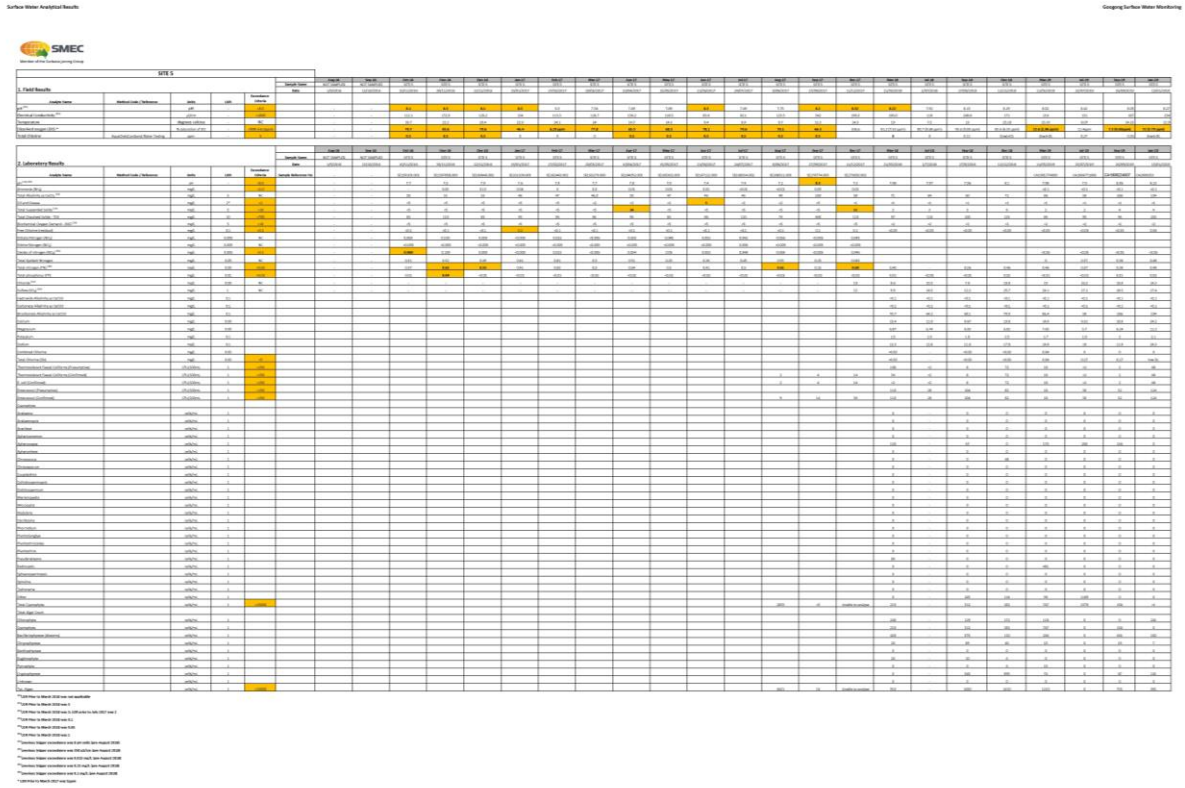
Googong Surface Water Monitoring

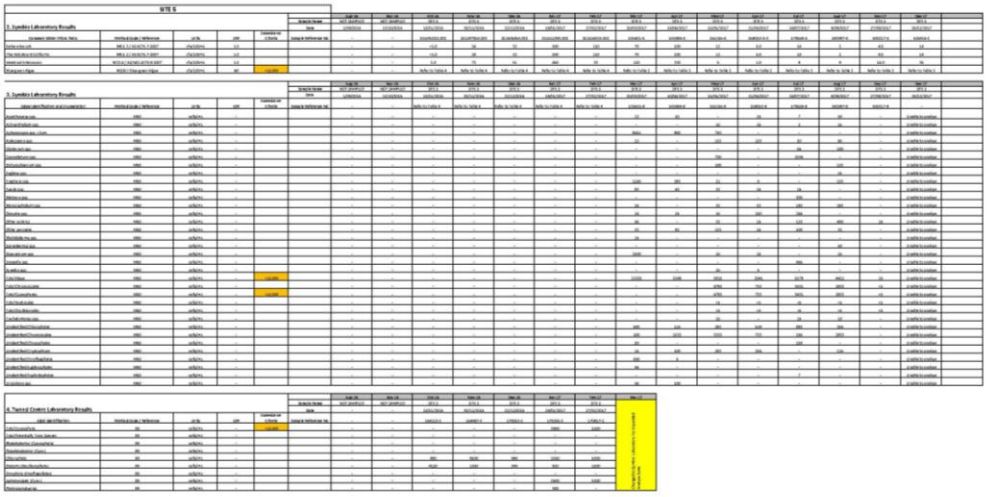


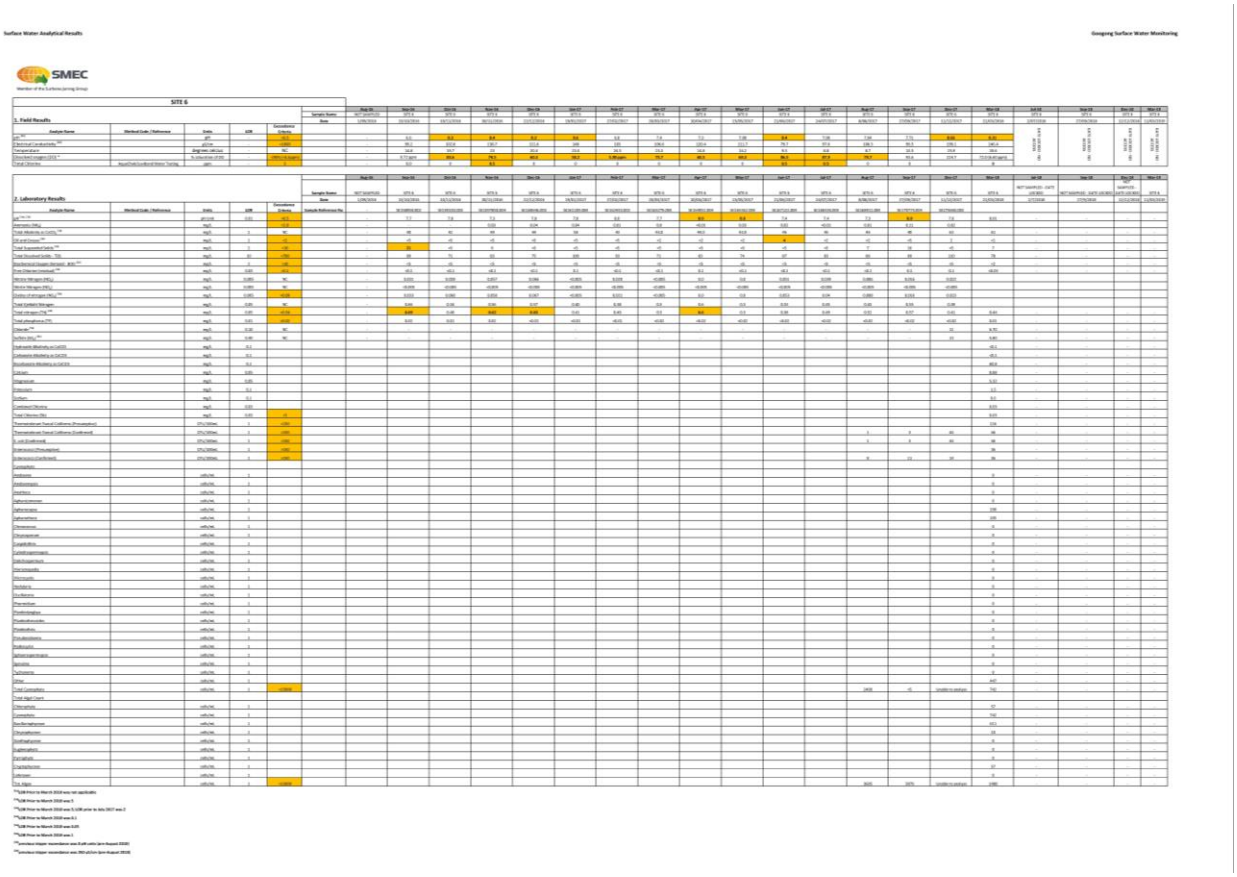


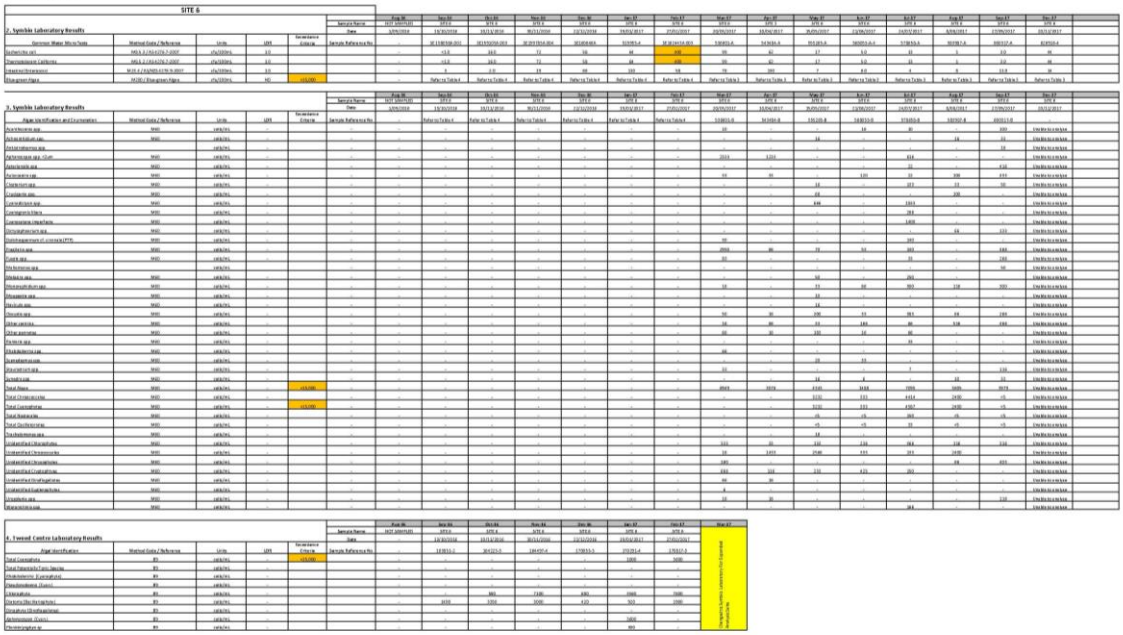


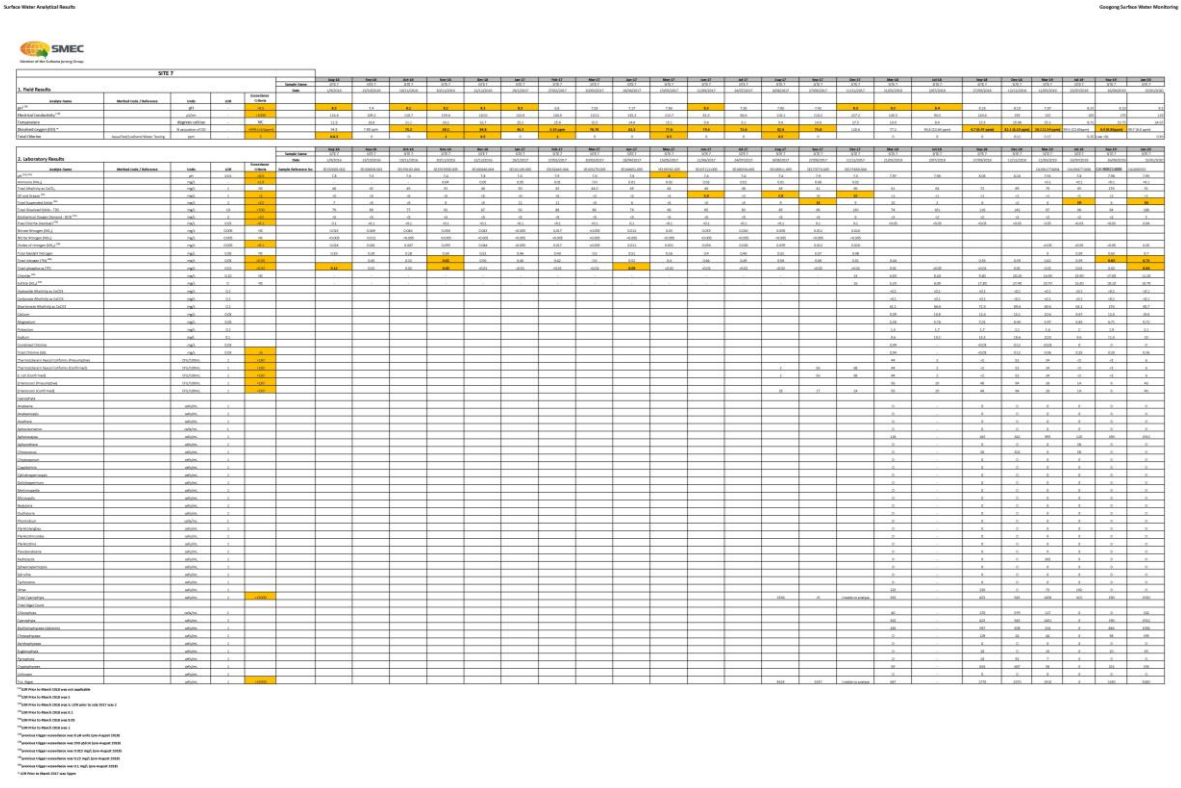


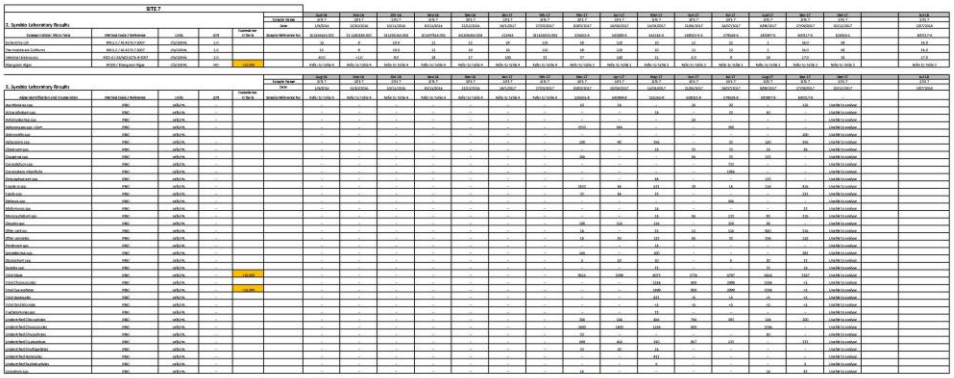




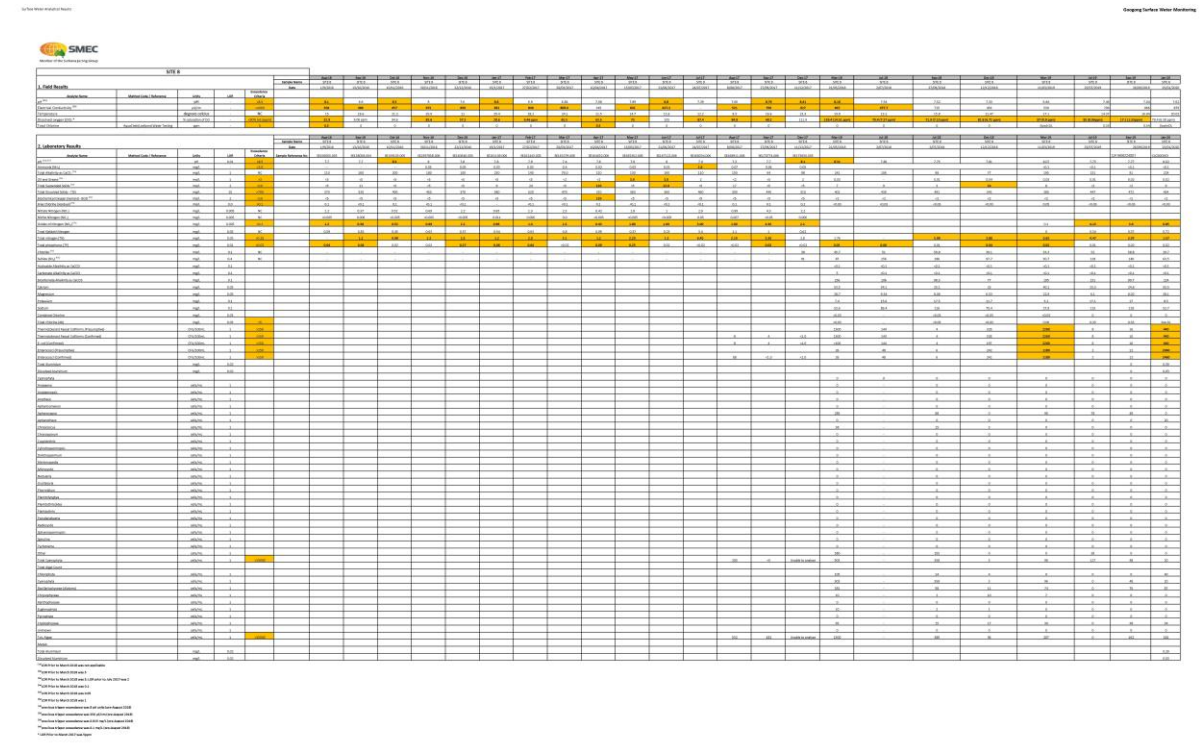


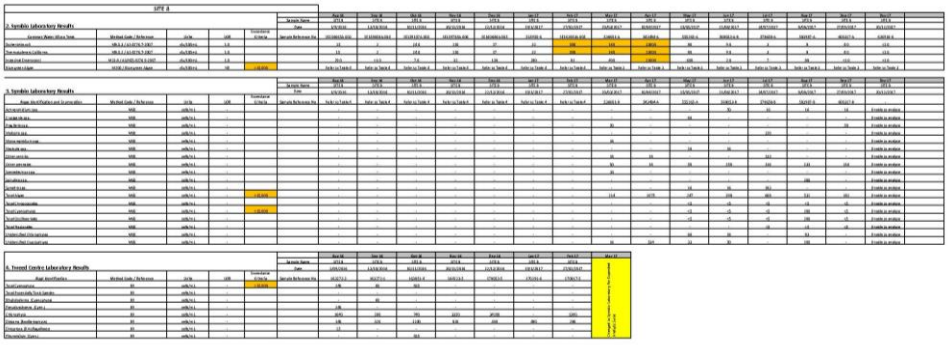


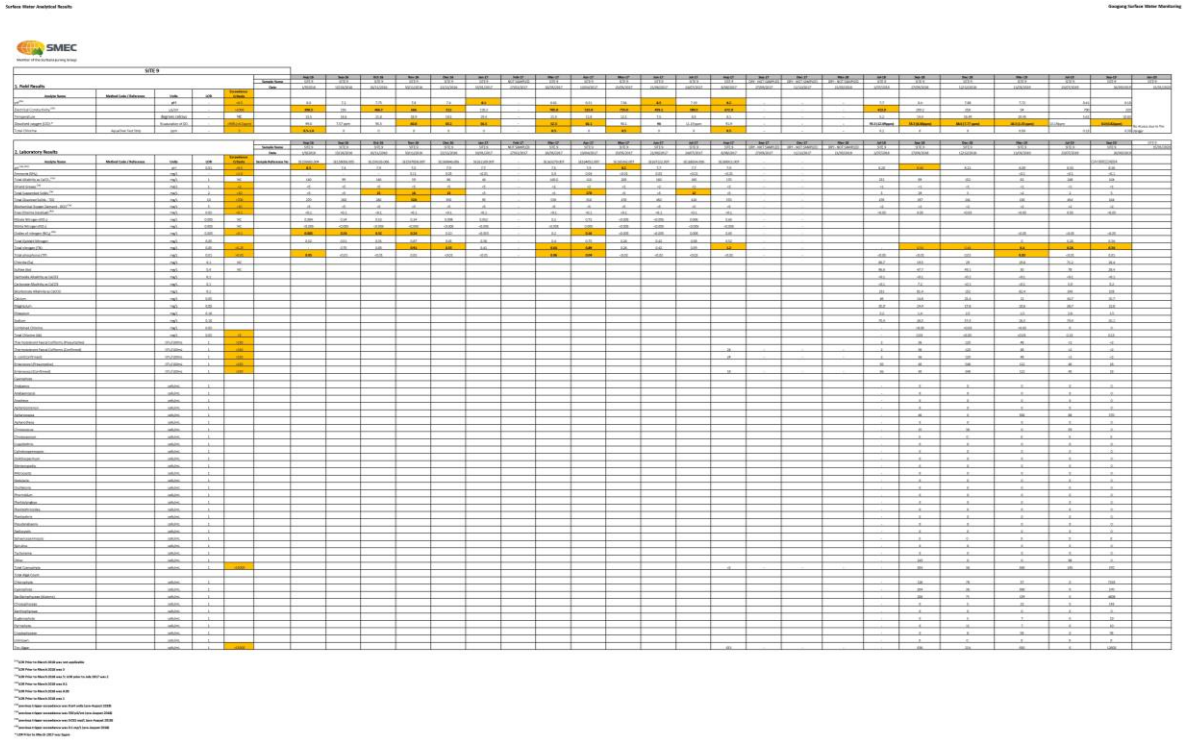


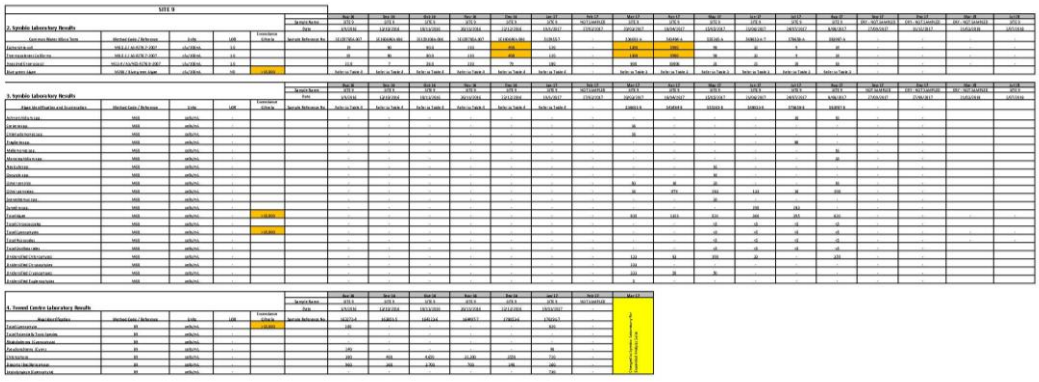


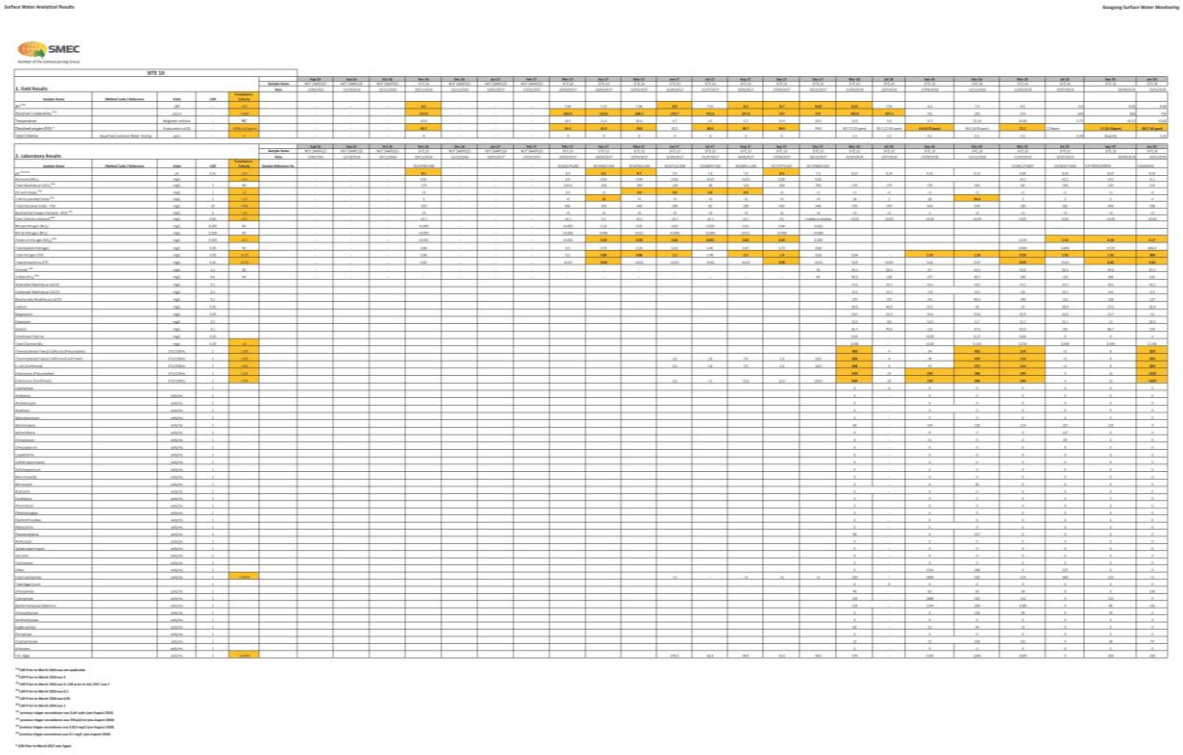


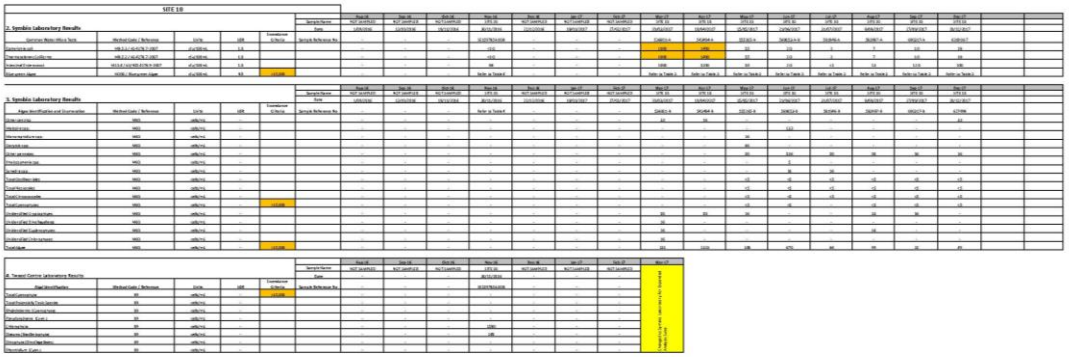












Surface Water Analytical Results

SMEC
Member of the Surbana Jurong Group

SITE 11														
1. Field Results					Sample Name	Dec-17 SITE 11	Mar-18 SITE 11	Jul-18 SITE 11	Sep-18 SITE 11	Dec-18 SITE 11	Mar-19 SITE 11	Jul-19 SITE 11	Sep-19 SITE 11	Jun-20 SITE 11
					Date	11/12/2017	21/03/2018	20/07/2018	27/09/2018	12/12/2018	11/03/2019	23/07/2019	26/09/2019	15/06/2020
Analyte Name	Method Code / Reference	Units	LOR	Exceedance Criteria										
pH[1][4]		pH	-	<6.5		**6.5**	7.02	7.5	7.79	7.1	7.1	7.9	7.86	7.83
Electrical Conductivity[2][3]		µS/cm	-	>1000		**698.0**	**626.0**	**377.7**	681	159	422	675	674	1057
Temperature		degrees celcius	-	NC		23.0	18.8	7.8	13.8	18.5	20.4	7.33	11.98	22.25
Dissolved oxygen (DO) *		% saturation of DO	-	<90% (<6.5ppm)		136.3	**56.7 (5.37 ppm)**	**73.7 (8.76ppm)**	**5.9 (5.63 ppm)**	**35.1 (1.72ppm)**	-	11 (1)ppm	**4.7 (0.47)ppm**	**59 (6.76 ppm)**
Total Chlorine[3][4]	AquaChek/Lovibond Water Testing	ppm	-	0			0	0	**0**	0	[low]<DL	0.25 low		0.97

2. Laboratory Results					Sample Name	Dec-17 SITE 11	Mar-18 SITE 11	Jul-18 SITE 11	Sep-18 SITE 11	Dec-18 SITE 11	Mar-19 SITE 11	Jul-19 SITE 11	Sep-19 SITE 11	Jun-20 SITE 11
					Date	11/12/2017	21/03/2018	20/07/2018	27/09/2018	12/12/2018	11/03/2019	23/07/2019	26/09/2019	15/06/2020
					Sample Reference No	SE177430-007							CA19085214001	CA19085-5
Analyte Name	Method Code / Reference	Units	LOR	Exceedance Criteria										
pH[1][4][5]		pH	0.01	<6.5		**6.1**	8.03	8.03	7.98	7.57	7.64	7.54	7.59	8.07
Ammonia (NH3)		mg/L		>2.0		0.06					<0.1	<0.1	<0.1	<0.1
Total Alkalinity as CaCO3 [3][4]		mg/L	1	NC		120	265	216	302	59	194	229	92	380
Oil and Grease[3][4]		mg/L	1	>2		<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Suspended Solids[3][4]		mg/L	2	>100		<5	3	3	5	**107**	6	4	5	6
Total Dissolved Solids - TDS		mg/L	10	>700		220	440	381	314	190	270	413	184	624
Biochemical Oxygen Demand - BOD[3][4]		mg/L	2	>10		<5	<2	<2	<2	2	<2	<2	<2	<2
Free Chlorine (residual)[3][4]		mg/L	0.03	>0.1		0.1	0.04	<0.03	<0.03	<0.03	0.09	<0.03	<0.03	<0.03
Nitrate Nitrogen (NO_3)		mg/L	0.005	NC		0.029								
Nitrite Nitrogen (NO_2)		mg/L	0.005	NC		<0.005								
Oxides of nitrogen (NO_x)[3][4]		mg/L	0.005	>0.1		0.059					0.1	**0.29**	0.14	<0.05
Total Kjeldahl Nitrogen		mg/L	0.05	NC		0.05					0	0.27	0.48	0.61
Total nitrogen (TN)[3][4]		mg/L	0.05	>0.25		**0.88**	**0.56**	-	**0.95**	**1.36**	**0.68**	**0.5**	**0.63**	**0.61**
Total phosphorus (TP)		mg/L	0.01	>0.02		<0.02	0.02	<0.05	0.02	**0.14**	**0.08**	0.01	**0.03**	**0.06**
Chloride[3][4]		mg/L	0.10	NC		20	37.3	45.2	20.2	16.5	34.2	49.2	23.9	49.6
Turbidity[3][4]		mg/L	0.4	NC		47	72.9	77.1	55.6	32.2	51.6	88.6	36.2	62.6
Inorganic Alkalinity as CaCO3		mg/L	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Carbonate Alkalinity as CaCO3		mg/L	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bicarbonate Alkalinity as CaCO3		mg/L	0.1				265	216	302	58.8	194	229	92.4	380
Calcium		mg/L	0.05				59.3	56.3	42.5	13.8	40.6	54.1	23.1	85.4
Magnesium		mg/L	0.05				35.8	33.7	35.1	7.73	22.3	35.9	16	60.8
Potassium		mg/L	0.1				3.3	3.6	3.5	2.6	3.4	3.2	1.7	3.1
Sodium		mg/L	0.1				39.6	35.2	28.2	11.8	29.9	40.8	14.7	65.5
Combined Chlorine		mg/L	0.03				<0.03	-	<0.03	<0.03	<0.03	0	0	0
Total Chlorine[3][4]		mg/L	0.03	>5			0.04	-	<0.03	<0.03	0.1	0.25	0.25	0.93
Thermotolerant Faecal Coliforms [Presumptive]		CFU/100mL	1	>150			8	2	<2	**300**	**170**	40	66	13
Thermotolerant Faecal Coliforms [Confirmed]		CFU/100mL	1	>150		<1.0	8	2	<2	**300**	**170**	40	66	22
E. coli [Confirmed]		CFU/100mL	1	>150		<1.0	6	2	<2	**120**	**170**	40	51	22
Enterococci [Presumptive]		CFU/100mL	1	>150			4	4	2	**420**	98	78	218	66
Enterococci [Confirmed]		CFU/100mL	1	>150		<1.0	4	4	2	**420**	98	78	218	66
Total Aluminium		CFU/100mL	0.02										0	0.14
Dissolved Aluminium		CFU/100mL	0.02										0	0.03
Cyanophyta														
Anabaena		cells/mL	1				0		0	0	0	0	0	0
Anabaenopsis		cells/mL	1				0		0	0	0	0	0	0
Arathron		cells/mL	1				0		0	0	0	0	0	0
Aphanizomenon		cells/mL	1				0		0	0	0	0	0	0
Aphanocapsa		cells/mL	1				11368		58	0	76	154	113	0
Aphanothece		cells/mL	1				186		0	0	0	0	0	0
Chroococcus		cells/mL	1				11995		15	0	0	0	0	0
Chroococcum		cells/mL	1				0		0	0	0	0	0	0
Coelosphrium		cells/mL	1				0		0	0	0	0	0	0
Cylindrospermopsis		cells/mL	1				0		0	0	0	0	0	0
Dactylococcopsis		cells/mL	1				0		0	0	0	0	0	0
Merismopedia		cells/mL	1				0		0	0	0	0	0	0
Microcystis		cells/mL	1				0		0	0	0	0	0	0
Nostocale		cells/mL	1				0		0	0	0	0	0	0
Oscillatoria		cells/mL	1				0		0	0	0	0	0	0
Pharmidium		cells/mL	1				118		0	0	0	0	0	0

Surface Water Analytical Results

Googong Surface Water Monitoring

Planktolyngbya		cells/mL	1				0	-	0	0	0	0	0	0
Planktothricoides		cells/mL	1				0	-	0	0	0	0	0	0
Planktothrix		cells/mL	1				0	-	0	0	0	0	0	0
Pseudanabaena		cells/mL	1				0	-	0	0	0	0	0	0
Radiocystis		cells/mL	1				0	-	0	0	0	0	0	0
Sphaerospermopsis		cells/mL	1				0	-	0	0	0	0	0	0
Tetrafilia		cells/mL	1				0	-	0	0	0	0	0	0
Trichormus		cells/mL	1				0	-	0	0	0	0	0	0
Other		cells/mL	1				1013	-	321	0	61	240	0	0
Total Cyanophyta		cells/mL	1	**>15,000**		Unable to analyse	25560	-	394	<1	137	394	115	<1
Total Algal Count														
Chlorophyta		cells/mL	1				164	-	0	29	0	0	0	38
Cyanophyta		cells/mL	1				25481	-	394	0	137	0	115	0
Bacillariophyceae (diatoms)		cells/mL	1				165	-	95	19	60	0	58	134
Chrysophyceae		cells/mL	1				28	-	0	0	0	0	23	0
Xanthophyceae		cells/mL	1				0	-	0	0	0	0	0	0
Euglenophyta		cells/mL	1				28	-	18	10	0	0	0	48
Pyrrophyta		cells/mL	1				0	-	0	0	0	0	0	0
Cryptophyceae		cells/mL	1				167	-	1519	28	22	0	23	54
Unknown		cells/mL	1				0	-	0	0	0	0	0	0
Tot. Algae		cells/mL	1	**>15000**		Unable to analyse	26281	-	2046	91	219	0	230	275
Metals														
Total Aluminium		mg/L	0.02											0.13
Dissolved Aluminium		mg/L	0.02											0.03

[1][4] **LOR Prior to March 2018 was not applicable**
[2][4] **LOR Prior to March 2018 was 5**
[3][4] **LOR Prior to March 2018 was 0.1**
[4][5] **LOR Prior to March 2018 was 0.05**
[5][4] **LOR Prior to March 2018 was 1**
[1][5] **previous trigger exceedance was 8 pH units (pre-August 2018)**
[2][5] **previous trigger exceedance was 350 µS/cm (pre-August 2018)**
[3][5] **previous trigger exceedance was 0.1 mg/L (pre-August 2018)**
[4][5] **Lowest reported trigger exceedance for SITE 11 - closest site to SITE 11**
*** LOR Prior to March 2017 was 5ppm**

2. Symbio Laboratory Results					Sample Name	Dec-17 SITE 11	Mar-18 SITE 11	Jul-18 SITE 11	Sep-18 SITE 11
Cawthron Water Mixin Tests					Date	20/12/2017	21/03/2018	2/07/2018	27/09/2018
					Sample Reference No	E20710-4			
Analyte Name	Method Code / Reference	Units	LOR	Exceedance Criteria					
Euchwhite 108	M8.9.3 / AS 4276.7:2007	cfu/100mL	1.0			<1.0			
Thermotolerant Coliforms	M9.9.2 / AS 4276.7:2007	cfu/100mL	1.0			<1.0			
Intestinal Enterococci	M10.4 / AS/NZS 4276.9:2007	cfu/100mL	1.0			<1.0			
Blue-green Algae	M200 / Blue-green Algae	cfu/100mL	NC	**>15,000**		Refer to Table 2			
Total Cyanophyta		cells/mL	1.0	**>15,000**		25593.0	-	394.0	
Tot. Algae		cells/mL	1	**>15,000**		26281	-	2046	

3. Symbio Laboratory Results					Sample Name	Dec-17 SITE 11		
					Date	20/12/2017		
Algae Identification and Enumeration	Method Code / Reference	Units	LOR	Exceedance Criteria	Sample Reference No	-		
Other centrics	M40	cells/mL	-			Unable to analyse		
Aulacoseira spp.	M42	cells/mL	-			Unable to analyse		
Minor achnanthes spp.	M43	cells/mL	-			Unable to analyse		
Cocconeis spp.	M49	cells/mL	-			Unable to analyse		
Other pennates	M49	cells/mL	-			Unable to analyse		
Rhoicosphenia spp.	M49	cells/mL	-			Unable to analyse		
Synedra spp.	M49	cells/mL	-			Unable to analyse		
Total Coscinodiscales	M42	cells/mL	-			Unable to analyse		
Total Nostocales	M43	cells/mL	-			Unable to analyse		
Total Chroococcales	M49	cells/mL	-			Unable to analyse		
Total Cyanophytes	M49	cells/mL	-	**>15,000**		Unable to analyse		
Unidentified Cryptophytes	M49	cells/mL	-			Unable to analyse		
Unidentified Chrysophytes	M49	cells/mL	-			Unable to analyse		
Unidentified Euglenophytes	M42	cells/mL	-			Unable to analyse		
Unidentified Chlorophytes	M43	cells/mL	-			Unable to analyse		
Total Algae	M49	cells/mL	-	**>15,000**		Unable to analyse		

Note: Started sampling as of December 2017

APPENDIX B: Surface Water Time Series and Piper Plots

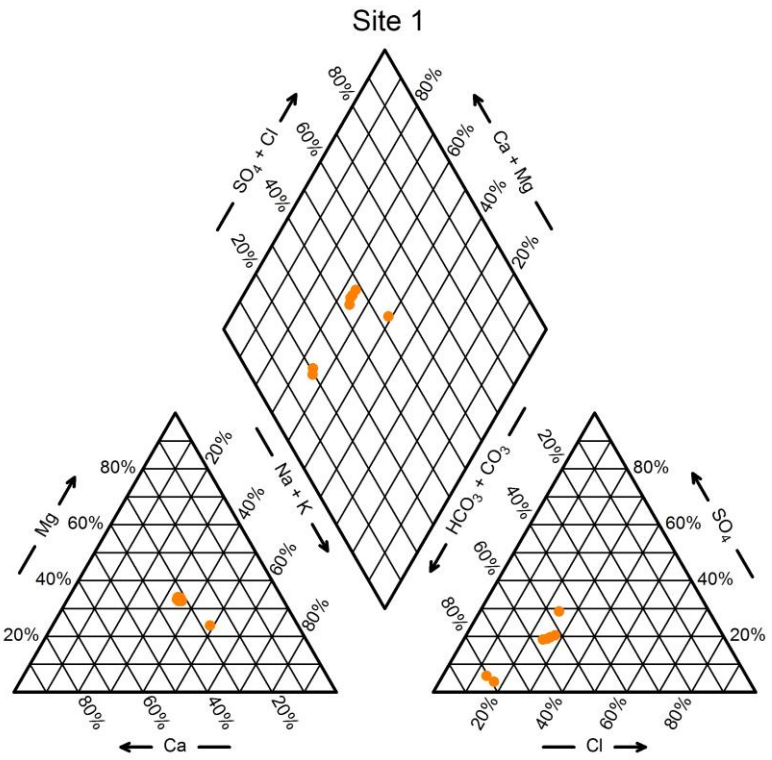


Figure B1: Piper diagram plot of Site 1 monitoring rounds

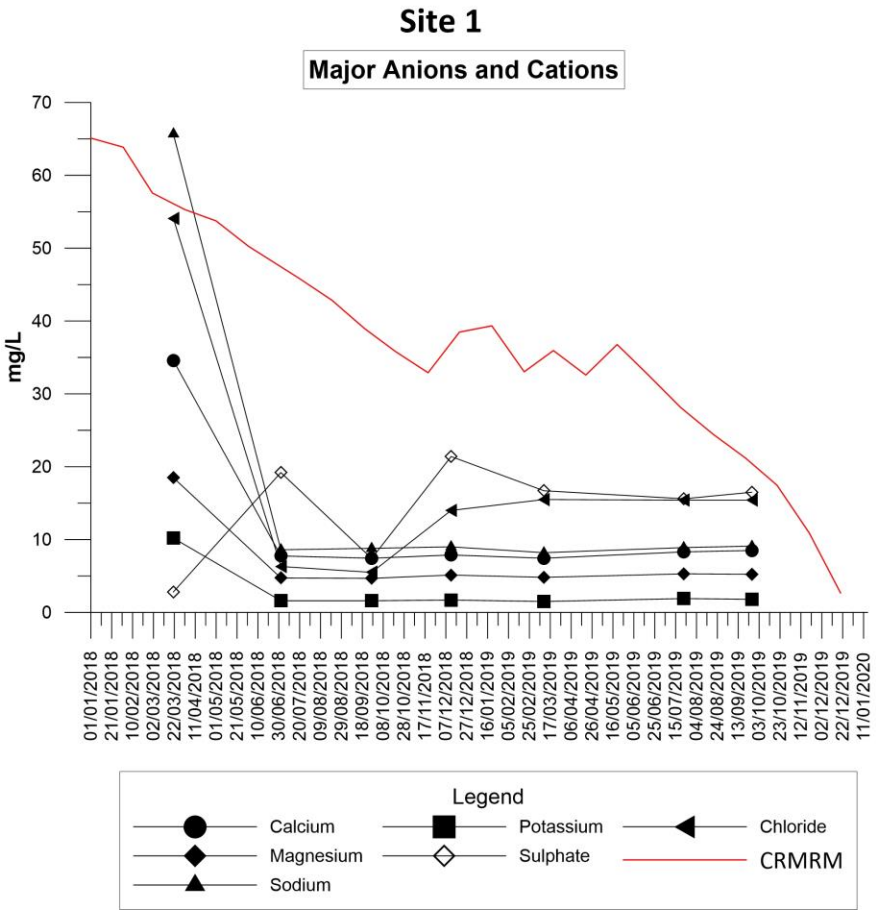


Figure B2: Time series plot of major ions at Site 1

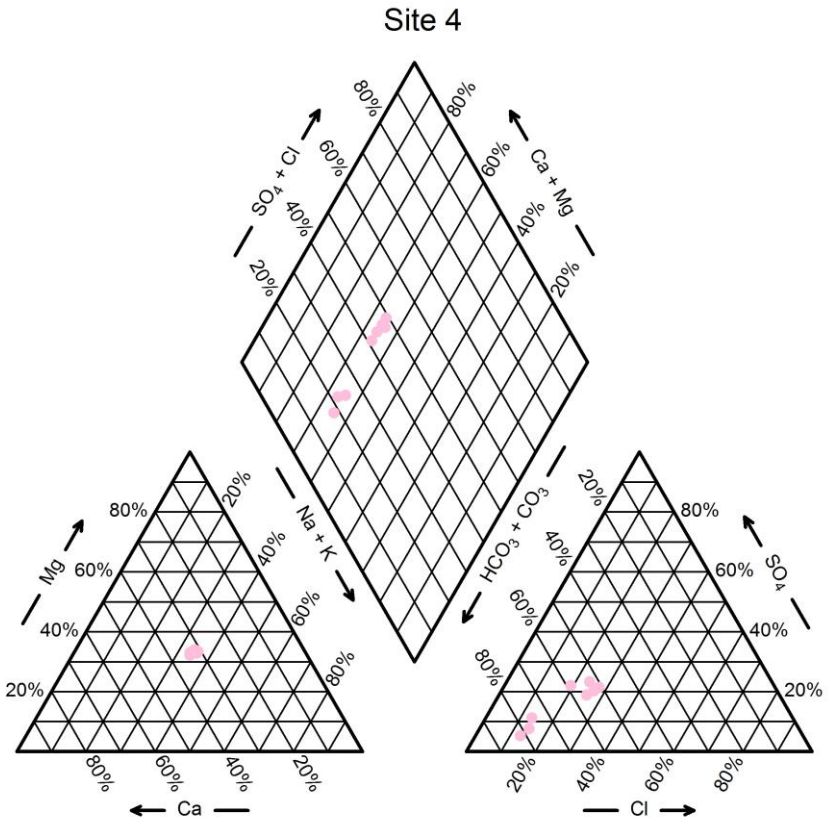


Figure B3: Piper diagram plot of Site 4 monitoring rounds

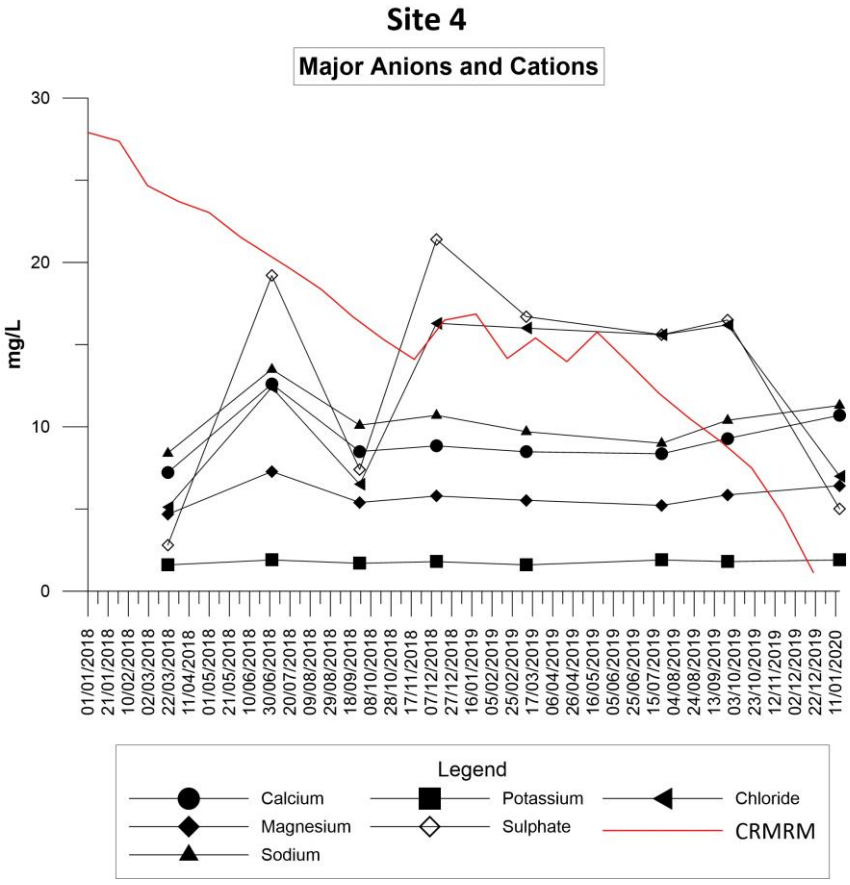


Figure B4: Time series plot of major ions at Site 4

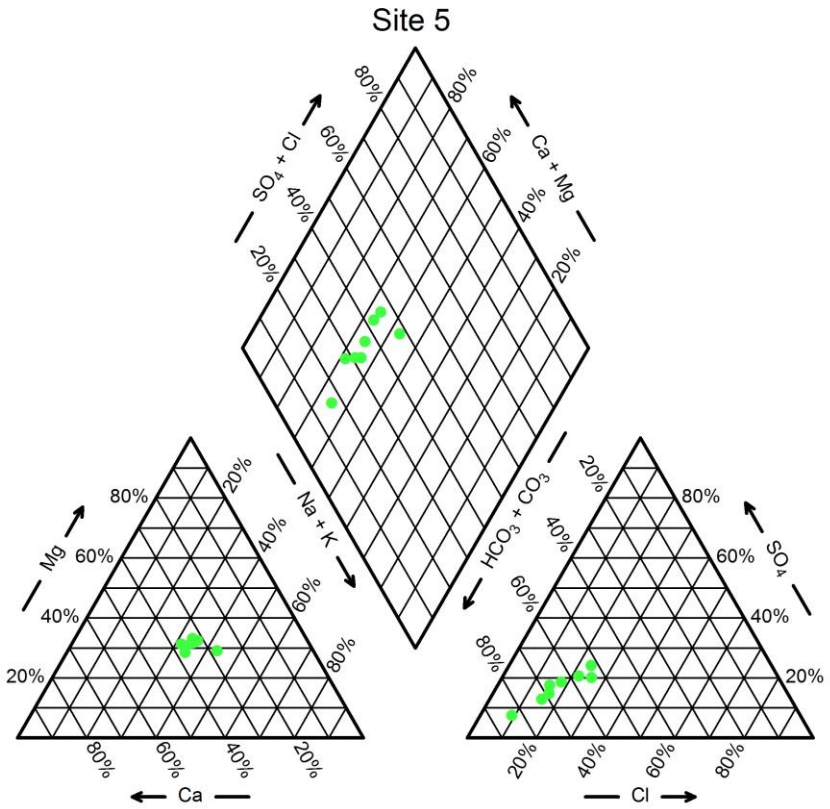


Figure B5: Piper diagram plot of Site 5 monitoring rounds

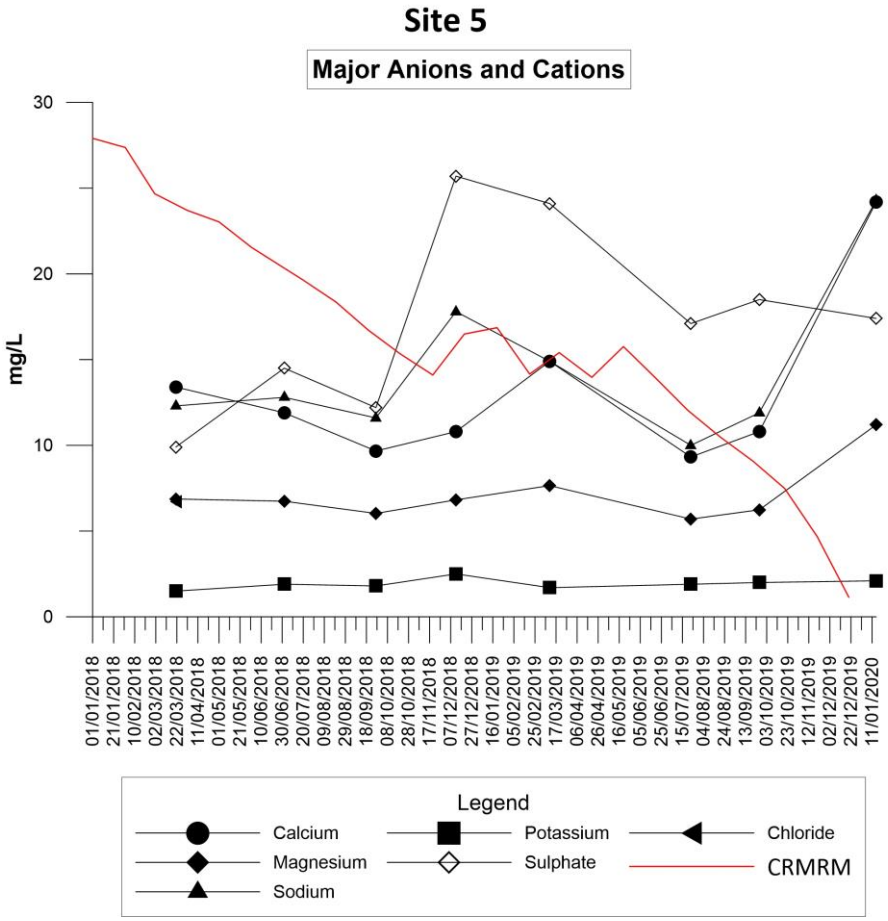


Figure B6: Time series plot of major ions at Site 5

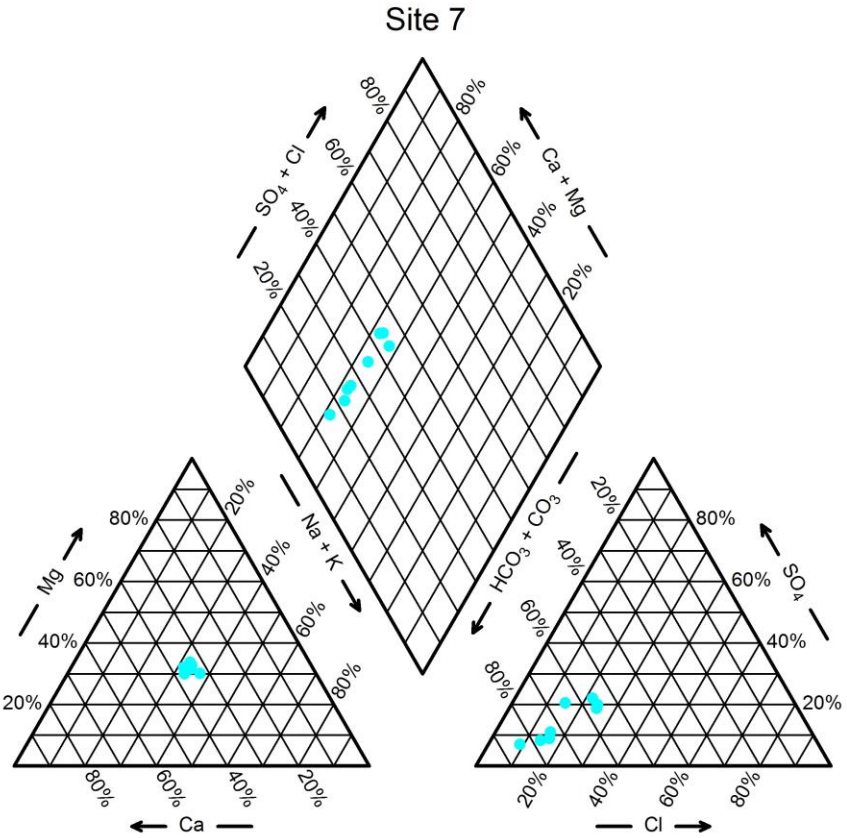


Figure B7: Piper diagram plot of Site 7 monitoring rounds

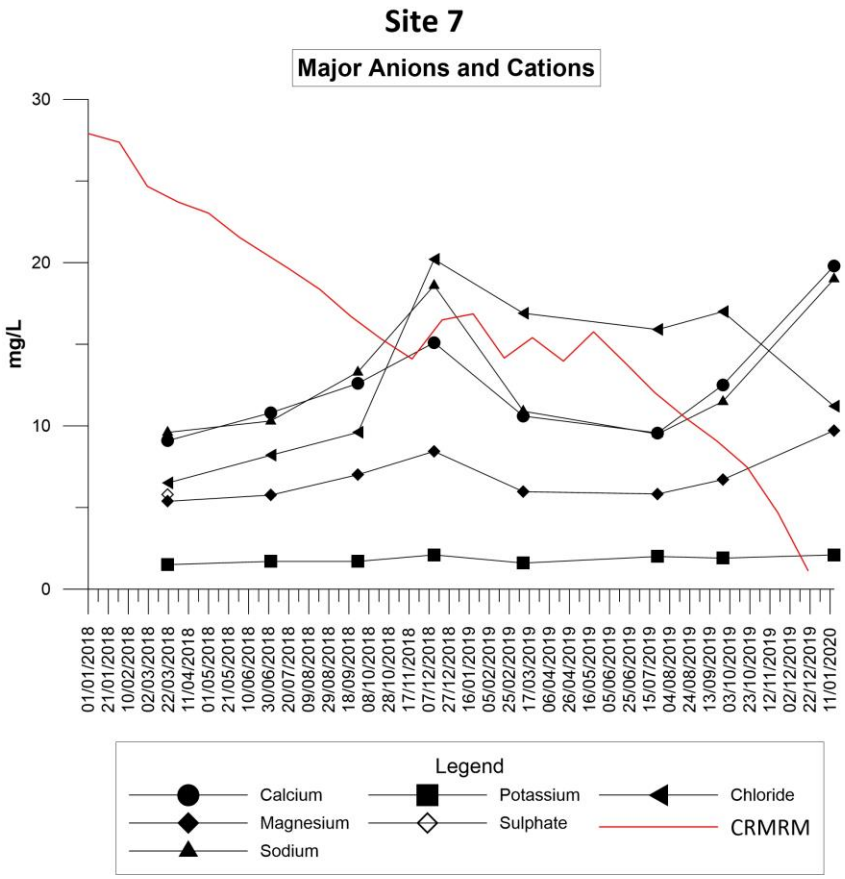


Figure B8: Time series plot of major ions at Site 7

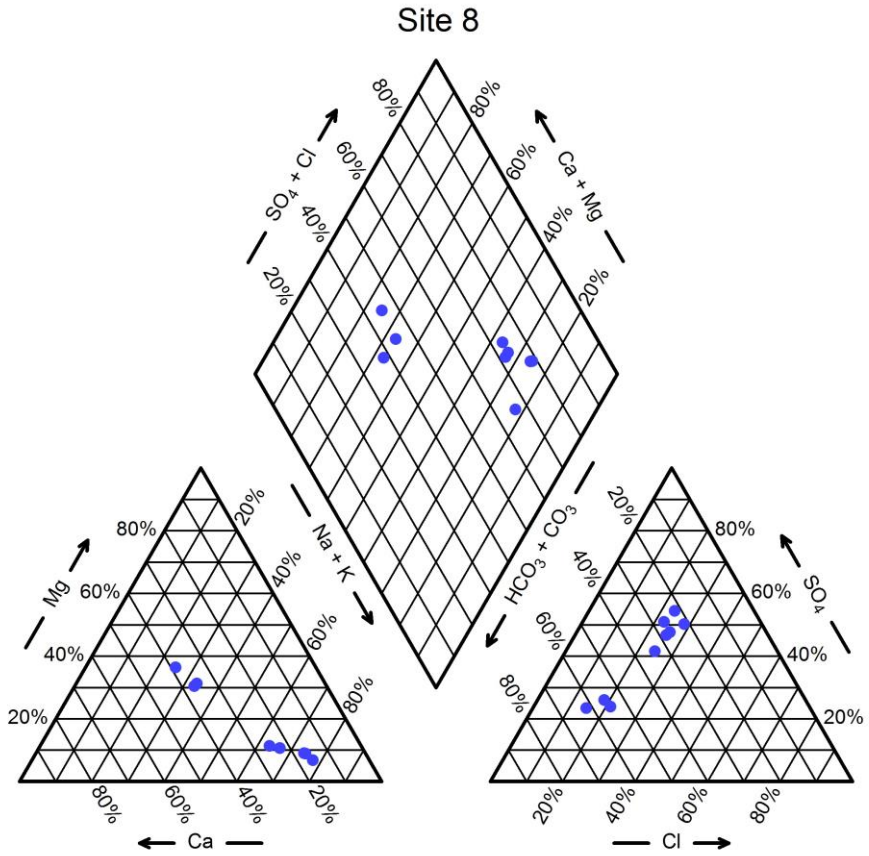


Figure B9: Piper diagram plot of Site 8 monitoring rounds

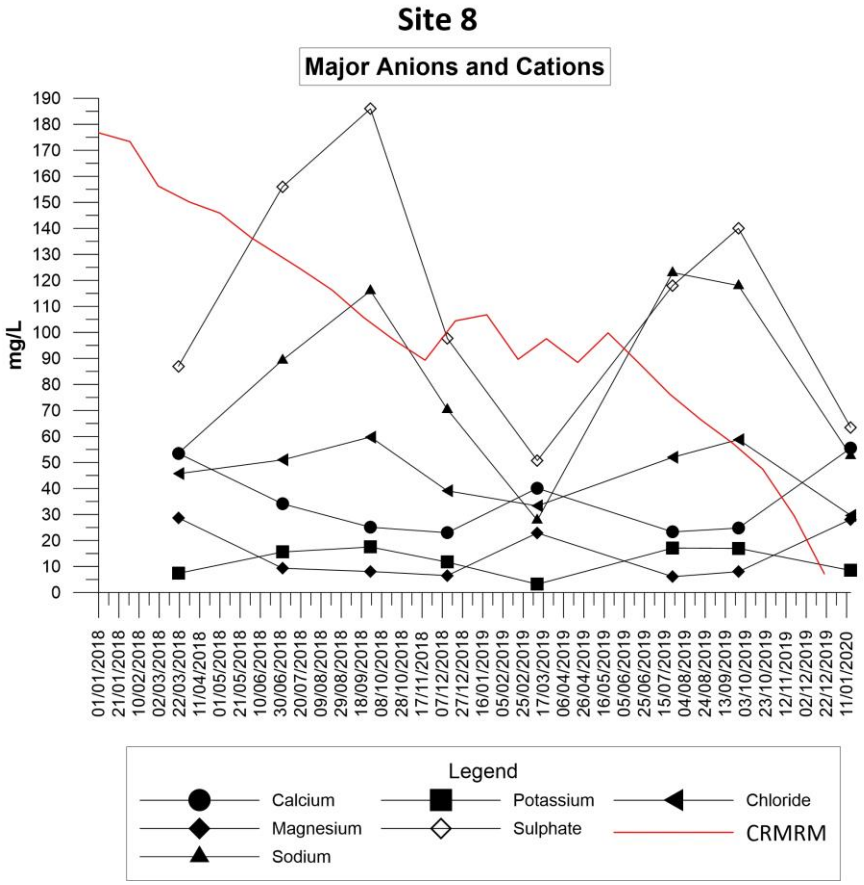


Figure B10: Time series plot of major ions at Site 8

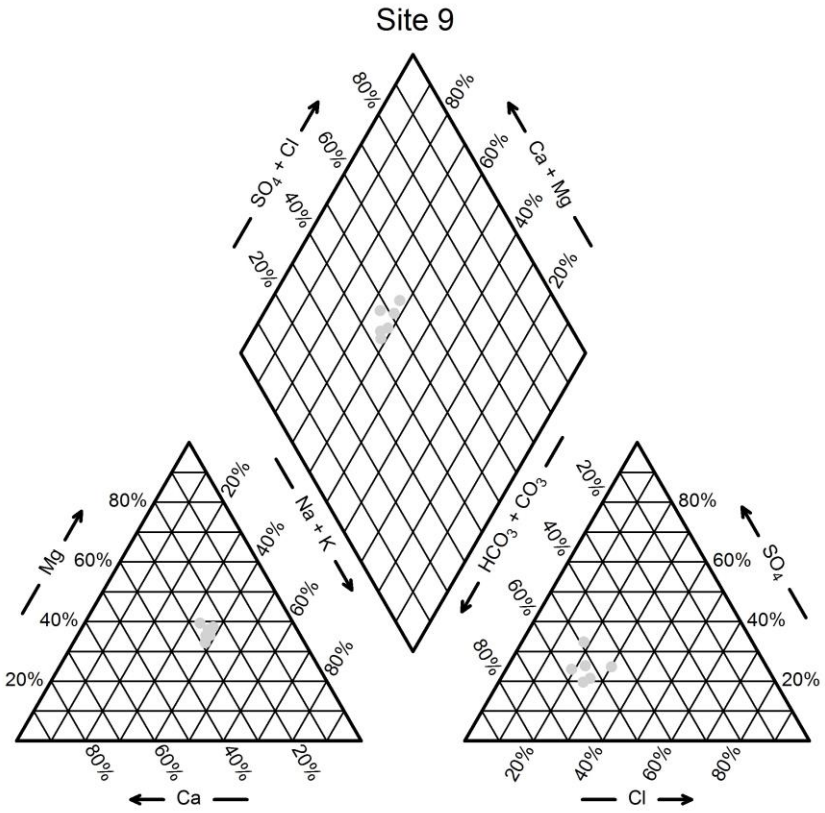


Figure B11: Piper diagram plot of Site 9 monitoring rounds

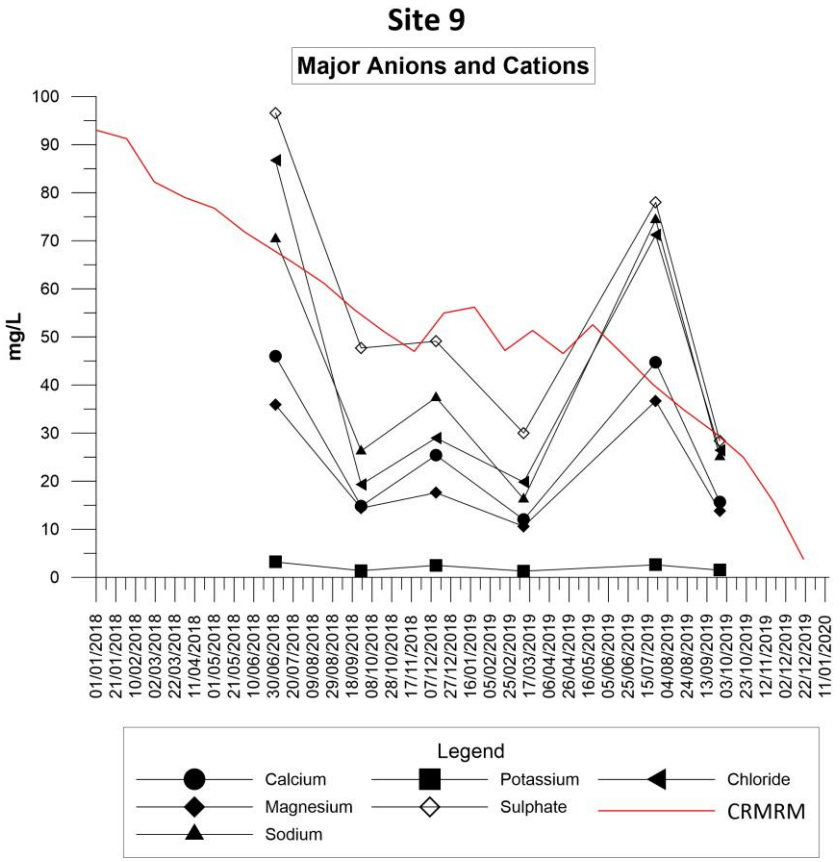


Figure B12: Time series plot of major ions at Site 9

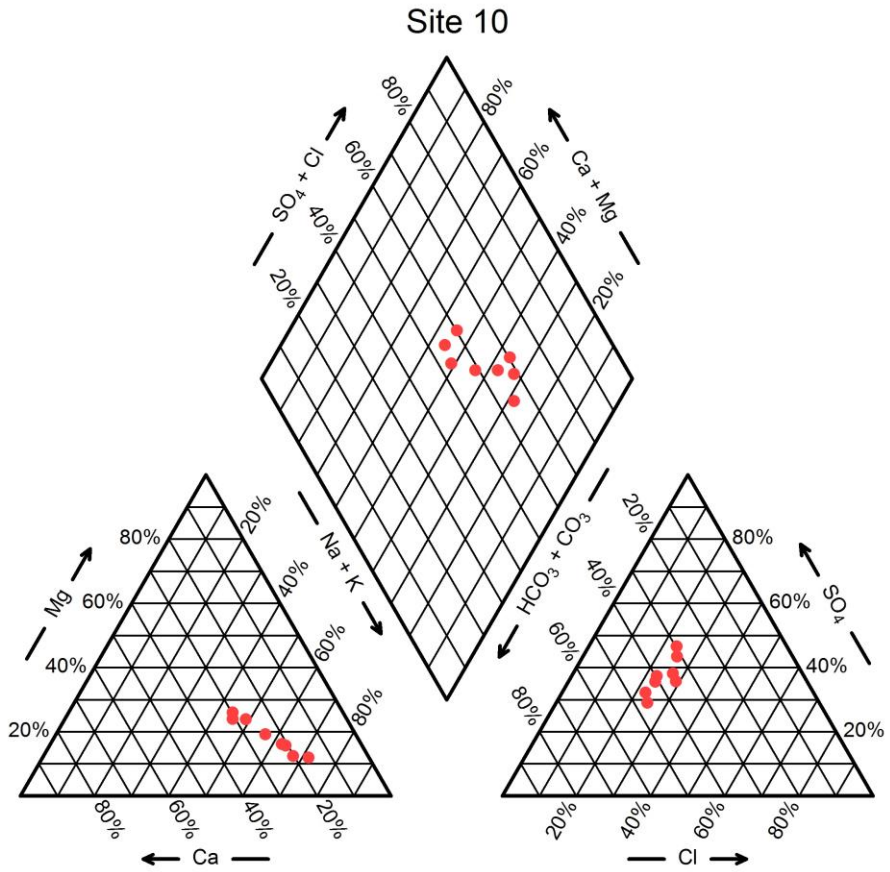


Figure B13: Piper diagram plot of Site 10 monitoring rounds

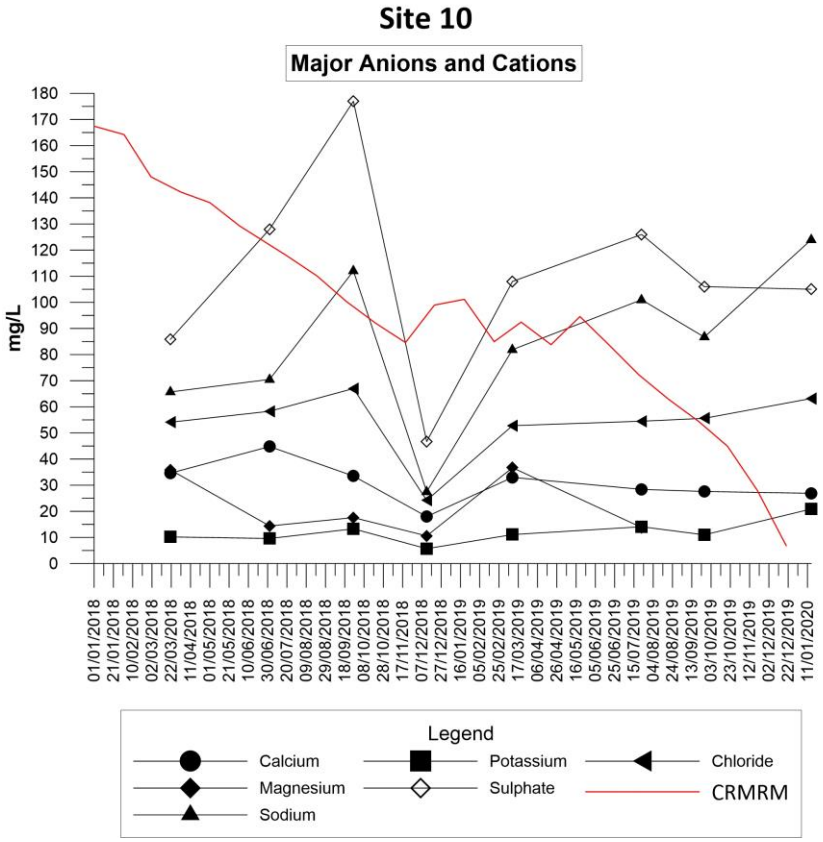


Figure B14: Time series plot of major ions at Site 10

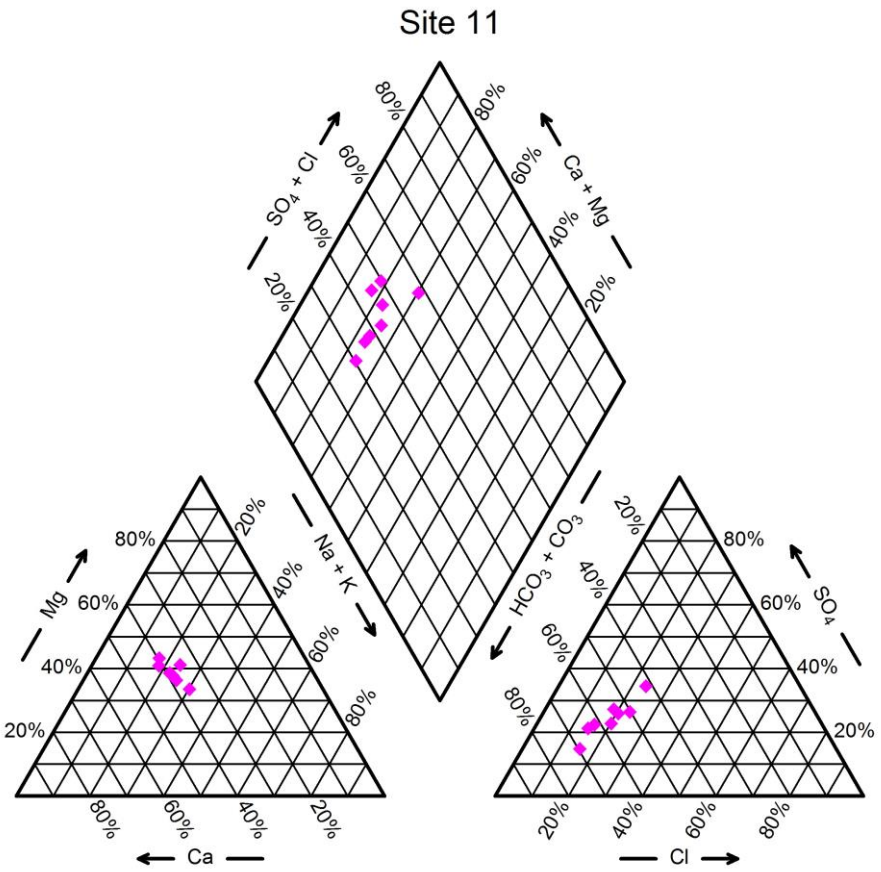


Figure B15: Piper diagram plot of Site 11 monitoring rounds

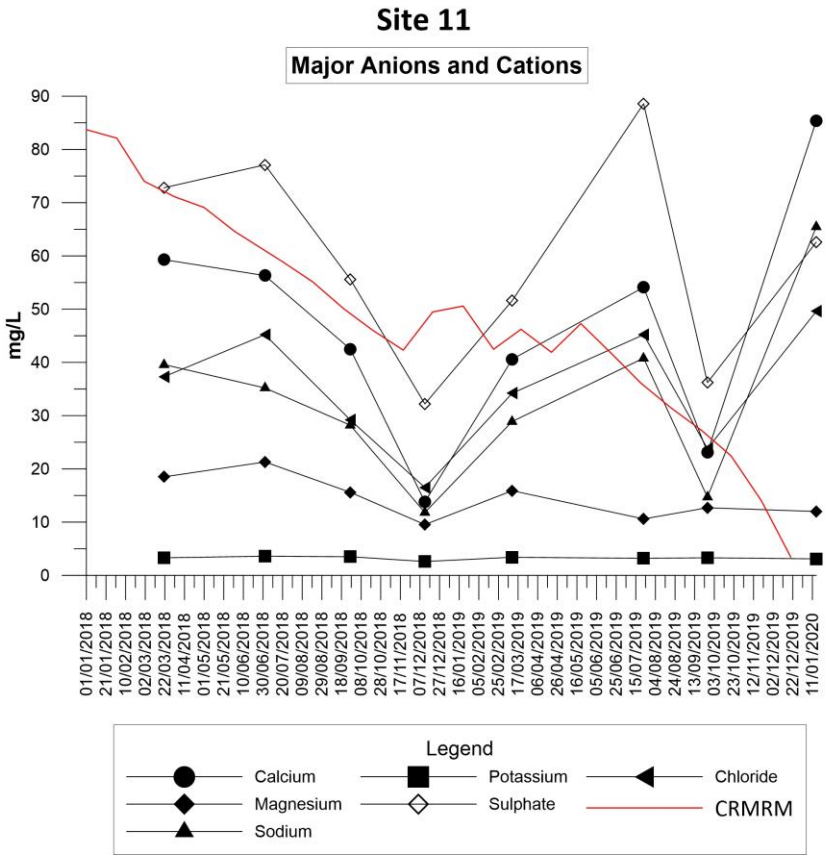


Figure B16: Time series plot of major ions at Site 11

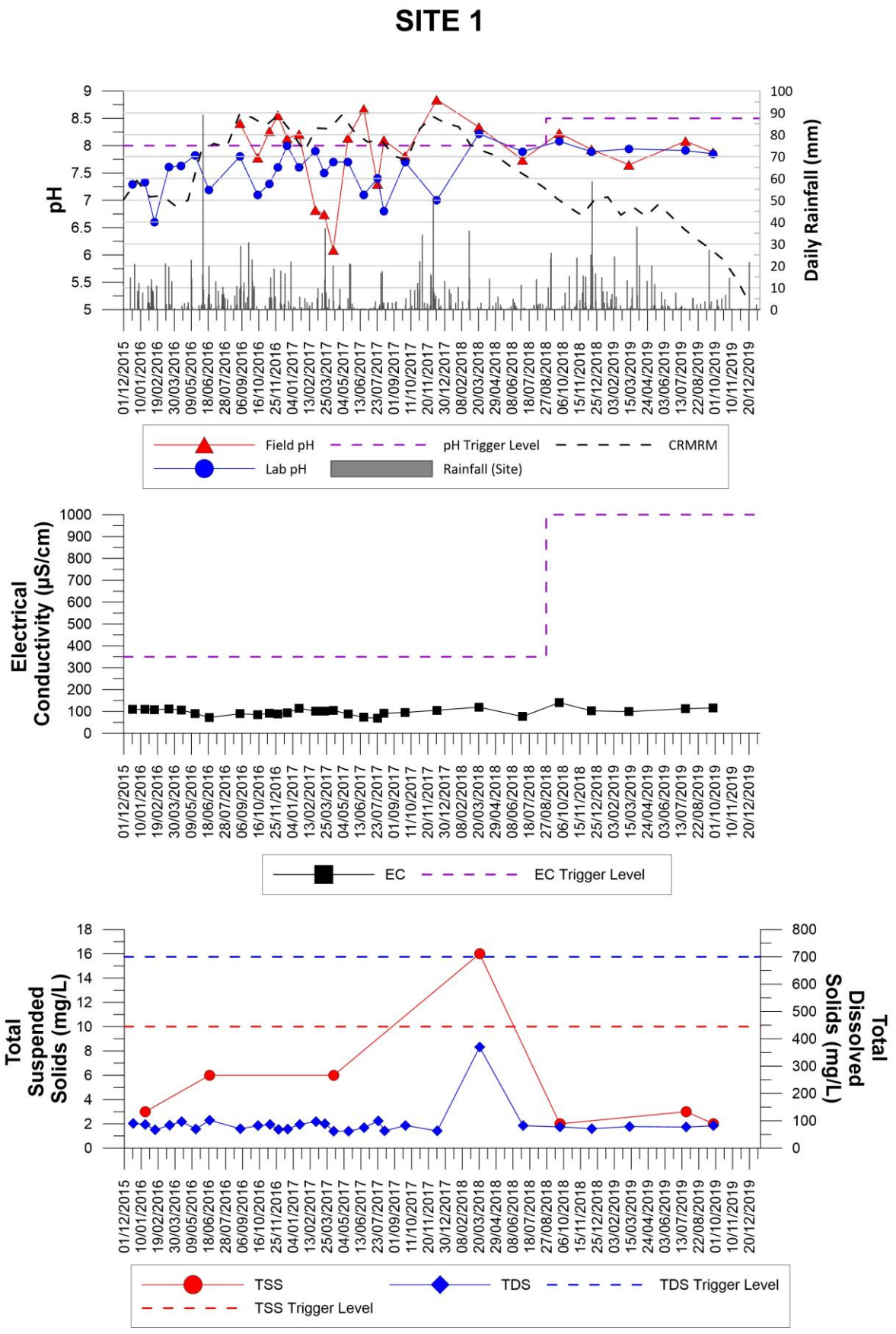


Figure B17: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 1 with rainfall and cumulative residual rainfall mass (CRMRM)

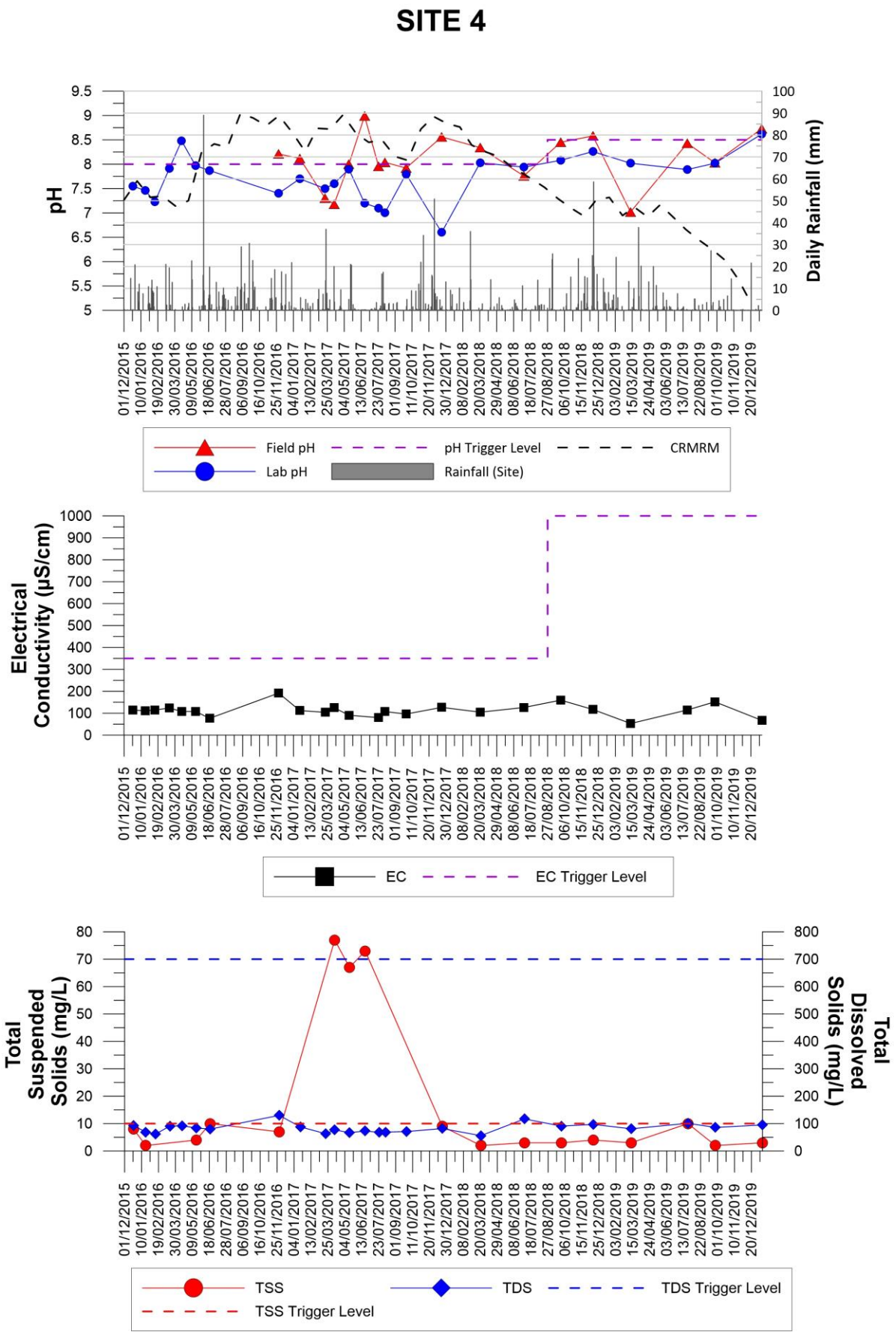


Figure B18: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 4 with rainfall and cumulative residual rainfall mass (CRMRM)

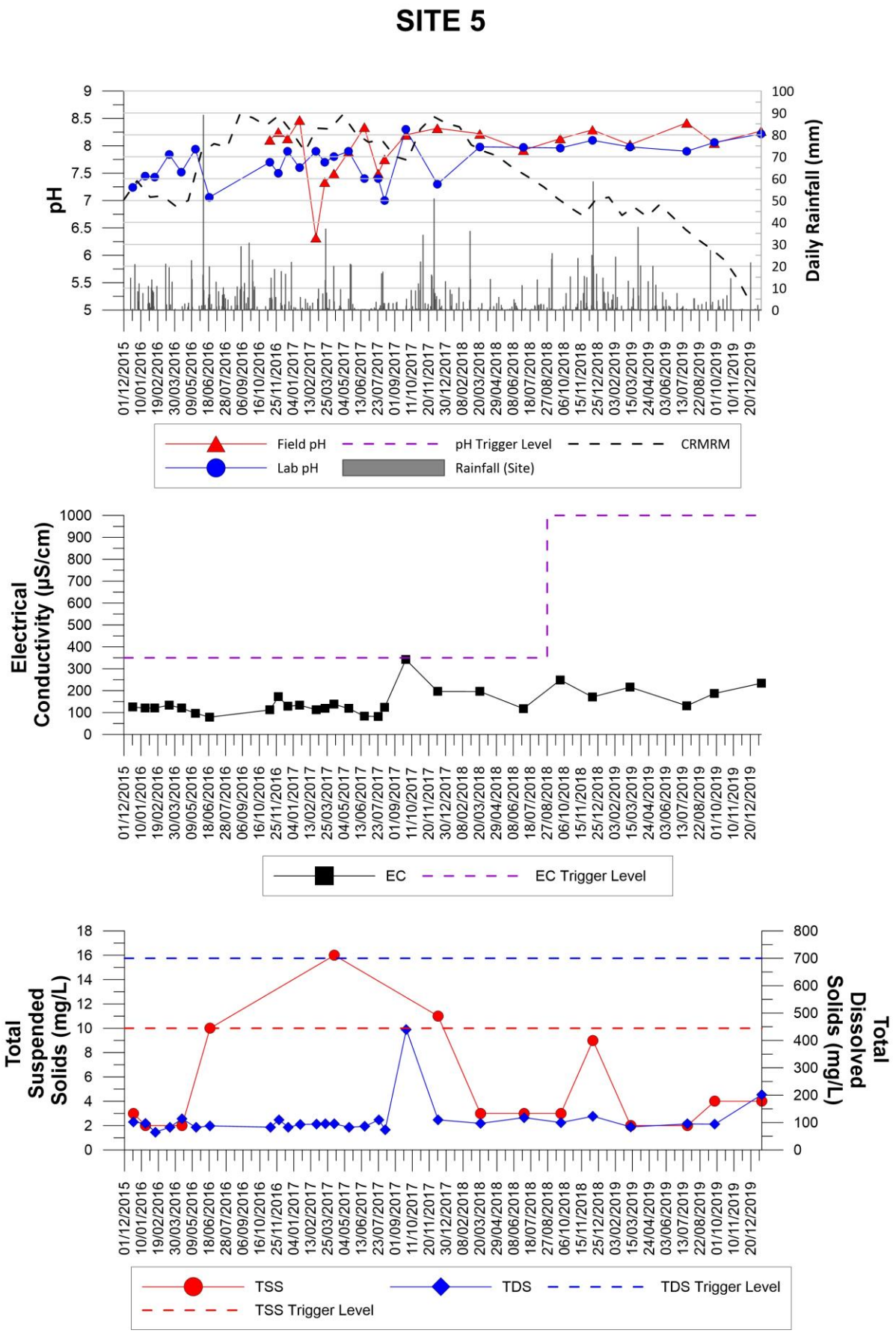


Figure B19: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 5 with rainfall and cumulative residual rainfall mass (CRMRM)

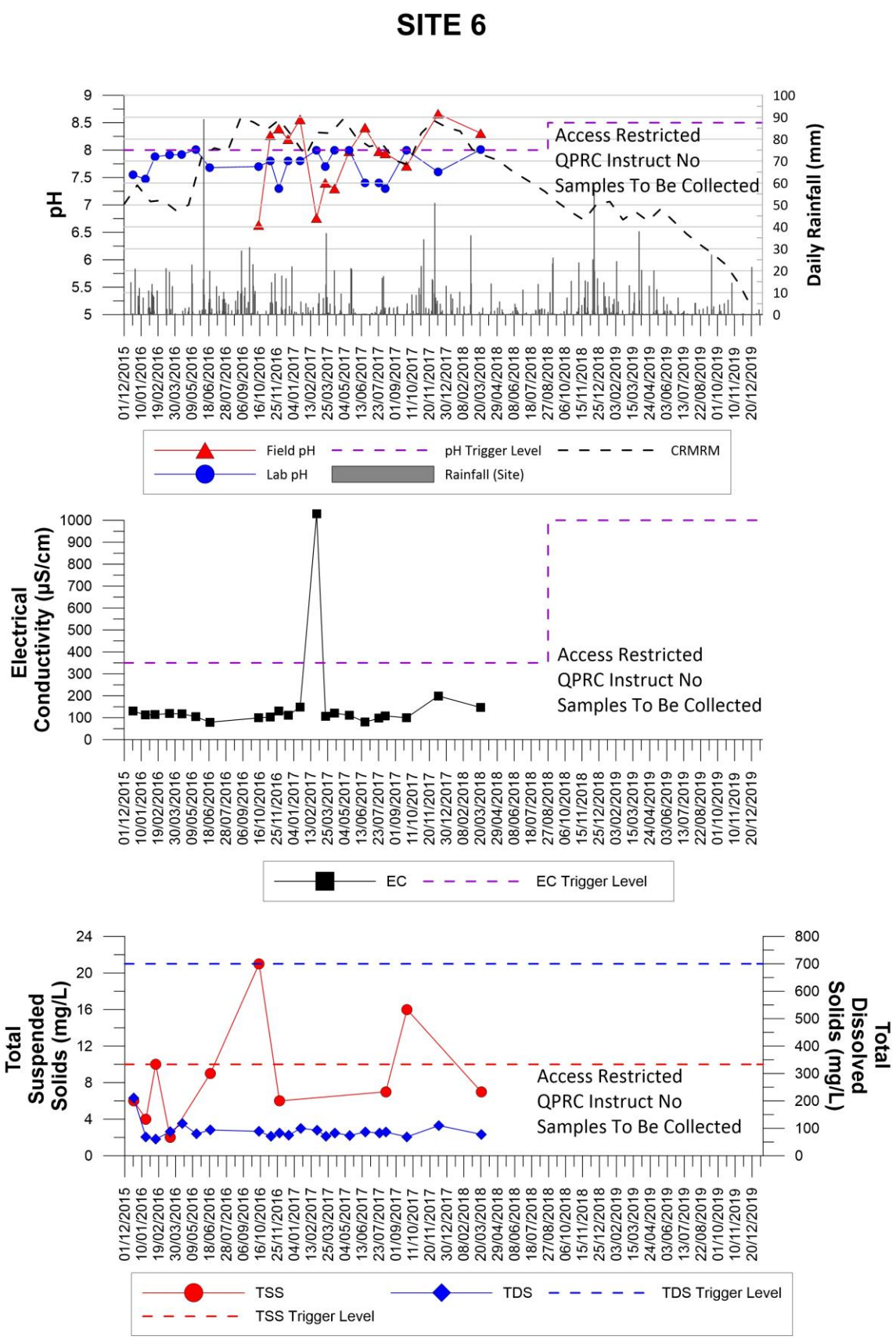


Figure B20: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 6 with rainfall and cumulative residual rainfall mass (CRMRM)

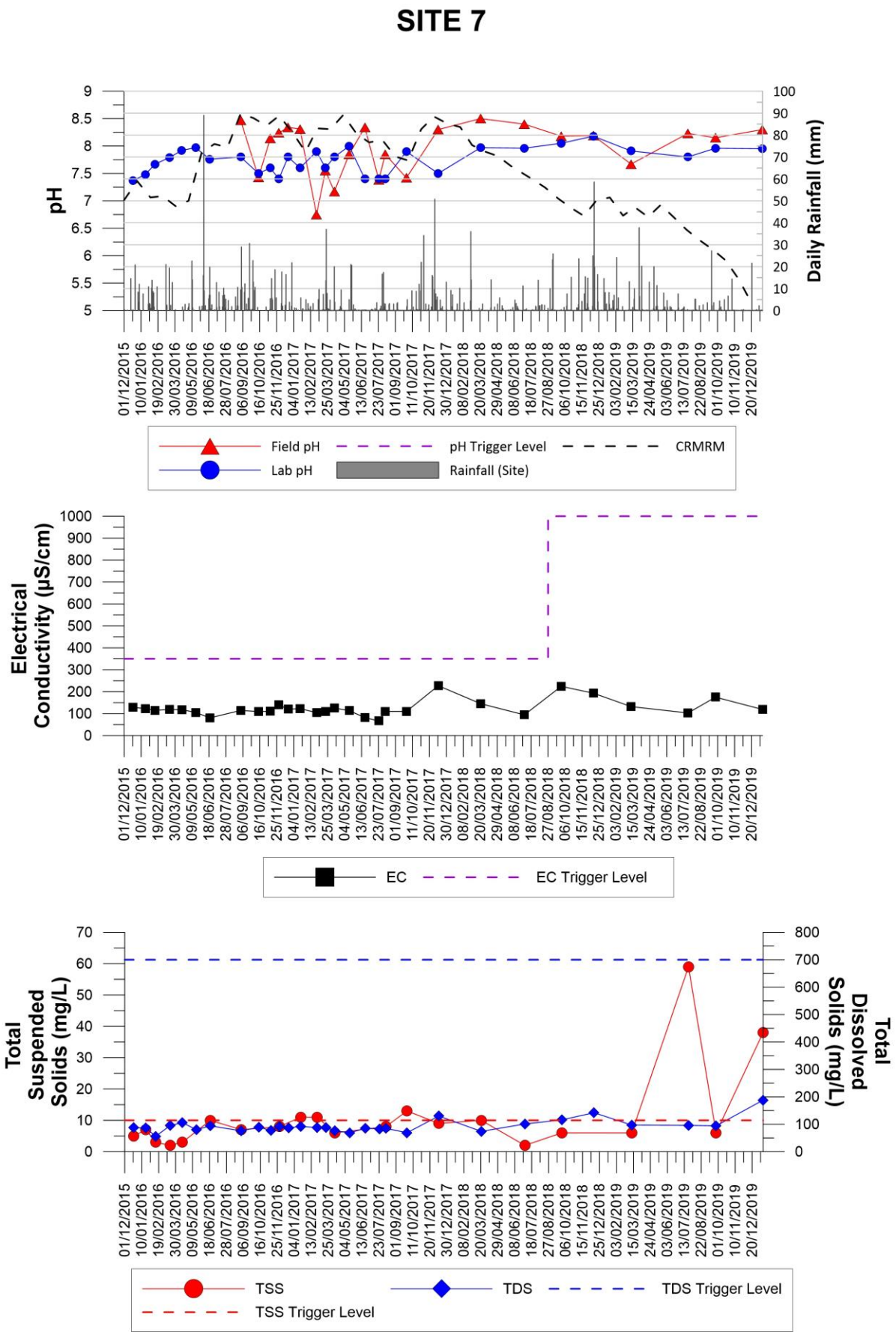


Figure B21: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 7 with rainfall and cumulative residual rainfall mass (CRMRM)

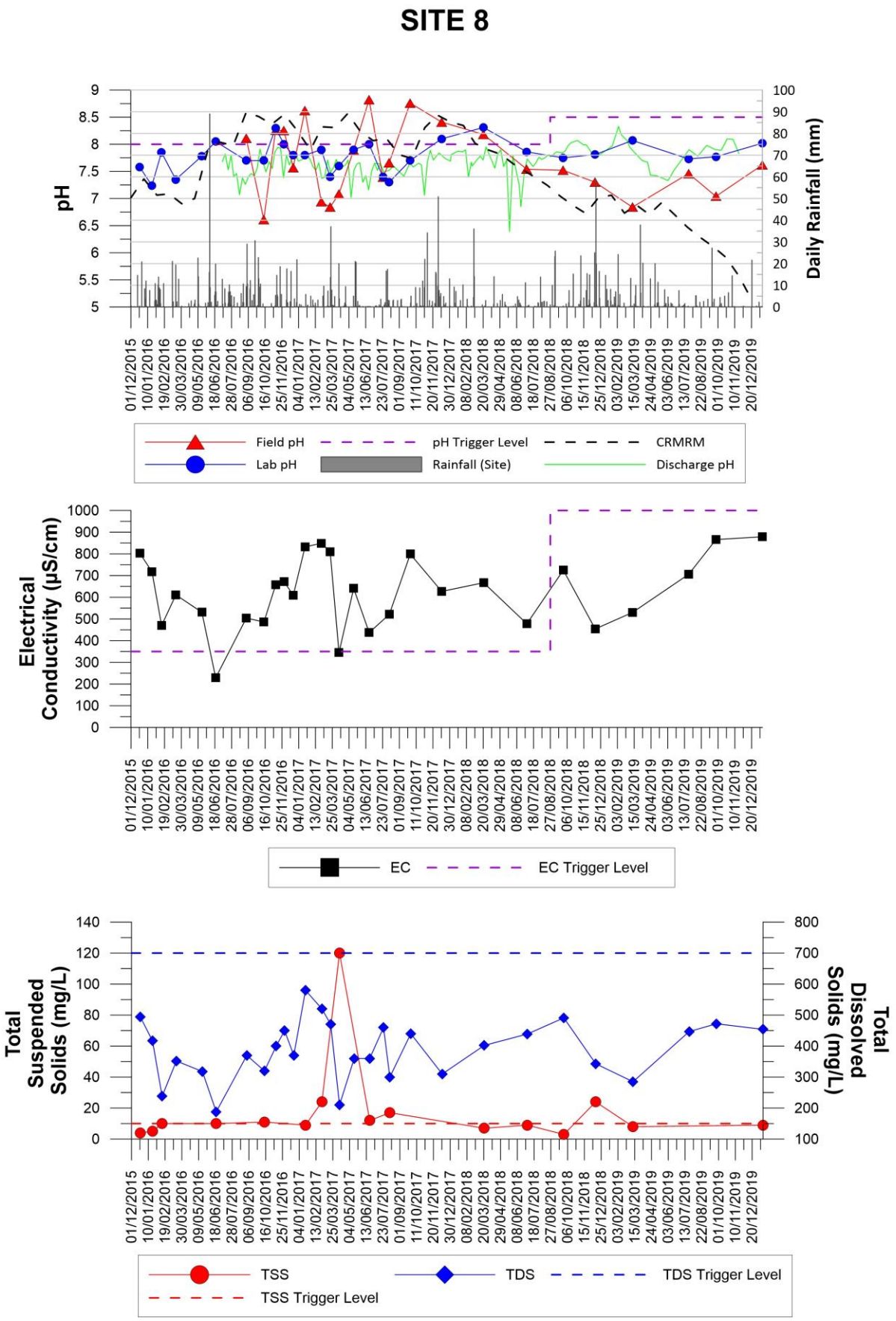


Figure B22: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 8 with rainfall and cumulative residual rainfall mass (CRMRM)

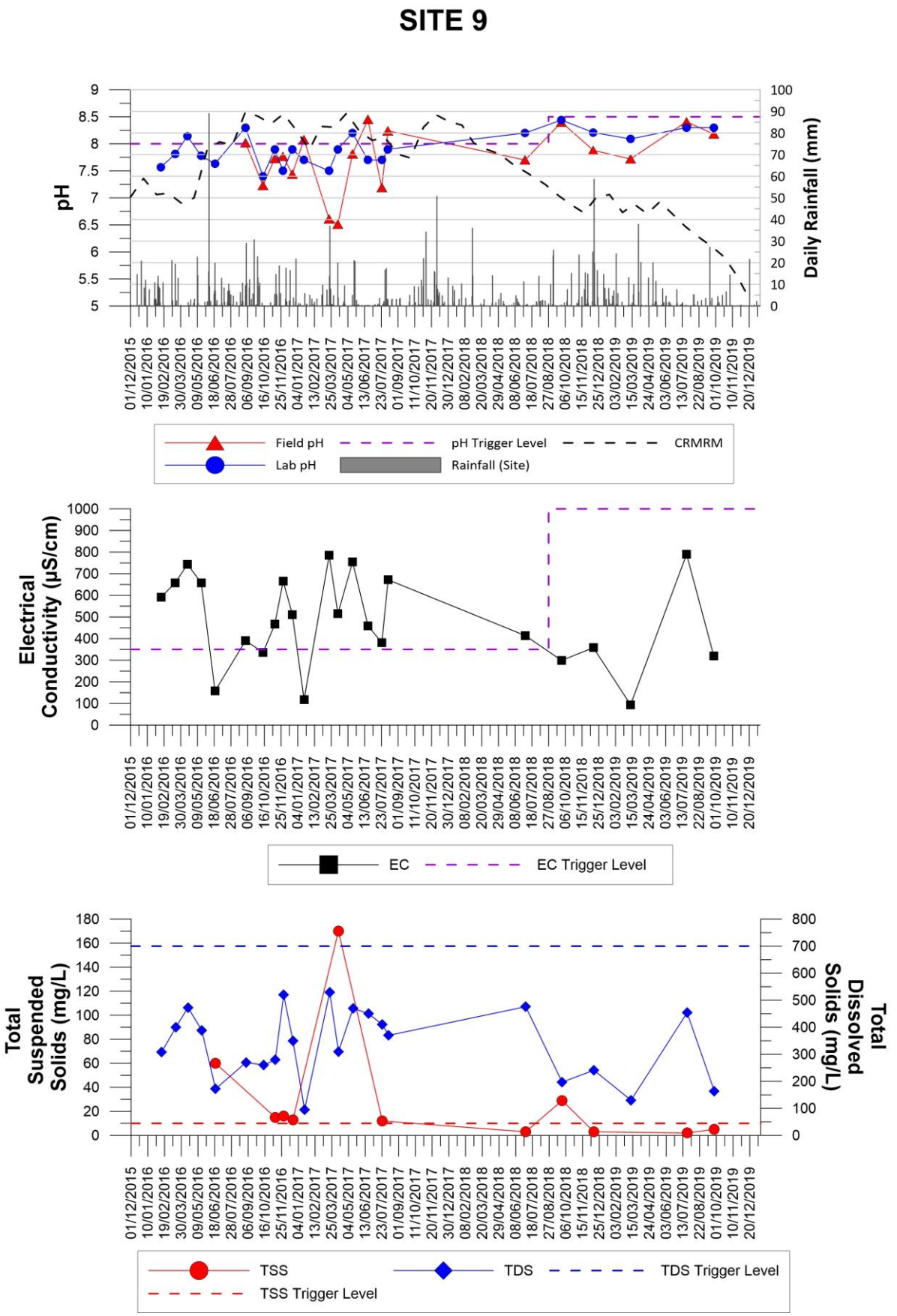


Figure B23: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 9 with rainfall and cumulative residual rainfall mass (CRMRM)

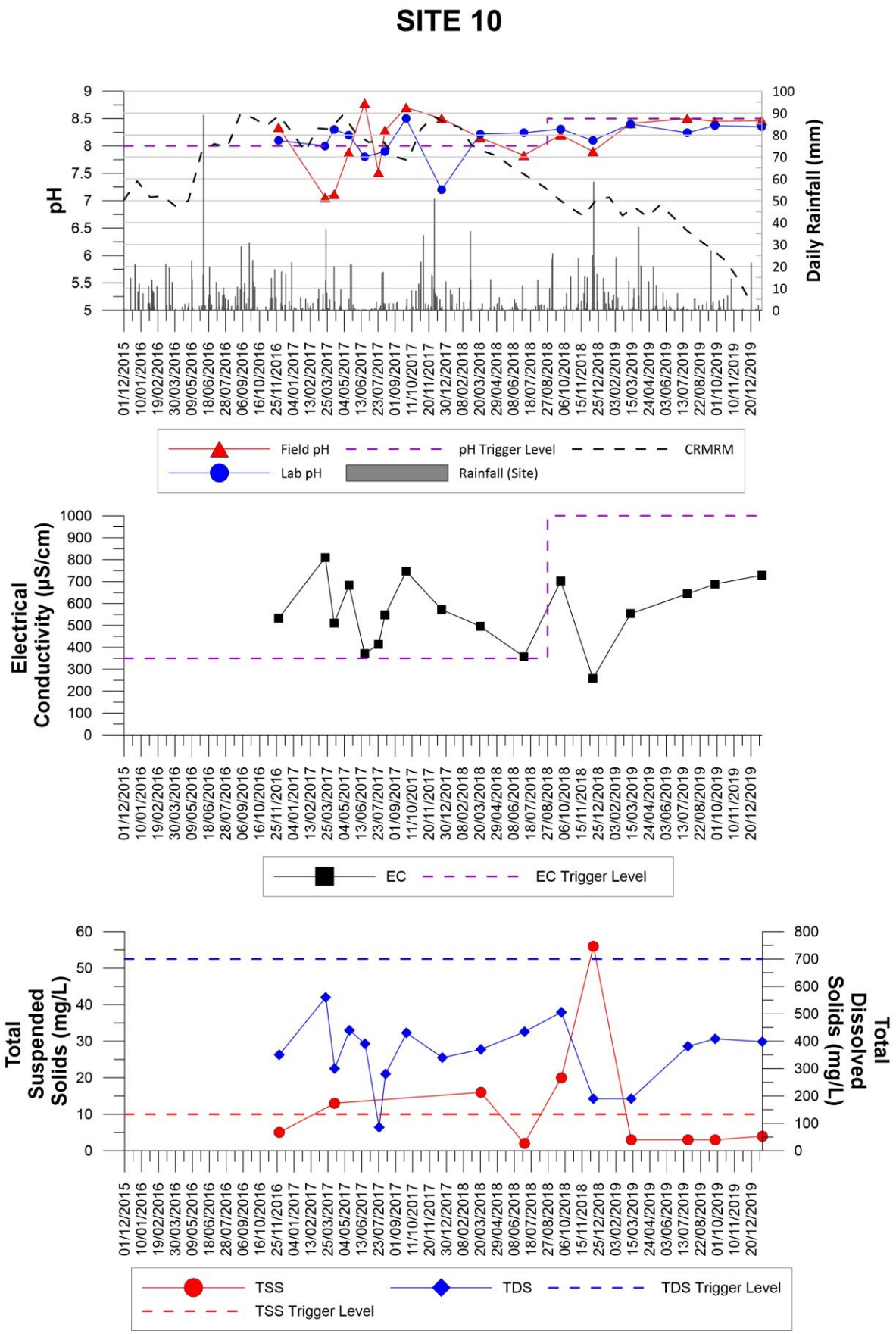


Figure B24: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 10 with rainfall and cumulative residual rainfall mass (CRMRM)

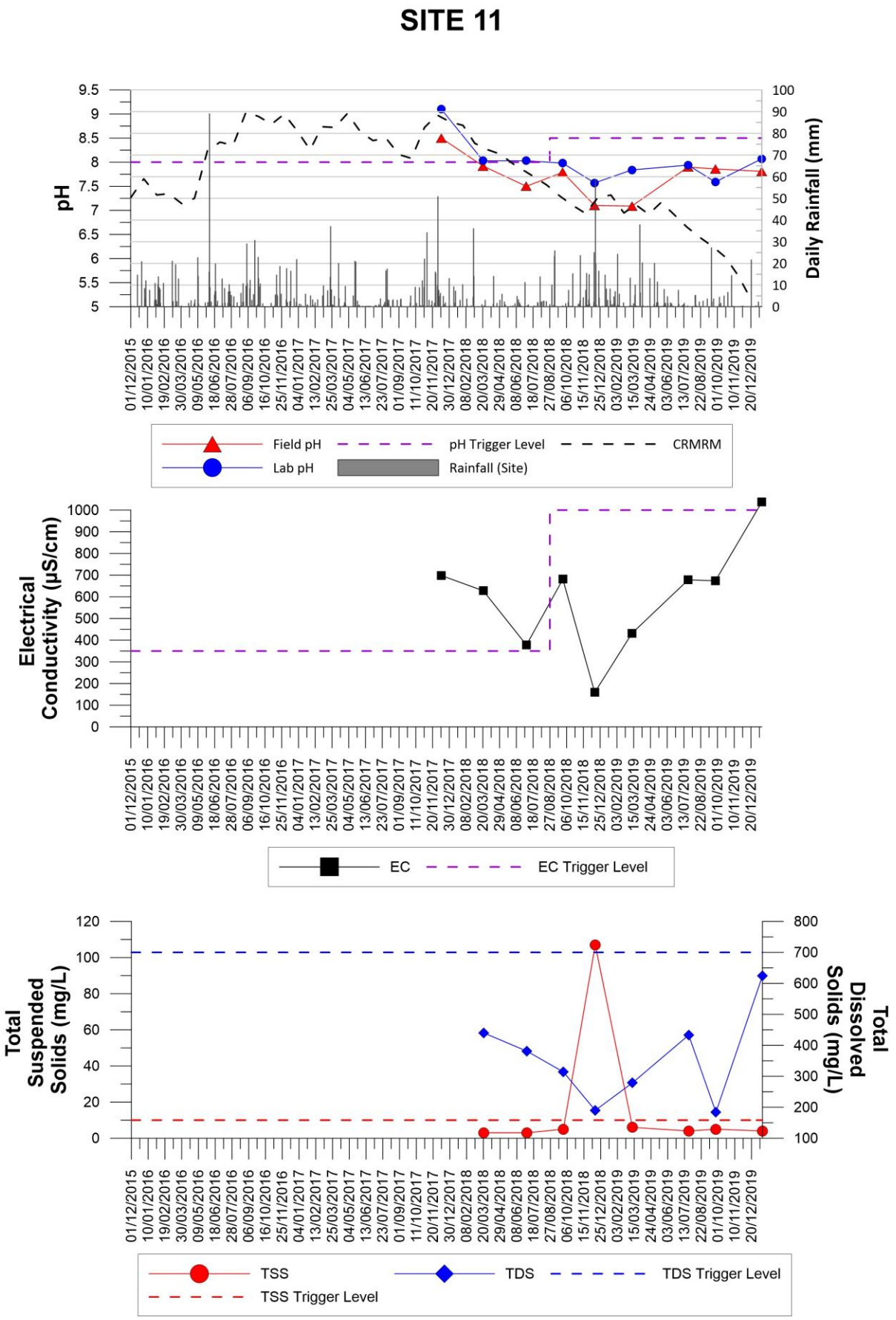


Figure B25: Time series plot of field pH, EC and laboratory total and dissolved solids at Site 11 with rainfall and cumulative residual rainfall mass (CRMRM)

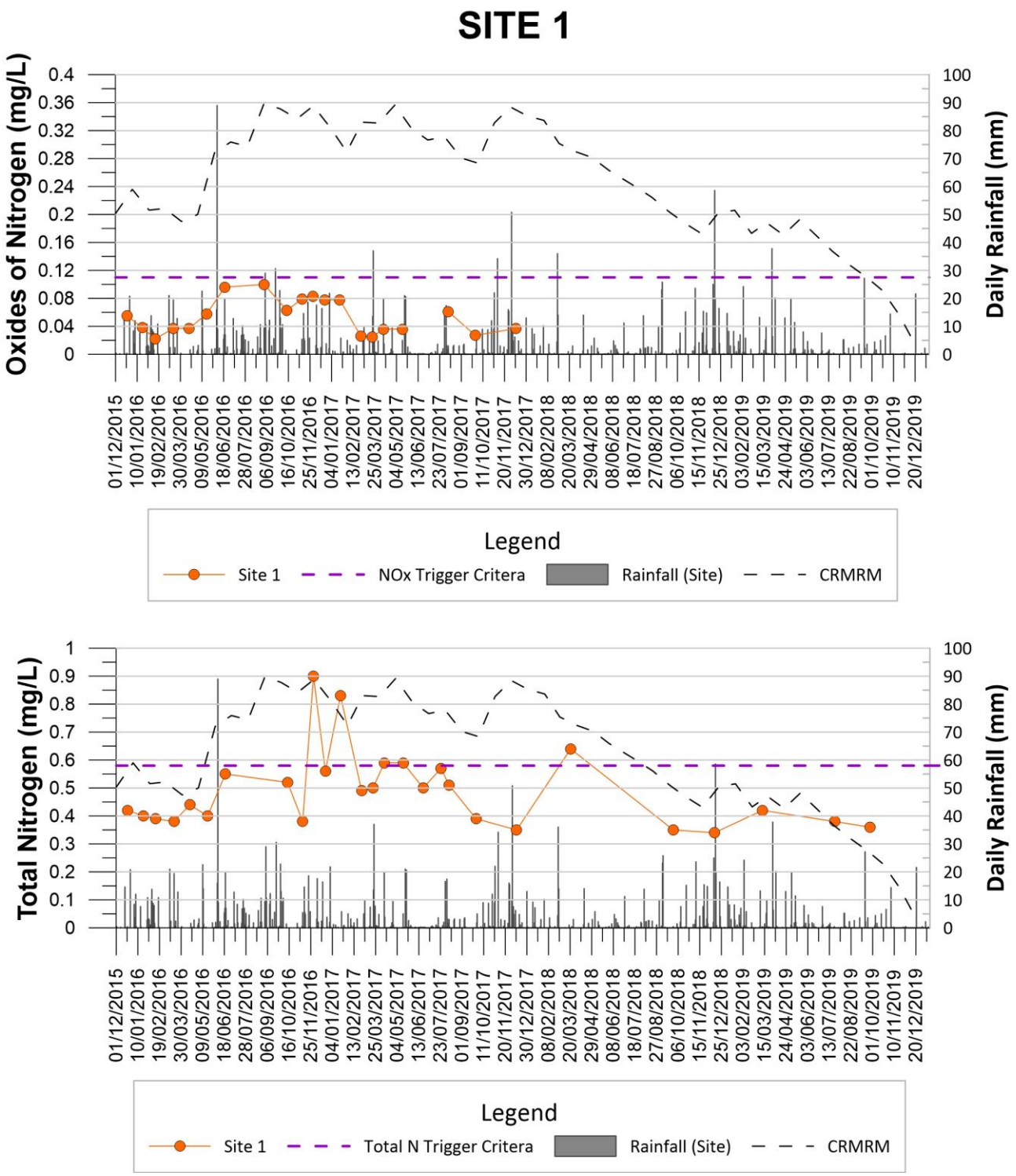


Figure B26: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 1

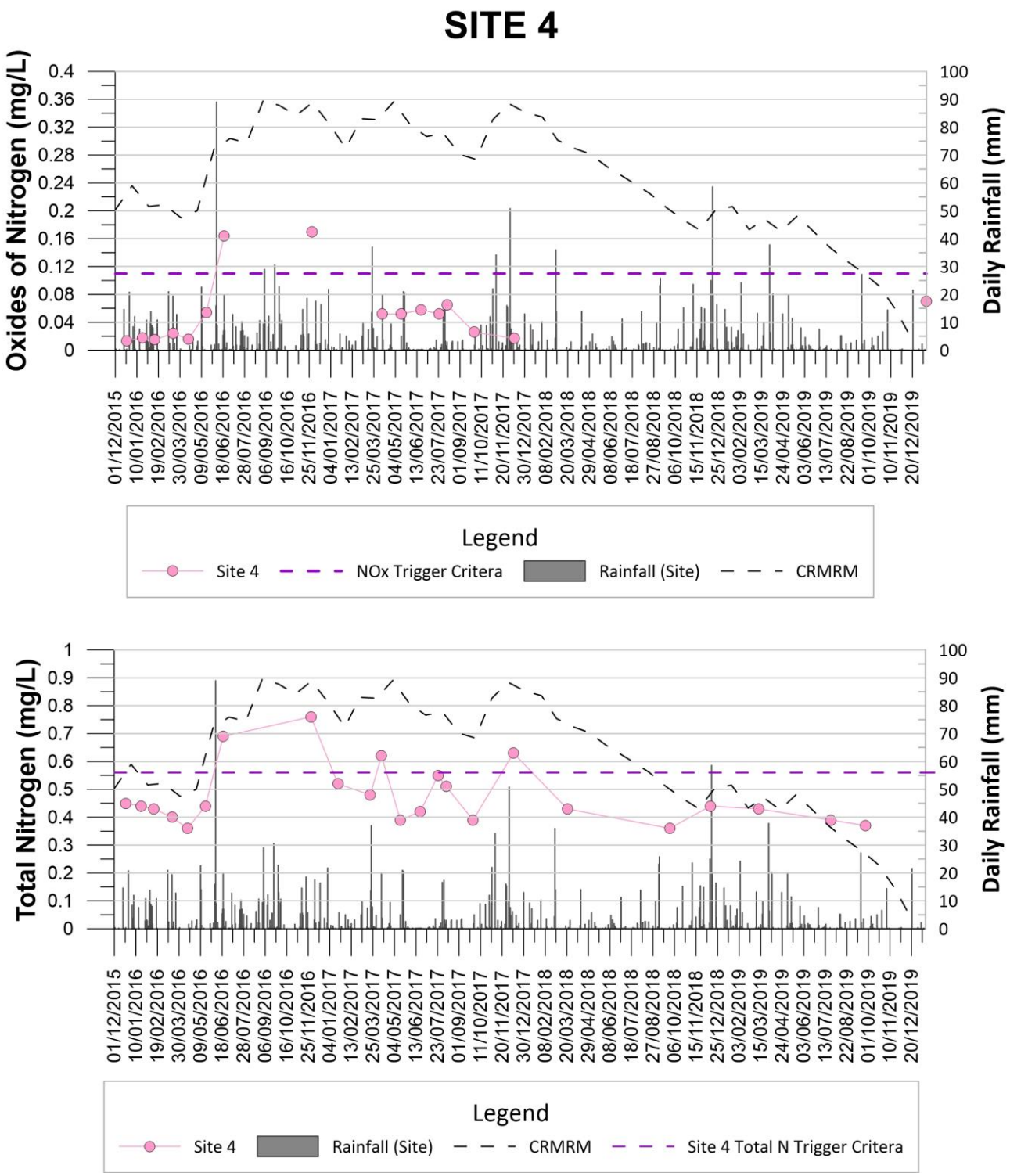


Figure B27: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 4

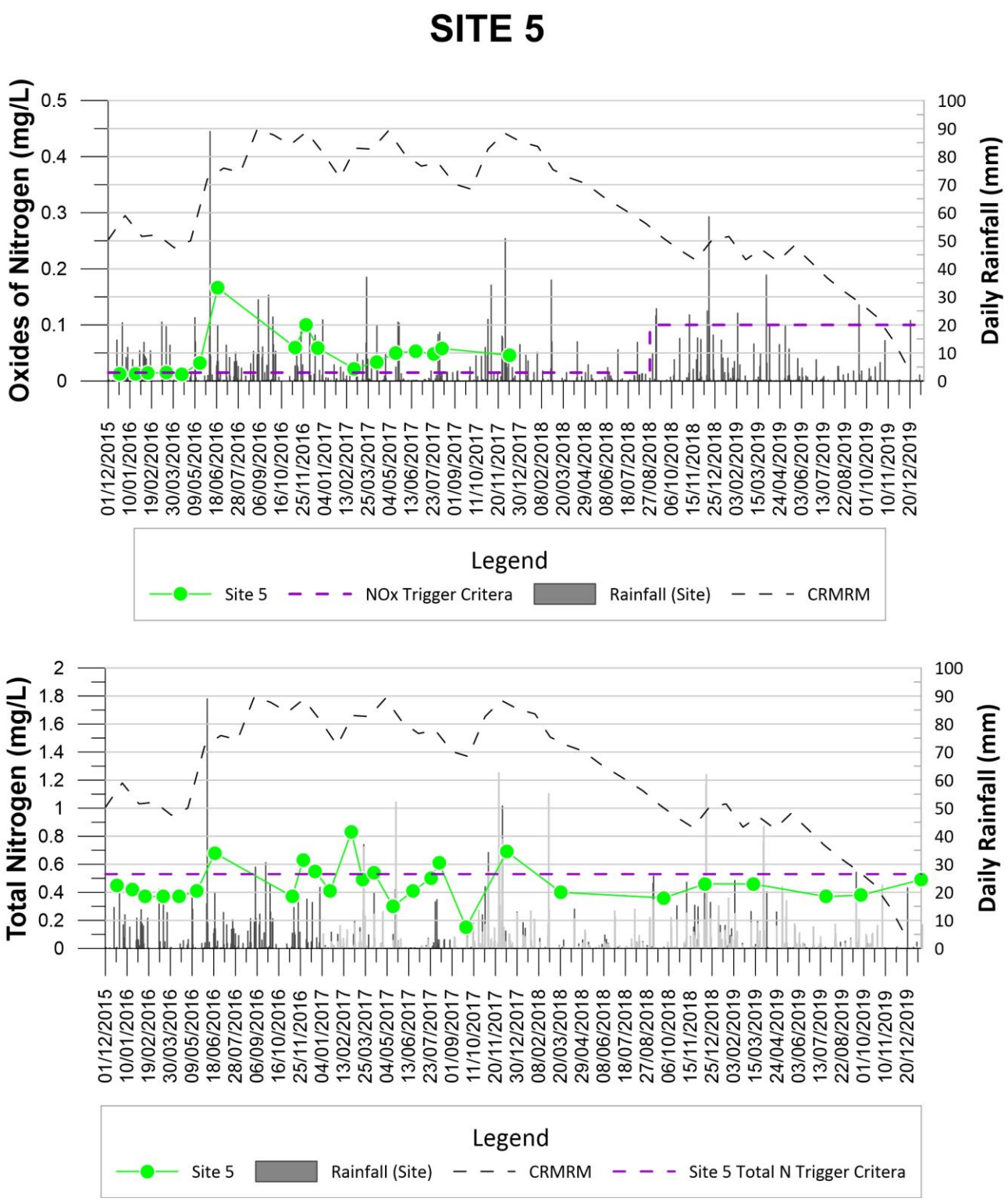


Figure B28: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 5

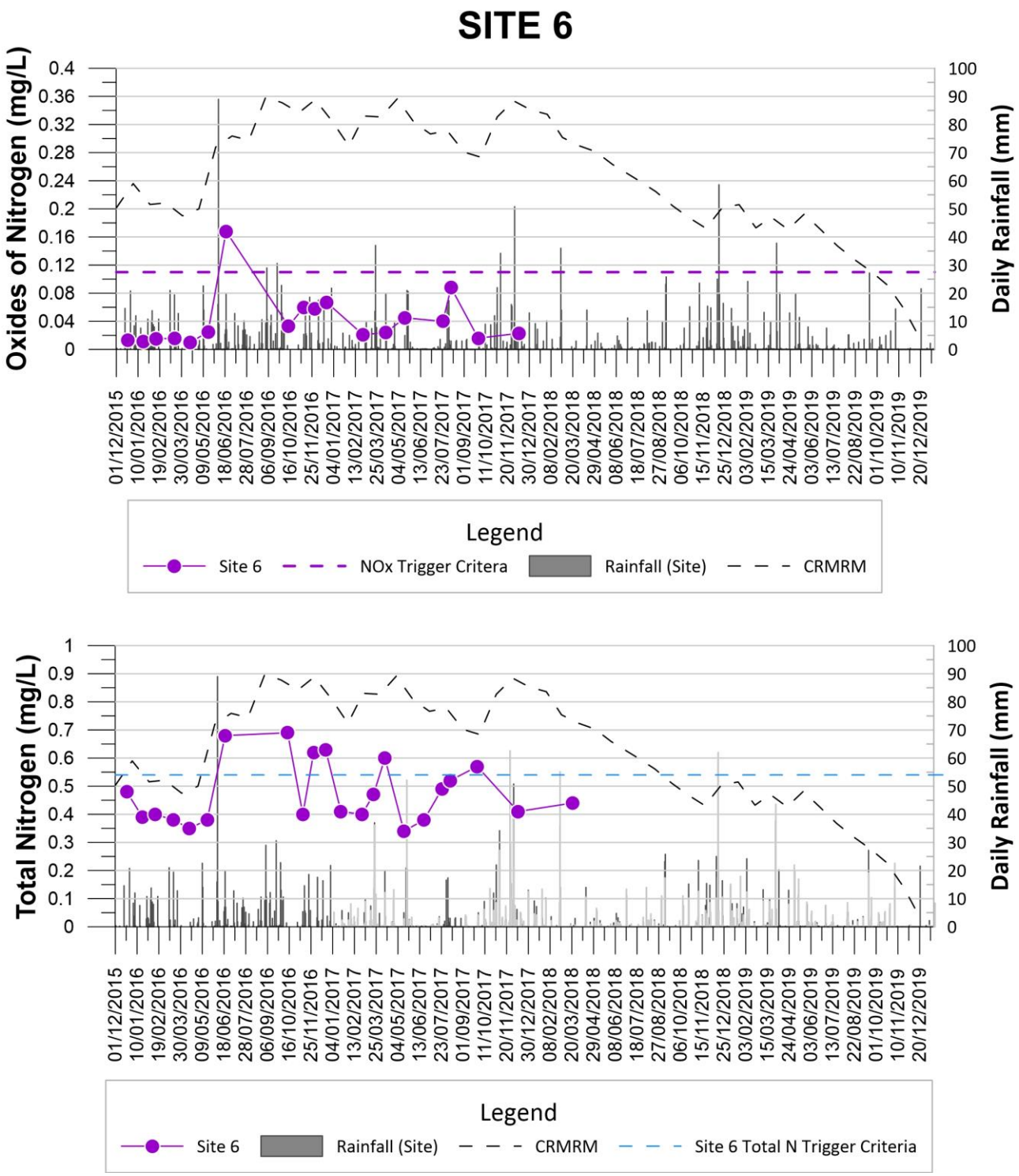


Figure B29: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 6

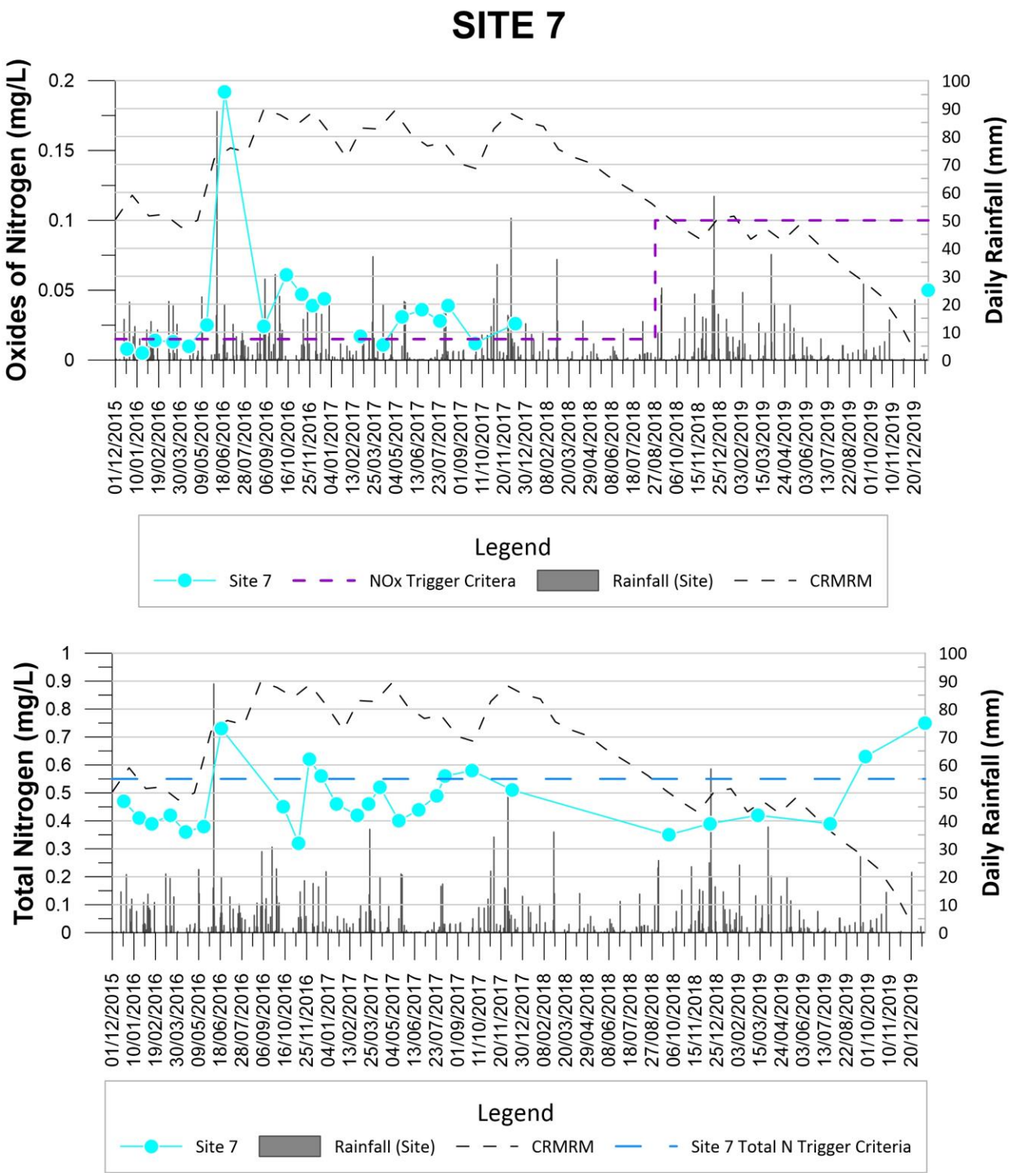


Figure B30: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 7

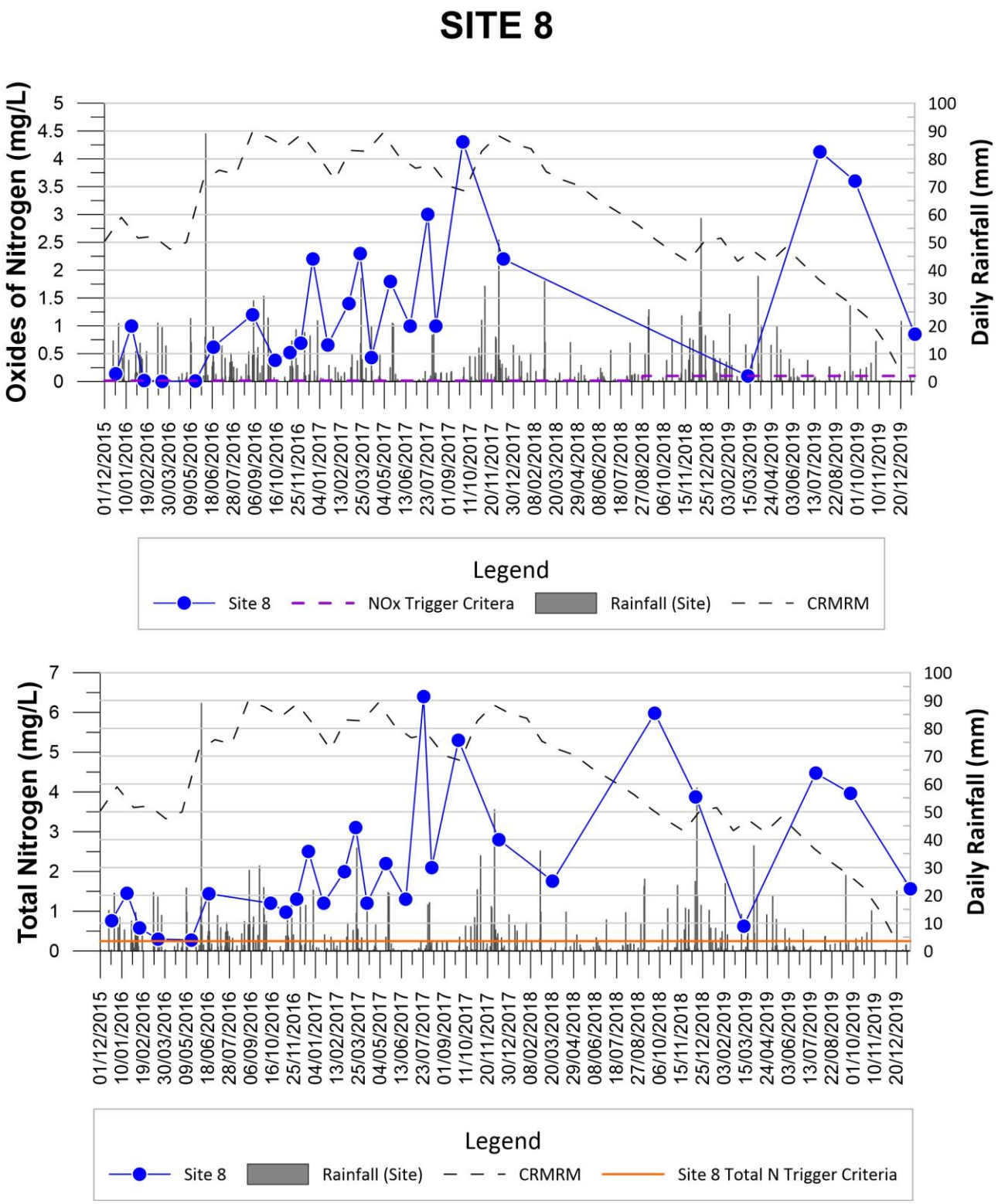


Figure B31: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 8

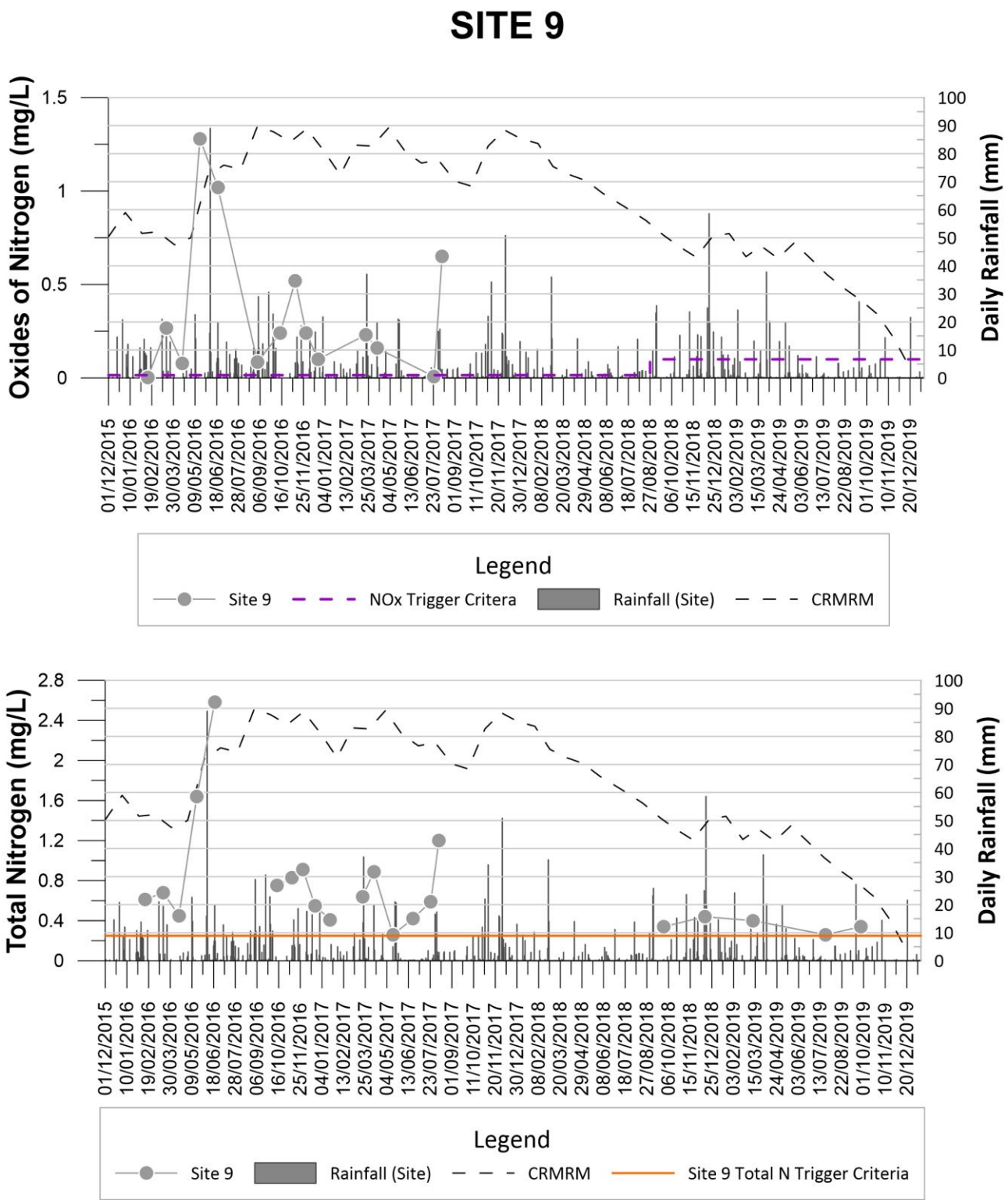


Figure B32: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 9

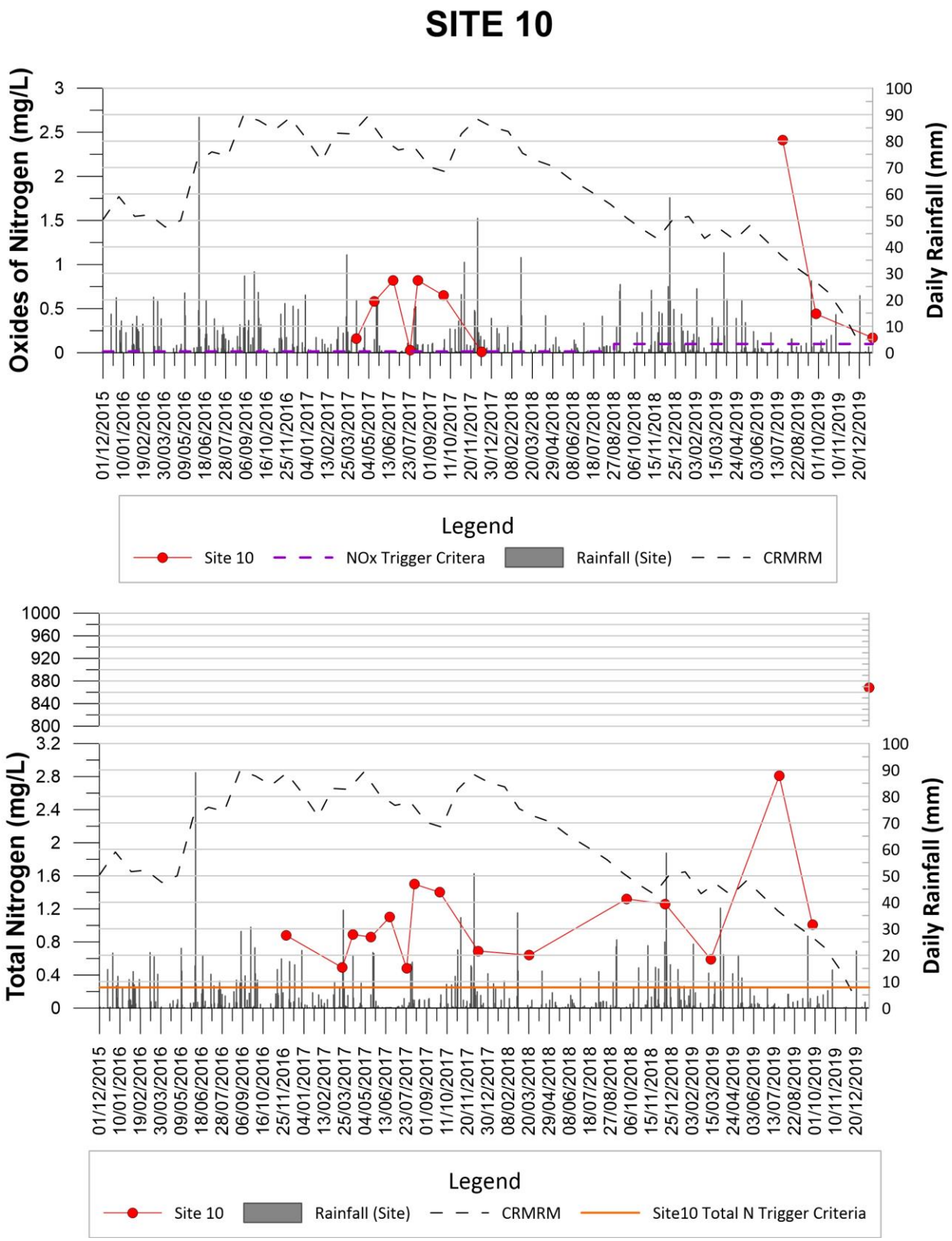


Figure B33: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 10

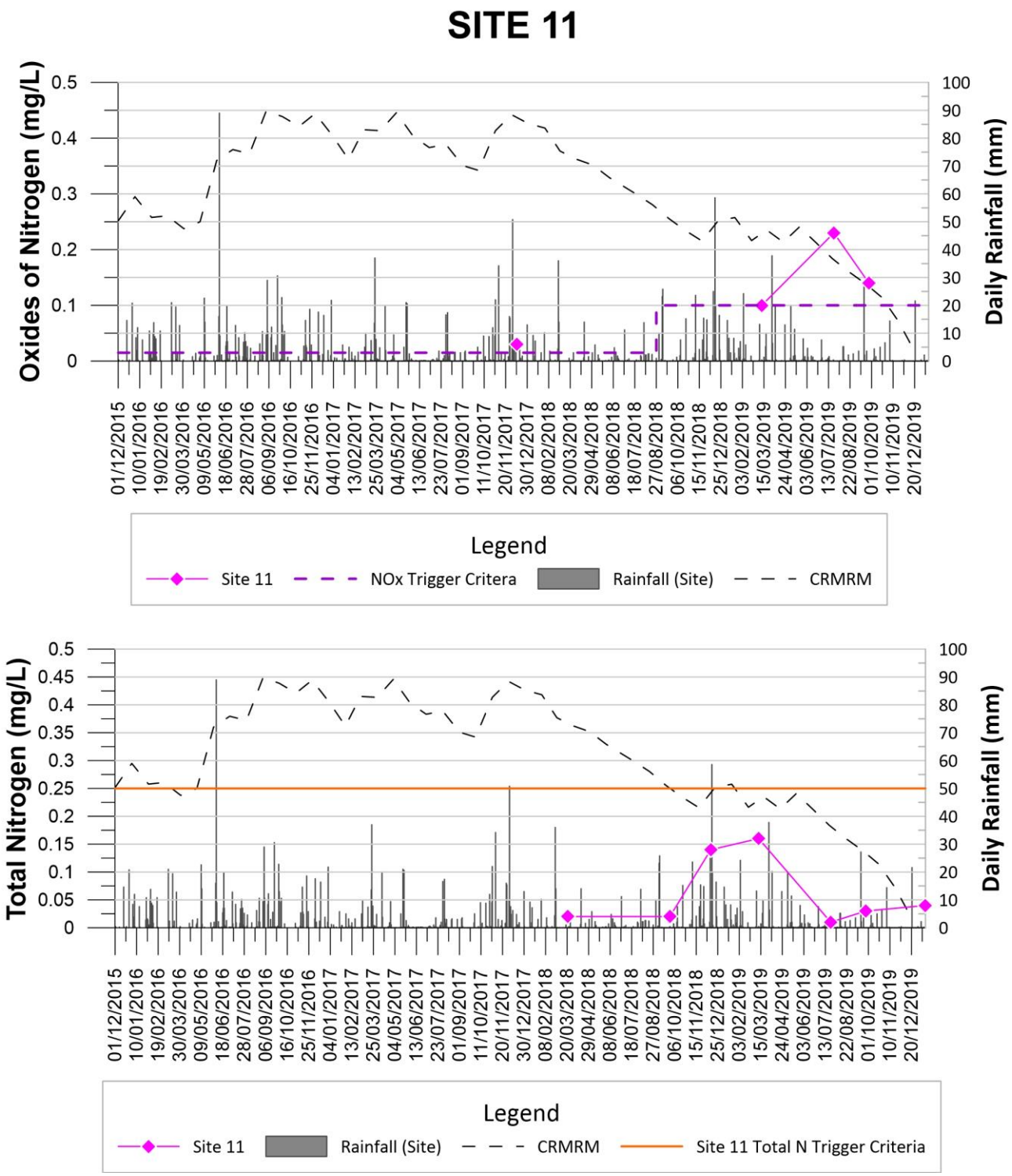


Figure B34: Time series plot total nitrogen and oxides of nitrogen with rainfall and cumulative residual rainfall mass (CRMRM) at Site 11

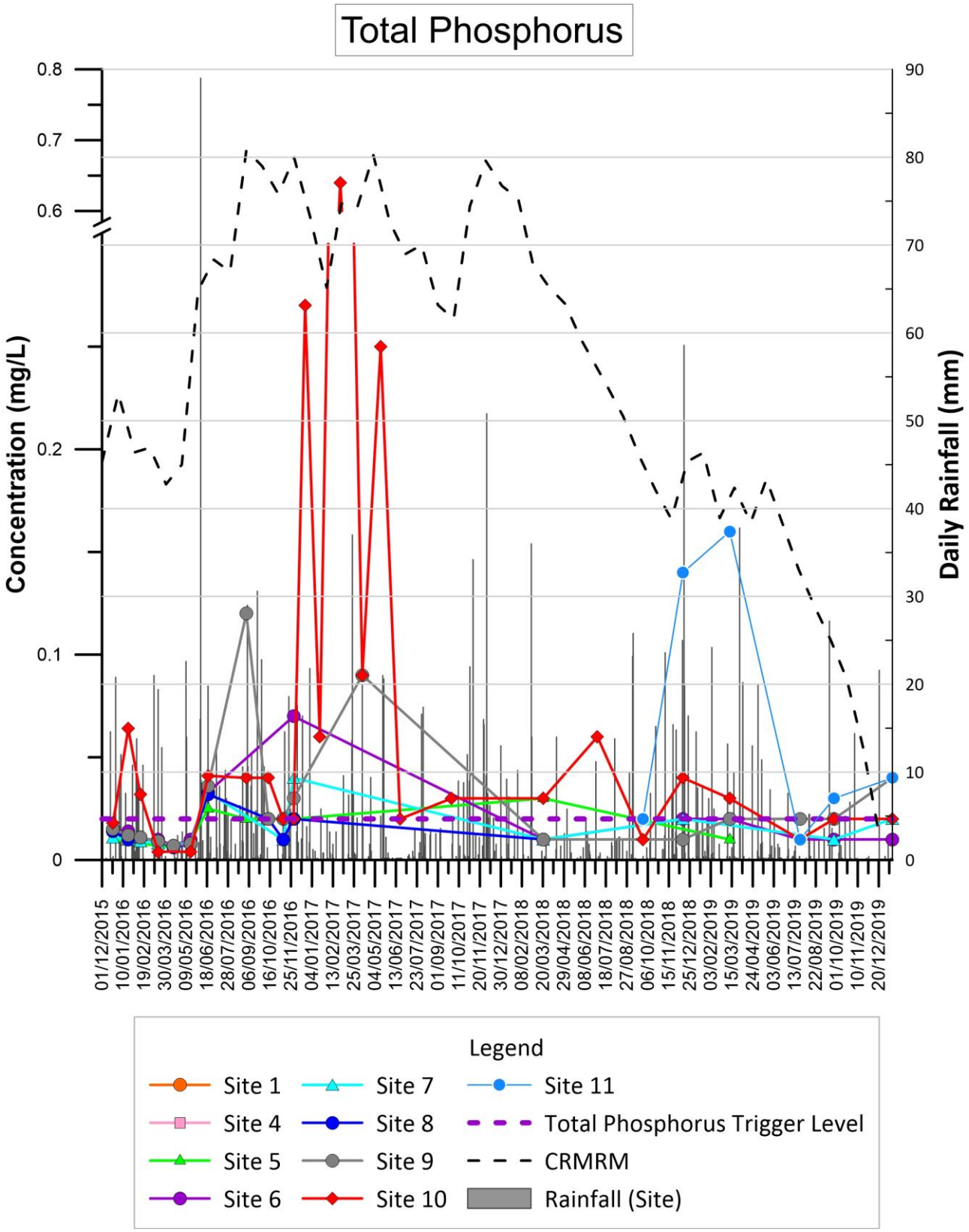


Figure B35: Time series plot total phosphorus with rainfall and cumulative residual rainfall mass (CRMRM) at all locations

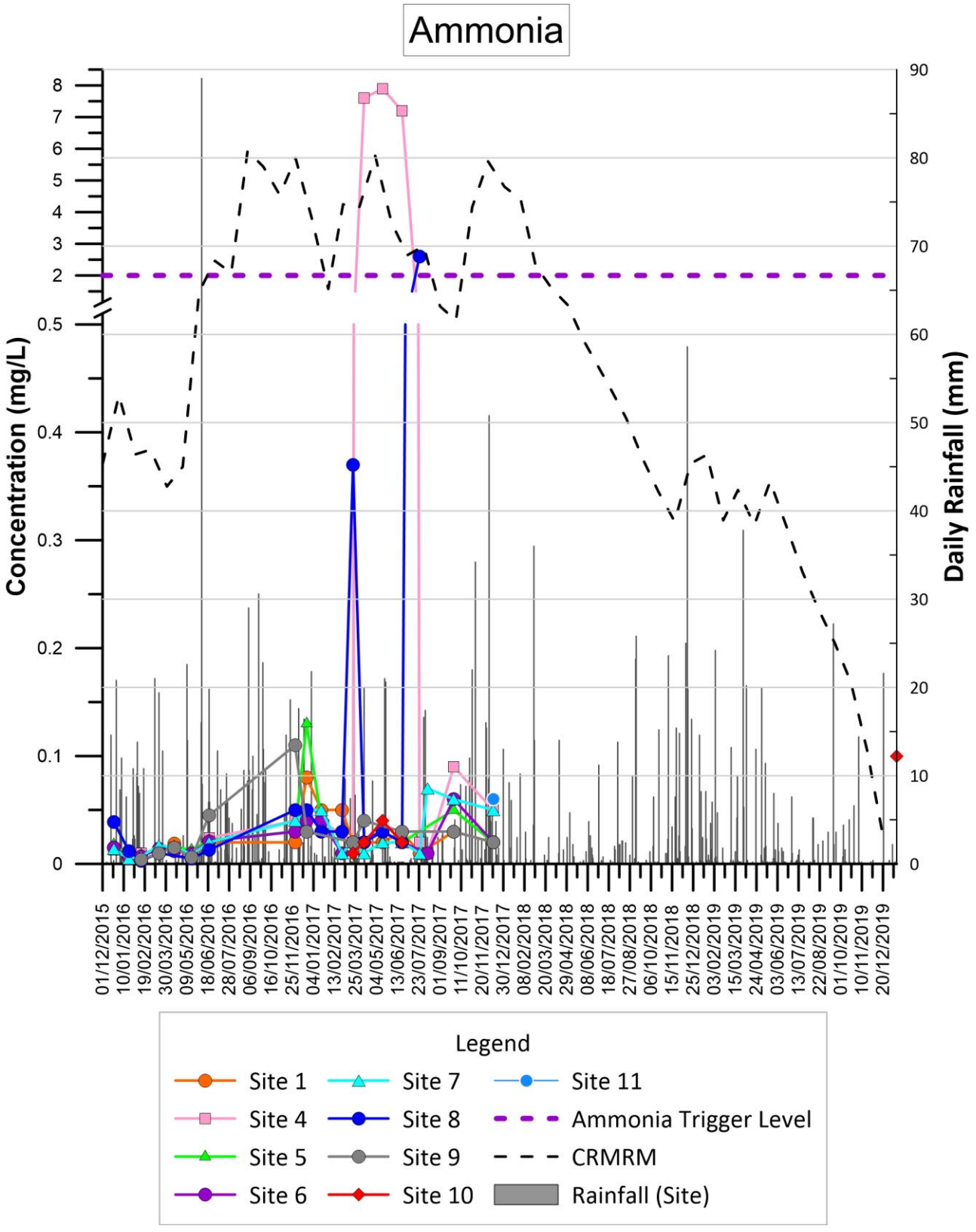


Figure B36: Time series plot ammonia with rainfall and cumulative residual rainfall mass (CRMRM) at all locations

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Appendix E Hydrogeological assessment

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Hydrogeological Assessment

Googong Integrated Water Cycle Project Stage D WRP and Permanent Reservoirs

Reference No. AU212000166
Prepared for RPS Manidis Roberts Pty Ltd
2 June 2020

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List of Abbreviations and Acronyms

Abbreviation/ Acronym	Description
ACT	Australian Capital Territory
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AGWR	Australian Guidelines for Water Recycling
BOM	Bureau of Meteorology
COA	Conditions of Approval
CRMRM	Cumulative Residual Monthly Rainfall Mass – calculated in the method described by Ferdowsian et al (2001)
CEMP	Construction Environmental Management Plan - A site or project specific plan designed to ensure appropriate environmental management practices are applied through the construction phases of the project
DO	Dissolved Oxygen
DEC	Department of Environment and Conservation
EC	Electrical Conductivity
EDT	Emergency Detention Tank
EP	Equivalent Population - Term used to describe sewage generation based on the average person in a residential development
EP&A Act	Environmental Planning and Assessment Act
EPL	Environmental Protection Licence
EQL	Lowest level that can be reliably achieved within the specified limits of precision and accuracy during routine laboratory operating conditions
GTPL	Googong Township Propriety Limited
GWMP	Groundwater Monitoring Program
kL	Kilo litre
IMP	Irrigation Management Plan
IWC	Integrated Water Cycle
ha	hectares
ID	Identification – refers to name of element
LLD	Low Level Detection
L/s	Litres per second
m	Metres
mAHD	Meters (Above) Australian Height Datum
mBGL	Meters Below Ground Level

Abbreviation/ Acronym	Description
MBR	Membrane Bioreactor
MCC	Motor Control Centre
mg/L	Milligrams per litre
ML	Mega litres
mTOC	Meters below Top of Casing
NA	Not Assessed
NH	Neighbourhood (of Googong Township)
NS	No Sample – refers to not enough for sample collection
NRMMC	Natural Resource Management Ministry Council
OEMP	Operational Environmental Management Plan
PLC	Programmable Logic Controller
PTWL	Pink Tailed Wormed Lizard
PVC	polymerization of vinyl chloride – a type of pipe
PW	Potable Water
µg/L	Micrograms per litre
QPRC	Queanbeyan-Palerang Regional Council
RAH	Rotary Air Blast
REF	Review of Environmental Factors
ReW	Recycled Water
RPD	Relative Percent Difference
RWRP	Recycled Water Flow Release Protocol
RWQMP	Recycled Water Quality Management Plan
RL	Relative Level, generally referenced to mAHD
SOC	Statement of Commitments
SCADA	Supervisory Control and Data Acquisition
SGRP	Surface and Groundwater Response Plan
SMEC	Snowy Mountains Engineering Company – SMEC Australia Pty Ltd
SPS	Sewage Pumping Station
STP	Sewage Treatment Plant
SWAEMP	Surface Water and Aquatic Ecology Monitoring Program
SWL	Standing Water Level
TOR	Terms of Reference

Abbreviation/ Acronym	Description
UTM	Universal Transverse Mercator – coordinate system
WMP	Water Management Plan (RPS, 2018)
WRP	Water Recycling Plant
WSG	World Survey Grid 1984
WTP	Water Treatment Plant

1 Introduction

Googong Township is located approximately 8 km south of Queanbeyan and 14 km south-east of Canberra, near the Googong Reservoir in New South Wales (Figure 1 and Figure 2). SMEC Australia Pty Ltd (SMEC) was engaged by RPS Manidis Roberts (RPS) on behalf of Googong Township Pty Ltd (GTPL) to prepare a Hydrogeological Assessment for the Stage D Water Recycling Plant (WRP) (the site) the final component of the Googong Integrated Water Cycle (IWC) Project.

The Googong Township is a planned housing development for about 18,850 people or Equivalent Population (EP) and is being developed over the next 25 years. The township is designed around an integrated water cycle (IWC), with a dedicated Water Recycling Plant (WRP) that will reduce the consumption of potable water in the community by around 60 per cent and recycle the township's water for non-potable use. The Googong IWC Project is being constructed and operated in stages to ensure the infrastructure is appropriately sized to meet the incremental level of demand as development of the Googong township progresses.

The stages of development are summarised as:

- Stage 1, incorporating Stages A and B, which was completed in Late 2016 for WRP and designed for 4,700 EP;
- Stage C which was completed in November 2019 and included the Stage C WRP for 9,400 EP; and
- Stage D the ultimate capacity of the project which is planned for 18,850 EP.

The Stage D IWC Project components assessed in this review of environmental factors (REF) comprises three parts:

- the upgrade of the existing WRP (construction and operation);
- the upgrade of Permanent Reservoirs located on Hill 800 (construction and operation); and
- the application of recycled water on public space (including sports fields) and on residential and other properties within the Googong Township.

Concept Approval for the ultimate development subject to future environmental assessment requirements, was granted by the Minister for Planning under Part 3A (now repealed) of the *Environment Planning and Assessment Act 1979* (EP&A Act). Stage D requires a hydrogeological assessment to address the requirements of the Part 3A Concept Approval and requirements for project approval under the EP&A Act. It incorporates all neighbourhoods, sporting grounds and open spaces for irrigation, both current and planned.

1.1 Part 3A Concept Plan Approval Requirement

Section 2.1 of the Part 3A Concept Plan Approval outlines:

Pursuant to section 75P(2)(c) of the EP&A Act, the following environmental assessment requirements apply with respect to any future development that is subject to Part 4 or Part 5 of the EP&A Act (which are not exempt or complying development), for the subsequent project stages:

***h)** assessment of the following key issues considering all components of the project (including temporary construction facilities) and cumulative impacts from other projects associated with the Concept Plan:*

- ***Groundwater** – including potential impacts on local recharge levels, contamination risks, groundwater mounding, isolated waterlogging of soils and impacts on groundwater quality*

***j)** the environmental assessment of the project must take into account relevant State Government guidelines, polices and plans; and*

***k)** the assessment of the subsequent project stages shall take into account, but not limited to the following guidelines as relevant;*

- *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000);*
- *National Water Quality Management Strategy – Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (NRMMC, 2006) and*
- *Environmental Guidelines: Use of Effluent by Irrigation (DEC, 2004).*

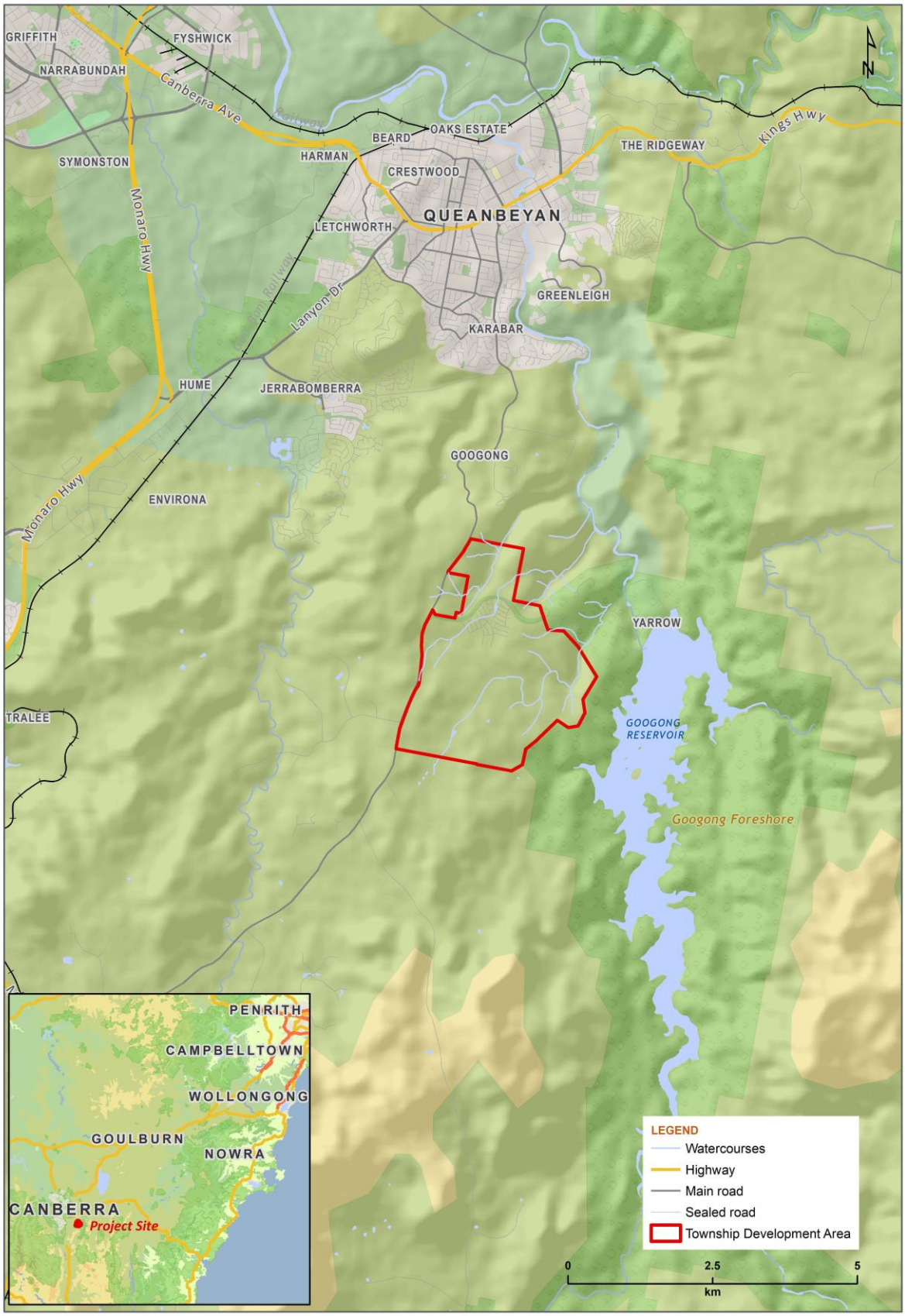


Figure 1: Googong Township Regional Location

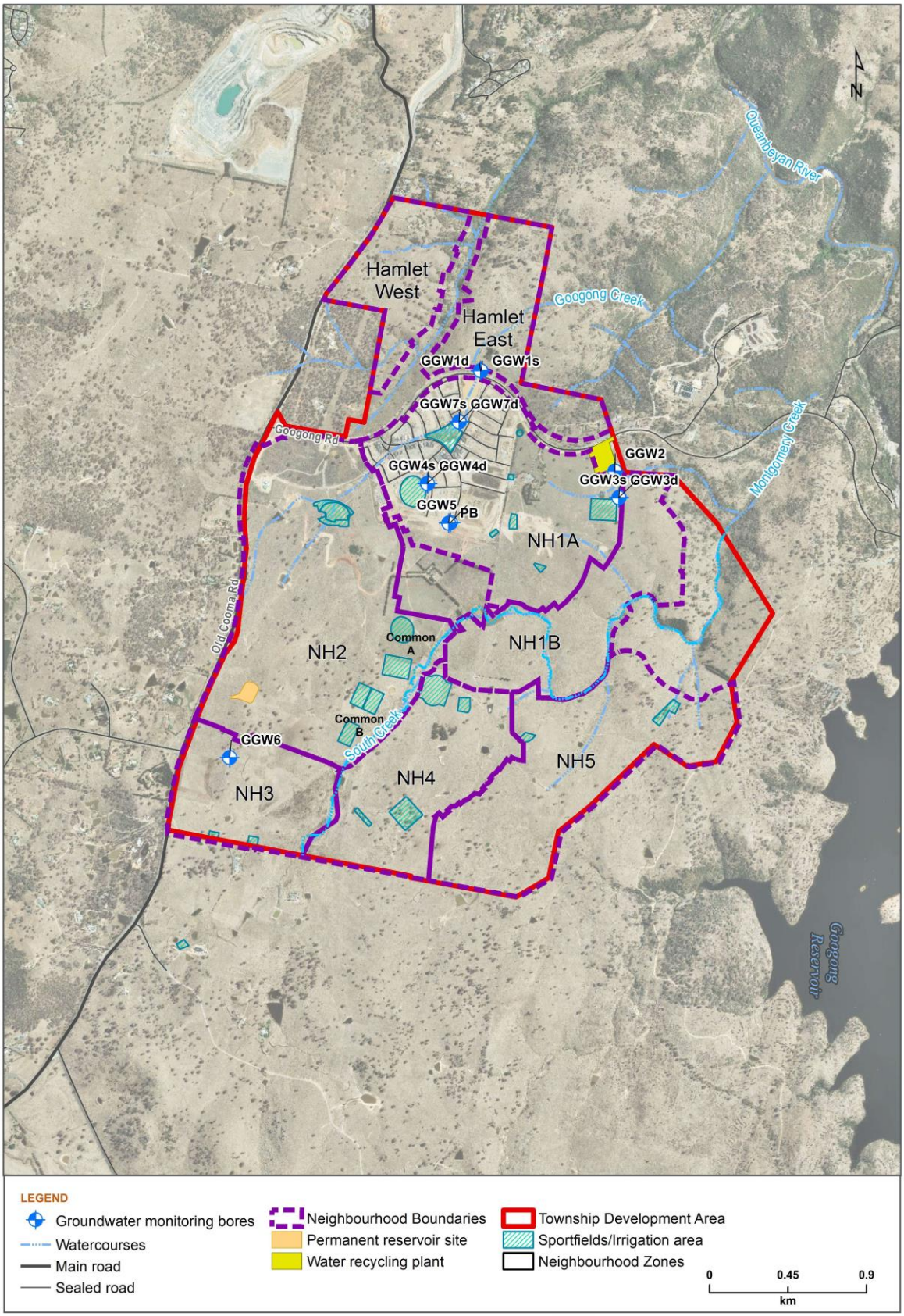


Figure 2: Googong IWC Project Stage D works and Neighbourhood Boundaries

2 Regional Setting

2.1 Googong Township

Googong Township is located approximately 8 km south of Queanbeyan, in NSW at the intersection of Old Cooma Road and Googong Road (Figure 2). Googong Reservoir is located approximately 600 m to the east of the eastern boundary of the township.

2.2 Climate

Climatic data is available from:

- Queanbeyan Bowling Club for rainfall from station no. 070072 to 31 October 2015;
- Tuggeranong (in the ACT) station no. 703390 from 1996;
- Canberra Airport (in the ACT) evaporation from station no. 070014.

These are the closest stations with long term records held by the Bureau of Meteorology. On-site a weather station records data which is available from September 2013 for rainfall, wind speed, wind direction, minimum and maximum temperature, solar radiation and minimum and maximum relative humidity. There is no on-site evaporation data and some months have incomplete records. The baseline hydrogeological data was collected during a period of below average rainfall conditions and subsequent monitoring data has been collected during both above average and below average rainfall conditions. This should be considered during any interpretation of results and trends.

Average annual rainfall at the Googong Township, from the township weather station between 2014 and 2019 is approximately 590 mm compared to the 595mm annual average for the region. Rainfall is variable and can be subject to prolonged periods of above or below average rainfall with the winter months generally being slightly drier. The Googong climate is temperate and characterised by warm dry summers and cold winters. Climate statistics from Canberra Airport show the mean temperatures range from -0.1°C to 12°C in winter to 13 °C to 34.5°C. Mean temperatures at Queanbeyan are within the range of 13-27°C during summer and 0.5-12° C in winter. The Googong township weather station shows since September 2019 the mean temperature ranges from 6-30°C in summer and 0.4-20°C in winter.

The cumulative residual monthly rainfall mass (CRMRM) compares the cumulative monthly rainfall with the long-term average. The CRMRM is calculated for Tuggeranong weather station, the closest rainfall station with a long record of data and shown where practical on figures within this report. It was not calculated for Canberra Airport or Googong Township weather station as they have only been in operation for a shorter period. The CRMRM is most effective where more than 50 years of continuous records exist. It is displayed on figures within this report without a numerical value as it is the slope of the line that is important.

2.3 Regional Geological Setting

General information sourced from Geological Survey of New South Wales and Bureau of Mineral resources shows the region is underlain by the Colinton Volcanics, a late Silurian aged volcanic unit within the Canberra block, part of the Lachlan Fold Belt. The Lachlan Fold Belt (LFB) is a 700-kilometre-wide belt of deformed, Palaeozoic, deep and shallow marine sedimentary rocks, cherts and mafic volcanic rocks. Surface structural elements suggest that it was formed by massive telescoping and strike-slip translation within a continental margin sediment prism along the former eastern margin of Gondwanaland during the mid-Palaeozoic.

During the Devonian (and to a lesser degree the Carboniferous) the introduction of granites and associated batholiths – such as the Ellenden, Gibraltar and Rossi Granites of the Bega Batholith to the east and south-east of the study area – marked the LFB's transition from an immature depositional basin comprising poorly sorted volcanoclastic sediments and airfall tuffs, towards a mature continental margin with the development of complex sedimentary deposits and explosive volcanic events. As a result of the numerous tectonic movements throughout the LFB's 'active' duration, the geological units throughout most of the fold belt have undergone multiple deformation events. In general, a strong regional tectonic inclination – from north-north-west to south-south-east – dominates the alignment of structures and geological units, particularly in the central and northern portions of the fold belt. In the Googong–Queanbeyan districts, however, the dominant tectonic inclination is north north-east–south-south-west (Figure 3).

The site (Figure 4) is underlain by the Colinton Volcanics, a unit of Silurian age. The Colinton Volcanics typically comprise limestone and dolomitic limestone, dark green dacitic ignimbrite and minor volcaniclastic sediments. The Stage AB field investigation encountered shale and dacite during the monitoring bore drilling program. A reef of igneous rock is

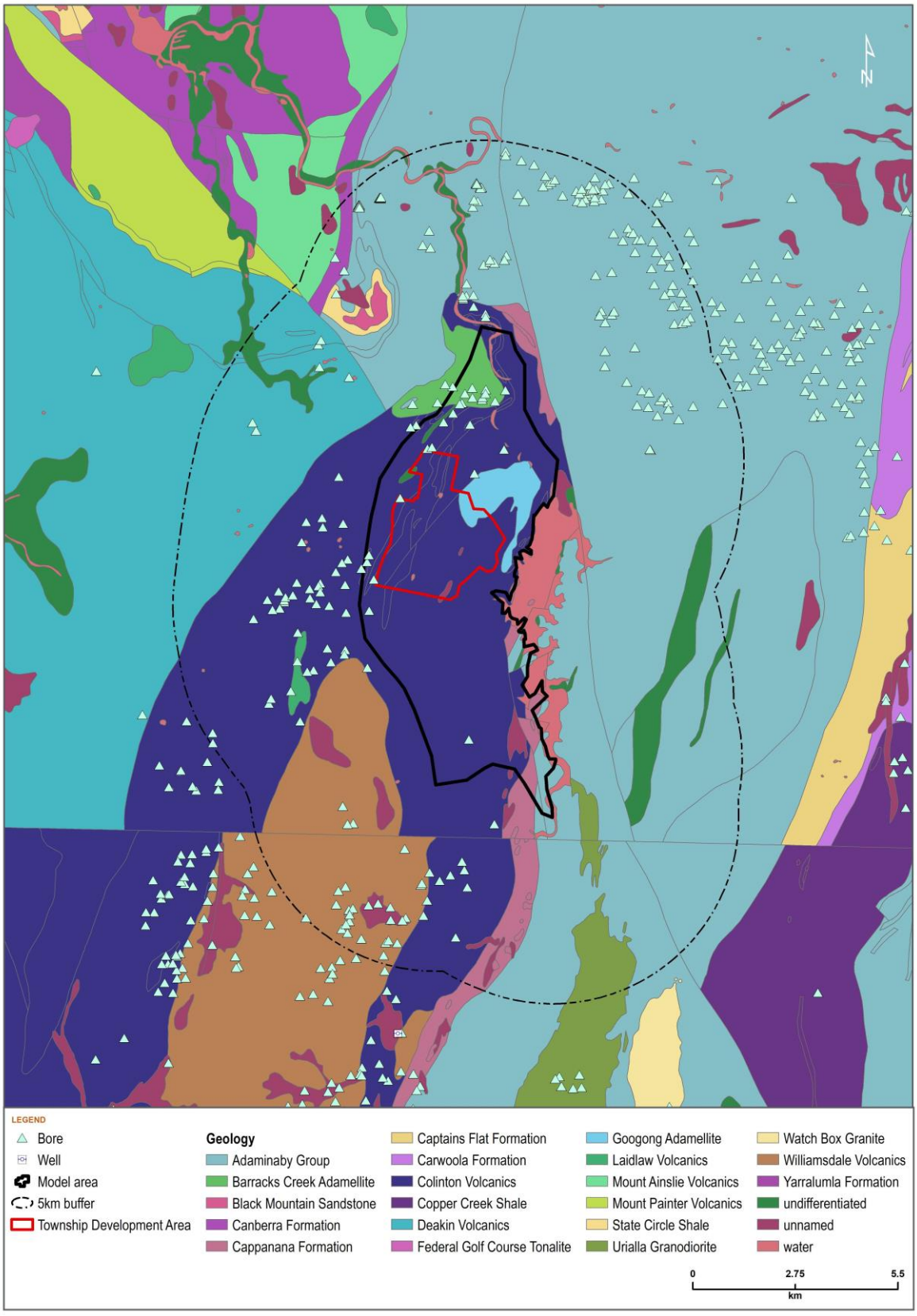


Figure 3: Regional Geology Map and Registered Private Bores

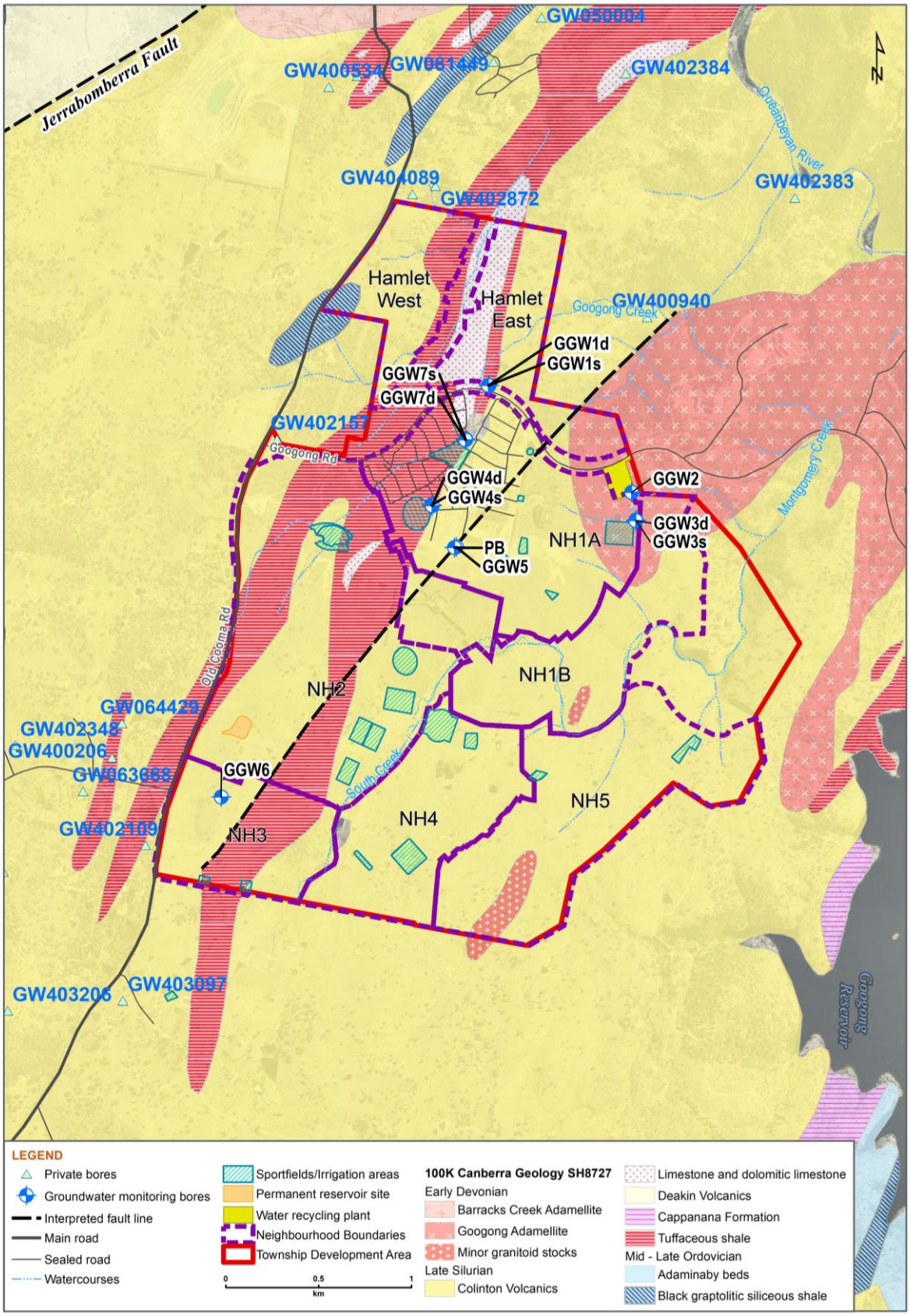


Figure 4: Googong Township Geological Map and Monitoring Bore Locations

exposed at the surface outside the south-eastern corner of the site and runs on about the line of the north-eastern boundary of the site. The north-eastern corner of the township, where the WRP is situated, is underlain by the Googong Adamellite, a locally significant intrusive body that is described as a medium to coarse-grained, moderately weathered, buff-coloured porphyritic adamellite. It is the youngest unit in the area, having been intruded into the surrounding Colinton Volcanics, and appears to have faulted boundaries. Hill 800 reservoirs are located on the Colinton Volcanics in the south-west of the site. Drilling of GGW6, located nearby, encountered a thin layer of shale over dacite.

2.4 Hydrogeology

Groundwater is hosted in a regionally extensive fractured-rock aquifer. Minor alluvial aquifers are located along the alignments of locally significant waterways, they are expected to have minimal storage and not to be of significance to this assessment. The depth to bedrock across much of the Googong Township is between about 0.5 m and 2 m, with fresh bedrock encountered at shallower depths at higher elevations, commonly marked by changes in slope. Shallow groundwater is expected to migrate along the interface between the soil horizons and relatively fresh bedrock, and to discharge to surface water drainage lines and creeks. The regional groundwater flow direction is north-east towards the Queanbeyan River.

2.4.1 Aquifer Types

An assessment of private borehole summary worksheets and township monitoring bore logs indicate that groundwater, in the vicinity of the site, is hosted in a regionally extensive, unconfined to semi confined fractured rock aquifer. Structural features thought to be significant to groundwater flow at the site include local and regional faults, joints, fractures and cleavage.

2.4.2 Groundwater Recharge

Rainfall recharge of fractured-rock aquifers occurs through areas of open fracturing, either at the surface or through superficial unconsolidated material. In the latter case, there may be a delay between a rainfall event and the entry of water into the aquifer, due to storage in the unconsolidated material of the recharge zone. Recharge of the aquifers would occur mainly via infiltration of rainfall, infiltration of slope runoff, and outflow from the Queanbeyan River and Jerrabomberra Creek (and other watercourses) during periods of high flow and flooding events. Overall, recharge in the area is expected to be limited by the generally low rainfall, particularly during winter months.

2.4.3 Groundwater Discharge

Discharge from the aquifer is primarily through natural flow from springs, both perennial and ephemeral, and from baseflow into perennial watercourses. Other discharges from the aquifer include bore pumping for domestic and stock purposes, whilst some localised irrigation is also possible. A potential spring was observed at the site in the vicinity of the WRP during the baseline groundwater monitoring program. The original assessment for Stage 1 works did not note any springs or ‘soaks’ but it is noted that the assessment was carried out in a relatively dry period. Commonly in rural farmland springs are often converted into dams as was the case with the original farm dams located at the WRP.

2.4.4 Groundwater Utilisation / Abstraction

Groundwater is anticipated to be of sufficient quality for general water supply purposes, and it may be suitable for potable use. Groundwater in the area is predominantly used for a combination of domestic and stock purposes. Of the 272 bores located within a 5 km buffer of the township, all but a few are registered for such use, and only a few appear to have achieved yields that would satisfy all the water requirements of a property without some form of reliance on surface water supplies. There are no private bores located within the township. There are five private bores located north of the township (within 1.5 km of the boundary) and three located to the west (within 500 m of the boundary) (Figure 4).

2.4.5 Bore Yields and Aquifer Hydraulic Properties

Yields for the boreholes drilled in the Late Silurian aged Colinton Volcanics throughout the Googong district vary from less than 0.1 L/s to up to about 10 L/s, including some into the margins of the Barracks Creek Adamellite. Most of the private bores are in the Colinton Volcanics where yields are more modest and typically range between 0.5 L/s and 1.0 L/s. The higher-yielding bores were drilled in the ignimbrite and metasedimentary units of the Colinton Volcanics, although a few higher-yielding bores have also been drilled along the southern margin of the Barracks Creek Adamellite where natural fracturing and deeper weathering profiles are thought to exist. Boreholes that have encountered multiple water-bearing zones appear to have markedly higher yields, and in most instances yields appear to increase with depth. The highest-yielding water-bearing zones throughout the area were typically identified at depths of between 20 m and 50 m, beyond which the degree of fracturing is thought to decline markedly, particularly in the Silurian intrusions.

2.5 Surrounding Land Use and Potential Receptors

The Googong Township is being developed on former rural farmland. The nearest surface water body is Googong Dam, located 600 m east of the township and is the primary potable water source for Queanbeyan (Figure 2). A quarry is located 950 m north-west of the northern boundary.

The nearest major river is the Queanbeyan River which flows in a north-westerly direction and is also dammed to form Googong Reservoir. Googong Creek located north-east of the site flows north-east into the Queanbeyan River. North Creek flows north into the Queanbeyan River west of Googong Creek. East of the township is Montgomery Creek which flows east into the Queanbeyan River. South Creek flows through the eastern portion of the township into Montgomery Creek. Surface water monitoring of Googong Creek, Montgomery Creek and the Queanbeyan River is currently undertaken at several locations (Figure 5) required by the project approvals for the Stages AB and C works. The private bore survey identified two bores along Googong Creek, north of the township, which are potential groundwater beneficial users. GTPL also indicated there are some potential surface water users who draw water directly from the Queanbeyan River which have been observed by SMEC.

2.6 Monitoring Bore Network

The dedicated groundwater monitoring network (Figure 4) has been established on the site since August 2013. The groundwater monitoring network consists of 11 monitoring bores at seven different locations. At four locations nested shallow and deep monitoring bores have been installed. As part of the initial investigations in 2013 a test production bore was established and tested adjacent to GGW5, it has since been decommissioned. The regional groundwater flow direction is north-east towards the Queanbeyan River. Localised shallow 'perched' groundwater flows towards the main drainage lines e.g. north towards Googong Creek or east towards Googong Reservoir. The following changes to the monitoring network have occurred:

- PB was decommissioned after the pumping test was completed in 2013;
- GGW2 was decommissioned in August 2015 and replaced in October 2015 to make way for WRP construction;
- GGW5 was raised between December 2013 and March 2014 as part of the road construction; and
- GGW3S and GGW3D were raised as part of the development of Duncan Sporting Fields between September and October 2014.

The borehole completion, construction and survey details are provided in Table 1 to Table 3.

Table 1: Drilling details summary

Bore ID	Date Completed	Total Depth Drilled (m)	Borehole Diameter (mm)	Method	Final Airlift Yield (L/sec)	Screened Lithology
GGW1S	14/08/2013	10.5	120	RAH	NA	Limestone / Shale
GGW1D	13/08/2013	19.0	120	RAH	0.14	Shale / Limestone
GGW2	20/08/2013	8.0	120	RAH	NA	Adamellite/ Dacite
GGW2A	20/10/2015	19.2	120	RAH	<0.1	Adamellite/ Dacite
GGW3S	19/08/2013	7.0	120	RAH	NA	Adamellite
GGW3D	19/08/2013	25.6	120	RAH	0.03	Dacite
GGW4S	27/08/2013	7.0	120	RAH	NA	Shale / Phyllite
GGW4D	26/08/2013	55.0	120	RAH	0.05	Shale / Phyllite
GGW5	20/08/2013	43.0	120	RAH	0.02	Dacite
GGW6	29/08/2013	43.0	120	RAH	0.16	Dacite
GGW7S	5/09/2013	3.0	120	RAH	NA	Fill – sandy clay
GGW7D	5/09/2013	19.0	120	RAH	NS	Shale / Phyllite
PB	12/09/2013	66.0	250	RAH	0.07	Dacite

ID – Identification, RAH – Rotary Air Hammer, L/Sec – Litres per Second (Flow), NA – Not Assessed, NS- not enough for sample

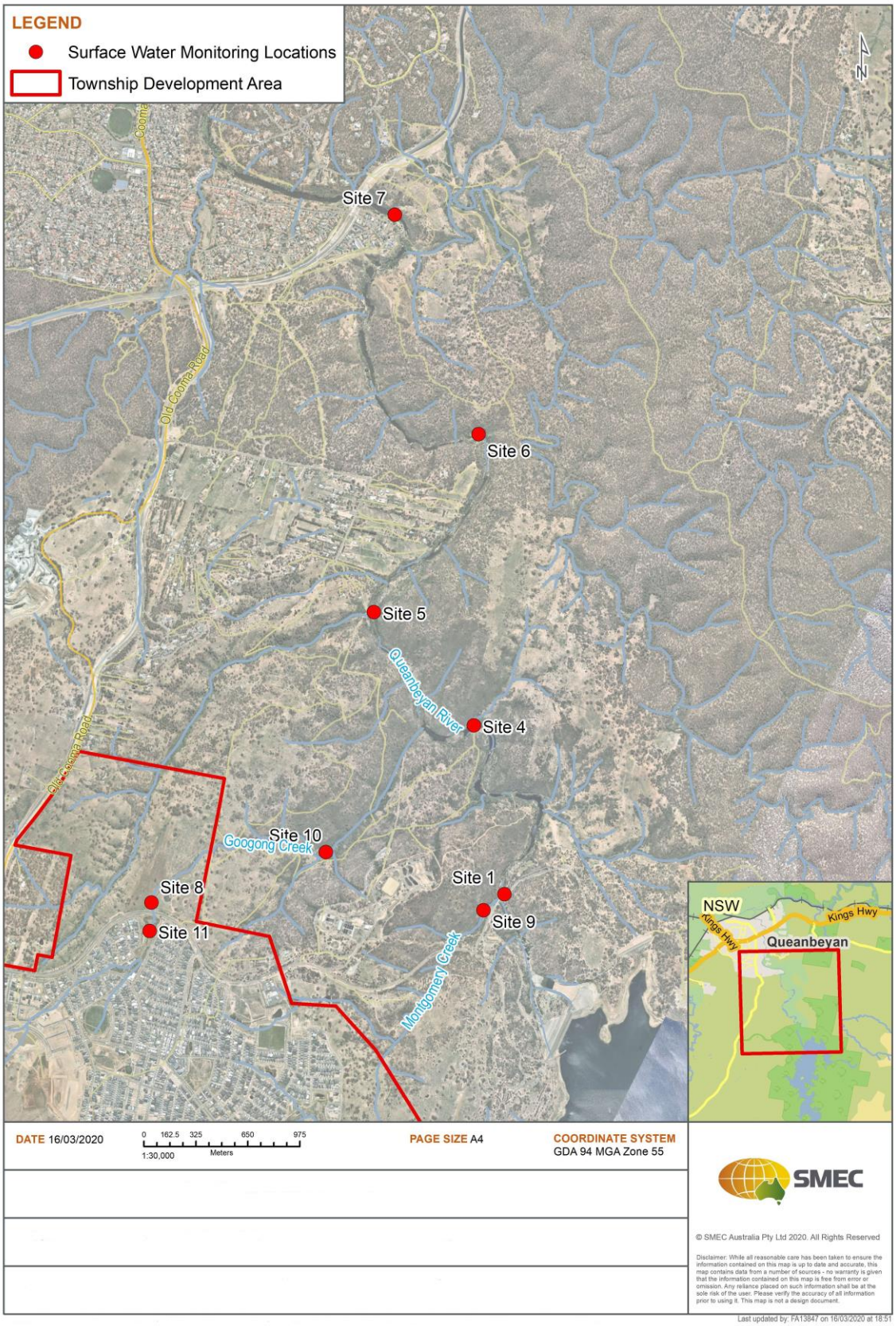


Figure 5: Surface Water Monitoring Locations

Table 2: Bore Construction Details

Bore ID	Casing Stickup (m)	Screen Interval (mbgl)	Gravel Pack Interval (mbgl)	Bentonite Seal (mbgl)	Backfill (mbgl)	Casing / Screen Size / Type
GGW1S	0.58	7.5 to 10.5	4.9 to 10.5	4 to 4.9	0 to 4	50mm / PVC
GGW1D	0.55	13 to 19	12 to 19	11 to 12	0 to 11	50mm / PVC
GGW2*	0.9	5 to 8	2.7 to 8	1.7	0 to 1.7	50mm / PVC
GGW2A	0.8	7.2 to 19.2	3.5 to 19.2	2.2 to 3.5	0 to 2.2	50mm / PVC
GGW3S	0.48	4.5 to 7	1.8 to 7	1 to 1.8	0 to 1	50mm / PVC
GGW3D	1.03	18.5 to 25.6	16 to 25.6	15 to 16	0 to 15	50mm / PVC
GGW4S	0.79	4 to 7	1.5 to 7	0.5 to 1.5	0 to 0.5	50mm / PVC
GGW4D	0.6	44 to 55	43 to 55	42 to 43	0 to 42	50mm / PVC
GGW5	3.83	32 to 43	27 to 43	26 to 27	0 to 26	50mm / PVC
GGW6	0.68	25 to 43	12 to 43	11 to 12	0 to 11	50mm / PVC
GGW7S	1.052	1 to 3	0.5 to 3	0 to 0.5		50mm / PVC
GGW7D	0.7	7 to 19	5 to 19	4 to 5	0 to 4	50mm / PVC
PB*	0.5	30 to 66	23 to 66	22 to 23	9 to 22	125mm / PVC

mbgl – meters below ground level, PVC – polyvinylchloride * bore has since been decommissioned and buried or destroyed

Table 3: Bore survey details as at September 2014

Bore ID	Easting (UTM WSG84)	Northing (UTM WSG84)	RL Ground (mAHD)	RL Concrete Base (mAHD)	RL Top Monument (mAHD)	RL Top PVC Casing* (mAHD)
GGW1W	702954.6	6078765.14	723.43	723.54	724.22	724.12
GGW1D	702951.99	6078765.86	723.26	723.33	724.02	723.88
GGW2	703722.77	6078189.89	719.78	719.87	720.97	720.77
GGW2A	703767.12	6078212.24	714.60			715.475
GGW3S	703745.88	6078039.82				723.12#
GGW3D	703745.03	6078037.55				723.20#
GGW4S	702646.37	6078120.3	738.53	738.61	739.62	739.4
GGW4D	702648.54	6078117.95	738.58	738.66	739.38	739.26
GGW5	702779.39	6077894.96				744.60#
GGW6	701513.5	6076548.21	789.04	789.19	789.95	789.87
GGW7S	702830.23	6078473.95	725.66	725.71	726.77	726.712
GGW7D	702828.67	6078472.34	725.97	726	726.84	726.67

UTM – Universal Trans Mercator, WSG84 – World Survey Grid 84, RL – Relative Level, mAHD – metres Australian Height Datum, *casing is measuring point RL # approximate following extension of PVC and to be confirmed by survey

3 Proposed Works and Existing Environment – WRP Site

This section of the hydrogeological assessment details the existing environment at the WRP site area. The Stage D WRP works are summarised in Table 4 from RPS and shown on Figure 6. The permanent works are anticipated to be contained within the existing WRP site boundary with the temporary access road from Stage C re-opened and utilised during Stage D. This section of the hydrogeological assessment details the existing environment at the WRP site area.

Table 4: Summary of Stage D works at the WRP

Infrastructure element	Equipment / component	Stage D scope of works
Bioreactor	Bioreactor and membrane tanks	Construction of one larger Bioreactor tank
	Diffused aeration system	Install the single Bioreactor trains with Fine Bubble Diffused Aeration systems
	Mixed liquor return / Membrane Feed Pumps	Install larger mixed liquor pumps and larger Membrane Feed Pumps
	Aeration Blowers	Replace the existing blowers with three new larger units
Membrane Bioreactor (MBR) Membranes	Membrane tank	Construction of three MBR membrane tanks
	MBR Membranes	Install two sets of MBR membranes Install one additional set of MBR membranes when required (nominally 2032)
	Membrane Blowers	Replace existing blowers with three new larger units
Tertiary Feed System	Filtrate Storage Tank	Filtrate Storage Tanks installed were for ultimate capacity – no further upgrade required at Stage D
	Tertiary Feed Pumps	Replace two existing smaller pumps with new larger pumps (identical model to existing larger pumps)
	Tertiary Filters	Install a new Tertiary Filter skid complete with 56 modules to enable duty/assist/standby trains
	UV Disinfection Units	UV Disinfection Units installed at Stage C were for ultimate capacity – no further upgrade works expected at Stage D provided feed water UV Transmissivity (UVT) remains above 60%
	Chlorine Disinfection System	Chlorine Disinfection Units installed at Stages AB and C were for ultimate capacity - no further upgrade required at Stage D.
Recycled Water Storage and Transfer	Recycled water storage tank	Recycled Water Storage Tanks installed at Stage C were for ultimate capacity – no further upgrade required at Stage D
	Recycled water transfer pump station	Replace one existing smaller transfer pump with a new larger pump identical to the units installed at Stage C
Aerobic Digester	Aerobic digester tank	Construct new Aerobic Digester tank adjacent to the Stage C digester – hydraulic connection to be via concrete weir cut-out Install Fine Bubble Diffused Aeration system in the new tank as per the existing digesters
	Aerobic digester blowers	Existing digester blowers installed at Stages AB and C were sufficient to meet ultimate aeration demand - no further upgrade required at Stage D
	Rotating drum thickener (RDT)	Relocate and recommission the RDT to the top of the new Stage D Aerobic Digester tank
	Dewatering centrifuge unit	Install one new larger dewatering centrifuge (4 L/s capacity) Install an additional centrifuge feed pump to enable feed flow to both smaller and larger centrifuges (up to 7.5 L/s)

Infrastructure element	Equipment / component	Stage D scope of works
Biosolids Dewatering and Storage	Biosolids outloading conveyor system	Install a new biosolids outloading conveyor system to allow for transfer of dewatered biosolids from the new centrifuge unit to a new biosolids bin area north of the centrifuge building
	Biosolids bins	Install a new bin weighing system on the north side of the centrifuge building for 10 kL bins to enable duty/standby bins operation
Chemical storage and dosing	Chemical storage tanks	Chemical Storage Tanks installed at Stages AB and C were for ultimate capacity – no further upgrade required at Stage D
	Chemical dosing system	Upgrade the sodium hydroxide dosing line from Dosing Skid 3 to the new Bioreactor(s) Install new ferric sulphate dosing line from the Dosing Skid 3 to the new Bioreactor(s) Reconfigure and extend the acetic acid dosing line from south-west corner of Bioreactor No. 2 to the new Bioreactor(s) Reconfigure and extend the sodium hypochlorite dosing line from south-west corner of Bioreactor No. 2 to the new Bioreactor(s) and Membrane Tanks Reconfigure and extend the citric acid dosing line from south-west corner of Bioreactor No. 2 to the new Membrane Tanks
Emergency Detention Tank (EDT)	EDT tank	The existing EDT storage volume is considered sufficient to cater for wet weather attenuation for Stage D flows. Interconnecting pipework to potential additional EDT storage south of the Neutralisation Pit has been installed at Stage C.
	EDT return pumps	No further upgrade required to the existing EDT Return Pumps
Off-Spec / Effluent transfer system	Off-Spec Water Tank	Off-Spec Water Tanks installed at Stages AB and C were for ultimate capacity – no further upgrade required at Stage D
	Effluent Transfer Pumps	Install one (1) new Off-Spec/Effluent Transfer Pump with larger units to the existing set to operate in Duty / Assist / Standby configuration
Compressed Air System	Air compressors	Replace the existing air compressors with two larger capacity units
Odour control	Odour extraction network	Install odour covers for the new Bioreactor and Aerobic Digester tanks Expand odour extraction network to service the new Bioreactor, Aerobic Digester, centrifuge and biosolids conveyor system. This includes fit-out of odour covers and ductwork for the empty membrane tanks Replace existing odour discharge stack efflux cone with larger diameter cone
	Activated carbon units	No further upgrade required to the Activated Carbon Units at Stage D
Yard piping	Yard piping	Yard piping to suit the new Stage D assets
Electrical and control systems	Motor Control Centre (MCC) and electrical systems	Install MCC No. 4 and drives associated with new Stage D assets. Upgrade Uninterrupted Power Supply (UPS) to meet requirements of Stage D assets
	Programmable Logic Controller (PLC) and Supervisory Control And Data Acquisition (SCADA) systems	Upgrade PLC and SCADA as required to reflect new Stage D assets
	Generator	No further upgrade required to the standby generator system at Stage D

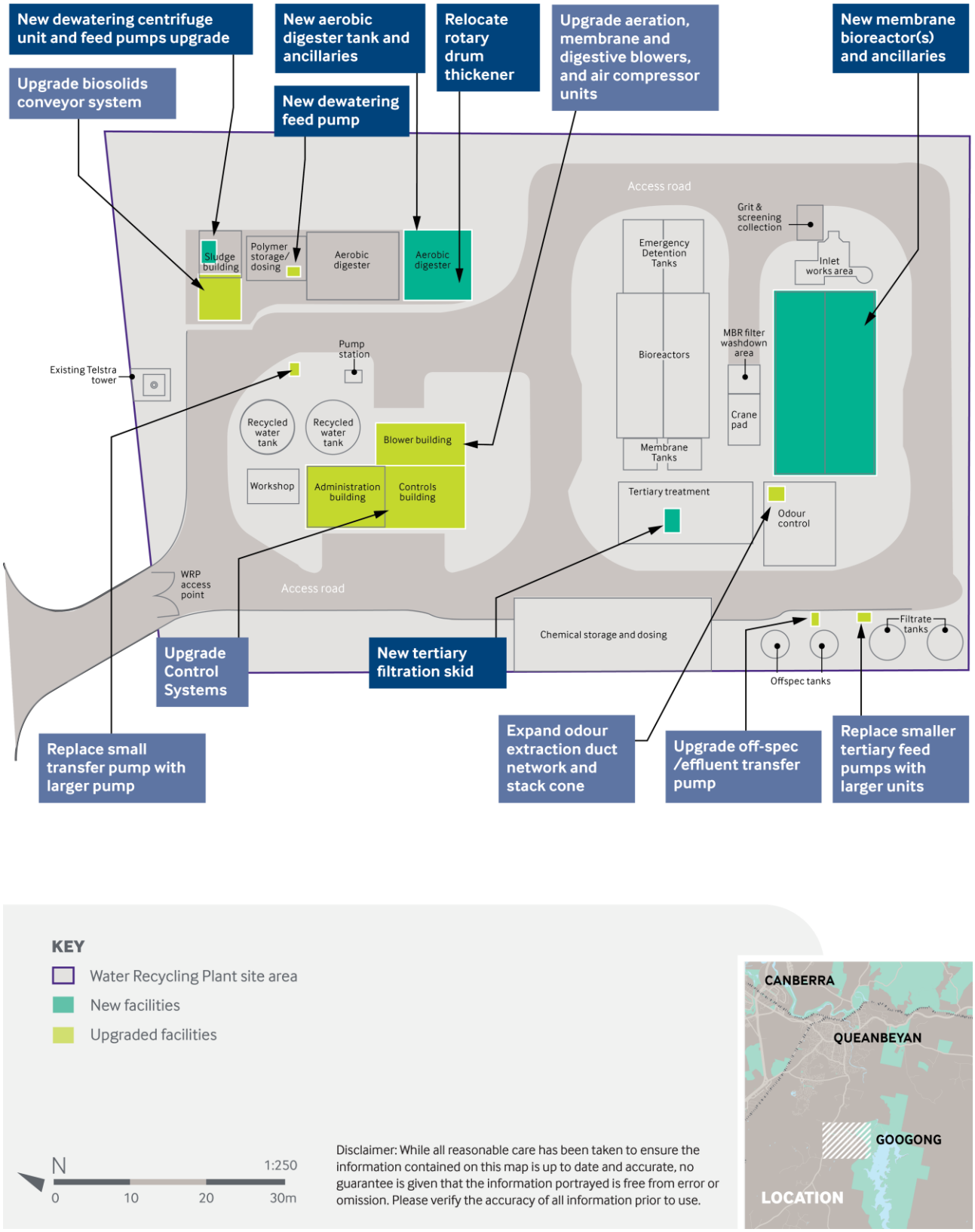


Figure 6: Stage D Infrastructure upgrades and works within the WRP (provided by RPS)

3.1 Site Location

The WRP is located within the north-eastern boundary of the Googong Township off Googong Road (Figure 4) and covers an area of approximately three hectares. Expansion of the WRP is to the south and east of the existing structures, within the existing WRP site footprint.

The recycled water discharge locations for Stage D of the IWC project are located at the permanent reservoir (Discharge Point 1) and at the Beltana Park Outlet Structure (Discharge Point 3) which are shown on Figure 7. Presently only Discharge Point 3 is used.

The following discharges will occur at these locations:

- Discharge Point 1 – EPA-licenced discharge point where recycled water in excess of township demand will discharge via a series of overland flow stormwater ponds in NH2 and the NH2 stormwater management system and flow into Beltana Pond. This discharge point is anticipated to come online in May 2020;
- Discharge Point 3 – EPA-licenced discharge point where recycled water that doesn't meet the *Essential Sewage and Recycled Water Quality Management Plan* (RWQMP) criteria but meets discharge criteria detailed in an operational Environmental Protection Licence is discharged. Discharge has been occurring at this location since 2016.

The emergency discharge point (EDP) is located at the WRP (Figure 7) and in the event of an emergency discharge is directed to Montgomery Creek. Discharge Point 3 is currently used for discharge of recycled water in excess of the township demand as there is no use in the township. QPRC propose a change to the designation of the discharge locations such at Point 1 is used on occasion for operational purposes and Point 3 remains as the primary discharge point for any excess recycled water after township demand.

3.2 Surface Drainage

Surface water drainage in the vicinity of the WRP is predominantly east to south-east towards the foreshore boundary and drainage lines which feed into Montgomery Creek (Figure 7). Within the WPR compound surface drainage is contained within the IWC.

The WRP is designed with three types of surface water drainage systems:

1. First Flush – all the areas which are considered 'dirty' and likely to have had raw sewage/dirty water contact the surface drains to a first flush tank. This has been designed to capture the first 10 mm rainfall across all of the dirty areas – this water is put back to the head of works as soon as possible;
2. Chemical drainage – all areas that could be contaminated with chemicals drain to the neutralisation pit which is then treated and put back to head of works; and
3. Stormwater – all other areas drain to stormwater and are discharged directly to the Montgomery creek outlet.

3.3 Soils

The WRP is constructed on residual ground and reworked spoil. No fill has been imported to the site. Significant hardstand areas are present with limited vegetation. Rip-rap is installed for erosion control on the emergency discharge point and spring seep.

3.4 Surrounding Land Use and Potential Receptors

To the west of the WRP are residential houses; to the south is Duncan Fields; to the north is Googong Road and farmland; and to the east is the Googong Foreshores protection area surrounding Googong Dam. The nearest receiving surface water environment is the ephemeral Montgomery Creek which flows into the Queanbeyan River, followed by Googong Reservoir.

3.5 Geophysics

In 2009 Agsol undertook surface geophysical mapping using EM-31 and EM-38 ground conductivity meters which showed area of low to moderate conductivity responses (green to yellow colours) with some more conductive responses around the area now a spring (Figure 8). In 2014 (SMEC, 2014) undertook a geophysical survey down-gradient of the WRP which shows generally low to moderate responses (blue to aqua colours) with higher conductivities (green colours)

observed within the drainage lines and area that is now a spring (Figure 9). Further surveying of these areas around the WRP is not practical due to the power lines and fences introducing significant geophysical interference.

3.6 Local Geology and Hydrogeology

The WRP is located within the contact aureole zone of the Googong Adamellite which has intruded the dacite of the Coliton Volcanics. The adamellite outcrops north of Googong Road and beneath the WRP is approximately 5 to 8 m deep, below a highly weathered rock and soil horizon.

Shallow groundwater is present approximately 4 m below the surface (at around 717 mAHD) within the weathered bedrock, and the flow direction is easterly towards the nearest drainage line (Montgomery Creek). Regional groundwater flow direction is north-east (Figure 10).

3.7 Groundwater Level

The groundwater level in GGW2 showed minor responses to rainfall events however during construction of a trench for SPS2 the groundwater level response to rainfall was greatly increased due to the increased infiltration from the trench (Figure 11).

The groundwater level at GGW2A is considered to be artesian in that the water level in the standpipe is above the ground surface as shown on the groundwater hydrograph of Figure 12. A lock in cap was installed to allow the groundwater level to be measured rather than overflow the top of the casing. In general the groundwater level is at or just below the top of the casing around RL 715.5. The relative level of the spring discharge beneath the WRP plant has not be surveyed, however it is likely this discharge may reflect the groundwater system which feeds the creek line that flows east towards Googong Dam into Montgomery's Creek.

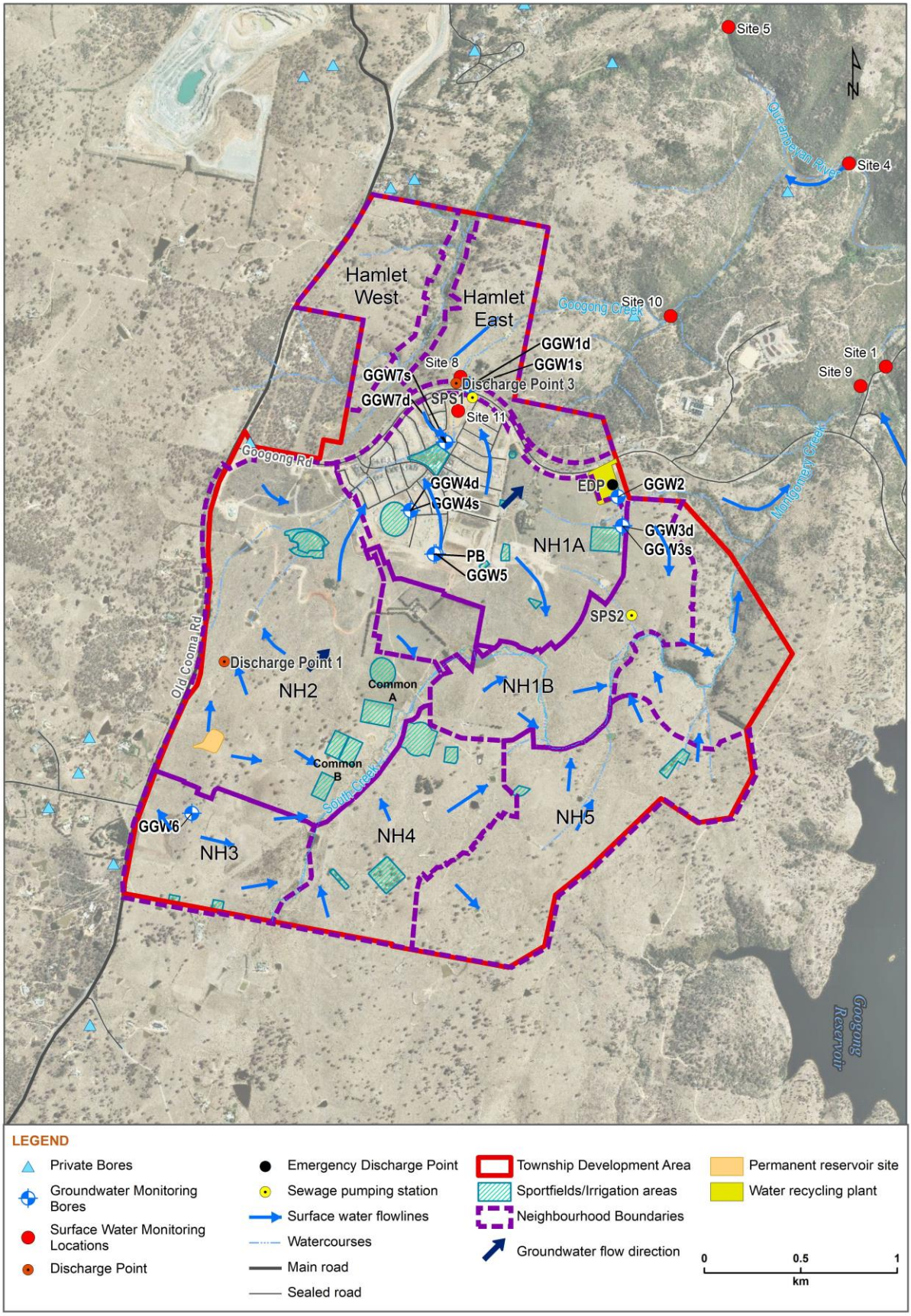


Figure 7: Location of WRP, Permanent Reservoirs, sewage pumping stations and discharge points with inferred surface water drainage

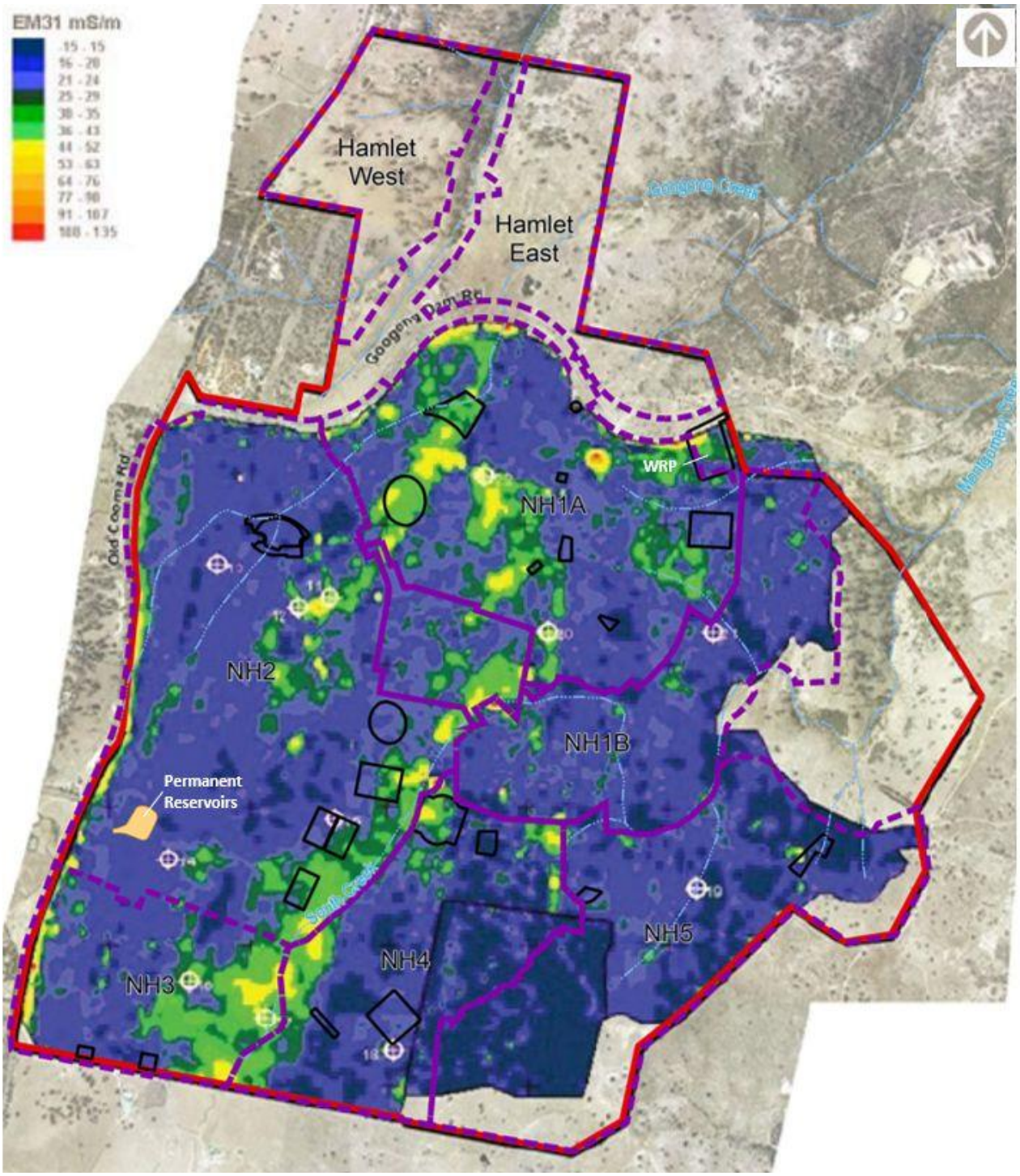


Figure 8: Agsol electromagnetic survey conductivity map (adapted from the WMP) with current and proposed sporting fields and irrigated open space outlined in black, permanent reservoirs (pale orange) and WRP

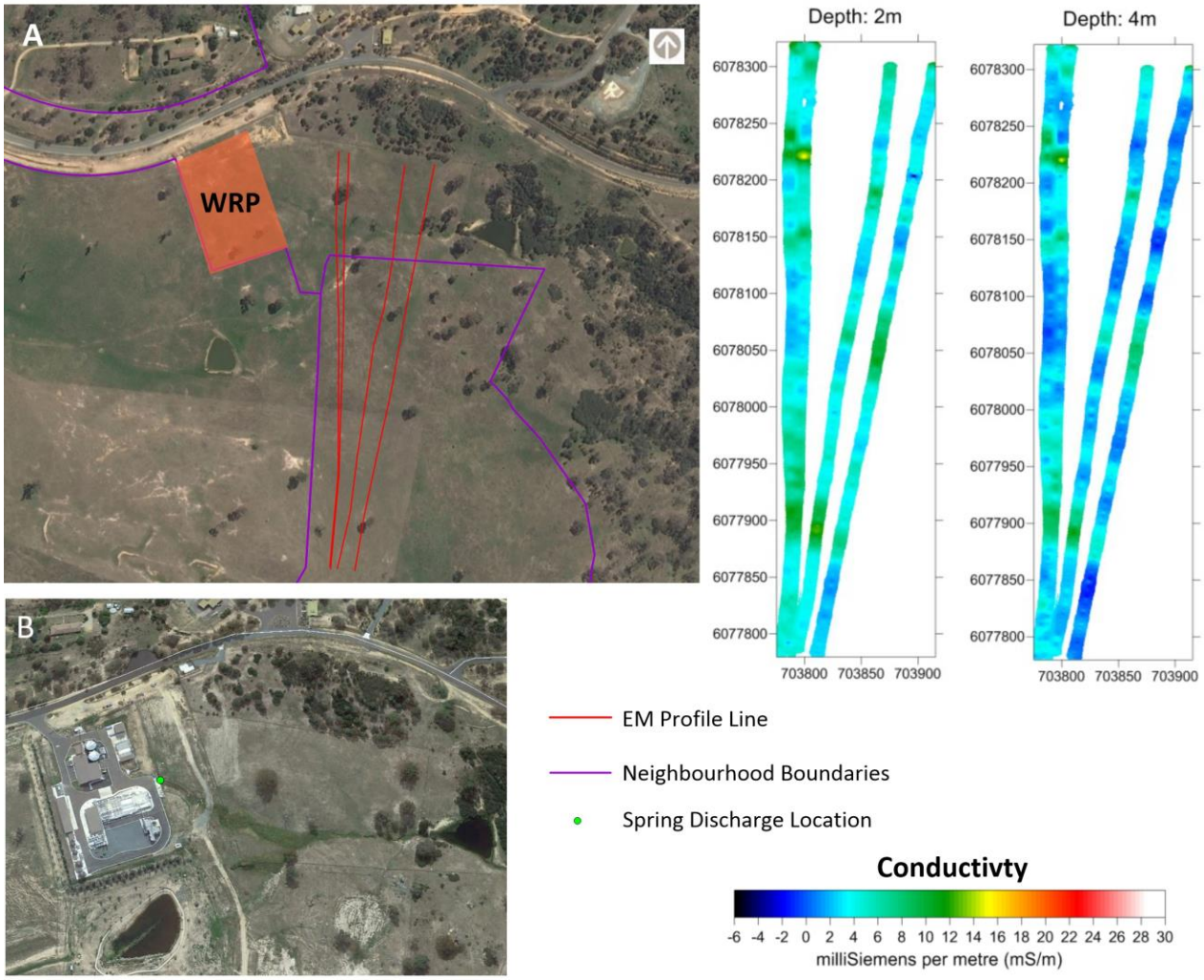


Figure 9: SMEC 2014 electromagnetic survey conductivity results at WRP to approximate depth of 2m and 4m with a) pre-development view and b) current WRP with spring discharge location

3.8 Groundwater Quality and Chemistry

The groundwater quality is monitored as part of the townships WMP. The groundwater monitoring parameters are described the GWMP of the WMP and include:

- Field measurements of pH, electrical conductivity, temperature;
- laboratory analysis of major ions, total and suspended solids, ammonia, nitrate, total nitrogen, total kjeldahl nitrogen, alkalinity; and
- laboratory measurement of dissolved heavy metals: cadmium, chromium, copper, lead, nickel, zinc ad total iron and manganese.

Site specific trigger values are outlined in the WMP for selected parameters and are shown on relevant figures within this report. Appendix A presents the groundwater monitoring results summary. Refer to the GWMP or Appendix A for the associated trigger value.

Monitoring bore GGW2 (was) located at the south-eastern corner of the WRP. Pre-construction monitoring (Figure 11) showed field pH generally ranged from 6.8 to 7.6 and a field EC ranging from 760 µS/cm to 1000 µS/cm. This bore showed impacts from the construction of the WRP and pipework trenches. In August 2015 it was decommissioned (for construction of the rising main pipeline) and replaced with a new bore (GGW2A) 48 m down gradient to the east. GGW2A (Figure 12) shows a field pH ranging from 6.6 to 8.1 and a field EC ranging from 1452 µS/cm to 2168 µS/cm.

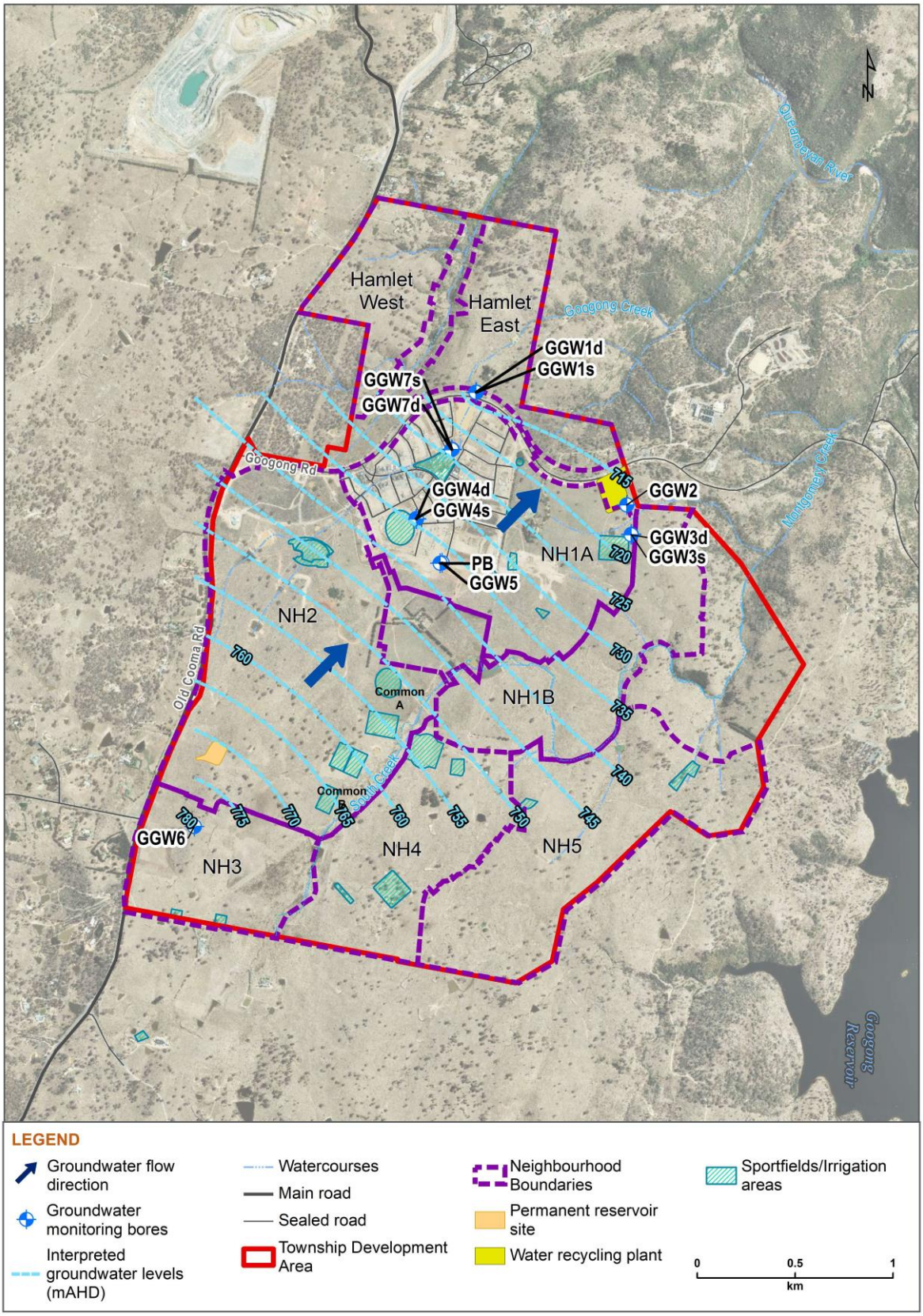


Figure 10: Regional Groundwater Contours and Flow Direction

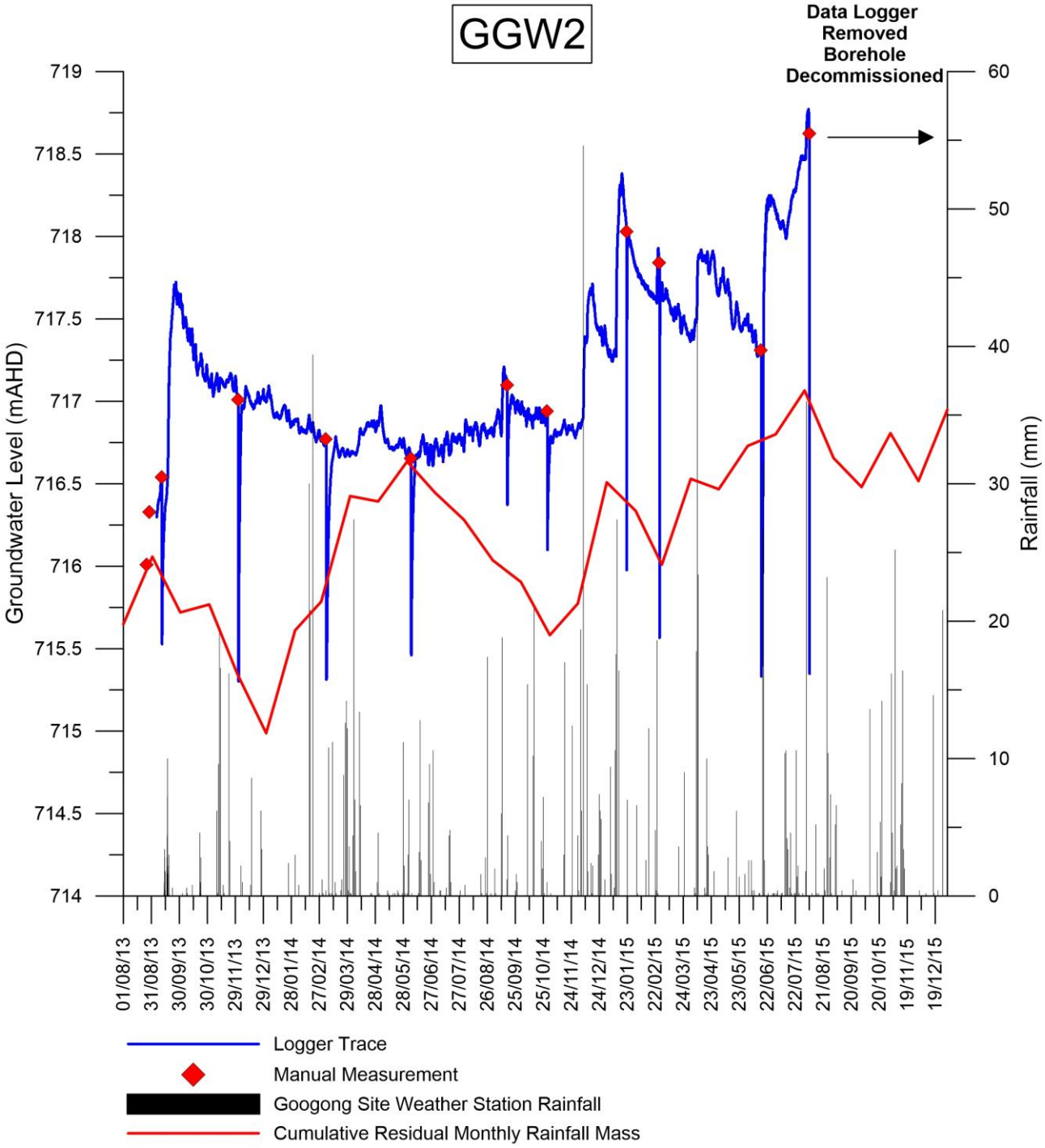


Figure 11: Groundwater level from GGW2 with rainfall and cumulative residual monthly rainfall mass

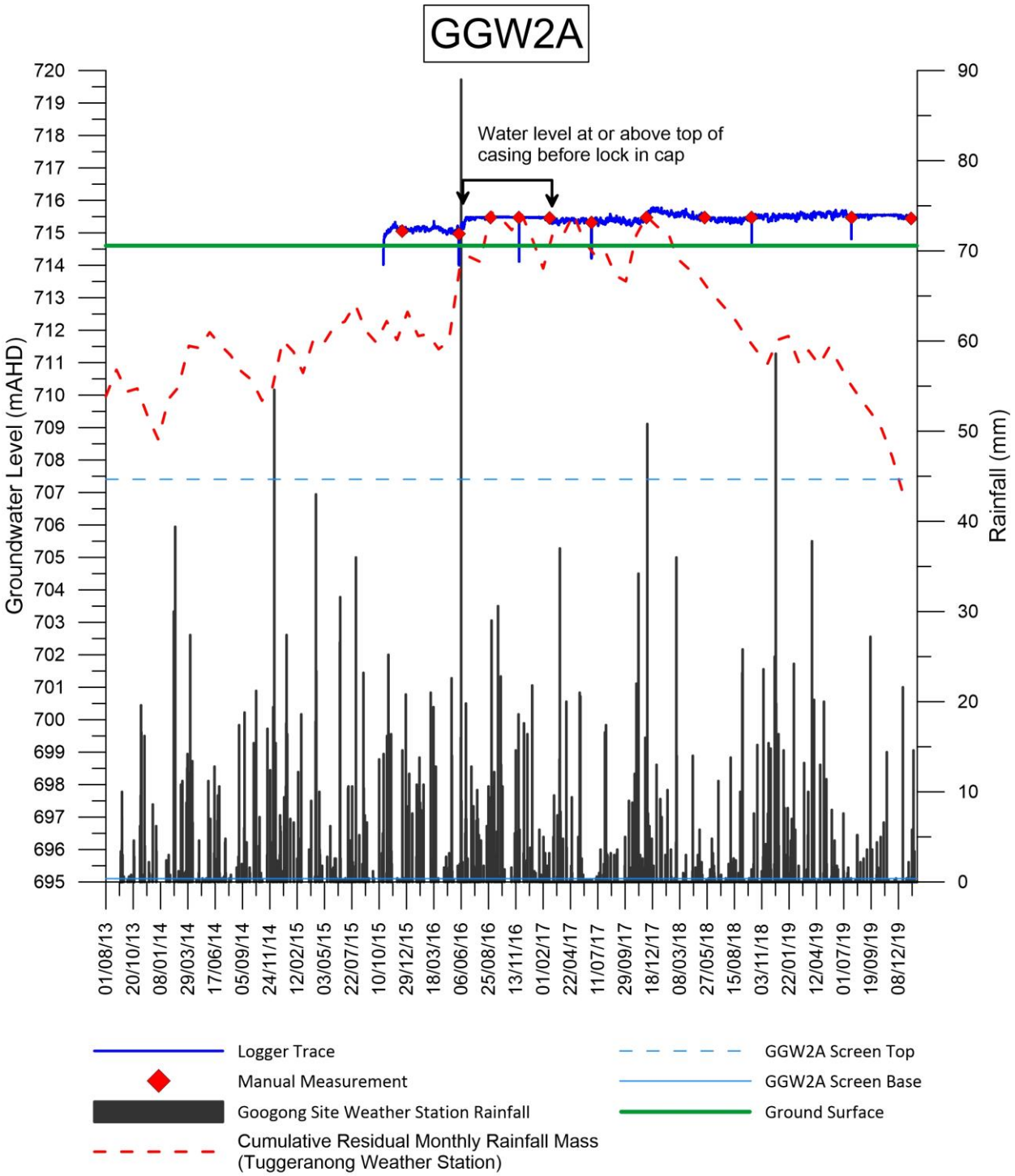


Figure 12: Groundwater level at GGW2A with rainfall, ground surface and screen interval

Figure 13 presents the time series plot of field pH and EC with major ion concentrations at GGW2A. The major ions are generally stable with an increase in sodium and chloride in July 2019. EC shows a general trend of increase which likely corresponds with the long-term trend of below average rainfall conditions and concentration of salts within the groundwater system (i.e. lack of dilution from recharge). Figure 14 shows the EC logger trace at GGW2A which increased until around November 2017, prior to a decreasing trend, followed by a further increase from September 2018. The decrease is likely due to increase irrigation with potable water during below average rainfall events.

The 2018 QPRC Annual Factual Monitoring Report (SMEC, 2019), and as shown on Figure 15, indicate the groundwater chemistry results for GGW2A were more similar to the results from GGW3D than GGW2. This reflects the change in location where moving downhill by 48 m has likely intersected the same groundwater aquifer which is intersected GGW3D located upgradient and to the south. Refer to Appendix A for groundwater chemistry results from the baseline monitoring period to July 2019.

3.9 Surface Water Quality

Montgomery Creek is the nearest surface water body to the WRP and the receiver of any emergency discharge water. To date there have been no emergency discharges of water. Montgomery Creek surface water Site 9 [of the WMP surface water monitoring program] is ephemeral and at times is dry. The field pH ranges from 6.5 to 8.5 and the field EC ranges from 94 µS/cm to 790 µS/cm. TDS ranges from 95 mg/L to 530 mg/L with TSS ranging from < 5 mg/L to 170 mg/L. When above the laboratory limit of detection TDS is generally higher than the other surface water monitoring sites.

3.10 Identification of Impacts

Impacts may be identified by comparing current monitoring data to baseline monitoring criteria, where available, WMP trigger values or observations of trends in the results not considered to be reflecting expected climatic variations. Increases in parameters such as pH, EC, TDS, heavy metals and nutrients may indicate a potential impact to the groundwater system. It is noted construction will likely have an impact that is typically short lived and may not be observed with the 6-monthly monitoring frequency indicated in the WMP.

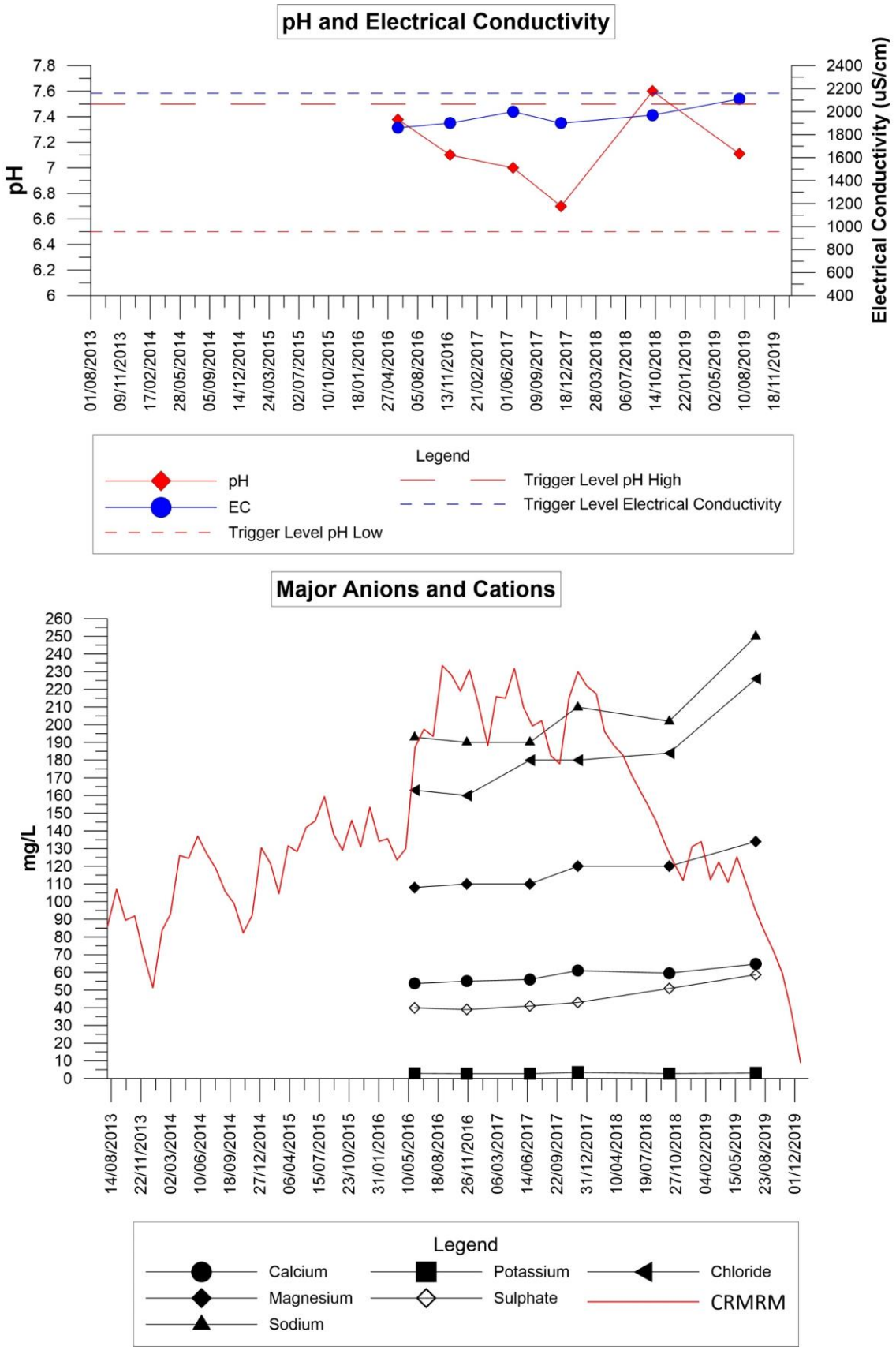


Figure 13: Time series plot of field pH and EC with major ion concentrations at GGW2A with cumulative residual monthly rainfall mass (CRMRM) and WMP trigger values

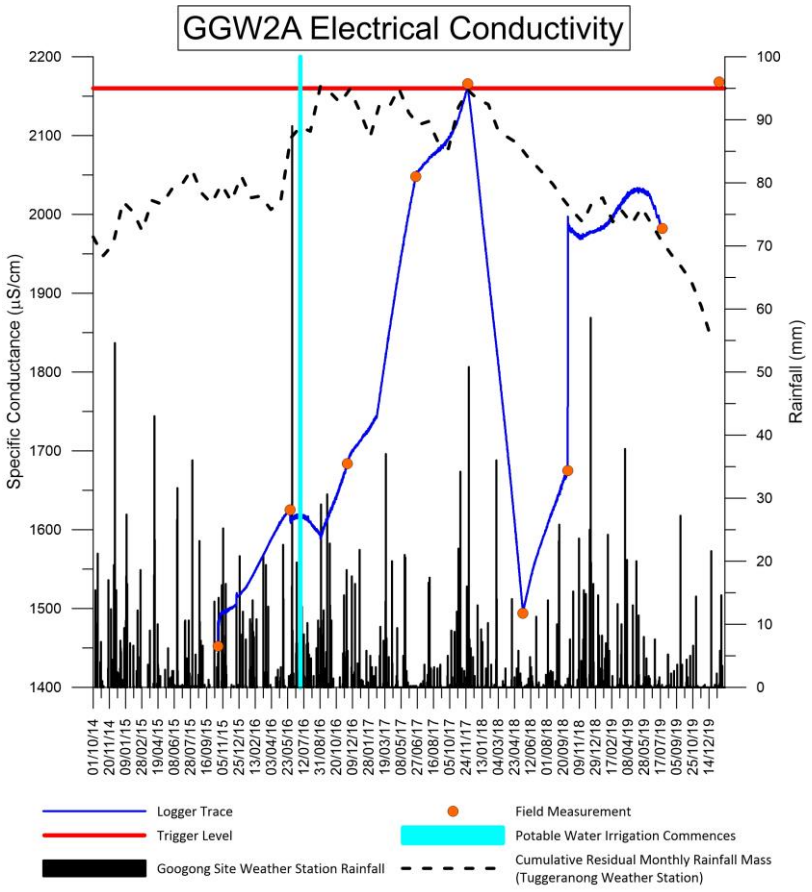


Figure 14: GGW2A electrical conductivity logger trace

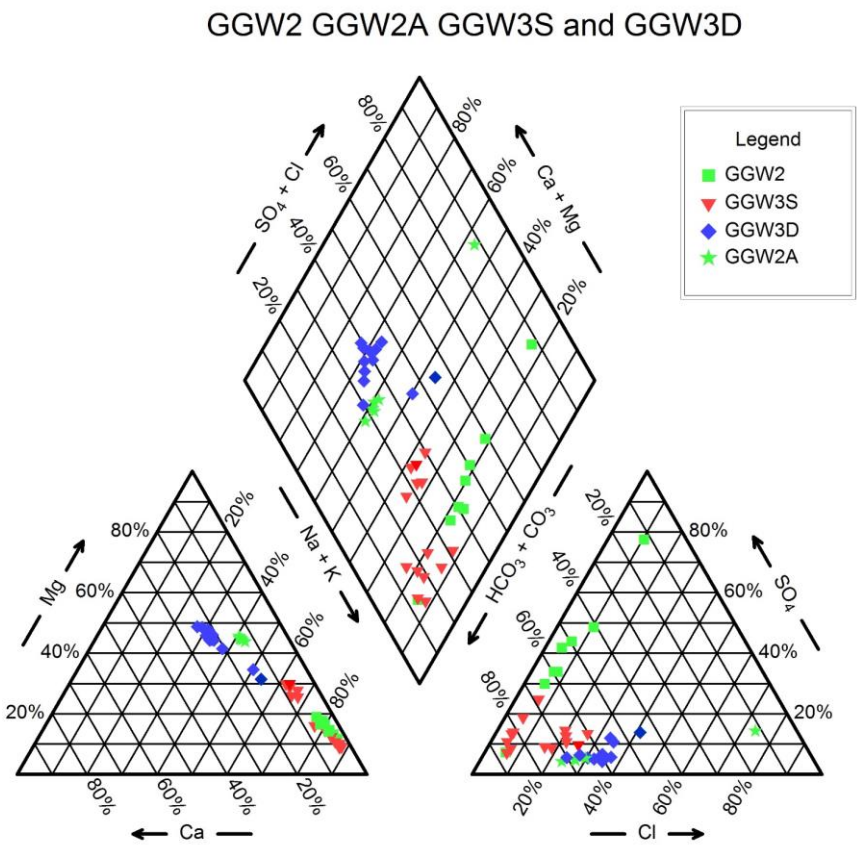


Figure 15: Piper diagram plot of groundwater results from GGW2, GGW2A, GGW3S and GGW3D for all monitoring rounds

4 Proposed Works and Existing Environment – Permanent Reservoirs

The Stage D works at the Permanent Reservoirs on Hill 800 are summarised in Table 5 from RPS and shown on Figure 16. The permanent works are anticipated to be contained within the existing WPR site boundary with the temporary access road from Stage C re-opened and utilised during Stage D. This section of the hydrogeological assessment details the existing environment at the Hill 800 Reservoirs site area.

Table 5: Summary of Stage D works at the Permanent Reservoirs on Hill 800

Infrastructure element	Equipment / component	Stage D scope of works
Recycled Water Reservoir	New 9 ML Recycled Water (ReW) Reservoir	Decommission of the existing Stage C sedimentation bund. Construct a new 9 ML ReW reservoirand associated pipework Piped connections to the new 8.5 ML ReW reservoir extended sufficiently far from the Stage C services terminating in direct buried isolation valves have all been included in Stage C
	Existing 4 ML ReW Reservoir	Convert the existing 4.0 ML ReW Reservoir into a Potable Water (PW) Reservoir (5.9 ML total potable water capacity). This includes emptying and cleaning (super-chlorination) of the existing reservoir for it to be repurposed for PW use
	Potable Water Booster Pumps	Decommission the existing Stage C PW Booster Pump Station Install a new Stage D PW Booster Pump Station and associated pipework to cater to flows for the higher elevation development areas
	Sodium Metabisulfite Dosing	Modify sodium metabisulfite dosing pipework to dose into the new Stage D chemical dosing chamber which will receive overflow stream from the new RW Reservoir
	Sodium Hypochlorite Dosing	Replace the existing recycled water sodium hypochlorite dosing pumps with new larger units (40 L/hr), if required
	Electrical and Control Systems	Upgrade the existing MCC, drives, PLC and SCADA systems to accommodate the new Stage D assets

4.1 Site Location

The Stage D Hill 800 reservoirs are located in NH2 in the south-west of the site, approximately 200 m from Old Cooma Road (Figure 2). The existing environment consists of two storage tanks of 4.0 ML capacity constructed as part of the Stage AB works, within a hardstand compound in the saddle of the hill.

4.2 Surface Drainage

The surface water within the permanent reservoirs compound, outside of the chemical areas, follows the site profile for overland drainage to surrounding areas. Chemical areas are bunded. Around the compound, surface water drainage is to the north-west and west. Discharge Point 1 is located north-west of the reservoir and forms the start of the overland flow system for excess recycled water.

4.3 Soils

The Hill 800 reservoirs are constructed on bedrock with some reworked spoil fill. No exotic fill has been imported to the site. Significant hardstand areas are present with limited vegetation. Outside the compound, bedrock outcrops at the surface.

4.4 Surrounding Land Use and Potential Receptors

The area surrounding the reservoirs site is currently farmland but will be developed as open space (Nangi Pimble Reserve) and residential areas within NH2 and NH3. Around 280 m south-west is an electricity substation. To the north is the start of development for Neighbourhood 2. Approximately 3.5 km to the east is the Googong Foreshores

protection area surrounding Googong Dam. The nearest surface water course is the ephemeral South Creek, located approximately 650 m to the east.

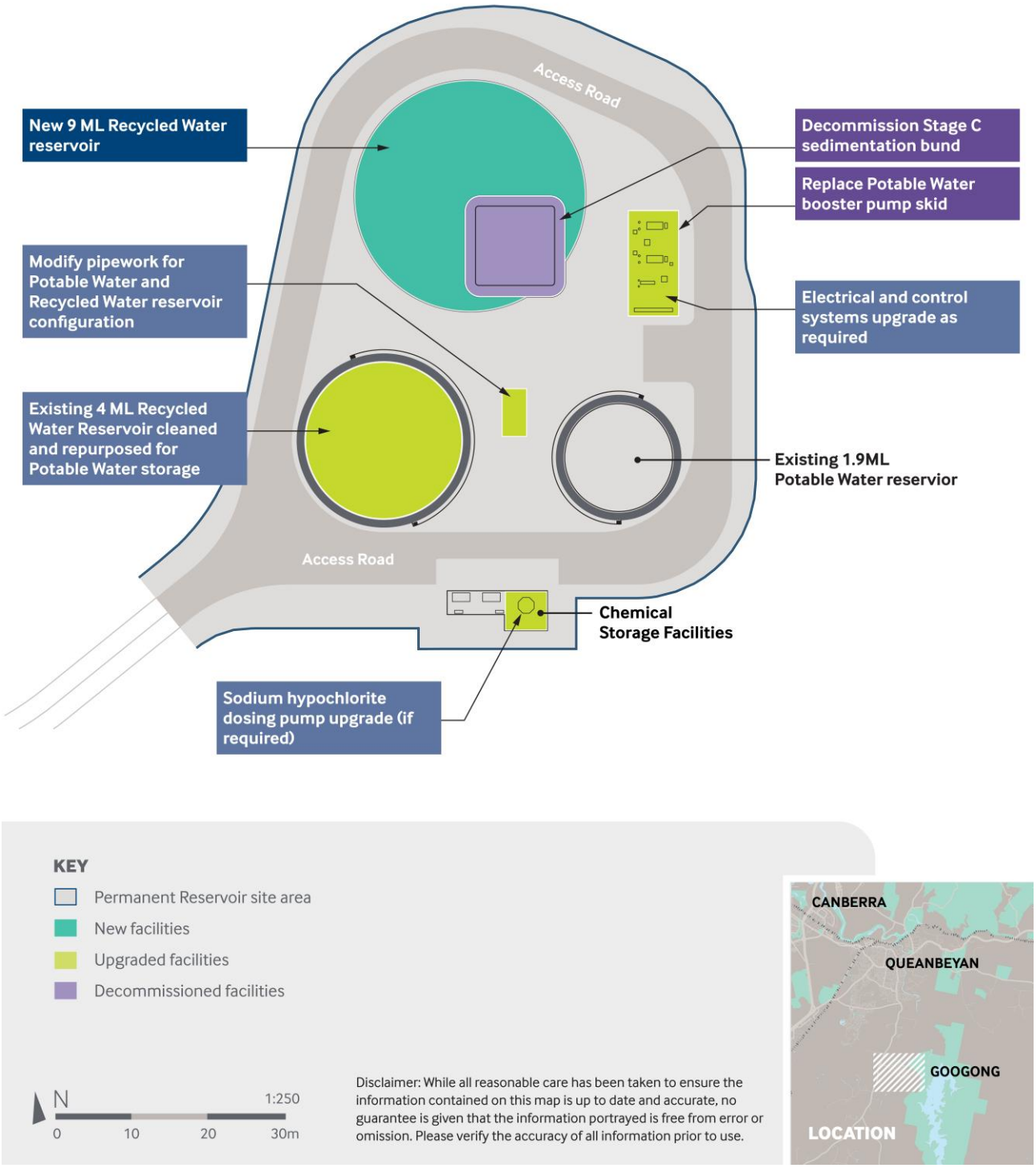


Figure 16: Permanent Reservoirs at Hill 800 Stage D design (provided by RPS)

4.5 Geophysics

The 2009 Agsol surface geophysical mapping using EM-31 and EM-38 ground conductivity meters which showed area of low conductivity responses (blue colours) on Figure 8 for Hill 800. To the north west of the site the linear feature of moderate conductivity (green colours) represents an existing natural drainage line where Stage D overland flow of excess recycled water is planned. No further geophysical surveys have been done in this area.

4.6 Local Geology and Hydrogeology

The geology of Hill 800 is anticipated to be dominated by Silurian Shale and dacitic Colinton Volcanics on the basis of drilling information at GGW6 and observed surface outcrops. Groundwater is hosted within a localised shallow (perched) unconfined aquifer which sits on top of the regionally semi-confined to confined fractured rock aquifer. The groundwater flow within the shallow aquifer is controlled by local topography and the direction is generally towards the nearest discharge line, i.e. creek or drainage channel. Groundwater is present within the rock at around 3 m to 9 m below ground surface (785 to 780 mAHD).

Approximately 640 m to the west of the site are four registered private bores, with yields of 0.76 L/s at GW400206, a stock and domestic bore in shale (total depth 39 m), and 12.5 L/s at GW402109, a stock a domestic bore in volcanics (total depth 23 m). These bores are up-gradient of the site and higher yields may be from influence of the nearby granitic intrusion.

4.7 Groundwater Level

The groundwater level at GGW6 is considered semi-confined and is shown on the groundwater hydrograph of Figure 17. Since February 2017 the groundwater level shows a long-term trend of decline in response to below average rainfall conditions. Responses to rainfall recharge appear smaller than in the baseline monitoring, potentially reflecting the prolonged below average rainfall conditions.

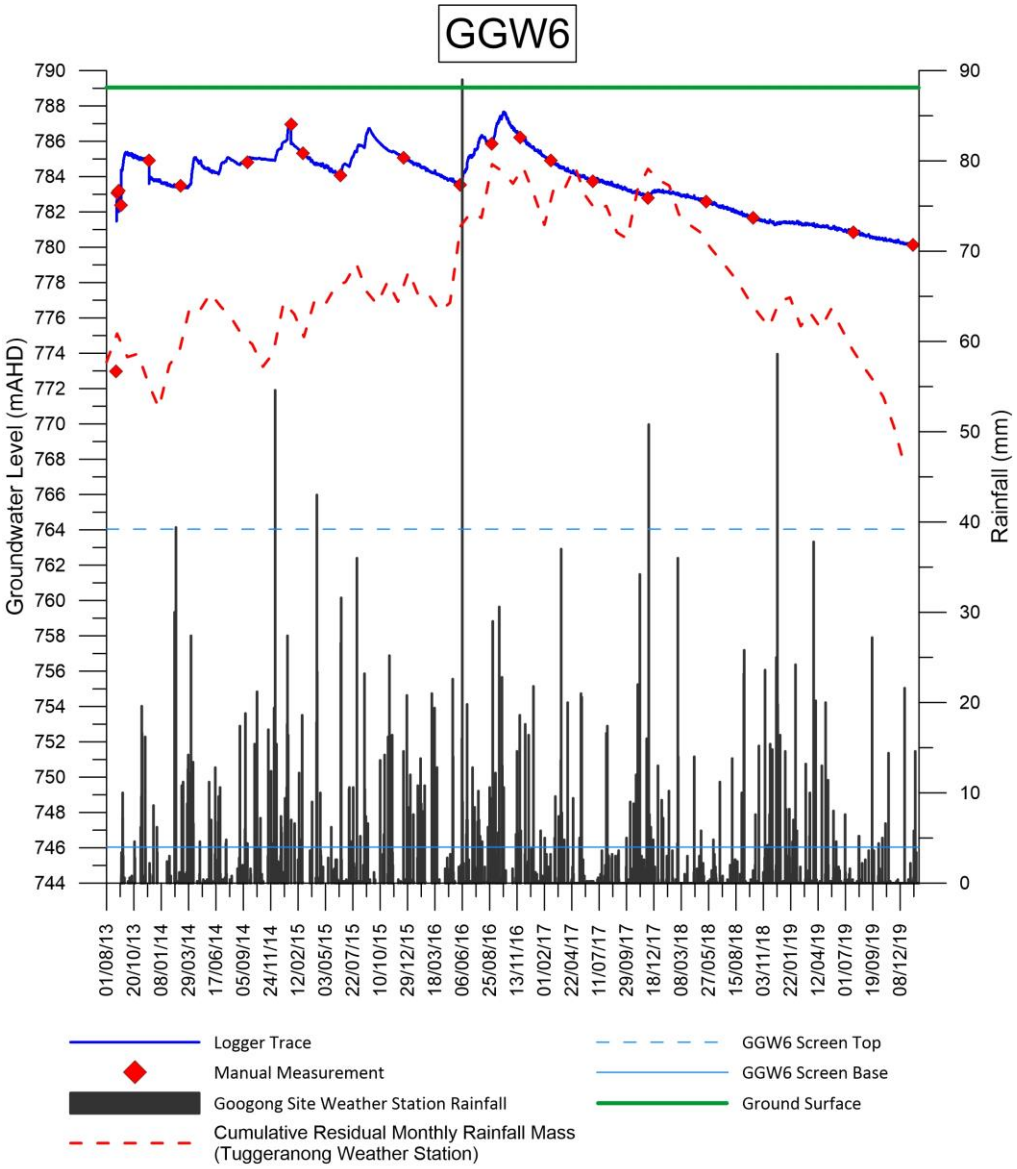


Figure 17: Groundwater level at GGW6 with rainfall, CRMRM, ground surface and screen interval

4.8 Groundwater Quality and Chemistry

Monitoring bore GGW6 is located 320 m south of Hill 800 reservoirs. Field pH generally ranges from 6.4 to 8.3 and a field EC ranging from 517 µS/cm to 1340 µS/cm. Figure 18 presents the time series plot of field pH and EC with major ions at GGW6. Except for sulphate major ions are generally stable. Construction for the electricity substation may have impacted some water quality results with increased recharge and disturbance from earthworks resulting in leaching of metals, nutrients and salts. This monitoring bore does not have an EC logger installed. Figure 19 presents the piper diagram plot of results for GGW6. With the exception of the November 2016, likely to have been influenced by the construction of the substation, each round of groundwater monitoring results is relatively consistent. Sulphate concentrations show an inverse relationship to the CRMRM long term climatic trend with increased concentrations during below average rainfall. Appendix A contains groundwater chemistry results from the baseline monitoring period to July 2019.

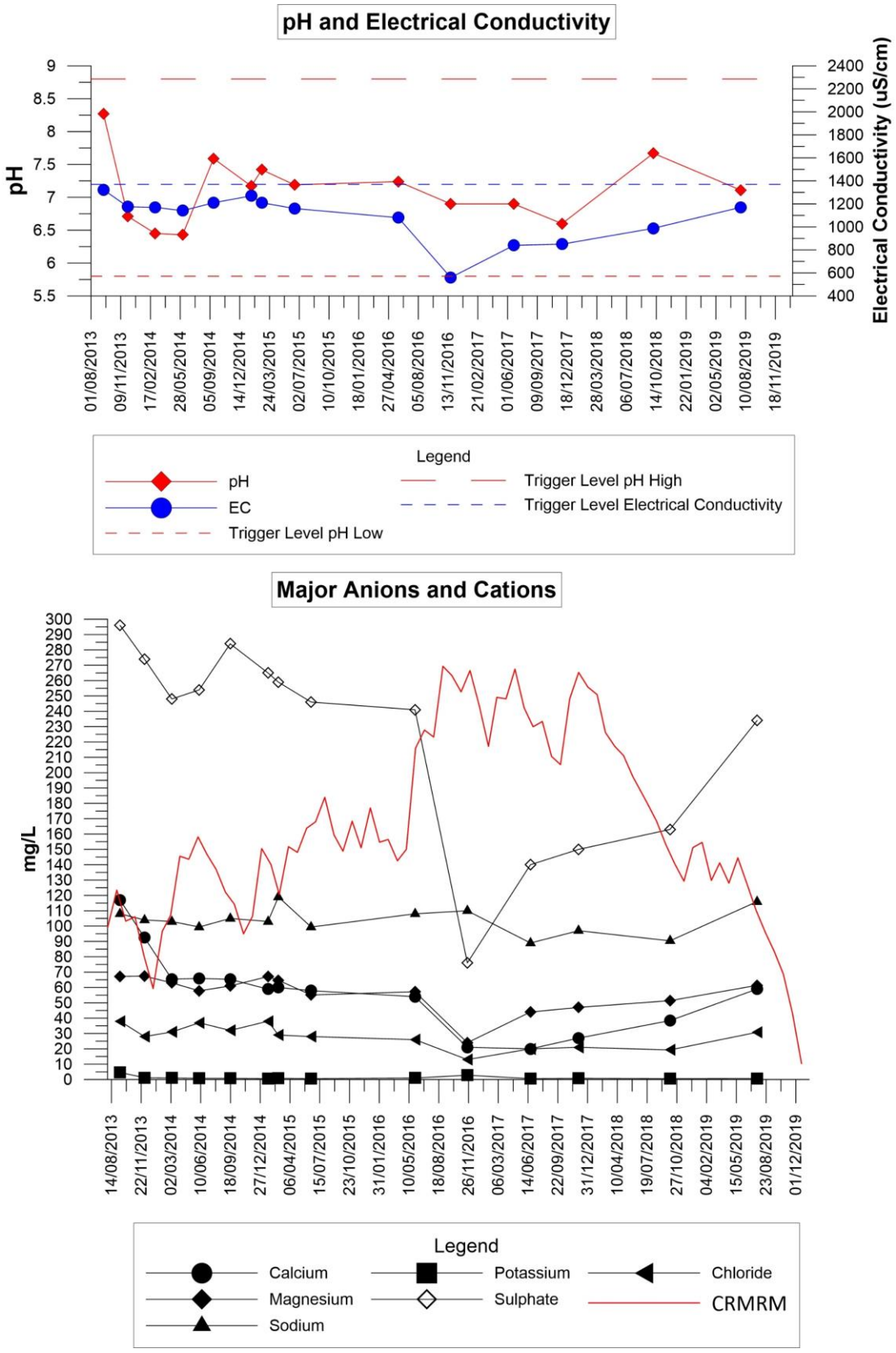


Figure 18: Time series plot of field pH and EC with major ion concentrations at GGW6 with cumulative residual monthly rainfall mass (CRMRM) and WMP trigger values

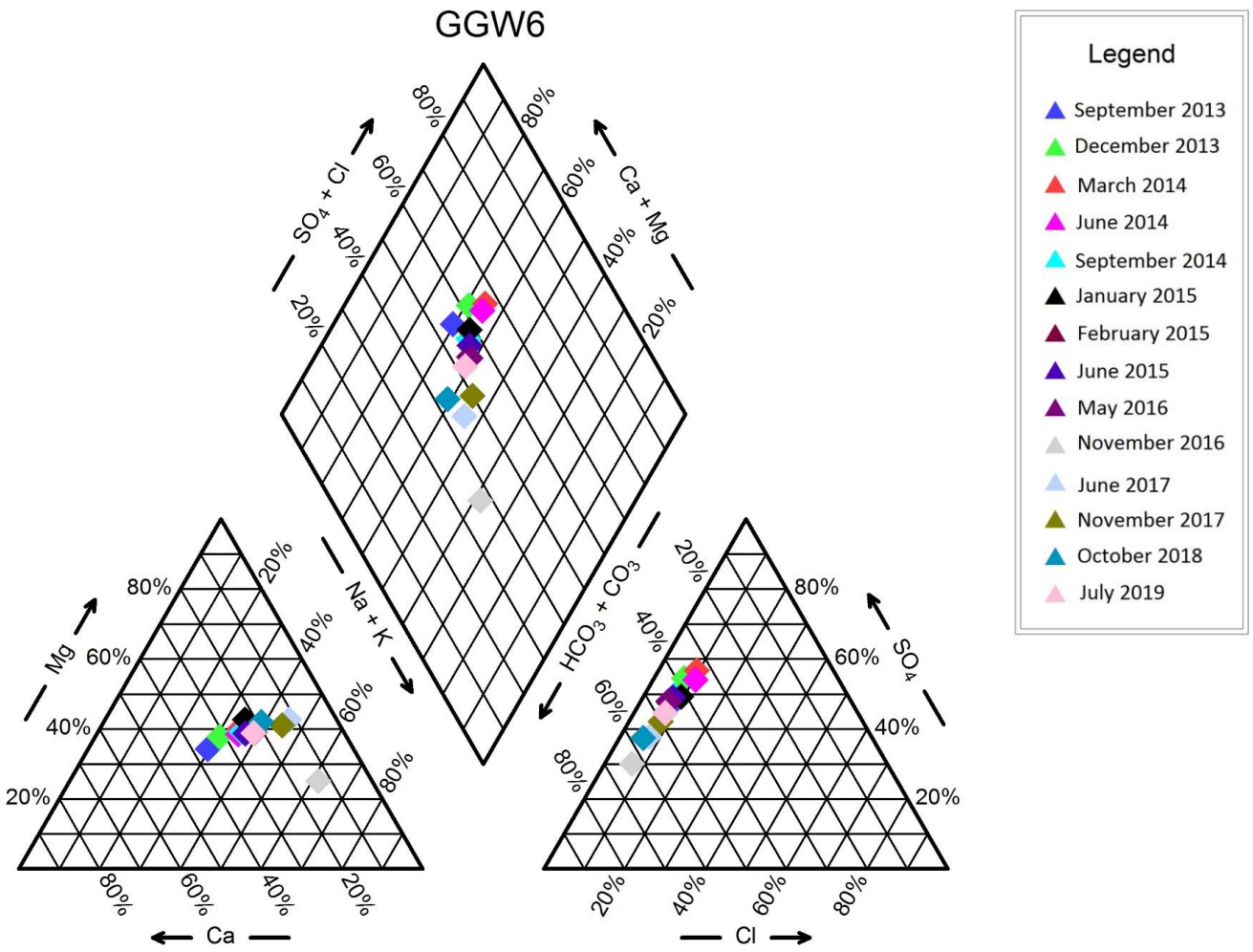


Figure 19: Piper diagram plot of groundwater results from GGW6 for all monitoring rounds

4.9 Surface Water Quality

There are no surface water sampling sites established in South Creek.

4.10 Identification of Impacts

Impacts may be identified by comparing current monitoring data to baseline monitoring criteria, where available, WMP trigger values or observations of trends in the results not considered to be reflecting expected climatic variations. Increases in parameters such as pH, EC, TDS, heavy metals and nutrients may indicate a potential impact to the groundwater system. It is noted construction will likely have an impact that is typically short lived and may not be observed with the 6-monthly monitoring frequency indicated in the WMP.

5 Existing Environment – Stage D Irrigation Areas

Once Stage D is completed, recycled water from the WRP will be used on public spaces (including sports fields) and residential and other properties across all neighbourhoods within the Googong Township. These include both current and future public spaces and properties. Figure 20 presents the township development plan with neighbourhood layout and open spaces consisting of parks, sporting fields and protected areas. NH1A and NH1B have been constructed, NH2 has commenced development in the norther portion. Residential development will be ongoing over the next 25 years. Existing open spaces as part of the Stages AB and C works are:

- Beltana Pond;
- NH1 Local Parks 2 and 3;
- Sportsfield 1 (Rockley Oval);
- Sportsfield 2 (Duncan Sporting Fields);
- NH1 Local Park 4 (Dog walking park); and
- NH1 Local Parks 5, 6 and 7.

Future planned open spaces within the Stage D development are proposed:

- NH2 Park 2 – September 2020;
- NH2 Town Centre – September 2025;
- NH2 local Park 8;
- NH3 Local Park 3;
- NH3 civic space;
- NH3 Local Park 10;
- Common A: Sportsfield 3 (S3) – December 2020;
- Common A: Sportsfield 4 (S4)– June 2023;
- Common B: Sportsfield 5 (S5) – April 2026;
- Common B: Indoor Sport Centre – January 2027;
- Neighbourhood 4 Civic Space;
- NH4 local Park 11;
- NH4 local Park 12;
- NH5 local Park 5 – August 2028;
- Neighbourhood 5 Civic Space;
- NH5 local Park 13
- Common B: Sportsfield 6 (S6)– November 2028;
- NH4 Sportsfield 7 (S7) – September 2031;
- Googong Common Drainage Reserve;
- NH5 Dam Foreshore protection reserve; and
- NH5 Pink tailed worm lizard conservation area.

Existing reports covering the hydrological environment for the township is are:

- Groundwater Assessment – Googong NSW, September 2010. (C.M Jewell and Associates; J0991.10R-rev4);
- Googong Hydrogeological Services: Annual Groundwater Monitoring Report – December 2014 (SMEC Australia, 30011525-AF);
- Groundwater Monitoring Program – October 2015 (RPS Manidis Roberts);
- Irrigation Management Plan – October 2015 (RPS Manidis Roberts);
- Stage C WRP Hydrogeological Assessment – August 2016 (SMEC Australia, 30011525-AR);

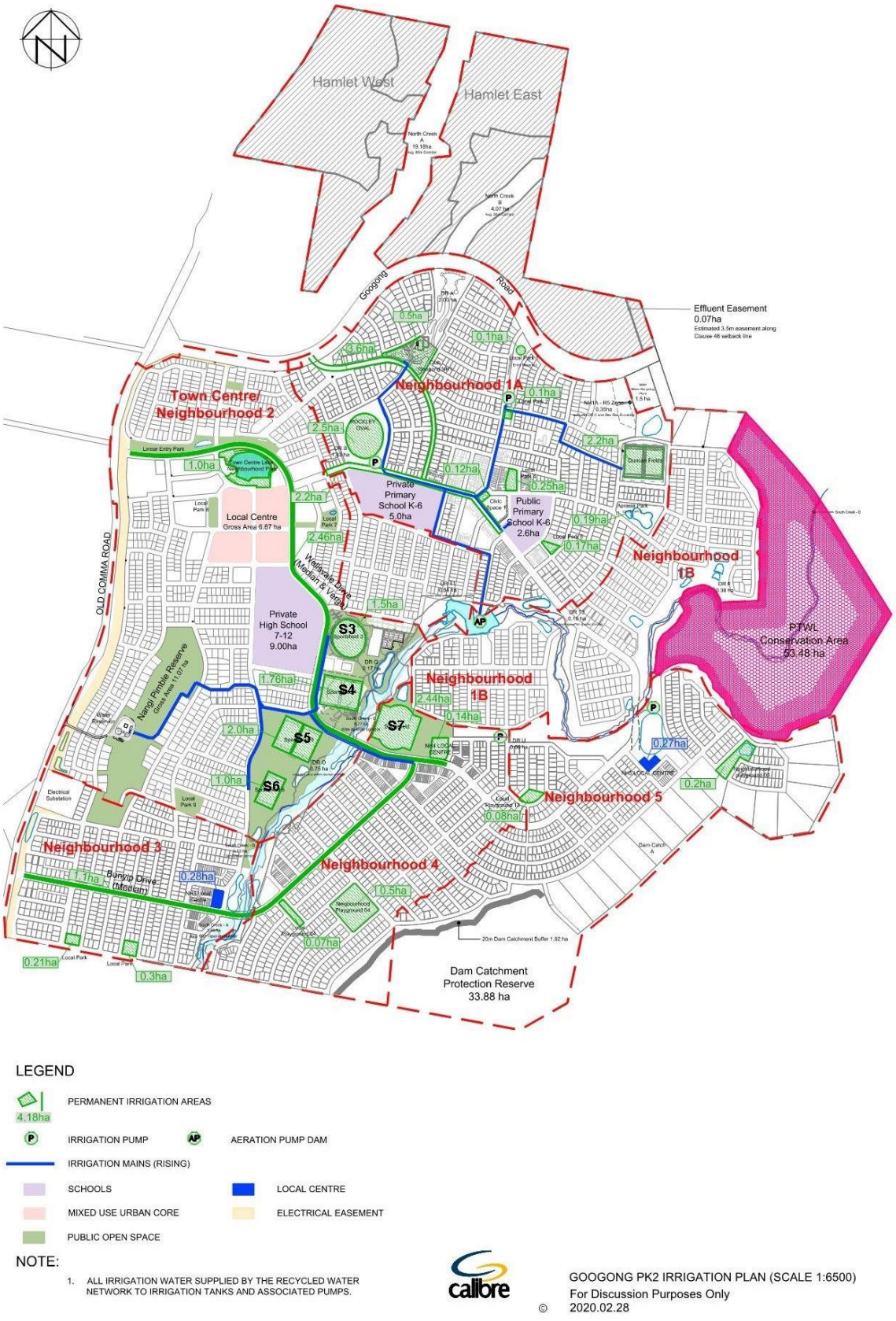


Figure 20: Googong Township Master Plan (provided by RPS) with neighbourhood developments, open spaces and sporting fields

- Googong Hydrogeological Services: Annual Monitoring Report – October 2017 (SMEC Australia, 30012126 – AR01); and
- Googong Hydrogeological Services: Annual Factual Monitoring Report – May 2019 (SMEC Australia, 30012126 – AR02).

NH1AB and NH2 have been discussed in the Stage C WRP Hydrogeological Assessment, although it is noted that there has been a change to the final design of NH2 with respect to the location of some open spaces for irrigation. The land for NH2 to NH5 is predominantly rural grazing land with sparse trees and several dams. Irrigation with potable water occurs in NH1A, with recycled water irrigation expected to commence in the second quarter of 2020.

5.1 Surface Drainage

The surface water drainage for the developed neighbourhoods is controlled by the township design and contained within the IWC. Within the developed open spaces, such as Beltana Pond the surface run-off is towards the drainage creek and pond. For areas yet to be constructed the current surface water flow and drainage is controlled by the existing topography and drainage creeks. Post development the surface drainage at several key locations is inferred as:

- Common A and Common B: sports fields – surface drainage from the sports field surfaces would be captured by the IWC stormwater;
- Common A and Common B area – surface drainage east to north east towards South Creek;
- NH2: Nangi Pimble Reserve - surface drainage would be towards the north and be contained within the IWC stormwater system;
- NH4: Sporting Field 7- surface drainage form the sporting field surface would be captured by the IWC stormwater, areas surrounding the sporting field would drain toward the north towards South Creek;
- Dam Foreshore Protection Zone: surface drainage is to east towards Googong Dam;
- PTWL Conservation Zone: surface drainage is north towards Montgomery Creek.

Other small parks and open spaces would have surface drainage contained within the IWC stormwater system. Flooding is generally not considered to be of concern for Common A and B and Sporting Field 7, but some localised inundation of low lying land may occur along South Creek.

5.2 Geophysics

The conductivity results reflect the soil composition (e.g. clays), soil moisture, soil salinity and shallow groundwater. Moderate to high conductivity values do not necessarily indicate high soil salinity. Higher values along waterways and drainage lines may indicate shallow groundwater and mobile salt discharge in these areas. The ground electromagnetic survey by Agsol (Figure 8) showed in general moderate conductivity values (greens to yellow) in the areas reflecting the surface water drainage pathways of South Creek and the upper reaches of Googong Creek.

It is important to note that these results will not be comparable with post-construction results within the township due to the significant landform changes, paving, buried services and buildings. Areas not significantly altered by the township development, such as parts of South Creek, are likely to be difficult to survey. Geophysical surveying is proposed for Rockley Oval and Duncan Sporting Fields post irrigation with recycled water under the Irrigation Management Plan (IMP).

5.3 Local Geology and Hydrogeology

The local geology of the township is shown on Figure 4. Limited investigation information is available in NH2 to NH5 for the bedrock material though the area is anticipated to be dominated by Silurian ages Colinton Volcanics with shale likely in parts of NH2 and NH3. Within NH2, Douglas Partners (2015) drilled five shallow boreholes, to depths of 5 m to 6 m around the permanent reservoir, which encountered the Silurian shale. Construction of Duncan Sporting fields did not intersect the Googong Adamellite which underlies it. Construction of Rockley Oval intersected shale and a shallow groundwater zone on the western side of the oval on the boundary with NH2. This 'groundwater spring' was observed during earthworks (when an old dam was removed) and discharge appeared to be higher following rainfall events.

Groundwater is hosted within a localised shallow (perched) unconfined aquifer which sits on top of the regional semi-confined to confined fractured rock aquifer. The groundwater flow within the shallow aquifer is controlled by local topography and is generally towards the nearest discharge point, i.e. creek or drainage line. For example: around the WRP the shallow groundwater flow direction is east towards Googong Dam. Near Beltana Pond and Googong Creek the

shallow groundwater flow direction is north to north-east towards the Queanbeyan River. The deep regional groundwater flow direction is north-east towards the Queanbeyan River (Figure 10).

The groundwater level at the highest monitoring bore GGW6, in NH3, ranges from 780 mAHD to 786.9 mAHD. North-east of NH2 near Rockley Oval the groundwater level at GGW4D ranges from 733.8 mAHD to 734.8 mAHD. East of NH2 the groundwater level at GGW5 ranges from 736.9 mAHD to 737.8 mAHD. The regional groundwater level in Common A and B is likely to be within the range of 760 mAHD to 740 mAHD. No groundwater level information is available in 1B, NH4 and NH5 the south eastern portion of the township nor in NH2 the western portion.

Groundwater head differs by less than 0.5 m between the shallow and deep aquifers, as has been recorded at nested monitoring sites GGW3 and GGW4. The shallow groundwater aquifer is connected to the deeper regional aquifer and is part of the rainfall recharge pathway. In areas of lower elevation and along creeks, groundwater is likely to be encountered at shallow depths (e.g. less than 5 m), with the depth of intersection largely related to climatic conditions. Shallow groundwater may be absent during extended dry periods. Based on the SMEC pumping test which had a yield of 0.07L/sec near GW5 in January 2014, yields are likely to be low.

5.4 Groundwater Quality and Chemistry

Groundwater monitoring has been undertaken at 11 locations as part of the pre-construction phase of Stage AB, the results of which are discussed in the SMEC 2014 Annual Groundwater Monitoring Report and subsequent monitoring is in accordance with the WMP and presented in the SMEC 2018 *Annual Factual Monitoring Report*. Refer to Appendix A for groundwater level and chemistry results from monitoring data. Monitoring shows the following field groundwater quality ranges:

- Field EC (shallow): 425 µS/cm to 2166 µS/cm;
- Field EC (deep): 425 µS/cm to 2887 µS/cm;
- Field pH (shallow): 6.5 to 8.8; and
- Field pH (deep): 5.8 to 8.3.

The installation of EC data loggers in late October 2014 in selected monitoring bores was to assess fluctuations in EC with rainfall and recycled water irrigation, as shown on Figure 21 to Figure 26 (refer to Figure 14 for GGW2A). It was however communicated by QPRC after the first year of data collection that irrigation was with potable water not recycled water. Recycled water irrigation is planned to commence in May 2020. Figure 21 presents a combined time series plot of EC logger data from monitoring bores with irrigation volume at Rockley Oval and Duncan Sporting Field. The data does not show any clear correlations of increases EC with irrigation over the changes in EC that occur in relation to long term climate trends observed in other bores.

The groundwater chemistry results indicate the water type is generally bicarbonate dominate, sulphate type with variable metals. Changes in the water type likely reflect natural variations or the act of sampling. Figure 27 and Figure 28 presents Piper and Durov plots of the monitoring results from 2013 to 2019. The results show groundwater clusters into generally two distinctive groupings. GGW3S and GGW2 are distinctly different from the other groundwater bores, reflecting screening within the Googong adamellite. GGW1S plots slightly distinct from the main cluster, reflecting the limestone lithology due to the increased calcium component. The July 2019 sample from GGW2A is distinctly different from the main sample groups, with increased sodium and chloride, and may reflect influence from potable irrigation water due to the presence of fluoride and free chlorine.

Within each monitoring location the groundwater chemistry plots show a general cluster of consistent results each monitoring round with minor variations likely reflecting seasonal influences and the prolonged period of below average rainfall. GGW4S and GGW4D plot as two distinct clusters of points, reflecting the difference between the weathered shale and fresh shale. Refer to Appendix B for Piper plots of each groundwater monitoring location.

Nutrients observed in the groundwater likely reflect the rural land use history of the site and disturbances caused during construction. Most monitoring bores show short durations of increase which are likely related to excavation activities within the township development. Increases in TDS concentrations may indicate potential impacts to the groundwater from construction activities as is evident in GGW3S and GGW3D (Figure 29) in June 2014. The very high increase in TDS was likely a result of flooding of the boreholes, which was reportedly observed following a significant rain event in June 2014. Increased TDS is also observed in GGW1D in January 2015 and is thought to be related to rainfall events prior, localised earthworks, and increased discharge from Beltana Pond into Googong Creek. From August 2016, increased TDS may be related to the discharge of recycled water to Googong Creek. Refer to Appendix A for nutrients results at each groundwater monitoring location.

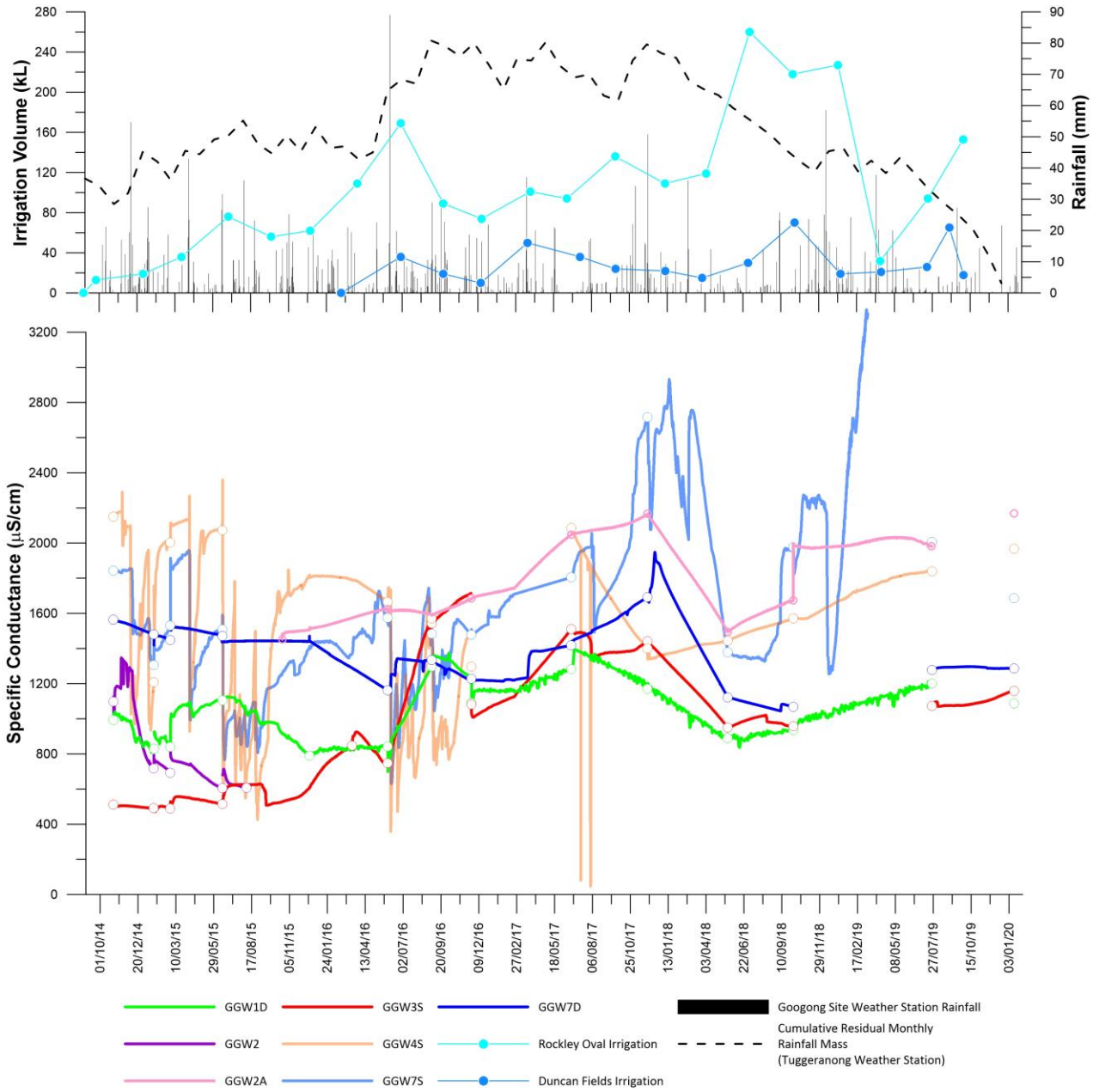


Figure 21: Time series plot of EC Data Logger results October 2014 to January 2020 with rainfall, CRMRM and potable irrigation volume

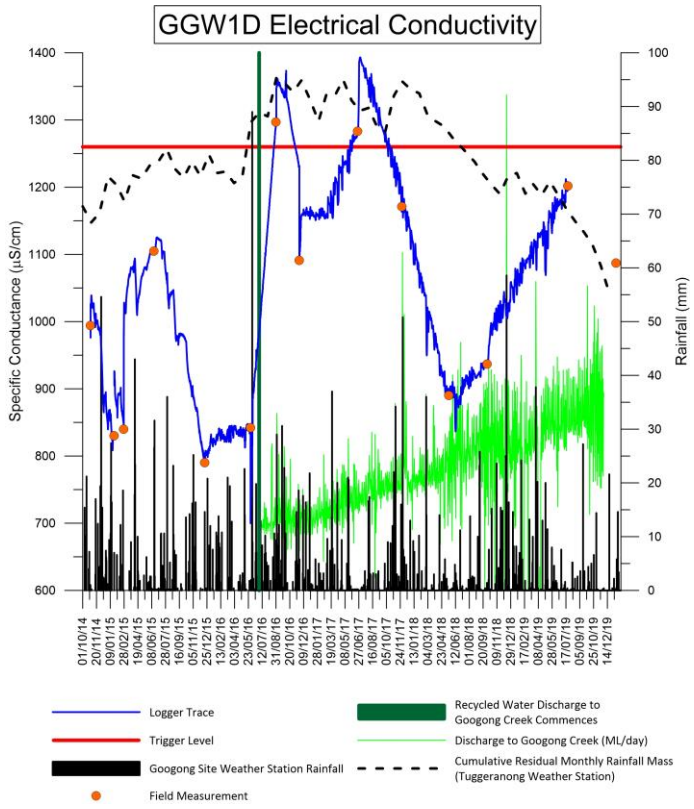


Figure 22: GGW1D time series plot of field EC and EC data logger results 2014 to January 2020 with rainfall, recycled water discharge and CRMRM

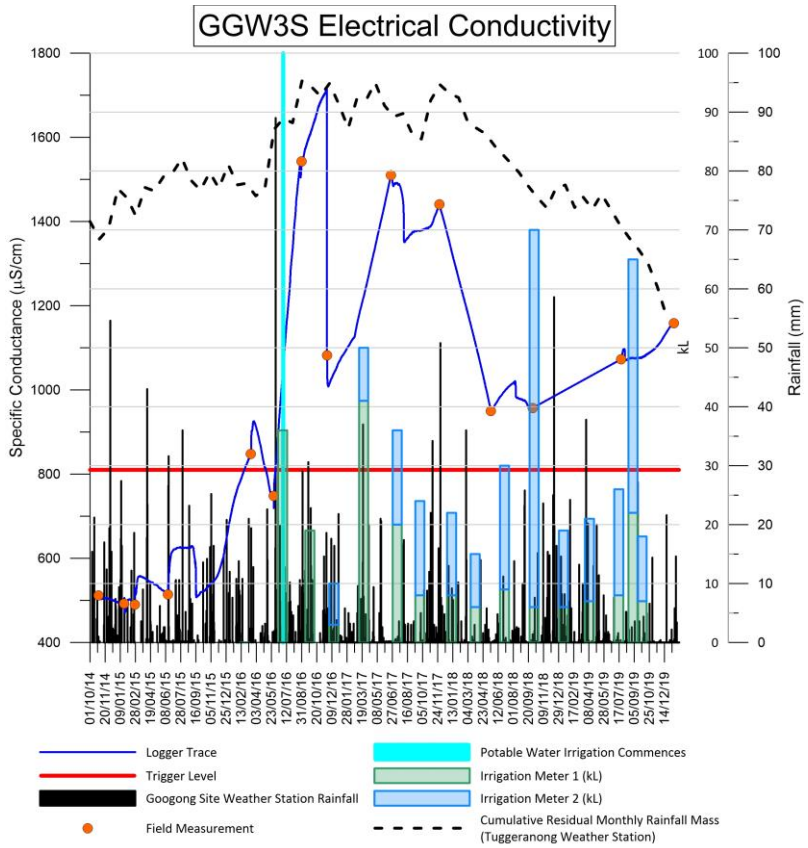


Figure 23: GGW3S time series plot of field EC and EC data logger results 2014 to January 2020 with rainfall, potable water irrigation load and CRMRM

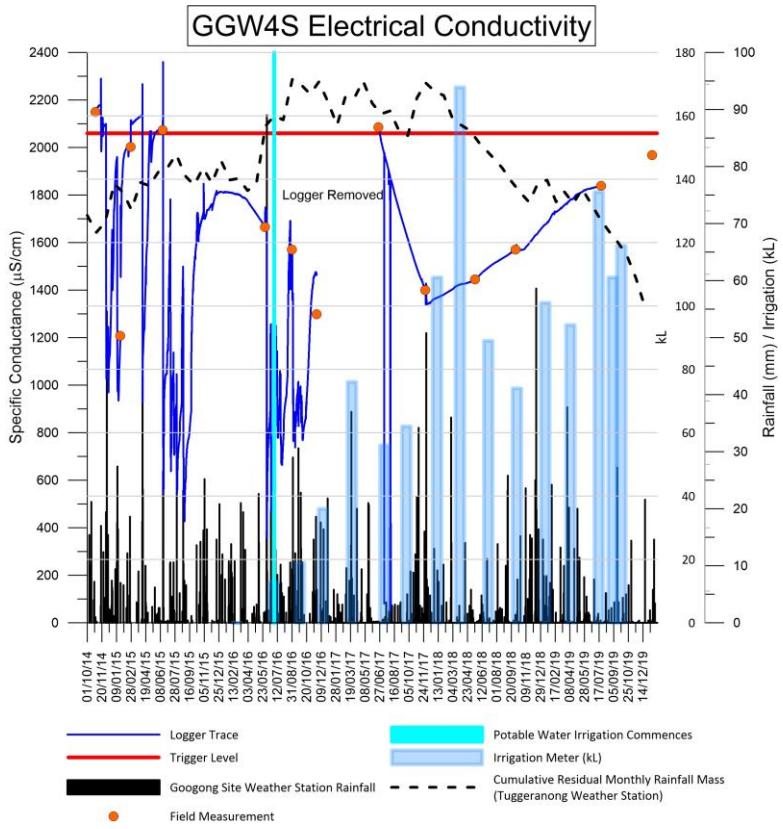


Figure 24: GGW4S time series plot of field EC and EC data logger results 2014 to January 2020 with rainfall, potable water irrigation load and CRMRM

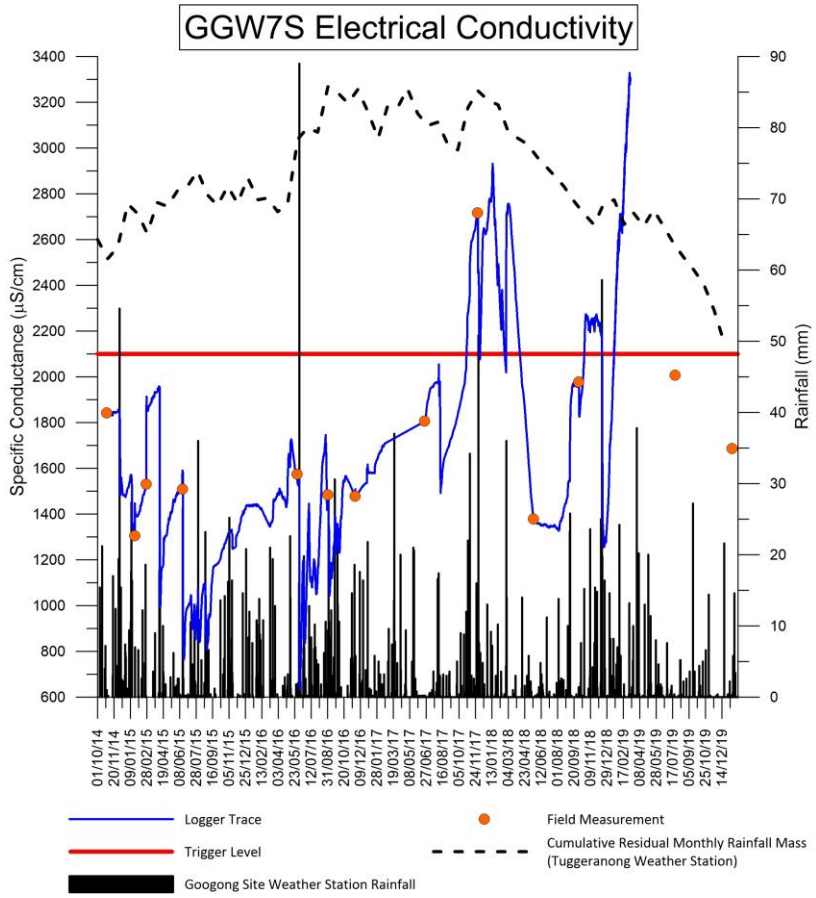


Figure 25: GGW7S time series plot of field EC and EC data logger results 2014 to January 2020 with rainfall and CRMRM

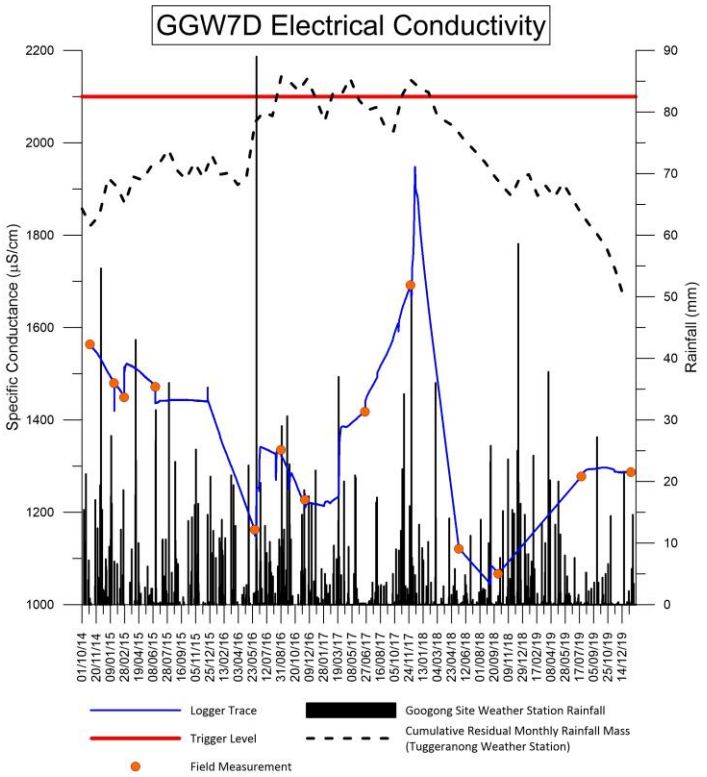


Figure 26: GGW7D time series plot of field EC and EC data logger results 2014 to January 2020 with rainfall and CRMRM

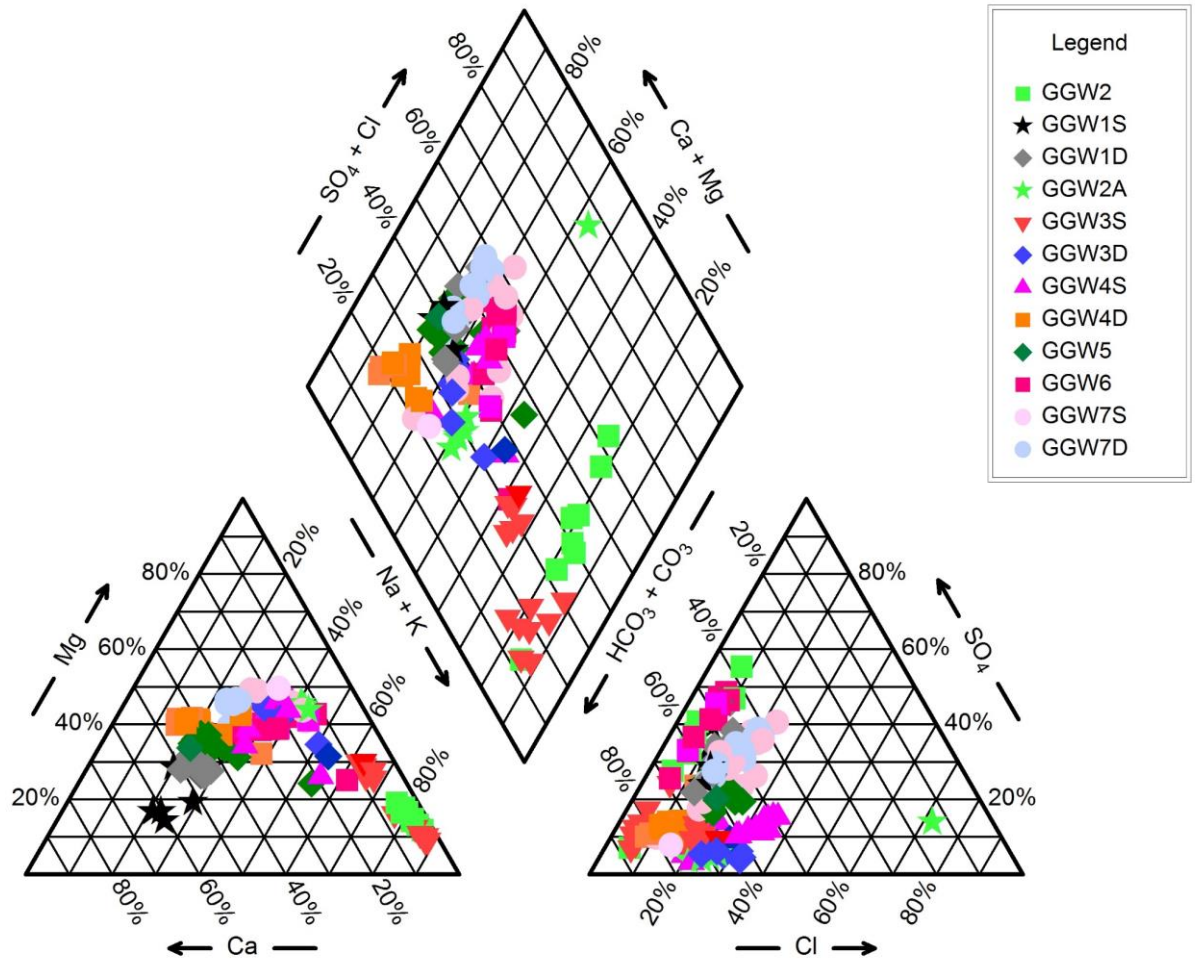


Figure 27: Piper diagram plot of all groundwater monitoring data from 2013 to 2019

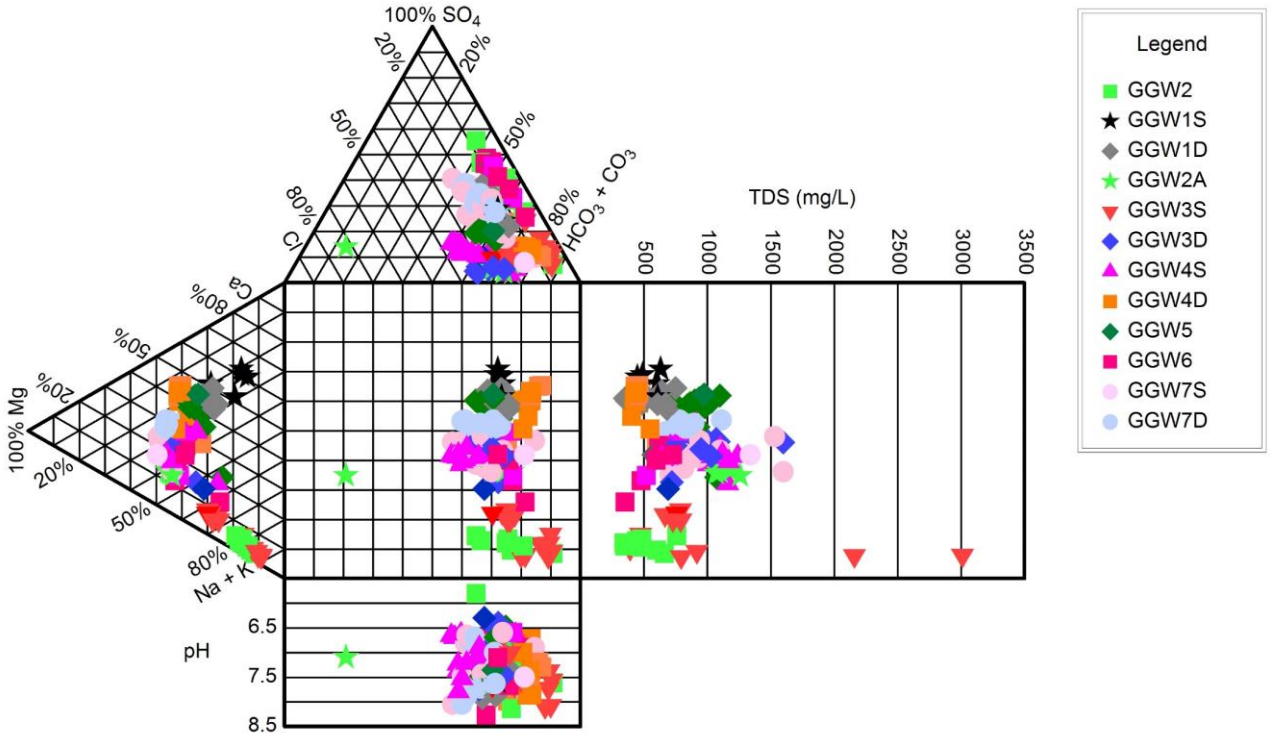


Figure 28: Durov diagram plot of all groundwater monitoring data from 2013 to 2019

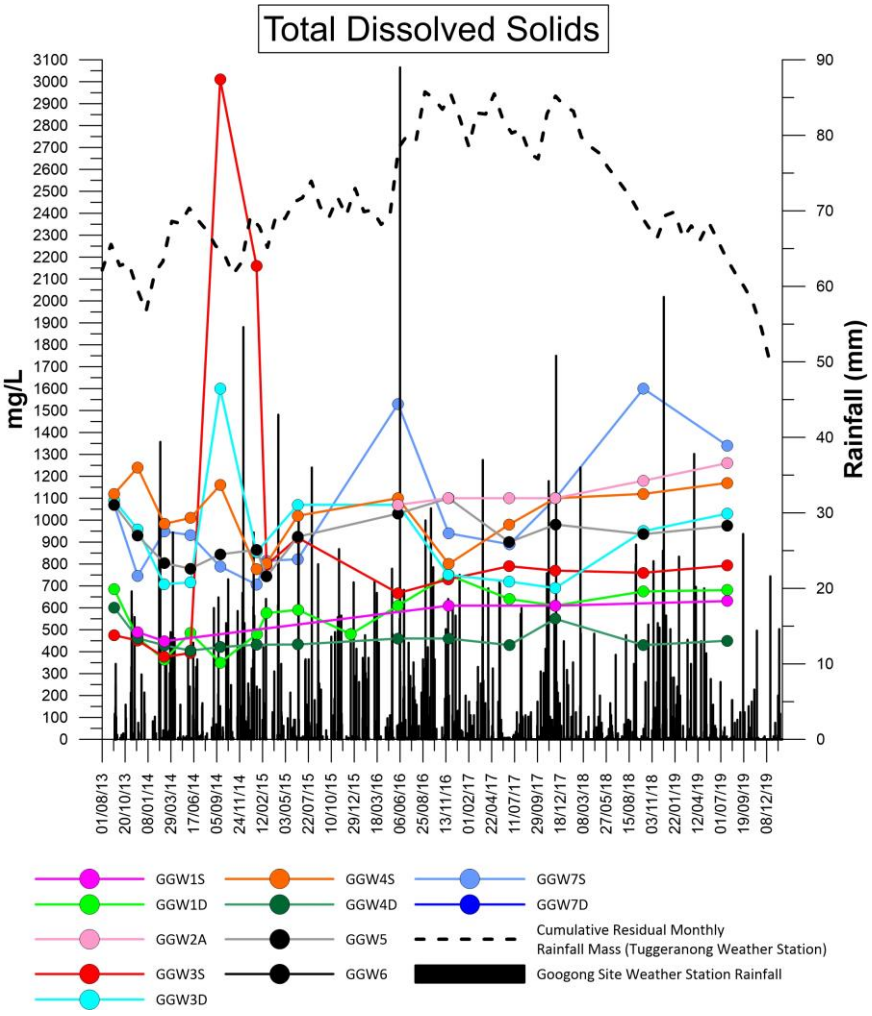


Figure 29: Time series plot of TDS results from September 2013 to July 2019

Dissolved heavy metals were analysed at ultra-trace levels (e.g. detection down to very low levels of 0.05 µg/L to 0.01 µg/L) with most results either below the LLD (Lower Limit of Detection) or below the SLD (Standard Limit of Detection). No significant contamination of heavy metals was observed. The dissolved heavy metals detected are considered representative of the natural geology. Concentrations at GGW7D have been observed to increase following sampling events where there is significant drawdown of the groundwater level. Refer to Appendix A for dissolved metals results at each groundwater monitoring location.

5.5 Surface Water Quality

Surface water monitoring has been undertaken as part of the Stages AB and C approvals of works in accordance with the WMP and the requirements of QPRC. The monitoring has occurred at:

- 1 site on Googong Creek,
- 1 site on Montgomery Creek, and
- 4 sites along the Queanbeyan River.

These are discussed in the Surface Water Assessment Report. Site 6 has been discontinued at the request of QPRC due to ongoing access issues. There has been no monitoring on South Creek, the upper reaches of Montgomery Creek. Both Googong Creek and Montgomery Creek are considered ephemeral and do not naturally have continuous flow.

5.6 Identification of Impacts

Impacts may be identified by comparing current monitoring data to baseline monitoring criteria, where available, WMP trigger values outlined in the GWMP or observations of trends in the results not considered to be reflecting expected climatic variations. Increases in parameters such as pH, EC, TDS, heavy metals and nutrients may indicate a potential impact to the groundwater system. It is noted construction will likely have an impact that is typically short lived and may not be observed with the 6-monthly monitoring frequency indicated in the WMP. Impacts from the operation of the Stage D irrigation areas may be identified through comparing results to baseline values and observing trends in parameters.

6 Potential Construction Impacts and Proposed Mitigation

6.1 Construction Activities

6.1.1 Stage D WRP

The construction activities within the WRP site are summarised as:

- New equipment/process units:
  - Additional Membrane Bioreactor train with consolidated design along with associated diffusers, mixers, pumps and pipework;
  - Additional Tertiary Filter train to provide increased tertiary treatment (chemical phosphorus removal) capacity;
  - Additional Aerobic Digester tank along with associated diffusers, pumps and pipework;
  - Additional centrifuge unit to provide increased sludge dewatering capacity;
  - Additional chemical dosing skids for the Stage D bioreactors; and
  - Addition of a fourth Recycled Water Transfer Pump.
- Replacements/upgrades:
  - Upgrade of blowers and/or air compressor in the Blowers Room;
  - Upgrade of one or both smaller Tertiary Feed Pump(s);
  - Upgrade of some existing chemical dosing pumps;
  - Upgrade of the Centrifuge Feed Pumps with higher capacity units;
  - Upgrade of the biosolids bins and weighing cells; and
  - General electrical and control system upgrade to cater to the upgrade works.
- Excavations for foundations and road access; and
- Construction of foundations using sub-base and concrete.

The excavation works for foundations of new structures will expose the shallow rock profile and any placed material.

For the Stage D WRP works, the temporary access road to the east of the WRP site will be re-opened within its existing footprint, and then rehabilitated for the operational phase of the development. The opening of the access road is likely to result in topsoil stripping, compaction and placement of materials.

Construction works associated with the WRP works are anticipated to be completed by end of 2024.

6.1.2 Stage D Permanent Reservoirs

The construction activities at the Permanent Reservoirs on Hill 800 are summarised as:

- Installation of an 8.5 ML reservoir for recycled water storage;
- The Stage C 4.0 ML ReW reservoir will be cleaned and re-purposed for PW, bringing the total PW storage volume up to 5.9 ML;
- A new PW booster pump skid will be provided to cater to flows in the higher elevation developments of the township;
- The Stage C PW booster pump skid will be decommissioned. Supply will be from the new Stage D PW booster pump skid;
- Decommissioning of the Stage C sedimentation bund and associated civil works required to re-purpose the area for the new 8.5 ML ReW reservoir;
- Sodium metabisulphite will be redirected to dose into the Stage D chemical dosing chamber that receives the overflow from the new reservoir;
- Recycled Water sodium hypochlorite dosing pumps may need to be replaced with 40 L/h dosing pumps. This is pending review of the operating data at concept design. Potable water sodium hypochlorite dosing pumps can be retained;
- Electrical and control system upgrade to cater for the new infrastructure;
- Excavations for foundations;
- Construction of foundations using sub-base and concrete;

- Stockpiling of topsoil and materials (to heights not greater than 3 m);
- Subgrade preparation;
- Backfilling and compaction;
- Transport and establishment of site amenities; and
- Installation of temporary power supply, water and plumbing.

The Hill 800 reservoir site layout in Stage C included provision for Stage D infrastructure. The main access to the site is off Old Cooma Road on a sealed access road.

Construction works associated with the WRP works are anticipated to be completed by the end of 2024.

6.2 Potential Construction Impacts

Construction activities for Stage D WRP and Permanent Reservoirs are not anticipated to require extensive earthworks and as such potential impacts are considered to be minimal. However, potential construction impacts on groundwater may include:

- excavation and trenching into the weathered bedrock zone providing direct pathways for recharge and contamination to the groundwater table;
- variation in groundwater recharge with localised increases in recharge to groundwater when significant rainfall is experienced;
- drainage systems redirect surface water recharge and may cause minor reductions in groundwater recharge for some parts of the site;
- backfilled trenches may provide increase recharge to the shallow groundwater table and act like conduits for shallow groundwater movement;
- spills of chemicals or wastes during plant equipment upgrade impacting the shallow groundwater table;
- imported fill material bringing potential contamination;
- fill areas changing the rainfall recharge rate; and
- over-application of fertilisers for the establishment of vegetation impacting groundwater quality.

Across the township, construction of each neighbourhood for residential development requires significant earthworks for the establishment of grade, roads, and lots. The impacts of these activities are much greater, although these impacts are typically short-lived in any case, than those proposed for the Stage D WRP and Hill 800 reservoirs.

6.3 Monitoring of Construction Activity Impacts

Around the WRP site monitoring for construction impacts should include:

- GGW2A groundwater monitoring point;
- Site 9 and Site 1 Montgomery Creek surface water monitoring point; and
- Spring discharge at the WRP.

Around the Permanent Reservoirs at Hill 800 and the overland flow at Discharge Point 1 there is not local monitoring infrastructure. The nearest down-gradient groundwater monitoring bores are GGW4S and GGW4D which are considered too far down-gradient for specific impacts.

Monitoring of construction impacts down-gradient of the Permanent Reservoirs will require the installation of a down-gradient groundwater monitoring bore as per the recommendations of the Stage C WRP Hydrogeological Assessment. This would also provide monitoring for the overland flow at Discharge Point 1 and address the limited hydrogeological information for NH2.

For the Stage D irrigation areas currently constructed there is existing monitoring infrastructure at Rockley Oval and Duncan Sporting Fields. The proposed areas of Common A and B and sporting field 7 do not have any down-gradient monitoring infrastructure. GGW4S is unlikely to be suitable for monitoring shallow groundwater impacts, due to the direction of flow of shallow groundwater likely being to the east rather than the north. GGW3D and GGW4D may be suitable for assessing the regional groundwater from these areas.

Monitoring of the construction of Stage D irrigation areas will require the installation of up- and down-gradient groundwater monitoring bores along South Creek corridor and in NH1B, NH4 and NH5. The monitoring bores should focus on the shallow groundwater with at least one location in NH4 considered as a nested site to assess the deeper groundwater. This would also address the limited hydrogeological information in these neighbourhoods.

Monitoring frequency for groundwater under the WMP is presently 6-monthly. This is not considered frequent enough for the identification of both construction and operational impacts of Stage D of the IWC. An increased frequency, such as quarterly over the first two years, is needed as the impacts to groundwater are likely more significant than the impacts to surface water.

6.4 Mitigation of Construction Activity Impacts

Mitigation of impacts to the groundwater from construction activities, whilst limited, should include the following:

- capturing and directing surface water runoff away from exposed areas and managed within the current IWC sites;
- ensuring required bunding is established during the upgrade or replacement of plant containing chemicals or biosolids to minimise the risk of spills;
- installation of sediment and erosion controls where appropriate on potential discharges which may reach South Creek to reduce sediment transport and TDS and recharge to the shallow groundwater system;
- sediment trap fencing to reduce sediment transport and TDS during the Hill 800 bund removal;
- minimising the period water may pond on disturbed ground; and
- limiting the application of fertilisers for vegetation establishment.

The main objective of mitigation of construction activities should be to minimise the time the shallow groundwater system is exposed to the potential of additional recharge as this recharge will be of a different quality to that of natural recharge from infiltration on undisturbed ground.

7 Potential Operational Impacts

7.1 WRP and Permanent Reservoirs

The potential operational impacts of the WRP and Permanent Reservoirs relate to spills of dosing chemicals, leaking pipes and tanks and emergency discharge releases. At the WRP, GGW2A is positioned for down-gradient monitoring. There is no down-gradient monitoring at the Permanent Reservoirs of Hill 800 and a groundwater monitoring bore is required. The risk of operational impacts are considered low and should be contained within the IWC.

The spring seepage under the WRP should also be considered. It is not clear if this spring flows underneath the foundations of the WRP. This may require further geophysical and geotechnical investigation. Operational impacts of the WRP are monitored through GGW2A.

Impacts that will be short lived are considered the emergency discharge of water down Montgomery Creek which cannot be mitigated any further than is currently possible within the IWC. To date there have been no reported emergency discharge events. Massive failure of the Permanent Reservoirs are also considered unlikely and any discharge would likely be contained with flows directed to Discharge Point 1, the overland flow system and into the NH2 stormwater system.

7.2 Public Space Irrigation with Recycled Water

The Stage D IWC Project works incorporate irrigation of recycled water on public spaces for the whole of the township. The township consists of a total of 705 hectares (ha) of which 325 ha are hardstand and 380 ha are open space. Of the open space 27 ha are irrigated sporting fields, 180 ha is open space for reserves and parklands and 200 ha is domestic lots that will not be built on as provided by Stantec under the assumption of 500 m^2 average lot size with max coverage of 50%.

There is a total of 9.8 ha of open space for irrigation already constructed in NH1AB. Currently the existing irrigation areas use potable water. Stantec have estimated for the total project at completion the total recycled water generation of the township (dry weather) is around 3,960 kL/day (118,755 kL/month). The monthly break down of the volume for irrigation, domestic consumption and excess recycled water discharge is shown in Table 6.

Table 6: Summary of ultimate IWC Project monthly recycled water average, minimum and maximum volumes to irrigation and domestic consumption and predicted excess discharge for environmental flow in kL

Month	Montly Volume to Irrigation and Domestic Consumption			Monthly Predicted Excess for Environmental Discharge		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Jan	3,004.9	237.4	5837.6	297.8	0.0	4,283.3
Feb	2,833.8	254.5	6051.7	351.6	0.0	3,496.9
Mar	2,320.3	254.7	5123.9	489.0	0.0	5,477.4
Apr	1,538.3	146.5	4222.7	899.5	0.0	3,771.8
May	943.2	88.7	3779.2	1,373.0	0.0	3,942.3
Jun	469.7	49.4	2663.0	1,818.4	0.0	3,773.6
Jul	370.1	9.4	931.4	1,922.9	1,226.8	3,640.0
Aug	492.4	0.0	1869.5	1,797.8	188.4	4,766.8
Sep	821.7	44.5	3343.8	1,478.9	0.0	3,288.2
Oct	1,554.3	103.8	4236.8	903.5	0.0	4,485.1
Nov	2,036.1	117.5	5219.0	687.3	0.0	4,445.6
Dec	2,881.0	254.5	5546.3	295.3	0.0	3,202.3

The predicted excess recycled water, to be discharged to the environment shows seasonal variability with the winter months generating the most excess. Township consumption of recycled water has a slight seasonal variability, likely related to garden watering.

Presently irrigation of Rockley Oval and Duncan Sporting Fields with potable water equates to around 48 kL/month. 2019 a total of 200,0197 kL of treated recycled water was discharged Googong Creek (equates to around 16,454 kL/month).

The long-term irrigation of public spaces, including sports fields, has the potential to impact groundwater and may include:

- localised groundwater mounding;
- increased localised recharge to the shallow groundwater table and may increase recharge to the deeper groundwater system;
- mobilisation of salts;
- increases nutrients from fertilisers from gardens and sporting fields;
- increased nutrients and other parameters from recycled water;
- water logging of soils; and
- down-gradient accumulation of salinity.

The hydrogeological assessment for the Stage C WRP undertook a numerical groundwater model to assess the impact of irrigation to the groundwater system and this model covered the township development up to Stage C and included Common A and Common B from NH2.

The overall impact of the township development is a reduction of rainfall recharge to the groundwater system. This is not fully offset by the artificial recharge from irrigation at a domestic or township level. The capture and redirection stormwater for further reduces the available recharge to the groundwater system. Point source discharge of excess recycled water to Googong Creek may have offset the reduction in baseflow from the groundwater system. Discharge of excess recycled water to Discharge Point 1, the overland flow system, introduces a point source recharge of shallow groundwater. This does not offset the overall losses in recharge from the development of the township.

The Googong numerical groundwater model was developed in 2014 as part of the baseline assessment of groundwater and is reported in the Googong Hydrogeology Services: Annual Groundwater Monitoring Report (SMEC, 2014). It was updated in the Stage C WRP Hydrogeological Assessment (SMEC, 2016). Refer to these reports for model details. The updated model considered the township development of NH1AB and NH2 with Common A and Common B sporting fields.

The operation phase model used partial tracking to define the flow path from the irrigation areas for assessing potential salinity migration pathways which are shown on Figure 30. Although some changes to the groundwater system are expected at the site, the flow path lines show no interaction with water stored in the Googong Dam. The expected groundwater flow directions beneath much of the proposed development area would see any impacted groundwater migrate to the north and north-east of the site, ultimately draining to the Queanbeyan River below Googong Dam.

The blue areas on Figure 30 (discharge zones) are related to surface topography where groundwater is within close proximity to the surface and therefore subject to evapo-transpiration processes or baseflow to a creek. There may be times where groundwater may be shallow enough to discharge [to surface] and this discharge may lead to accumulated / extra salts. The model does not define the potential concentrations of salts; only areas where discharge may occur, and monitoring should be considered. The particle tracking assumed at these irrigation locations that water of slightly higher EC may be introduced and the tracking assessed where this higher EC water may go. With this method potential points of discharge were assessed, and it is at these locations where impacts may occur. These impacts could include discharge of groundwater with elevated salinity. Overall the volume of discharge at the locations identified is considerably smaller than the volume of groundwater discharging from the system and the volume of surface water. During low flow periods, where groundwater is the dominant component of flow, these impacts may increase.

The shallow groundwater monitoring bores GGW7D, GGW1S, GGW2A and GGW3S are designed to intercept shallow groundwater perched above the interface with unweathered bedrock and are located down-gradient of the main irrigation and recycled water discharge points. Information is needed in NH2 between the overland flow discharge zone / reserve and proposed town centre lake. Increased recharge to this area may result in a flow path towards the drainage line that feeds north towards Googong Creek or North Creek. It was the outcome of this groundwater model that

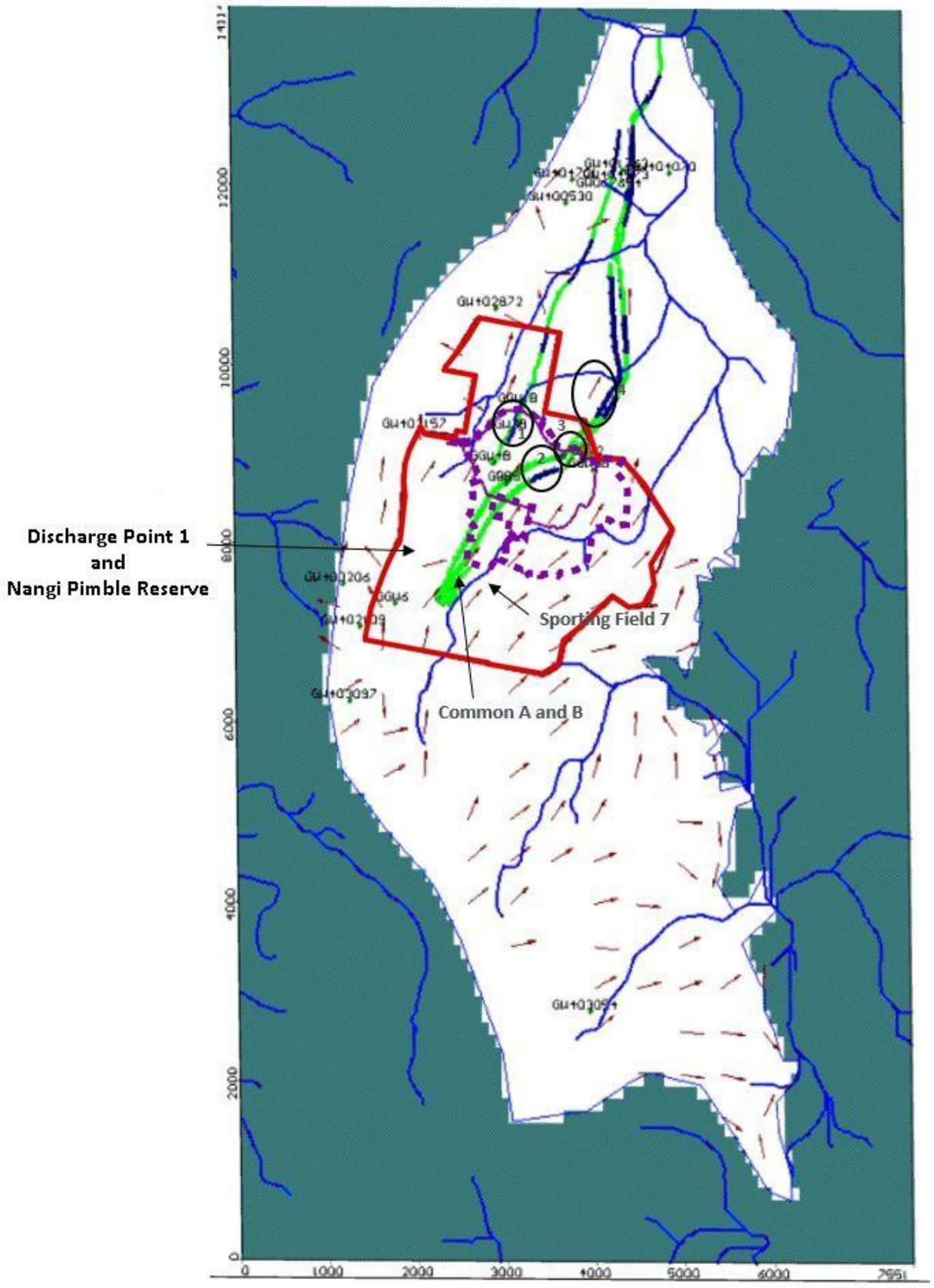


Figure 30: Groundwater model extract showing flow path lines from the nominated irrigation areas. Township development area is shown in red, Stage C boundary shown in dashed purple, WRP shown as brown and potential discharge zones are shown with black circles.

resulted in the re-establishment of surface water monitoring location on Googong Creek (Site 10 of the Surface Water Monitoring).

The Agsol (2009) electromagnetic survey of the township prior to construction shows connected higher conductivity features which appear to correlate with the groundwater model predicted pathways. The potential volume of any impacted groundwater is also very low in comparison to the overall baseflow discharging to the river. Since the start of irrigation with potable water the impacts to groundwater appear minimal with potential impacts not able to be distinguished from variations resulting from natural climate trends. It may, therefore, be very difficult to identify any impacts in the receiving waters outside of very dry periods. In addition, the general reduction in baseflow during dry periods will [likely] reduce the potential discharge of impacted groundwater which would be masked by subsequent rainfall events.

The flow paths are not considered to change significantly with the addition of a sporting field (S7) but the potential concentrations at the discharge locations may (change). The potential consequences of the use of recycled water, and indeed the overall township development, is the slight decrease in groundwater quality, regardless of whether recharge increases (e.g. owing to the infiltration of recycled water into the aquifer) or decreases (e.g. owing to stormwater capture across the developed parts of the site). Reducing the recharge from the development of the township through NH3 to NH5 is not likely to change the flow paths but the concentration of salts at the discharge points may increase.

The groundwater model has not been updated for this Hydrogeological assessment as there is no additional groundwater or geological information in NH2 to NH5. As the flow pathways are unlikely to change and no significant impacts have been observed with the use of potable water over the last few years, update of the groundwater model should be undertaken as a validation step, to review if the impacts may be considered acceptable, after the results of at least one year of irrigation with recycled water.

The reticulation and use of recycled water in the township is expected to commence in the second or third quarter of 2020.

7.3 Use of Recycled Water on Residential and Other Properties

Use of recycled water, upon commencement of reticulation, on residential, commercial and other (e.g. educational) properties in the township will include:

- toilet flushing;
- garden use;
- car washing; and
- firefighting.

These uses will continue in the future neighbourhoods of the township. Operational impacts to groundwater resulting from residential and other uses of recycled water are considered to be minimal.

The potential impacts to groundwater from long term recycled water usage may include the following:

- uneven distribution of recharge with potential for localised mounding and drawdown due to variable residential water use practices;
- potential increased contamination (including nutrients) to groundwater from car washing, fertilizers and household chemicals;
- increased recharge from leaking pipes; and

7.4 Discharge of Excess Recycled Water

The township development Stages AB and C proposed that excess recycled water is to be discharged from Discharge Point 1 in NH2. Whilst this discharge point was under construction excess recycled water has been discharged from Discharge Point 3 on Googong Creek just below Beltana Pond (Figure 7). Any water that is discharged must meet the effluent criteria listed in the RWQMP and be in accordance the EPA licences conditions under EPL Licence Number 20188.

The Stage D development proposes to retain the location of excess recycled water discharge as Discharge Point 3 on Googong Creek. QPRC considers that pumping excess recycled water up hill to the permanent reservoirs at Discharge Point 1 is not as efficient as release from Discharge Point 3. Discharge Point 1 would be retained to allow discharge of recycled water as required to meet operational requirements.

This change would mean that the bio-retention basins, vegetated swales and wetland element of the townships stormwater management system would not receive excess recycled water. The bio-retention basins, vegetated swales, and wetland elements are designed to capture, reduce, and in some instances, remove excess nitrogen and phosphorous. Beltana Pond has been designed with passive water flow to ensure water is regularly passed through the wetland and a recirculation pump to provide increased oxygenation. It would also mean that less recycled water would recharge the shallow groundwater system from this process and more surface flow reaching the Queanbeyan River. Using Discharge Point 1 for excess recycled water discharge may not be economically reasonable and is likely to have a greater impact to the groundwater system than using Discharge Point 3.

At Discharge Point 3 a small temporary bio-swale has been created on Googong Creek, below the Googong Dam Road culvert to reduce flow velocity and improve water quality by passing through reeds and a sediment trap. The potential impacts of increased excess recycled water discharge to the groundwater in this location may include:

- localised point source recharge of the shallow groundwater system during dryer periods;
- increased TSS / TDS and nutrient load to recharging shallow groundwater;
- water logging which leads to increased evapotranspiration which may lead to increased salinity; and
- recharge to the shallow groundwater system of other contaminants.

Figure 31 presents the time series plot of excess recycled water discharge to Googong Creek. The volume of excess water increases from around 200 kL/day in July 2017 to 400 kL/day by December 2017 to 700 kL/day by December 2019. Several peak discharge events of 1300 kL/day and 1900 kL/day occurred in November 2017 and December 2018 respectively.

In 2019 the total excess recycled water discharge was 200,197 kL. When the township commences reticulation of recycled water the volume of excess discharge to Googong Creek may initially reduce but as the township development increases with more EP the volume of excess is will then increase. At full development the township is estimated by Stantec to have an average monthly excess that ranges from around 297 kL/day to around 1923 kL/day (refer to Table 6). The seasonal variability in discharge volume may be such that no excess occurs during the summer months and discharge during the winter months. Figure 32a presents the predicted excess recycled water discharge as a monthly summary of average, minimum and maximum discharge as kL/day with the result of discharge from 2019. Figure 32b presents the seasonal average daily discharge with results from 2017 and 2019.

For assess the potential impacts to Googong Creek for the ultimate IWC project the overall it is important to understand how the volume of discharge will change from the current situation. As there has been no consumption of recycled water the recycled water has been discharged and the volume increased over time. When this is compared to the ultimate IWC project estimated discharge it can been see that seasonal disparity in volume will occur. That is, more discharge in winter months and less to none in summer, spring and autumn months. The winter months discharge will be higher than what has been discharged to date. There will be a return to the 2017 discharge volumes for the summer period in the ultimate IWC and for the winter months the assessed increase is 174% on the 2019 discharge volumes.

The 2019 discharge to Googong Creek is higher than the ultimate IWC project predicted average excess for summer months but lower compared to the winter months. When the 10^{th} and 90^{th} percentile of excess flow are considered (Figure 33), then excess recycled water greater than current volume is predicted for the winter months as a 142% and 214% increase respectively. It is likely that the start of reticulation of recycled water in min 2020 would result in minimal to no excess discharged as environmental flow to Googong Creek in the summer months and reduced volumes in the winter months of the following year. The would be a significant change from the current conditions, returning Googong Creek to a more ephemeral state.

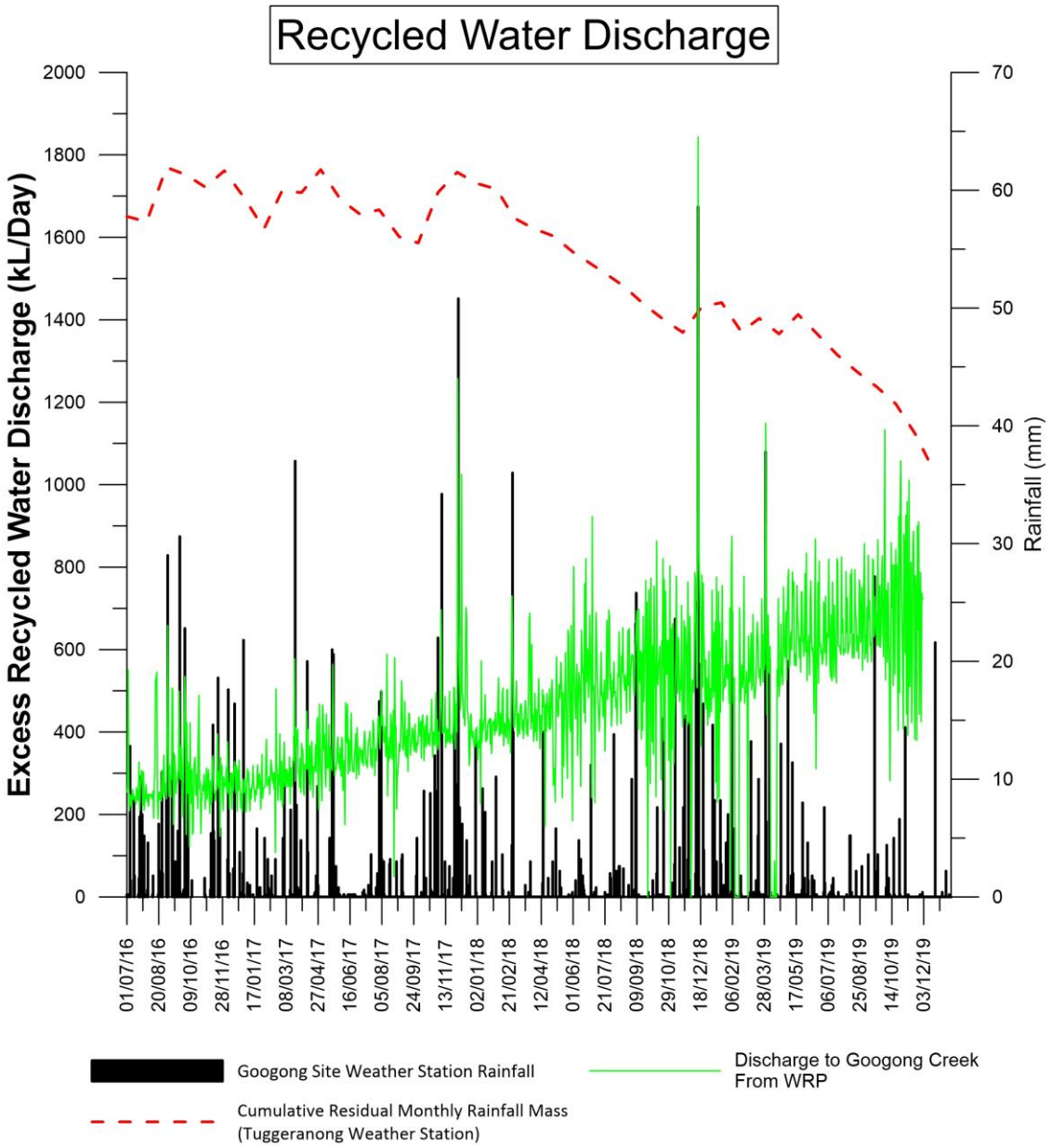


Figure 31: Excess recycled water discharge to Googong Creek from July 2016 to December 2019

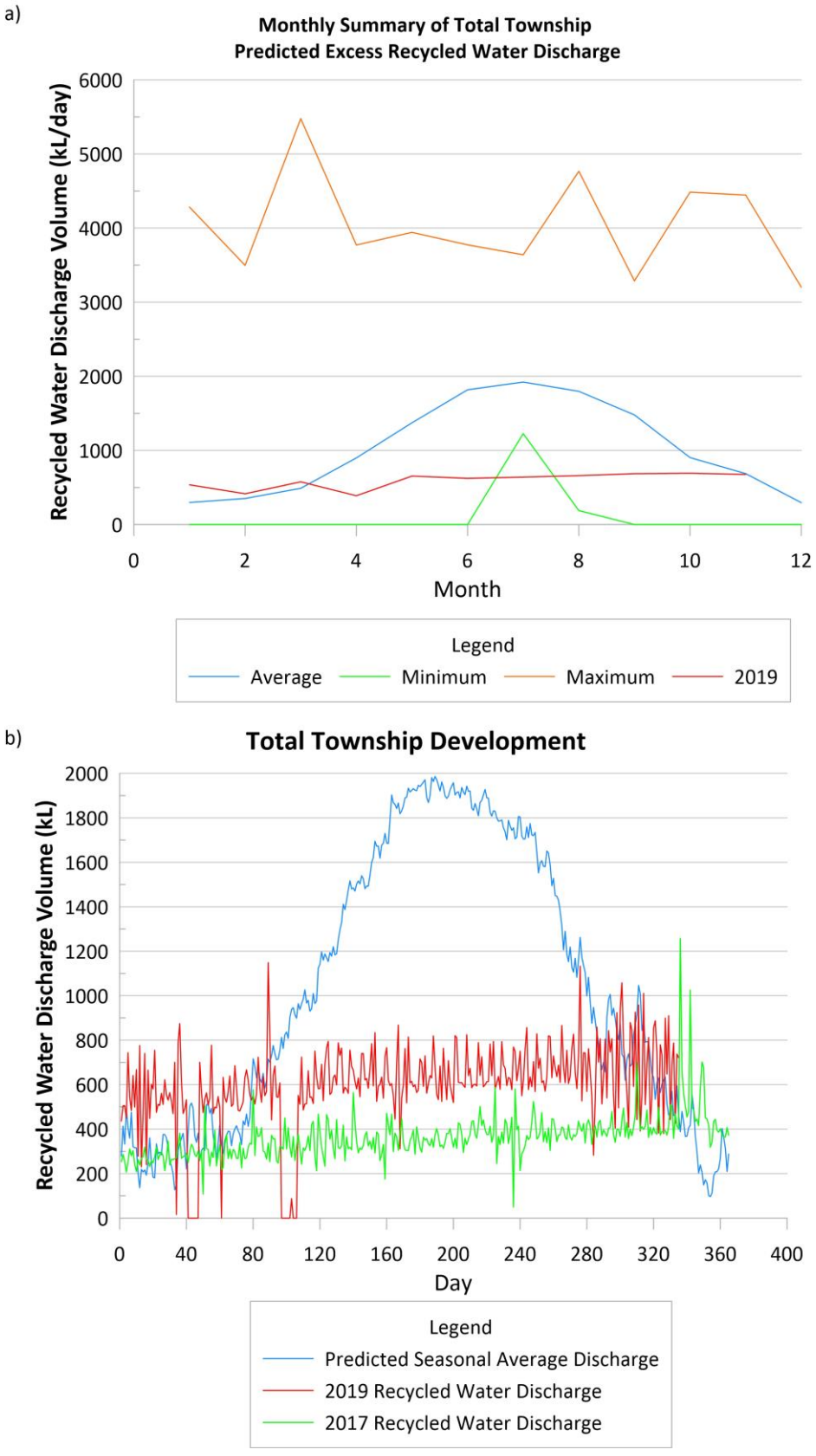


Figure 32: Predicted Excess recycled water discharge to Googong Creek a) month summary with predicted minimum, average and maximum and 2019 results and b) daily summary of average predicted discharge with 2017 and 2017 results

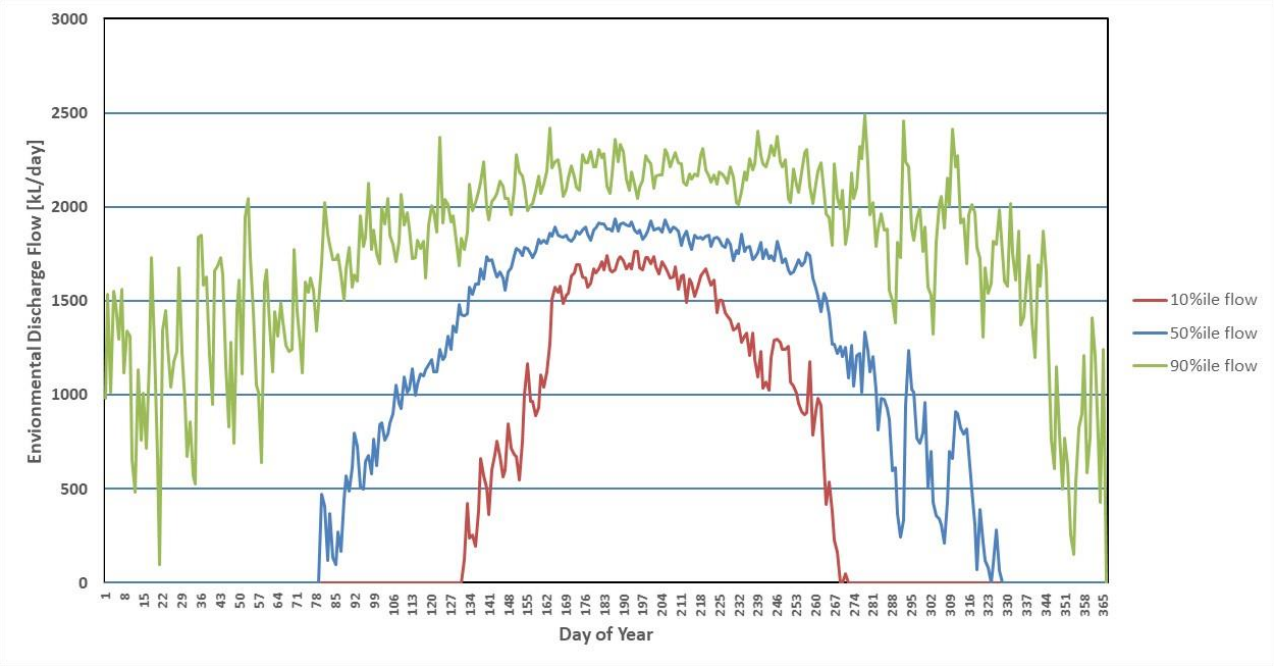


Figure 33: Summary of percentile daily environmental discharge (Stantec)

Figure 34 presents the time series plot of river flow at the Wickerslack Gauge on the Queanbeyan River. The commencement of recycled water discharge occurred during a period of above average rainfall conditions where it can be seen there in a relative stable flow of 1 m^3/sec until around September 2017 where the flow decreased to around 0.2 m^3/sec during the period of below average rainfall conditions. Very low flow conditions are seen in March to June 2019 and the river flow shows significant decrease from September 2019 to December 2019 with the prolonged below average rainfall.

The 2019 average excess recycled water discharge of 700 kL/day equates to around 8L/sec (or 0.008 m^3/sec) and unlikely to provide significant contribution to flow in the Queanbeyan River over rest of the catchment and discharges from the reservoir. Stantec have estimated for the ultimate IWC Project the average excess recycled water to discharge to the environment is 1029 kL/day to a maximum of 5477 kL/day. This equates to around 11 L/sec (0.01 m^3/s) to 63 L/sec (0.06 m^3/sec) of discharge to Googong Creek and similar to the very low flow conditions of the Queanbeyan River.

Discharge of excess recycled water must meet the EPL conditions. Figure 35 presents the time series plot of recycled water quality results from QPRC. It shows as discharge has increased over time pH has generally remained consistent along with the concentrations of major ions and ammonia and total phosphorus. Sulphate concentration shows some variability which may be related to seasonal variability. Total nitrogen shows a significant increase in concentration from May 2017 to September 2017 to around 5 mg/L. The TDS of the water ranges from 288 mg/L to 586 mg/L.

Figure 36 presents a piper diagram plot of the recycled water chemistry and selected surface and groundwater locations. It shows the recycled water, which has varied slightly each year, appears distinctly different to the surface and groundwater quality. Prior to recycled water quality discharge, Site 8 on Googong had a chemistry similar to the groundwater at GGW1S and GGW1D but now shows the same signature as the recycled water. Site 10, downstream from Site 8 on Googong Creek, shows there is mixing zone between the groundwater and recycled water. Site 11 in Beltana Pond, which is upstream from the recycled water discharge in Beltana pond, shows a similar chemistry to the groundwater.

The increase in the amount of excess recycled water to Googong Creek is unlikely to cause significant issues to groundwater. Any localised recharge up on the plateau (around GGW1S) would move only a short distance towards the discharge zones of Googong Creek and the Queanbeyan River.

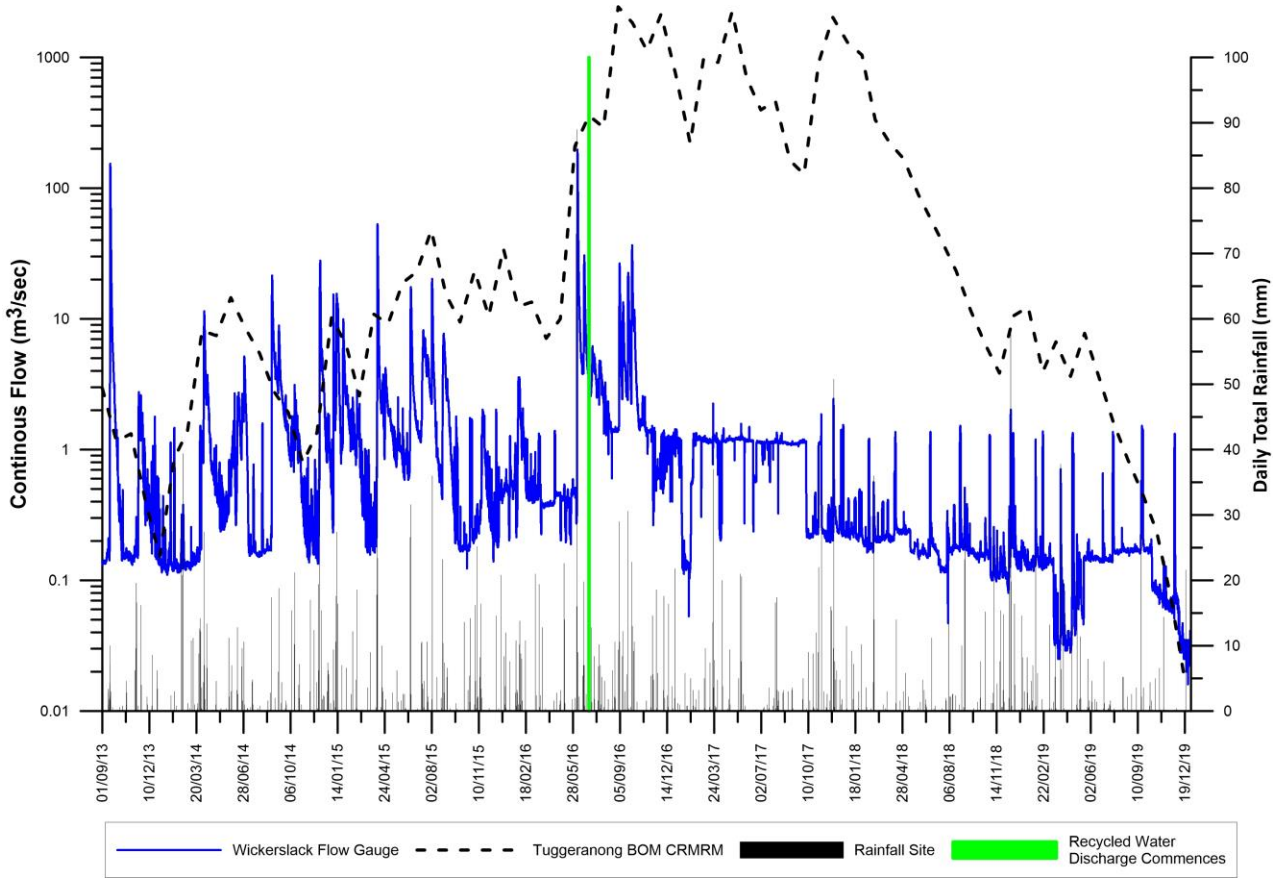


Figure 34: Queanbeyan River flow at Wickerslack Gauge September 2013 to December 2019

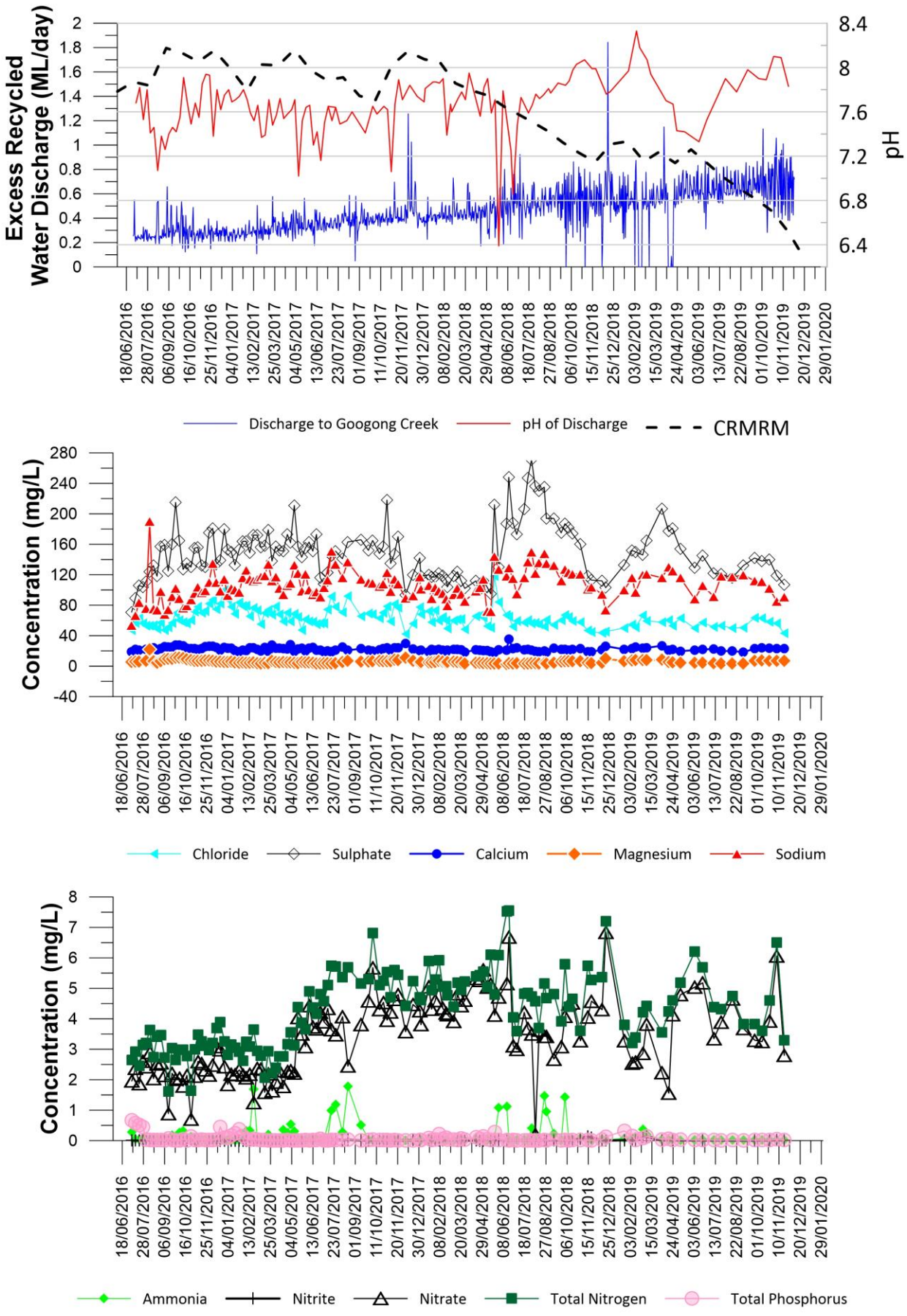


Figure 35: Time series plot of recycled water quality

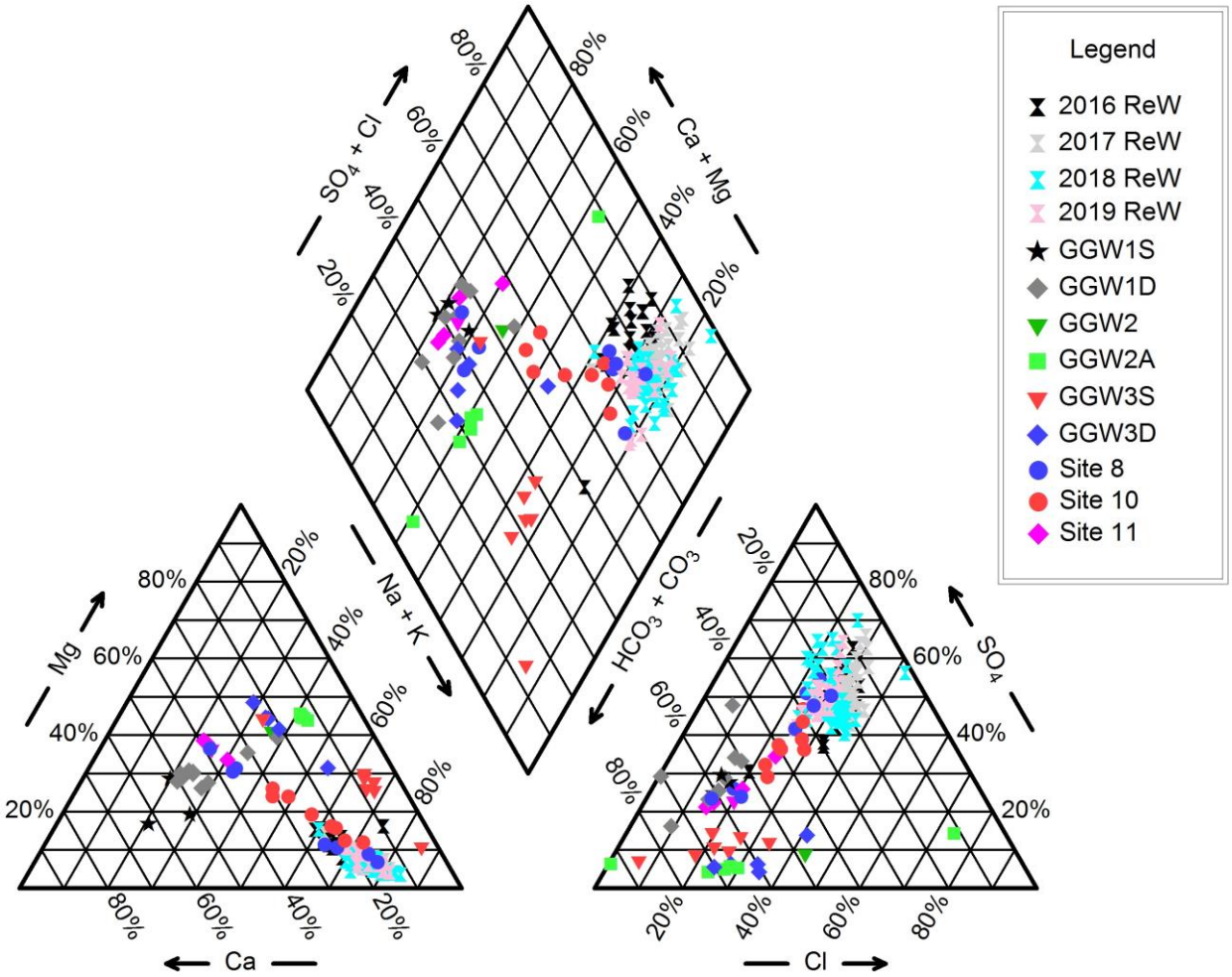


Figure 36: Piper diagram plot of recycled water quality with selected surface and groundwater sampling locations

7.5 Mitigation of Excess Recycled Water

It is noted that the quality of the recycled water discharge does not meet the ANZECC (2000) criteria for the 95% protection of species for some assessment criteria and is worse for some parameters than the baseline data. Excess recycled water must meet the effluent criteria of the EPL before release. Other mitigation measures relate to ensuring sufficient flow velocity to minimise potential backwaters being created and recharge of the shallow groundwater in the upper reaches. Shallow groundwater recharge is only considered an issue in the upper reaches, i.e. on the plateau however its likely to have only a relatively short flow path to the point of discharge.

The temporary sediment fence and reeds, Figure 37, at Surface Water Site 8 should be replaced with a more permanent series of gabion walls and smaller bio-swales / wetlands with the aim of minimising pooled water areas whilst achieving some of the benefits of improved water quality that come from wetlands with vegetation. Erosion is not considered a major issue given the steep and incised nature of Googong Creek in the lower reaches however a series of gabion walls would assist with reducing flow velocity and minimise erosion in the plateau area between Beltana Pond and the existing dam on Googong Creek.

The use of Discharge Point 1 as Off Spec water discharge point during wet weather is unlikely to require any mitigation. The overland pond design should consider the infrequent nature of discharges to minimise the potential for recharge the shallow groundwater system.

Monitoring of excess recycled water discharge impacts should continue under the GWMP at GGW1S and GGW1D and surface water Site 8 and Site 10 under the SWAEMP.

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Figure 37: Surface Water Site 8 on Googong Creek with reed bed

7.6 Monitoring and Mitigation of Public Space Irrigation with Recycled Water

Under the WMP monitoring of soil chemistry is undertaken on an annual basis as outlined in the IMP. This is generally in accordance with the Use of Effluent by Irrigation (DEC, 2004). In addition, geophysical surveys are undertaken in accordance with the GWMP at two sporting fields. These surveys are designed to assess potential changes to the shallow soil profile after three and six months of irrigation. To date these surveys have been conducted post irrigation with potable water but not recycled water.

Geophysical surveying of sports fields provides a good field coverage of conductivity and potential soil salinity, particularly if undertaken with soil sampling. Rockley Oval and Duncan Sporting Field has one regular soil sampling location from which composite soil samples are collected. The geophysical surveying can be used to expand the available information of the condition of the field and provide better feedback for management under the IMP.

The mapped conductivity is a bulk conductivity measurement of several meters of the soil and or rock profile. High conductivity values do not necessarily indicate salinity and conversely low conductivity does not necessarily indicate a lack of salinity. Results from post irrigation with potable water at the Rockley Oval showed the influence of irrigation over time and the natural variation in the soil profile. The NH1A sporting fields may be considered a test case for the value of geophysical survey with soil sampling results as part of an IMP.

Regular geophysical surveying is unlikely to be beneficial, however when surface [observable] issues (such as salt scalding or water logging or turf performance issues), or groundwater quality issues are identified, then a geophysical survey may be of benefit to assess targeted areas for further soil testing to develop remediation or mitigation strategies. Likewise, a township wide survey to monitor the impact of public space irrigation and domestic irrigation is not practical with the urban infrastructure that comes with a township development.

It is recommended that no further routine geophysical surveying be conducted and the GWMP and IMP be revised to outline this method as a response tool under the IMP.

Monitoring requires a township wide regional groundwater monitoring network, consisting of up-gradient and down gradient groundwater bores, targeting both shallow and deep aquifers. The monitoring frequency needs to balance the ability to assess for construction impacts with the long-term monitoring of changes to the system. At present a 6-monthly frequency is not considered sufficient to address construction related impacts within a timeframe to provide suitable mitigation measures. A more realistic frequency is quarterly. Likewise, quarterly captures the seasonal variations of both the natural climate and consumption trends of recycled water. Operational impacts are also more likely to be observed at this frequency with sufficient time to assess mitigation options.

The long-term monitoring of the groundwater system is to validate the success of the IWC and that any impacts / changes to the groundwater system are acceptable. Mitigation measure are limited however as the township development progresses there is opportunity to make some changes, such as increasing the percentage of open spaces for natural rainfall infiltration to improve the distribution of groundwater recharge and minimise potential negative impacts.

8 Discussion

8.1 Stage D Construction

The hydrogeological assessment of the Stage D WRP and Permanent Reservoirs at Hill 800, and monitoring conducted for the township development since 2013, concluded that construction-related impacts to the groundwater system are likely to be minor but unavoidable.

Earthworks will disturb the soil profile, allow increased recharge to the shallow and therefore regional groundwater aquifers and result in dissolution of additional ions from the disturbed ground. With this increased recharge there is increased TDS, nutrients and salts. However, this is not considered a significant issue as most of the significant earthworks occurred during the construction of Stage C works. The mitigation measures recommended to be undertaken as part of the CEMP and the construction methodology are considered sufficient.

Any impacts are likely short-lived and the system will re-establish a new equilibrium once the construction is complete, however the timeframe required for this to occur is unclear. These impacts are considered relatively minor and are not anticipated to have significant long-term impacts on the groundwater quality in the local and regional aquifers.

Development of the township and the associated activities which occur through population of the development are considered more likely to result in long term changes to the groundwater system than irrigation with recycled water and are not controllable and difficult to mitigate. These include; the development its self, use of fertilizers, chemicals (pest control, weed killers etc.), chemical and fuel spills, residential water use practices and damaged infrastructure (sewage, stormwater and water supply pipes).

8.2 Stage D Operation

The township development will have an impact and change the groundwater system through:

- the physical changes to the land form and surface profile;
- the reduction in (natural) groundwater recharge volume and distribution;
- localised point source recharge with recycled water which is of a different nature than rainwater; and
- anthropogenic activities within the township.

The IWC system results in an overall net loss of rainfall recharge through impermeable surface and the capturing of surface water (i.e. stormwater run-off) of which a portion is re-used (i.e. domestic rainwater tanks) and redirection of stormwater to discharge to the surface water environment at specific locations.

These impacts have been considered acceptable as the township has received approval. Monitoring information to date shows no significant negative impacts to the groundwater system however the township is still expanding and construction activities are ongoing. Ongoing monitoring focuses on validation that an IWC system is both successful for this township and the impacts to the environment are not causing significant degradation and causing negative down-gradient impacts. The regional groundwater flow is to the north to north-east discharging to the Queanbeyan River and shallow groundwater flow discharging to Googong Creek and South / Montgomery Creek.

The addition of open spaces in NH2 to NH5 where there may be some irrigation is unlikely to have a significant impact on the groundwater system over the reduction of recharge from the increased hardstand in the neighbourhoods as they are developed. Numerical groundwater modelling is needed to assess the full township development and irrigation of open spaces. This numerical modelling needs to be supported with an update of the groundwater and geological information in NH2 to NH5 where information is currently limited. The collection of baseline groundwater quality information should ideally occur before there are construction impacts at Common A/B around 2023.

The results from the first year of operational phase of irrigation with recycled water may provide more clarity on how the groundwater is responding to the township development and what the potential long-term changes and impacts may be. To date, potable water irrigation has shown a slight lag in effects that are best observed in the groundwater rather than the surface water monitoring. Discharge of excess recycled water into Googong Creek has shown no significant issues with channel stability or habitat and no significant impacts to the surface water quality in the Queanbeyan River. The volume of discharge to Googong Creek for the total township development is going to increase by 80% compared to the 2019 discharge volume. This increase will be over the next 25 years and gradual, giving the surface water system time to adapt and should not have an impact on the groundwater system at the township.

The location of current monitoring points in relation to predicted groundwater Discharge Zone 1 (Figure 30) indicates GGW7D, GGW1S, GGW1D and Surface Water Monitoring Point 8 may be used to monitor around Beltana Pond. GGW2A and GGW3S may be suitable for the predicted groundwater Discharge Zone 2/3 but would benefit from monitoring of the seepage / spring beneath the WRP.

On Googong Creek the potential groundwater Discharge Zone 4 is monitored by Surface Water Monitoring Site 10. The water quality in Beltana Pond is being monitored by Surface Water Monitoring Site 11. Surface water monitoring sites would need to be established in the Town Centre Lake in NH2 and downstream of Discharge Point 1. EPL 20188 currently requires monthly sampling of the recycled water discharged from Discharge Point 1 and at Surface Water Site 8. The change of discharge of excess recycled water from Discharge Point 1 to Discharge Point 3 for the operational phase of the township may help to offset potential concentrated groundwater discharge by providing more sustained surface flow to Googong Creek.

At present there are no groundwater monitoring locations established for the Common A and B sporting fields adjacent to South Creek. Down-gradient, at GGW3S and GGW3D, monitoring would assess the cumulative impacts of the irrigation of two sets of sporting fields. Likewise, the surface water quality of South Creek, and shallow groundwater discharge to east towards the PTWL Conservation Area, remains unassessed.

Under the current irrigation program using potable water, the groundwater system appears to be showing some changes which may be in response to the extra recharge and/or long-term climatic pattern of below average rainfall. Leaching of soil nutrients and salts occurs with potable water irrigation, as well as recycled water irrigation. The main difference between potable and recycled water quality is that recycled water may have a slightly higher TDS concentration, in addition to elevated nutrients, salts and heavy metals and some pathogens (although these parameters would be within EPL limits under normal operation of the WRP). The groundwater system is more likely to show impacts of irrigation than the surface water monitoring. It is noted that surface water monitoring is unlikely to distinguish between recycled water discharge quality and urban runoff. Urban runoff water quality is indicated to swamp recycled water quality especially during wet periods.

The frequency of monitoring currently required by the WMP is not sufficient to adequately monitor changes in the groundwater system and should be increased to quarterly for the first two years of recycled water irrigation. Surface water monitoring recommended to have the same frequency as the groundwater monitoring program for better correlation of seasonal variations and site activities. After review of the results of the groundwater modelling the groundwater monitoring frequency should be reviewed and the WMP updated accordingly. Long term the staged neighbourhood developments may require periods of intensive (i.e. quarterly to 2 monthly monitoring) and periods of less intensive monitoring (e.g. 6-monthly to annually) as part of IWC construction impact monitoring and validation of sustainable recycled water use over the next 25 years.

9 Conclusions and Recommendations

On this basis of the assessment documented in this report, and previous groundwater quality monitoring results, SMEC offers the following conclusions. With regards to construction of Stage D WRP and Permanent Reservoirs:

- construction impacts to the groundwater system may occur, but will likely be minimal, short lived and the system is expected to return to an equilibrium following entry into the operational phase;
- construction impacts for each neighbourhood development will have a larger impact to the groundwater system than construction of the WRP and Permanent Reservoirs;
- construction works are within the existing constructed footprint of the WRP and Permanent Reservoirs;
- there are no anticipated impacts to Googong Dam;
- the quality of the groundwater discharge at the WRP spring is unclear;
- practical mitigation of construction related impacts to groundwater is very difficult however control measures outlined in the construction methodology are considered sufficient;
- primary impact of construction is increased recharge (initially) with an associated increased total dissolved solids, nutrients and salts in groundwater; and
- monitoring of impacts during construction requires a groundwater monitoring frequency of at least quarterly.

With regards to operation of Stage D WRP and Permanent Reservoirs:

- operational impacts of the WRP and Permanent Reservoirs to groundwater are minimal and operational control measures are considered adequate;
- no impact to Googong Dam; and
- a groundwater monitoring location for down-gradient of the Permanent Reservoirs is required.

With regards to operation of Stage D public space irrigated areas:

- shallow groundwater flow follows topography and recharges the regional groundwater which has a flow direction of north to north-east;
- discharge of groundwater likely occurs in the lower reaches of Googong Creek and Montgomery Creek;
- irrigation with potable water has been undertaken for several years;
- irrigation with potable water shows minimal impact to the groundwater over the impact of long-term climate trends;
- impacts of irrigation to the groundwater system are likely to be increased localised recharge, total dissolved solids, nutrients and salts;
- discharge of groundwater with elevated concentrations of salts and nutrients is likely on Googong Creek;
- groundwater monitoring bores are required up and down gradient of the proposed sporting fields of Common A, Common B and Sporting Field 7;
- operational impacts require a monitoring frequency of at least quarterly;
- groundwater model update is required for IWC validation after at least one year of irrigation with recycled water;
- irrigation with recycled water is proposed by QPRC to commence in the third quarter of 2020;
- geophysical survey of sporting fields and discharge points should be removed from the GWMP and the IMP be updated to use geophysical survey as an investigative tool should an impact be observed; and
- revision of the groundwater monitoring program should occur after two years of irrigation with recycled water.

With regards to operation of Stage D excess recycled water discharge:

- impacts of discharge of excess recycled water from Discharge Point 3 to the groundwater system are likely to be minimal;
- mitigation of potential impacts to groundwater involves reducing the backwater pooling on Googong Creek;

- the ultimate IWC Project would see an average 174% increase in recycled water excess discharged to Googong Creek over the next 25 years (compared to 2019 discharge volumes) during winter months, summer months may be the same or less;
- increases in discharge at Discharge Point 3 is unlikely to have a significant impact to the groundwater system and may partly offset loss of shallow groundwater discharge to Googong Creek from land use change from township development; and
- Discharge Point 1 should be considered as an occasional release point as its not economically reasonable to pump water up-hill for release.

SMEC makes the following recommendations:

- installation of a minimum of six groundwater monitoring bores in the following locations:
  - one in NH2,
  - one in Common A (captures common B);
  - nested (2) location in NH4 and
  - two in NH5;
- addition of the groundwater seep/spring at the WRP into the groundwater monitoring program including quality and flow rate;
- new monitoring bores should be installed now to allow 12 months of data to facilitate additional hydrogeological inputs to the groundwater model update after the first year of irrigation;
- update of the numerical groundwater model for whole of township development stages and irrigation after one year of irrigation with recycled water (i.e. May 2021);
- geophysical electromagnetic survey be revised in the IMP as an investigative tool should an impact be identified at the open spaces such as salt scalding or regular water logging or groundwater salinity is observed in the monitoring bores;
- groundwater monitoring is more likely to show impacts of irrigation and the monitoring frequency should be increased to quarterly for the first two years of recycled water irrigation; and
- the WMP (RPS, 2018) including supporting documents outlining monitoring programs such as the GWMP, should be amended to include these recommendations and ensure their implementation.

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APPENDIX A: Groundwater Level and Chemistry Results

Table A1. Groundwater Level Measurements meters below top of casing

Date	GGW1s	GGW1d	GGW2	GGW3s	GGW3d	GGW4s	GGW4d	GGW5	GGW6	GGW7s	GGW7d	PB	GGW2A
14/08/2013		10.8											
19/08/2013					12.63								
20/08/2013								18.96					
21/08/2013	Dry	11.11											
26/08/2013			4.76	6.24	6.74			4.29					
27/08/2013						7.28							
28/08/2013							12.6						
29/08/2013			4.44	5.98	6.72	5.28	5.08	4.27	16.9				
2/09/2013									6.81				
4/09/2013						5.29	5.4						
5/09/2013						5.36	5.1		6.67	3.84	14.91		
6/09/2013					6.81					3.18	3.75		
11/09/2013			4.23	5.88	6.89	5.15	4.87	4.97		2.54	3.02		
12/09/2013	Dry	11.55							7.5				
2/12/2013			3.76	5.44	10.33					2.245	2.57		
3/12/2013	9.55	8.94			6.23	5.08	4.74	4.06	4.97			3.29	
4/12/2013								4.18					
11/01/2014						5.32	4.97	4.445					
11/01/2014						5.28	4.91						
12/01/2014								4.476					
12/01/2014								4.445					
13/01/2014						5.32	4.94	4.49			2.655		
5/03/2014				5.57	6.3				6.38				
6/03/2014	11.15	6.22	4			5.39	4.98	7.43		2.235	2.53		
5/06/2014	Dry	11.69	4.115	5.05	5.92	5.36	4.955	7.46	5.65	2.405	2.72		
3/07/2014				3.58	6.08								
16/09/2014	Dry		3.67	7.755	8.02	5.38	4.82	7.43					
17/09/2014		11.42							5.06	2.08	2.72		
2/10/2014								7.48					
29/10/2014		11.67	3.83	7.675		5.26				2.24	2.7		
22/01/2015			2.74	6.685	7.67	4.98	4.601	6.562	2.915	2.228	2.682		
23/01/2015	Dry	11.2											
26/02/2015	Dry	11.31	2.93	7.36	7.58	5.13	4.71	6.5	4.54	2.225	2.49		
15/06/2015			3.46	7.58	7.98	5.35	4.86	6.74		2.48	2.7		
16/06/2015	Dry	11.99							5.81				
6/08/2015			2.145				4.415						
20/10/2015							4.76						
21/10/2015													7.34
17/12/2015	Dry	10.885		6.22	6.55	5.15	4.595	6.32	4.8	2.22	2.36		0.425
15/03/2016	11.085												
16/03/2016				6.09									
30/05/2016	Dry	11.18		6.24	6.69	5.3	4.74	6.66	6.345	2.4	2.48		0.5
31/08/2016	10.955	10.57		5.83	5.93	4.87	4.5	6.07	4.015	1.18	2.1		0
22/11/2016				5.15	5.4				3.65				0
23/11/2016	10.58					4.91	4.4	5.45		2.05	2.17		
20/02/2017	11.25	10.935		5.12	5.4	5.09	4.56	5.93	4.96	2.235	2.23		0.015
22/06/2017				5.59	5.9	5.26		6.405	6.125				0.15
23/06/2017	Dry	11.04					4.73			2.335	2.33		
23/06/2017	Dry	11.04					4.73			2.335	2.33		
30/11/2017	10.78	10.67		5.44	5.81	4.89	4.48	6.56	7.09	2.21	2.4		0
19/05/2018	10.92	10.755		5.49	5.83	5.02	4.54	6.655	7.28	2.36	2.33		0
4/10/2018	Dry	11.44		5.68	6.17	5.23	4.73	6.88	8.215	2.455	2.46		0.01
24/07/2019	10.63	10.45		5.38	5.81	5.16	4.61	6.67	9.02	2.435	2.43		0
14/01/2020	11.14	11.09		5.67	5.99	5.4	4.99	6.5	9.75	2.61	2.51		0.025

Table A2. Groundwater Level Measurements mAHD

Date	GGW1s	GGW1d	GGW2	GGW3s	GGW3d	GGW4s	GGW4d	GGW5	GGW6	GGW7s	GGW7d	PB	GGW2A
Casing Level mAHD	724.12	723.88	720.77	720.6	721.31	739.4	739.26	742.26	789.87	726.712	726.67	741.66	715.475
				723.125	723.29			745.3					
								744.6					
								743.87					
14/08/2013		713.08											
19/08/2013					708.68								
20/08/2013								723.3					
21/08/2013	Dry	712.77											
26/08/2013			716.01	714.36	714.57			737.97					
27/08/2013						732.12							
28/08/2013							726.66						
29/08/2013			716.33	714.62	714.59	734.12	734.18	737.99	772.97				
2/09/2013									783.06				
4/09/2013						734.11	733.86						
5/09/2013						734.04	734.16		783.2	722.88	711.76		
6/09/2013					714.5					723.54	722.92		
11/09/2013			716.54	714.72	714.42	734.25	734.39	737.29		724.172	723.65		
12/09/2013	Dry	712.33							782.37				
2/12/2013			717.01	715.16	710.98					724.467	724.1		
3/12/2013	714.57	714.94			715.08	734.32	734.52	738.2	784.9			738.37	
4/12/2013													
11/01/2014						734.08	734.29	737.815					
11/01/2014						734.12	734.35						
12/01/2014								737.784					
12/01/2014								737.815					
13/01/2014						734.08	734.32	737.77			724.015		
5/03/2014				715.03	715.01				783.49				
6/03/2014	712.97	717.66	716.77			734.01	734.28	737.87		724.477	724.14		
5/06/2014		712.19	716.655	715.55	715.39	734.04	734.305	737.84	784.22	724.307	723.95		
3/07/2014				717.02	715.23								
16/09/2014	Dry		717.1	715.37	715.27	734.02	734.44	737.87					
17/09/2014	Dry	712.46							784.81	724.632	723.95		
2/10/2014								737.12					
29/10/2014		712.21	716.94	715.45		734.14				724.472	723.97		
22/01/2015			718.03	716.44	715.62	734.42	734.659	737.308	786.955	724.484	723.988		
23/01/2015	Dry	712.68											
26/02/2015		712.57	717.84	715.765	715.71	734.27	734.55	737.37	785.33	724.487	724.18		
15/06/2015			717.31	715.545	715.31	734.05	734.4	737.13		724.232	723.97		
16/06/2015	Dry	711.89							784.06				
6/08/2015			718.625				734.845						
20/10/2015							734.5						
21/10/2015													708.135
17/12/2015	Dry	712.995		716.905	716.74	734.25	734.665	737.55	785.07	724.492	724.31		715.05
15/03/2016	713.035												
16/03/2016				717.035									
30/05/2016		712.7		716.885	716.6	734.1	734.52	737.21	783.525	724.312	724.19		714.975
31/08/2016	713.165	713.31		717.295	717.36	734.53	734.76	737.8	785.855	725.532	724.57		715.475
22/11/2016				717.975	717.89				786.22				715.475
23/11/2016	713.54					734.49	734.86	738.42		724.662	724.5		
20/02/2017	712.87	712.945		718.005	717.89	734.31	734.7	737.94	784.91	724.477	724.44		715.46
22/06/2017				717.535	717.39	734.14		737.465	783.745				715.325
23/06/2017		712.84					734.53			724.377	724.34		
23/06/2017		712.84					734.53			724.377	724.34		
30/11/2017	713.34	713.21		717.685	717.48	734.51	734.78	737.31	782.78	724.502	724.27		715.475
19/05/2018		713.125		717.635	717.46	734.38	734.72	737.215	782.59	724.352	724.34		715.475
4/10/2018		712.44		717.445	717.12	734.17	734.53	736.99	781.655	724.257	724.21		715.465
24/07/2019	713.49	713.43		717.745	717.48	734.24	734.65	737.2	780.85	724.277	724.24		715.475
14/01/2020	712.98	712.79		717.455	717.3	734	734.27	737.37	780.12	724.102	724.16		715.45

NOTE: red value indicates development recovery level

Table A3. GGW1S - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>740	<7 or >7.5	>0.1	>0.85
3/12/2013	100	16.8	43.4	< 0.5	222				131	21	489	723	7.22	< 0.05	0.8
6/03/2014	104	14.8	48.7	< 0.5	261				109	31	448	816	7.11	0.08	0.6
23/11/2016	110	37	48	1.1	400				120	53	610	950	7.5	<0.1	<1
30/11/2017	120	27.0	69.0	14	390				120	54	610	960	6.90	<0.1	<1
24/07/2019	172	28	65.7	0.7	364	<0.1	<0.1	364	142	49.9	631	1000	7.6	<0.05	<2

Table A4. GGW1S - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>1.75	>0.2	>1.5	>30	No Criteria	No Criteria	No Criteria	>0.03	>0.02	>3.7	No Criteria	No Criteria	>0.03	>4
3/12/2013	1.4	0.1	< 0.5	19	42	5.6	16	0.02	< 0.1	3.68			< 0.02	0.6
6/03/2014	1.4	< 0.1	1	59	20600	621	11	0.02	< 0.01	3.9			< 0.01	0.3
23/11/2016	<1	<1	2	15	1700	110	<10	<0.01	2.3	<0.005			<0.005	0.12
30/11/2017	2	<1	<1	<5	1400	34	12	0	2	0.01			<0.005	0.7
24/07/2019	2	<0.2	<5	<5	3940	201	40	<0.1	<0.01	1.54	1.54	1.73	<0.02	0.19

Table A5. GGW1D - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>1260	<6 or >8.5	>0.1	>0.32
12/09/2013	115	39.6	76.8	1.3	339				162	56	685	1148	8.02	< 0.05	< 0.05
3/12/2013	77.2	30.4	45.5	< 0.5	199				160	25	463	732	7.27	< 0.05	< 0.2
6/03/2014	68.8	29.6	43	< 0.5	212				105	27	363	742	7.15	0.09	< 0.2
5/06/2014	73.2	31.5	48.8	<0.5	279				118	40	486	821	6.7	<0.05	<0.2
17/09/2014	75	28.4	45.6	<0.5	217				136	37	350	808	7.93	<0.05	<0.2
23/01/2015	69.8	28	39.7	0.6	214				108	35	480	794	7.71	<0.05	0.3
26/02/2015	59.8	64.7	120	0.8	335				260	30	576	1200	7.41	<0.05	<0.2
16/06/2015	90.2	36.4	54.4	0.9	291				144	54	591	1020	7.6	<0.05	0.3
17/12/2015	80.9	30.3	40.3	1.3	246				125	40	480	791	7.81	<0.1	<1
30/05/2016	93.4	36.9	56	1.7	321				124	48	610	946	7.68	<0.1	<1
23/11/2016	110	37	54	1.4	490				150	67	750	1200	7.3	<0.1	<1
23/06/2017	110	39	57	1.6	440				130	58	640	1100	7.3	<0.1	<1
30/11/2017	110	38	76	2.9	450				120	54	610	1000	6.9	<0.1	<1
4/10/2018	109	42	74	1.4	367	<0.1	<0.1	367	132	57	675	1130	7.9	<0.05	<2
24/07/2019	110	42.2	83.5	1.4	444	<0.1	<0.1	444	118	53.6	681	1100	7.33	<0.05	<2

Table A6. GGW1D - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>4.6	>1.8	>2.4	>52	No Criteria	No Criteria	No Criteria	>0.06	>4	>3.3	No Criteria	No Criteria	>0.03	>7
12/09/2013	< 0.5	< 0.1	2	15	16200	1120	50	< 0.01	1.97	2.28			< 0.01	0.7
3/12/2013	3.8	1.4	< 0.5	22	34	15.5	11	0.03	0.02	3.22			< 0.02	0.5
6/03/2014	1.2	0.1	0.7	45	29	3.8	< 5	< 0.01	< 0.01	2.42			< 0.01	0.5
5/06/2014	2.5	0.3	<0.5	26	106	31.2		<0.01	2.67	<0.01			<0.01	0.3
17/09/2014	0.7	<0.1	<0.5	4	14	30	<10	0.02	2.11	<0.01			<0.01	0.2
23/01/2015	0.8	<0.1	1.2	31	2140	127	21	0.05	<0.01	2.04			<0.01	0.9
26/02/2015	1.1	0.1	0.8	16	104	473	<10	<0.01	<0.01	0.3			<0.01	0.1
16/06/2015	<0.5	<0.1	<0.5	4	28	29.6	<10	<0.01	2.33	0.02			<0.01	0.2
17/12/2015	<1	<1	<1	22	160	50	<10	0.01	0.64	<0.01			<0.01	0.2
30/05/2016	<1	<1	<1	<5	170	34	13	<0.01	1.19	<0.01			<0.01	<0.2
23/11/2016	<1	<1	1	<5	350	130	<10	<0.01	1.9	0.024			0.008	0.13
23/06/2017	<1	<1	<1	8	210	36	<10	<0.01	1.7	0.009			<0.005	<0.05
30/11/2017	<1	<1	<1	31	6	<1	<10	0.08	1.3	0.006			<0.005	0.79
4/10/2018	<1	<0.2	4.8	<5	290	71	<5	<0.1	<0.01	1.340	1.340	1.540		0.2
24/07/2019	2	<0.2	<5	6	170	40.8	6	<0.1	0.01	1.56	1.57	1.64	<0.02	0.07

Table A7. GGW2A - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>2060	<6.3 or >7.5	>2	>0.9
30/05/2016	53.7	108	193	2.9	766				40	163	1070	1860	7.38	<0.1	<1
22/11/2016	55	110	190	2.7	980				39	160	1100	1900	7.1	<0.1	<1
22/06/2017	56	110	190	2.7	930				41	180	1100	2000	7.0	<0.1	<1
30/11/2017	61	120	210	3.5	950				43	180	1100	1900	6.7	<0.1	<1
4/10/2018	60	120	202	2.8	794	<0.1	<0.1	794	51	184	1180	1970	7.6	<0.05	<2
23-Jul-2019	64.7	134	250	3.1	70	318	<0.1	388	58.7	226	1260	2110	7.11	<0.05	2

Table A8. GGW2A - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)

Trigger Value	>16.5	>8.2	>3.4	>140	No Criteria	No Criteria	No Criteria	>0.07	>4.6	>9.8	No Criteria	No Criteria	>0.03	>15
30/05/2016	<1	<1	<1	10	200	68	13	<0.01	2.13	0.01			0.02	0.3
22/11/2016	3	<1	<1	7	35	87	<10	0.01	3.2	0.021			0.012	<0.05
22/06/2017	<1	<1	<1	<5	110	82	11	0.02	2.8	0.024			0.013	0.18
30/11/2017	<1	<1	<1	12	21	15	<10	0.05	1.5	<0.005			<0.005	0.38
4/10/2018	<1	<0.2	3.7	<5	160	164	6	<0.1	<0.01	2.210	2.210	2.520		0.31
23-Jul-2019	2	<0.2	<5	<5	1570	495	37	<0.1	0.02	2	2.02	2.38	<0.02	0.36

Table A9. GGW3S - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>810	<7 or >8.5	>0.46	>1.35
12/09/2013	12.2	17.3	157	0.7	342				34	11	475	730	8.08	< 0.05	< 0.05
3/12/2013	6.2	13	134	< 0.5	275				48	10	451	636	7.29	0.08	1.1
5/03/2014	5.8	11.2	118	< 0.5	256				30	8	376	626	7.38	0.39	1.2
5/06/2014	4.8	9.2	118	<0.5	254				34	9	394	584	8.1	<0.05	0.6
17/09/2014	2.7	4.4	81	1.2	146				40	8	3010	387	7.69	<0.05	<0.2
22/01/2015	2.2	5.2	84.1	<0.5	175				16	21	2160	455	7.56	<0.05	0.2
26/02/2015	2.9	5.8	107	0.8	198				15	9	795	469	7.73	<0.05	<0.2
15/06/2015	3.3	5.8	87.5	<0.5	194				12	8	920	474	7.57	<0.05	<0.2
30/05/2016	16.1	29.6	141	0.7	332				30	47	667	828	7.67	<0.1	<1
22/11/2016	17	38	190	0.4	550				84	83	730	1200	7.2	<0.1	<1
22/06/2017	23	51	200	0.7	630				83	100	790	1400	7.2	<0.1	<1
30/11/2017	21	48	200	0.8	560				69	100	770	1200	6.7	<0.1	<1
4/10/2018	17	44	174	0.4	414	<0.1	<0.1	414	47	92	760	1230	7.7	<0.05	<2
24/07/2019	16.5	47.3	214	0.7	466	<0.1	<0.1	466	48.5	72.3	793	1180	7.01	<0.05	<2

Table A10. GGW3S - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>5.7	>0.6	>1.1	>45	No Criteria	No Criteria	No Criteria	>0.1	>2.4	>9.8	No Criteria	No Criteria	>0.03	>12
12/09/2013	1.1	< 0.1	0.6	3	21700	212	116	0.03	1.89	1.89			< 0.01	1.1
3/12/2013	1.9	0.5	1	10	34400	514	52	< 0.01	< 0.1	2.25			< 0.02	0.9
5/03/2014	4.8	0.4	1	35	20300	255	62	0.02	< 0.01	1.86			< 0.01	0.5
5/06/2014	2.2	0.4	1.2	20	19300	265		0.06	8.26	<0.01			<0.01	1.8
17/09/2014	0.7	0.2	<0.5	24	50000	369	12	0.09	3.87	<0.01			0.02	9.8
22/01/2015	<0.5	<0.1	<0.5	6	2010	28.4	21	0.03	<0.01	3.01			<0.01	2.6
26/02/2015	0.7	<0.1	<0.5	25	30800	249	77	0.01	0.07	3.53			<0.01	1.3
15/06/2015	2.6	<0.1	<0.5	10	83000	774	115	0.04	3.23	<0.01			<0.01	5.2
30/05/2016	1	<1	2	7	9150	96	38	<0.01	3.17	<0.01			<0.01	0.8
22/11/2016	4	<1	2	20	5400	120	68	0.02	0.98	<0.005			<0.005	1.6
22/06/2017	1	<1	1	49	16000	140	70	0.04	0.54	<0.005			0.019	1.2
30/11/2017	<1	<1	2	25	19	30	89	0.08	0.01	<0.005			<0.005	1.7
4/10/2018	2	<0.2	5	21	1820	138	77	<0.1	<0.01	0.14	0.14	1.6		1.5
24/07/2019	3	<0.2	7	29	5560	171	142	<0.1	<0.01	0.08	0.08	1.66	<0.02	1.58

Table A11. GGW3D - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>2060	<6.3 or >7.5	>2	>0.9
12/09/2013	107	139	164	2.9	779				36	235	1090	1995	7.36	< 0.05	< 0.05
3/12/2013	98	120	126	1.5	642				36	198	958	1776	7.39	< 0.05	0.8
5/03/2014	63	82.6	109	1.6	466				28	136	708	1410	6.87	1.57	0.6
5/06/2014	72.2	95.1	128	1.7	646				38	161	716	1545	7.28	0.15	0.3
17/09/2014	85.6	103	132	1.7	615				38	179	1600	1790	7.75	<0.05	<0.2
22/01/2015	73.2	98.6	120	1.3	533				41	158	854	1670	7.22	<0.05	0.3
15/06/2015	94.7	122	136	1.9	742				36	221	1070	2030	7.19	0.05	0.6
30/05/2016	81.8	100	141	1.9	648				45	182	1070	1740	7.09	<0.1	<1
22/11/2016	85	100	140	1.9	510				53	110	750	1200	6.5	<0.1	<1
22/06/2017	37	51	140	1.0	540				45	110	720	1300	6.4	<0.1	1
30/11/2017	33	43	140	1.1	430				50	110	690	1100	6.3	<0.1	1
4/10/2018	76	94	137	1.7	642	<0.1	<0.1	642	45	146	950	1640	7.4	<0.05	<2
24/07/2019	81.9	100	173	1.9	766	<0.1	<0.1	766	44.4	145	1030	1800	7.46	<0.05	<2

Table A12. GGW3D - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>16.5	>8.2	>3.4	>140	No Criteria	No Criteria	No Criteria	>0.07	>4.6	>9.8	No Criteria	No Criteria	>0.03	>15
12/09/2013	< 0.5	< 0.1	0.8	22	6440	105	48	0.02	0.96	1.03			< 0.01	0.4
3/12/2013	2.1	6.7	1.1	14	1170	32	6	0.01	< 0.1	1.38			< 0.02	0.5
5/03/2014	13.4	0.6	2.9	114	1560	53.3	29	0.06	< 0.01	8.07			< 0.01	1.4
5/06/2014	4.3	0.6	1	109	362	22.5		0.04	3.91	<0.01			0.01	1.2
17/09/2014	0.7	<0.1	<0.5	6	24300	118	23	0.02	2.8	<0.01			0.01	<1.0
22/01/2015	1	<0.1	0.6	3	908	15.3	39	0.05	<0.01	2.24			<0.01	0.5
15/06/2015	2.4	<0.1	<0.5	64	3240	27.9	<10	0.02	1.44	<0.01			<0.01	0.4

30/05/2016	1	<1	1	23	380	31	36	<0.01	1.13	<0.01			<0.01	0.5
22/11/2016	2	<1	2	9	68	52	82	0.07	0.96	0.014			<0.005	0.95
22/06/2017	1	<1	4	11	540	140	120	0.83	0.070	<0.005			0.047	2.9
30/11/2017	<1	<1	2	55	1200	280	99	1.20	<0.005	<0.005			0.03	3.20
4/10/2018	<1	<0.2	5	<5	1780	79	40	0.30	<0.01	1.070	1.070	2.280		1.21
24/07/2019	1	<0.2	<5	<5	2380	65.2	41	0.3	<0.01	1.52	1.52	2.68	<0.02	1.16

Table A13. GGW4S - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>2060	<6.3 or >7.5	>0.2	>0.55
12/09/2013	83	126	190	0.8	610				138	234	1120	1929	7.37	< 0.05	< 0.05
3/12/2013	80.8	126	183	< 0.5	589				142	239	1240	1838	6.7	< 0.05	0.3
6/03/2014	76.4	123	171	< 0.5	557				137	238	983	1950	6.66	0.2	< 0.2
5/06/2014	65.3	115	185	<0.5	651				140	239	1010	1881	6.63	<0.05	<0.2
17/09/2014	74.6	62.2	248	2	655				112	138	1160	1870	7.36	<0.05	0.5
22/01/2015	76.4	48.9	87.9	4.6	456				24	68	776	1220	6.64	<0.05	4.5
26/02/2015	75.9	108	180	1.7	642				102	200	803	1930	7.44	<0.05	0.5
15/06/2015	70.5	105	157	1.2	589				103	230	1020	1920	7.24	<0.05	0.5
30/05/2016	87.7	104	154	1.4	637				110	215	1100	1900	7.22	<0.1	<1
23/11/2016	82	65	100	4.7	700				23	120	800	1300	6.9	<0.1	2
22/06/2017	73	100	160	1.6	740				100	210	980	1900	7.1	<0.1	<1
30/11/2017	75	110	170	1.2	760				100	210	1100	1800	6.9	<0.1	<1
4/10/2018	76	112	161	0.8	564	<0.1	<0.1	564	104	218	1120	1880	7.8	<0.05	<2
24/07/2019	79	119	199	0.9	621	<0.1	<0.1	621	98.2	228	1170	1950	7.53	<0.05	<2

Table A14. GGW4S - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>1.6	>2.8	>13.5	>40	No Criteria	No Criteria	No Criteria	>1.5	>0.2	>0.2	No Criteria	No Criteria	>0.03	>0.5
12/09/2013	< 0.5	< 0.1	2.4	7	43700	7920	45	0.03	0.17	0.17			< 0.01	1.1
3/12/2013	1	2.3	3.8	10	45200	9670	25	0.05	< 0.1	< 0.05			< 0.02	0.7
6/03/2014	1.4	0.2	2.2	26	53500	8530	78	0.09	< 0.01	0.01			< 0.01	0.6
5/06/2014	1.1	0.3	2.8	34	37200	3360		0.02	0.02	<0.01			0.01	1
17/09/2014	0.5	0.1	11.3	6	29700	6200	518	1.18	<0.10	<0.10			<0.10	13.4
22/01/2015	0.7	2.6	12.6	36	20400	4910	16	1.82	<0.01	0.04			0.01	6.3
26/02/2015	<0.5	<0.1	1	5	9270	8180	38	1.06	<0.01	<0.01			<0.01	2.7
15/06/2015	<0.5	<0.1	1.4	28	8680	8440	30	0.79	0.02	<0.01			<0.01	1.7
30/05/2016	<1	<1	2.00	25	5760.00	8850.00	32	0.47	0.02	<0.01			<0.01	1
23/11/2016	1	<1	2.00	12	22000	19000	81	2.7	0.008	<0.005			0.33	4.9
22/06/2017	<1	<1	3.00	23	13000	10000	77	0.66	0.012	<0.005			<0.005	2.8
30/11/2017	<1	<1	3.00	12	350	6100.00	270	0.52	<0.005	<0.005			0.036	5
4/10/2018	<1	<0.2	3.80	<5	4190	4280.00	11	0.30	<0.01	<0.05	<0.05	0.64		0.6
24/07/2019	2	0.7	69	116	59200	4070	186	0.2	<0.01	<0.05	<0.05	1.39	<0.02	1.39

Table A15. GGW4D - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>1080	<6.5 or >8.3	>0.1	>0.3
12/09/2013	70.8	46.7	104	2.9	378				110	44	601	1025	7.99	0.07	0.07
3/12/2013	78.5	44.3	48.2	1.4	343				50	30	461	813	6.85	< 0.05	< 0.2
6/03/2014	78.7	45.4	44.7	1.1	366				49	28	429	801	6.72	0.09	< 0.2
5/06/2014	69.7	43.2	58.2	1	389				46	35	405	800	6.85	<0.05	<0.2
17/09/2014	70.1	40.6	39.4	0.8	330				46	29	421	838	7.87	<0.05	<0.2
22/01/2015	66.2	42	37.1	0.7	318				49	35	432	854	7.49	<0.05	<0.2
15/06/2015	65.9	40.5	37.9	0.7	339				44	28	433	819	7.47	<0.05	<0.2
30/05/2016	74.4	45.8	36.4	0.8	356				47	28	460	808	7.55	<0.1	<1
23/11/2016	75	40	28	0.8	470				45	27	460	790	7.3	<0.1	<1
23/06/2017	76	43	28	0.8	430				45	27	430	840	7.2	<0.1	<1
30/11/2017	74	65	82	0.9	480				50	53	550	900	7.0	<0.1	<1
4/10/2018	75	45	34	0.8	351	<0.1	<0.1	351	46	26	430	806	7.9	<0.05	<2
24/07/2019	78.1	44.3	34.4	0.8	394	<0.1	<0.1	394	48.7	32.1	450	834	7.38	<0.05	<2

Table A16. GGW4D - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>6.5	>0.5	>1.2	>35	No Criteria	No Criteria	No Criteria	<0.6	>1.7	>1	No Criteria	No Criteria	>0.03	>3

12/09/2013	0.7	0.2	0.9	2	96400	3280	241	0.46	0.87	1.35			< 0.01	7.4
3/12/2013	< 0.5	0.3	0.6	9	1820	256	< 5	0.11	< 0.1	< 0.05			< 0.02	0.2
6/03/2014	3.6	0.2	1.1	22	307	176	5	0.05	< 0.01	0.02			< 0.01	0.1
5/06/2014	5.4	0.5	1	28	277	145		0.01	0.02	<0.01			<0.01	<0.1
17/09/2014	<0.5	<0.1	<0.5	10	415	202	<10	0.06	<0.01	<0.01			<0.01	<0.1
22/01/2015	<0.5	<0.1	0.5	2	323	155	300	0.02	<0.01	0.03			<0.01	<0.1
15/06/2015	<0.5	<0.1	<0.5	10	192	161	<10	0.02	<0.01	<0.01			<0.01	<0.1
30/05/2016	<1	<1	<1	<5	140	153	<10	<0.01	1.96	<0.01			<0.01	<0.1
23/11/2016	<1	<1	2	<5	70	87	<10	<0.01	<0.005	<0.005			<0.005	<0.05
23/06/2017	<1	<1	<1	<5	140	92	<10	<0.01	0.022	<0.005			<0.005	<0.05
30/11/2017	<1	<1	5	7.0	79	1500	<10	0.03	<0.005	<0.005			<0.005	0.13
4/10/2018	<1	<0.2	3	<5	90	64	<5	<0.1	<0.01	<0.05	<0.05	<0.05		<0.05
24/07/2019	<1	<0.2	<5	<5	60	86.6	<5	<0.1	<0.01	<0.05	<0.05	<0.05	<0.02	<0.05

Table A17. GGW5 - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>1750	<6 or >8	>0.1	>0.45
12/09/2013	82.9	55	230	4.3	501				250	65	1070	1540	7.81	< 0.05	< 0.05
3/12/2013	128	67.9	137	2.1	483				218	93	930	1460	6.83	< 0.05	0.6
6/03/2014	123	66.8	109	2.4	510				166	69	804	1450	6.63	0.1	0.4
5/06/2014	114	59.5	87.7	2	602				152	81	779	1354	6.48	<0.05	0.4
17/09/2014	131	68.8	86.3	1.6	485				162	96	844	1500	7.73	<0.05	<0.2
22/01/2015	133	72.7	83.2	1	481				139	121	865	1620	7.35	<0.05	<0.2
26/02/2015	149	78.3	92.6	1.4	537				168	117	743	1640	7.55	<0.05	0.6
15/06/2015	139	73.1	82.3	1	508				140	138	924	1610	7.27	<0.05	0.7
30/05/2016	145	80.2	88	1	530				142	130	1030	1600	7.49	<0.1	<1
23/11/2016	160	76	86	1.3	710				150	120	1100	1600	7.0	<0.1	<1
22/06/2017	140	75	82	1.0	650				140	120	900	1600	7.0	<0.1	<1
1/12/2017	130	74	89	1.0	640				130	120	980	1400	6.7	<0.1	<1
4/10/2018	144	73	81	1.2	584	<0.1	<0.1	584	149	109	936	1540	7.6	<0.05	<2
24/07/2019	161	72.3	85.7	1.1	575	<0.1	<0.1	575	152	108	974	1570	7.96	<0.05	<2

Table A18. GGW5 - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>4	>0.7	>14	>200	No Criteria	No Criteria	No Criteria	>1.3	>4.6	>2.5	No Criteria	No Criteria	>0.03	>3
12/09/2013	0.9	0.5	11.5	16	55300	3240	382	1.18	< 0.01	< 0.01			< 0.01	7.6
3/12/2013	< 0.5	0.2	4.6	25	7310	2110	61	0.85	0.01	< 0.05			< 0.02	2
6/03/2014	1.8	0.6	2.5	163	10300	3350	27	0.85	< 0.01	0.13			< 0.01	1.7
5/06/2014	3.4	0.6	3.4	50	10000	2940		0.86	0.02	<0.01			<0.01	1.6
17/09/2014	<0.5	<0.1	0.8	48	7520	1490	16	0.52	1.97	0.02			<0.01	1.2
22/01/2015	<0.5	<0.1	1.3	17	4320	882	<10	0.29	<0.01	3.68			<0.01	1.1
26/02/2015	<0.5	<0.1	1.7	99	649	420	<10	0.13	<0.01	2.16			<0.01	0.2
15/06/2015	0.9	<0.1	0.7	46	1400	429	<10	0.09	4.19	0.02			<0.01	0.6
30/05/2016	<1	<1	1	19	610	50	<10	<0.01	4.62	<0.01			<0.01	0.3
23/11/2016	<1	<1	1	10	220	140	<10	0.07	3.0	<0.005			0.009	<0.05
22/06/2017	<1	<1	<1	10	37	35	<10	0.02	4.7	<0.005			<0.005	<0.05
1/12/2017	<1	<1	3	22.0	8	60	<10	0.09	5.6	<0.005			<0.005	0.85
4/10/2018	<1	<0.2	7	<5	900	84	<5	<0.1	<0.01	2.8	2.8	3.2		0.36
24/07/2019	2	<0.2	<5	9	210	70.7	<5	<0.1	<0.01	2.88	2.88	2.96	<0.02	0.08

Table A19. GGW6 - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>1370	<5.8 or >8.8	>2.2	>0.03
12/09/2013	117	67.2	108	4.6	356				296	38	850	1323	8.27	< 0.05	< 0.05
3/12/2013	92.5	67.4	104	1.2	344				274	28	766	1175	6.71	< 0.05	< 0.2
5/03/2014	65.4	63	103	1	330				248	31	643	1170	6.45	1.78	0.3
5/06/2014	65.9	57.8	99.4	0.8	380				254	37	618	1141	6.43	0.07	<0.2
17/09/2014	65.3	61	105	0.8	329				284	32	663	1210	7.59	<0.05	<0.2
22/01/2015	58.9	67.1	103	0.6	324				265	38	730	1270	7.17	<0.05	<0.2
26/02/2015	60	64.7	119	0.8	338				259	29	634	1210	7.42	<0.05	<0.2
16/06/2015	57.9	55.1	99.4	0.6	316				246	28	684	1160	7.19	<0.05	<0.2
30/05/2016	54	57.2	108	1	324				241	26	703	1080	7.24	<0.1	<1
22/11/2016	21	24	110	2.8	260				76	13	350	560	6.9	<0.1	<1
22/06/2017	20	44	89	0.6	330				140	20	480	840	6.9	<0.1	<1
1/12/2017	27	47	97	0.8	350				150	21	520	850	6.6	<0.1	<1
4/10/2018	38	51	90	0.6	328	<0.1	<0.1	328	163	19	597	988	7.7	<0.05	<2
24/07/2019	59	61.4	116	0.7	371	<0.1	<0.1	371	234	30.8	727	1170	7.11	<0.05	<2

Table A20. GGW6 - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>28	>1.1	>5.5	>130	No Criteria	No Criteria	No Criteria	>0.02	>0.72	>0.45	No Criteria	No Criteria	>.03	>0.7
12/09/2013	< 0.5	< 0.1	4	33	16800	610	64	< 0.01	0.02	0.02			< 0.01	<0.1
3/12/2013	0.6	0.7	1.2	12	851	545	11	0.02	0.01	0.17			< 0.02	0.1
5/03/2014	22.2	0.5	4.5	105	533	423	< 5	< 0.01	< 0.01	0.5			< 0.01	0.1
5/06/2014	3.2	0.9	2	22	127	438		<0.01	0.35	<0.01			<0.01	0.1
17/09/2014	<0.5	<0.1	0.7	5	3490	1120	<10	<0.01	0.36	<0.01			0.01	<0.1
22/01/2015	<0.5	<0.1	0.7	5	1660	472	10	0.02	<0.01	0.58			<0.01	0.2
26/02/2015	0.8	0.1	0.6	7	101	468	<10	0.01	<0.01	0.32			<0.01	0.1
16/06/2015	<0.5	<0.1	0.7	4	285	600	<10	<0.01	0.27	<0.01			<0.01	<0.1
30/05/2016	<1	<1	1	23	130	388	11	<0.01	0.4	0.01			<0.01	0.1
22/11/2016	14	<1	2	<5	560	410	16	0.05	0.26	<0.005			0.007	0.81
22/06/2017	2	<1	2	20	1800	1500	17	0.01	0.15	<0.005			<0.005	0.34
1/12/2017	<1	<1	4	12	8	160	13	0.08	0.19	<0.005			<0.005	0.43
4/10/2018	<1	<0.2	2	<5	2620	281	17	<0.1	<0.01	0.15	0.15	0.37		0.22
24/07/2019	2	<0.2	<5	<5	1740	428	<5	<0.1	0.02	0.22	0.24	0.37	<0.02	0.13

Table A21. GGW7S - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>2100	<6.3 or >8.4	>0.25	>0.45
12/09/2013	84.8	93.7	127	3.7	333				291	122	1070	1468	8.05	< 0.05	< 0.05
3/12/2013	25.2	34.4	56.6	0.6	167				114	41	746	625	7.4	< 0.05	0.4
6/03/2014	85.6	110	130	0.9	437				276	124	949	1660	6.81	< 0.05	< 0.2
5/06/2014	74.3	101	167	2	591				252	179	932	1803	6.65	0.21	0.2
17/09/2014	53.4	93.7	148	2.9	496				171	128	789	1600	7.64	0.08	0.4
22/01/2015	36.9	61.1	124	2.5	376				111	70	706	1230	7.23	<0.05	0.4
26/02/2015	52	86.1	155	2.7	468				193	90	814	1490	7.48	<0.05	0.2
15/06/2015	52.9	83.7	112	1.8	353				233	107	822	1430	7.48	<0.05	<0.2
30/05/2016	98.7	125	131	2.9	744				334	152	1530	2240	7.44	<0.1	<1
23/11/2016	75	100	110	4.3	900				87	69	940	1500	6.9	<0.1	<1
23/06/2017	60	94	130	4.6	680				140	100	890	1600	7.1	<0.1	<1
1/12/2017	84	120	160	4.4	800				190	120	1100	1700	6.6	<0.1	<1
4/10/2018	97	180	324	8.1	874	<0.1	<0.1	874	415	131	1600	2420	7.4	<0.05	<2
24/07/2019	92.5	164	208	3.9	1010	<0.1	<0.1	1010	80.2	114	1340	2160	7.5	<0.05	2

Table A22. GGW7S - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>1.55	>0.45	>6.7	>45	No Criteria	No Criteria	No Criteria	>0.15	>1.2	>1.2	No Criteria	No Criteria	>0.03	>2.5
12/09/2013	1.1	< 0.1	2.4	6	159000	6090	161	0.05	0.96	0.96			< 0.01	2.4
3/12/2013	3.6	0.2	1.3	16	96600	3360	70	0.09	0.02	< 0.05			< 0.02	1.9
6/03/2014	2	0.4	4	18	70800	2160	86	0.03	< 0.01	0.04			< 0.01	1.2
5/06/2014	3.8	0.2	5.6	37	26800	993		0.01	0.11	<0.01			0.01	2.3
17/09/2014	6.6	<0.1	4.6	30	39800	3070	100	<0.01	<0.01	<0.01			0.02	4
22/01/2015	4.6	<0.1	4.5	9	4680	354	<10	0.03	<0.01	0.1			<0.01	5
26/02/2015	<0.5	<0.1	3.7	8	25000	1500	52	0.04	<0.01	0.01			<0.01	1.8
15/06/2015	0.8	<0.1	2.6	8	30400	1340	60	0.03	0.11	<0.01			<0.01	2.3
30/05/2016	<1	<1	4	20	23700	6580	67	0.03	<0.01	<0.01			<0.01	1.5
23/11/2016	<1	<1	5	13	32000	2400	110	0.16	0.04	<0.005			<0.005	3.80
23/06/2017	<1	<1	3	<5	290000	6900	460	0.34	<0.005	<0.005			<0.005	14.00
1/12/2017	<1	<1	4	7	7400	4900	150	0.46	<0.005	<0.005			<0.005	5.10
4/10/2018	3.0	<0.2	6	8	29000	5030	50	<0.1	<0.01	<0.05	<0.05	1.78		1.78
24/07/2019	3	<0.2	<5	15	27000	3610	121	<0.1	<0.01	<0.05	<0.05	1.49	<0.02	1.49

Table A23. GGW7D - Groundwater Chemistry Results

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Carbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Dissolved Solids (mg/L)	Conductivity (µS/cm)	pH	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)
Trigger Value	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	No Criteria	>1550	<6.3 or >8.4	>0.4	>0.3
12/09/2013	93.4	66.5	84.8	3.9	300				204	91	804	1134	8.05	< 0.05	< 0.05
3/12/2013	98.4	87.8	86.2	1	353				256	96	1110	1304	7.61	< 0.05	0.3
6/03/2014	87	83.2	87.1	0.8	354				220	91	764	1350	6.76	0.33	< 0.2
5/06/2014	76.1	79.5	88.9	1.5	429				211	104	673	1335	6.69	0.08	<0.2
17/09/2014	87.3	81	83.1	0.6	362				241	98	814	1390	7.89	<0.05	<0.2

22/01/2015	84.8	79.5	80.7	<0.5	346				226	91	816	1420	7.62	<0.05	<0.2
15/06/2015	80.1	78.8	82.3	1	382				208	86	767	1370	7.63	<0.05	<0.2
30/05/2016	88.4	84.5	84.5	0.9	391				219	77	894	1330	7.72	<0.1	<1
23/11/2016	85	85	86	2.2	600				190	84	860	1400	7.1	<0.1	<1
23/06/2017	87	81	81	0.9	510				180	81	770	1400	7.3	<0.1	<1
1/12/2017	86	87	93	1.5	510				190	80	830	1200	7.0	<0.1	<1
4/10/2018	86	80	75	0.6	459	<0.1	<0.1	459	189	70	780	1300	7.6	<0.05	<2
24/07/2019	88.1	82.7	85.6	2.2	430	<0.1	<0.1	430	161	65.5	773	1250	7.63	<0.05	<2

Table A24. GGW7D - Groundwater Chemistry Results continued

Date	Dissolved Copper (µg/L)	Dissolved Lead (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Chemical oxygen demand (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite + Nitrate (NOx) (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	TKN (mg/L)
Trigger Value	>5.8	>0.07	>4.3	>42	No Criteria	No Criteria	No Criteria	>0.045	>0.61	>0.67	No Criteria	No Criteria	>0.03	>1.2
12/09/2013	< 0.5	< 0.1	2.8	3	246000	6620	172	0.02	0.54	0.54			< 0.01	2.7
3/12/2013	0.7	0.4	1	7	78900	2150	39	0.02	< 0.01	0.16			< 0.02	0.2
6/03/2014	3.3	0.1	1.3	30	51700	1480	39	< 0.01	< 0.01	0.39			< 0.01	0.9
5/06/2014	4.7	0.2	2	34	1380	422		0.02	0.33	<0.01			0.01	0.3
17/09/2014	0.5	<0.1	0.5	1	36400	1480	<10	0.02	0.25	<0.01			0.02	1.2
22/01/2015	<0.5	<0.1	<0.5	<1	171	2.3	<10	0.01	<0.01	0.24			<0.01	0.5
15/06/2015	<0.5	<0.1	1.5	4	36800	1940	37	0.08	0.09	<0.01			<0.01	2.3
30/05/2016	<1	<1	2	<5	8920	486	<10	0.02	0.12	<0.01			<0.01	0.2
23/11/2016	<1	<1	4	<5	7700	1900	11	0.03	<0.005	0.005			<0.005	0.25
23/06/2017	<1	<1	2	5	5600	970	<10	0.02	0	<0.005			<0.005	0.28
1/12/2017	<1	<1	2	<5	120	1100	12	0.06	0	<0.005			0.006	0.67
4/10/2018	<1	<0.2	6	<5	23600	2420	<5	<0.1	<0.01	<0.05	<0.05	0.29		0.29
24/07/2019	2	<0.2	<5	<5	27000	815	79	<0.1	<0.01	<0.05	<0.05	0.38	<0.02	0.38

APPENDIX B: Groundwater Piper Plots

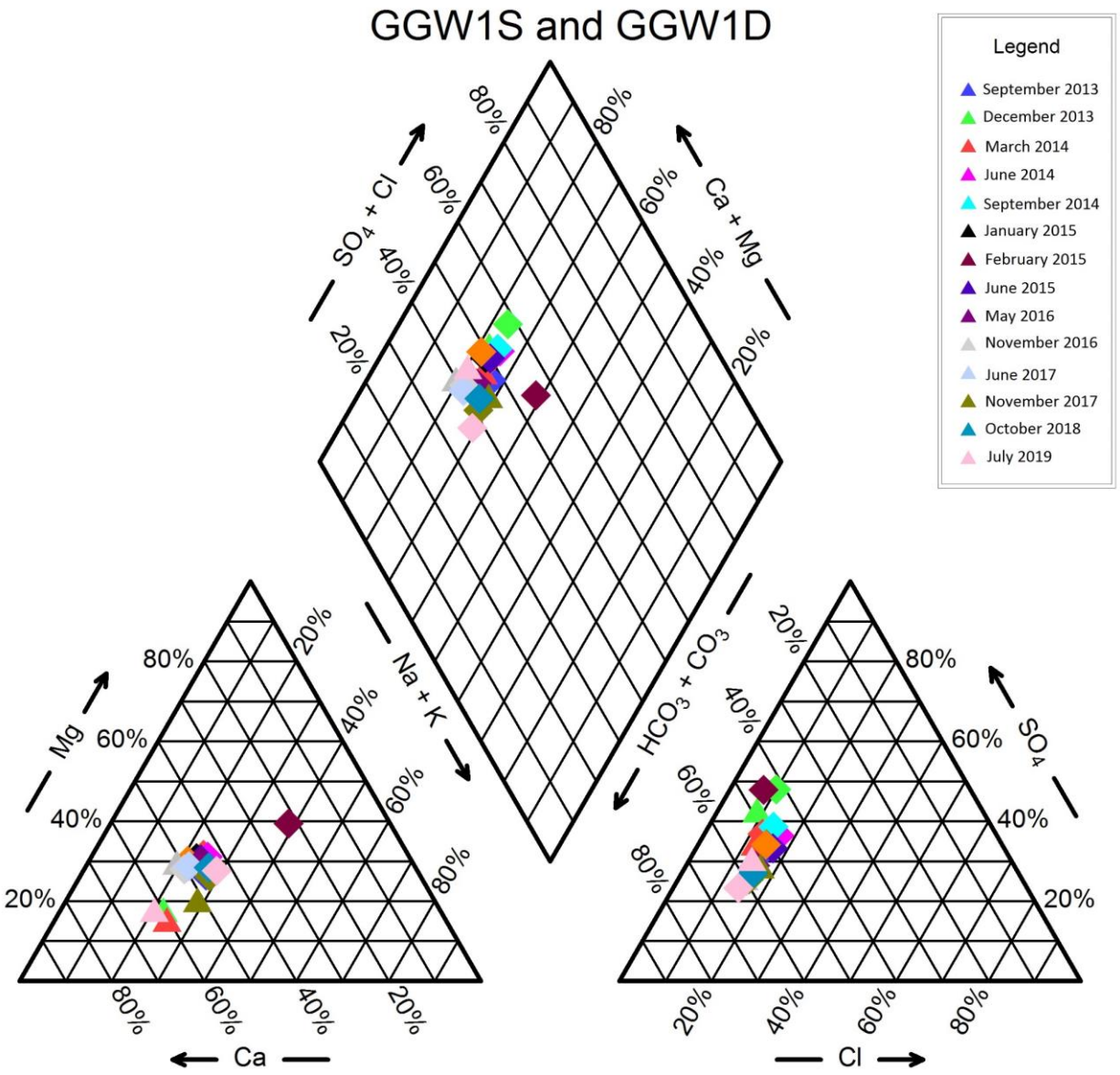


Figure B1: Piper diagram plot of GGW1S (triangles) and GGW1D (diamonds) monitoring rounds

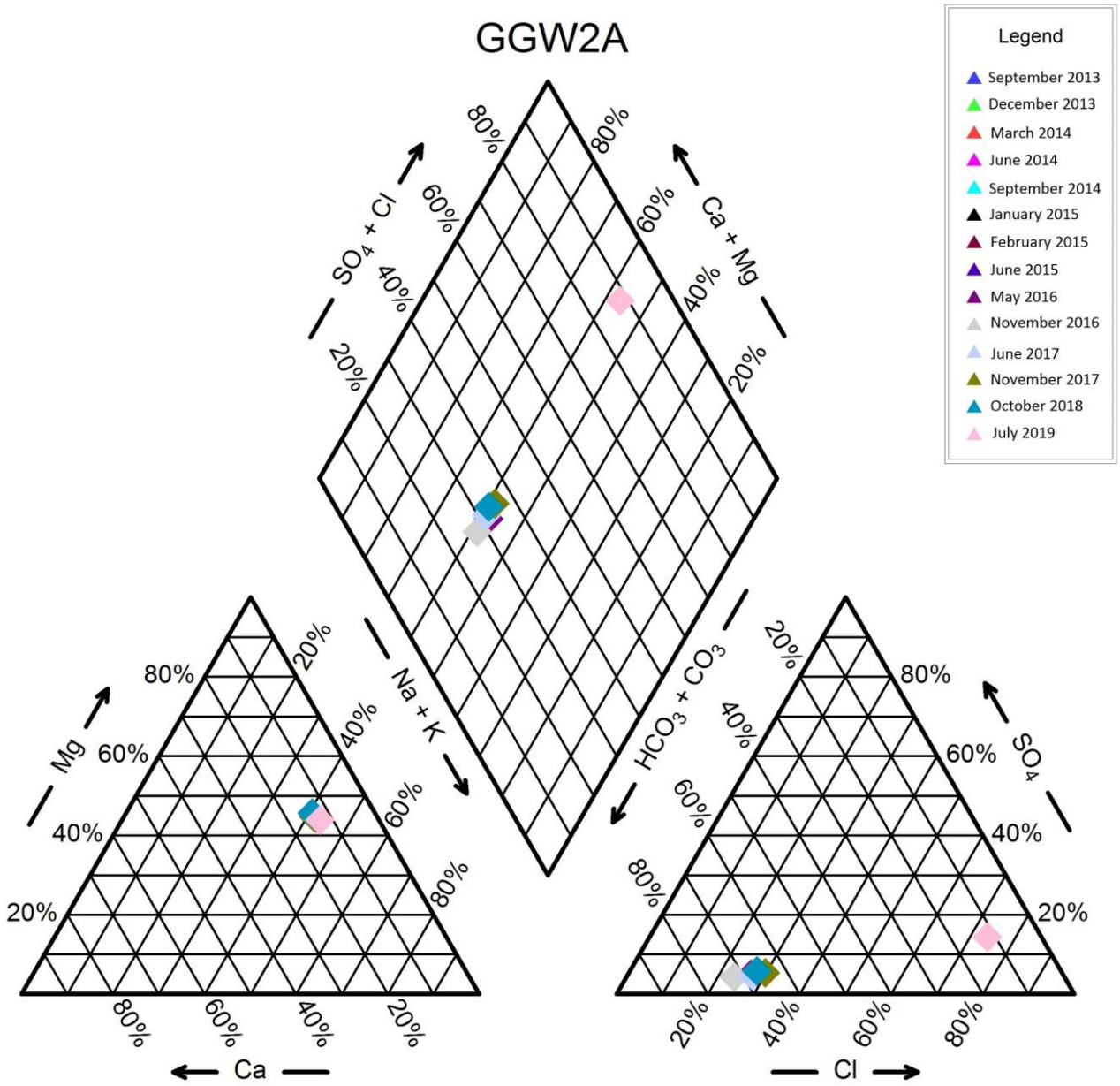


Figure B2: Piper diagram plot of GGW2A monitoring results

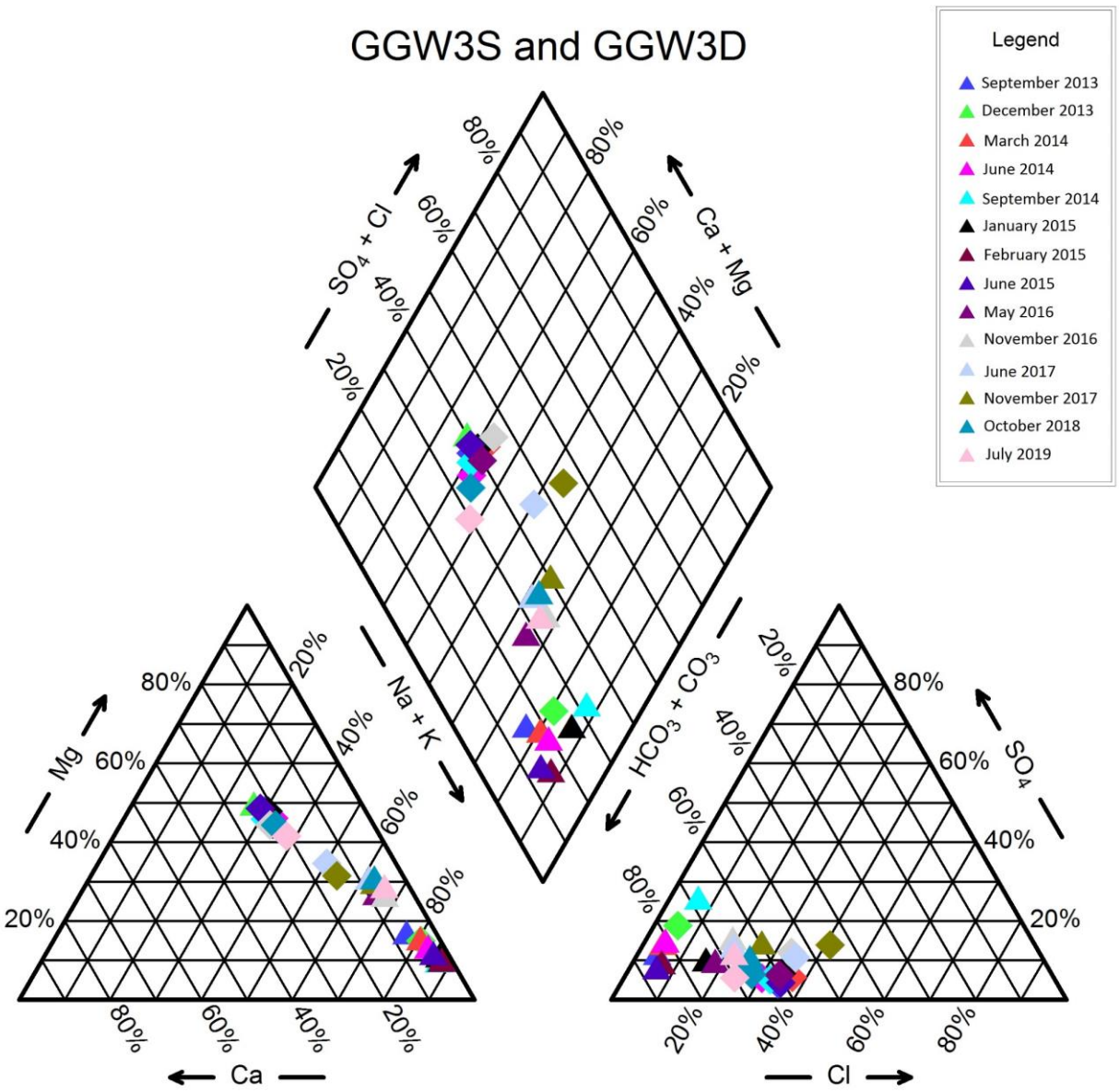


Figure B3: Piper diagram plot of GGW3S (triangles) and GGW3D (diamonds) monitoring results

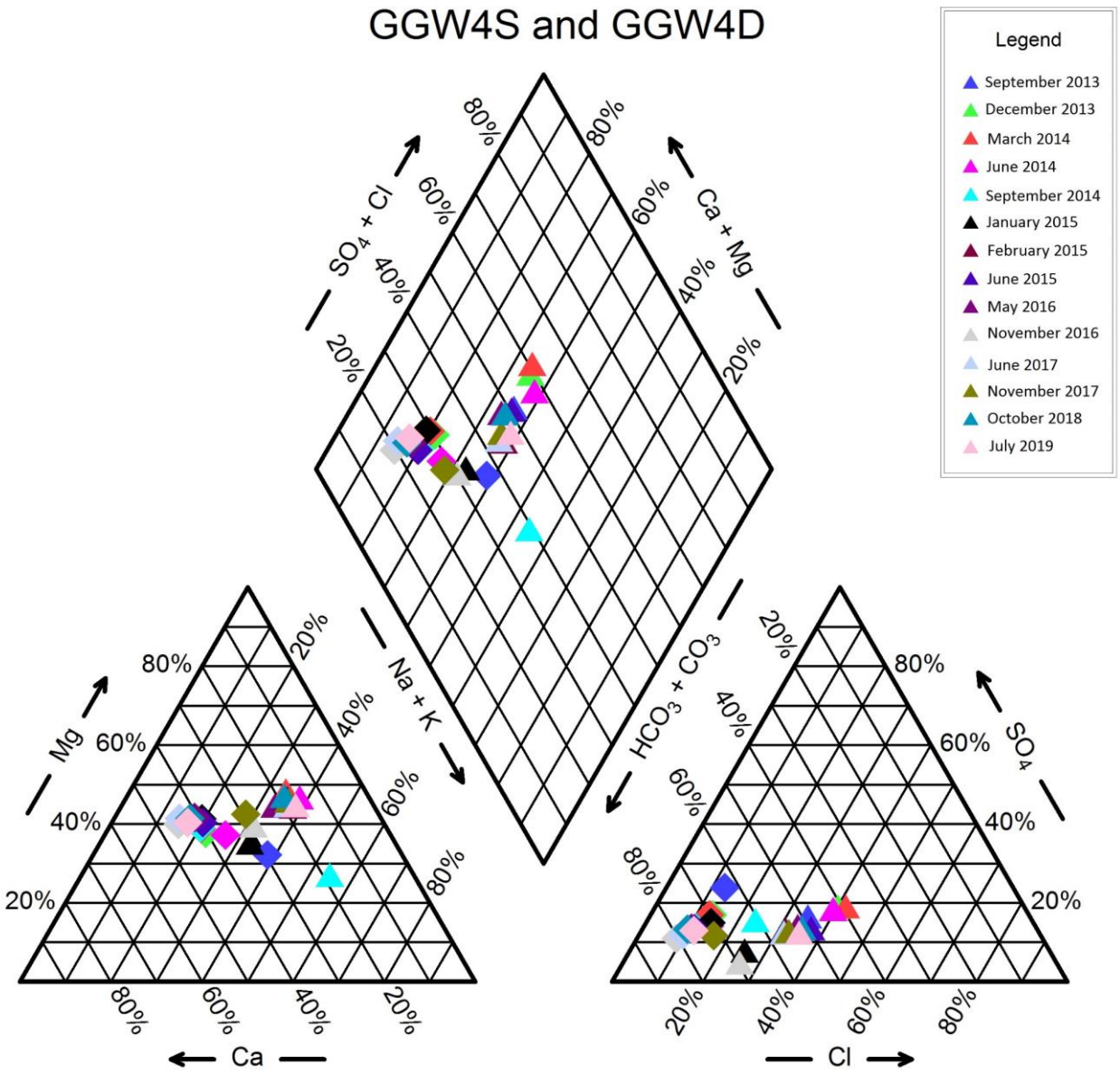


Figure B4: Piper diagram plot of GGW4S (triangles) and GGW4D (diamonds) monitoring results

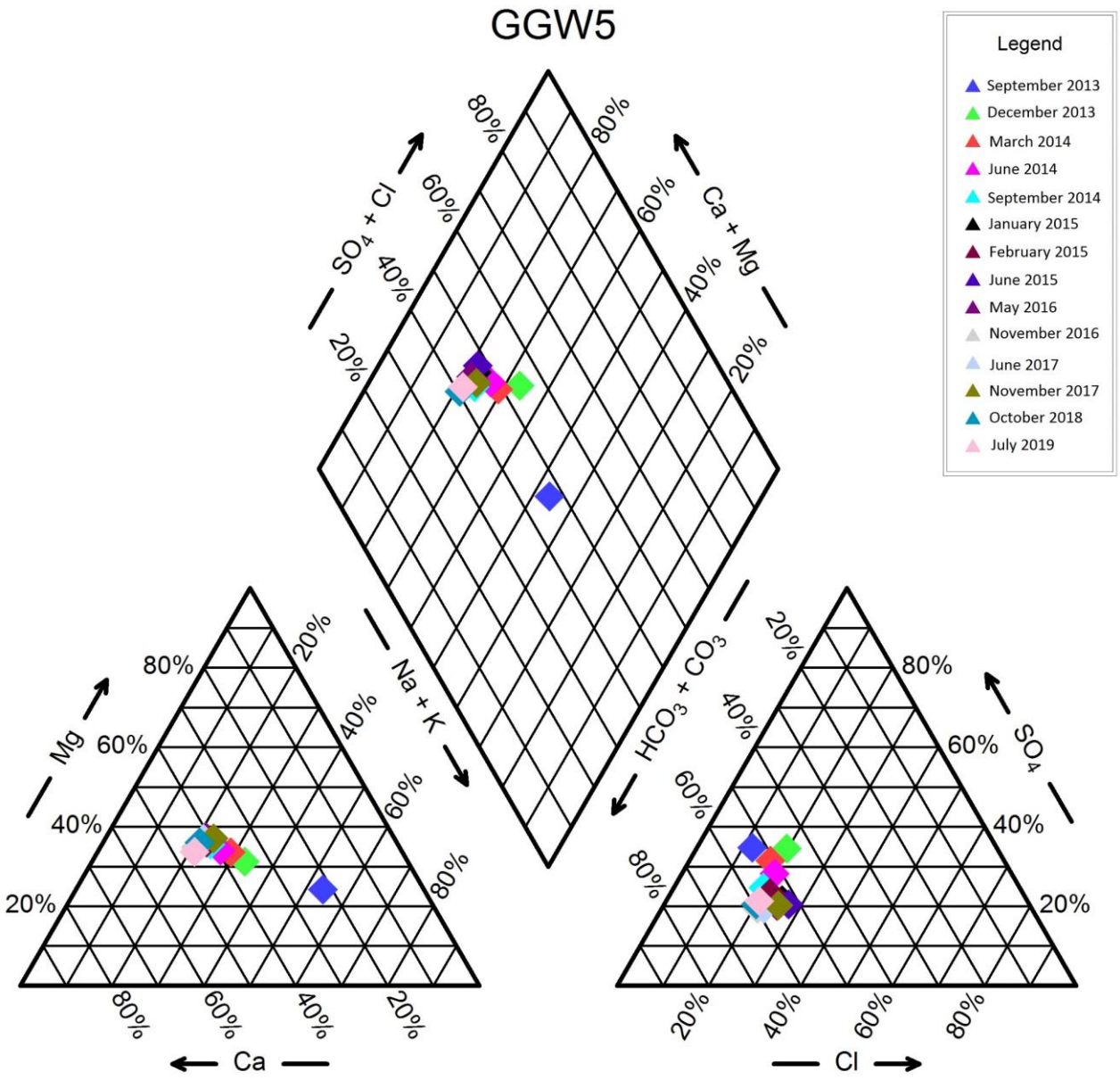


Figure B5: Piper diagram plot of GGW5 monitoring results

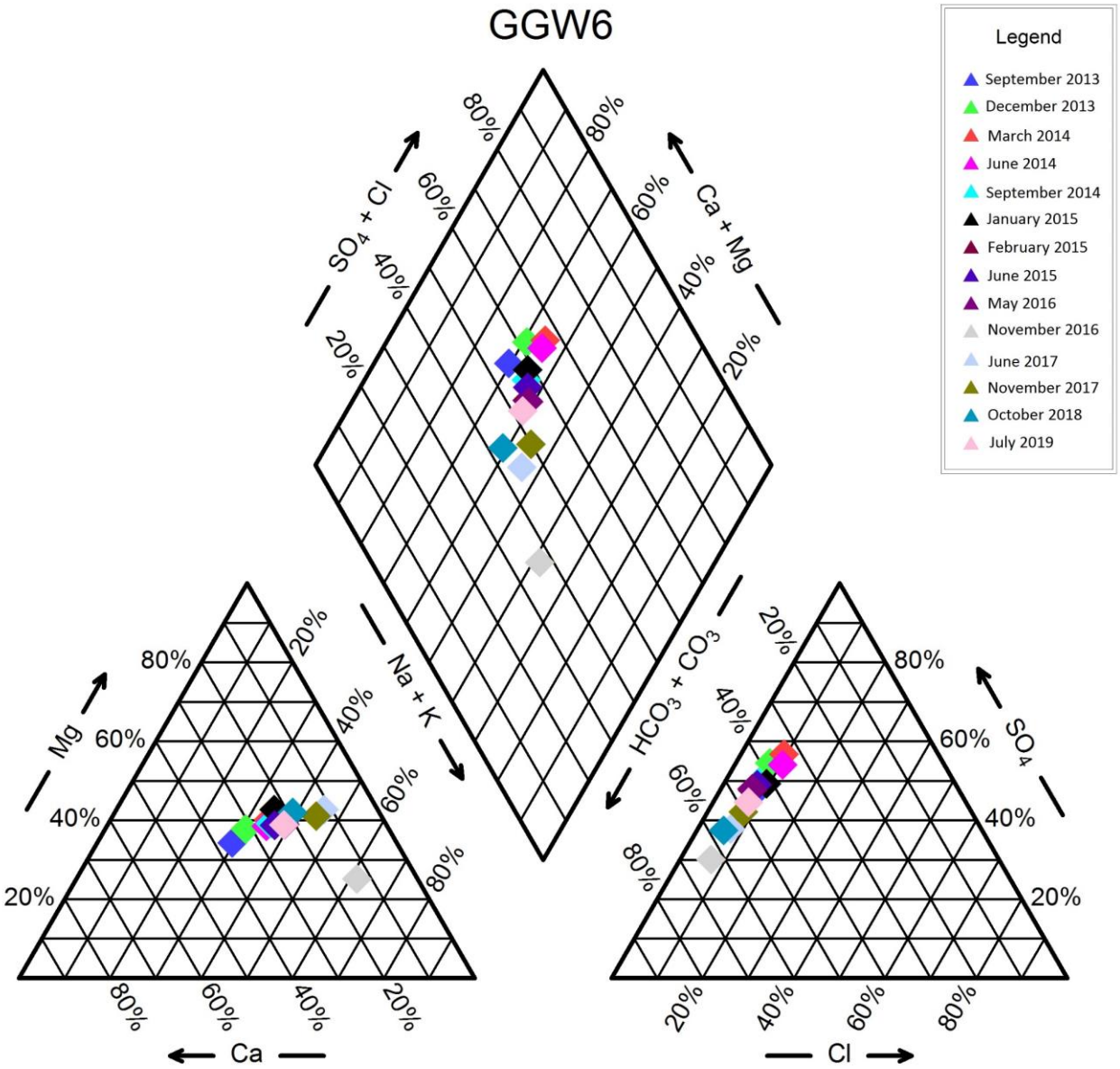


Figure B6: Piper diagram plot of GGW6 monitoring results

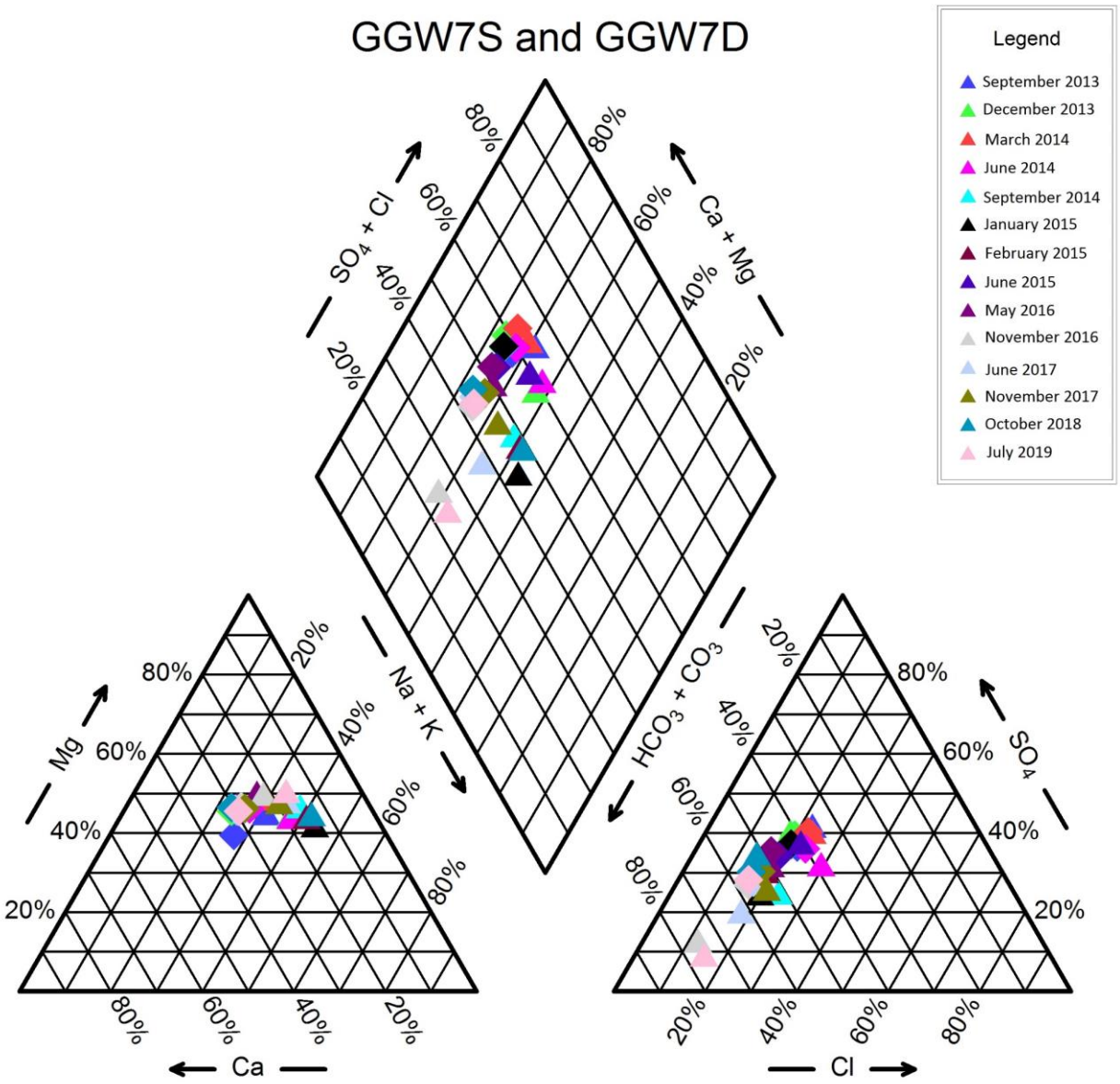


Figure B7: Piper diagram plot of GGW7 (triangles) and GGW7D (diamonds) monitoring data

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GOOGONG

Googong Integrated Water Cycle Project Stage D

Review of Environmental Factors

Water Recycling Plant and Permanent Reservoirs

Volume Three: Appendices F – L

June 2020

Appendix F Aquatic ecology assessment

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Aquatic Ecology Assessment

Googong Integrated Water Cycle Project Stage D WRP and Permanent Reservoirs

Reference No. AU212000166
Prepared for RPS Manidis Roberts Pty Ltd
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List of Abbreviations and Acronyms

Abbreviation/ Acronym	Description
ACT	Australian Capital Territory
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AGWR	Australian Guidelines for Water Recycling
BOM	Bureau of Meteorology
COA	Conditions of Approval
CRMRM	Cumulative Residual Monthly Rainfall Mass – calculated in the method described by Ferdowsian et al (2001)
CEMP	Construction Environmental Management Plan - A site or project specific plan designed to ensure appropriate environmental management practices are applied through the construction phases of the project
DO	Dissolved Oxygen
DEC	Department of Environment and Conservation
EC	Electrical Conductivity
EDT	Emergency Detention Tank
EP	Equivalent Population - Term used to describe sewage generation based on the average person in a residential development
EP&A Act	Environmental Planning and Assessment Act
EPL	Environmental Protection Licence
EQL	Lowest level that can be reliably achieved within the specified limits of precision and accuracy during routine laboratory operating conditions
GTPL	Googong Township Propriety Limited
IMP	Irrigation Management Plan
IWC	Integrated Water Cycle
ha	hectares
ID	Identification – refers to name of element
LLD	Low Level Detection
L/s	Litres per second
m	Metres
mAHD	Meters (Above) Australian Height Datum
mBGL	Meters Below Ground Level
MBR	Membrane Bioreactor

Abbreviation/ Acronym	Description
MCC	Motor Control Centre
mg/L	Milligrams per litre
ML	Mega litres
mTOC	Meters below Top of Casing
NA	Not Assessed
NH	Neighbourhood (of Googong Township)
NRMMC	Natural Resource Management Ministry Council
NS	No Sample – refers to not enough for sample collection
PLC	Programmable Logic Controller
PTWL	Pink Tailed Wormed Lizard
PW	Potable Water
µg/L	Micrograms per litre
QPRC	Queanbeyan-Palerang Regional Council
REF	Review of Environmental Factors
ReW	Recycled Water
RPD	Relative Percent Difference
RWRP	Recycled Water Flow Release Protocol
RWQMP	Recycled Water Quality Management Plan
RL	Relative Level, generally referenced to mAHD
SOC	Statement of Commitments
SCADA	Supervisory Control and Data Acquisition
SGRP	Surface and Groundwater Response Plan
SMEC	Snowy Mountains Engineering Company – SMEC Australia Pty Ltd
SPS	Sewage Pumping Station
STP	Sewage Treatment Plant
SWAEMP	Surface Water and Aquatic Ecology Monitoring Program
SWL	Standing Water Level
TOR	Terms of Reference
UTM	Universal Transverse Mercator – coordinate system
WMP	Water Management Plan
WRP	Water Recycling Plant

Abbreviation/ Acronym	Description
WSG	World Survey Grid 1984
WTP	Water Treatment Plant

1 Introduction

Googong Township is located approximately 8 km south of Queanbeyan and 14 km south-east of Canberra, near Googong Reservoir in New South Wales (Figure 1 Figure 2). SMEC Australia Pty Ltd (SMEC) was engaged by RPS Manidis Roberts (RPS) on behalf of Googong Township Pty Ltd (GTPL) to prepare the Aquatic Ecology Assessment for the Stage D Water Recycling Plant (WRP) (the site) the final component of the Googong Integrated Water Cycle (IWC) Project.

The Googong Township is a planned housing development for about 18,850 people and is being developed over the next 25 years. The township is designed around an integrated water cycle (IWC), with a dedicated Water Recycling Plant (WRP) that will reduce the consumption of potable water in the community by around 60 per cent and recycle the township's water for non-potable use. The Googong IWC Project is being constructed and operated in stages to ensure the infrastructure is appropriately sized to meet the incremental level of demand as development of the Googong township progresses.

The stages of development are summarised as:

- Stage 1 which was completed in Late 2016 for WRP Stage AB and designed for 4,700 EP;
- Stage C which was completed in November 2019 and included the Stage C WRP for 9,400 EP; and
- Stage D the ultimate capacity of the project which has been planned for 18,850 EP.

The Stage D IWC Project components assessed in this report contains three parts:

- the upgrade of the existing WRP (construction and operation);
- the upgrade of Permanent Reservoirs located on Hill 800 (construction and operation);
- the application of recycled water on public space (including sports fields) and on residential and other properties within the Googong Township; and
- the discharge of recycled water in excess of the demands of the township to the environment.

Concept Approval for the ultimate development has been granted, subject to future environmental assessment requirements, and was granted by the Minister for Planning under Part 3A (now repealed) of the *Environment Planning and Assessment Act 1979* (EP&A Act). Stage D requires an aquatic ecology assessment to address the requirements of the Part 3A Concept Approval and requirements for the project approval under the EP&A Act. It incorporates all neighbourhoods, sporting grounds and open spaces for irrigation both current and planned.

1.1 Part 3A Concept Plan Approval Requirement

The Stage D IWC Project requires an aquatic ecology assessment that considered Section 2.1 of the Part 3A Concept Plan Approval:

- *Flora and Fauna – including terrestrial riparian and aquatic, with accurate estimates of vegetation disturbance associated with the project*

This assessment shall take into account, but not be limited to the following statutory considerations and guidelines as relevant:

  - *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000);*
  - *National Water Quality Management Strategy – Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (NRMMC, 2006);*
  - Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
  - NSW *Fisheries Management Act 1994* (FM Act); and
  - NSW *Biodiversity Conservation Act 2016* (BC Act).

1.2 Data Sources

The following data sources and reports were used for this surface water assessment:

- Stage C WRP Aquatic Ecology Assessment (Biosis, September 2016) – provided by RPS;
- Googong Township Water Management Plan – provided by RPS;

- SMEC 2017 Annual Monitoring Report and SMEC 2018 Annual Factual Monitoring Report;
- QPRC 2019 monitoring data in the SMEC 2019 Annual Factual Monitoring Report; and
- Stage D WRP construction methodology and operational details – provided by RPS.

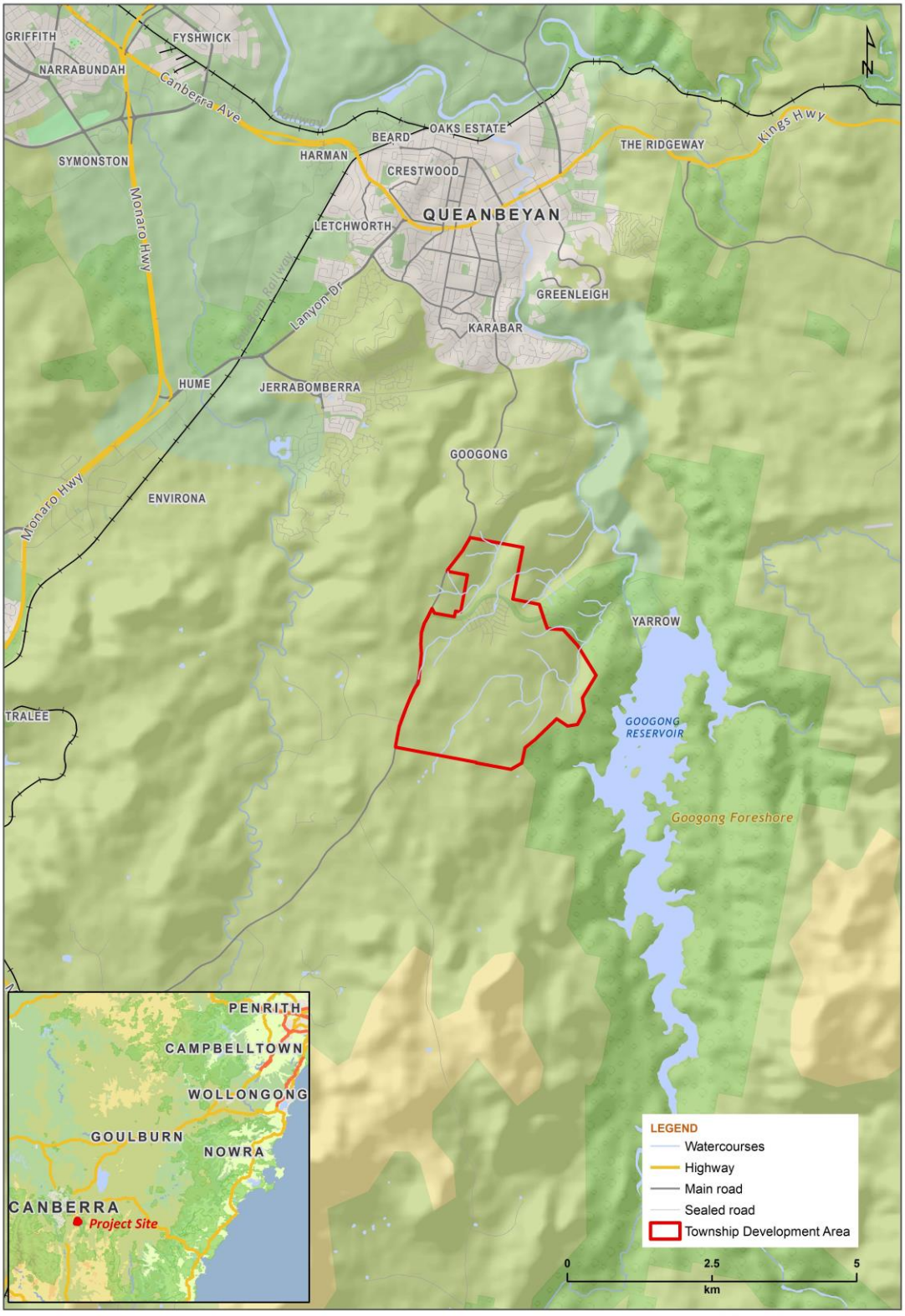


Figure 1: Googong Township Regional Location

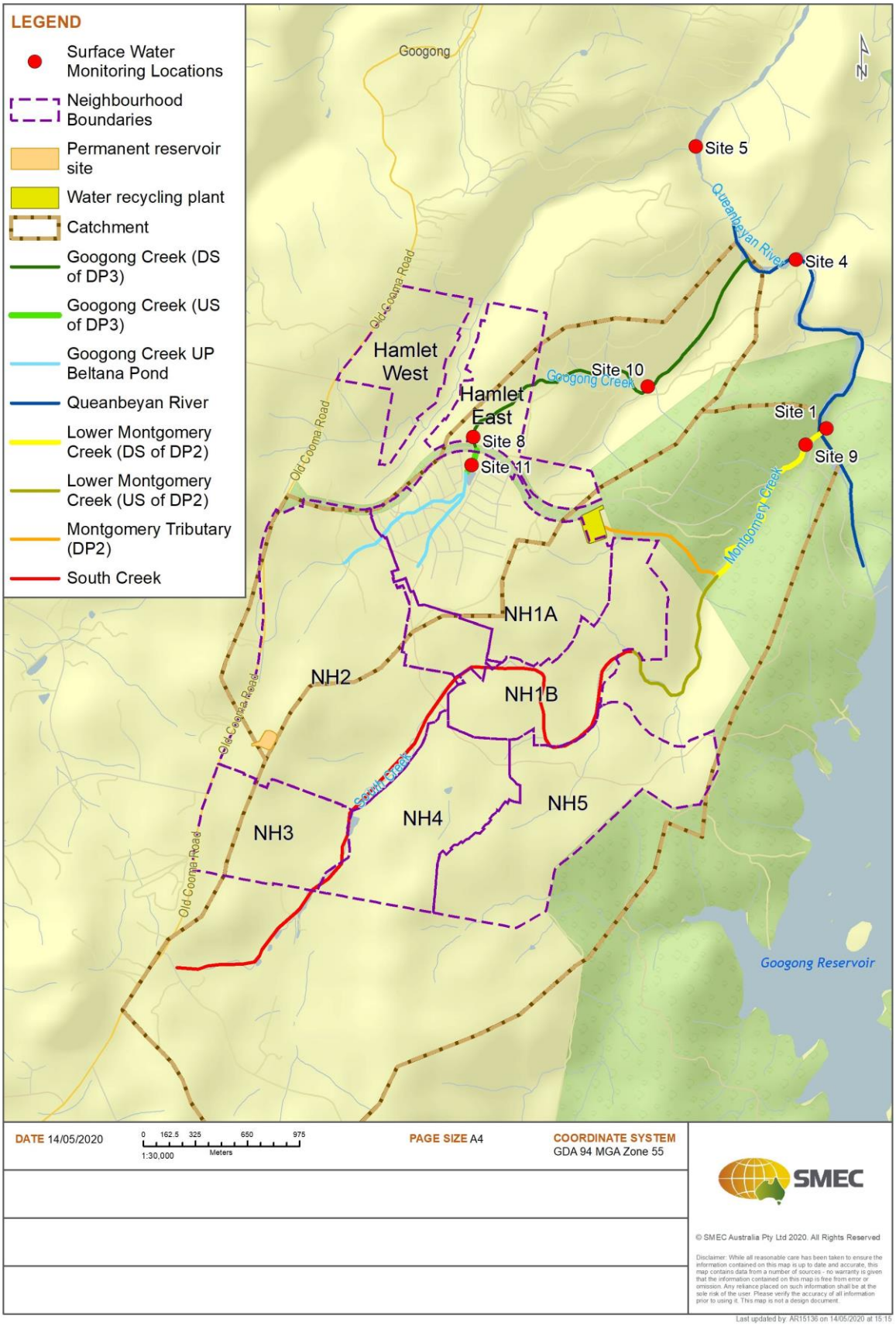


Figure 2: Googong IWC Project Stage D works with Neighbourhood Boundaries and Surface Water Catchments

2 Regional Setting

2.1 Googong Township

Googong Township is located approximately 8 km south of Queanbeyan, in NSW at the intersection of Old Cooma Road and Googong Road. Googong Reservoir is located approximately 600 m to the east of the eastern boundary of the township. The area is within the south-eastern highlands bioregion and part of the Murrumbidgee Catchment of the Murray-Darling Basin in the Queanbeyan-Palerang Regional Council Local Government Area.

2.2 Climate

Climatic data is available from:

- Queanbeyan Bowling Club for rainfall from station no. 070072 to 31 October 2015;
- Tuggeranong (in the ACT) station no. 703390; and
- Canberra Airport (in the ACT) evaporation from station no. 070014.

These are the closest stations with long term records held by the Bureau of Meteorology. On-site a weather station records data which is available from September 2013 for rainfall, wind speed, wind direction, minimum and maximum temperature, solar radiation and minimum and maximum relative humidity. There is no on-site evaporation data and some months have incomplete records. The baseline hydrogeological data was collected during a period of below average rainfall conditions and subsequent monitoring data has been collected during both above average and below average rainfall conditions. This should be considered during any interpretation of results and trends.

Average annual rainfall at the Googong Township, from the township weather station between 2014 and 2019 is approximately 590 mm compared to the 595mm annual average for the region. Rainfall is variable and can be subject to prolonged periods of above or below average rainfall with the winter months generally being slightly drier. The Googong climate is temperate and characterised by warm dry summers and cold winters.

Climate statistics from Canberra Airport show the mean temperatures range from -0.1°C to 12°C in winter to 13 °C to 34.5°C. Mean temperatures at Queanbeyan are within the range of 13-27°C during summer and 0.5-12°C in winter. The Googong township weather station shows since September 2019 the mean temperature ranges from 6-30°C in summer and 0.4-20°C in winter.

The nearest active Bureau of Meteorology (BOM) weather station is Tuggeranong (station number 70339) in the Australian Capital Territory (ACT), which has records from 1996. Figure 3 and Table 1 present a summary of the monthly mean and median rainfall totals at the Tuggeranong weather station with those from the Googong Township weather station. It should be noted that the Googong Township weather station has a limited dataset for statistical analysis and this should be considered when comparing results. Canberra Airport, also in the ACT, is the only BOM weather station with evaporation records.

Statistic	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Googong Mean rainfall (mm)	41.1	62.8	54.0	43.8	32.7	55.8	23.7	39.5	54.5	33.2	62.5	72.8	590
Tuggeranong Mean rainfall	52.8	72.2	52.5	32.4	24.8	52.8	38.0	45.9	58.3	49.3	74.3	67.3	620
Googong Median rainfall (mm)	32.3	52.3	67.8	35.2	32.5	42.2	11.5	27.8	36.6	36.0	73.4	49.4	497
Tuggeranong Median rainfall (mm)	46.0	56.0	34.2	17.2	19.4	41.6	34.5	36.0	64.0	41.4	61.9	61.4	513

Statistic	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Googong Highest Daily (mm), day and year	27.4, 12th 2015	47.2, 11th 2020	44.2, 5th 2020	43.0, 8th 2015	22.6, 9th 2016	89, 6th 2016	12.8, 6th 2016	36.0, 3rd 2015	55.8, 18th 2013	21.2, 15th 2014	34.2, 7th 2017	58.6, 14th 2018	
Tuggeranong Highest Daily (mm), day and year	65.2, 27th 2013	83.6, 3rd 2011	87.6, 4th 2012	65.0, 8th 2015	52.2, 20th 2017	81.8, 6th 2016	51.0, 9th 2005	47.0, 18th 2011	76.2, 17th 2013	60.0, 19th 2000	91.6, 26th 2011	93.0, 9th 2010	

Table 2 presents a compilation summary of available climate statistic data from Canberra Airport, Tuggeranong and Googong Township weather station for evaporation, temperature, wind speed, relative humidity and solar radiation.

The cumulative residual monthly rainfall mass (CRMRM) compares the cumulative monthly rainfall with the long-term average. The CRMRM is calculated for both Queanbeyan Bowling Club weather station and Tuggeranong weather station, the two closest rainfall stations with significant data records, as shown on Figure 4. It was not calculated for Canberra Airport or Googong Township weather station as they have only been in operation for a shorter period. The CRMRM is most effective where more than 50 years of continuous records exist. On Figure 4 and other figures within this report showing the CRMRM it is the slope of the line that is important not a numerical value.

It shows the same trends for periods of above or below average rainfall, with a prolonged period of below average conditions occurring between 2002 and 2010. The CRMRM for Tuggeranong is shown, where practicable, on figures within this report. From 2010 to 2017, the trend at Tuggeranong shows generally above average rainfall conditions, with short periods of below average conditions before the start of another period of below average rainfall from 2017 to 2019. The Queanbeyan Bowling Club weather station was taken offline in 2015. The baseline surface water data was collected during a period of below average rainfall conditions and subsequent monitoring data has been collected during both above average and below average rainfall conditions. This should be considered during any interpretation of results and trends.

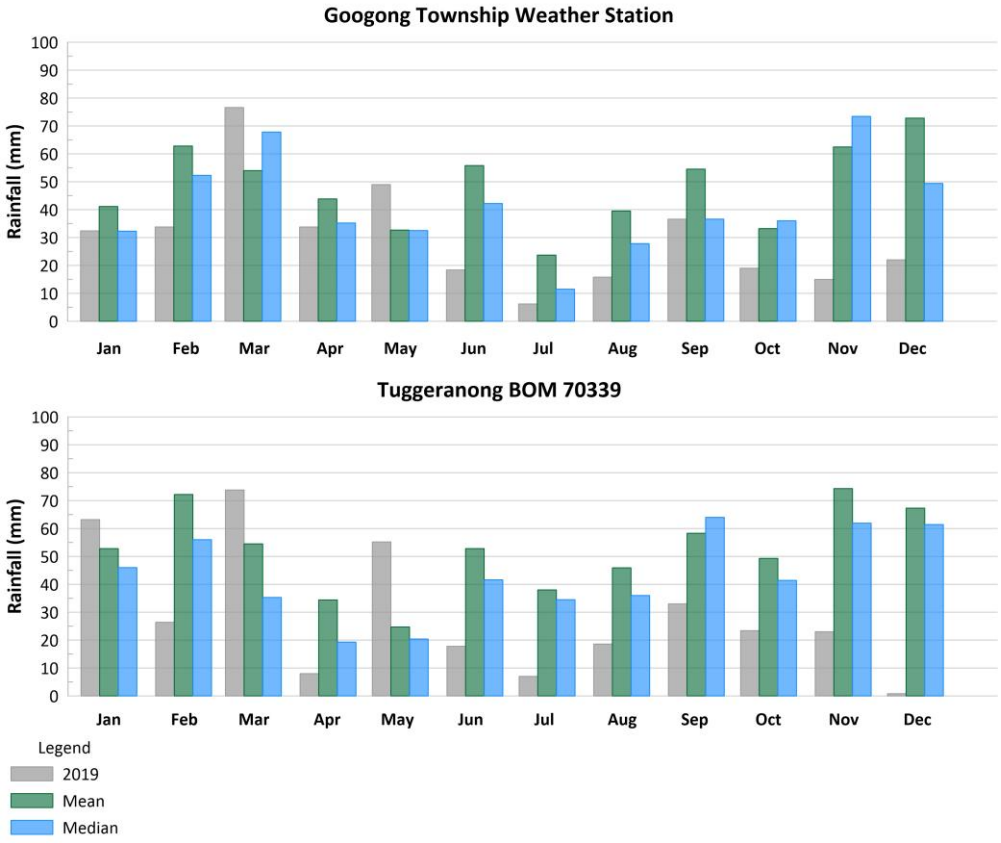


Figure 3: BOM Weather Station Tuggeranong monthly rainfall summary with mean and median results

Table 1: Rainfall data from Googong Weather Station (Sep 2013 to May 2020) and Tuggeranong (BOM 70339 for all years to February 2020)

Statistic	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Googong Mean rainfall (mm)	41.1	62.8	54.0	43.8	32.7	55.8	23.7	39.5	54.5	33.2	62.5	72.8	590
Tuggeranong Mean rainfall	52.8	72.2	52.5	32.4	24.8	52.8	38.0	45.9	58.3	49.3	74.3	67.3	620
Googong Median rainfall (mm)	32.3	52.3	67.8	35.2	32.5	42.2	11.5	27.8	36.6	36.0	73.4	49.4	497
Tuggeranong Median rainfall (mm)	46.0	56.0	34.2	17.2	19.4	41.6	34.5	36.0	64.0	41.4	61.9	61.4	513
Googong Highest Daily (mm), day and year	27.4, 12th 2015	47.2, 11th 2020	44.2, 5th 2020	43.0, 8th 2015	22.6, 9th 2016	89, 6th 2016	12.8, 6th 2016	36.0, 3rd 2015	55.8, 18th 2013	21.2, 15th 2014	34.2, 7th 2017	58.6, 14th 2018	
Tuggeranong Highest Daily (mm), day and year	65.2, 27th 2013	83.6, 3rd 2011	87.6, 4th 2012	65.0, 8th 2015	52.2, 20th 2017	81.8, 6th 2016	51.0, 9th 2005	47.0, 18th 2011	76.2, 17th 2013	60.0, 19th 2000	91.6, 26th 2011	93.0, 9th 2010	

Table 2: Climate data for Canberra Airport weather station for 2019

Statistic	January	February	March	April	May	June	July	August	September	October	November	December
Average daily PAN Evaporation (mm) (Canberra Airport)	7.4	6.0	4.3	2.9	1.7	1.2	1.6	2.3	3.4	5.1	7.1	8.1
Googong Average Minimum Relative Humidity (%)	30.0	32.9	38.9	43.8	48.7	56.8	52.0	44.8	39.5	33.8	30.2	28.8
Canberra Airport Average Minimum Relative Humidity (%)	28.7	28.9	35.3	38.8	48.9	51.4	49.7	41.1	32.2	23.9	19.6	16.6
Googong Average Maximum Relative Humidity (%)	87.6	88.5	90.9	92.4	93.8	94.7	93.9	92.2	90.8	89.0	87.5	87.3
Canberra Airport Average Maximum Relative Humidity (%)	87.8	88.5	91.7	94.4	94.5	98.4	96.7	93.7	92.7	88.3	74.1	73.7
Googong Average Windspeed (m/sec)	3.5	3.5	3.2	3.0	3.2	3.3	3.4	3.6	3.5	3.5	3.7	3.5
Canberra Airport Average Windspeed (m/sec)	3.9	4.0	3.8	2.7	3.2	2.6	4.0	4.1	4.0	4.0	5.4	4.8
Canberra Airport Average daily solar radiation (MJ/sq m)	25.6	23.0	16.0	14.1	10.3	9.3	10.0	12.8	16.4	22.2	25.9	26.8
Googong Mean minimum temperature (°C)	14.1	13.1	11.6	7.9	3.6	1.9	0.4	0.9	3.1	6.7	8.9	12.3
Tuggeranong Mean minimum temperature (°C)	14.5	14.2	11.4	7.0	2.5	1.2	-0.1	0.9	3.7	6.4	9.8	12.4
Googong Mean maximum temperature (°C)	30.2	28.3	24.9	20.5	15.6	12.1	11.2	12.6	16.4	21.4	24.3	28.0
Tuggeranong Mean maximum temperature (°C)	29.8	28.1	25.3	21.0	16.6	13.1	12.4	14.1	17.7	21.1	24.4	27.4

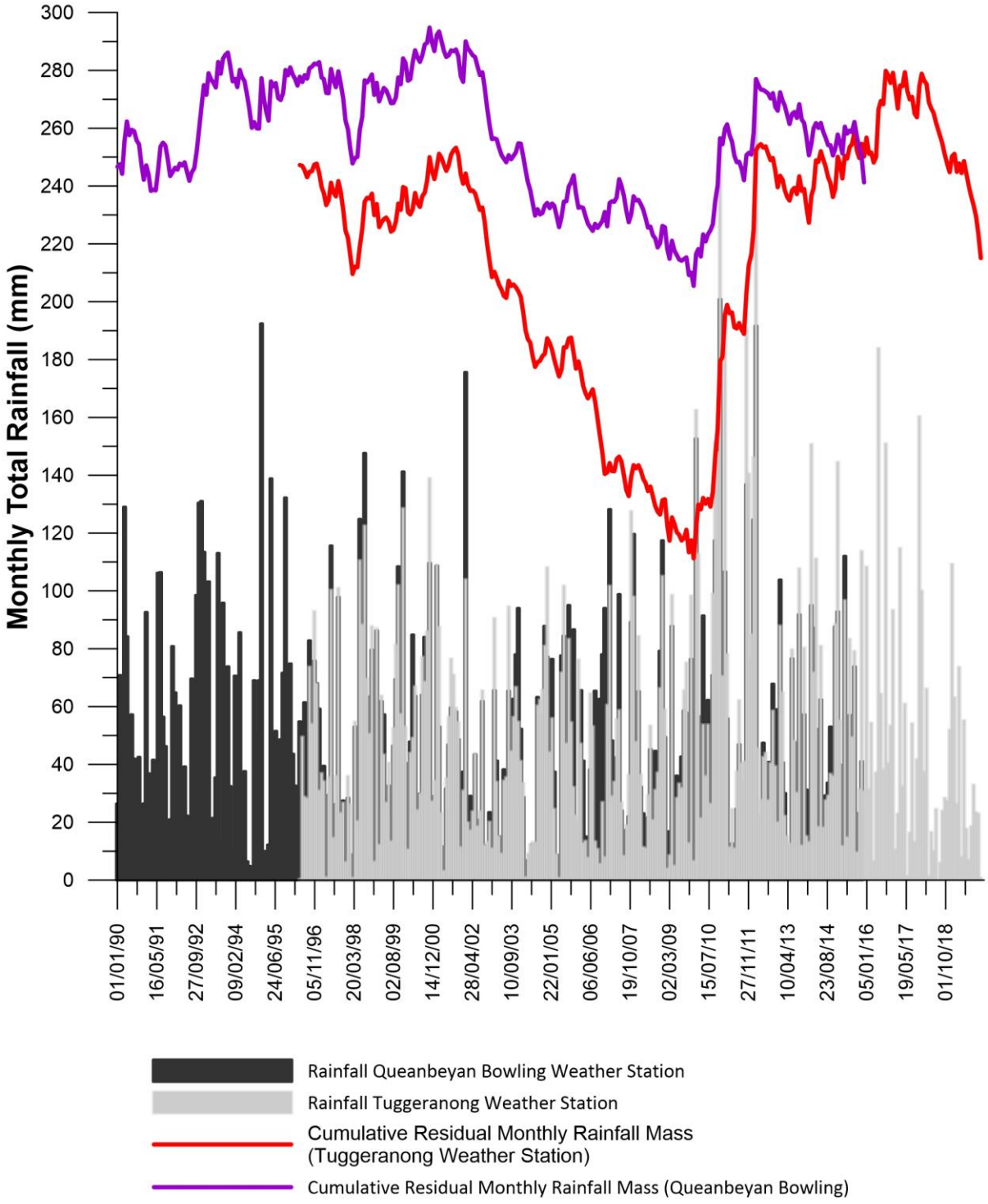


Figure 4: Monthly rainfall and cumulative residual rainfall mass from 1990 to 2019

2.3 Surface Water Catchments

The catchment area is characterised by the ongoing Googong Township development of low-intensity grazing land, natural bushland, and rural residential land uses. Part of the township is located within the Googong Reservoir water supply catchment, although most of the township is located in the catchment of the Queanbeyan River downstream of the Googong Dam.

The Stage C IWC Project saw the start of the discharge of excess recycled water to Googong Creek. Topographically the township's surface water catchment is bounded by Old Cooma Road to the west, Googong Reservoir to the east and elevated area between Wells Place and Burra Road to the south of the site. Within the township catchment area are three ephemeral water courses:

- South Creek / Montgomery Creek,
- North Creek, and
- Googong Creek.

All join the Queanbeyan River north of the township and their catchment boundaries are shown on Figure 2 with the Stages AB and Stage C surface water monitoring locations. Of these water courses, Googong Creek primarily will receive flows of excess recycled water as part of the IWC (Discharge Point 3) and Montgomery Creek in the event of an emergency would receive discharge from the WRP. The Queanbeyan River was dammed in 1977. The surface water catchments are described in detail in the Stage D WRP and Permanent Reservoirs Surface Water Assessment Report (SMEC, 2020).

The Stage C surface water assessment report (Hydrobiology 2016), WMP and other earlier reports may have differing nomenclature for the creeks. Montgomery Creek has been divided into South Creek for the upper reach and Montgomery for the lower reach on the recent master Irrigation Management Plan provided by RPS. The previously unnamed creek west of Googong Creek has been named North Creek. Its catchment starts at the junction of Old Cooma Road and Googong Dam Road and is contained to Hamlet West with Old Cooma Road as the west boundary and the Googong Creek as the eastern boundary.

Figure 5 presents a longitudinal elevation profile, with vertical exaggeration, of Googong Creek and South Creek / Montgomery Creek into the Queanbeyan River with the location of the discharge points. These creeks show significant changes in elevation (noting a vertical exaggeration of about 8:1) over a relatively short distance.

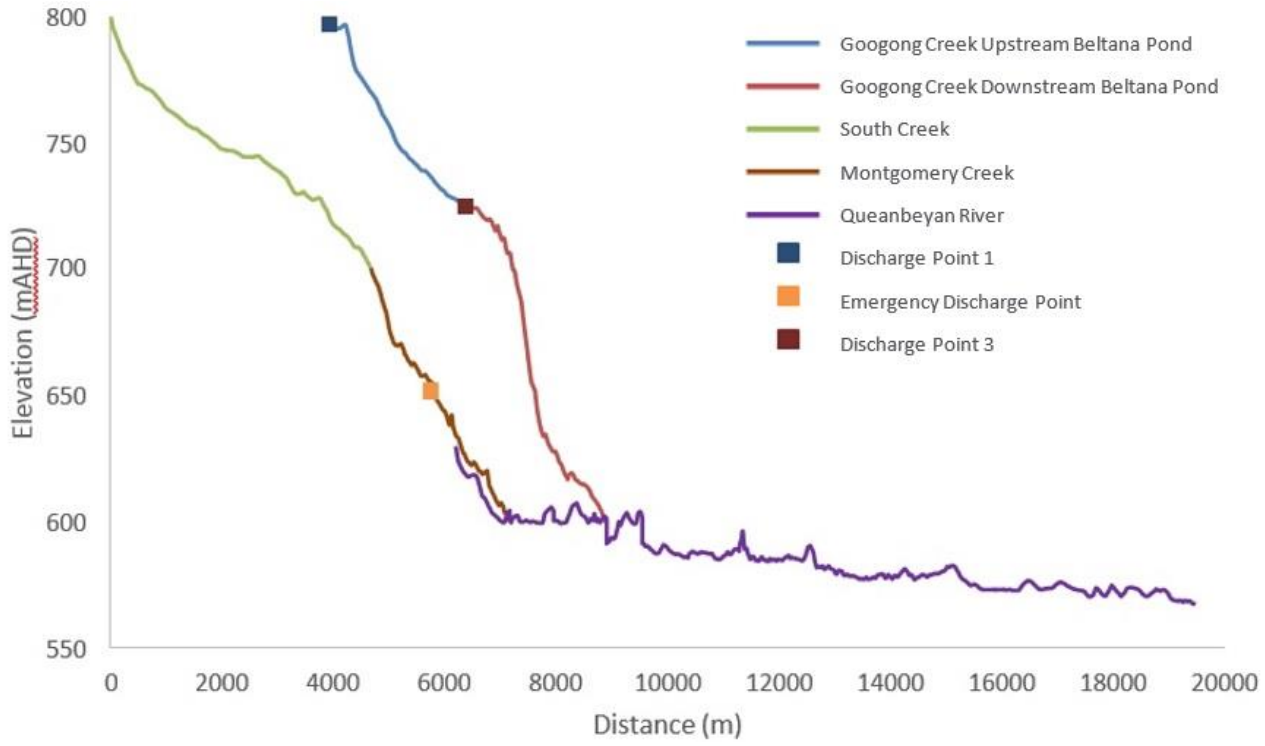


Figure 5: Longitudinal profile of the waterways change in elevation and location of recycled water discharge points (Note: sudden spikes in elevation on the Queanbeyan River are a result of the resolution of the DEM – Adapted from Hydrobiology, 2016)

3 Proposed Works and Existing Environment

This section of the aquatic ecology assessment details the existing environment at the WRP site, Permanent Reservoir Site at Hill 800 and Stage D irrigation and discharge areas. The Stage D WRP and Permanent Reservoir works are summarised in Table 3 and in Table 4 for the Permanent Reservoir works and shown on Figure 6 and Figure 7. Figure 8 presents the township development plan with neighbourhood layout and open spaces consisting of parks, sporting fields and protected areas.

Table 3: Summary of Stage D works at the WRP

Infrastructure element	Equipment / component	Stage D scope of works
Bioreactor	Bioreactor and membrane tanks	Construction of one larger Bioreactor tank
	Diffused aeration system	Install the single Bioreactor trains with Fine Bubble Diffused Aeration systems
	Mixed liquor return / Membrane Feed Pumps	Install larger mixed liquor pumps and larger Membrane Feed Pumps
	Aeration Blowers	Replace the existing blowers with three new larger units
Membrane Bioreactor (MBR) Membranes	Membrane tank	Construction of three MBR membrane tanks
	MBR Membranes	Install two sets of MBR membranes Install one additional set of MBR membranes when required (nominally 2032)
	Membrane Blowers	Replace existing blowers with three new larger units
Tertiary Feed System	Filtrate Storage Tank	Filtrate Storage Tanks installed were for ultimate capacity – no further upgrade required at Stage D
	Tertiary Feed Pumps	Replace two existing smaller pumps with new larger pumps (identical model to existing larger pumps)
	Tertiary Filters	Install a new Tertiary Filter skid complete with 56 modules to enable duty/assist/standby trains
	UV Disinfection Units	UV Disinfection Units installed at Stage C were for ultimate capacity – no further upgrade works expected at Stage D provided feed water UV Transmissivity (UVT) remains above 60%
	Chlorine Disinfection System	Chlorine Disinfection Units installed at Stages AB and C were for ultimate capacity - no further upgrade required at Stage D.
Recycled Water Storage and Transfer	Recycled water storage tank	Recycled Water Storage Tanks installed at Stage C were for ultimate capacity – no further upgrade required at Stage D
	Recycled water transfer pump station	Replace one existing smaller transfer pump with a new larger pump identical to the units installed at Stage C
Aerobic Digester	Aerobic digester tank	Construct new Aerobic Digester tank adjacent to the Stage C digester – hydraulic connection to be via concrete weir cut-out Install Fine Bubble Diffused Aeration system in the new tank as per the existing digesters
	Aerobic digester blowers	Existing digester blowers installed at Stages AB and C were sufficient to meet ultimate aeration demand - no further upgrade required at Stage D
	Rotating drum thickener (RDT)	Relocate and recommission the RDT to the top of the new Stage D Aerobic Digester tank
	Dewatering centrifuge unit	Install one new larger dewatering centrifuge (4 L/s capacity)

Infrastructure element	Equipment / component	Stage D scope of works
Biosolids Dewatering and Storage		Install an additional centrifuge feed pump to enable feed flow to both smaller and larger centrifuges (up to 7.5 L/s)
	Biosolids outloading conveyor system	Install a new biosolids outloading conveyor system to allow for transfer of dewatered biosolids from the new centrifuge unit to a new biosolids bin area north of the centrifuge building
	Biosolids bins	Install a new bin weighing system on the north side of the centrifuge building for 10 kL bins to enable duty/standby bins operation
Chemical storage and dosing	Chemical storage tanks	Chemical Storage Tanks installed at Stages AB and C were for ultimate capacity – no further upgrade required at Stage D
	Chemical dosing system	Upgrade the sodium hydroxide dosing line from Dosing Skid 3 to the new Bioreactor(s) Install new ferric sulphate dosing line from the Dosing Skid 3 to the new Bioreactor(s) Reconfigure and extend the acetic acid dosing line from south-west corner of Bioreactor No. 2 to the new Bioreactor(s) Reconfigure and extend the sodium hypochlorite dosing line from south-west corner of Bioreactor No. 2 to the new Bioreactor(s) and Membrane Tanks Reconfigure and extend the citric acid dosing line from south-west corner of Bioreactor No. 2 to the new Membrane Tanks
Emergency Detention Tank (EDT)	EDT tank	The existing EDT storage volume is considered sufficient to cater for wet weather attenuation for Stage D flows. Interconnecting pipework to potential additional EDT storage south of the Neutralisation Pit has been installed at Stage C.
	EDT return pumps	No further upgrade required to the existing EDT Return Pumps
Off-Spec / Effluent transfer system	Off-Spec Water Tank	Off-Spec Water Tanks installed at Stages AB and C were for ultimate capacity – no further upgrade required at Stage D
	Effluent Transfer Pumps	Install one (1) new Off-Spec/Effluent Transfer Pump with larger units to the existing set to operate in Duty / Assist / Standby configuration
Compressed Air System	Air compressors	Replace the existing air compressors with two larger capacity units
Odour control	Odour extraction network	Install odour covers for the new Bioreactor and Aerobic Digester tanks Expand odour extraction network to service the new Bioreactor, Aerobic Digester, centrifuge and biosolids conveyor system. This includes fit-out of odour covers and ductwork for the empty membrane tanks Replace existing odour discharge stack efflux cone with larger diameter cone
	Activated carbon units	No further upgrade required to the Activated Carbon Units at Stage D
Yard piping	Yard piping	Yard piping to suit the new Stage D assets
Electrical and control systems	Motor Control Centre (MCC) and electrical systems	Install MCC No. 4 and drives associated with new Stage D assets Upgrade Uninterrupted Power Supply (UPS) to meet requirements of Stage D assets
	Programmable Logic Controller (PLC) and Supervisory Control And Data Acquisition (SCADA) systems	Upgrade PLC and SCADA as required to reflect new Stage D assets
	Generator	No further upgrade required to the standby generator system at Stage D

Table 4: Summary of Stage D works at the Permanent Reservoirs on Hill 800

	Equipment / component	Stage D scope of works
Recycled Water Reservoir	New 9 ML Recycled Water (ReW) Reservoir	Decommission of the existing Stage C sedimentation bund. Construct a new 9 ML ReW reservoir and associated pipework Piped connections to the new 9 ML ReW reservoir extended sufficiently far from the Stage C services terminating in direct buried isolation valves have all been included in Stage C
	Existing 4 ML ReW Reservoir	Convert the existing 4.0 ML ReW Reservoir into a Potable Water (PW) Reservoir (5.9 ML total potable water capacity). This includes emptying and cleaning (super-chlorination etc.) of the existing reservoir for it to be repurposed for PW use
	Potable Water Booster Pumps	Decommission the existing Stage C PW Booster Pump Station Install a new Stage D PW Booster Pump Station and associated pipework to cater to flows for the higher elevation development areas
	Sodium Metabisulfite Dosing	Modify sodium metabisulfite dosing pipework to dose into the new Stage D chemical dosing chamber which will receive overflow stream from the new RW Reservoir
	Sodium Hypochlorite Dosing	Replace the existing recycled water sodium hypochlorite dosing pumps with new larger units (40 L/hr), if required
	Electrical and Control Systems	Upgrade the existing MCC, drives, PLC and SCADA systems to accommodate the new Stage D assets

Existing reports covering the aquatic ecology environment for the township are:

- Stage C Googong Aquatic Ecology Survey May 2016 memorandum – Hydrobiology 2016
- Surface Water and Aquatic Ecology Monitoring Program – October 2015 (RPS Manidis Roberts);
- Googong Hydrogeological Services: 2017 Annual Monitoring Report – October 2017 (SMEC Australia, 30012126 – AR01);
- Googong Hydrogeological Services: 2018 Annual Factual Monitoring Report – May 2019 (SMEC Australia, 30012126 – AR02.

These reports have been used to inform, along with the 2019 monitoring data from QPRC, this aquatic ecology assessment.

3.1 Site Investigations

Field surveys were undertaken on the following dates in a manner that would allow the existing aquatic environment to be assessed:

- May 2016 and August 2016;
- November 2016 and March 2017; and
- October 2018.

All field surveys were undertaken by the sub-contractors with the relevant permits, where required. Revision of the WMP in July 2018 recommended the SWAEMP have the discontinuation of the fish survey. QPRC have not undertaken a fish survey since March 2017. Habitat assessment and bank and channel stability is undertaken in the WMP via photography of the surface water monitoring locations. With the delay with the use of recycled water in the township, QPRC is undertaking monitoring to meet compliance with the project EPL. Diatom sampling has been undertaken during each surface water monitoring event, at a quarterly frequency and macroinvertebrate surveys have not been undertaken since October 2018. These surveys will recommence once the operational phase (i.e. irrigation with recycled water) of the project has been reached.

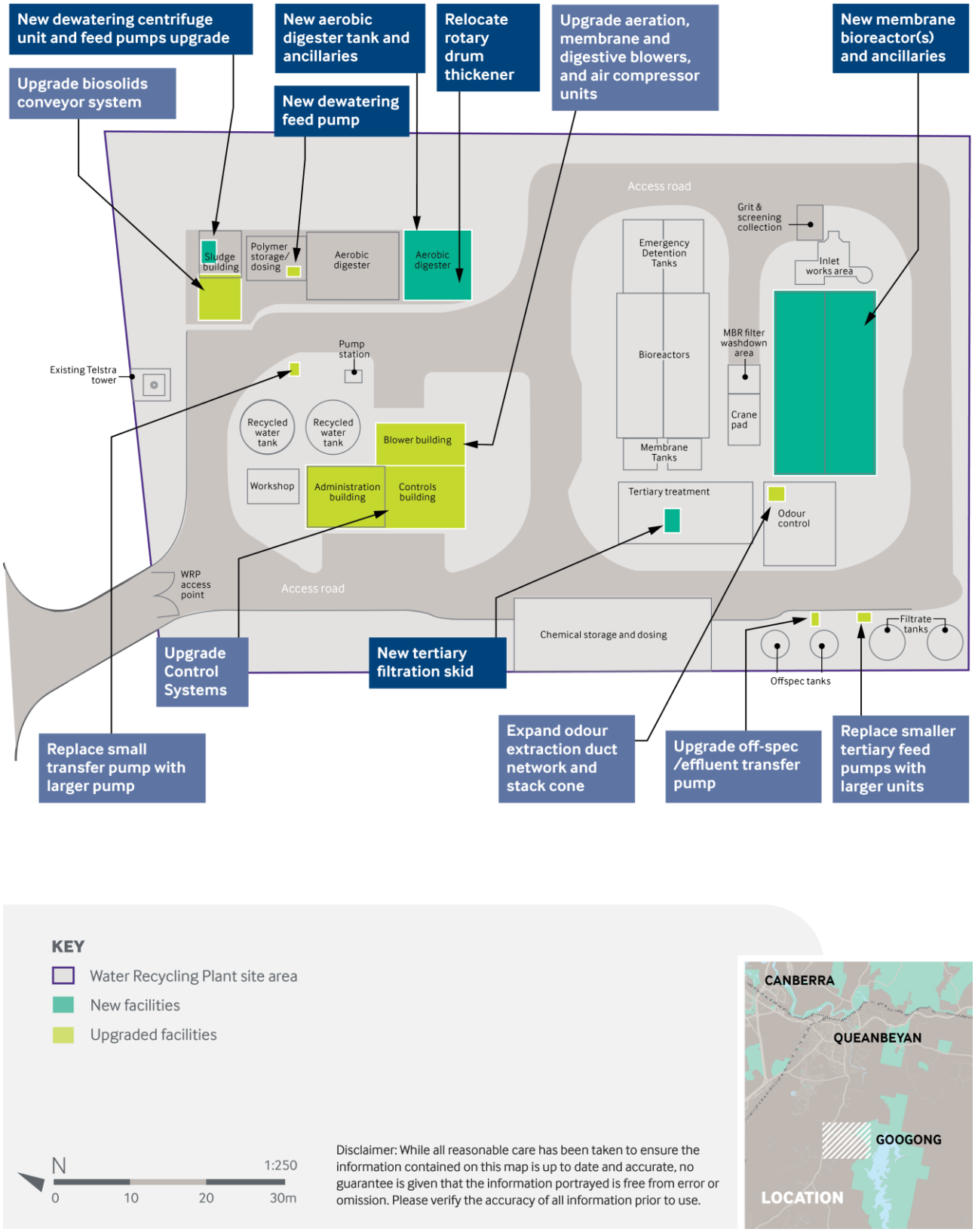


Figure 6: Stage D Infrastructure upgrades and works within the WRP (provided by RPS)

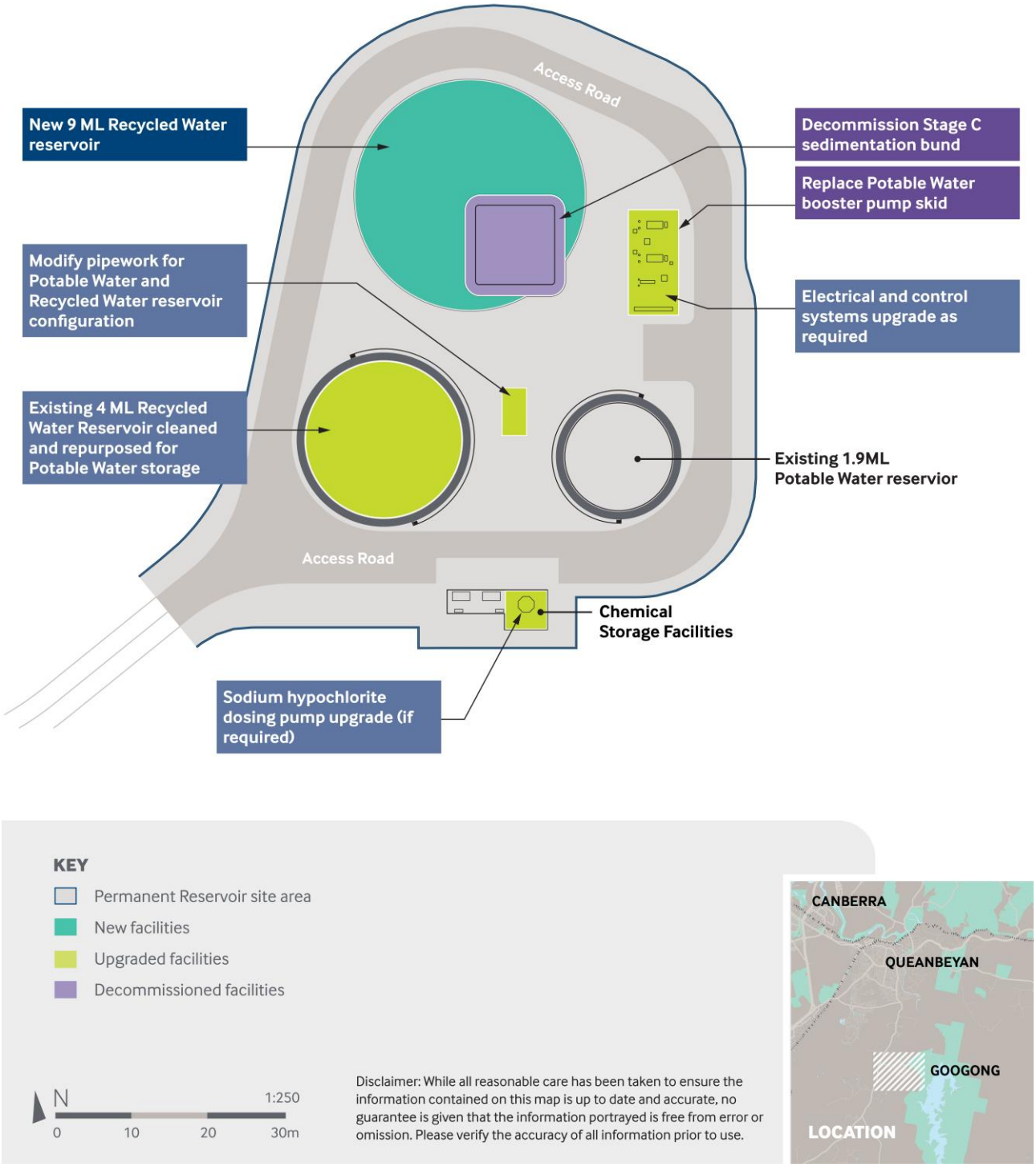


Figure 7 Permanent Reservoirs at Hill 800 Reservoir Stage D design (provided by RPS)

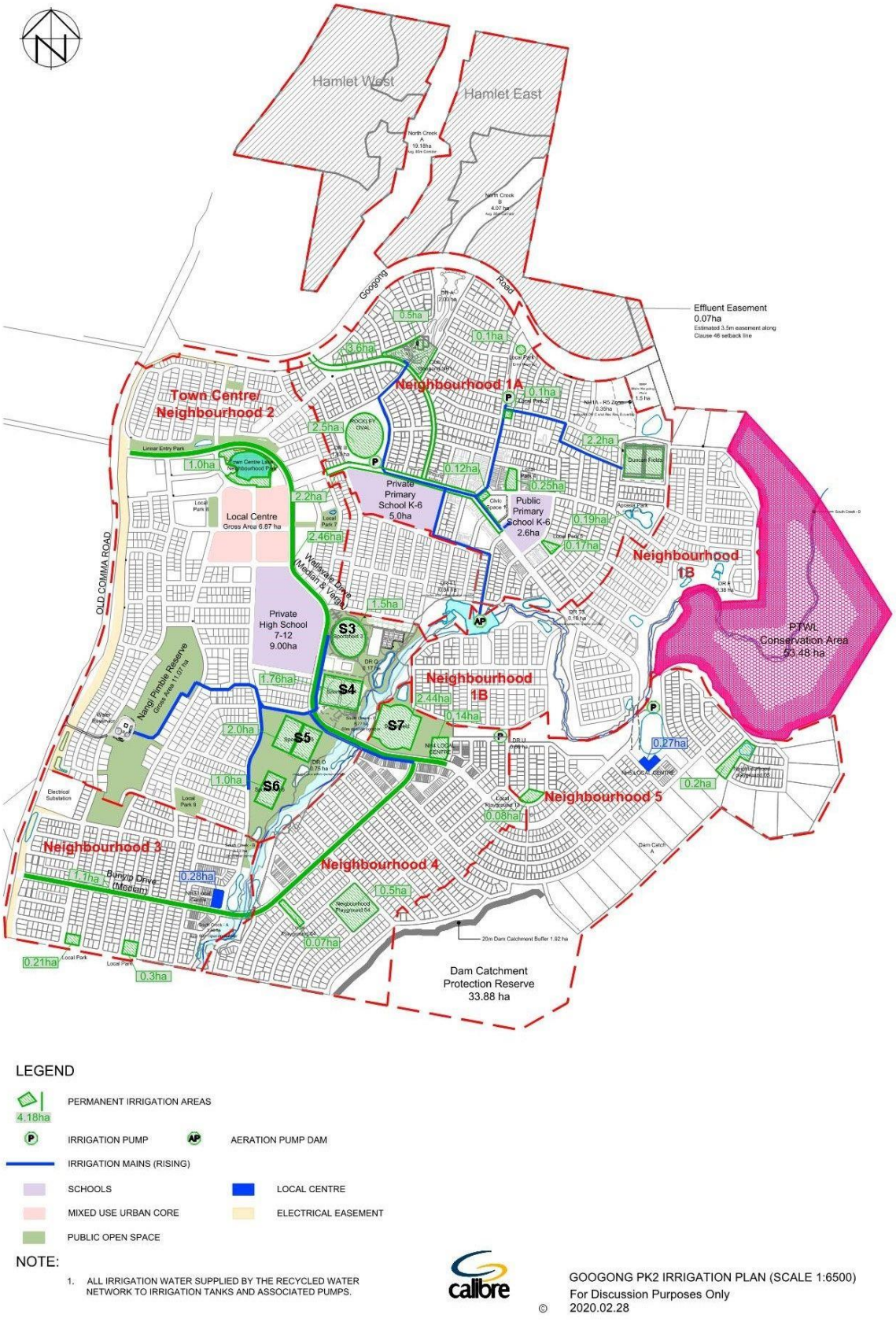


Figure 8: Googong Township Master Plan (provided by RPS) showing proposed neighbourhoods and irrigation areas and open spaces

3.2 Existing Aquatic Environment

The Stage C WRP Aquatic Ecology Assessment (Biosis, 2016) outlines in detail the existing aquatic environment, which is summarised below for Googong Creek and Montgomery Creek.

For Googong Creek the existing environment in the headwaters to Beltana Pond has been heavily altered since the baseline survey as the township has been developed. The broad valley agricultural pastures with scattered trees and farm dams has been converted to urban housing estates and open park lands of NH1A/B with NH2 development recently commenced. A section of Googong Creek has been piped underground to accommodate the urbanisation. In the section from Beltana Pond, downstream of the Googong Road culvert to the woodland area, the creek becomes increasingly steep with an asymmetric flood plain habitat. Creek bed erosion was occurring, and the stream channel has some artificial modifications such as embankment dams. The bed compaction was low and comprised of silt/clay, likely reflecting increased run off from finer sediments associated with agricultural land use and township development. Localised impacts from grazing could be observed. Very little native vegetation was present, vegetation was dominated by introduced herbs and pastures grasses as well as introduced mid storey such as Briar Rose *Rosa rubiginosa* and Blackberry *Rubus fruticosus sp. agg.*

The woodland section to Queanbeyan River is characterised by steep valley / gorge type valley with riparian vegetation in good condition and extensive. The bed substrate was primarily bedrock and boulders. Stream flow observed during low flow conditions was represented by riffles and pools. The bank slope is steep to moderate with some small vegetated side bars and mid-channel bars as the confluence is approached. The vegetation is considered moderately disturbed with native vegetation present both sides of the riparian zone and only minor exotic species. Submerged and emergent macrophytes were in excellent condition along this reach of Googong creek although many introduced species were present in their composition such as Watercress *Nasturtium officinale*. Dense beds of *Potamogeton* spp. and *Myriophyllum* spp. were present in slow flowing pool reaches.

For Montgomery Creek the existing environment of the headwaters, known as South Creek, has been altered with the township development, though less intensely than Googong Creek. The area is in a broad valley typified by agricultural pastures with livestock grazing, scattered trees and many farm dams. Vegetation is dominated by introduced herbs and pasture grasses and populations of Saffron Thistle *Carthamus lanatus*, Purple Top *Verbena bonariensis* and St Johns Wort *Hypericum perforatum*. Tree cover is minimal and macrophyte cover is minimal. Steep gorge terrain where bedrock is exposed occurs around 750m upstream of the tributary that would receive emergency discharges from the WRP. Introduced species such as Blackberry *Rubus fruticosus sp. agg.* are observed. Within the tributary, flow attenuation structures exist to reduce excessive flow velocities.

Downstream of the tributary Montgomery Creek is characterised by steep banks and valley sides. Bedrock and boulders are present in the bed substrate and during very low flow conditions may be some isolate pools. The bank slope is steep to moderate with small vegetated side bars and mid-channel bars present closer to the confluence with the Queanbeyan River. The vegetation is disturbed with native vegetation present on both sides of the riparian zone but with a moderately impacted canopy of exotic species. Understory vegetation and soil structure is impacted by grazing by macropods and wombats and pig traps were noted in this area.

Further details are contained within the SWAEMP of the WMP for the baseline observations at the surface water monitoring locations (i.e. study sites).

The Queanbeyan River has been altered by the construction of the Googong Reservoir. Flow at the dam wall is a combination of discharge from the Reservoir, shallow groundwater discharge and local catchment run-off. At the confluence with Googong Creek the river is characterised by a shallow valley shape. The bed substrate is highly variable and there are sections of braided channel which are broken by deeper pools. The vegetation is moderately disturbed with native vegetation present on both sides of the riparian zone with intact canopy and only minor exotic species.

For Googong Creek, Montgomery Creek and the Queanbeyan River, factors affecting bank stability include human access and unsealed roadways. Stock access and wastewater releases are other factors which affect bank stability for Googong Creek.

3.2.1 Riparian and Aquatic Vegetation

The primary vegetation communities found within the township and catchment area are:

- South Eastern Tablelands Dry Shrub-Grass-Herb Forest;
- Tablelands Dry Shrub-Tussock Grass Forest; and
- South Eastern Tablelands Dry Shrub-Grass-Herb Forest.

Googong Creek transitions from South Eastern Tablelands Dry Shrub-Grass-Herb Forest in the upper catchment to Tablelands Dry Shrub-Tussock Grass Forest closer to the Queanbeyan River and in the proceeding steeper segments. The vegetation along the assessed area of the Queanbeyan River is primarily Tablelands Dry Shrub-Tussock Grass Forest.

South Eastern Tablelands Dry Shrub-Grass-Herb Forest comprises a diverse mosaic of vegetation groups which occupy the valley floors and slopes on heavier clay podzolics and yellow earths. The dominant overstorey of this class includes *Eucalyptus dives, E. rubida, E. bridgesiana, E. viminalis,* and *E. pauciflora.* Typical understorey species in include grasses *Themeda australis, Poa sieberiana,* and *Dichelachne* spp., as well as low growing shrubs, such as *Bossiaea buxifolia* and *Pultenaea procumbens.*

Tablelands Dry Shrub-Tussock Grass Forest is characterised by a canopy of *E. macrorhryncha, E. nortonii,* and *E. polyanthemos,* over an understorey of mixed grasses and herbs, such as *Danthonia* spp., *Anthosachne scabra, Hydrocotyle laxiflora, Daucus glochidiatus, Gonocarpus tetragynus* and *Lomandra filiformis* subsp. *coriacea.*

Vegetation along the assessed area of the Queanbeyan River is classified as Tablelands Dry Shrub-Tussock Grass Forest that is characterised by a canopy of *E. macrorhryncha, E. nortonii,* and *E. polyanthemos,* over an understorey of mixed grasses and herbs, such as *Danthonia* spp., *Anthosachne scabra, Hydrocotyle laxiflora, Daucus glochidiatus, Gonocarpus tetragynus* and *Lomandra filiformis* subsp. *coriacea.*

3.2.2 Study Sites

Surveys occurred at six sites on the Queanbeyan River, two on Googong Creek and one on Montgomery Creek. Googong and Montgomery Creeks are not considered by DPI Fisheries as Key Fish Habitat, but the Queanbeyan River is Type 1 Key Fish Habitat. Site 8 in baseline surveys was established during the spring 2016 period. Site 8 from the Hydrobiology 2016 study is re-numbered as Site 10.

The existing habitat of the Queanbeyan River has long been altered by Googong Reservoir. The SWAEMP describes the existing habitat, Table 5, in relation to baseline conditions.

Table 5: Existing habitat at surface water sampling sites - baseline (adapted from SWAEMP)

Site	Location	Stream Width	Habitat Description
1	Queanbeyan River – 1.5km downstream of Googong Reservoir wall	14 m	Vegetation mainly consists of macrophytes providing limited vegetation cover. In-stream habitat consists largely of cobbles, pebbles and some boulders.
4	Queanbeyan River – 2.25km downstream of Googong Reservoir wall	Not Specified	The upper and lower ends of the reach are separated by a large pool. The upstream end consists of 100% sand substrate with native forest on one side of the bank. The downstream end consists of mainly boulders (80%) and cobbles (15%) with thick native forest on both sides of the bank providing approx. 40% shading
5	Queanbeyan River – downstream of confluence of Googong Creek	15 m	There is native forest on one side of the bank and cleared grassland with 5% tree cover on the other side. In-stream habitat consists of mainly cobbles and boulders.
6	Queanbeyan River – 970m downstream of Site 5 (Private Property)	Not Specified	One side of the bank consists of cobbles with vegetation set behind this, the other has small shady areas/macrophytes and some overhanging native vegetation. In-stream habitat consists largely of cobbles with some boulders and pebbles.
7	Queanbeyan River – 6.5km downstream of Googong Reservoir wall	12 m	Banks are predominantly covered with grass, riparian vegetation (mainly one side) or bare. Overhanging vegetation provides approx. 10% cover, with 20% shading. In-stream habitat consist of mainly sand with areas of large boulders and cobbles.

Site	Location	Stream Width	Habitat Description
9	Montgomery Creek – upstream of the Queanbeyan River confluence	2 m Ephemeral, regularly dry	Riparian vegetation mostly consists of grass and *Rubus fruticosus sp. agg.* (Blackberry). In-stream habitat consists of large boulders and cobbles.
10 (Former Site 8)	Googong Creek – upstream of the Queanbeyan River confluence	1 m Ephemeral, regularly dry	Riparian vegetation mostly consists of grass and *Rubus fruticosus sp. agg.* (Blackberry). In-stream habitat consists of large cobbles, boulders and a small amount of sediment.

Ecowise Environmental undertook assessment of the physical habitat in April 2008 as part of the preliminary assessment of the proposed IWC Project. The upstream section of Googong Creek was gently sloping to a previously constructed farm dam and the creek was dry the entire length with the majority of the vegetation degraded grassland with a small number of native trees. In the long, middle gully section there are stretches that are moderately weed infested and areas with dense native scrub. The understory native vegetation in the middle section of terrain was dominated by Burgan (*Kunzea ericoides*) which were overhanging the creek bed in many stretches. There were access tracks and areas where litter and rubbish had been dumped in sections of the creek and riparian areas.

Since the commencement of monitoring under the WMP by GTPL and QPRC each surface water monitoring location has been regularly photographed as part of the habitat assessment. During the 2016-2017 Aquatic Ecology Survey (SMEC, 2017) a detailed description of each surface water monitoring sites was undertaken as summarised in Table 6 and compared with observations from 2019. Refer to Appendix A for the historical site photographs. Site 11, which is part of Beltana Pond, is not listed under WMP. It is a part of the interim monitoring program by QPRC which commenced in December 2017.

Table 6: Habitat at surface water sampling sites – 2016-2017 survey and 2019 observations (SMEC, 2017)

Site	Habitat Description 2016-2017	2019 Observations
1	This site is on the Queanbeyan River and is approximately 720 m downstream of Googong Dam, where there is a pool 45 m long, 12 m wide, and 75 cm deep. The river has a predominantly cobble bed with broad, shallow cobble and bedrock riffles upstream and downstream of the pool. A shallow backwater created an area of still water at the downstream end of the pool. *Typha orientalis* grew along half the edge of the backwater. Large woody debris was rare in the river, although a root ball created habitat near the downstream end of the pool was present. Teatree shrubs overhung the water, providing some shading and aerial structure for the river margins. Submerged macrophytes were common above the downstream riffle.	Teatree shrubs overhanging the water appear to be unchanged from the 2016/17 surveys. Groundcover vegetation is reduced compared to previous years effort, however the prolonged drought may have contributed to the reduction in vegetation cover.
4	The Queanbeyan River flows around a left-hand bend at this site. A large sandbar occurs on the inside of the bend and the river gets rapidly deep adjacent to this bar. Both banks are vegetated with teatrees. The pool sampled is approximately 320 m long, but the study reach extended 100 m along the southern bank and included both edge and riffle habitat. Blackberries are abundant towards the downstream riffle	Teatree shrubs overhanging the water appear to be unchanged from the 2016/17 surveys. Blackberries are still observed at the site, occupy a similar area and have not appeared to have spread or covered more native flora.
5	This is a broad pool 25 m wide and 150 m long in the Queanbeyan River. The bed is a mix of cobble and bedrock and becomes a series of 7 m wide rapids at the downstream end. Vegetation on both sides of the river consisted of mixed *Leptospermum* and *Acacia*. Blackberry shrubs were present along the river.	There appears to be no change in *Acacia* or Teatree shrub cover between the most recent and 2016/17 surveys. Blackberry shrubs are still present with seemingly little change in cover.
6	Site 6 was accessed through a reserve off Wickerslack Lane. The reserve was vegetated with native vegetation, and land slopes moderately down to the Queanbeyan River. Banks consisted mostly of coarse sand and bedrock, and the river was approximately 20 m wide and up to 2 m deep. Exotic poplar trees grow on the river-side sand, mixed with teatrees. Dense mats of poplar roots extend below the sand and into the river. There were deep pools here, and a shallow riffle at the upstream end. Mid-way along the reach, flow was constricted through a narrow 3 m gap between bedrock outcrops.	There appears to be no change in the species composition and vegetation cover between 2016/17 surveys and the most recent surveys.

Site	Habitat Description 2016-2017	2019 Observations
7	This site is on the inside bend of the Queanbeyan River on the south-eastern edge of Queanbeyan. Before reaching the site, the river flows through approximately 2 km of a valley vegetated by mostly native trees and shrubs. The riparian zone at the site is moderately well-vegetated with teatree (*Leptospermum* sp.) shrubs and *Lomandra longifolia*, and with dense areas of common reed (*Phragmites australis*) and blackberry shrubs (*Rubus fruiticosus sp. agg.*) at the water's edge. There is a walking track alongside the river, giving locals access to a swimming spot. The reach sampled consisted of a large, deep pool that had sand banks on the left side, and bedrock edge on the right side. At the upstream end of the pool was a shallow riffle approximately 15 m long and 10 m wide.	*Phragmites* reeds appear reduced in 2019 compared to the 2016/17 surveys. The cover and density of established shrubs such as Teatrees and the *Lomandra* appear unchanged. No change in cover of the blackberry.
8	This site was a narrow reach of Googong Creek that flowed underneath Googong Road. There was a small pool created by water trapped behind sediment retention fences and straw bales. Downstream of the sediment retention devices, the stream becomes little more than a trickle approximately 30 cm wide and 10 cm deep. Bank vegetation consists of pasture grass, sedges and herbaceous species, with only two shrubs shading the water of the study reach.	*Phragmites* reeds have increased in abundance when compared to the 2016/17 surveys. Established shrubs cover and density appear to have remained unchanged
9	This site is on the lower reaches of Montgomery Creek, where the bed is narrow and made of cobble. Parts of the stream and most of the riparian zone were covered with blackberry bushes. There was a shallow run and pool at this site in spring 2016, but no water in the autumn 2017 survey periods. The site starts 30 m upstream of the Queanbeyan River confluence and extends for a further 100 m upstream.	There appears to be no change in the species composition and vegetation cover between 2016/17 surveys and the most recent surveys.
10	This site is also on Googong Creek and was previously named Site 8 in the baseline survey. The study is a narrow cobble bed creek lined with blackberry bushes and sparse wattle trees (*Acacia sp.*). There was water at this site for both survey periods although it was only between 10cm and 20cm deep and around 40cm wide.	There appears to be no change in the species composition and vegetation cover between 2016/17 surveys and the most recent surveys.
11	N/A	This site is on the Beltana Pond foreshore with landscaped plantings of shrubs and reeds. They appear to be establishing well and covering the banks of the wetland area. Banks are predominantly covered with grass, riparian vegetation. In-stream habitat consists largely of macrophytes or deeper water. Large cobbles and rocks are present under the surface of the water.

3.2.3 Diatoms

Diatoms are a major group of algae, specifically microalgae found in waterways classified as belonging to the division of Chrysophyta, class Bacillariophyceae. Diatoms represent an important component of freshwater ecosystems and respond quickly to environmental changes. Diatom sampling at each of the nine surface water sampling sites was undertaken as part of the baseline monitoring for the IWC Project and is summarised in the SWAEMP. Diatom total abundance and richness varied between sites over time with no clear distinction between seasons but a distinction between the Queanbeyan River sites and the ephemeral creeks.

In 2015 there was a significant dominance of benthic over planktonic diatoms in the populations observed (Table 7). Table 8 presents the diatom motility levels and Table 9 presents the most abundant genus of diatoms from the 2015 baseline survey.

Table 7: Diatom habitat preference from baseline sampling (source SWAEMP)

Habitat Type	Richness	Abundance
Benthic	184	22,265
Epiphytic	11	2,109
Faculative Planktonic	16	10,061
Planktonic	7	7,024
Aerophilous	6	62
Unknown	28	553
Total	252	42,074

Table 8: Diatom motility levels from baseline sampling (source SWAEMP)

Motility Level	Richness	Abundance
Non-motile	10	12,039
Weakly motile	4	964
Slightly motile	16	13,790
Moderately motile	48	3,323
Highly motile	4	225
Unknown	170	11,824
Total	252	42,074

Table 9: Diatom abundance from baseline sampling (source SWAEMP)

Taxa	Group	Comment	Abundance (in % of total)
Achnanthidium minutissimum	Benthic	Broad niche, usually associated in early colonisation of biofilms, common freshwater diatom, also associated with low nutrient streams	20.4
Staurosirella pinnata	Facultative planktonic	Indicative of high nutrient status, non-motile, alkaliphilic diatoms	8.9
Aulacoseira subborealis	Planktonic	Alkaline, associated with high turbidity and phosphorous concentrations	8.0

Taxa	Group	Comment	Abundance (in % of total)
Rossithidium pusilla	Benthic	Occurs in environments with poor supply of nutrients, tolerates very small concentrations of organically bound nutrients	6.1
Staurosira construens forma venter	Facultative planktonic	Common in waters with low nutrient levels	5.4
Cymbella affinis	Benthic	Alkaliphilic, associated with rich nutrient environments	5.4

In 2015 the genus *Achanthidium sp*. was the most common sampled at 20% total abundance, however in the 2017 survey contributed just 1%. *Achnanthidium minutissium,* which is a species of benthic diatom associated with early biofilm development and low nutrient streams, would be commonly anticipated in ephemeral waterways. In 2017 the genus *Fragilaria* was the most common sampled, accounting of 15% of the total, which was not observed during the baseline monitoring. The baseline monitoring showed the diatoms sampled had a range of pH preferences with the majority being circum-neutral and alkaliphilic and a range of oxygen requirement classifications. The majority recorded required higher oxygen levels.

Monitoring by QPRC has recorded the total diatom abundance. The total diatom abundance varied between sites and over time, with clear peaks in spring / early summer and late summer / early autumn. Figure 9 presents the total diatom abundance from QPRC monitoring data.

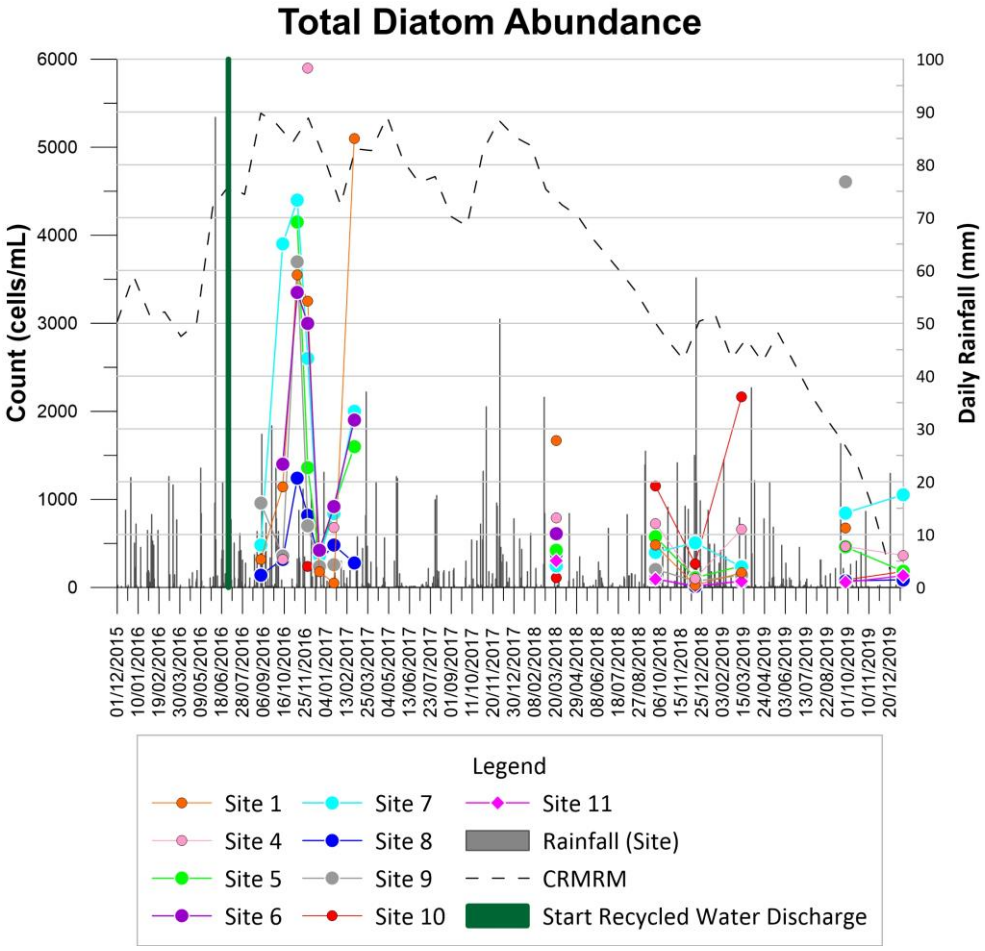


Figure 9: Total diatom abundance at each surface water monitoring site

3.2.4 Fish Survey

The baseline fish surveys and 2016-2017 fish survey noted the sites on the Queanbeyan River returned results but not the tributary creeks. In terms of abundance there is a clear dominance by volume of introduced fish to native fish. Fish numbers generally peaked in summer months. The results of the 2016-2017 fish survey results for the Queanbeyan River sites are shown in Table 10. Observations are dominated by exotic species. The only native species in this river was carp gudgeon (*Hypseleotris* sp.), which were only collected at Site 7 in spring. Brown trout and rainbow trout occurred at three sites, although not in the same season and not at the same sites.

Table 10: Fish observations in the Queanbeyan River 2016-2017 survey (source SMEC, 2017)

Common Name	Scientific Name	Site 1		Site 4		Site 5		Site 6		Site 7	
		Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut
Carp gudgeon	*Hypseleotris* sp.									33	
Redfin perch	*Perca fluviatilis*	2	9	7	4	3	10	1	41	3	
Rainbow trout	*Oncorhynchus mykiss*						5				
Brown trout	*Salmo trutta*	5		2							
Oriental weatherloach	*Misgurnus anguillicaudatus*							1		2	
Mosquitofish	*Gambusia holbrooki*		19		91		11		19		

The baseline survey notes a seasonal variance in the number of fish, with numbers peaking in summer months. Additional aquatic fauna was recorded, of note the presence of turtles and platypus along the Queanbeyan River. The 2016-2017 survey noted yabbies (*Cherax destructor*) were collected at all sites except Site 5 and Site 9 and were most numerous at Site 1. One female platypus was caught at Site 1 and another was seen at Site 7 but no turtles were observed. Trout numbers were not considered to be influenced by the Googong Township Development but rather by the water temperature and stocking history.

3.2.5 Macroinvertebrate Assessment

Baseline monitoring was undertaken in accordance with the NSW AUSRIVAS protocols, with separate AUSRIVAS models for stream edge and riffle habitats. Macroinvertebrate populations can vary according to the season and the assessments are generally based around the autumn spring or spring sampling periods. The AUSRIVAS model compares the expected (E) number of taxa and the expected SIGNAL (Stream Invertebrate Grade Number Average Level) score against what taxa were observed (O) at the site. For the baseline survey the O/E Taxa is divided into bands representing different levels of biological condition, as outlined in

Table 11, with results presented in Table 12.

Another model for macroinvertebrate community assessment is the average SIGNAL (Stream Invertebrate Grade Number Average Level). It describes the tolerance of macroinvertebrate taxonomic families to pollution, grading from 1 to 10 (Table 13) with 10 being very pollution sensitive and 1 being very pollution tolerant. For a healthy waterway it is common to find macroinvertebrates sensitive to pollution and with a high SIGNAL score and for a polluted waterway where sensitive taxa would be unable to survey it would be common to find macroinvertebrates that have a low SIGNAL score.

Table 11: AUSRIVAS Banding Scheme (source SWAEMP)

Band	Description	O/E Taxa	Taxa Interpretations
X	More biologically diverse than Reference	O/E greater than 90th percentile of reference sites used to create the model	More families found than expected. Potential biodiversity 'hot-spot' or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream
A	Similar to Reference	O/E within range of central 80% of refences sites used to create the model	Expected number of families within the range found at 80% of the reference sites
B	Significantly Impaired	O/E below 10th percentile of reference sites used to create the model. Same width as Band A	Fewer families than expected. Potential impact either on water and / or habitat quality resulting in a loss of families
C	Severely Impaired	O/E below Band B. Same Width as Band A	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and or habitat quality
D	Extremely Impaired	O/E below Band C down to zero	Few of the expected families and only the hard, pollution tolerant families remain. Severe impairment

Table 12: Summary of AUSRIVAS Bands for the baseline data (source SWAEMP)

Site	Edge Habitat			Riffle Habitat		
	Spring 2013	Autumn 2014	Spring 2014	Spring 2013	Autumn 2014	Spring 2014
1	C (0.35/1.12)	C (0.45/0.93)	B (0.7/0.9)	C (0.55/1.13)	C (0.42/0.9)	C (0.55/0.77)
4		C (0.36/0.57)	C (0.55/1.12)		D (0.34/0.76)	C (0.38/0.68)
5	B (0.66/1.23)	A (0.87/0.98)	B (0.78/1.06)	C (0.38/1.14)	D (0.27/0.76)	C (0.38/0.68)
6	C (0.55/1.31)	C (0.25/0.61)	A (0.99/1.06)	B (0.69/1.13)	D (0.37/0.92)	B (0.76/1.0)
7	B (0.78/1.18)	C (0.2/1.04)	A (0.89/1.2)	B (0.61/1.16)	D (0.28/0.95)	C (0.46/0.8)
9			C (0.59/0.83)			C (0.55/0.91
10 (formally 8)						B (0.64/0.98)

Table 13: Average SIGNAL Classification scheme (source Biosis, 2016)

SIGNAL Value	Impairment	Water Quality Status
Greater than 7	Unimpaired and rich in sensitive taxa	Excellent water quality
6 – 7	Unimpaired	Good water quality
5 – 6	Mildly impaired	Fair quality, possible mild pollution
4 – 5	Moderately impaired	Poor quality
Less than 4	Severely impaired	Very poor water quality

The baseline macroinvertebrate analysis shows temporal heterogeneity with seasonal fluctuations strongly influenced by river flow. Edge habitat generally performed better than riffle habitat, supporting invertebrate communities similar

to the AUSRIVAS reference site, particularly in Spring 2014. Autumn results were typically worse than spring results and the SIGNAL scores were very high suggesting that the pollution sensitive taxa were persisting. *Diptera* (fly larvae) were often absent from site collections; the taxa was largely dominated by those that are considered relatively tolerant to various forms of pollution. The SWAEMP notes that Site 1 and Site 5 have been routinely monitoring by Icon Water from 2008 to 2012 and the results showed a decline in site condition in 2012 which was attributed to the impact of floods in early autumn of that year.

The results of a May 2016 Autumn survey (Hydrobiology, 2016) undertaken in accordance with ACT AUSRIVAS protocol and provided as a memorandum of results to GTPL with a summary table of the macroinvertebrate taxa and abundances are shown in Table 14.

Table 14: May 2016 macroinvertebrate taxa (source Hydrobiology, 2016)

Taxa	Site 1	Site 4	Site 5	Site 6	Site 7	Site 9	Site 10 (Formerly 8)
Dugesiidae	4						
Planorbidae			1				
Lymnaeidae							15
Physidae					1	13	
Planorbidae						5	28
Corbiculidae			4	1	5		
Sphaeriidae	1	1					
Oligochaeta	23	16	26	16	27	116	38
Acarina	3	10	3	1	5		
Dugesiidae	4						
Dytiscidae						2	1
Elmidae	1	2	2				
Ceratopogonidae		1				5	80
Culicidae						1	
Empididae	2		4	1			
Chironominae	48	147	21	27	32	55	23
Orthocladiinae	23	24	9	19	7		8
Tanypodinae	2	13	3	9	6	5	2
Simuliidae	2		14	1	3		1
Tipulidae		3	1	1	2		
Baetidae	32	14	18	25	20	2	4
Caenidae	70	41	83	120	83	1	
Leptophlebiidae		14	4	22	4	1	
Corixidae						1	2
Diphlebiidae				2			
Gomphidae	2			5			
Ecnomidae	2	11		1			
Glossomatidae				1			
Hydrobiosidae			1				

Taxa	Site 1	Site 4	Site 5	Site 6	Site 7	Site 9	Site 10 (Formerly 8)
Hydropsychidae	2	21	7	2	6		
Hydroptilidae	3	17	4	11	9		4
Leptoceridae		2	2			4	
Philopotamidae			4	8			
Gripopterygidae	8	1		1	7		
Species Richness	**17**	**17**	**19**	**20**	**15**	**13**	**12**
Abundance	**228**	**338**	**211**	**274**	**217**	**211**	**206**

Biosis (2016) undertook macroinvertebrate surveys in May 2016 and August 2016 at two locations on Googong Creek and one site on the Queanbeyan River. Only one location, GC1 is consistent with the current surface monitoring network called Site 8. The report notes around the sampling site that the riparian and aquatic vegetation was highly disturbed with very little native vegetation present and both banks severely modified by grazing. The result was a Band A score with a SIGNAL score of 3.22 and O/E 50 of 0.85 and 16 taxa families present. The score suggest impacts present were not of a type that results in a loss of taxa but the sensitive taxa have been moderately impacted and that mild nutrient enrichment may be compensating for their loss through increased primary productivity. It is important to note this survey was conducted after the start of discharge of excess recycled water to Googong Creek. The low SIGNAL score may indicate impairment in long term water quality.

SMEC (2017, 2019) undertook a macroinvertebrate survey in Spring 2016 and Spring 2018 through Eco Logical Australia. Summary tables of results are provided in Appendix B. There were 46 invertebrate taxa collected during the spring of 2016 (Table 15) and 56 in the Spring of 2018.

The result of Spring 2016 showed Site 1 had the highest richness with 27 taxa and all sites had between 20 to 27 taxa except for Site 8 which had 13. This is slightly less than the 16 taxa identified by Biosis (2016) during their survey. *Dipteria* (fly larvae) numerically dominated all sites. Ephemeroptera (mayfly larvae) were common in Sites 1, 4, 5 and 6 whilst *Gastropoda* were abundant at Site 7, 8, 9 and 10. Edge habitats generally had more taxa than riffle habitats.

In the Queanbeyan River, edges had between 12 and 22 taxa and riffles had between 12 and 19 taxa and the tributary sites had between 12 and 19 taxa in edges and 17 and 18 in riffles. For the Queanbeyan River average SIGNAL scores (Table 16) were higher in riffle than edge habitats, with riffle habitats at Site 1, 5 and 6 indicating mild pollution whilst edge habitats had moderate to severe pollution. Both riffle and edge communities at Site 7 indicate moderate pollution. The tributary sites had SIGNAL scores indicative of severe pollution for both habitats except for the edge at Site 10.

Invertebrate communities at the Queanbeyan River sites were different to Googong Creek. Googong Creek has a higher abundance of Physidae and Dytiscidae, while Queanbeyan River sites had higher abundances of Simuliidae, Chironomidae, Caenidae, and Baetidae.

Table 15: May 2016 macroinvertebrate taxa in edge, riffle and both habitats (source SMEC, 2017)

Edge only	Riffle only	Both habitats	
Nematoda	*Ptilodactylidae*	*Oligochaeta*	*Gerridae*
Planorbidae	*Tabanidae*	*Physidae*	*Aeshnidae*
Eusiridae	*Mesoveliidae*	*Hydracarina*	*Gomphidae*
Gyrinidae	*Megapodagrionidae*	*Atyidae*	*Gripopterygidae*
Scirtidae	*Helicopsychidae*	*Dytiscidae*	*Notonemouridae*
Dolichopodidae	*Hirudinea*	*Elmidae*	*Hydropsychidae*

Edge only	Riffle only	Both habitats	
Psychodidae		*Psephenidae*	*Hydroptilidae*
Stratiomyidae		*Ceratopogonidae*	*Leptoceridae*
Corixidae		*Chironomidae*	*Hydrobiosidae*
Notonectidae		*Simuliidae*	*Philopotamidae*
Protoneuridae		*Culicidae*	*Corbiculidae*
		Baetidae	*Corydalidae*
		Caenidae	*Collembola*
		Leptophlebiidae	*Copepoda*
		Veliidae	

Table 16: 2016 average SIGNAL scores and total number of taxa for edge and riffle habitats (source SMEC, 2017)

	Habitat	Site 1	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Average SIGNAL	Edge	3.91	4.15	3.83	3.93	4.25	3.23	2.95	4.25
Total Taxa	Edge	22	20	18	15	12	13	19	12
Average SIGNAL	Riffle	5.06		5.50	5.53	4.92		3.78	3.47
Total Taxa	Riffle	18		12	19	12		18	17

The 2018 survey were undertaken in accordance with ACT AUSRIVAS protocol and the average SIGNAL score is shown in Table 17. During this survey Beltana Pond (Site 11) was assessed.

Table 17: 2018 average SIGNAL scores and total number of taxa for edge and riffle habitats (source SMEC, 2019)

	Habitat	Site 1	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
Total Abundance	Riffle	1396	363	887	1044	986	243	303	832	
Number of Taxa	Riffle	18	18	20	20	15	10	9	15	
Average SIGNAL	Riffle	4.7	4.9	4.9	4.9	5.0	2.9	3.8	3.6	
Total Abundance	Edge	1357	230	298	750	614	499	224	300	528
Number of Taxa	Edge	17	25	19	24	20	16	18	18	18
Average SIGNAL	Edge	4.4	4.3	3.5	4.3	3.9	3.6	3.6	2.9	2.8

When compared to the 2016 results the SIGNAL score for edge habitat at Site 1, 4, 6 and 8 improved whilst the other site SIGNAL scores were worse. For the riffle habitats Sites 7, 8 and 10 improved whilst the others were worse or not comparable.

Out of the nine sites sampled in October 2018, the highest average SIGNAL score was recorded in the riffle zone of Site 7, with a score of 5.0 to indicate moderate disturbance levels. SIGNAL scores indicate moderate disturbance at both

habitats of Sites 1, 4, and 6, and for the riffle habitats at Sites 5 and 7. The edge habitats at Sites 5 and 7 were severely disturbed, as were both habitats at Sites 8, 9, 10, and 11.

Of the 54 taxa collected during the spring survey, the edge habitat at Site 1 had the greatest number of different taxa collected. Both habitats in Site 1 also had the highest number of organisms collected. Edge habitats generally had more macroinvertebrate taxa than riffle habitats at the same site, with the exception of Site 5. The three subfamilies of Chironomidae were the most widespread taxa present. These occurred at all sites and in both riffle and edge habitats. Ceratopogonidae were also present at all sites, though preferred edge habitats to riffles. Another midge family, Simuliidae, occurred at all sites except Site 11, and preferred riffle habitat. Caenidae mayflies occurred at all sites except Site 10. The more sensitive families (those with SIGNAL scores of 8 or higher), are less common. These were represented by Telephlebiidae, Calocidae, Gripiterygidae, Hydrobiosidae, and Philopotamidae. Of these, Gripopterygidae stoneflies were the most widespread, being collected at all sites except Site 8 and Site 11 and were more abundant in riffles than edges.

Macroinvertebrate families such as Culicidae, Lymnaeidae, Physidae and Notonectidae have a SIGNAL score of 1, which means they are very tolerant to pollution. Site 10 and Site 11 had the highest number of Culicidae collected, which may indicate that these sites were affected by pollution. Both these sites also had high levels of turbidity and relatively high levels of total dissolved solids and electrical conductivity.

3.2.6 Surface Water Quality

The surface water quality was recorded at sites surveyed for macroinvertebrate or fish communities. The surface water quality of the Queanbeyan River, Googong Creek, Montgomery Creek, and Beltana Pond is monitored by QPRC under the WMP and the SWEAMP. The surface water monitoring parameters are described the SWEAMP of the WMP and include:

- field measurements of pH, electrical conductivity, dissolved oxygen, temperature, and total chlorine; and
- laboratory analysis of major ions, total and suspended solids, oil and grease, ammonia, nitrate, nitrite, oxides of nitrogen, total nitrogen, total phosphorus, total kjeldahl nitrogen, faecal coliforms and algae (summer and spring months).

Refer to the Surface Water Assessment Report for detailed discussion on surface water quality. Site specific trigger values are outlined in the WMP for selected parameters and are shown on relevant figures within this report.

Macroinvertebrate surveys compare the surface water quality with that of the ANZECC (2000) guidelines for upland rivers in NSW whilst the surface water monitoring program follows the WMP criteria. Table 18 presents selected field parameters and the ANZECC (2000) and WMP trigger criteria. In general, the WMP trigger criteria is higher, though prior to August 2018 EC was set at the ANZECC (2000) trigger level. Table 19 presents a summary of the surface water quality results from the macroinvertebrate surveys.

Table 18: Water quality assessment criteria for selected parameters

Parameter	ANZECC (2000) trigger for upland rivers	WMP Trigger
Temperature	NA	NA
Electrical Conductivity	30 to 350 µS/cm	>1000 µS/cm
pH	6.5 to 8.0	>8.5
Dissolved Oxygen (%)	90 to 110	<90%
Turbidity (NTU)	2 to 25	NA

Table 19: Water quality results from macroinvertebrate surveys

	Site 1	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
May 2016 - Hydrobiology									
Temp.	15.5	15.3	13.3	13.1	12.8		13.3	11.1	
pH	8.0	8.0	7.7	7.8	7.7		7.9	7.8	
EC	90	93	121	104	108		635	521	
DO (%)	109.2	101.9	101.5	110	98.9		100.8	89.6	

	Site 1	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
Turb. (NTU)	Below detection	Below detection	Below detection	Below detection	Below detection		Below detection	Below detection	
Autumn 2016 - Biosis									
Temp.						10.97			
pH						6.91			
EC						532			
DO (%)						109			
Turb. (NTU)						6.4			
November 2016 - SMEC									
Temp.	15.7	15.8	18.6	19.4	23.9	21.3	19.6	17.5	
pH	7.51	7.47	7.83	8.16	7.88	7.49	7.84	8.16	
EC	130	140	210	170	170	390	610	570	
DO (%)	101	69.9	83.8	159	129	70.2	131	77.8	
Turb. (NTU)	5.8	8.5	10.7	6.4	67.2	87.5	23.8	14.6	
March 2017 - SMEC									
Temp.	19.6	20.8	21.1	21.2	22	23.6		19.3	
pH	7.85	7.77	7.91	7.97	7.88	8.44		7.84	
EC	140	140	140	140	140	670		900	
DO (%)	89.3	86.4	105	106	106	198		76.9	
Turb. (NTU)	7.1	15.6	6.2	10.5	7.9	30.7		7.7	
Spring 2018 - SMEC									
Temp.	12.0	12.2	10.7	10.4	12.4	12.5	13.5	10.8	11.2
pH	7.61	8.23	7.95	7.69	7.43	7.67	8.31	8.15	7.76
EC	88	97	136.5	139.5	145	718	239	812.5	545
DO (%)	112.4	107.4	82.3	75.0	81.5	90.4	109.7	93.3	117.3
Turb. (NTU)	5.1	6	5.7	5.6	6.1	21.5	9.9	59.4	18.6

The spring 2016 and Autumn 2017 survey (SMEC, 2017) showed exceedance of pH, EC, turbidity and dissolved oxygen. Biosis (2016) noted that the surface water parameters measured at Site 8 in Autumn 2016 exceeded the ANZECC (2000) guidelines for upland rivers for electrical conductivity. The 2018 survey (SMEC, 2019) showed exceedance of pH, EC, turbidity and dissolved oxygen.

Biosis (2016) noted that elevated nutrients have been confirmed present within the wider catchment. Nutrient levels in both groundwater and surface water appear to be elevated and concentrations in the recycled water which is discharged to the environment exceed the ANZECC (2000) 95% species protection for total nitrogen but do not exceed the WRP EPL (Licence Number 20188) limit of 10 mg/L. Biosis (2016) suggested elevated salinity within Googong Creek is attributed to the recycled water discharge on the basis of the average salt concentration (of the recycled water) being equivalent to around 1000 µS/cm. QPRC have been monitoring the quality of the recycled water as per the EPL and to date EC has not been directly tested.

3.2.7 Limitations

Ecological surveys provide a sampling of diatoms, macroinvertebrates, flora and fauna at a given time and season. There can be many reasons why not all species may be detected at a site during the survey, such as species dormancy, seasonal conditions, ephemeral status of water bodies, migration and breeding behaviours. The water quality parameters measured also provide a snapshot of conditions at a given point in time at a given location. Some parameters typically exhibit a high degree of temporal variation and can change substantially over small periods of time and with increases in depth of the monitoring device relative to the surface and impacts of rainfall events.

3.3 Recycled Water Discharge Locations and Quality

The recycled water discharge locations for Stage D of the IWC Project are located downstream of the Permanent Reservoirs (Discharge Point 1) and at the Beltana Park Outlet Structure (Discharge Point 3). These points are shown on Figure 10. Presently only Discharge Point 3 is used.

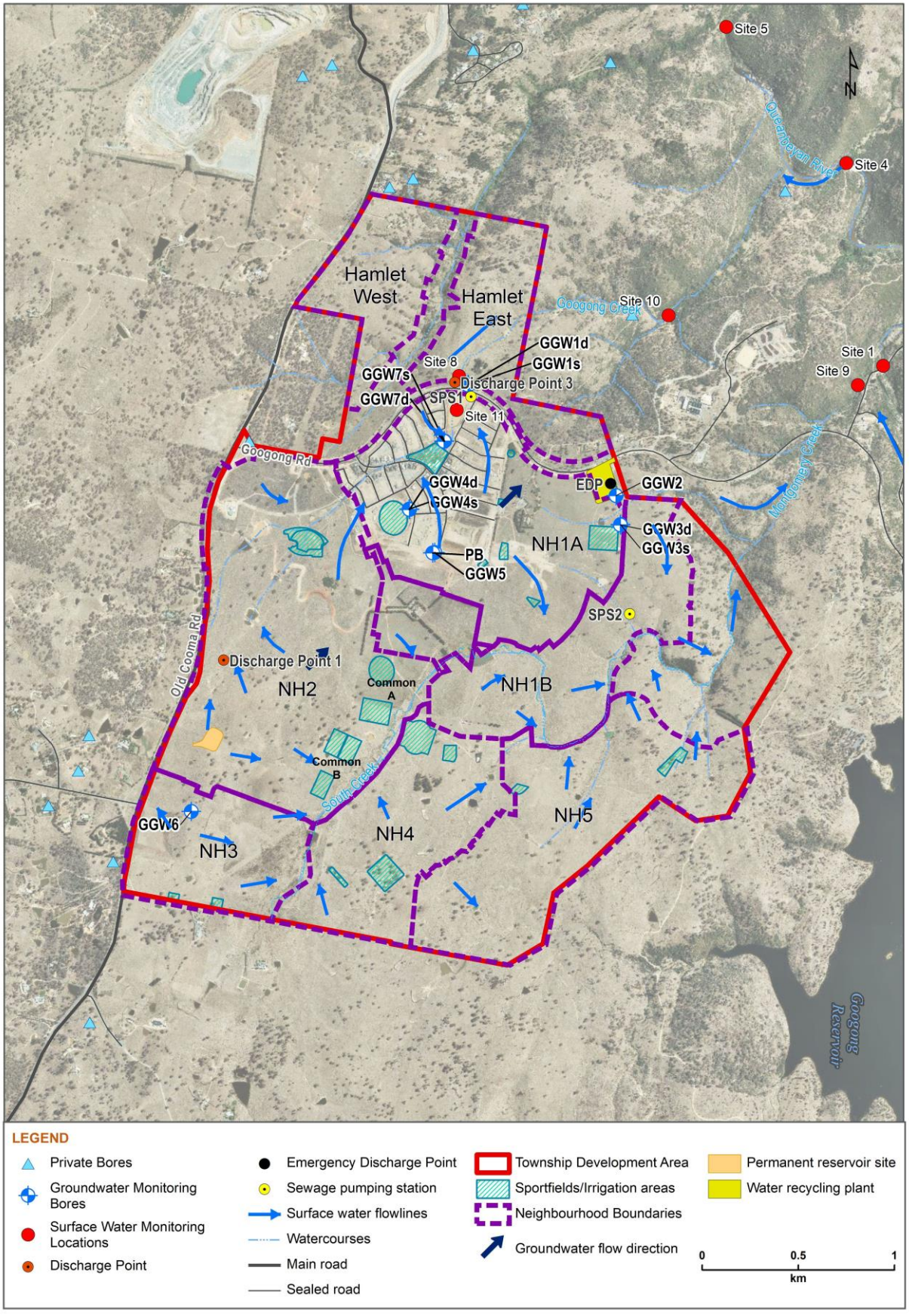


Figure 10: Location of WRP, sewage pumping stations and recycled water discharge locations with inferred surface water drainage

The following discharges will occur at these locations:

- Discharge Point 1 – EPA-licenced discharge point where recycled water in excess of township demand can be discharged via a series of overland flow stormwater ponds in NH2 and the NH2 stormwater management system and flow into Beltana Pond. This discharge point is anticipated to become available in May 2020 with the approval of recycled water use in the township;
- Discharge Point 3 – EPA-licenced discharge point where excess recycled water can be discharged and recycled water that doesn't meet the *Essential Sewage and Recycled Water Quality Management Plan* (RWQMP) criteria but meets discharge criteria detailed in an operational EPL is discharged. Discharge has been occurring at this location since 2016.

The emergency discharge point (EDP) is located at the WRP (Figure 10Figure 10) and in the event of an emergency discharge is directed to Montgomery Creek. Discharge Point 3 is currently used for discharge of recycled water in excess of the township demand as there is no use in the township. QPRC propose a change to the designation of the discharge locations such at Point 1 is used on occasion for operational purposes and Point 3 remains as the primary discharge point for any excess recycled water after township demand.

The raw water source for the township is Googong Reservoir. No information is available on the raw water quality. After use in the township the sewage generated is reticulated to the WRP and treated to become the recycled water. The quality of the recycled water is influenced by is sources and pathways of travel. The WRP process also alters the water quality with the addition of chlorine and other treatment chemicals. Discharge of excess recycled water must meet the EPL conditions before it can be released as environmental flow to Googong Creek. Quality samples are taken each month (or multiple times a month) from the treatment plant in accordance with the EPL. Figure 11 presents a time series plot of selected recycled water quality parameters and Figure 12 presents a piper diagram plot of recycled water chemistry with selected surface water and groundwater monitoring locations.

Figure 11 shows as recycled water discharge has increased over time pH has generally remained consistent along with the concentrations of major ions and ammonia and total phosphorus. Sulphate concentration shows some variability which may be related to seasonal variability. Total nitrogen shows a significant increase in concentration from May 2017 to September 2017 to around 5 mg/L.

Figure 12 shows the recycled water discharge, which has varied slightly each year, appears distinctly different to the surface water and groundwater quality. Prior to recycled water quality discharge, Site 8 on Googong had a chemistry similar to the groundwater at GGW1S and GGW1D but now shows the same signature as the recycled water. Site 10, downstream from Site 8 on Googong Creek, shows there is mixing zone between the groundwater and recycled water. Site 11 in Beltana Pond, which is upstream from the recycled water discharge in Beltana pond, shows a similar chemistry to the groundwater.

3.3.1 Recycled Water Volumes

Discharge of excess recycled water has been occurring in Googong Creek since July 2016 (see Figure 13) after the initial trial of discharge in December 2015. The volume of excess recycled water increased from around 200 kL/day in July 2017 to 400 kL/day by December 2017 to 700 kL/day by December 2019. Several peak discharge events of 1300 kL/day and 1900 kL/day occurred in November 2017 and December 2018 respectively. The 2019 discharge which was around 700 kL equates to around 8 L/s or 0.008 m^3/s.

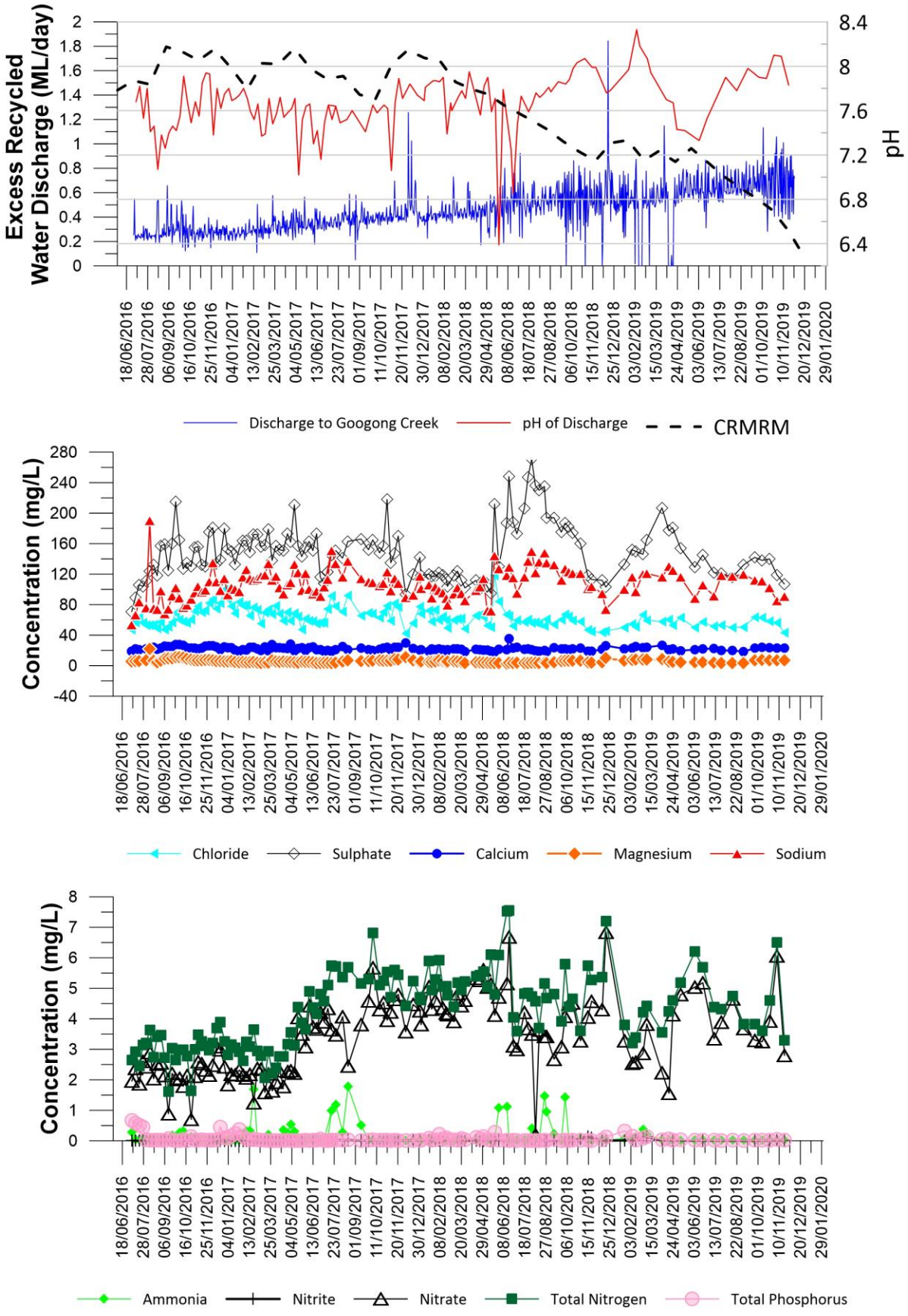


Figure 11: Time series plot of recycled water quality

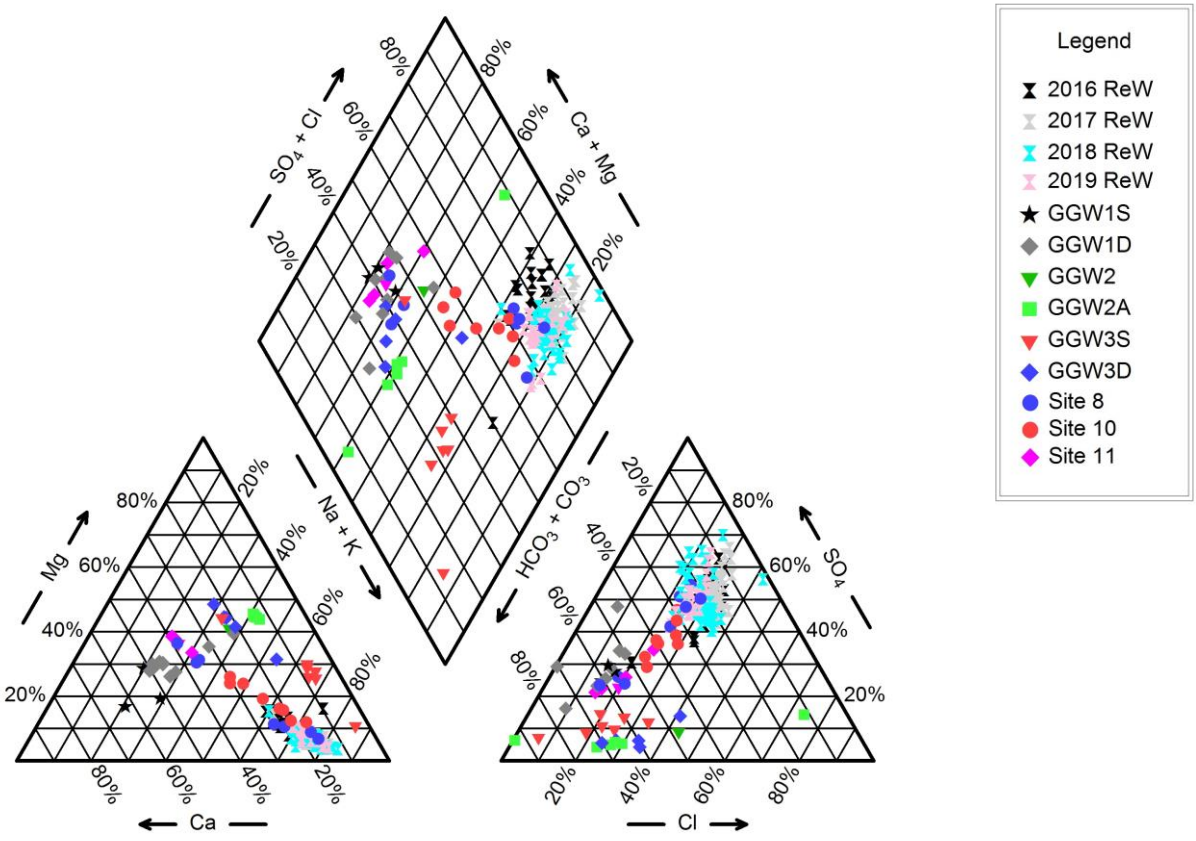


Figure 12: Piper diagram plot of recycled water quality with selected surface and groundwater sampling locations

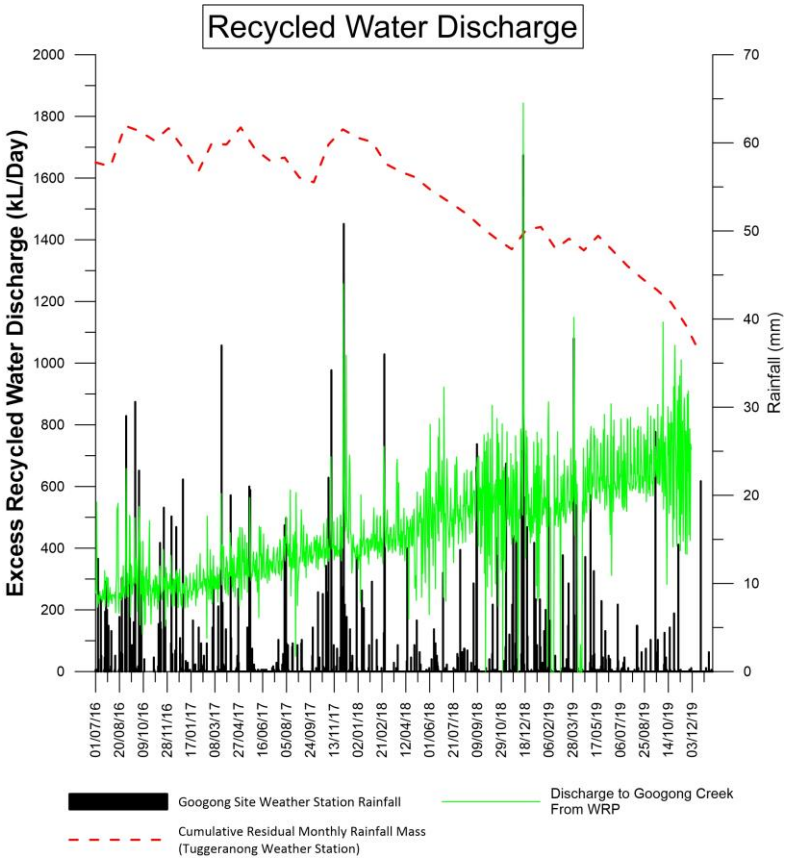


Figure 13: Excess recycled water discharge to Googong Creek from July 2016 to December 2019

3.4 Queanbeyan River

The Queanbeyan River downstream of Googong Dam receives surface water from Googong Creek and Montgomery Creek. Its catchment area covers around 873 km^2 and primarily consists of rural land uses. ICON Water has a sewage treatment plant (operated by ACTEW) within the Queanbeyan River Catchment, to the north of the township. The Stage C surface water assessment report (Hydrobiology, 2016) describes the river as perennial, draining in a general northerly direction towards Queanbeyan and the Molonglo River. The nearest river gauge is Wickerslack located, located approximately 3.1 km downstream and to the north of Googong Dam. Information on levels at Googong Reservoir are available through Water Data Online (BOM website) Station number 41078. The Wickerslack gauge data is shown on Figure 14 with the long term climatic trend. The Stage C surface water assessment report (Hydrobiology, 2016) estimated that the regulation of the system resulted in a reduction of baseflow from about 1 m^3/s to 0.1 m^3/s. At the end of 2019 flow was very low in response to prolonged below average rainfall conditions.

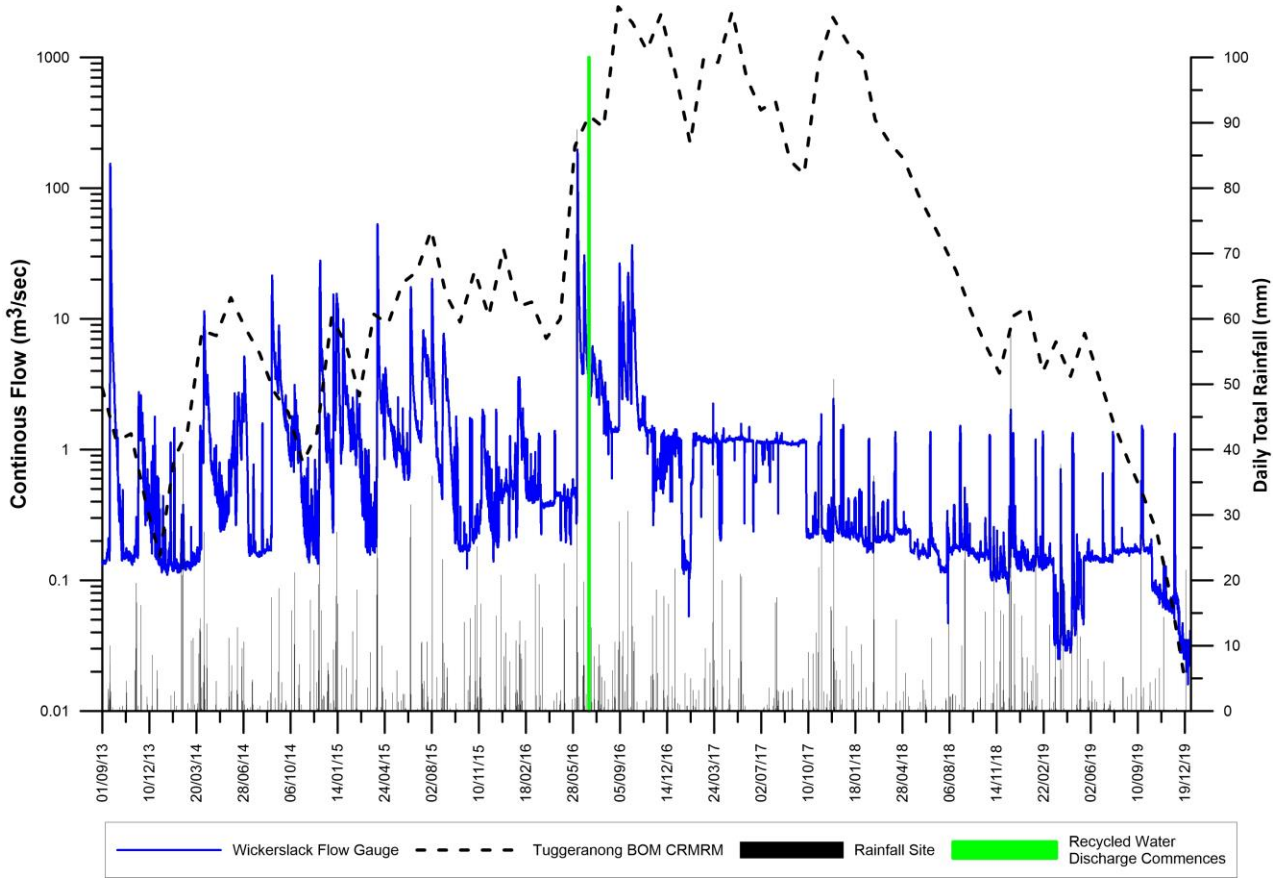


Figure 14: Queanbeyan River flow at Wickerslack Gauge September 2013 to December 2019

3.5 Surface Drainage

Surface water within the township development areas (Figure 10) is controlled by the topography of the environment, either existing (i.e. natural slopes) or developed (i.e. residential). In the developed neighbourhoods surface water is directed through the IWC stormwater system. In areas under development surface water is controlled through the CEMP. In the natural areas surface water flow direction follows topography flowing from elevated areas to lower lying areas and drainage lines. The stormwater system for the constructed neighbourhoods flows into Beltana Pond which overflows to Googong Creek.

3.5.1 WRP

Surface water drainage in the vicinity of the WRP is predominantly east to south-east towards the foreshore boundary and drainage lines which feed into Montgomery Creek (Figure 10).

The WRP is designed with three types of surface water drainage systems:

1. First Flush – all the areas which are considered 'dirty' and likely to have had raw sewage/dirty water contact the surface drains to a first flush tank. This has been designed to capture the first 10 mm rainfall across all of the dirty areas – this water is put back to the head of works as soon as possible;
2. Chemical drainage – all areas that could be contaminated with chemicals drain to the neutralisation pit which is then treated and put back to head of works; and
3. Stormwater – all other areas drain to stormwater and are discharged directly to the Montgomery creek outlet.

Access to the WRP will involve reopening and using the Stage C temporary access road on the eastern site boundary for which surface drainage is east towards Montgomery Creek.

3.5.2 Permanent Reservoirs

The surface water within the permanent reservoirs compound is collected and treated within the site. Around the compound, surface water drainage follows topography and is generally to the north-west and west. Discharge Point 1 is located north-west of the reservoir and forms the start of the overland flow system for excess recycled water. On the eastern side surface water may also flow east towards South Creek (Figure 10). Access will be from Old Cooma Road on a sealed road for which surface drainage is towards the west and northwest.

3.6 Surrounding Land Use and Potential Receptors

Land use surrounding the township development to the west, north and south is farmland and rural residential and to the east the water supply catchment of Googong Reservoir. The key aquatic receptors are Googong Creek, Montgomery Creek and South Creek which are tributaries of the Queanbeyan River.

4 Potential Construction and Operation Impacts

4.1 Construction Activities and Potential Impacts

4.1.1 WRP

The WRP site layout in Stage C included provision for Stage D infrastructure. Construction activities within the WRP will result in the temporary reopening of the access road to the east of the WRP (within its existing footprint) and will later be rehabilitated for the operational phase of the development. The opening of the access road is likely to result in topsoil stripping, placement and compaction of materials. Within the WRP site there will be excavation works for foundations of new structures which will likely expose the shallow rock profile and any placed material. Potential impacts include:

- degradation and erosion of the temporary access track;
- sediment discharge to the drainage line from the road construction;
- spills of chemicals from decommissioned and disassembled plant; and
- contaminated surface run off.

Construction works associated with the WRP works are anticipated to be completed by end of 2024.

4.1.2 Permanent Reservoirs

The layout of the Permanent Reservoirs site on Hill 800 in Stage C included provision for Stage D infrastructure. The main access to the site is from Old Cooma Road by way of a sealed access road. Potential impacts include:

- sediment discharge during the removal of the earth bund;
- spoil from foundation excavation in surface water run-off;
- spills of chemicals from decommissioned and disassembled plant;
- contaminated surface run off.

Construction works associated with the WRP works are anticipated to be completed by the end of 2024.

4.2 Mitigation and Monitoring of Construction Impacts

Construction activities for Stage D WRP and Permanent Reservoirs are not anticipated to require extensive earthworks and as such potential impacts on aquatic ecology are minimal. Any impact of flows into receiving waterways resulting from construction of Stage D WRP and Permanent Reservoirs are likely to be negligible and measures in place within the CEMP are considered sufficient.

Impacts to the aquatic ecology from construction of the Stage D WRP and Permanent Reservoirs are considered minor and may be difficult to attribute due to the seasonal variation in communities observed and the ongoing long-term impacts of the township development. Given the short duration of construction is it unlikely that aquatic ecology surveys (i.e. diatoms and macroinvertebrates) would be of benefit or observe the potential impacts as the monitoring frequency is either quarterly (diatoms) or six monthly (macroinvertebrates).

4.3 Operational Impacts at the WRP and Permanent Reservoirs

The potential operational impacts of the WRP and Permanent Reservoirs relate to:

- spills of dosing chemicals, leaking pipes and tanks and emergency discharge releases;
- overall reduction of surface water flow due to township development.

Operational impacts are considered relatively unlikely and should be contained within the sites, excluding emergency discharge releases. Emergency discharge of water down Montgomery Creek may be visually unsightly but short lived. Potential impacts may include erosion of the upper creek channel and a potential decrease in water quality. There is no further practical mitigation with respect to emergency discharge.

4.4 Operational Impacts of Recycled Water Irrigation

The Stage D IWC Project incorporates irrigation of recycled water on public spaces and private properties for the whole of the township. The township consists of a total of 705 hectares (ha) of which 325 ha are estimated to be hardstand and 380 ha are open space. Of the open space 27 ha are irrigated sporting fields, 180 ha is open space for reserves and

parklands and 200 ha is domestic lots that will not be built on. These estimates have been provided by Stantec and assume a 500 m^2 average lot size with max coverage of 50%. There is a total of 9.8 ha of open space for irrigation already constructed in NH1AB. Currently the existing irrigation areas use potable water, with reticulation of recycled water planned for third quarter of 2020.

The potential operation impacts of open space irrigation relate to:

- overapplication of water leading to surface ponding or run-off;
- spray drift; and
- pipe failure leading to uncontrolled discharge of recycled water.

These impacts are considered minor. The irrigated areas are unlikely to contribute significant volumes of water to the surface water system as volumes and times of irrigation are controlled under the IMP. Run-off from these irrigated areas would be managed within the stormwater infrastructure.

The development of the township increases surface water run-off and stormwater is and will be directed to specific areas which report to Googong Creek, Montgomery Creek and South Creek. There is an overall reduction in surface water reaching these creeks due to the township development and domestic capture through rainwater tanks.

Impacts to aquatic ecology from reduced flows as a result of the operation of the WRP, permanent reservoirs and irrigation areas are likely to be difficult to observe over the overall impacts associated with township development and natural climatic and seasonal variations.

4.5 Operational Impacts of Discharge of Excess Recycled Water

The operation of the IWC Project proposed for Stages AB and C included the discharge of excess recycled water from Discharge Point 1 in NH2. However, as the use of recycled water has not been approved, excess recycled water has been discharged from Discharge Point 3 on Googong Creek just below Beltana Pond to date. Any water that is discharged must meet the effluent criteria listed in the RWQMP and be in accordance the EPA licence conditions under EPL Licence Number 20188.

The Stage D development proposes to retain the location of excess recycled water discharge as Discharge Point 3 on Googong Creek. QPRC considers that pumping excess recycled water up hill to the permanent reservoirs at Discharge Point 1 is not as efficient as release from Discharge Point 3. Discharge Point 1 would be retained to allow discharge of recycled water as required to meet operational requirements.

This change would mean that the bio-retention basins, vegetated swales and wetland element of the townships stormwater management system between Hill 800 and Beltana Pond would not receive as much excess recycled water as previously proposed. The bio-retention basins, vegetated swales, and wetland elements are designed to capture, reduce, and in some instances, remove excess nitrogen and phosphorous. Beltana Pond has been designed with passive water flow to ensure water is regularly passed through the wetland and a recirculation pump to provide increased oxygenation. It would also mean that less recycled water would recharge the shallow groundwater system from this process and more surface water flow would reach the Queanbeyan River.

Stantec have estimated for the IWC Project at completion (i.e. the ultimate project including all stages, A-D) the total recycled water generation of the township is around 3,960 kL/day (118,755 kL/month). The monthly break down of the volume for irrigation, domestic consumption and excess recycled water discharge is shown in Table 20.

Table 20: Summary of ultimate IWC Project monthly recycled water average, minimum and maximum volumes to irrigation and domestic consumption and predicted excess discharge for environmental flow in kL

Month	Montly Volume to Irrigation and Domestic Consumption			Monthly Predicted Excess for Environmental Discharge		
	Average	Minimum	Maximum	Average	Minimum	Maximum

Month	Montly Volume to Irrigation and Domestic Consumption			Monthly Predicted Excess for Environmental Discharge		
Jan	3,004.9	237.4	5837.6	297.8	0.0	4,283.3
Feb	2,833.8	254.5	6051.7	351.6	0.0	3,496.9
Mar	2,320.3	254.7	5123.9	489.0	0.0	5,477.4
Apr	1,538.3	146.5	4222.7	899.5	0.0	3,771.8
May	943.2	88.7	3779.2	1,373.0	0.0	3,942.3
Jun	469.7	49.4	2663.0	1,818.4	0.0	3,773.6
Jul	370.1	9.4	931.4	1,922.9	1,226.8	3,640.0
Aug	492.4	0.0	1869.5	1,797.8	188.4	4,766.8
Sep	821.7	44.5	3343.8	1,478.9	0.0	3,288.2
Oct	1,554.3	103.8	4236.8	903.5	0.0	4,485.1
Nov	2,036.1	117.5	5219.0	687.3	0.0	4,445.6
Dec	2,881.0	254.5	5546.3	295.3	0.0	3,202.3

The predicted excess recycled water, to be discharged to the environment shows seasonal variability with the winter months generating the most excess. Figure 15a presents the predicted minimum, average and maximum monthly excess recycled water discharge compared with the 2019 recycled water discharge data. Figure 15b presents the predicted average daily excess recycled water discharge with the 2017 and 2019 recycled water discharge results.

For assess the potential impacts to Googong Creek for the ultimate IWC project the overall it is important to understand how the volume of discharge will change from the current situation. As there has been no consumption of recycled water the recycled water has been discharged and the volume increased over time. When this is compared to the ultimate IWC project estimated discharge it can been see that seasonal disparity in volume will occur. That is, more discharge in winter months and less to none in summer, spring and autumn months. The winter months discharge will be higher than what has been discharged to date. There will be a return to the 2017 discharge volumes for the summer period in the ultimate IWC and for the winter months the assessed increase is 174% on the 2019 discharge volumes.

Figure 16 presents the 10^{th}, 50^{th} and 90^{th} percentile flows for the predicted daily excess of recycled water for the ultimate ICW project. It shows the winter months for each percentile have the highest excess and as the percentile reduces discharge in the summer months declines. By the 10^{th} percentile discharge in spring and autumn is effectively zero. For the 10^{th} percentile the winter discharge would be around a 142% increase on 2019 volumes and the 90^{th} percentile would be around a 214% increase on the 2019 volumes.

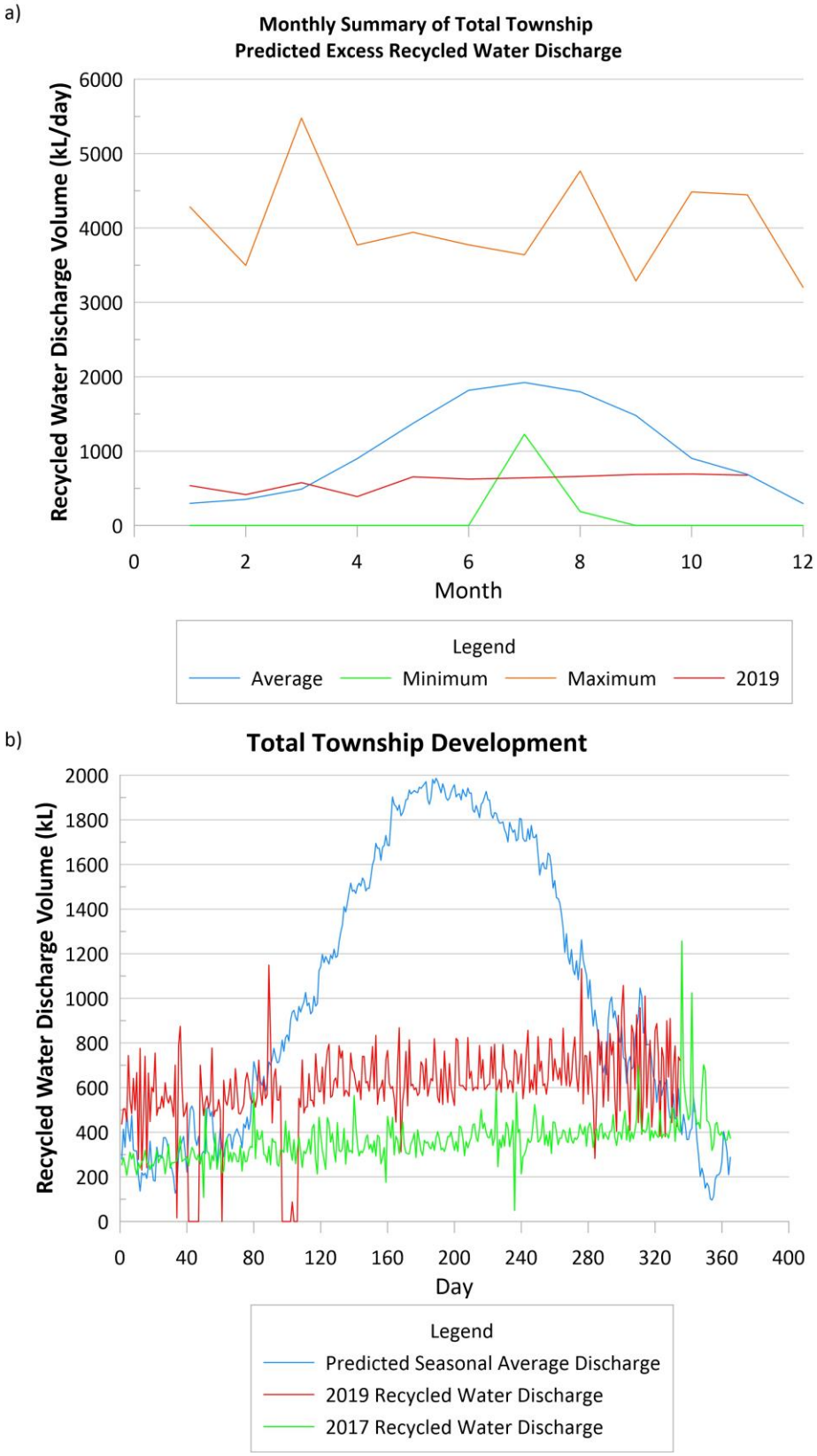


Figure 15: Predicted Ultimate IWC project excess recycled water discharge to Googong Creek a) month summary with predicted minimum, average and maximum and 2019 results and b) daily summary of average predicted discharge with 2017 and 2019 discharge

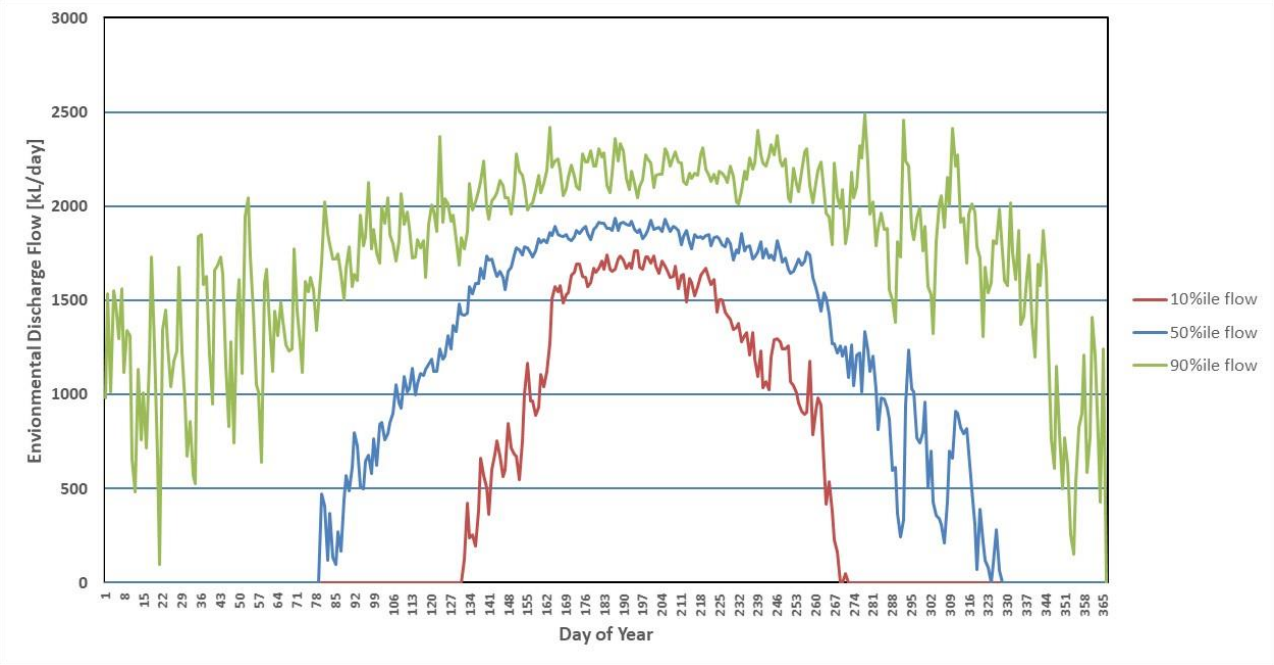


Figure 16: Summary of percentile daily environmental discharge (Stantec)

Stantec have estimated for the ultimate IWC Project the average excess recycled water to discharge to the environment is 1029 kL/day to a maximum of 5477 kL/day. This equates to around 11 L/sec (0.01 m^3/s) to 63 L/sec (0.06 m^3/sec) of discharge to Googong Creek compared to the 2019 discharge which was around 700 kL/day which equates to around 8 L/sec (or 0.008m^3/s.)

Potential impacts of discharge of excess recycled water to Googong Creek may include:

- increased surface flow in Googong Creek reporting to the Queanbeyan River during wet periods and winter periods;
- increased TSS / TDS, nutrient and metals load to surface water; and
- erosion in Googong Creek from increased flow.

It is likely when reticulation of recycled water commences in the third quarter of 2020 the volume of excess recycled water discharged will reduce or may cease, particularly in the summer months, returning Googong Creek to a more ephemeral state. Over time as development of the township proceeds and the population increases the volume of excess recycled water discharged will also increase.

4.6 Monitoring and Mitigation of Operational Impacts

Aquatic ecology monitoring for the operational impacts of the WRP, Permanent Reservoirs and recycled water irrigation is unlikely to be necessary. In the event of spills that are not captured by the IWC system an event-based surface water monitoring of the nearest receiving water body may be considered and should target relevant parameters. Short duration impacts would be difficult to monitor on aquatic ecology with a quarterly and six monthly monitoring frequency and may be indistinguishable from impacts of the overall township development.

Hydrobiology (2016) indicated that impacts to channel morphology and stream flow downstream of Discharge Point 3 are considered low during most flow scenarios, though the greatest changes are predicted during lower flow. Impacts on aquatic ecological values are primarily restricted to Googong Creek. Impacts of discharge of excess recycled water to Googong Creek on the aquatic ecology may be monitored through the SWAEMP through river health assessment using diatoms and macroinvertebrates. The annual fish survey is of no benefit as Googong Creek did not have any fish observed during baseline monitoring. Mitigation of impacts of the discharge of excess recycled water are limited to meeting the EPL criteria and reducing flow velocity to minimise erosion. The conditions of the EPL have limits on some parameters such as total nitrogen which are higher than the ANZECC (2000) guidelines for species protection and some impact to the aquatic ecology from elevated nutrients and changes in flow is likely to be ongoing.

Mitigation measures, such as the temporary silt fence at Site 8 (Figure 17) should be replaced with a more permanent series of gabion walls and smaller bio-swales / wetlands with the aim of minimising pooled water areas whilst achieving some of the benefits of improved water quality that come from wetlands with vegetation. Erosion is not considered a major issue given the steep and incised nature of Googong Creek in the lower reaches however a series of gabion walls would assist with reducing flow velocity and minimise erosion in the plateau area between Beltana Pond and the existing dam on Googong Creek. This would be in accordance with the Water Quality Objective under the State Water Management Outcomes Plan (in the Water Management Act 2000) 'minimise effects of weirs and other structures'.

Aquatic ecology monitoring, through diatom and macroinvertebrate surveys is recommended to continue for the first two years of open space irrigation with recycled water and then be reviewed. The macroinvertebrate surveys should be recommenced in the Spring of 2020 in line with the AUSRIVAS protocols and the commencement of recycled water irrigation.



Figure 17: Site 8 on Googong Creek with reed bed

5 Discussion

5.1 Stage D Construction

The aquatic ecology assessment of the Stage D WRP and Permanent Reservoirs at Hill 800 outlines that construction related impacts to the aquatic ecology whilst unlikely would be minor and short lived in any case. Earthworks will disturb the soil profile and may cause additional sediment load to surface water however mitigation measures undertaken as part of construction management plans and the construction methodology are considered sufficient.

Any impacts are likely short lived and are not anticipated to have significant long-term impacts on the aquatic ecology of Googong Creek or the Queanbeyan River.

5.2 Stage D Operation

The operation of Stage D is considered unlikely to contribute impacts to the aquatic ecology from the WRP, Permanent Reservoirs and irrigation with recycled water. Any impacts would be difficult to distinguish over the impacts from township runoff.

Within the catchment there are many activities associated with township development and residential living that contribute to the overall surface water quality in Googong Creek and Montgomery Creek and thus the aquatic ecology. Some of these residential activities, such as gardens and pets, are outside the control of the WMP. In parts of the township yet to be developed, animals are being grazed and native wildlife such as kangaroos and wombats are observed in the Foreshore Protection Area and feral animals such as pigs are observed in the areas around the lower reaches of Googong Creek and Montgomery Creek. The assessments of waterway health through diatom and macroinvertebrate surveys may still find it difficult to discern the operational impacts of the IWC Project over other impacts and long-term climate trends.

Within the township the headwaters of Googong Creek have been significantly altered and the headwaters of Montgomery Creek will be significantly altered as the township development progresses. The township development has likely reduced both baseflow and surface flows to Googong Creek and Montgomery Creek which are both ephemeral with some natural baseflow from groundwater discharge, particularly in the lower reaches. This will have an impact on aquatic ecology and riparian vegetation communities. Some of these impacts in Googong Creek may have been offset by the start of discharge of recycled water. The Stage C WRP surface water report (Hydrobiology, 2016) noted improvements in river health which may be related to this discharge but may also have been due to the prevailing above average rainfall conditions.

Over the last three years Googong Creek has had continuous discharge of recycled water and thus continuous flow which has changed it from an ephemeral creek. The macroinvertebrates and diatoms surveyed reflect the changed environment and the elevated nutrient component of the water. The SIGNAL scores for some sites improved whilst others got worse. When reticulation of recycled water commences and the volume of excess recycled water for discharge reduces this will again impact the aquatic ecology with communities shifting to populations more representative of ephemeral waterways. Over time as the township grows and flows increase or become permanent again in Googong Creek it is likely the aquatic ecology will reflect the changing conditions.

Review of the site photography undertaken as part of the SWAEMP shows no significant changes in riparian and aquatic vegetation to date. Seasonal variance was noted to be consistent across the 2017 to 2019 period between the spring/ summer growth of riparian vegetation and the autumn/winter herbaceous nature of the riparian species. A slight change in composition of species due to drought conditions was noted towards the end of 2019. Surface water quality results suggest no significant impact to Googong Creek or the Queanbeyan River as a result of recycled water discharge though the impacts are likely masked by the overall impact that is the township development and other catchment related activities.

Assessment of the Stage D WRP and Permanent Reservoirs against key biodiversity legislation and government policy is summarised in

. Of note is the recommendation in Section 4.5 of works in Googong Creek around Site 8 to update Discharge Point 3 would fall as an activity within the waterway and may require approvals.

Table 21: Summary of Stage D WRP and Permanent Reservoirs against legislation and government polices

Legislation / Policy	Item	Details	Assessment Comments
Commonwealth			
Environmental Protection and Biodiversity Conservation Act 1999	Threatened species (Flora and Fauna)	Protected Matters Search Tool (dated 11th May 2020) predicts the occurrence of three listed species of aquatic fauna: • Silver Perch *Bidyanus bidyanus* • Macquarie Perch *Macquaria australasica* • Murray Cod *Maccullochella peelii*	Not likely to occur within the study area and unlikely to constitute significant impact
	Threatened ecological communities	None within the study area	Not required
	Wetlands of international importance	Hattah-kulkyne Lakes, located more than 600km away	Unlikely to be impacted
State			
Environmental Planning and Assessment Act 1979	Assessment of Significance	The three threatened fish species	These fish are not considered to have a medium or higher likelihood of occurrence within the study area – no further consideration under the act is required
Fisheries Management Act 1994		Googong Creek and Montgomery Creek. Both are defined as first and second order streams with a Class 3 waterway.	Not considered key fish habitat.
		Queanbeyan River – Type 1 Key Fish Habitat and Class 1 waterway	Fish survey identifies exotic species dominance. Stage D works are within the footprint of Stage C. Unlikely to be impacted.
Water Management Act 2000	Controlled Activities	Works within 40m of a designated waterway	Stage D works are within the Stage C footprint. No additional works are proposed within 40m of waterways. Discharge Points are already constructed.
Biosecurity Act 2015		Study area includes priority weeds within the South East region: • Serrated Tussock (*Nassella trichotoma*) • Blackberry (*Rubus fruticosus sp. agg.*) • Willow (*Salix* sp.)	Priority weeds occurring in the riparian zone within the township development to be managed in accordance with the relevant duties specified under the Act.
Biodiversity Conservation Act 2016	Threatened species (Flora and Fauna)	No Threatened Ecological communities within the study area	Not likely to occur within the study area and unlikely to constitute significant impact

Monitoring in accordance with the SWAEMP is designed to assess the aquatic ecology and waterway health through the fish survey, macroinvertebrates and diatoms. The SWAEMP has been revised to remove the fish survey as there were no fish in Googong Creek and the Queanbeyan River was full of invasive species. It was considered not be an adequate way of monitoring river health. Whilst diatoms and macroinvertebrate surveys provide a more tangible statistical assessment of the health of the waterways impacts they are unlikely to pick up short duration impacts, such as construction activities, and the impact of operation of Stage D WRP and Permanent reservoirs over the township development.

Discharge of nutrient rich recycled water to Googong Creek may impact the aquatic ecology and terrestrial vegetation in the creek, however as this water is mixed with stormwater from the township and there are other activities within the catchment that may also impact on aquatic ecology and terrestrial vegetation such that it may be difficult to distinguish the impact source. Site photography has provided a qualitative documentation of the aquatic ecology sampling sites and should be continued.

The Australian Guidelines for Water Recycling look for validation of a successful recycled water scheme. As recycled water irrigation is yet to commence the diatom and macroinvertebrate surveys should continue for the first two years of recycled water irrigation and then the results reviewed. Ongoing monitoring frequency should then be reduced, such as every year the next two years then every 5 years until the township development is complete. It would provide ongoing assessment of waterway health and validation of the IWC Project. The pre-WRP baseline data is not considered representative of background conditions given construction activities within the township had commenced and alteration of the aquatic ecology from baseline conditions is anticipated due to the township development.

The flows to the Queanbeyan River of excess recycled water from the ultimate IWC Project are predicted to be higher than is currently being discharged during the winter months. Overall, the volumes are predicted to make a minor contribution to the total flow in the Queanbeyan River. The surface water monitoring locations on the Queanbeyan River, which may be considered control points during the baseline assessment, reflect a wider source and changes or potential impacts to the quality and aquatic and terrestrial ecology may not be directly attributable to the IWC Project.

6 Conclusions and Recommendations

On the basis of the assessment documented in this report, and previous aquatic ecology monitoring results, SMEC offers the following conclusions. With regards to construction of Stage D WRP and Permanent Reservoirs:

- mitigation measures during construction in the CEMP are considered sufficient;
- construction impacts to the aquatic ecology are unlikely but may occur, but should be minimal and short lived in any case;
- the primary potential impact of construction is an increase in sediment load to the tributary creeks;
- impacts are unlikely to Googong Reservoir and the Queanbeyan River.

With regards to operation of Stage D:

- impacts of irrigation with recycled water to the aquatic ecology are considered unlikely;
- impacts of discharge of recycled water to aquatic ecology are likely to be minimal and may be beneficial;
- direct impacts from the operation of the WRP and Permanent Reservoirs to are unlikely;
- changing the flow regime in Googong Creek will change the aquatic ecology communities observed;
- unlikely to be any impact to Googong Reservoir as no irrigation will occur within this catchment;
- Discharge Point 3 is considered more suitable than Discharge Point 1 for excess recycled water release;
- the ultimate IWC Project would see an average 174% increase in recycled water excess discharged to Googong Creek over the next 25 years (compared to 2019 discharge volumes) during winter months, summer months may be the same or less; and
- monitoring locations on the Queanbeyan River reflect a wider source and changes in the quality may not be directly attributable to the IWC and are a combination of all activities in the catchment zone.

The monitoring conducted to date has highlighted the issue of surface water and aquatic ecology monitoring for impacts associated with the use of recycled water downstream of a township development. Runoff from the township, both during construction and during ongoing occupation is not able to be distinguished from recycled water use impacts. This is especially evident during rainfall events where runoff contamination (hydrocarbons, nutrients, chemicals) often peak. It is the opinion of SMEC that as long as the recycled water meets the discharge quality potential for impacts to the receiving environment are likely to be low and may in fact (in some instances) be beneficial. Aquatic ecology monitoring should be scaled back and the WMP revised to reflect regular and ongoing assessments of waterway health in relation to the operation of the IWC and township development.

SMEC makes the following recommendations:

- removal of Site 6 and Site 7 from the aquatic ecology monitoring program;
- survey of macroinvertebrates should recommence in Spring 2020 following use of recycled water in the township; and
- update of the WMP to ensure the above recommendations are implemented.

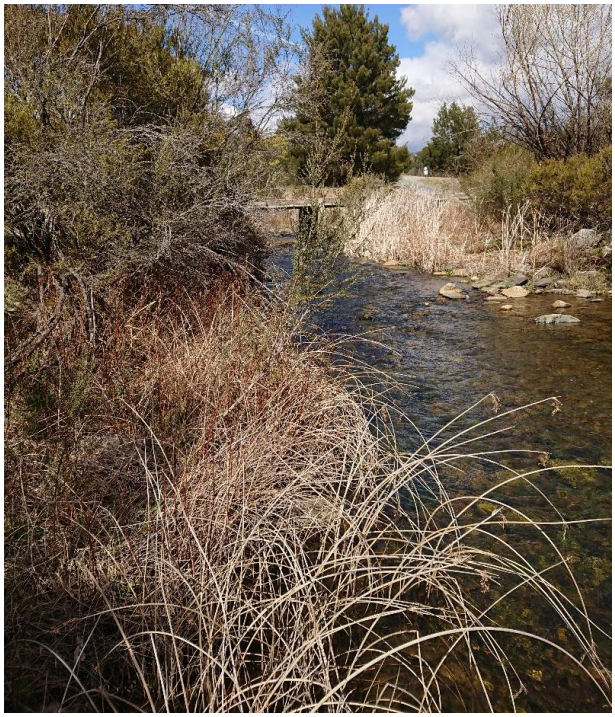
7 References

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- SMEC 2017. Annual Monitoring Report – October 2017 (Document Reference 30012126-AR01)
- SMEC 2019. Annual Factual Monitoring Report – May 2019 (Document Reference 30012126-AR02)
- SMEC 2020. Annual Factual Monitoring Report for 2019 – May 2020 (Document Reference 30012126-AR03)

Appendix A Historical Site Photographs

Site 1
January 2020 NOT ACCESSED DUE TO FORESHORE CLOSURE FOR SEVER FIRE DANGER

Site 1
September 2019





Site 1
June 2019
 
Reed growing on bank near edges, green growth on rocks

Site 1

March 2019







Site 1

December 2018







Site 1
27 September 2018  

Site 1

July 2018





Site 1
21 March 2018 

Site 1
8 August 2017 

Site 1
24 July 2017



Site 1
21 June 2017



Site 1
15 May 2017 

Site 1
10 April 2017 

Site 1
20 March 2017



Site 1
27 February 2017



Site 1

18 January 2017



Site 1

22 December 2016



Site 1

30 November 2016



Site 1

10 November 2016



Site 1
13 October 2016 

Site 1
1 September 2016 

Site 4

January 2020







Site 4

September 2019







Site 4

July 2019







Site 4

March 2019







Site 4

December 2018





Site 4

27 September 2018





Site 4
23 March 2018 

Site 4
8 August 2017 

Site 4
31 July 2017 

Site 4
21 June 2017 

Site 4
15 May 2017 

Site 4
10 April 2017 

Site 4
20 March 2017 

Site 4
27 February Gate locked, No Access. Could not sample.

Site 4
18 January 2017 

Site 4
22 December 2016 Gate locked, no access. Could not sample.

Site 4
30 November 2016 

Site 4
10 November 2016 No access. Could not sample.

Site 4
13 October 2016 No access. Could not sample.

Site 4
1 September 2016 No access. Could not sample.

Site 5

January 2020







Site 5

September 2019





Site 5

July 2019





Site 5

March 2019





Site 5

December 2018





Site 5

27 September 2018





Site 5
21 March 2018 

Site 5
8 August 2017 

Site 5
31 July 2017 

Site 5
21 June 2017 

Site 5
15 May 2017 

Site 5
10 April 2017 

Site 5
20 March 2017 

Site 5
27 February 2017 

Site 5
18 January 2017 

Site 5
22 December 2016 

Site 5

30 November 2016



Site 5

10 November 2016



Site 5
13 October 2016 No access. Could not sample.

Site 5
1 September 2016 No access. Could not sample.

Site 6
December 2018 Gate locked. QPRC instructed no sample.

Site 6
27 September 2018 Gate locked. Not sampled.

Site 6
21 March 2018



Site 6
8 August 2017



Site 6
31 July 2017



Site 6
21 June 2017 

Site 6
15 May 2017 

Site 6

10 April 2017

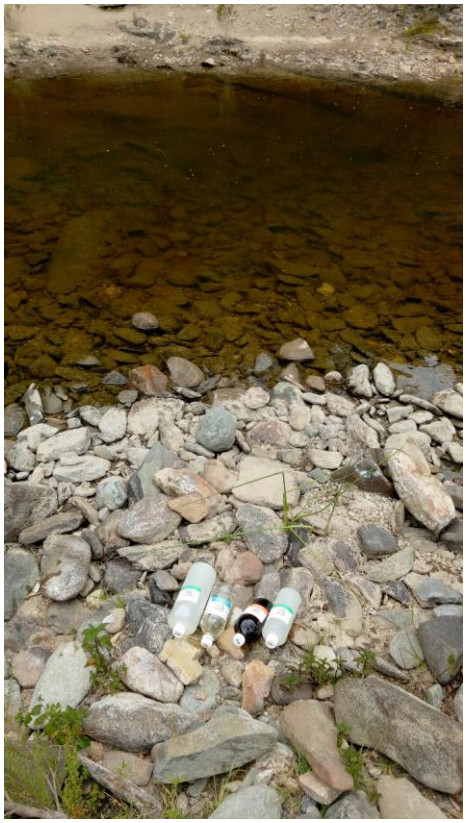


Site 6

20 March 2017



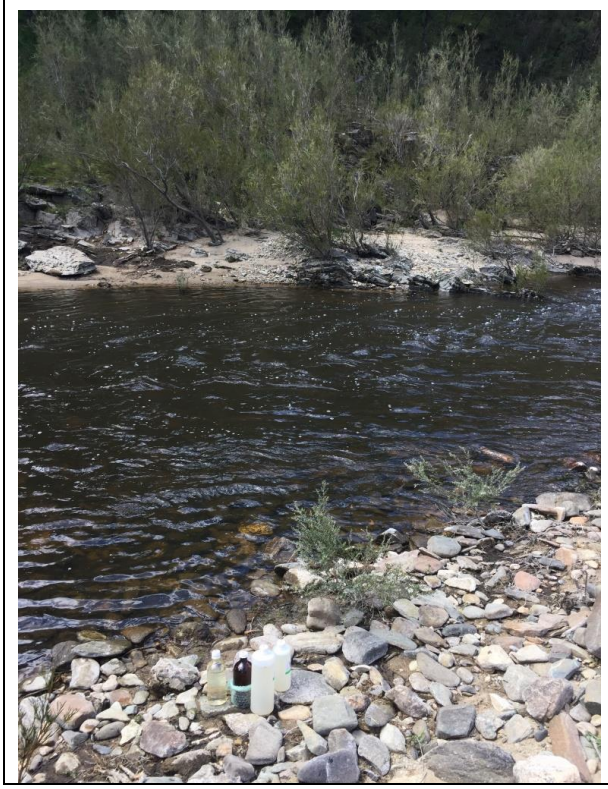
Site 6
27 February 2017 

Site 6
18 January 2017 

Site 6
22 December 2016 

Site 6
30 November 2016 

Site 6
10 November 2016 

Site 6
13 October 2016  Algae blooms in water

Site 6
1 September 2016 No access. Could not sample.

Site 7
January 2020    

Site 7

September 2019





Site 7

July 2019





Site 7

March 2019







Site 7

December 2018

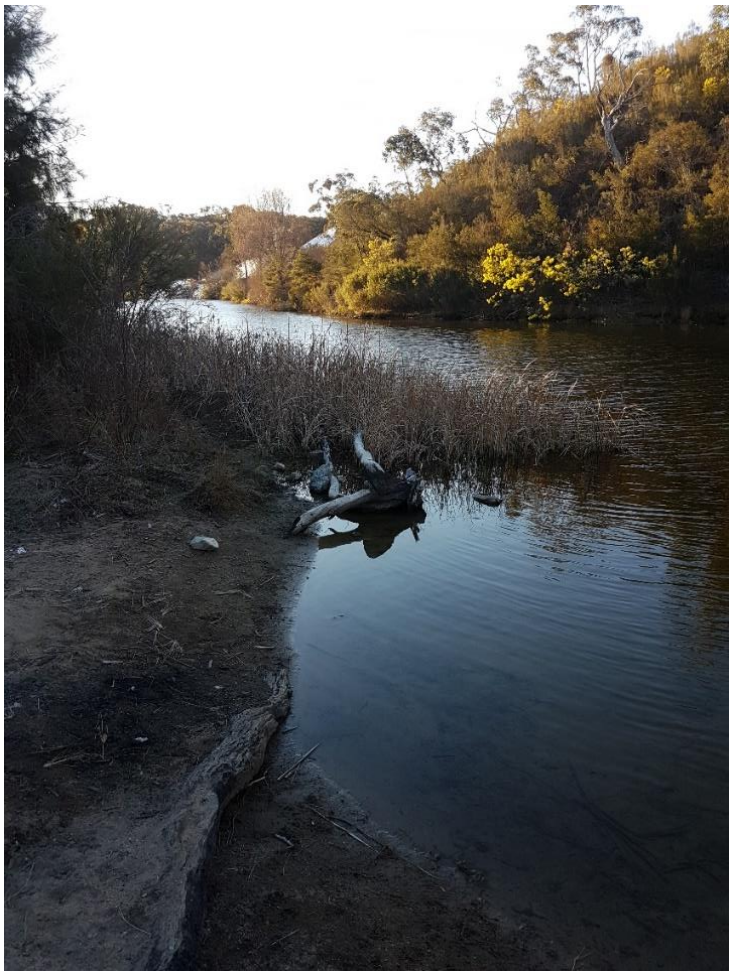






Site 7

27 September 2018





27 September 2018





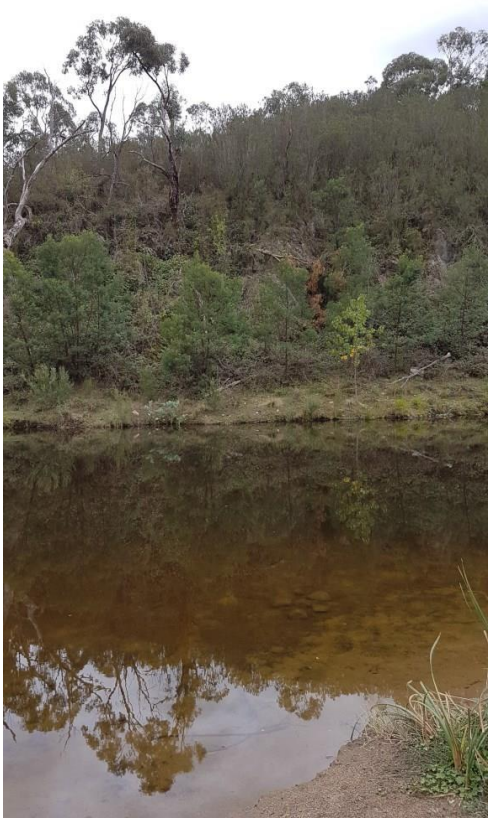
Site 7
21 March 2018 

Site 7
8 August 2017 

Site 7
24 July 2017 

Site 7
21 June 2017 

Site 7
15 May 2017 

Site 7
10 April 2017 

Site 7
20 March 2017  Sandy beach, stable, medium vegetation cover.

Site 7
27 February 2017 

Site 7
18 January 2017 

Site 7
22 December 2016 

Site 7
30 November 2016 

Site 7
10 November 2016 

Site 7

13 October 2016



Site 7

1 September 2016



Site 8

January 2020





January 2020





Site 8

September 2019







Site 8

July 2019

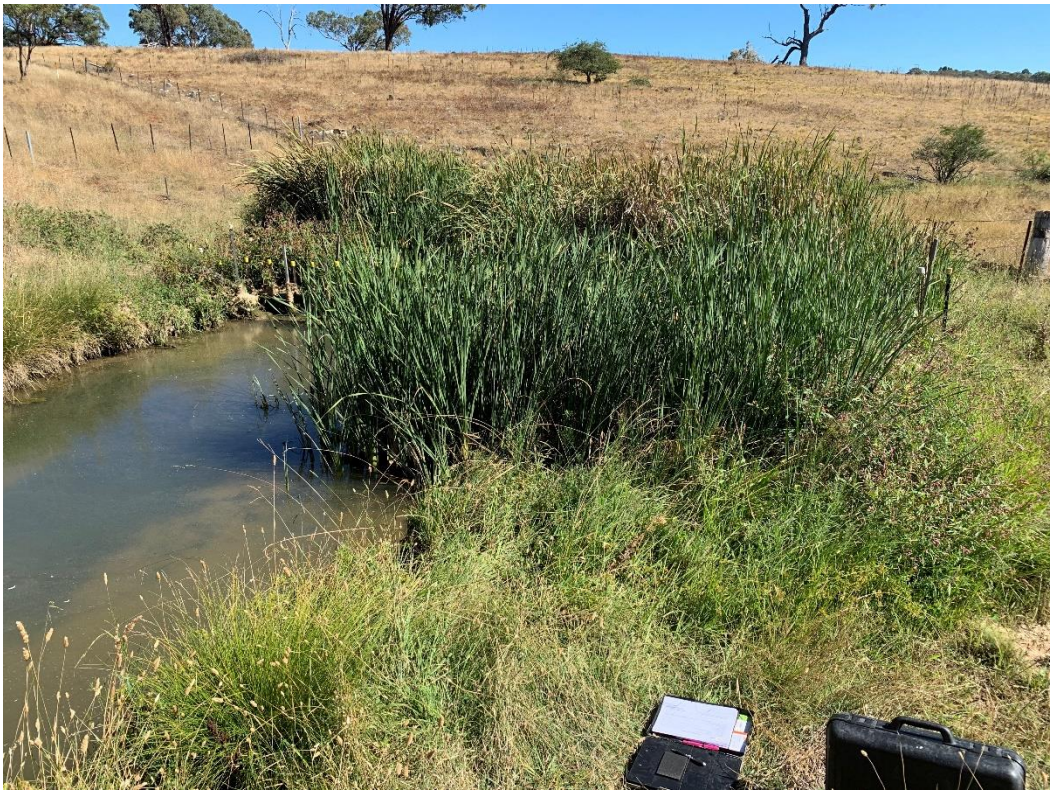




Site 8

March 2019





Site 8

December 2018







Site 8

27 September 2018







Site 8
21 March 2018 

Site 8
8 August 2017 

Site 8
24 July 2017 

Site 8
21 June 2017 

Site 8
15 May 2017 

Site 8
10 April 2017 

Site 8
20 March 2017 

Site 8
27 February 2017 

Site 8

18 January 2017



Site 8
22 December 2016 

Site 8
30 November 2016 

Site 8

10 November 2016



Site 8

13 October 2016



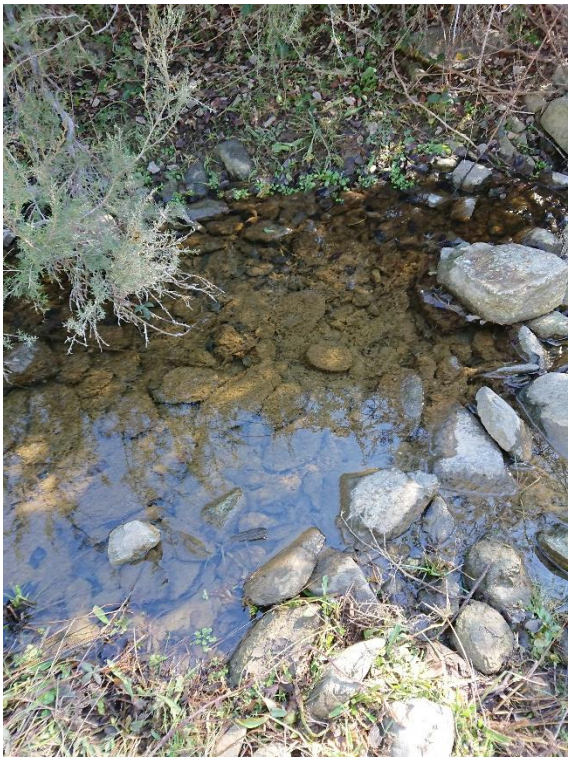
Site 8
1 September 2016 

Site 9
NOT ACCESSED DUE TO FORESHORE CLOSURE FOR SEVER FIRE DANGER

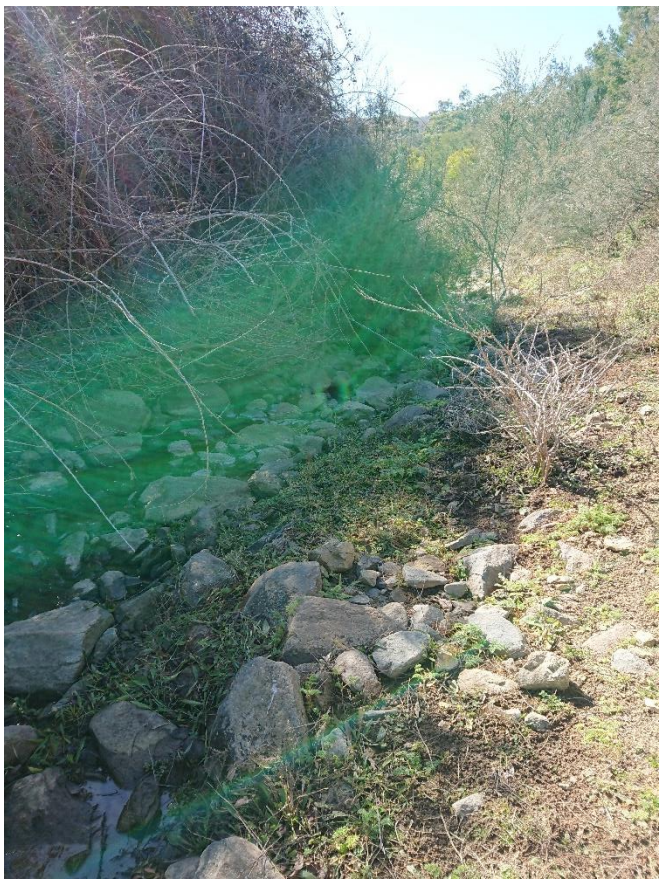
Site 9
September 2019  

Site 9

July 2019







Site 9

March 2019







Site 9

December 2018





Site 9

27 September 2018









Site 9
21 March 2018 

Site 9
8 August 2017 

Site 9
24 August 2017 

Site 9
21 June 2017 

Site 9
15 May 2017 

Site 9
10 April 2017 

Site 9
20 March 2017 

Site 9
27 February 2017  No Flow

Site 9
18 January 2017 No photo taken

Site 9
22 December 2016



Site 9
30 November 2016



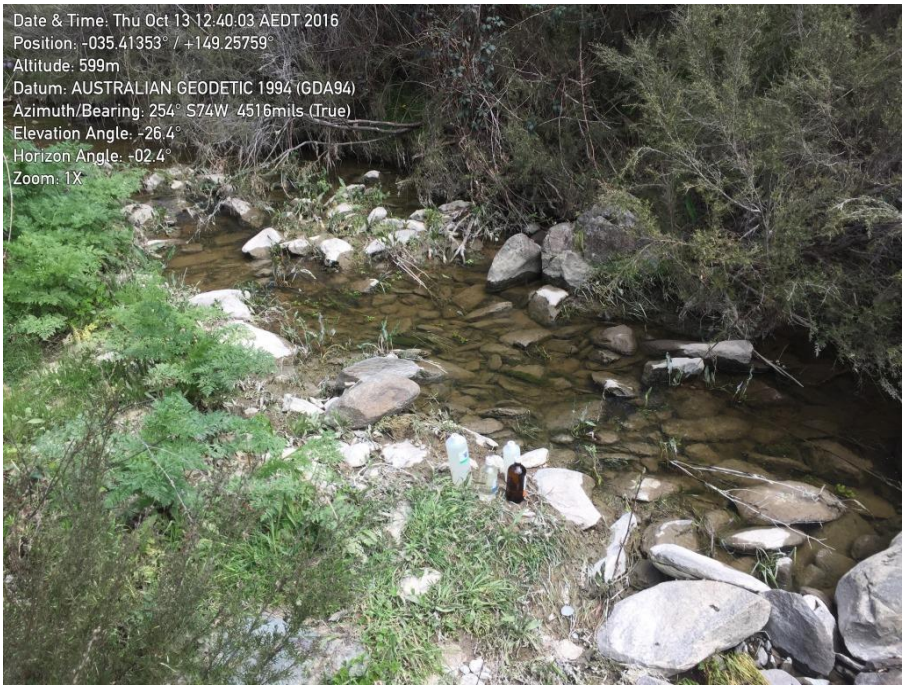
Site 9

10 November 2016



Site 9

13 October 2016



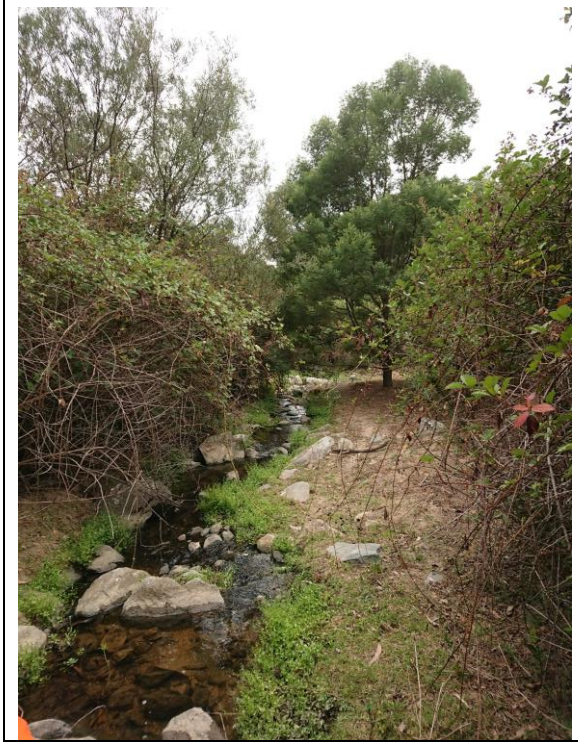
Site 9

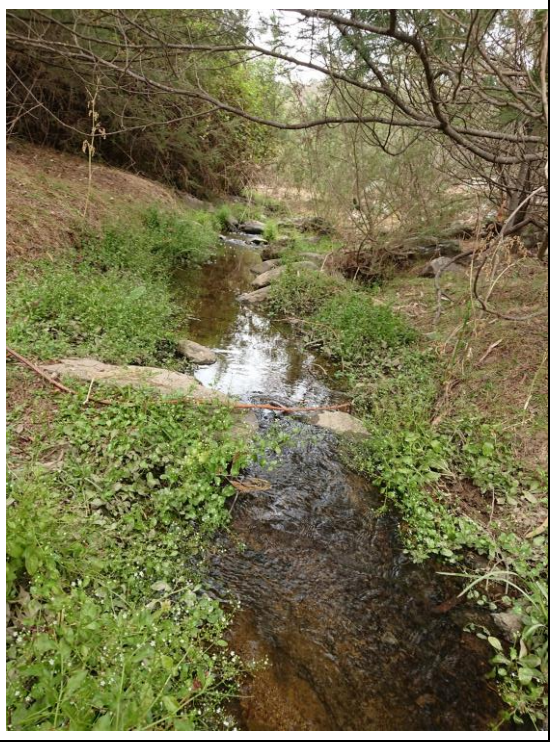
1 August 2016



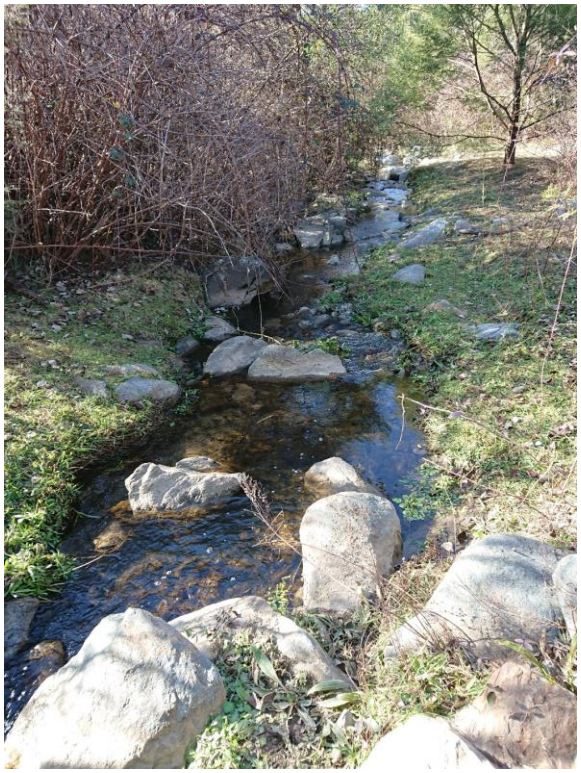
Site 10

January 2020





Site 10
September 2019 

Site 10
July 2019  

Site 10

March 2019



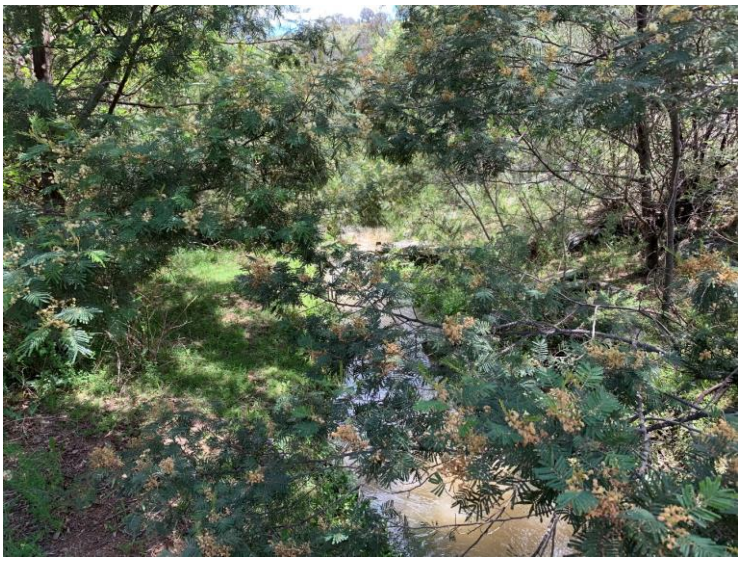


Site 10

December 2018







Site 10

27 September 2018







Site 10
21 March 2018 

Site 10
20 December 2017 

Site 10
27 September 2017 

Site 10
8 August 2017 

Site 10
24 July 2017 

Site 10
21 June 2017 

Site 10
15 May 2017



Site 10
10 April 2017



Site 10
20 March 2017 

Site 10
27 February 2017 Gate locked. Could not sample.

Site 10
18 January 2017 No photo taken.

Site 10
22 December 2016 Gate locked. Could not sample.

Site 10
30 November 2016 

Site 10
10 November 2016 No access. Could not sample.

Site 10
13 October 2016 No access. Could not sample.

Site 10
1 September 2016 No access. Could not sample.

Site 11
January 2020  

Site 11

September 2019







Site 11

July 2019





Site 11

March 2019







Site 11

December 2018





Site 11

27 September 2018





Site 11

December 2017





Appendix B Macroinvertebrate Survey Results 2016 to 2018

Macroinvertebrate Results Summary May 2016

Order	Family	SIGNAL	SITE	1				4				5				6			
			HAB	Edg.			Rif.	Rif.	Edg.			Rif.	Edg			Rif.		Edg.	
			Rep.	1	2	3	1	1	1	2	3	1	1	2	1	1	2	1	2
Nematoda		3				14													
Oligochaeta		2				3	2		2								1		
Gastropoda	*Physidae*	1				1		6	12	10	12		7					1	
	Planorbidae	2																	
Acarina	*Hydracarina*	6			4	1			2	1	2			1			1		
Ostracoda		n/a				1					1							1	
Amphipoda	*Eusiridae*	7																	
Decapoda	*Atyidae*	3		4	5	2													
Coleoptera	*Dytiscidae*	2		3	8				5	1	3	1		1	1			2	
	Gyrinidae	4									2								
	Scirtidae	6																	
	Elmidae	7		1	3	1	3	3	1					1		7	3	6	2
	Ptilodactylidae	10										2				2			
	Psephenidae	6											4						
Diptera	*Ceratopogonidae*	4			2		15		18	7	3			2	1		18	9	17
	Chironomidae	3		361	421	174	222	16	12	64	44	3	168	67	88		37	258	200
	Dolichopodidae	3																	
	Psychodidae	3													3				
	Simuliidae	5					62	467		1		423				41	382	2	1
	Stratiomyidae	2											2		1				
	Culicidae	1		48	19	11	17	5	37	8	15		15	14	12	3	14	31	3
	Tabanidae	3																	
Ephemeroptera	*Baetidae*	5					35	7				68				45	40		

Order	Family	SIGNAL	SITE	1				4				5				6			
			HAB	Edg.			Rif.	Rif.	Edg.			Rif.	Edg			Rif.		Edg.	
			Rep.	1	2	3	1	1	1	2	3	1	1	2	1	1	2	1	2
	Caenidae	4		2	9	5	3		8	10	5	2	16	12		1	4	24	15
	Leptophlebiidae	8			1		1	3		2			1	2	1	16	9		
Hemiptera	*Corixidae*	2		1	2	1							4	6	2			1	1
	Notonectidae	1			1						1			1	1				
	Veliidae	3		1	1														
	Gerridae	4														1	1	15	9
	Mesoveliidae	2																	
Odonata	*Aeshnidae*	4				1	2					1							
	Gomphidae	5							1	1							1		
	Megapodagrionida	5																	
	Protoneuridae	4																	

Order	Family	SIGNAL	SITE	7		8			9					10				
			HAB	Riff.	Edg.	Edg.			Edg.			Rif.		Rif.		Edg.		
			Rep.	1	1	1	2	3	1	2	3	1	2	1	2	1	2	3
Nematoda		3																
Oligochaeta		2		2		3					2			3	2			
Gastropoda	*Physidae*	1			9	213	213	157	23	2		11	186	130	116	278	134	266
	Planorbidae	2							2									
Acarina	*Hydracarina*	6			6	1	1		1	1	2		2			3	4	2
Ostracoda		n/a							2				1			2		
Amphipoda	*Eusiridae*	7			12													
Decapoda	*Atyidae*	3			1								1					
Coleoptera	*Dytiscidae*	2		1		2	1		1	4		4	8	9	6	1	1	2
	Gyrinidae	4																
	Scirtidae	6								2								
	Elmidae	7			3	5	5		1			3	1	2			4	1
	Ptilodactylidae	10																
	Psephenidae	6		1														
Diptera	*Ceratopogonidae*	4		3					7		4	3	50	34	3	16	4	51
	Chironomidae	3		98	227	20	25	38	22	10	9	77	48	37	51	27	35	2
	Dolichopodidae	3				1			1									
	Psychodidae	3																
	Simuliidae	5		342			2			1	1	3		74	85	4	5	
	Stratiomyidae	2							1									
	Culicidae	1			5		12	8	16	26	14	2	11	9	1	19	17	10
	Tabanidae	3																10
Ephemeroptera	*Baetidae*	5		11	2							1						
	Caenidae	4		23	6					1		1	2					

Order	Family	SIGNAL	SITE	7		8			9					10				
			HAB	Riff.	Edg.	Edg.			Edg.			Rif.		Rif.		Edg.		
			Rep.	1	1	1	2	3	1	2	3	1	2	1	2	1	2	3
	Leptophlebiidae	*8*		11														
Hemiptera	*Corixidae*	*2*				4	3	3	1		2							
	Notonectidae	*1*				2	2		1									
	Veliidae	*3*														1	1	
	Gerridae	*4*			27													
	Mesoveliidae	*2*											1					
Odonata	*Aeshnidae*	*4*																
	Gomphidae	*5*				1												
	Megapodagrionida	*5*														1		
	Protoneuridae	*4*				4	2	2										
Plecoptera	*Gripopterygidae*	*8*		6													2	
	Notonemouridae	*6*												1				1
Trichoptera	*Helicopsychidae*	*10*																
	Hydropsychidae	*6*																
	Hydroptilidae	*4*			2							1	1	1	1	3	4	2
	Leptoceridae	*6*			4													
	Hydrobiosidae	*8*		1								2		1	3			
	Philopotamidae	*8*											1	3				
Bivalvia	*Corbiculidae*	*4*		2					4			1						
Megaloptera	*Corydalidae*	*7*																
Collembola		*1*									3		2					
Copepoda		*n/a*														66		89
Hirudinea		*1*																1

Macroinvertebrate Survey Results (Biosis Autumn 2016)

Taxa	Site 8 (GC1)
Physidae	3
Oligochaeta	2
Hydrachnidae	2
Ostracoda	14
Dytiscidae	1
Culicidae	2
Ceratopogonidae	2
Tanypodinae	4
Orthocladiinae	4
Chironominae	29
Chironomidae (Pupa)	2
Baetidae	14
Caenidae	2
Corixidae	6
Notonectidae	5
Coenagrionidae	3
Aeshnidae	13
Leptoceridae	5

Macroinvertebrate Survey 2018 Results

Class/Order	Family	Subfamily	SIGNAL	Site 1 Riffe	Site 1 Edge	Site 4 Riffle	Site 4 Edge	Site 5 Riffle	Site 5 Edge	Site 6 Riffle	Site 6 Edge
			% sorted:	10	10	20	50	20	20	10	20
Acarina	*Hydrcarina*		6	16	12	0	14	0	11	14	10
Arachnida	*Tetragnathidae*			0	0	0	2	0	0	0	0
Arachnida	*Pisauridue*			0	0	0	2	0	0	0	0
Bivalva	*Sphaeriidae*		5	0	10	16	2	10	0	11	14
Coleoptera	*Curculionidae*		2	0	0	0	0	0	0	0	0
Coleoptera	*Dytiscidae*		2	0	14	0	6	17	14	0	16
Coleoptera	*Elmidae*		7	0	18	16	0	5	0	0	0
Coleoptera	*Gyrinidae*		4	0	0	0	4	0	0	0	5
Coleoptera	*Hydraenidae*		3	0	0	0	0	0	5	0	0
Coleoptera	*Hydrochidae*		4	0	0	0	0	0	0	0	0
Coleoptera	*Hydrophilidae*		2	0	0	0	0	0	0	0	0
Coleoptera	*Psephenidae*		6	0	0	0	2	0	0	10	0
Coleoptera	*Scirtidae*		6	0	0	0	0	0	0	0	0
Coleoptera	*Dytiscidae (Larvae)*		2	0	0	0	0	12	5	0	0
Crustacea	*Atyidae*		3	0	0	0	0	0	5	0	5
Decapoda	*Palamonidae*		4	0	10	0	0	0	0	0	0
Diptera	*Chironomidae*	*Chironominae*	3	70	100	5	4	145	30	40	25
Diptera	*Chironomidae*	*Tanypodinae*	3	280	280	30	32	80	30	50	245
Diptera	*Chironomidae*	*Orthocladiinae*	3	420	360	30	8	200	80	71	85
Diptera	*Tipulidae*		5	10	10	8	0	0	0	0	0
Diptera	*Culicidae*		1	10	12	5	0	0	18	12	12
Diptera	*Ceratopogonidae*		4	0	10	0	6	0	5	10	15

Class/Order	Family	Subfamily	SIGNAL	Site 1 Riffe	Site 1 Edge	Site 4 Riffle	Site 4 Edge	Site 5 Riffle	Site 5 Edge	Site 6 Riffle	Site 6 Edge
Diptera	*Dolichopodid*		3	0	0	0	0	0	0	0	0
Diptera	*Empididae*		5	16	12	0	0	0	0	8	6
Diptera	*Simuliidae*		5	90	8	106	6	75	0	352	40
Diptera	*Stratiomyidae*		2	0	0	0	0	5	0	0	0
Diptera	*Psychodidae*		3	0	0	0	0	8	0	0	5
Ephermeroptera	*Baetidae*		5	80	50	5	2	90	20	120	30
Ephermeroptera	*Caenidae*		4	60	100	10	32	125	30	120	95
Ephermeroptera	*Leptophlebiidae*		8	45	50	5	2	45	5	20	30
Gastropoda	*Lymnaeidae*		1	0	0	0	0	0	0	0	0
Gastropoda	*Physidae*		1	0	0	0	4	0	6	0	0
Gastropoda	*Planorbidae*		2	0	0	0	0	0	0	0	0
Hemiptera	*Corixidae*		2	0	12	0	18	0	10	0	16
Hemiptera	*Naucoridae*		2	0	0	0	0	0	0	0	0
Hemiptera	*Notonectidae*		1	0	3	0	2	0	4	0	5
Hemiptera	*Gerridae*		4	0	0	0	6	0	0	0	15
Lepidoptera	*Pyralidae*		3	0	0	0	0	0	0	0	0
Megaloptera	*Corydalidae*		7	5	0	0	0	8	0	0	0
Megaloptera	*Sialid*		5	0	6	0	0	0	0	0	0
Odonata	*Aeshnidae*		4	16	18	0	0	12	5	0	0
Odonata	*Coenagrionidae*		2	0	0	0	0	0	0	0	0
Odonata	*Gomphidae*		5	0	0	0	6	0	0	11	6
Odonata	*Isosticidae*		3	0	0	0	0	0	0	0	5
Odonata	*Protoneuridae*		4	0	0	0	0	0	0	0	0
Odonata	*Telephelibiidae*		9	0	0	0	0	5	0	8	0
Oligochaeta			2	180	160	55	26	0	0	10	0

Class/Order	Family	Subfamily	SIGNAL	Site 1 Riffe	Site 1 Edge	Site 4 Riffle	Site 4 Edge	Site 5 Riffle	Site 5 Edge	Site 6 Riffle	Site 6 Edge
Platyhelminthes			2	0	0	0	0	0	0	10	0
Plecoptera	*Gripopterygidae*		8	46	28	15	4	10	5	54	15
Trichoptera	*Calocidae*		9	0	10	5	12	0	0	0	10
Trichoptera	*Ecnomidae*		4	0	18	16	6	0	10	0	0
Trichoptera	*Hydroptillidae*		4	16	20	5	0	5	0	0	0
Trichoptera	*Leptoceridae*		6	23	0	15	22	0	0	0	0
Trichoptera	*Hydropsychidae*		6	13	26	16	0	10	0	61	0
Trichoptera	*Hydrobiosidae*		8	0	0	0	0	20	0	52	40
Trichoptera	*Philopotamidae*		8	0	7	0	0	0	0	0	0
Total abundance				1396	1357	363	230	887	298	1044	750
Number of taxa				18	27	18	25	20	19	20	24
Average SIGNAL (not abundance weighted)				4.7	4.4	4.9	4.3	4.9	3.5	4.9	4.3

Class/Order	Family	Subfamily	SIGNAL	Site 7 Riffle	Site 7 Edge	Site 8 Riffle	Site 8 Edge	Site 9 Riffle	Site 9 Edge	Site 10 Riffle	Site 10 Edge	Site 11 Edge (pond)
			% sorted:	10	20	20	10	20	50	10	50	10
Acarina	*Hydrcarina*		6	0	6	0	12	0	18	7	0	12
Arachnida	*Tetragnathidae*			0	5	0	0	0	2	0	0	0
Arachnida	*Pisauridue*			0	0	0	0	0	0	0	0	0
Bivalva	*Sphaeriidae*		5	17	10	0	10	0	0	10	0	0
Coleoptera	*Curculionidae*		2	0	0	0	0	0	0	0	0	6
Coleoptera	*Dytiscidae*		2	0	0	15	0	0	6	0	4	9
Coleoptera	*Elmidae*		7	20	0	0	0	0	0	0	0	0
Coleoptera	*Gyrinidae*		4	0	0	0	0	0	0	0	0	4
Coleoptera	*Hydraenidae*		3	0	0	0	0	0	0	0	0	0
Coleoptera	*Hydrochidae*		4	0	0	0	0	0	0	0	0	4
Coleoptera	*Hydrophilidae*		2	0	5	0	0	0	0	0	0	0
Coleoptera	*Psephenidae*		6	0	0	0	0	0	0	8	0	0
Coleoptera	*Scirtidae*		6	0	0	0	0	0	0	0	8	0
Coleoptera	*Dytiscidae (Larvae)*		2	0	12	0	0	0	8	0	0	0
Crustacea	*Atyidae*		3	0	0	0	6	0	0	0	8	0
Decapoda	*Palamonidae*		4	0	0	0	0	0	0	0	0	0
Diptera	*Chironomidae*	*Chironominae*	3	40	30	50	70	30	34	110	46	103
Diptera	*Chironomidae*	*Tanypodinae*	3	60	200	0	0	20	8	120	22	60
Diptera	*Chironomidae*	*Orthocladiinae*	3	220	70	45	180	35	46	231	28	60

Class/Order	Family	Subfamily	SIGNAL	Site 7 Riffle	Site 7 Edge	Site 8 Riffle	Site 8 Edge	Site 9 Riffle	Site 9 Edge	Site 10 Riffle	Site 10 Edge	Site 11 Edge (pond)
Diptera	*Tipulidae*		5	0	0	0	0	0	0	0	0	0
Diptera	*Culicidae*		1	8	14	7	21	0	2	21	22	20
Diptera	*Ceratopogonidae*		4	0	5	20	41	43	36	167	94	120
Diptera	*Dolichopodid*		3	0	0	26	0	0	0	0	0	0
Diptera	*Empididae*		5	0	0	0	0	0	0	0	0	0
Diptera	*Simuliidae*		5	245	0	25	0	95	6	50	0	0
Diptera	*Stratiomyidae*		2	0	0	0	0	5	0	8	2	10
Diptera	*Psychodidae*		3	0	0	0	0	0	0	0	0	0
Ephermeroptera	*Baetidae*		5	30	0	0	0	0	0	0	0	60
Ephermeroptera	*Caenidae*		4	90	145	5	10	0	10	0	0	20
Ephermeroptera	*Leptophlebiidae*		8	40	10	0	0	0	0	0	0	0
Gastropoda	*Lymnaeidae*		1	0	0	0	0	0	8	30	18	0
Gastropoda	*Physidae*		1	0	4	0	0	0	0	0	6	12
Gastropoda	*Planorbidae*		2	0	15	0	32	0	0	30	0	0
Hemiptera	*Corixidae*		2	0	0	5	0	0	21	0	8	6
Hemiptera	*Naucoridae*		2	0	0	0	0	0	0	0	0	8
Hemiptera	*Notonectidae*		1	0	0	0	9	0	0	0	8	6
Hemiptera	*Gerridae*		4	0	0	0	18	0	0	0	0	0
Lepidoptera	*Pyralidae*		3	0	0	0	0	0	0	0	2	0
Megaloptera	*Corydalidae*		7	0	0	0	0	0	0	0	0	0
Megaloptera	*Sialid*		5	0	0	0	0	0	0	0	0	0

Class/Order	Family	Subfamily	SIGNAL	Site 7 Riffle	Site 7 Edge	Site 8 Riffle	Site 8 Edge	Site 9 Riffle	Site 9 Edge	Site 10 Riffle	Site 10 Edge	Site 11 Edge (pond)
Odonata	*Aeshnidae*		4	0	0	0	0	0	0	0	0	0
Odonata	*Coenagrionidae*		2	0	0	0	6	0	2	0	0	8
Odonata	*Gomphidae*		5	6	0	0	8	0	0	0	8	0
Odonata	*Isosticidae*		3	0	0	0	0	0	5	0	0	0
Odonata	*Protoneuridae*		4	0	0	0	6	0	0	0	0	0
Odonata	*Telephelibiidae*		9	0	5	0	0	0	0	0	0	0
Oligochaeta			2	0	5	45	60	60	0	20	12	0
Platyhelminthes			2	0	5	0	0	0	0	10	2	0
Plecoptera	*Gripopterygidae*		8	54	15	0	0	10	6	0	2	0
Trichoptera	*Calocidae*		9	0	0	0	0	0	0	10	0	0
Trichoptera	*Ecnomidae*		4	0	25	0	0	0	0	0	0	0
Trichoptera	*Hydroptillidae*		4	34	0	0	0	5	4	0	0	0
Trichoptera	*Leptoceridae*		6	0	28	0	0	0	0	0	0	0
Trichoptera	*Hydropsychidae*		6	72	0	0	0	0	0	0	0	0
Trichoptera	*Hydrobiosidae*		8	50	0	0	10	0	2	0	0	0
Trichoptera	*Philopotamidae*		8	0	0	0	0	0	0	0	0	0
Total abundance				986	614	243	499	303	224	832	300	528
Number of taxa				15	20	10	16	9	18	15	18	18
Average SIGNAL (not abundance weighted)				5.0	3.9	2.9	3.6	3.8	3.6	3.6	2.9	2.8

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Appendix G Noise and vibration Assessment

GOOGONG TOWNSHIP PTY LTD

GOOGONG WATER RECYCLING PLANT
STAGE D REVIEW OF ENVIRONMENTAL FACTORS

CONSTRUCTION AND OPERATIONAL NOISE ASSESSMENT



Question today
Imagine tomorrow
Create for the future

Googong Water Recycling Plant
Stage D REVIEW OF ENVIRONMENTAL FACTORS
Construction and Operational Noise Assessment

Googong Township Pty Ltd

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REV	DATE	DETAILS
B	16 April 2020	Final issue following project team's review
C	4 May 2020	Revised issue to capture minor amendments
D	14 May 2020	Revised issue to include possible future council's depot and scout's

	Name	date	signature
Prepared by:	Martin Tonner Zhang Lai	14 May 2020	
Reviewed by:	Andrew Boladz	14 May 2020	
Approved by:	Zhang Lai	14 May 2020	

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EXECUTIVE SUMMARY

WSP Australia Pty Ltd has been engaged by Googong Township Pty Ltd to conduct a noise impact assessment for the proposed operation and construction of the Stage D Water Recycling Plant (WRP) and the expansion of the Hill 800 Reservoir site located within the Googong Township. The objectives of this noise impact assessment are:

- Undertake a construction noise and vibration assessment of WRP Stage D expansion and Hill 800 Reservoir Site.
- Complete a noise assessment of WRP Stage D expansion and the Hill 800 Reservoir Site to determine the noise attenuation requirements to achieve compliance with Part 3A Concept Plan Approval for the entire Integrated Water Cycle Project.

CONSTRUCTION NOISE AND VIBRATION

During the construction of the Stage D expansion to the WRP and Hill 800 Reservoir site, various activities and construction stages will likely cause notable construction noise impact at surrounding receivers.

A construction noise and vibration management plan should be developed for the project, prior to commencement of works. This should be prepared on the basis of detailed construction methodologies from the contractor and would include (but not limited to) the following:

- Noise and vibration assessment as per the Interim Construction Noise Guideline;
- Identification of nearby residences and other sensitive land uses, including a survey of all occupied dwellings within the Googong Township;
- Approved hours of work and what work will be undertaken;
- Construction works should be planned and carried out during standard construction hours wherever possible;
- Identification of dominant noise and vibration generating activities;
- Details of noise mitigation and management measures to be applied;
- Information for worker training to minimise noise impacts;
- Community consultation protocol(s);
- Complaints handling protocol(s);
- Construction works should be planned and carried out during standard construction hours wherever possible.

Based on the recommended safe working distances for vibration intensive equipment likely to be used for the project, the risk of significant vibration impact due to the proposed construction methodology was found to be low.

OPERATIONAL NOISE – WRP

Accounting for existing WRP A, B and C noise levels as well as the proposed Stage D expansion, the predicted noise impact associated with the ultimate WRP is predicted to comply with the Part 3A conditions of the Project Approval previously granted by the NSW Department of Planning and Infrastructure as well as the sleep disturbance screening criterion per the NPfI. It also complies with the trigger levels at the proposed council's depot and scout's hall. No further specific assessment of mitigation is expected to be required. The noise assessment includes consideration of the currently intended future development areas of Googong Stage 4D and Stage 9.

OPERATIONAL NOISE – HILL 800 RESERVOIR

Compliance with the Part 3A conditions has been demonstrated to be achievable at the Hill 800 reservoir site at all existing residential receivers and future Neighbourhood 2 receivers. No further specific assessment of mitigation is expected to be required.

ROAD TRAFFIC NOISE ASSESSMENT

Road noise assessment has been conducted for the most impacted receivers on Old Cooma Road and Googong Road. It was found that additional road noise impact during construction and operation of the subject facilities are not likely to be significant and not likely to cause notable disturbance, per the NSW Road Noise Policy.

1 PROJECT BACKGROUND

1.1 INTRODUCTION

WSP Australia Pty Ltd (WSP) has been engaged by Googong Township Pty Ltd (GTPL) to conduct a noise impact assessment for the proposed operation and construction of the Stage D Water Recycling Plant (WRP) and the expansion of the Hill 800 Reservoir site located within the Googong Township.

The WRP and Hill 800 Reservoir site form part of the wider Integrated Water Cycle (IWC) Project to support the development of the Googong Township. The IWC Project involves construction and operation of various water cycle infrastructure to deliver potable and recycled water to the township.

1.1.1 WRP

Similar to the wider IWC Project, the development of the WRP has been staged in the following way:

- Stage AB – construction completed and currently in operational phase;
- Stage C – construction completed and currently in operational phase;
- Stage D – currently proposed expansion of the WRP to its ultimate capacity, expected to be commence in 2023.

WSP has previously conducted a noise assessment for the proposed operation of the Stage D WRP to outline the potential noise impacts and assess the implications of amending the existing buffer zone surrounding the WRP (WSP report PS106081-Googong-WRP-D-171122, dated 22 November 2017). This was followed by a noise assessment for the existing operation of WRP Stage AB and Stage C (WSP report PS106081-WRP C Commissioning Noise Assessment-Rev0, dated 24 October 2018).

1.1.2 HILL 800 RESERVOIR SITE

The development of the Hill 800 Reservoir site has also been staged as:

- Stage C – construction completed and currently in operational phase;
- Stage D – currently proposed expansion.

1.2 OBJECTIVES OF THIS ASSESSMENT

The objectives of this assessment for the proposed Stage D expansion are primarily to support the Review of Environmental Factors (REF) for the proposed expansion, summarised as follows:

- Undertake a construction noise and vibration assessment of WRP Stage D expansion and Hill 800 Reservoir Site.
- Complete a noise assessment of WRP Stage D expansion and the Hill 800 Reservoir Site to determine the noise attenuation requirements to achieve compliance with Part 3A Concept Plan Approval for construction and operational noise.

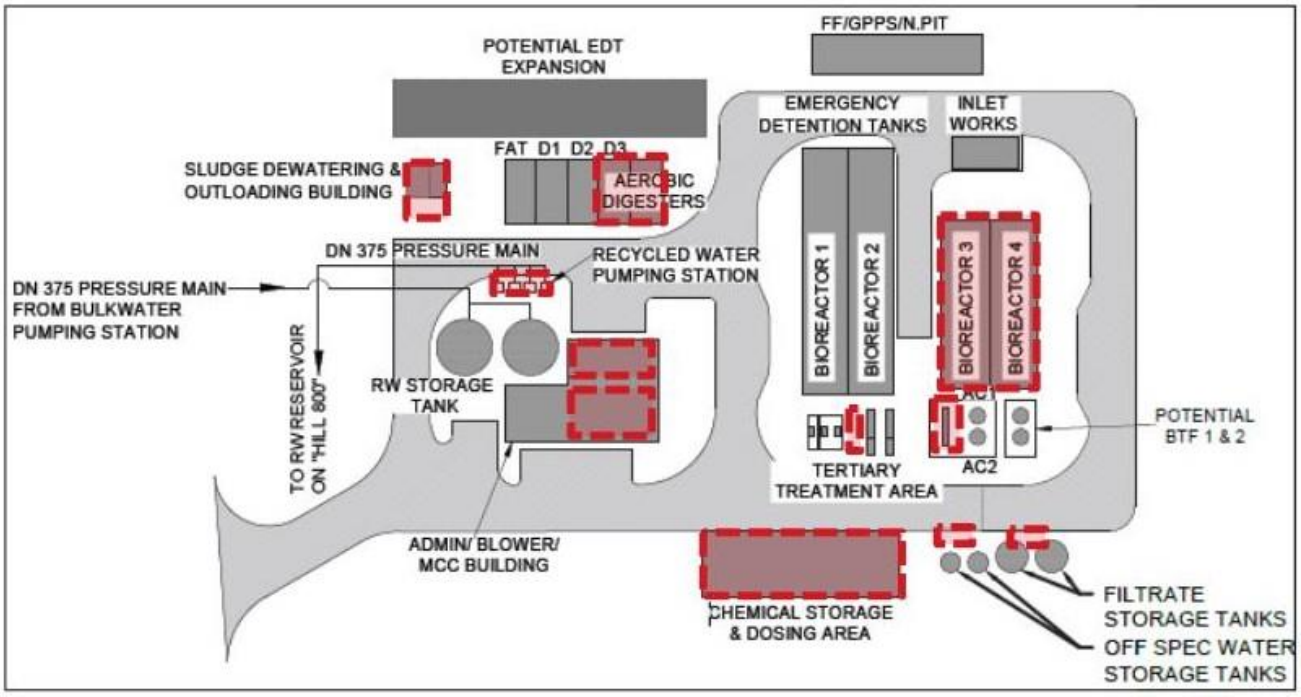
1.3 PROPOSED DEVELOPMENT WORKS

1.3.1 STAGE D WRP

The Stage D expansion to the WRP comprises of the following major unit operations:

- Additional 4/5-stage Membrane Bioreactor train and associated pumps for the removal of nutrients and organic loads, and suspended solids;
- Upgraded Tertiary Feed Pumps (existing smaller pumps to larger units);
- Additional Tertiary Filtration (microfiltration) skid;
- Additional Aerobic Digester tank;
- Additional Dewatering Centrifuge and Feed Pump unit;
- Upgraded Biosolids Bins and Outloading Conveyor system;
- Upgraded Effluent (Off-Spec) Pumps;
- Upgraded RW Transfer Pump (existing temporary small pump replaced with larger unit);
- Upgraded Bioreactor and Membrane blowers within the existing blower building;
- Upgraded Compressed Air System.

Figure 1.1 provides a high level layout of the Stage D expansion works within the existing WRP. The areas identified as requiring upgrade within the WRP are highlighted in red.



Source: Googong WRP Stage D Noise and Vibration Impact Assessment Request for Proposal, dated 28 January 2020,

Figure 1.1 Stage D expansion works within the existing WRP

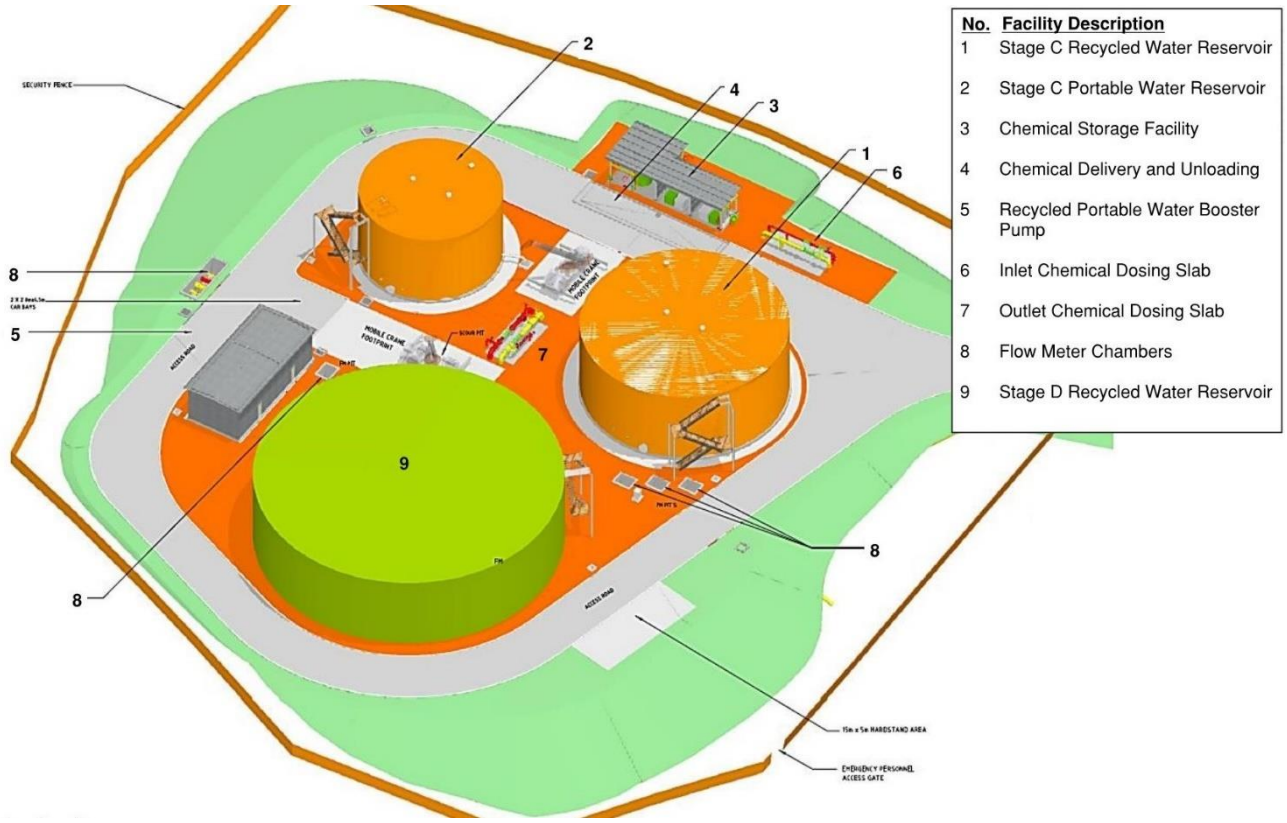
1.3.2 STAGE D EXPANSION OF HILL 800 RESERVOIR SITE

The major Stage D expansion works at the Hill 800 Reservoir site involves construction of a new recycled water (RW) reservoir and repurposing the existing reservoir into portable water (PW) storage. The planned works will involve:

- A new 9ML reservoir will be built for recycled water storage;
- The Stage C 4.0 ML RW reservoir will be cleaned and re-purposed for PW;
- A new Stage D RW booster pump skid will be provided to cater to flows in the higher elevation developments of the township;

- The Stage C PW booster pump skid shall be decommissioned and replaced by a new, larger Stage D PW booster pump skid;
- Decommissioning of the Stage C sedimentation bund and associated civil works required to re-purpose the area for the new 9ML RW reservoir;
- Sodium metabisulphite will be redirected to dose into the Stage D chemical dosing chamber that receives the overflow from the new reservoir;
- Recycled water sodium hypochlorite dosing pumps may need to be replaced with 40 L/h dosing pumps;
- Electrical and control system upgrade to cater for the new infrastructure.

Figure 1.2 illustrates the general arrangements of the Hill 800 Reservoir site, showing the new (highlighted in green) and existing (highlighted in orange) reservoirs.



Source: Googong WRP Stage D Noise and Vibration Impact Assessment Request for Proposal, dated 28 January 2020,

Figure 1.2 Hill 800 Reservoir proposed Stage D works

2 EXISTING ENVIRONMENT

This section provides a summary of the identified noise sensitive receivers which have the potential to be affected by noise emissions from construction and operation of the Stage D expansion of the WRP and Hill 800 Reservoir site. The prevailing external noise environment has been established with the completion of noise monitoring measurements carried out in previous noise studies within the vicinity of Googong Township and at the existing Googong WRP site.

2.1 SENSITIVE RECEIVERS

2.1.1 CONSTRUCTION ASSESSMENT

Representative sensitive receivers that would potentially be affected by the proposed construction and operation of the Stage D expansion of the WRP and Hill 800 Reservoir site, have been identified by WSP in previous noise assessments on the construction and operation of the IWC project for Googong Township.

For consistency, the receivers identified in the previous studies have been adopted for this assessment and are presented in Figure 2.1. Receivers are marked with a prefix “R” or “C” which represents residential type receivers and commercial type receivers respectively. The identified receivers in the vicinity of the project are:

- R1 to R10 – Existing receivers built prior to the Googong Township development near to Old Cooma Road;
- R11 – Existing receiver ‘Talpa’ built prior to the Googong Township development, 120 metres north of the WRP;
- R14 – Representative of residential and non-residential sensitive receivers within the Googong Township development (refer to Figure 2.2);
- R15 – Isolated dwelling east of Googong Township development;
- R16 – Isolated dwelling north of Googong Township development;
- C1 – ICON Water treatment facility;
- C2 – Ranger station.

Receivers R12 and R13, which were identified in the previous studies, have not been included in this assessment as these locations are contained within the receiver locations for Googong Township (R14).



Figure 2.1 Identified noise affected receivers

An aerial image marked with the noise sensitive receivers within the Googong Township development is provided in Figure 2.2 and have been identified as:

- R14-01 to R14-14 - Residential noise sensitive receivers within the Googong Township development;
- R14-DF – Duncan Fields (active recreation area);
- R14-PPS – Public Primary School (school classrooms);
- R14-VCC – Village Childcare Centre (childcare centre);
- R14-AS – Anglican School (school classrooms);
- R14-RO – Rockley Oval (active recreation area).



Figure 2.2 Identified noise affected receivers with the Googong Township development

2.1.2 OPERATIONAL ASSESSMENT

For operational noise assessment purposes, the noise impact from the proposed operation of the Stage D expansion works of the WRP and the Hill 800 Reservoir site, will be assessed at the Googong Township residential lot boundaries only (receivers R14). Figure 2.3 and Figure 2.4 show Googong Township's existing and future (Stages 4D, 9 and Neighbourhood 2 NH2) residential lots surrounding Googong WRP and the Hills 800 Reservoir site.



Figure 2.3 Existing and future residential lots near WRP (highlighted in orange)



Figure 2.4 Future residential lots (outlined in yellow) near Hills 800 Reservoir (highlighted in red)

2.2 NOISE MONITORING OF EXISTING ENVIRONMENT

WSP has previously conducted site surveys and unattended noise monitoring within the vicinity of Googong Township and at the existing Googong WRP site. The results of these noise measurements are used to provide the relevant background noise data for each site. All measurements were conducted in accordance with AS1055.1:1997 *Acoustics – Description and measurement of environmental noise Part 1: General procedures*. All noise loggers were checked with a field calibrator at the time of monitoring and no significant drift (i.e. greater than ±0.5 dB) in results prior to and post monitoring was observed.

2.2.1 NOISE MONITORING LOCATION (NML)1 - OUTSIDE OF THE GOOGONG TOWNSHIP DEVELOPMENT

The results of noise monitoring conducted near 1241 Old Cooma Road between 23 February to 9 March 2018, has been selected to represent the background noise level of the sensitive receivers located outside of Googong Township. The noise monitoring location is shown in Figure 2.5, with the results summarised in Table 2.1. The local noise environment is generally dominated by road traffic noise along Old Cooma Road, and is therefore considered representative of receivers R1 to R10 as discussed in Section 2.1.1. Contributions from natural sounds such as birds and wind in the trees were also observed.

Renewed noise monitoring has not been conducted specifically for this REF as existing receivers in vicinity of the Hill 800 site have been affected by general ongoing construction noise from the Googong Township. Under such influence, any background noise monitoring is not considered appropriate or representative.



Figure 2.5 Aerial photograph indicating background noise monitoring location and Hill 800 Reservoir

Table 2.1 Noise monitoring results carried out between 23 February to 9 March 2018

EQUIPMENT	DESCRIPTION	TIME PERIOD[2]	RESULT
ARL EL-316 noise logger S/N 16-306-008)	Rating Background Noise Level (RBL)[1]	Day period	35 dB $L_{A90\ (15min)}$[3]
		Evening	30 dB $L_{A90\ (15min)}$[3]
		Night	30 dB $L_{A90\ (15min)}$[3]
	Ambient noise level	Day period	50 dB $L_{Aeq\ (15min)}$
		Evening	53 dB $L_{Aeq\ (15min)}$

EQUIPMENT	DESCRIPTION	TIME PERIOD[2]	RESULT
		Night	44 dB $L_{Aeq\ (15min)}$

(1) The Rating Background Noise Level (RBL) is the background noise level used for assessment purposes at the nearest potentially affected receiver. The RBL is defined as the 90th percentile of the daily background noise levels during each assessment period.

(2) Day: the periods from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and public holidays; Evening: the period from 6 pm to 10 pm; Night: the remaining periods.

(3) Under the NSW Environment Protection Authority Noise Policy for Industry (EPA, 2017), where daytime RBL is below 35 dBA, and evening and night-time RBLs are below 30 dBA, they are set instead to 35 dBA for day, and 30 dBA for evening and night.

2.2.2 NML2 – WITHIN THE GOOGONG TOWNSHIP DEVELOPMENT

Noise monitoring of the background noise level within Googong Township was conducted in June 2019, to support the proposed development of Googong Neighbourhood 1A Stage 4D (reported in WSP report PS106081-Googong NH1A Stage 4D-RBL, dated 19 August 2019). The noise monitoring location is within the vicinity of the Googong WRP site boundary, as shown in Figure 2.6. The measurement results are summarised in Table 2.2 and have been selected to represent the background noise level of the sensitive receivers within the Googong Township development for this assessment. This noise monitoring site was located approximately 200m from the WRP, which was a far enough distance where noise from the WRP was not perceived as audible.

The acoustic environment at the monitoring location was influenced by noise sources such as construction noise from certain residential lots in the vicinity, aircraft noise, increased road traffic noise and activities at the nearby sports field.

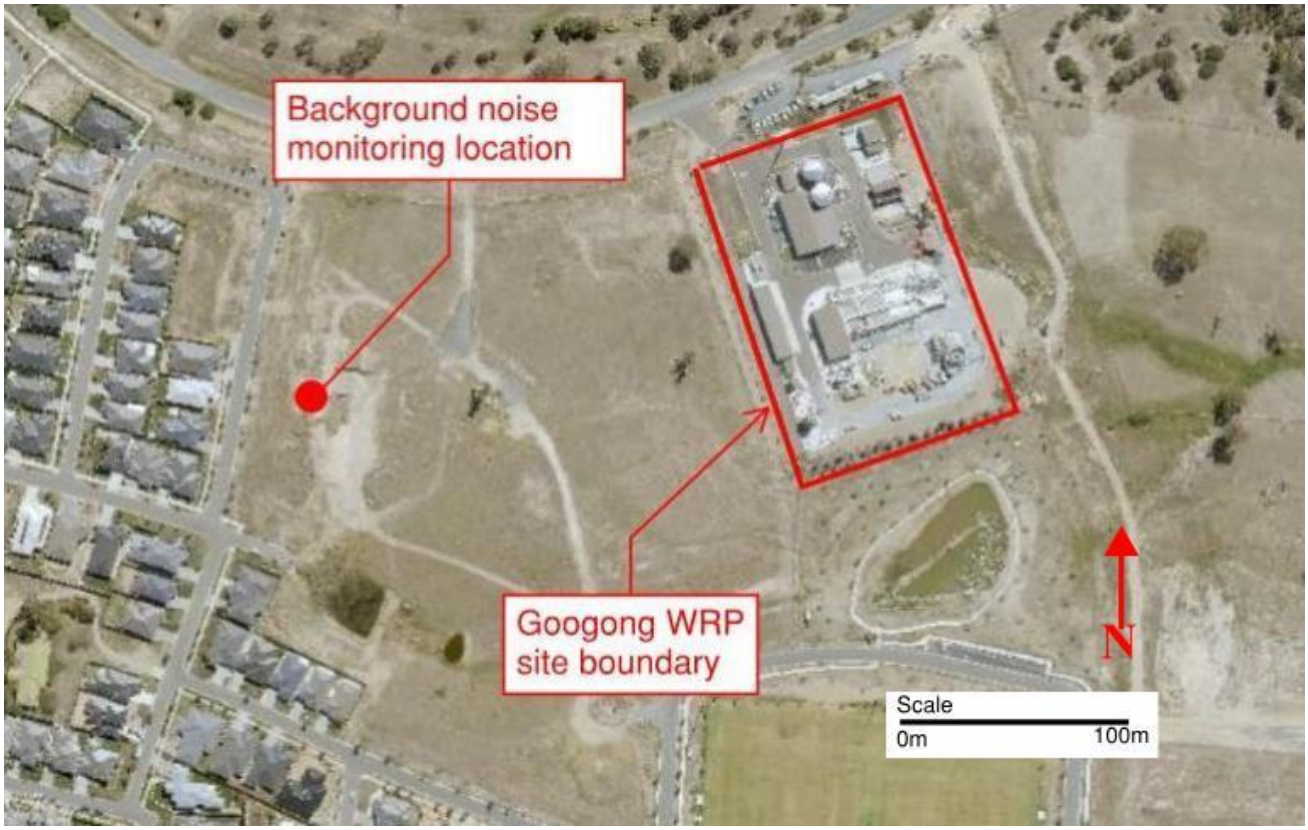


Figure 2.6 Background noise monitoring location within the Googong Township development

Table 2.2 Noise monitoring results carried out between 13 June to 26 June 2019

EQUIPMENT	DESCRIPTION	TIME PERIOD	RESULT
Norsonic Nor140 (S/N 4294981)	RBL[1]	Day period	35 dB $L_{A90\ (15min)}$
		Evening	30 dB $L_{A90\ (15min)}$
		Night	30 dB $L_{A90\ (15min)}$
	Ambient noise level	Day period	44 dB $L_{Aeq\ (15min)}$
		Evening	38 dB $L_{Aeq\ (15min)}$
		Night	36 dB $L_{Aeq\ (15min)}$

(1) Under the Noise Policy for Industry (EPA, 2017), where daytime RBL is below 35 dBA, and evening and night-time RBLs are below 30 dBA, they are set instead to 35 dBA for day, and 30 dBA for evening and night.

3 ASSESSMENT CRITERIA

The construction and operational noise assessment has been prepared with reference to the following guidelines, policies and standards:

- NSW Department of Environment and Climate Change (DECC) – Interim Construction Noise Guideline (ICNG) (2009).
- Part 3A Concept Plan Approval for the entire IWC Project.
- NSW Environment Protection Authority– Noise Policy for Industry(NPfI) (EPA, 2017).
- Australian/New Zealand Standard AS/NZS 2107:2016 - Acoustics – Recommended design sound levels and reverberation times for building interiors. (AS 2107).
- NSW Road Noise Policy 2011 (NSW RNP).
- Concept Approval application number MP 08_0236 as modified 27 October 2014.

3.1 CONSTRUCTION NOISE

Noise impacts from construction noise are assessed using the Interim Construction Noise Guideline (ICNG) (DECC, 2009). The ICNG defines a noise management level for residential and other sensitive land uses. Above this level, feasible and reasonable mitigation should be considered to reduce noise levels.

Table 3.1 defines noise management levels (NML) as specified in the ICNG and how they are applied for residential receivers. NMLs are the level of noise above which receivers are considered to be 'noise affected'. They are based on the measured RBL, as defined in the NPfI (EPA,2017), plus an additional allowance of 10 dB during standard hours and 5 dB outside of standard hours.

Where construction noise levels are above 75 dBA at residential receivers during standard hours, they are considered 'highly noise affected' and require additional considerations to mitigate potential impacts.

Table 3.1 Construction noise management levels for residential receivers and working hours (Source: Table 2 of the NSW ICNG)

TIME OF DAY	**NML dBA $L_{eq;15\ minute}$ [1,2]**	**HOW TO APPLY**
Standard Hours (SH): Monday – Friday 7 am – 6 pm Saturday 8 am – 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. — Where the predicted or measured dBA $L_{eq;15\ minute}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. — The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

TIME OF DAY	NML dBA $L_{eq;15\ minute}$[1,2]	HOW TO APPLY
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: — times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) — if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times
Outside standard hours (OOHW)	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent of any development works within the SAP should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent of any development works within the SAP should negotiate with the community.

(1) Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

(2) The RBL is the overall background noise level representing each assessment period (day/evening/night) over the whole monitoring period. The term RBL is described in detail in the NSW NPfI (EPA, 2017).

Table 3.2 provides a summary of the applicable NML based on the background noise monitoring conducted (Section 2). In addition, Table 3.3 lists the NML that have been adopted for non-residential sensitive receivers as required by the ICNG.

Table 3.2 Construction noise management levels for residential receivers

RECEIVER	NOISE MANAGEMENT LEVELS, $L_{eq15\ min}$ dBA			
	DAY (SH)	DAY (OOHW)	EVENING (OOHW)	NIGHT (OOHW)
R1 to R10	45	40	35	35
R11 to R14	45	40	35	35
R15 to R16	45	40	35	35

Note: SH = recommended standard working hours, OOHW = outside of recommended standard hours work as defined in Table 3.1

Table 3.3 Construction noise management levels for non-residential sensitive land uses

LAND USE	NOISE MANAGEMENT LEVELS, $L_{eq\ 15\ min}$ dBA Applies when properties are being used
School classrooms, places of worship	45 (internal) or 55 (external)[1]
Industrial	75 (external)
Active recreation areas	65 (external)
Childcare centre	45 (internal) or 55 (external)[1]

(1) External noise level estimated based on an outside to inside correction of 10 dB, assuming windows are partially open for ventilation.

(2) Based on the maximum recommended internal noise level as specified in Australian Standard AS 2107 Recommended design sound levels and reverberation times for building interiors. External noise level estimated based on an outside to inside correction of 10 dB, assuming windows are partially open for ventilation.

3.2 ROAD TRAFFIC NOISE

Additional road traffic on public roads as a result of the proposed project are assessable per the NSW RNP. The application notes from the RNP detail the requirements for operation-generated traffic noise as follows:

- *For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies where the noise level without the development is within 2 dB of, or exceeds the relevant day or night noise assessment criterion.*

The consideration of mitigation is required where additional construction related traffic or operational off-site traffic on existing roads creates an increase of more than 2 dB at existing sensitive receivers.

Arterial and sub-arterial roads are assessed over day (7 am to 10 pm) and night (10 pm to 7 am) periods and local roads are assessed over a one hour period (typically the peak hour) within the respective day and night periods. Table 3.4 presents a summary of noise level criteria for the arterial, sub-arterial and local roads affected by additional traffic from land use developments and construction activities.

Table 3.4 Road traffic noise criteria for receivers on existing roads affected by the additional traffic from land use developments

ROAD TYPE	EXTERNAL ROAD TRAFFIC NOISE CRITERIA[1]	
	Day 7 am – 10 pm	Night 10 pm – 7 am
Freeway/arterial/sub-arterial roads	60 dB $L_{Aeq\ 15hr}$	55 dB $L_{Aeq\ 9hr}$
Local roads	55 dB $L_{Aeq\ 1hr}$	50 dB $L_{Aeq\ 1hr}$

(1) Façade corrected noise levels

3.3 OPERATIONAL NOISE

An overarching Project Approval has previously been granted by the NSW Department of Planning and Infrastructure for the Googong Township IWC Project, which included both subject sites. In relation to the applicable noise limits associated with any modification, assessment approach as suggested in the new NPfI (EPA, 2017) will likely be applicable.

3.3.1 PART 3A OF THE CONCEPT PLAN APPROVAL

According to the existing Concept Approval previously granted by the NSW Department of Planning and Infrastructure (application number MP 08_0236 incorporating Modification 3 dated 27 October 2014), all noise emitted from the operation of the project infrastructure (including the subject WRP) shall not exceed 35 dB $L_{Aeq,\ 15\ min}$ (A-weighted decibel) at any residence on privately owned land.

3.3.2 NOISE POLICY FOR INDUSTRY (NPA,2017)

The NPfI (EPA, 2017) sets out the procedure to determine the project noise trigger levels relevant to an industrial development. The project specific noise trigger level is determined by the lower of the project intrusiveness noise level and project amenity noise level, both of which are dependent on:

- The receiver's background noise environment;
- The time of day of the activity;
- The character of the noise;
- The type of receiver and nature of the area.

3.3.2.1 PROJECT INTRUSIVENESS NOISE LEVEL

The project intrusiveness noise level for residential receivers prescribed in the NSW NPfI (EPA, 2017) is summarised as:

$L_{Aeq;\ 15\ minute} \leq$ Rating Background Level (L_{A90}) + 5 dB(A)

Based on the RBLs as outlined in Section 2.2, the project intrusiveness noise level has been established for the proposed operation in accordance with the NSW NPfI (EPA, 2017) and is presented in Table 3.5.

Table 3.5 RBLs and applicable project intrusiveness noise levels

RECEIVER LOCATION	TIME PERIOD	RBL dBA[1]	PROJECT INTRUSIVENESS NOISE LEVEL (RBL + 5 dB)
R1 to R10 (NML-1 Section 2.2.1)	Day	35	40
	Evening	30	35
	Night	30	35

RECEIVER LOCATION	TIME PERIOD	RBL dBA[1]	PROJECT INTRUSIVENESS NOISE LEVEL (RBL + 5 dB)
R11 to R14	Day	35	40
(NML-1 Section 2.2.2)	Evening	30	35
	Night	30	35
R15 to R16	Day	35	40
(NML-1 Section 2.2.1)	Evening	30	35
	Night	30[1]	35

(1) In accordance with NPfI (EPA, 2017), where the measured rating background level is less than 30 dBA for the evening and night periods, it is set to 30 dBA. When it is found to be less than 35 dBA for the day period, it is set to 35 dBA.

3.3.2.2 PROJECT AMENITY NOISE LEVELS

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the amenity noise levels recommended in the NPfI (EPA, 2017). The applicable amenity noise levels are dependent on the land use types associated with the assessed receivers. The project amenity noise level is then determined as follows:

Project amenity noise level ($L_{Aeq, period}$) = Recommended amenity noise level - 5 dB

In order to compare the intrusiveness and amenity criteria using the same time period, the NPfI (EPA, 2017) states that the $L_{Aeq, 15min}$ noise level is taken to equal the $L_{Aeq, period}$ + 3 dB unless robust evidence can be provided for an alternative approach. In this case, the approach in the NPfI (EPA, 2017) is considered appropriate.

Based on the Queanbeyan Local Environmental Plan 2012 (Amendment 9), the Googong Neighbourhood Stage 4D is currently located in Zone R1 General Residential and Zone R5 Large Lot Residential for the large lots to the southeast. Surrounding land include Zone RU2 Rural Landscape. The applicable amenity levels are presented in Table 3.6.

Table 3.6 Project amenity noise levels – for residential and non-residential receivers

LOCATION	DAY	EVENING	NIGHT
Recommended amenity noise levels[1]			
R1 Urban general residential use	60 dB $L_{Aeq, period}$	50 dB $L_{Aeq, period}$	45 dB $L_{Aeq, period}$
R5 Rural residential use	50 dB $L_{Aeq, period}$	45 dB $L_{Aeq, period}$	40 dB $L_{Aeq, period}$
Project amenity noise levels ($L_{Aeq, period}$)			
R1 Urban general residential use	55 dB $L_{Aeq, period}$	45 dB $L_{Aeq, period}$	40 dB $L_{Aeq, period}$
R5 Rural residential use	45 dB $L_{Aeq, period}$	40 dB $L_{Aeq, period}$	35 dB $L_{Aeq, period}$
Project amenity noise level ($L_{Aeq, 15min}$)[2]			
R1 Urban general residential use	58 $L_{Aeq, 15min}$	48 $L_{Aeq, 15min}$	43 $L_{Aeq, 15min}$
R5 Rural residential use	48 $L_{Aeq, 15min}$	43 $L_{Aeq, 15min}$	38 $L_{Aeq, 15min}$
Industrial premises	65 dB $L_{Aeq, period}$, 68 $L_{Aeq, 15min}$		
Active recreation area	50 dB $L_{Aeq, period}$, 53 $L_{Aeq, 15min}$		

(1) Daytime RBL <40 dBA, evening RBL <35 dBA, night RBL <30 dBA.

(2) In accordance with the NPfI (EPA, 2017), the amenity noise level is converted from $L_{Aeq, period}$ to $L_{Aeq, 15min}$ by adding 3 dB to the $L_{Aeq, period}$ level.

3.3.2.3 PROJECT CONTROLLING CRITERION

Regarding the nature of operation of the WRP and Hill 800 Reservoir site, it is understood that the following pattern is typically applicable:

- Up to 90% of equipment operates intermittently, dependent on the amount of inflow to the facility;
- Continuous operation during the morning peak period (typically 8 am to 11 am);
- Continuous operation during the afternoon and evening peak period (typically 6 pm to 10 pm);
- Sporadic operation during the day time between the two peak periods (11 am to 6 pm);
- Minimal overnight operation (typically 11 pm to 6 am);
- Foul air fans typically in continuous operation 24/7, including during no-load condition;
- Bioreactors, membrane and digester blowers typically operates intermittently 24/7.

On this basis, as all plant equipment have the potential to operate at any time of the day, the controlling criterion for assessment purposes will be the most onerous of all project intrusiveness noise levels and project amenity noise levels:

- 35 dB $L_{Aeq,\ 15\ min}$, being met at all existing and planned residential premises.

The determined project trigger level was therefore determined to be consistent with the existing approval condition per Section 3.3.1.

3.3.3 VARIATION TO EXISTING ENVIRONMENT PROTECTION LICENCE

It is noted that the existing WRP is operating under an Environment Protection Licence (EPL number 20188) with a prescribed noise limit of ≤35 dB $L_{Aeq,\ 15min}$ at all residential receivers, consistent the Part 3A Concept Plan Approval. It is noted that this limit was set in accordance with the superseded NSW Industrial Noise Policy (EPA, 2000).

Based on the ambient noise monitoring conducted in the project area not affected by existing noise from the WRP (Section 2.2.2), the most stringent intrusiveness noise trigger levels per the current NPfI were found to be applicable i.e. 40 dB $L_{Aeq,\ 15min}$ and 35 dB $L_{Aeq,\ 15min}$ for day and evening/night periods respectively (Section 3.3.2.3).

It is therefore recommended that the noise limits are updated in accordance with the current NPfI to the following if the EPL is varied to capture Stage D expansion:

- 40 dB $L_{Aeq,\ 15min}$ during day period at all residential receivers;
- 35 dB $L_{Aeq,\ 15min}$ during evening and night period at all residential receivers;
- 68 dB $L_{Aeq,\ 15min}$ at all industrial premises when those premises are in use (e.g. a depot operation by QPRC);
- 53 dB $L_{Aeq,\ 15min}$ at all active recreation area when those premises are in use (e.g. a scouts hall).

It is however noted that the design of the proposed expansion is still subject to the most stringent evening and night trigger levels (same as the current EPL limit of ≤35 dB $L_{Aeq,\ 15min}$).

3.4 MODIFYING FACTORS FOR ATTENTION-DRAWING CHARACTERISTICS

Certain noise characteristics have a higher potential to cause annoyance, generally requiring additional considerations. Tonality, low frequency emphasis and intermittency are generally considered to be attention-drawing and can cause greater disturbance. On the other hand, short-term single noise events are likely to be less disturbing and may warrant some relaxation in the applicable noise criteria.

To address these scenarios, the NPfI (EPA, 2017) prescribes specific modifying factors in the assessment of the relevant noise events, as summarised in Table 3.7.

Table 3.7 Industrial Noise Policy – modifying factor corrections

FACTOR	ASSESSMENT / MEASUREMENT	WHEN TO APPLY	CORRECTION (ADDED/SUBTRACTED TO THE MEASURED / PREDICTED LEVEL)1	
Tonal Noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: — 5 dB or more if the centre frequency of the band containing the tone is in the range of 500 to 10,000 Hz. — 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive. — 15 dB or more if the centre frequency of the band containing the tone is in the range of 25 to 125 Hz.	+5 dB[2]	
Low-frequency Noise	Measurement of C-weighted and A-weighted level	Measure to assess C- and A-weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more and: — Where any of the one-third octave noise levels are exceeded by up to and including 5 dB and cannot be mitigated, a 2 dBA positive adjustment applies for the evening and night periods. — Where any of the one-third octave noise levels are exceeded by up to and including 5 dB and cannot be mitigated, a 2 dBA positive adjustment applies for the daytime period.	+5 dB[2]	
Intermittent Noise	Subjectively assessed but should be assisted with measurement to gauge extent of change in noise level.	The source noise heard at the receiver varies by more than 5 dBA and the intermittent nature of the noise is clearly audible.	+5 dB, applied for night time only	
Duration	Single-event noise duration	One event in any 24-hour period, with duration as below.	**Night**	**Day and evening**
		1 to 2.5 hours	0	-2
		15 min to 1 hour	0	-5
		6 min to 15 min	-2	-7
		1.5 min to 6 min	-5	-15
		Less than 1.5min	-10	-20

(1) Where two or more modifying factors are present, the maximum correction is limited to 10 dB.

(2) Where a source emits noise which has both tonal and low-frequency components, only one 5 dB correction should be applied.

3.5 SLEEP DISTURBANCE DURING MAXIMUM NOISE EVENTS

Activities taking place at night have the potential to disturb people's sleep patterns. The potential for sleep disturbance from maximum noise level events and operational noise during the night-time period is detailed in the NPfI. The operational sleep disturbance criteria for developments at the proposed residential locations are the following:

- 40 dB $L_{Aeq, 15min}$ or the rating background level plus 5 dB, whichever is the greater, and/or
- 52 dB L_{AFmax} or the rating background level plus 15 dB, whichever is the greater.

Where the development night-time noise levels at a residential location exceed the following, a detailed maximum noise level event assessment should be undertaken.

Based on the above, the external sleep disturbance screening criteria are set as follows for all residential receivers:

- **40 dB $L_{Aeq, 15min}$ and 52 dB L_{AFmax}.**

3.6 CONSIDERATION OF STANDARD AND NOISE-ENHANCING METEOROLOGICAL CONDITIONS

The NPfI (EPA, 2017) acknowledges the certain meteorological conditions may increase noise levels by focusing soundwave propagation paths at a single point. Both standard and potentially noise-enhancing meteorological conditions local to the project study area therefore should ideally be considered with conducted noise impact assessment. The assessable meteorological conditions defined by NPfI (EPA, 2017) are summarised in Table 3.8.

Table 3.8 Standard and potentially noise-enhancing meteorological conditions assessable under NPfI

CONDITION	METEOROLOGICAL PARAMETERS
Standard	Day/evening/night: stability categories A–D with wind speed up to 0.5 m/s at 10 metres AGL[1]
Potentially noise-enhancing meteorological conditions	Daytime/evening: stability categories A–D with light winds (up to 3 m/s at 10 metres AGL[1]). Night-time: stability categories A–D with light winds (up to 3 m/s at 10 metres AGL[1]) and/or stability category F with winds up to 2 m/s at 10 metres AGL[1].

(1) Above ground level

Where the defined noise-enhancing meteorological conditions occur for less than 30% of the time, standard meteorological conditions may be adopted for the noise assessment.

Section (1) provides an analysis of historic meteorological conditions of the subject development area from 1 May 2018 to 30 June 2019 inclusive, which shows that potential noise-enhancing meteorological condition should be considered for receivers in the north and west of the WRP.

4 ON-SITE CONSTRUCTION NOISE ASSESSMENT

4.1 ASSESSMENT METHODOLOGY

To assist with the noise assessment for the proposed construction and operation of the project, a three dimensional noise model was created using SoundPLAN version 7.4. The model accounts for the following:

- Digitised ground elevation contours/ points in one (1) metre intervals for the terrain of the area surrounding the project site;
- Receivers were modelled at 1.5 metres above ground level for single storey buildings and free field receivers locations;
- Ground coverage has been assumed to be hard ground and modelled with a 0.2 absorption co-efficient to account for hard surfaces;
- Shielding provided by existing buildings.

For assessment purposes, construction plant and equipment have been modelled to operate simultaneously to represent the potential worst case noise impacts.

The predicted noise levels at individual receivers are dependent upon the plant location and the number of plant operating during each activity. Noise impacts have been determined for a worst case 15 minute scenario where all construction plant equipment and machinery are in simultaneous operation. Where fewer plant and machinery are in operation or undertaken at greater separation distance to nearest receivers, noise levels would be significantly reduced.

4.2 ASSESSMENT SCENARIOS

Fifteen (15) construction scenarios representing each construction stage of the WRP and Hill 800 Reservoir site Stage D expansion have been considered. Table 4.1 presents the construction scenarios considered in the assessment, based on information provided by RPS Group and the highest allowable noise levels for construction equipment given in NSW Transport Roads & Maritime Services (Roads and Maritime) Construction Noise and Vibration Guideline (CNVG) (2016).

The working time periods as defined in the ICNG are as follows:

- Standard Hours:
  - Monday to Friday 7 am to 6 pm.
  - Saturday 8 am to 1 pm.
- Outside of Standard Hours Work:
  - Day:
    - Saturday 7 am to 8 am and 1 pm to 10 pm.
    - Sundays and Public Holidays 7 am to 6 pm.
  - Evening, Monday to Friday 6 pm to 10 pm.
  - Night, Monday to Sunday 10 pm to 7 am.

It is expected that all construction works will generally occur during the designated standard hours. Any out of hours would need to be individually assessed and approved by QPRC and the EPA, as the need arises. Therefore, the modelling and assessment were based on the determined standard hours daytime NMLs only. Should out-of-hours works be required, a separate noise assessment should be undertaken to determine the acoustic risk associated with the specific activities proposed to occur outside of standard hours.

Table 4.1 WRP and Hill 800 Reservoir site Stage D Expansion construction scenarios

SCENARIO	ACTIVITY	EQUIPMENT	NUMBER OF EQUIPMENT	SWL (dBA)	SCENARIO SWL (dBA)
Site establishment (WRP & Hill 800 site)	Services search	Excavator	1	112	122
	Survey location	Roller	1	118	
	Installation of perimeter fencing	Petrol picket driver	1	100	
	Installation of environmental controls	Hand tools	2	106	
	Clearing, grubbing and stockpiling	Compactor	1	106	
	Subgrade preparation (i.e. the compacted material underneath concrete or pavement)	Crane	1	107	
	Transport and establishment of required site amenities	Truck	4	109	
	Installation of temporary power supply, water and plumbing	Hand power tools	2	109	
Services location (WRP & Hill 800 site)	Vacuum truck to identify service locations	Truck	1	109	114
	Water cart for dust suppression	Water cart	1	110	
	Staff site vehicles	4WD	2	105	
Mobilisation (WRP & Hill 800 site)	Heavy vehicles	Truck	4	109	121
	Generators	Generator	1	103	
	Excavator for preparing grade materials	Excavator	1	112	
	Roller to compact grade materials	Roller	1	118	
Implementation of erosion and sediment controls (WRP & Hill 800 site)	Vegetation clearance and topsoil removal	Dozer	1	116	124
	Stockpiling	Compactor	1	106	
	Excavation	Excavator	1	112	
	Backfilling and compaction	Roller	1	118	

SCENARIO	ACTIVITY	EQUIPMENT	NUMBER OF EQUIPMENT	SWL (dBA)	SCENARIO SWL (dBA)
	Road construction	Roller	1	118	
	Topsoil respreading	Excavator	1	112	
	Revegetation	Mulcher	1	116	
	Demobilisation.	Truck	4	109	
Clearing, stripping and stockpiling (WRP & Hill 800 site)	Dozer for clearing and vegetation removal	Dozer	1	115	120
	Excavator for clearing, stripping and stockpiling	Excavator	1	112	
	Tipper to relocate spoil	Truck	4	109	
	Water cart for dust suppression.	Water cart	1	110	
Construction amenities (WRP & Hill 800 site)	Excavator for the preparation of grade materials	Excavator	1	112	120
	Roller for the compaction of grade materials	Roller	1	118	
	Water cart for dust suppression	Water car	1	110	
	Staff site vehicles	4WD	4	105	
Temporary services (WRP & Hill 800 site)	Generators for site power	Generator	2	103	120
	Excavator for the preparation of grade materials	Excavator	1	112	
	Roller for the compaction of grade materials	Roller	1	118	
	Water cart for dust suppression	Water cart	1	110	
	Staff site vehicles	4WD	4	105	
Road works (WRP site only)	Truck and dog for the delivery of road base materials	Truck and dog	4	109	125
	Roller for the compaction of backfill materials	Roller	1	118	
	Excavator for the excavation of roadways	Excavator	1	112	
	Concrete truck for the delivery of concrete	Concrete truck	4	115	
	Kerb profiler for the concrete vibration and formwork fabrication	Pavement profiler	1	117	
	Water cart for dust suppression	Water cart	1	110	
	Staff site vehicles	4WD	4	105	

SCENARIO	ACTIVITY	EQUIPMENT	NUMBER OF EQUIPMENT	SWL (dBA)	SCENARIO SWL (dBA)
Earth works	Bucket excavators	Excavator	1	112	117
(WRP & Hill 800 site)	Tippers for spoil transportation	Truck	4	109	
Form work, reinforcement and concrete	Crane for lifting formwork and reinforcement steel	Crane	1	107	124
(WRP site only)	Excavators for excavating, backfilling and stockpiling	Excavator	1	112	
	Concrete truck to supply concrete to the site	Concrete truck	4	115	
	Concrete pump to pump concrete to foundations	Concrete pump	1	120	
	Staff site vehicles	4WD	4	105	
Services / yard piping (WRP & Hill 800 site)	Excavator for trenching, backfilling and stockpiling	Excavator	1	112	121
	Roller to compact backfilled materials	Roller	1	118	
	Whacker to compact ground around pipe work	Whacker	1	116	
	Water cart for dust suppression.	Water cart	1	110	
Mechanical and process equipment (WRP & Hill 800 site)	Crane for unloading and installation of plant and equipment	Crane	1	107	113
	Elevated work platform for installation of piping	Scissor lift	1	98	
	Welder for pipe welding and cutting	Welder	2	96	
	Staff site vehicles	4WD	4	105	
Electrical (WRP & Hill 800 site)	Crane for unloading and installing the plant and equipment	Crane	1	107	
	Elevated work platform for installation of cable trays and lighting	Scissor lift	1	98	113
	Staff site vehicles	4WD	4	105	
Demolition and demobilisation (WRP & Hill 800 site)	Heavy vehicles	Truck	4	109	118
	Crane for loading demolished plant and equipment	Crane	4	107	

SCENARIO	ACTIVITY	EQUIPMENT	NUMBER OF EQUIPMENT	SWL (dBA)	SCENARIO SWL (dBA)
	Staff site vehicles (4WD)	4WD	4	105	
Restoration and landscaping (WRP & Hill 800 site)	Excavators for distribution of topsoil and mulch	Excavator	1	112	
	Tipper cart for the movement of topsoil and mulch	Truck	4	109	118
	Water cart for dust suppression.	Water cart	1	110	

4.3 PREDICTED NOISE LEVELS

Construction noise levels for scenarios with the highest (125 dBA SWL) and lowest (113 dBA SWL) noise emissions listed in Table 4.1, were predicted using the noise model described in Section 4.1. Noise sources were positioned in the noise model in the identified work areas on the WRP and Hill 800 Reservoir site. The results of the predicted construction noise levels are presented in Table 4.2, showing that the construction noise levels at some receiver locations are in exceedance of applicable NMLs (highlighted in red).

Table 4.2 Modelled construction noise levels

RECEIVER	NML – STANDARD HOURS (dBA)	SCENARIO (dBA)	
		ROAD WORKS (HIGHEST NOISE EMISSIONS)	MECHANICAL AND PROCESS EQUIPMENT (LOWEST NOISE EMISSIONS)
C1	75	48	36
C2	75	61	49
R1	45	45	34
R2	45	44	32
R3	45	46	35
R4	45	47	36
R5	45	49	38
R6	45	47	36
R7	45	56	45
R8	45	58	47
R9	45	60	49
R10a	45	59	48
R10b	45	58	47
R11	45	63	51
R15	45	50	38
R16	45	22	10

RECEIVER	NML – STANDARD HOURS (dBA)	SCENARIO (dBA)	
Receivers within Googong Township (R14)[1]			
R14-01	45	59	47
R14-02	45	61	49
R14-03	45	63	51
R14-04	45	66	54
R14-05	45	65	53
R14-06	45	67	55
R14-07	45	63	51
R14-08	45	50	39
R14-09	45	47	36
R14-10	45	40	29
R14-11	45	36	25
R14-12	45	36	25
R14-13	45	41	30
R14-14	45	43	31
R14 - 6B Public Primary School	55	42	30
R14 - Duncan Fields	65	68	56
R14 - Public Primary School	55	42	30
R14 - Village Centre Childcare	55	55	43
R14 Rockley Oval	65	45	33

(1) Receiver points set at the boundary closest to the WRP and Hill 800 Reservoir site

Based on the results presented above, the following findings were made:

- All noise levels were less than the 'Highly Noise Affected' NML of 75 dBA;
- The standard hours NML at receivers R8 to R10b near Old Cooma Road are exceeded for all construction scenarios;
- The standard hours NML was exceeded at receiver R11 (Talpa) for all construction scenarios by 6 to 18 dB;
- For receivers within the Googong Township, residents at R14-01 to R-14-07 are predicted to exceed the standard hours NML for all scenarios by 2 to 22 dB;
- Predicted noise levels at Duncan Fields are also in exceedance of the standard hours NML for active recreation;
- Noise levels for all scenarios were predicted to meet the respective NMLs at all schools and child care centres within Googong Township.

4.4 CONSTRUCTION NOISE MANAGEMENT

Due to the predicted exceedances of the NMLs at numerous locations, the ICNG requires that feasible and reasonable mitigation strategies be considered to reduce the potential noise impact. Prior to the commencement of works, a construction noise and vibration management plan (CNVMP) should be developed for the project. This document should be prepared on the basis of detailed construction methodologies from the contractor and would include (but not limited to) the following:

- Identification of nearby residences and other sensitive land uses, including a survey of all occupied dwellings within the Googong Township;
- Approved hours of work and what work would be undertaken;
- Construction works should be planned and carried out during standard construction hours wherever possible. Shall works are required outside of standard hours, a detailed assessment shall be undertaken specific to the proposed activities. Any works conducted outside of standard hours should also be accompanied with a strong justification;
- Identification of Dominant noise and vibration generating activities;
- Details of noise mitigation and management measures to be applied;
- Information for worker training to minimise noise impacts;
- Community consultation protocol(s);
- Complaints handling protocol(s).

In addition to the above, information contained within the Transport for NSW's *Construction Noise Strategy* (CNS) (TfNSW, 2013) in relation to standard construction noise mitigation measures are provided in Table 4.3.

Table 4.3 Transport for NSW Construction Noise Strategy standard mitigation measures

ACTION REQUIRED	DETAILS
Management measures	
Implement any project specific mitigation measures required	In addition to the measures set out in this table, any project specific mitigation measures identified in this report.
Implement community consultation measures	Periodic notification (monthly letterbox drop or equivalent), website, project Infoline, Construction Response Line, email distribution list.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Source controls	
Construction hours and scheduling	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period	High noise and vibration generating activities may only be carried out in continuous blocks, not exceeding three hours

	each, with a minimum respite period of one (1) hour between each block.
Equipment selection	Use quieter and less vibration emitting construction methods where feasible and reasonable.
Maximum noise levels	The noise levels of plant and equipment must have operating sound power or sound pressure levels that would meet the predicted noise levels.
Rental plant and equipment	Noise emissions should be considered as part of the selection process.
Use and siting of plant	Avoid simultaneous operation of noisy plant within discernible range of a sensitive receiver. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Plant and vehicles to be turned off when not in use. Noise-emitting plant to be directed away from sensitive receivers.
Plan works site and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out-of-hours work.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Path controls	
Shield stationary noise sources such as pumps, compressors, fans etc.	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained.
Shield sensitive receivers from noisy activities	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

In general, it should be noted that construction noise has formed part of the acoustic characteristic of the project assessment area in recent years. It is understood that the majority of the bulk earthworks associated with Township have been completed. However, construction of individual dwellings throughout the entire Township is still constantly underway. This implies that the potential construction noise impact associated the WRP is not likely to cause additional

disturbance to the residents in a significant manner. This notion is further supported on the basis that no noise complaints were received during the construction for Stage AB and C (as confirmed by the projects team), which included noisier construction activities such as major earthworks and road construction.

4.5 CONSTRUCTION VIBRATION

The most dominant construction vibration sources from the assessed scenarios presented in Table 4.1 are considered to be vibratory rollers which have the potential to result in vibration impacts on nearby sensitive receivers, if appropriate mitigation measures are not implemented.

To assist with assessment of the potential construction, CNVG (2016) provides minimum working distances from sensitive receivers for dominant vibration generating equipment. Table 4.4 presents the indicative safe working distances for the most dominant vibration generating plant. The distances are based on meeting the five millimetres per second limit for cosmetic damage from British Standard (BS) 7385 and human comfort as given in EPA's vibration guidelines.

Table 4.4 Recommended safe working distances for vibration intensive equipment (NSW RMS CNVG)

PLANT ITEM	RATING / DESCRIPTION	MINIMUM WORKING DISTANCE	
		COSMETIC DAMAGE	HUMAN RESPONSE
Vibratory roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 to 20m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small hydraulic hammer	300 kg - 5 to 12t excavator	2 m	7 m
Medium hydraulic hammer	900 kg – 12 to 18t excavator	7 m	23 m
Large hydraulic hammer	1600 kg – 18 to 34t excavator	22 m	73 m
Jackhammer	Hand held	1 m (nominal)	2 m

All identified sensitive receivers are located at least 100 metres or greater from the perimeter of the WRP and Hill 800 Reservoir site. This excludes any further development that may occur closer to the proposed construction areas. It is however understood that any possible development near these construction areas is likely to only occur after the construction of the Stage D WRP. Based on the above, the proposed construction methodologies are not expected to cause significant vibration impact at the identified sensitive receivers.

5 ON-SITE OPERATIONAL NOISE ASSESSMENT

5.1 ASSESSMENT METHODOLOGY

A 3-dimensional computer noise model was created using SoundPLAN version 7.4 to simulate the operation of the WRP. The model accounts for the following:

- The adopted prediction method for the model was the CONCAWE method for calculating the propagation of noise from open-air industrial plants, which is based on separate attenuation values for factors such as spherical spreading, atmospheric absorption, ground effects, meteorological categories, source/receiver height, and barrier effects.

  It is acknowledged that the CONCAWE method is primarily design for noise source to receiver distance of 100 metres to 2 km. For this assessment the noise source to receiver distances are generally less than 100 metres. However, this method is still adopted to allow an assessment that takes into account meteorological conditions per the NPfI (EPA, 2017). To increase the robustness of the modelling and assessment, noise modelling results are compared against actual noise measurement results for the existing WRP, and show good agreement. WSP therefore consider this approach to be acceptable;
- Digitised ground elevation contours in one (1) metre intervals for the terrain of the area surrounding the project site;
- Receivers were modelled at 1.5 metres above ground level for single storey buildings and free field receivers locations;
- Shielding provided by existing building and retaining wall structure on the WRP site.

5.2 MODELLED SOUND POWER LEVELS

5.2.1 WRP

To facilitate the quantification of the likely noise levels associated with proposed ultimate development of the WRP and Hill 800 Reservoir site (see Section 5.2.2), the modelled operational scenario has accounted for the following:

- WRP Stage A, B and Stage C (calibrated using on-site noise survey);
- WRP Stage D, based on the concept design provided by the designer.

The modelled sound power levels of the dominant noise sources are summarised in Table 5.1. The sources of the modelled sound power levels were mostly obtained by on-site measurements. These were input in the noise model to predict the noise levels at the relevant assessment receivers.

Table 5.1 Modelled sound power levels of dominant noise sources – Scenario 1 Stage A, B and Stage C (July 2019)

ITEM	MODELLED SOUND POWER LEVEL (dBA)
A recycle pump	63
Filtrate pump	85
Membrane feed pump	79
R recycle pump	59

ITEM	MODELLED SOUND POWER LEVEL (dBA)
Scum pump	66
WAS feed pump	79
Inlet works - coarse screen	73
Inlet works - fine screen	73
Inlet works - grit classifier	78
Inlet works - washpress	76
Effluent transfer pump (enclosed)	63
Foul air fan (enclosed)	71
Neutralization transfer pump	81
Polymer dosing pump	72
Recycled water transfer pump	85
Site service water pump	71
Sludge dewatering feed pump	65
Tertiary filter feed pump (enclosed)	61
WAS recouperative thickening pump	75
Aeration blower ductwork (enclosed)	42 dBA/metre
Digester blower ductwork	56 dBA/metre
Membrane blower ductwork	34 dBA/metre
Bioreactor membrane tank	56 dBA/m^2
Blower pipework pit	42 dBA/m^2
Centrifuge north block wall	55 dBA/m^2
Centrifuge west roller door	61 dBA/m^2
Foul air fan ductwork	65 dBA/m^2

Regarding Stage D, the adopted sound power levels for Stage D are summarised in Table 5.2.

Table 5.2 Modelled sound power levels of dominant noise sources – Scenario 2 Stage D

ITEM	MODELLED SOUND POWER LEVEL (dBA)[1]
A recycle pump	66
Filtrate pump	88
Membrane feed pump	82
R recycle pump	62
Scum pump	69
WAS feed pump	82
Effluent transfer pump (enclosed)	63

ITEM	MODELLED SOUND POWER LEVEL (dBA)[1]
Polymer dosing pump	72
Recycled water transfer pump	85
Tertiary filter feed pump (enclosed)	61
WAS recouperative thickening pump	75
Pump associated with new aerobic digester	80
Motor associated with the rotary drum thickener	77
Aeration blower ductwork (enclosed)	45 dBA/metre
Bioreactor membrane tank	56 dBA/m^2

5.2.2 HILL 800 RESERVOIR

Dominant noise sources at the reservoir site are described in Table 5.3.

Table 5.3 Modelled sound power levels of dominant noise sources – Hill 800 reservoir site

ITEM	QUANTITY	ASSUMED SOUND POWER LEVEL (dBA)
Within pump station building		
Existing recycle water booster pump	5[1]	85 each
New potable water booster pump	3[2]	85 each
New recycle water booster pump	5[1]	85 each
Chemical dosing		
Chemical dosing pump	4	69 each

(1) Duty/ Assist/ Assist/ Standby plus a separate jockey pump.

(2) Duty/ Assist/ Standby.

5.3 ANALYSIS OF HISTORIC METEOROLOGICAL CONDITIONS

To determine if potentially noise-enhancing meteorological conditions are a feature of the subject development area, 13 months' data of historic meteorological conditions (1 May 2018 to 30 June 2019 inclusive) local to the subject development area have been analysed per procedure described in NPfI. Results of the analysis are presented in Table 5.4.

Table 5.4 NPfI noise-enhancing meteorological conditions analysis – percentage of occurrence

SEASON	DAY	EVENING	NIGHT
Stability categories A–D with light winds blowing from noise source to the north (towards R11 from WRP)			
Summer	<10%	10.4%	28.2%
Autumn	11.3%	23.4%	**48.7%**

SEASON	DAY	EVENING	NIGHT
Winter	<10%	**31.3%**	**40.1%**
Spring	<10%	10.2%	**33.5%**
Stability categories A–D with light winds blowing from noise source to the west (towards Stage 4D from WRP)			
Summer	<10%	19.8%	**43.7%**
Autumn	12.9%	23.2%	21.2%
Winter	12.2%	12.7%	12.5%
Spring	<10%	22.4%	29.6%
Stability categories A–D with light winds blowing from noise source to the southwest (towards Stage 4D from WRP)			
Summer	<10%	16.9%	15.1%
Autumn	<10%	<10%	<10%
Winter	<10%	<10%	<10%
Spring	<10%	13.9%	<10%
Stability categories A–D with light winds blowing from noise source to the south (towards sports field and dog park from WRP)			
Summer	<10%	<10%	<10%
Autumn	<10%	<10%	<10%
Winter	<10%	<10%	<10%
Spring	<10%	<10%	<10%
Stability categories A–D with light winds blowing from noise source to the southeast (towards Stage 9 from WRP)			
Summer	13.3%	12.4%	<10%
Autumn	21.3%	17.7%	<10%
Winter	14.1%	17.2%	<10%
Spring	10.1%	17.3%	<10%

SEASON	DAY	EVENING	NIGHT
Stability category F with winds up to 2 m/s at 10 metres AGL			
Winter, 6 pm to 7 am	-	14.1%	

(1) Analysed using Noise Enhancement Wind Analysis (NEWA) program from NSW Environment Protection Authority's website.

Based on the results of the analysis:

- Potential noise-enhancing meteorological condition (Stability categories A–D with light winds blowing up to 3 m/s) should be considered for receivers in the north and west of the WRP (including all receivers in between these bearings). This will impact on the existing R11 'Talpa' receiver and proposed Googong Stage 4D to the west and northwest.

Consideration of noise-enhancing conditions in the other directions (e.g. in the direction of Googong Stage 9) are not required by the NPfI.

5.4 ASSESSED AVERAGED NOISE LEVELS

5.4.1 WRP

Based on the description provided in Section 5.2 above, noise levels were predicted for the modelled Stage D operational scenario. The receivers covered in this scenario are based on existing and future receivers closest to the WRP site as indicated in Figure 5.1, with the future residential developments represented by yellow lines.



Figure 5.1 Assessed receivers for WRP Stage D operational noise

The results and prediction locations are summarised in Table 5.5.

Table 5.5 Predicted operational noise levels – Stages A, B, C and D (dB $L_{Aeq, 15min}$)

LOCATION	DIRECTION (RELATIVE TO WRP)	OPERATIONAL NOISE CRITERION	PREDICTED OPERATIONAL NOISE LEVELS (dBA, $L_{Aeq, 15min}$)		COMPLY?
			STANDARD METEOROLOGICAL CONDITION	UP TO 3 m/s WIND BLOWING FROM SOURCE TO RECEIVER	
R11 Talpa existing receiver	North	35 dB $L_{Aeq, 15min}$	27	29	Complies
R Stage 4D - 01	West	35 dB $L_{Aeq, 15min}$	32	35	Complies
R Stage 4D - 02	West	35 dB $L_{Aeq, 15min}$	32	35	Complies
R Stage 4D - 03	West	35 dB $L_{Aeq, 15min}$	33	36	Minor 1 dB exceedance
R Stage 4D - 04	West	35 dB $L_{Aeq, 15min}$	31	33	Complies
R Stage 4D - 05	West	35 dB $L_{Aeq, 15min}$	26	28	Complies
R Stage 4D - 06	West	35 dB $L_{Aeq, 15min}$	20	22	Complies
R Stage 4D - 07	West	35 dB $L_{Aeq, 15min}$	19	21	Complies
R Stage 4D - 08	Southwest	35 dB $L_{Aeq, 15min}$	29	Not applicable	Complies
R Stage 4D - 09	Southwest	35 dB $L_{Aeq, 15min}$	22	Not applicable	Complies
R Stage 4D - 10	Southwest	35 dB $L_{Aeq, 15min}$	26	Not applicable	Complies
R Stage 4D - 11	Southwest	35 dB $L_{Aeq, 15min}$	25	Not applicable	Complies
R Stage 4D - 12	Southwest	35 dB $L_{Aeq, 15min}$	28	Not applicable	Complies
R Stage 9 - 01 Rural block	Southeast	35 dB $L_{Aeq, 15min}$	36	Not applicable	Minor 1 dB exceedance
R Stage 9 - 02 Rural block	Southeast	35 dB $L_{Aeq, 15min}$	35	Not applicable	Complies
R Stage 9 - 03 Rural block	Southeast	35 dB $L_{Aeq, 15min}$	33	Not applicable	Complies

LOCATION	DIRECTION (RELATIVE TO WRP)	OPERATIONAL NOISE CRITERION	PREDICTED OPERATIONAL NOISE LEVELS (dBA, $L_{Aeq, 15min}$)		COMPLY?
			STANDARD METEOROLOGICAL CONDITION	UP TO 3 m/s WIND BLOWING FROM SOURCE TO RECEIVER	
R Stage 9 - 04 Rural block	Southeast	35 dB $L_{Aeq, 15min}$	33	Not applicable	Complies
R Stage 9 - 05 Rural block	Southeast	35 dB $L_{Aeq, 15min}$	33	Not applicable	Complies
R Stage 9 - 06 Rural block	Southeast	35 dB $L_{Aeq, 15min}$	32	Not applicable	Complies
R Stage 9 - 11	Southeast	35 dB $L_{Aeq, 15min}$	33	Not applicable	Complies
R Stage 9 - 12	Southeast	35 dB $L_{Aeq, 15min}$	32	Not applicable	Complies
R Stage 9 - 13	Southeast	35 dB $L_{Aeq, 15min}$	32	Not applicable	Complies
Council's depot	West	68 dB $L_{Aeq, 15min}$	46	Not applicable	Yes
Scout's hall	West to southwest	53 dB $L_{Aeq, 15min}$	42	Not applicable	Yes

Based on the predicted noise levels above, the following findings are made:

- The ultimate WRP is predicted to generally comply with the Part 3A approval noise limit at all future receivers within Googong Stage 4D, at the existing 'Talpa' receiver to the north and the non-residential receivers (possible council's depot and scout's hall).
- The only exception is at one Stage 4D lot ("R Stage 4D – 03") where a 1 dB exceedance is predicted during possible noise-enhancing meteorological condition.
- A portion of one proposed rural block within Googong Stage 9 is predicted to exceed the noise limit by up to 1 dB. This exceedance is considered acceptable as 1 dB is generally acoustically negligible. In addition, the majority of the proposed rural block is predicted to meet the noise limit. When developed, the associated dwelling should be construction within the area predicted to be <35 dBA $L_{eq, 15min}$.

In addition to the single point receiver results, noise contour plots associated with the predicted operational noise impact of WRP Stage D are presented in 0 to provide a graphical representation of the assessment.

5.4.2 HILL 800 RESERVOIR

Based on the modelled noise sources as described in Section 5.2.2, the potential noise impact associated with the operation of the Hill 800 reservoir has been predicted for the potentially worst impact receivers in the future Googong Neighbourhood 2 (Figure 5.2). The results are summarised in Table 5.6.



Figure 5.2 Assessed receivers for Hill 800 Reservoir operational noise

Table 5.6 Predicted operational noise levels – ultimate Hills 800 Reservoir (dB $L_{Aeq, 15min}$)

LOCATION	DIRECTION (RELATIVE TO WRP)	OPERATIONAL NOISE CRITERION	PREDICTED OPERATIONAL NOISE LEVELS (dBA, $L_{Aeq, 15min}$)		COMPLY?
			STANDARD METEOROLOGICAL CONDITION	UP TO 3 m/s WIND BLOWING FROM SOURCE TO RECEIVER	
R NH2 - 01	North	35 dB $L_{Aeq, 15min}$	28	28	Complies
R NH2 - 02	East	35 dB $L_{Aeq, 15min}$	27	Not applicable	Complies
R NH2 - 03	South	35 dB $L_{Aeq, 15min}$	29	Not applicable	Complies
R NH2 - 04	West	35 dB $L_{Aeq, 15min}$	27	27	Complies

Based on the predicted noise levels above, the following findings are made:

- Compliance with the Part 3A approval noise limit has been predicted for all future residential receivers, under the noise-enhancing meteorological condition where applicable.

The predicted operational noise impact associated with the Hills 800 reservoir site is presented graphically in the noise contour plot in 0.

5.5 RISK OF SLEEP DISTURBANCE

5.5.1 WRP

During noise monitoring previously conducted at 35 metres to the west of the WRP, several maximum noise events were observed (0). These noise events were observed to be generally <50 dBA Lmax, at a worse case scenario of 35 metres from the WRP boundary.

It is understood that the nature of the existing maximum noise events are not likely to alter as a result of the proposed Stage D expansion. The potential maximum noise levels at the proposed Googong Stage 4D and Stage 9 (and all other residential receivers) are expected to comply with the sleep disturbance screening criterion of ≤52 dBA L_{max}.

5.5.2 HILL 800 RESERVOIR

Based upon a review of the noise sources at the reservoir site, it is understood that noise is expected to be generally steady state. Notable maximum noise events that could increase the risk of sleep disturbance are not expected to occur.

6 ROAD NOISE ASSESSMENT

6.1 CONSTRUCTION

6.1.1 PREDICTED TRAFFIC GENERATION

During construction of the Stage D works, the associated likely peak daily traffic generation is provided in Table 6.1 and Table 6.2. It is understood that these figure are generally adopted from the preceding stage C works as the nature of the works during peak period is generally expected to be similar. It is noted that traffic generation associated with Hill 800 site is expected to entirely utilise Old Cooma Road. On the other hand, construction traffic associated with the WRP will use Googong Road, which will be the emphasis of the road noise assessment.

Table 6.1 Peak construction vehicle movements estimated per day (Hill 800 reservoir)

CONSTRUCTION ACTIVITY	PEAK TRIPS PER DAY	CONSTRUCTION ACTIVITY
Set up/mobilisation	10	Delivery of plant and amenities to site
Earthworks	20	Fuel and materials delivery
Concrete pouring	50	Concrete truck deliveries for reservoir foundation pours
Roadworks	20	Delivery of road base materials
Mechanical/electrical works	10	Delivery and installation of reservoir and booster pump plant and equipment
Removal of waste	10	Demolition of interim reservoir site
Construction staff	20	Construction staff accessing the site
Total	120 heavy vehicles 20 light vehicles	

Table 6.2 Peak construction vehicle movements estimated per day (WRP)

CONSTRUCTION ACTIVITY	PEAK TRIPS PER DAY	CONSTRUCTION ACTIVITY
Construction staff	20	Construction staff accessing the site.
Set-up and mobilisation	20	Delivery of plant and amenities to site.
Roadwork	30	Delivery of road base materials and construction of temporary and permanent roadwork.
Earthworks	15	Preparation and excavation for foundation work.
Concrete works and pouring	40	Concrete truck deliveries and construction of WRP foundations.
Mechanical and electrical	15	Delivery and installation of unit process equipment, pipeline and electrical equipment.
Demolition, restoration and removal of waste	20	Demolition of existing package inlet works, site offices, amenities buildings, and the rehabilitation/landscaping of the site.
Total	140 heavy vehicles 20 light vehicles	

6.1.2 ASSESSMENT

The road noise assessment will be based on the following:

- Old Cooma Road:
  - Category: sub-arterial – noise trigger level of 60 dB $L_{Aeq\ 15hr}$
  - Closest setback distance between receiver and road – approximately 110 metres
  - It is assumed that the predicted total daily peak volumes described in Table 6.1 will use Old Cooma Road during the RNP assessment period between 7 am and 10 pm.
- Googong Road:
  - Category: local road – noise trigger level of 55 dB $L_{Aeq\ 1hr}$
  - Closest setback distance between receiver and road – approximately 40 metres
  - It is assumed that 20% of the predicted total daily peak volumes described in Table 6.2 will use Googong Road during the peak hour.

Based on the assumptions above, the following road noise levels have been predicted:

- 45 dB $L_{Aeq,\ 15hr}$ at 110 metres from Old Cooma Road. This predicted road noise contribution from construction traffic meets the daytime criterion for an arterial road.
- 57 dB $L_{Aeq,\ 1hr}$ at 40 metres from Googong Road. This predicted road noise contribution from construction traffic exceeds the daytime criterion for a local road. It should however be noted that a noise level difference of 2 dB or less is typically not a perceptible change. The predicted exceedance is therefore not considered significant and not likely to cause significant disturbance per the RNP.

6.2 OPERATION

During operations of the subject facilities, only minor volumes of road traffic are expected to be generated. This is expected to be limited to light vehicles used by staff members or service personnel. The additional road noise impact as a result of the operational stage of the facilities is therefore expected negligible.

7 CONCLUSIONS

WSP has been engaged by Googong Township Pty Ltd to conduct a noise impact assessment for the proposed operation and construction of the Stage D Water Recycling Plant (WRP) and the expansion of the Hill 800 Reservoir site located within the Googong Township. The primary objectives of the assessment were:

- Undertake a constriction noise and vibration assessment of WRP Stage D expansion and Hill 800 Reservoir Site;
- Complete a noise assessment of WRP Stage D expansion and Hill 800 Reservoir Site to determine the noise attenuation requirements to achieve compliance with Part 3A Concept Plan Approval for the entire Integrated Water Cycle Project.

7.1 CONSTRUCTION NOISE

Fifteen (15) construction scenarios representing each construction stage of the WRP and Hill 800 Reservoir site Stage D expansion were considered. Construction noise levels for scenarios with the highest and lowest noise emissions were predicted. The noise modelling and assessment were based on the determined standard hours Noise Management Levels (NMLs) in accordance to the ICNG only.

It was indicated that the construction NMLS determined in accordance to the Interim Construction Noise Guideline (ICNG) were exceeded at numerous sensitive receivers, which triggered the requirement to consider feasible and reasonable mitigation strategies. A list of possible mitigation strategies has been provided and should be implemented as far as practical to reduce the construction noise impact.

7.2 CONSTRUCTION VIBRATION

The nearest sensitive receiver is located at least 100 metres away from the perimeter of the WRP and the Hill 800 reservoir site. Based on the recommended safe working distances for vibration intensive equipment likely to be used for the project, the risk of significant vibration impact due to the proposed construction methodology was found to be low.

7.3 OPERATIONAL NOISE

7.3.1 WRP

Accounting for existing WRP A, B and C noise levels as well as the proposed Stage D expansion, the predicted noise impact associated with the ultimate WRP is predicted to comply with the Part 3A conditions of the Project Approval previously granted by the NSW Department of Planning and Infrastructure as well as the sleep disturbance screening criterion per the NPfI. It also complies with the trigger levels at the proposed council's depot and scout's hall. No further specific assessment of mitigation is expected to be required.

7.3.2 HILL 800 RESERVOIR

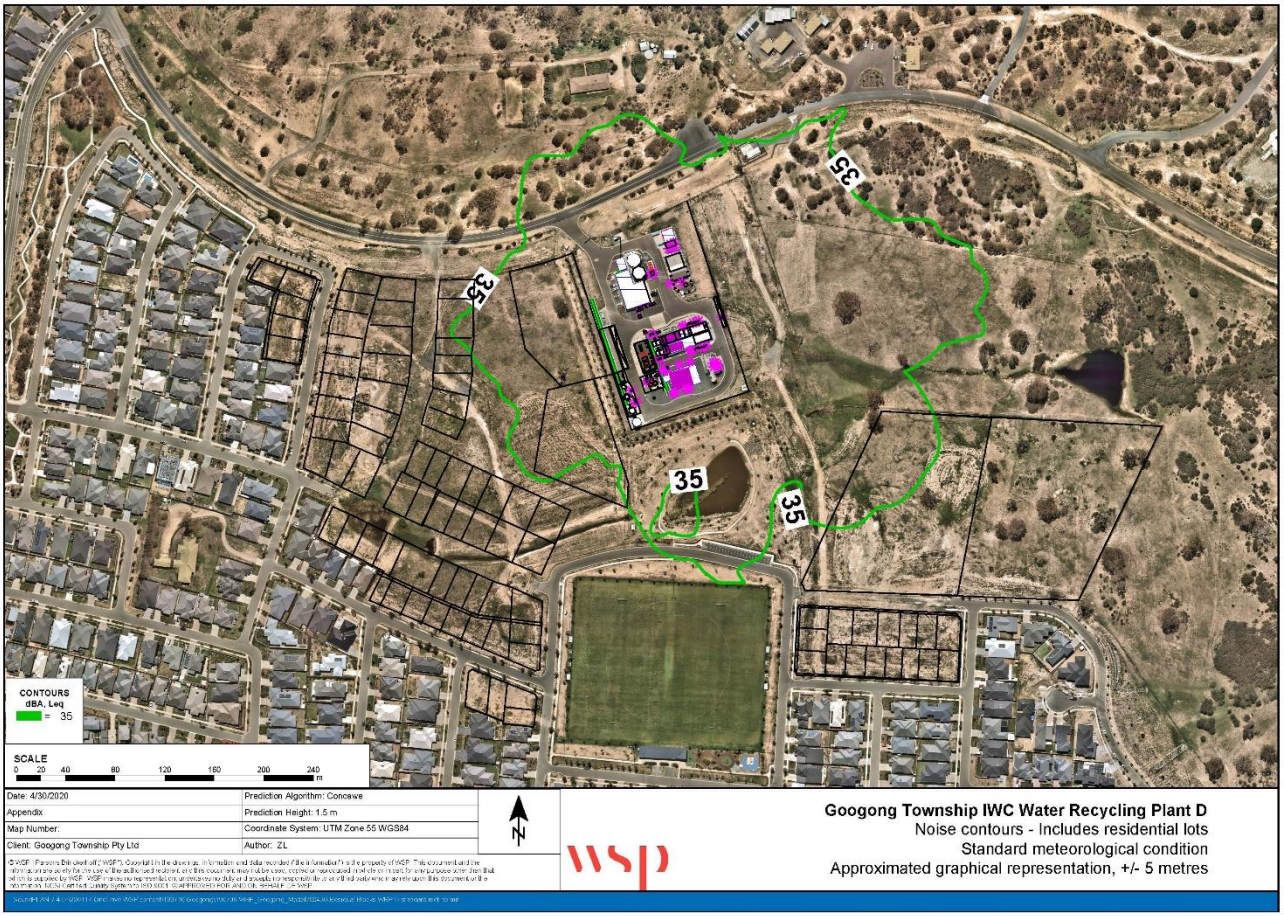
Compliance with the Part 3A conditions has been demonstrated to be achievable at the Hill 800 reservoir site at all existing residential receivers and at all possible future residential receivers within Googong Neighbourhood 2. No further specific assessment of mitigation is expected to be required.

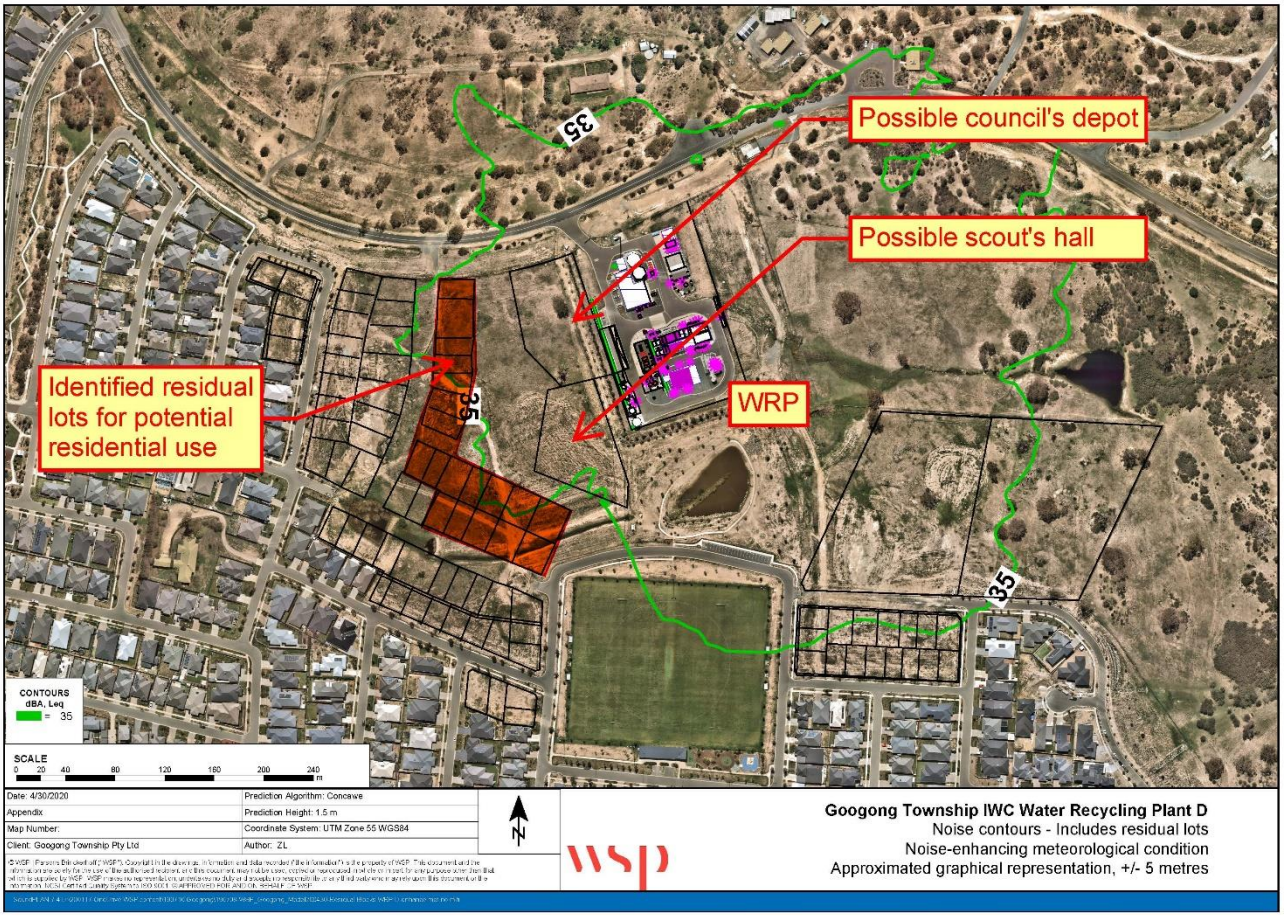
7.4 ROAD TRAFFIC NOISE

Road noise assessment has been conducted for the most impacted receivers on Old Cooma Road and Googong Road. It was found that additional road noise impact during construction and operation of the subject facilities are not likely to be significant and not likely to cause notable disturbance, per the NSW Road Noise Policy.

APPENDIX A

OPERATIONAL NOISE CONTOURS – WRP STAGE D ($L_{Aeq, 15min}$)


35
35
35
35
CONTOURS
dBA, Leq
= 35
SCALE
0 20 40 80 120 160 200 240 m
Date: 4/30/2020
Prediction Algorithm: Concawe
Appendix:
Prediction Height: 1.5 m
Map Number:
Coordinate System: UTM Zone 55 WGS84
Client: Googong Township Pty Ltd
Author: ZL
N
wsp
Googong Township IWC Water Recycling Plant D
Noise contours - Includes residential lots
Standard meteorological condition
Approximated graphical representation, +/- 5 metres


Possible council's depot
Possible scout's hall
Identified residual lots for potential residential use
WRP
35
35
35
CONTOURS
dBA, Leq
= 35
SCALE
0 20 40 80 120 160 200 240 m
Date: 4/30/2020
Prediction Algorithm: Concawe
Appendix:
Prediction Height: 1.5 m
Map Number:
Coordinate System: UTM Zone 55 WGS84
Client: Googong Township Pty Ltd
Author: ZL
N
Googong Township IWC Water Recycling Plant D
Noise contours - Includes residual lots
Noise-enhancing meteorological condition
Approximated graphical representation, +/- 5 metres

APPENDIX B

OPERATIONAL NOISE CONTOURS – STAGE D HILL 800 RESERVOIR ($L_{Aeq, 15min}$)


35
CONTOURS
dBA, Leq
= 35
SCALE
0 15 30 60 90 120 150 180
m
Date: 4/15/2020
Prediction Algorithm: Concawe
Appendix to REF report
Prediction Height: 1.5 m
Map Number: Appendix B
Coordinate System: UTM Zone 55 WGS84
Client: Googong Township Pty Ltd
Author: ZL
N
wsp
Googong Township IWC
Noise contours - Stage D Hill 800 Reservoir operational noise
Noise-enhancing meteorological condition
Approximated graphical representation, +/- 5 metres

APPENDIX C

WRP C ATTENDED NOISE MONITORING

A1 NOISE MONITORING LOCATIONS AND METHOD

The noise monitoring locations are shown in Figure 0.1 and described in Table 0.1. The noise monitoring locations are located at 35 metres and 75 metres offset west of the WRP site boundary. It is understood that these setback distances represent the two potential development scenarios where the nearest future residential dwellings will be located.

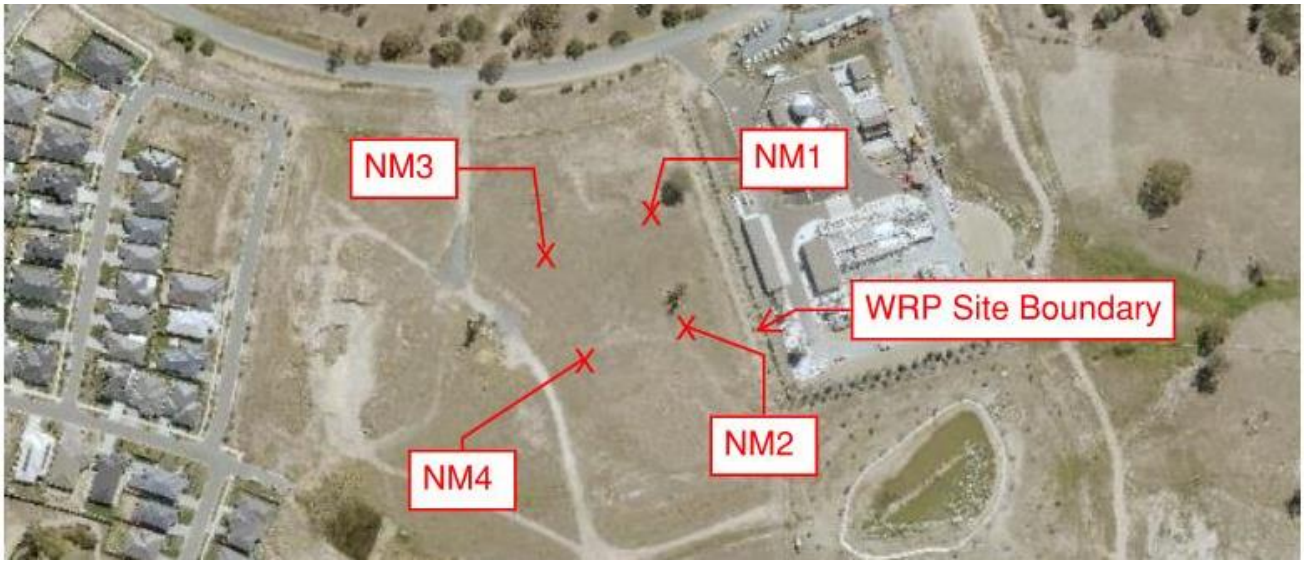


Figure 0.2 Noise monitoring locations

Table 0.2 Noise monitoring locations description and equipment information

LOCATION	DESCRIPTION	EQUIPMENT
NM1	At 35 metres from WRP boundary with direct straight line of sight to the pipework out of the blower building.	NTI XL2 S/N A2A-05718-E0
NM2	At 35 metres from WRP boundary with direct straight line of sight to the foul air fans and filtrate tanks.	Norsonic Nor140 S/N 4294981
NM3	At 75 metres from WRP boundary with direct straight line of sight to the pipework out of the blower building.	SVANTEK 958 S/N 36659
NM4	At 75 metres from WRP boundary with direct straight line of sight to the foul air fans and filtrate tanks.	ARL EL-316 S/N 16-207-008

All equipment were last calibrated by a NATA-approved laboratory less than two years ago and have current calibration certificates as required in AS1055:2018. The in-field calibration was checked before and after the measurements and no significant drift (greater than ±0.5 dB) was observed (using Rion NC-74 acoustic calibrator S/N 34315156).

As previously discussed, the WRP has been identified as the dominant industrial noise source affecting the proposed development area. All attended noise monitoring is therefore conducted between 7.00 pm to 10.00 pm, which is understood to be a peak operational period of the WRP.

A2 NOISE MONITORING RESULTS

The results of the operator-attended noise monitoring are tabulated in Table 0.3.

Table 0.4 Measured noise levels, operator-attended noise monitoring

COMPLIANCE LOCATION & MEASUREMENT TIME	MOST STRINGENT PROJECT SPECIFIC TARGET LEVELS	MEASURED/ESTIMATED WRP $L_{Aeq\ 15min}$ NOISE LEVELS (dB)[1]	OBSERVED WRP $L_{AFmax\ 15min}$ NOISE LEVELS (dB) [1]
Location NM1 (35 metres west of WRP site boundary)			
26 June 2019 8.46 pm to 9.16 pm	48 dB $L_{Aeq,\ 15min}$ (amenity) Sleep disturbance screening: 40 dB $L_{Aeq,\ 15min}$,52 dB L_{AFmax}	39-40	<50
Location NM2 (35 metres west of WRP site boundary)			
21 June 2019 9.10 pm to 9.40 pm	48 dB $L_{Aeq,\ 15min}$ (amenity) Sleep disturbance screening: 40 dB $L_{Aeq,\ 15min}$,52 dB L_{AFmax}	41	<45
26 June 2019 7.53 pm to 8.23 pm		40-41	<45
Location NM3 (75 metres west of WRP site boundary)			
26 June 2019 8.30 pm to 9.00 pm	48 dB $L_{Aeq,\ 15min}$ (amenity) Sleep disturbance screening: 40 dB $L_{Aeq,\ 15min}$,52 dB L_{AFmax}	36	<45
Location NM4 (75 metres west of WRP site boundary)			
21 June 2019 8.42 pm to 9.12 pm	48 dB $L_{Aeq,\ 15min}$ (amenity) Sleep disturbance screening: 40 dB $L_{Aeq,\ 15min}$,52 dB L_{AFmax}	35	<45
26 June 2019 7.50 pm to 8.20 pm		36-37	<45

(2) Estimated noise contribution from WRP (or all industrial noise sources) only. Extraneous noise sources (e.g. wind induced noise, road traffic, general neighbourhood noise) excluded.

Based on WSP's observations and the results reported in Table 0.5, the following findings are made:

- At all noise monitoring locations:
  - The acoustic environment is generally dominated by noise from the WRP.
  - The observed noise from the WRP did not contain notable attention-drawing characteristics. This is demonstrated in the analysis of the one-third octave band

samples as presented in Figure 0.3 and Figure 0.4.

- Other noise source affecting these locations are distant road traffic, local Googong road traffic and general neighbourhood noise. When the nearby sports field was in use, the noise monitoring locations were also affected by sports activities (ball sports) and public announcement (PA) system.

- At a setback distance of 35 metres west of the WRP boundary:
  - The measured equivalent noise levels ($L_{Aeq, 15min}$) due to the existing WRP (Stages AB and C) are in the range of 39 to 41 dB $L_{Aeq, 15min}$..
  - The NPfI requires that exceedance of the sleep disturbance screening criteria be subject further maximum noise level assessment. Observed maximum noise events from all industry are below the prescribed L_{AFmax} screening criterion for sleep disturbance. Risk of sleep disturbance is therefore expected to be minimal.
- At a setback distance of 75 metres west of the WRP boundary:
  - The measured equivalent noise levels due to the WRP (Stages AB and C) are in the range of 35 to 37 dB $L_{Aeq, 15min}$.
  - Observed maximum noise events from all industry are below the prescribed L_{AFmax} criterion.

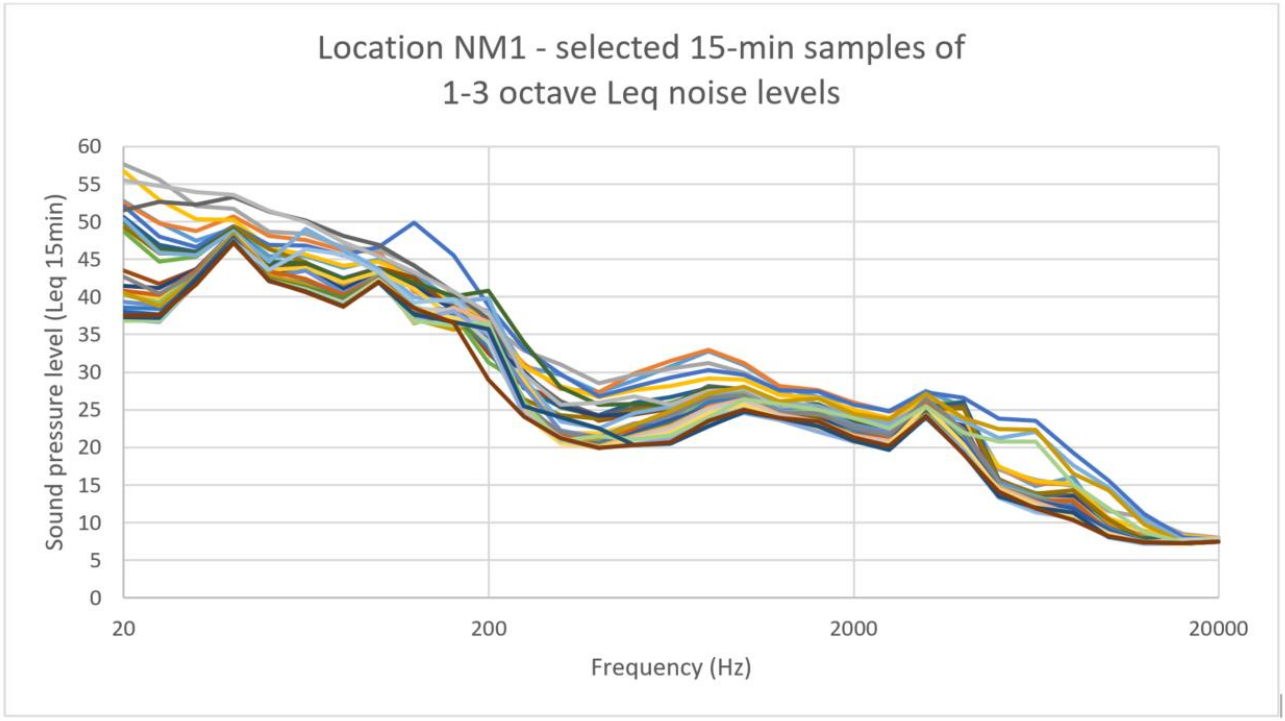


Figure 0.5 1-3 octave $L_{eq\ 15min}$ samples – Location NM1

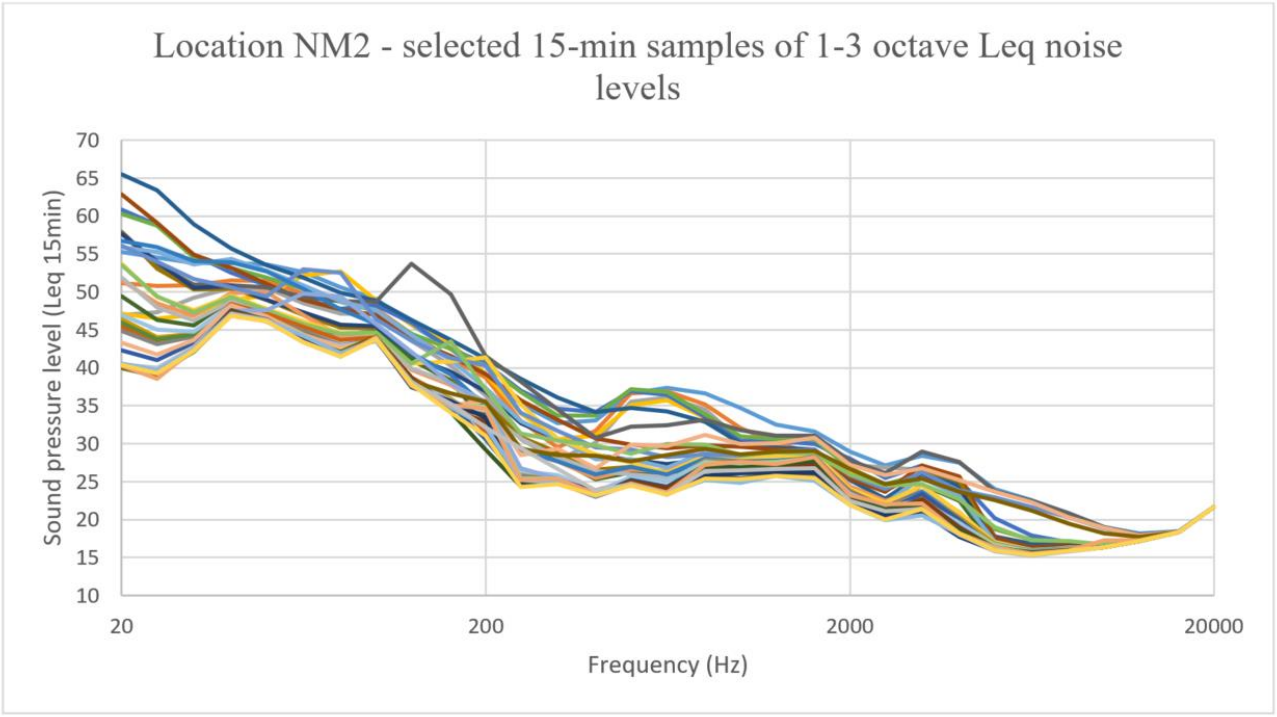
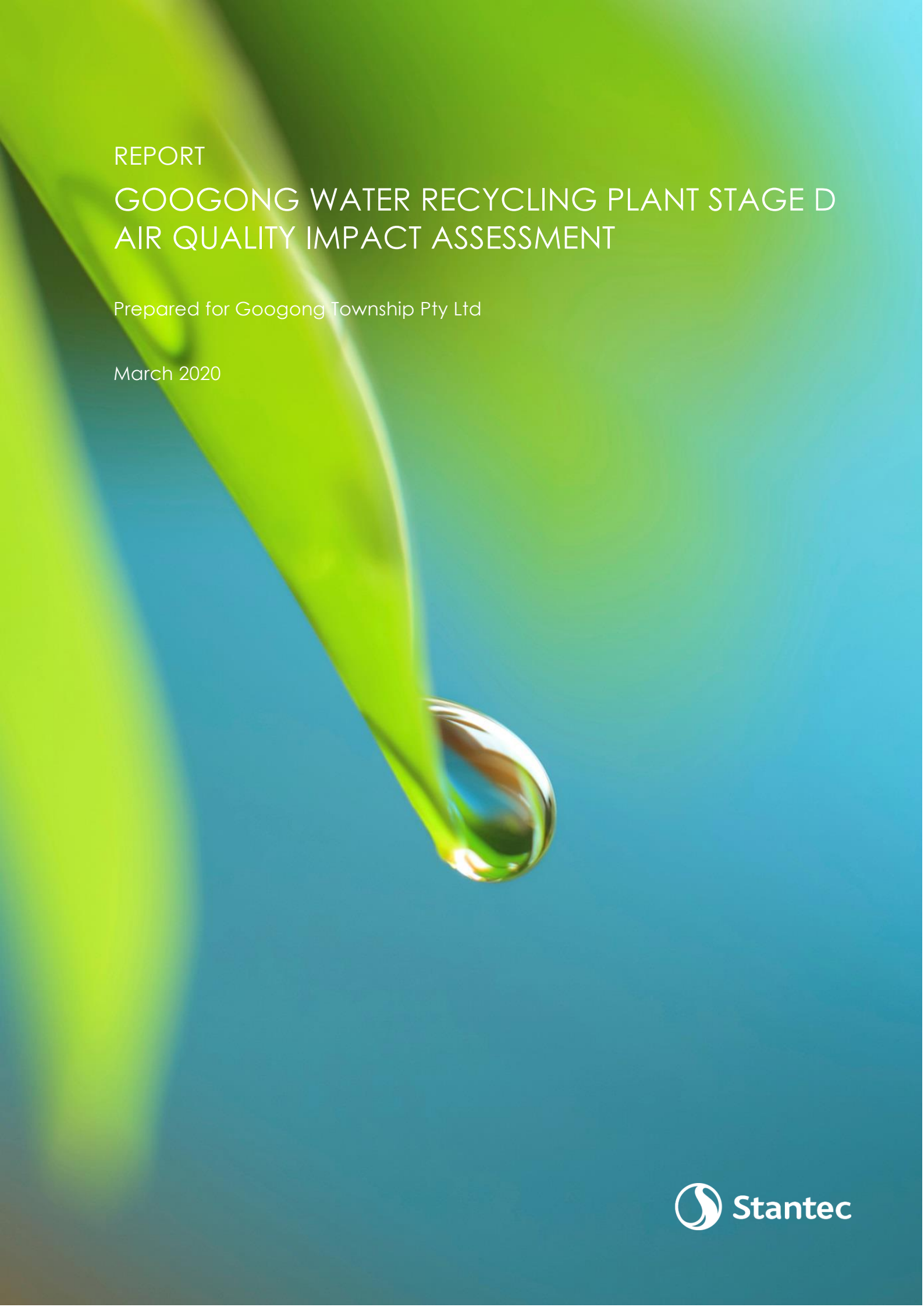


Figure 0.6 1-3 octave $L_{eq\ 15min}$ samples – Location NM2

Project No PS106081
Googong Water Recycling Plant
Stage D REVIEW OF
ENVIRONMENTAL FACTORS
Construction and Operational Noise
Assessment
Googong Township Pty Ltd

Appendix H Air quality assessment



REPORT

GOOGONG WATER RECYCLING PLANT STAGE D AIR QUALITY IMPACT ASSESSMENT

Prepared for Googong Township Pty Ltd

March 2020

Stantec

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QUALITY STATEMENT

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CHECKED BY		
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REVIEWED BY		
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REVISION SCHEDULE

Rev No	Date	Description	Signature or Typed Name (documentation on file).			
			Prepared by	Checked by	Reviewed by	Approved by
A	31/08/2016	Draft	DB	JM	AS	AS
B	15/11/2017	Final	JLM	AS	AS	AS
C	20/11/2017	Updated with GTPL comments	JLM	AS	AS	AS
D	23/11/2017	Updated with GTPL comments	JLM	AS	AS	AS
E	20/12/2017	With updated lotting	SS/DG	AS	AS	AS
F	30/03/2020	With updated lotting	JG	AS	AS	GH

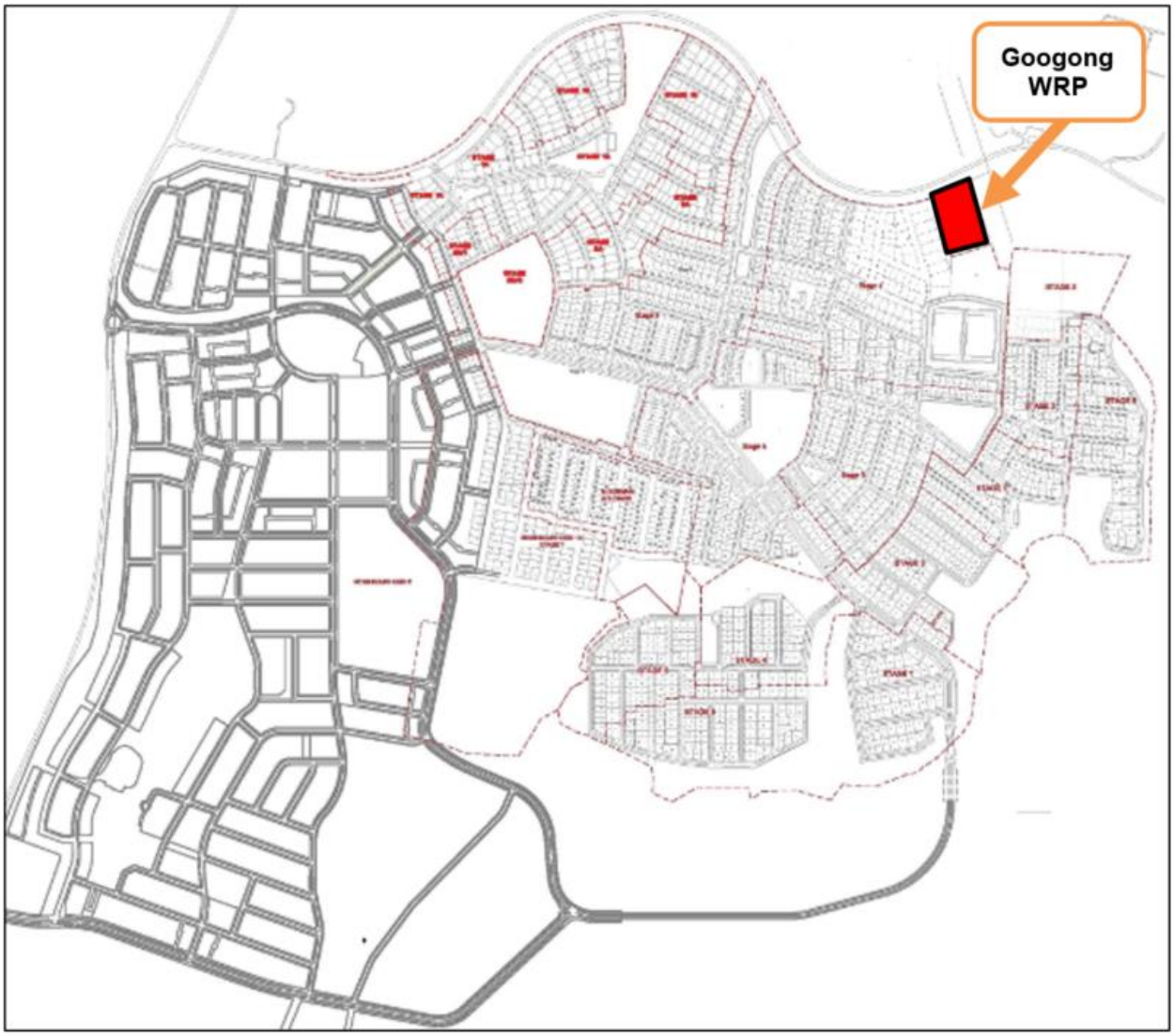
Executive Summary

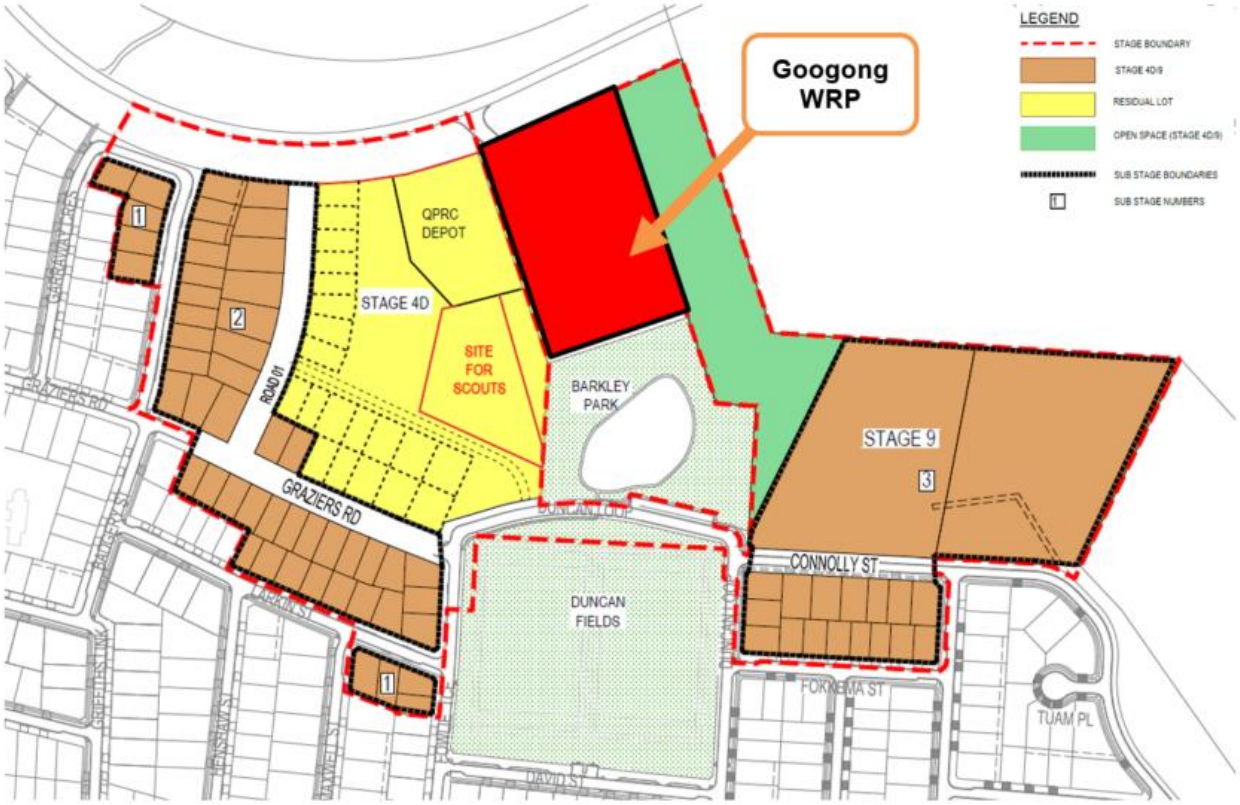
Introduction

This report has been prepared to establish the potential for odour nuisance and dust air quality impacts associated with the construction and operation of the WRP at Stage D (the ultimate development of the WRP) so as to support the updates and augmentation of the WRP site. The predicted odour impact sets the need to plan for distance between the WRP and odour sensitive receptors.

Stantec Australia Pty Ltd (Stantec), previously MWH Australia Pty Ltd (MWH), was commissioned by Googong Township Pty Ltd (GTPL) to prepare an air quality assessment in support of GTPL's proposed Stage D expansion of the Googong Water Recycling Plant (WRP), which is located off Googong Road in Googong, Queanbeyan, New South Wales, as shown in the diagram below.

The GTPL Planning proposal for NH1A stage 4D includes for additional residential lots to the west of the WRP. This Planning proposal is in parallel with the Stage D expansion of the WRP with additional lots also proposed in the future. The latest lot plan, including these additional plots for NH1A stage 4D, is shown in the diagram of the Googong township below. The location of the WRP in relation to the Googong township is also shown in this diagram.





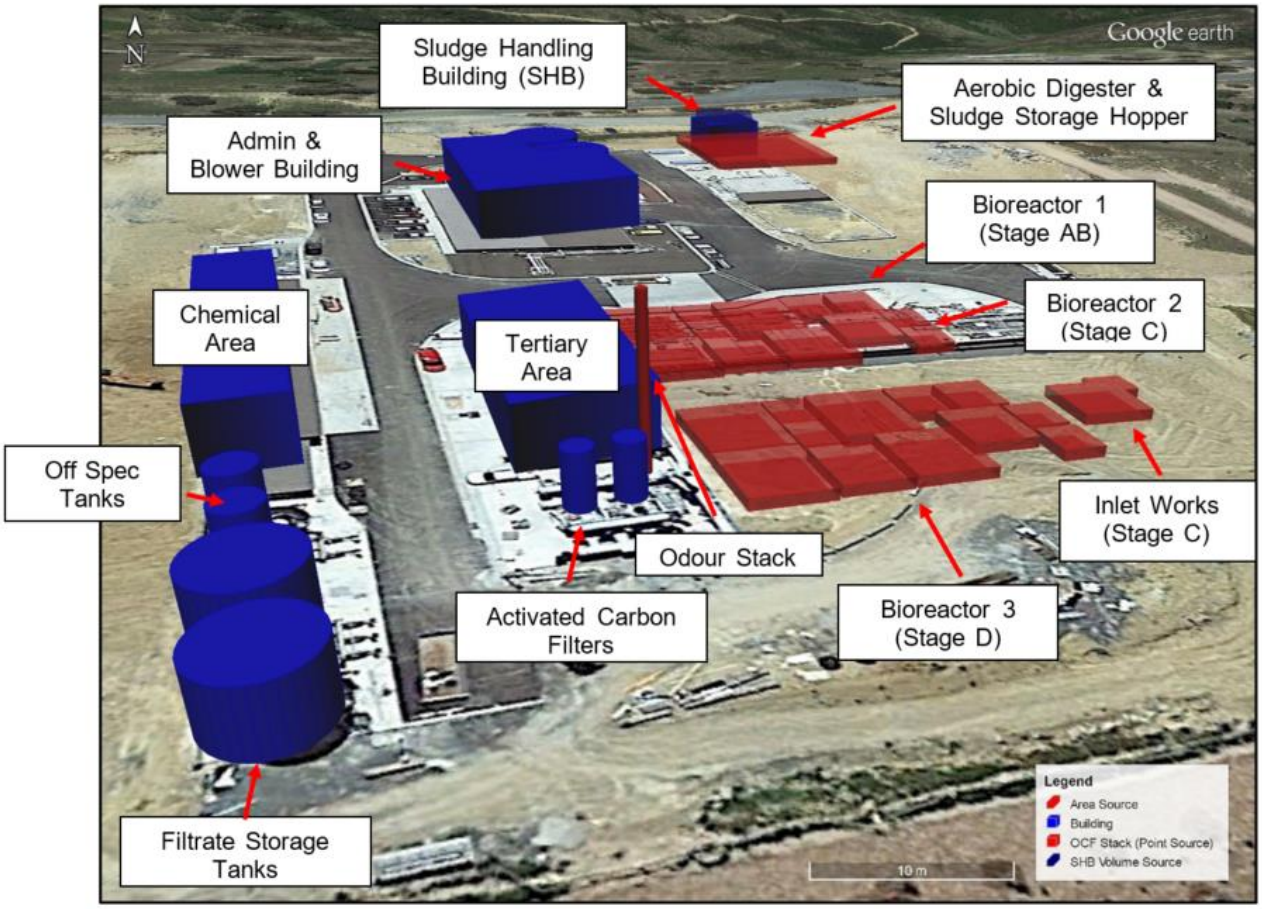
WRP Planned Expansion to Stage D

The WRP receives wastewater from the Googong township and uses a number of mechanical and biological processes to treat the wastewater to allow it to be recycled. The WRP has been designed and installed to be increased in capacity as the Googong township is developed.

The first stage of the WRP (known as the Stage AB WRP) has been operational since October 2015. The Stage C expansion, which was completed in 2018, involved the augmentation of the WRP with a new inlet works (replacing the existing inlet works), a new bioreactor, additional aerobic digestion capacity and a number of other modifications to increase the plant capacity.

The proposed Stage D expansion will provide further bioreactor and aerobic digester capacity in addition to other modifications to increase the plant capacity. The proposed Stage D expansion will provide the ultimate capacity for the WRP.

The main structures and facilities at the WRP that will comprise up to and including Stage D are shown in the diagram below.



Location of the Emission Sources Input into the Odour Impact Assessment Model

The planned odour control, for all stages of development of the WRP, is that all odorous sources at the WRP are enclosed or covered, with the odorous air from under the covers extracted and passed through an Odour Control Facility (**OCF**) before the treated air is discharged to atmosphere via a stack. Biosolids are treated in a dedicated building, with odour extraction and control being applied to equipment inside the building.

Given the extent of odour control currently, and to be, installed, there are no significant uncontrolled odour sources on site.

Analysis of the odour emission rates input into the model indicates that the principal emission sources at the Googong WRP (Stage D) will be the OCF stack (SRC_1) and SHB (SRC_2), as indicated below:

- SRC_1 OCF Stack 3,735 ou.m^3/s (or 91.67% of the total site odour emissions)
- SRC_2 SHB 278 ou.m^3/s (or 7.68% of the total site odour emissions); and
- Total Area Sources 23.6 ou.m^3/s (0.65% of the total site odour emissions).

Conservatism in Odour Modelling

The odour impact modelling undertaken for this Report is based on the conservative approaches of:

- Using odour emission data that has been used from the inception of the design of the Googong WRP, and which are *many times* greater than actual odour emission values measured in 2016. The detailed reasoning for this is shown in Section 2.6 of this Report but some examples of conservatism include:
  - Most area sources modelled using approximately 8-10 times the odour emission than measured during 2016

  - The dominant emission from the entire site, and that which has the highest overall Odour Emission Rate (OER) is the OCF stack. The odour concentration in the stack was estimated as 500 ou in 2009 based on the use of activated carbon adsorption (filtration) to treat the foul air. The installed system is designed based on provision of a guarantee of 500 ou at the stack and monitoring data confirms this is currently being achieved. The OCF stack discharge concentration is not anticipated to significantly increase so long as the system is operated and maintained correctly (primarily meaning activated carbon media is changed at the appropriate time) and as such the 500 ou value has also been adopted for the Stage D assessment.
  - The only volume source, the Sludge Handling Building, modelled using over 4 times the maximum odour measured in 2016. For conservatism, it was assumed that the total area of the opening(s) on the leeward side(s) of the building is 78.32 m^2 (based on 4.4 m multiplied by 8.9 m multiplied by 2, i.e. two walls of the building). This is highly conservative as normal operation has all openings on the Sludge Handling Building closed.
- Using conservative odour leakage rates from the covered / enclosed areas of the WRP. Some odour leakage is always present, however the values used for this in the Report are considered conservative.
- Using the most stringent of the NSW EPA's odour impact criteria as the criterion applicable to this Air Quality Impact Assessment.
- Continuous operation (24 hrs per day, 7 days per week) has been assumed for odour emitting processes, when in reality operation will be intermittent.
- For this Report, to establish a conservatively high estimate of peak odour concentrations, a peak-to-mean ratio (P/M60) of 2.3 has been adopted, corresponding to near-field receptors, as required by the NSW EPA. In other words, the 1-hour mean ground level odour concentrations predicted by the model have been multiplied by a factor of 2.3 to give the results presented in Section 2.5.

Odour Impact Criteria

The aim of the air quality assessment is to determine the potential for odour nuisance impacts associated with the proposed Stage D Googong WRP.

In NSW, odour impact regulations are based upon the likelihood of odour nuisance, i.e. the likelihood of emitted odours creating a negative impact on people, occurring. In NSW, the term "sensitive receptor" is used. A sensitive receptor is a location where people are likely to be e.g. a residence, a school, a hospital, a recreation area. The NSW EPA has set odour impact criteria – odour units (**ou**) - to be assessed at sensitive receptors.

The NSW EPA has set out a sliding scale of odour impact criteria, based on the size of the potentially impacted population. The larger the potentially impacted population, the greater the possibility that a person who is highly sensitive to the odour may be present. Therefore, the sliding scale ranges from 7 ou for an isolated residence down to 2 ou for an urban population, a school, a hospital or a park. For this Report, **the 2 ou odour impact criterion** has been used as the assessment criterion to be met, as shown below:

Population of Affected Community	Impact Assessment Criteria (ou)
Urban area (>2,000)	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single residence (<2)	7.0

Odour Impact Assessment Methodology

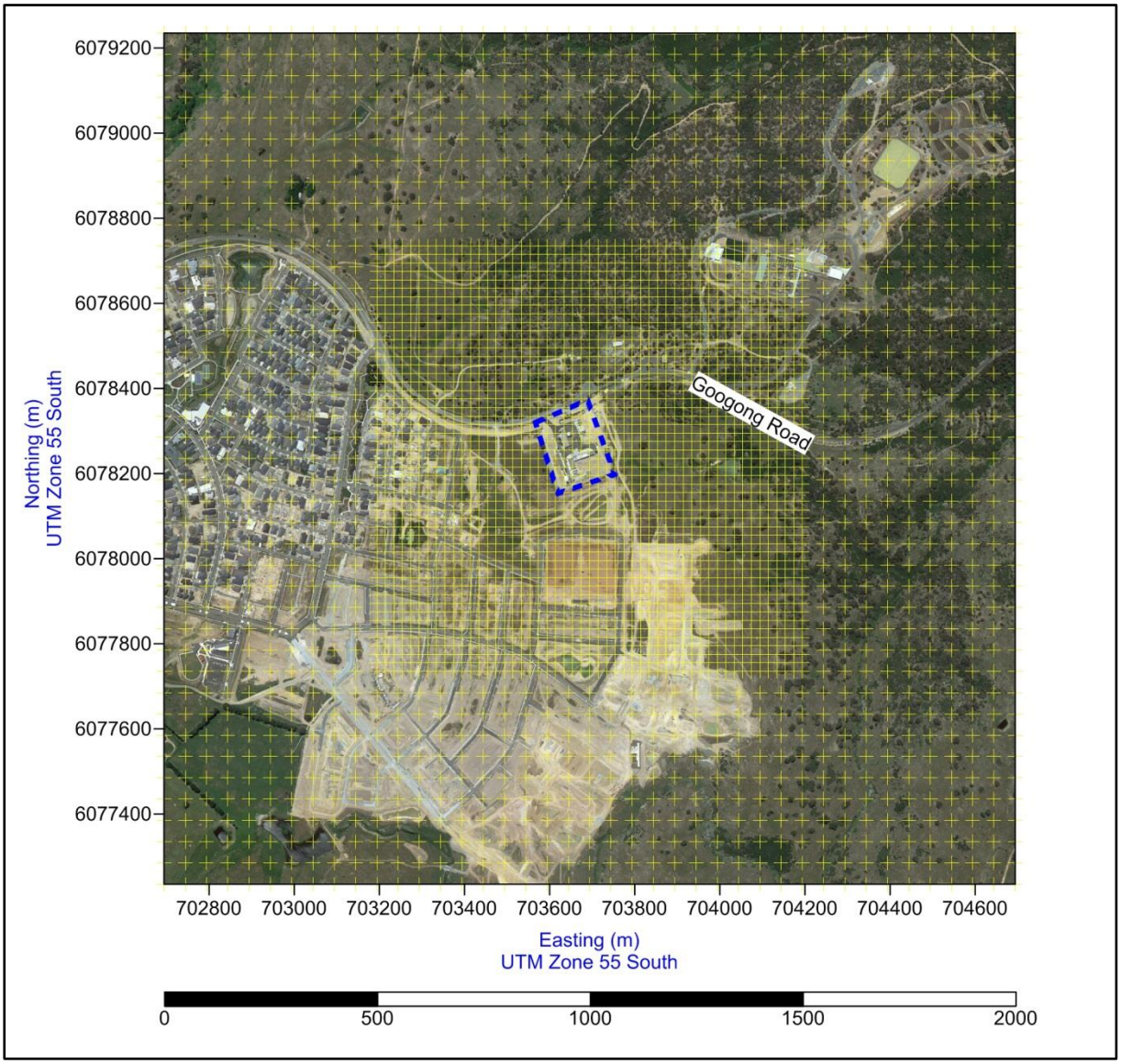
The potential for odour impacts in the community surrounding the WRP has been assessed in this report on a quantitative basis using the CALPUFF atmospheric dispersion model, one of the methods approved by the NSW EPA. The model was set up and run in accordance with the recommendations of the NSW EPA.

The meteorological data used in the models, based on site measured data, shows a high frequency of conditions typical of stability class “D” and class “F”, indicative of neutral to stable conditions which will neither enhance nor impede atmospheric pollutant dispersion. A neutral atmosphere neither enhances nor inhibits mechanical turbulence and, as a result, the vertical and lateral diffusion of a given atmospheric pollutant may be expected to be of a small to moderate scale.

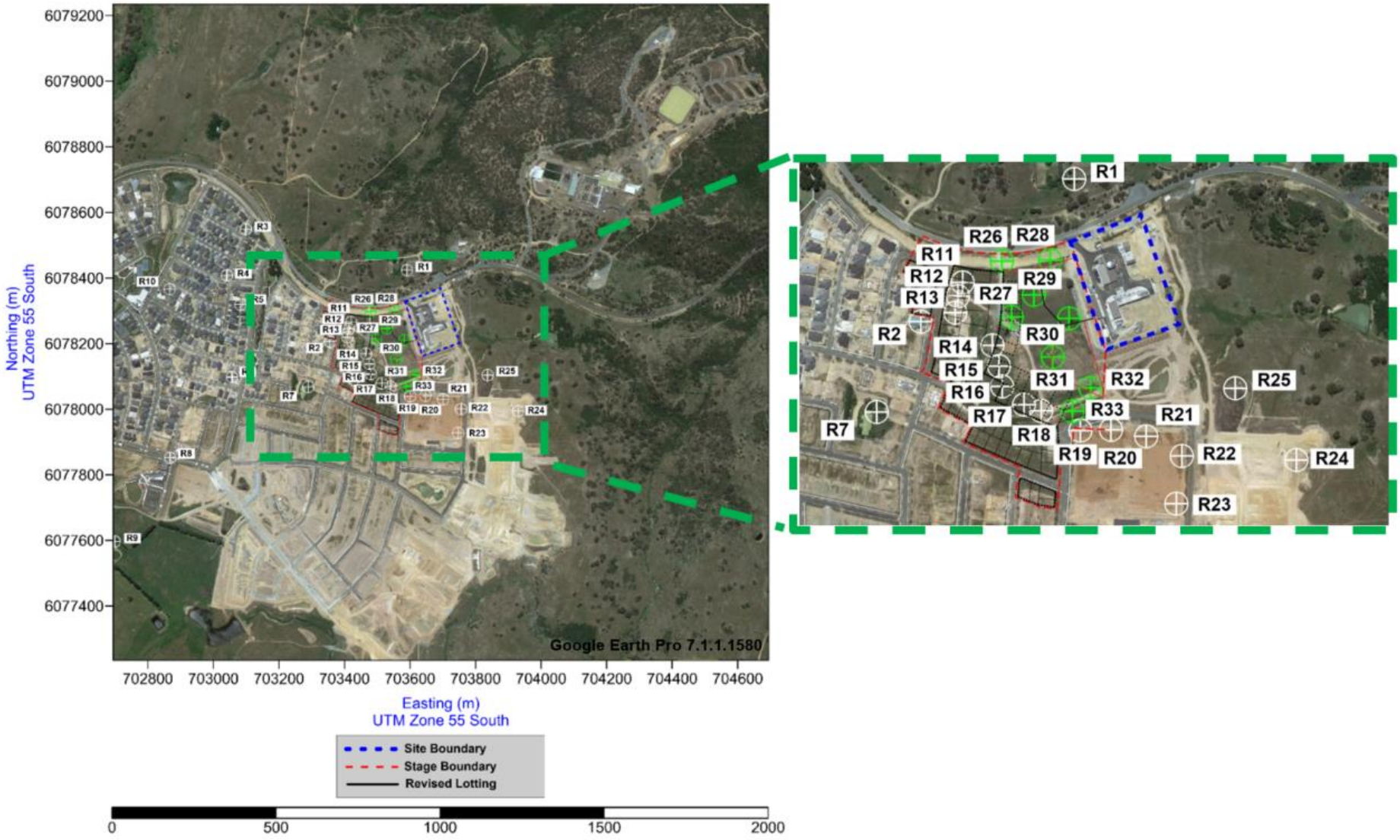
The predicted ground-level odour concentrations were compared against the NSW Office of Environment and Heritage (NSW OEH) odour impact assessment criterion of 2 ou (the most stringent of the criteria). As required, this 2 ou was assessed at the 99th percentile of predictions, and the 2 ou was at the predicted duration of the nose-response-time average, taken to be 1 second.

In order for the modelling of odour impacts to occur, receptor locations need to be set up in the model. In the modelling undertaken for this Report, several sets of receptors were set up, as follows:

- 113 plant boundary (fence line) discrete receptors were input into the model at a 5 m spacing along the WRP site boundary. The WRP fence line is shown as the blue broken line in the diagram below
- At every 20 metres for the 1 km by 1 km area centred on the WRP location (shown as yellow crosses in the diagram below), then
- At every 50 metres up to the boundary of the 2 km by 2 km area centred on the WRP location (also shown as yellow crosses in the diagram below)



In addition, 33 sensitive receptors (locations where members of the public are likely to be, see Section 2.3.3) were also input into the model. Receptors 1 to 25 (R1 to R25 in the diagram below) are associated with the development stages incorporated in WRP Stages A, B and C. Receptors 26 to 33 (R26 to R33 shaded green in the diagram below) are locations associated with GTPL Planning proposal for NH1A stage 4D.


Northing (m)
UTM Zone 55 South
6079200
6079000
6078800
6078600
6078400
6078200
6078000
6077800
6077600
6077400
Google Earth Pro 7.1.1.1580
702800
703000
703200
703400
703600
703800
704000
704200
704400
704600
Easting (m)
UTM Zone 55 South
Site Boundary
Stage Boundary
Revised Lotting
0
500
1000
1500
2000
R1
R2
R3
R4
R5
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
R26
R27
R28
R29
R30
R31
R32
R33

For each of these receptors, the odour concentration at each receptor for each hour of the year was calculated and recorded within the model i.e. for each location about 8,700 values were recorded. In accordance with EPA requirements, at each location, the reported odour concentration was at the 99th percentile of those 8,700 values at each location. Details of how the model was run are contained within this Report.

Dust Management

The dust management assessment indicates that there will not be a significant risk of adverse air quality impact associated with dust during the operation of the Stage D WRP. During construction, there is a potential for impacting on the air quality due to a number of activities as shown below. For each risk a proposed mitigation method has been recommended and will primarily be addressed via the the future Contractor's CEMP. These mitigation measures are consistent with those adopted for construction of the existing Stage AB and C WRP.

Risk	Mitigation
Dust generation due to general construction activities	The CEMP will include typical dust suppression measures. Nuisance dust will be minimised by: • Employment of water trucks and/or use of WRP recycled water system to reduce dust in dry, windy conditions. • Reducing speed limits during high dust conditions • Clearing vegetation and topsoil only within the designated footprint • Progressive reinstatement of disturbed areas
Dust generation due to construction activities such as rock excavation	Rock excavation will be conducted at appropriate times, with consideration of site conditions and sensitive receivers.
Adverse weather conditions and potential for dust storms	Working practices will be modified during periods of high winds by limiting the use of some machinery, particularly when in close proximity to dwellings in addition to reducing travel speeds of vehicles.
Adverse impacts on air quality due to smoke and other conditions	The burning of material on site will be prohibited on site, except under the instruction of fire services.
Emissions from vehicle use	Vehicles will be well maintained to ensure emissions are kept to the minimum practicable.

Results and Recommendations

Odour Management

The dispersion modelling study revealed that:

- Odour emissions were concentrated at the Stack (91.67% of total site emissions).
- Odour concentrations were predicted to be less than 2.0 ou at any existing or future sensitive receptor location (including residences, a school, public parks and recreations grounds) after the implementation of comprehensive odour control at the Googong WRP under Stage D – including an Odour Management Plan for odour risk from abnormal operations (as detailed in Section 5.3) This is shown in graphical format in the diagram below.

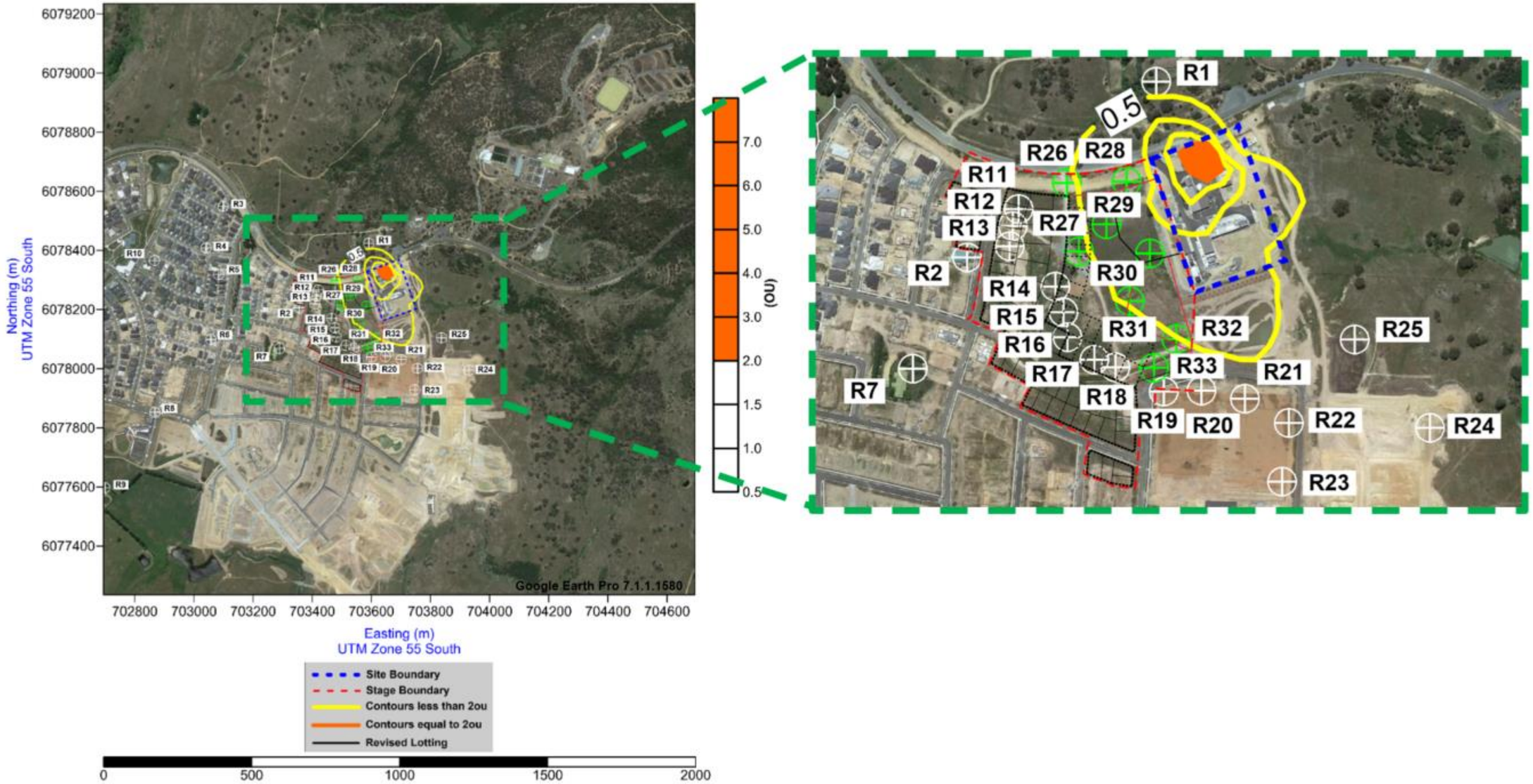
Given that the odour impact criterion for the Assessment was 2 ou, ***the modelling results show that NSW EPA odour impact criterion is met at all locations outside of the WRP.*** Given this, the

likelihood of odour nuisance from odour emissions from the WRP under normal operating conditions is very low.

Dust Management

The dust management assessment indicates that there will not be a significant risk of adverse air quality impact associated with dust during the operation of the Stage D WRP.

It is recommended that the risk mitigation measures are developed further as the construction methodology (and particularly the Construction Environmental Management Plan (CEMP)) are developed.


Northing (m)
UTM Zone 55 South
6079200
6079000
6078800
6078600
6078400
6078200
6078000
6077800
6077600
6077400
Google Earth Pro 7.1.1.1580
702800
703000
703200
703400
703600
703800
704000
704200
704400
704600
Easting (m)
UTM Zone 55 South
Site Boundary
Stage Boundary
Contours less than 2ou
Contours equal to 2ou
Revised Lotting
0
500
1000
1500
2000
7.0
6.0
5.0
4.0
3.0
2.0
1.5
1.0
0.5
(OU)
R1
0.5
R26
R28
R11
R12
R13
R27
R29
R2
R30
R14
R15
R16
R31
R32
R25
R17
R33
R21
R7
R18
R19
R20
R22
R24
R23

Googong Township Pty Ltd

Googong Water Recycling Plant Stage D Air Quality Assessment

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1 Introduction

1.1 Project Overview

The aim of this Stage D air quality impact assessment is to determine the potential for odour nuisance and dust air quality impacts associated with the construction and operation of the proposed Stage D Googong WRP). Stantec Australia Pty Limited (Stantec) was commissioned by Googong Township Pty Ltd (GTPL) to prepare an air quality assessment accordingly, for the future Stage D expansion of the Googong Water Recycling Plant (WRP), which is located off Googong Road in Googong, Queanbeyan, New South Wales (NSW).

The Stage AB WRP has been operational since October 2015. The Stage C expansion was completed in 2018.

The Stage C works involved the augmentation of the WRP with a new inlet works (replacing the existing inlet works), a new bioreactor, additional aerobic digestion capacity and a number of other modifications to increase the plant capacity.

The Stage D expansion will provide the ultimate capacity and is currently anticipated to be completed in 2023. The Stage D expansion will provide further bioreactor and aerobic digester capacity in addition to other modifications to increase the plant capacity.

In NSW, odour impact regulations are based upon the likelihood of odour nuisance, i.e. the likelihood of emitted odours creating a negative impact on people, occurring. In NSW, the term “sensitive receptor” is used. A sensitive receptor is a location where people are likely to be e.g. a residence, a school, a hospital, a recreation area.

The SP2 zone is the area that contains the WRP.

The potential for odour nuisance impacts in the surrounding community has been assessed in this report on a quantitative basis using the CALPUFF atmospheric dispersion model. This report also provides discussion of a number of additional considerations including:

- A comparison of measured odour emission rates and those used in the air quality assessment
- Review and discussion of the predicted Stage C and Stage D odour impact
- Discussion of any potential buffer zone including risk associated with abnormal operation
- Discussion of the potential impact of uncovering areas of plant at Stage D
- Proposed subdivision layout for NH1A Stage 4D west of the SP2 zone

The results of the present dispersion modelling are consistent with the findings of Stantec’s previous odour impact assessments. Refer to technical memorandum dated 3 November 2014 entitled *‘Googong WRP Odour Dispersion Modelling Assessment’* for the ultimate Googong WRP (Stage D) site layout, and Stantec’s report dated June 2016 entitled ‘Googong Water Recycling Plant Stage C Air Quality Assessment’.

A number of odour control measures for the Stage D Googong WRP are presented in Section 2.6.

1.2 Study Overview

This report seeks to quantify the potential odour impacts at the nearest identified sensitive receptors and the risk of dust generation during the construction and operation of Stage D of the Googong WRP, and to make recommendations regarding the control of dust and odour emissions at the WRP, where required.

In order to determine the potential for odour nuisance effects in the surrounding community due to odorous emissions during the operation of Stage D of the Googong WRP, Stantec undertook an atmospheric dispersion modelling study using CALPUFF to assess the existing and proposed odour emissions at the site and their potential to cause nuisance effects beyond the site boundary.

This report has taken into consideration the following sources of information, reports and/or drawings:

- The most up-to-date site layout plan for Googong WRP Stage D (Stage D Site Plan submitted as part of the Stage D Concept Design., 300201413-01-001-G005, dated 17.02.2020);

- The most up-to-date overall lot plan for the Googong township development, referred to as the PDF document entitled 'Googong Stage 4D/9 Staging Plan 18-000755 D020'; and,
- Odour monitoring report prepared by AirLabs Environmental Pty Ltd for the Googong WRP, dated 9 May 2016.

1.3 Study Location

The Googong WRP is located off Googong Road in Googong, NSW, approximately 7 km south of Queanbeyan and 16 km south-east of Canberra. The Googong WRP is located at 703694 metres East and 6078235 metres North Universal Transverse Mercator (UTM) Zone 55 South, or latitude 35.41849 ºSouth, longitude 149.24352 ºEast.

The location of the Googong WRP is shown in Figure 1-1 by a solid blue circle. The figure was produced for a 30 km by 30 km basemap centred on the WRP (corresponding to the CALMET modelling domain) using OpenStreetMap (OSM) under the Open Database License. OSM has been used throughout this report and Stantec has acknowledged OSM and its contributors, where relevant. The Open Database License can be read in full on the OSM website[1].

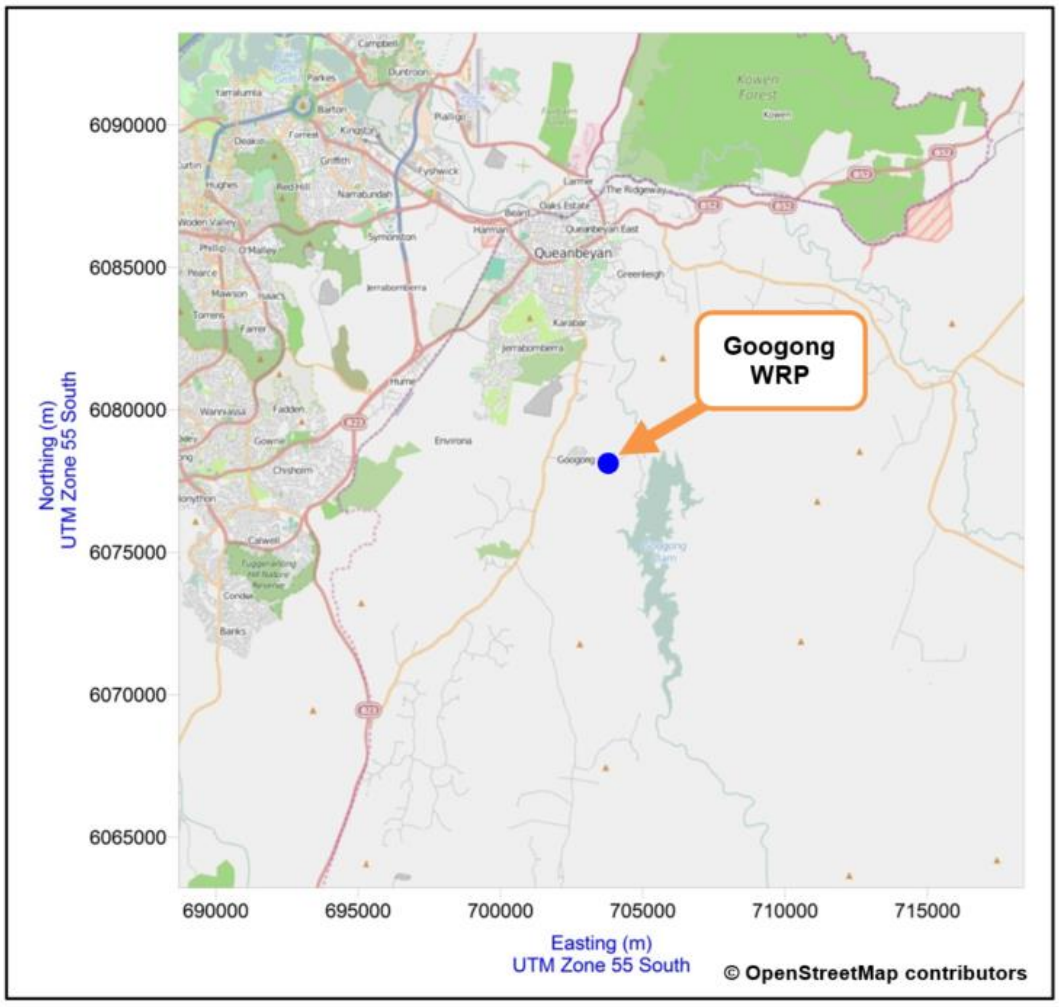


Figure 1-1: Site Location Plan **© OpenStreetMap contributors**

The most up-to-date overall lot plan for the Googong township development, referred to as pdf 'X-Block 14000153-A1 2000 P2' is shown in Figure 1-2. A more detailed plan of the area surrounding the WRP is shown in Figure 1-3 with the relotting as of February 2020 from pdf 'Googong Stage 4D/9 Staging Plan 18-000755 D020'.

[1] OpenStreetMap website: http://opendatacommons.org/licenses/odbl/1.0/.

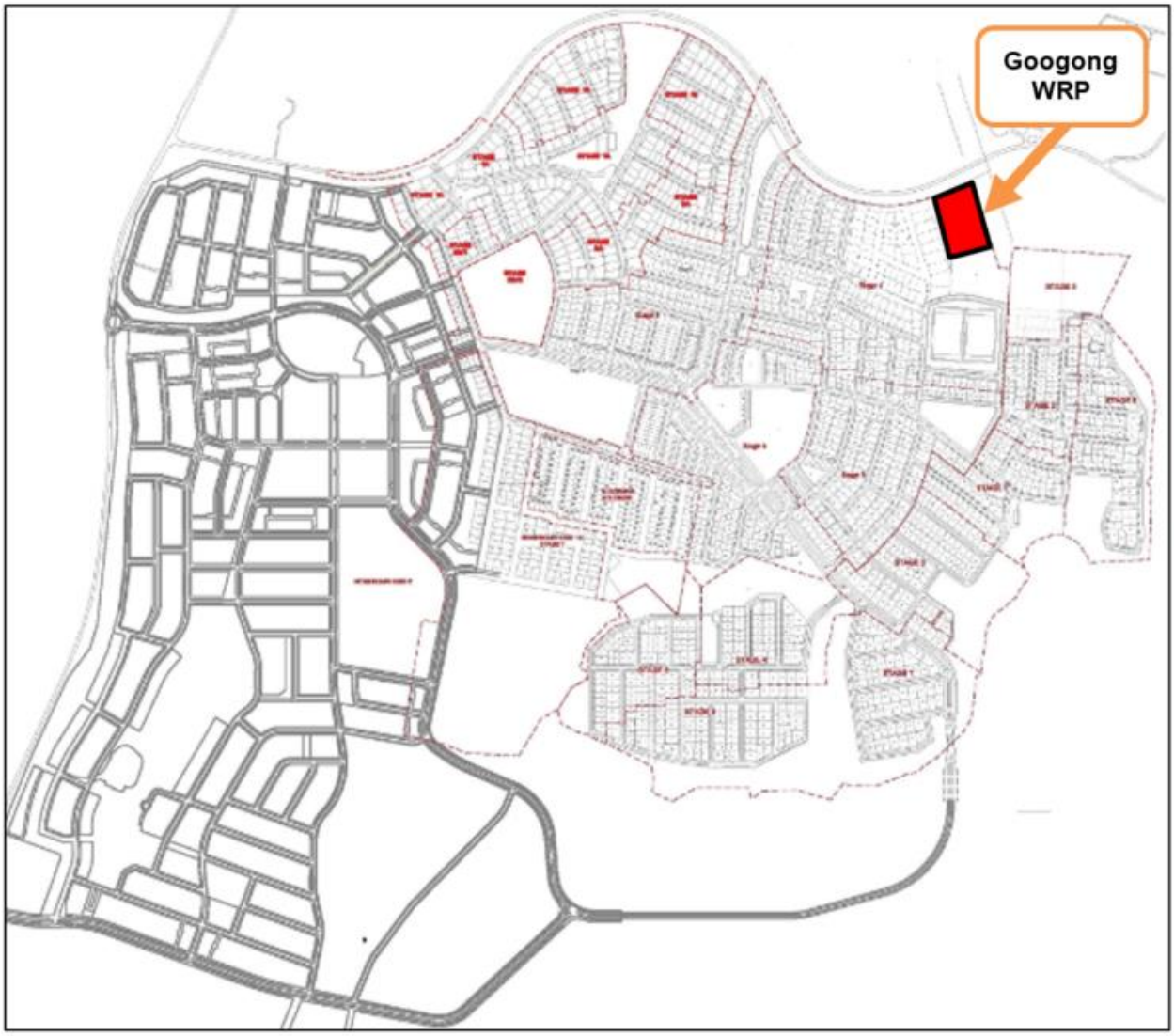


Figure 1-2: Googong Township Development Lot Plan

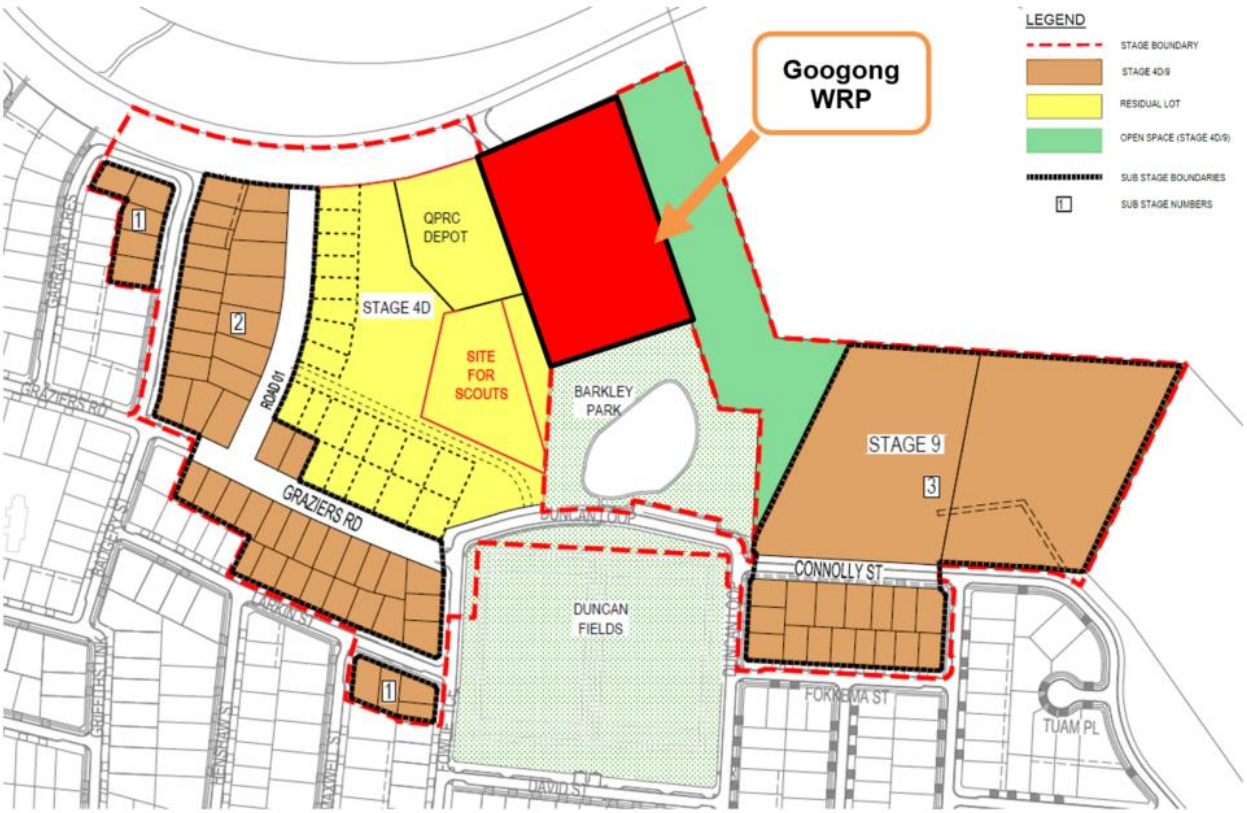


Figure 1-3: Detail of Relevant Area

2 Odour Impact Assessment

In NSW, odour impact regulations are based upon the likelihood of odour nuisance, i.e. the likelihood of emitted odours creating a negative impact on people, occurring. In NSW, the term “sensitive receptor” is used. A sensitive receptor is a location where people are likely to be e.g. a residence, a school, a hospital, a recreation area.

The SP2 zone is the area that contains the WRP.

The potential for odour nuisance impacts in the surrounding community has been assessed in this report on a quantitative basis using the CALPUFF atmospheric dispersion model. This report also provides discussion of a number of additional considerations including:

- A comparison of measured odour emission rates and those used in the air quality assessment
- Review and discussion of the predicted Stage C and Stage D odour impact
- Discussion of any potential buffer zone including risk associated with abnormal operation
- Discussion of the potential impact of uncovering areas of plant at Stage D
- Proposed subdivision layout for NH1A Stage 4D west of the SP2 zone

The results of the present dispersion modelling are consistent with the findings of Stantec’s previous odour impact assessments. Refer to technical memorandum dated 3 November 2014 entitled *‘Googong WRP Odour Dispersion Modelling Assessment’* for the ultimate Googong WRP (Stage D) site layout, and Stantec’s report dated June 2016 entitled ‘Googong Water Recycling Plant Stage C Air Quality Assessment’.

A number of odour control measures for the Stage D Googong WRP are presented in **Section 2.6**.

2.1 Googong WRP Stage D Odour Emissions

This assessment has taken into account the odour emissions from the ultimate planned (Stage D) plant layout catering for 18,850 Equivalent Persons. The Stage D site layout plan for the Googong WRP is shown in and a 3 dimensional diagram of the WRP is shown in Figure 2-2.

In the modelling of odour emissions, there are several types of odour emission sources used. Those relevant to this Report are:

- Point sources, such as exhaust stacks and exhaust vents, where the odours are emitted as part of an air stream which has some velocity to it
- Area sources, such as open lagoons and tanks, where are odours are released through evaporation under the influence of the weather
- Volume sources, such as buildings, where odours released inside the building exit through doors and windows

The principal odour emissions sources following the completion of the Stage D expansion will include:

- Odour Control Facility (OCF) stack (point emission source) (existing but modified);
- Existing sludge handling building (volume emission source);
- Existing (Stage AB) bioreactor (area emission source);
- Existing (Stage C) bioreactor (area emission source);
- Proposed Stage D bioreactor (area emission source);
- Existing Inlet works (area emission source) (constructed during Stage C replacing the Stage AB inlet works);
- Existing (Stage AB) aerobic digester (area emission source);
- Existing (Stage C) aerobic digester (area emission source); and
- Proposed Stage D aerobic digester (area emission source).

In Stage D, the proposed mitigation measures (as implemented at Stages A to C) will be in place at each emission source, which will predominantly comprise of the use of covers (in line with the existing strategy and the extent of covering for the Stage AB WRP & Stage C WRP) i.e. the new bioreactor and

aerobic digester expansion will all be covered and with the captured odorous air being treated in an odour control facility.

The Stage D works layout is shown at Figure 2-1.

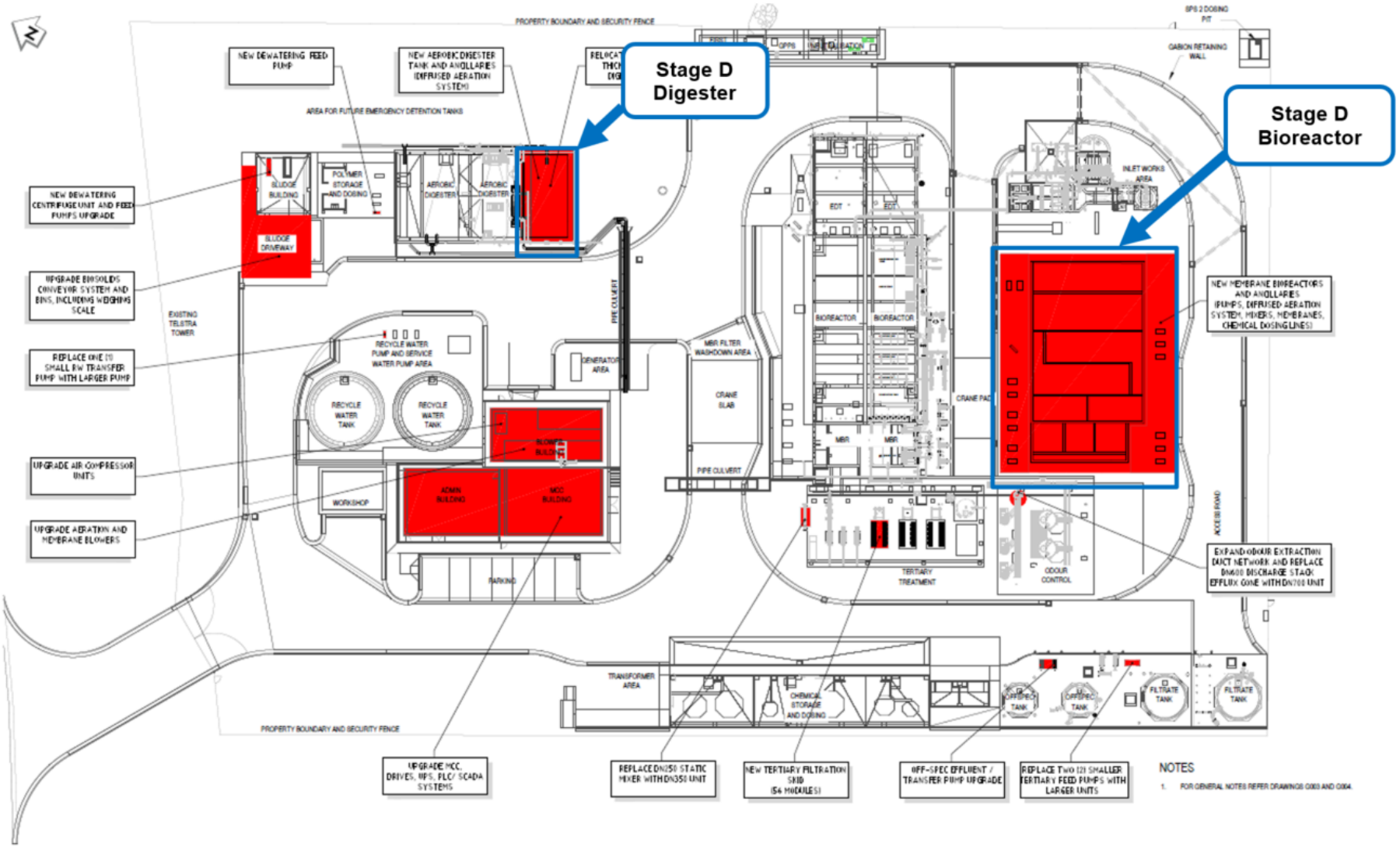


Figure 2-1: Googong WRP Stage D Site Layout Plan

The location of the emission sources input into the model is shown in red in Figure 2-2, as visualised in Google Earth (looking north). The Odour Control Facility (OCF) stack can also be seen in the figure, whist the SHB is situated at the northern end of the site, immediately north of the aerobic digester. The bioreactor area sources are shown in the centre of the image (just north of the OCF stack). The buildings are shown in the figure as blue polygons.

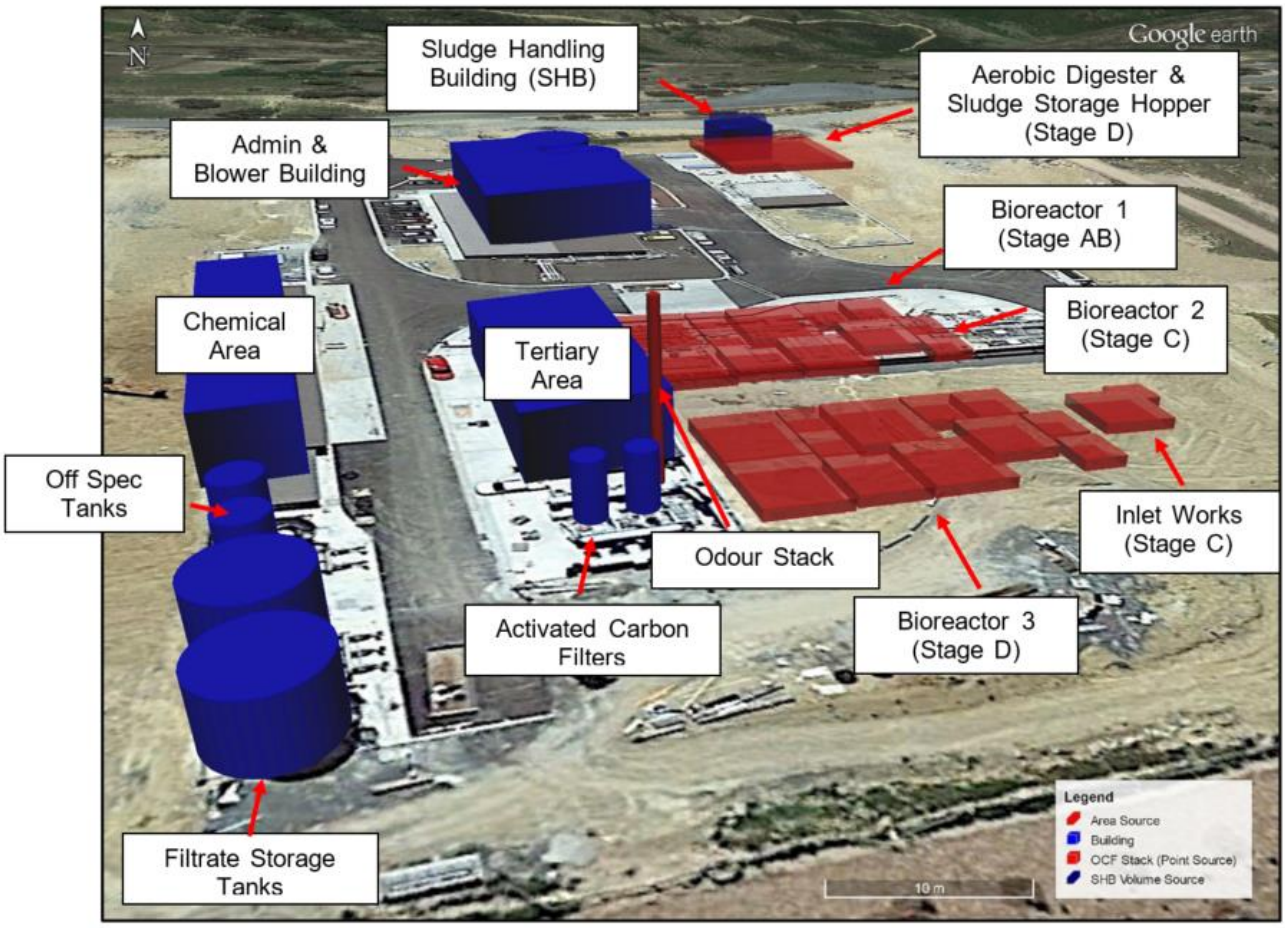


Figure 2-2: Location of the Emission Sources Input into the Model

2.2 Assumptions and Limitations

Assumptions and Limitations of the atmospheric dispersion modelling study include:

- The odour emission rates for the area sources are considered to be conservative (see Section 2.4.3);
- The modelling is based on odour emission mitigation measures being in place at each emission source, which will predominantly comprise of the use of covers with the captured odorous air being treated in the OCF;
- Whilst it is considered that the odour emission rate used in this assessment for the OCF stack is conservative and is based on worst-case conditions at peak load, it is acknowledged that in developing the emission rate it was assumed that the OCF stack after Stage D will achieve an in-stack odour concentration of no greater than 500 ou, which is as per the current OCF discharge specification and demonstrated performance; and
- General limitations and assumptions contained within the dispersion model algorithms:
  - Dispersion models are numerical models of real life situations and therefore have their limitations. Regulatory authorities understand these limitations and address these by specifying how the models should be operated.

Stantec has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of GTPL. This report was prepared in February 2020 and is based on the conditions encountered and information reviewed at the time of preparation. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to Regulatory or Approval Authorities and other persons for an application for permission or approval to fulfil a legal requirement. This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

2.3 Assessment Criteria for Odour

2.3.1 Legislative Context

The *Protection of the Environment Operations Act 1997* (the 'POEO Act') is one of the key pieces of environmental legislation administered by the NSW EPA. The POEO Act commenced on 1 July 1999 and repealed or incorporated a number of previous Acts.

The aim of the POEO Act is to "*achieve the protection, restoration and enhancement of the quality of the NSW environment.*"

It is stated in the POEO Act that the EPA that planning authorities and other authorities specified in a Protection of the Environment Policy (PEP) must take into account the requirements of the PEPs when making decisions that affect the environment.

2.3.2 Potential Odour Nuisance Effects

The odour assessment contained in this report has been carried out regarding the potential for the activities and processes at the Googong WRP to cause odour nuisance at sensitive receptors (e.g. residential properties, medical centres, hospitals and schools) located in close proximity to the WRP site boundary (see Section 2.3.3).

It is generally accepted that the following factors create odour nuisance or odour complaints:

- **Frequency:** How often a person is exposed to the odour. In this modelling the frequency aspect is addressed by the limits set in the percentile limits of the odour being present
- **Intensity:** In this context the intensity is the perceived strength of the odour. In this modelling this is addressed by the odour strength as reported in ou, as described below
- **Duration:** How long the odour is present for. In this modelling the frequency aspect is addressed by the limits set in the percentile limits and the averaging times of the odour being present
- **Offensiveness:** often combined with
    - **Location or Context:** This can be highly subjective. For instance, bakery odour: A person passing a bakery may find the smell of the baking pleasing, but if a person living near a bakery was exposed to the same odours continuously within their home they may find the same baking odours highly offensive. Alternatively, many people would find rendering odours offensive on their own but in the context of that person being at the rendering facility, and expecting the odours to be present, they may find the odours unpleasant but not offensive. **In NSW this has been addressed by setting the odour impact criteria at such a low concentration that it should not be possible for the average person to detect the new odour over the top of ambient odours**.

Dispersion modelling can assess the frequency, intensity (strength) and duration of an odour at a receptor, but cannot assess offensiveness. The odour impact criteria as set out by the NSW EPA addresses offensiveness.

2.3.3 Sensitivity of the Receiving Environment and Land Use

The sensitivity of the receiving environment must be considered in an odour impact assessment. The degree of sensitivity in a particular location is based on characteristics of the land use, including the time of day and the reason why people are at the particular location (e.g. for work or recreation). Different locations have different sensitivities to odour and can be classified as having 'high', 'medium' or 'low' sensitivity.

The term 'sensitive receptor' is defined in the Odour Framework as follows:

> *"A location where people are likely to work or reside; this may include a residential dwelling, school, hospital, office or public recreational area. An odour assessment should also consider the location of known or likely future receptors."*

A desk-study was undertaken to identify discrete receptors deemed sensitive to changes in the baseline odour conditions as a result of discharges of odour into the air from the proposed Stage D Googong WRP. The sensitive receptors identified in this assessment represent locations where people of *high* sensitivity to odours have the potential to be exposed to odours released at the Googong WRP.

A total of 33 discrete sensitive receptors (referred to herein as receptors R1 to R33) were input into the dispersion model (see Table 2-1). Receptors R1 to R25 are receptors used in previous modelling. Receptors R26 to R33 are those that have been identified as being within the GTPL planning proposal for NH1A Stage 4D land west of the SP2 zone. The GTPL Planning proposal for NH1A stage 4D includes for additional residential lots to the west of the WRP. This Planning proposal is in parallel with the Stage D expansion of the WRP with additional lots also proposed in the future.

The table also shows the distance and direction of the receptors from the Googong WRP site boundary. Note that the dispersion model also assessed odour impact across a grid and at 5 m spacings along the WRP fence line (see Section 2.4.3 for further information) and at larger spacing up to 2 km from the WRP.

The nearest sensitive receptors predominantly include residential properties situated in Googong to the north, west and south-west of the Googong WRP. Sensitive receptors identified in this assessment also include public outdoor locations (recreational grounds and parks) and a school.

The location of the receptors relative to the WRP are shown in Figure 2-3 and Table 2-1. As odour concentrations generally decrease with distance from the emission sources at the WRP due to atmospheric dispersion and dilution, those receptors closest to the WRP were investigated in detail in this report.

Table 2-1: Sensitive Receptor Locations

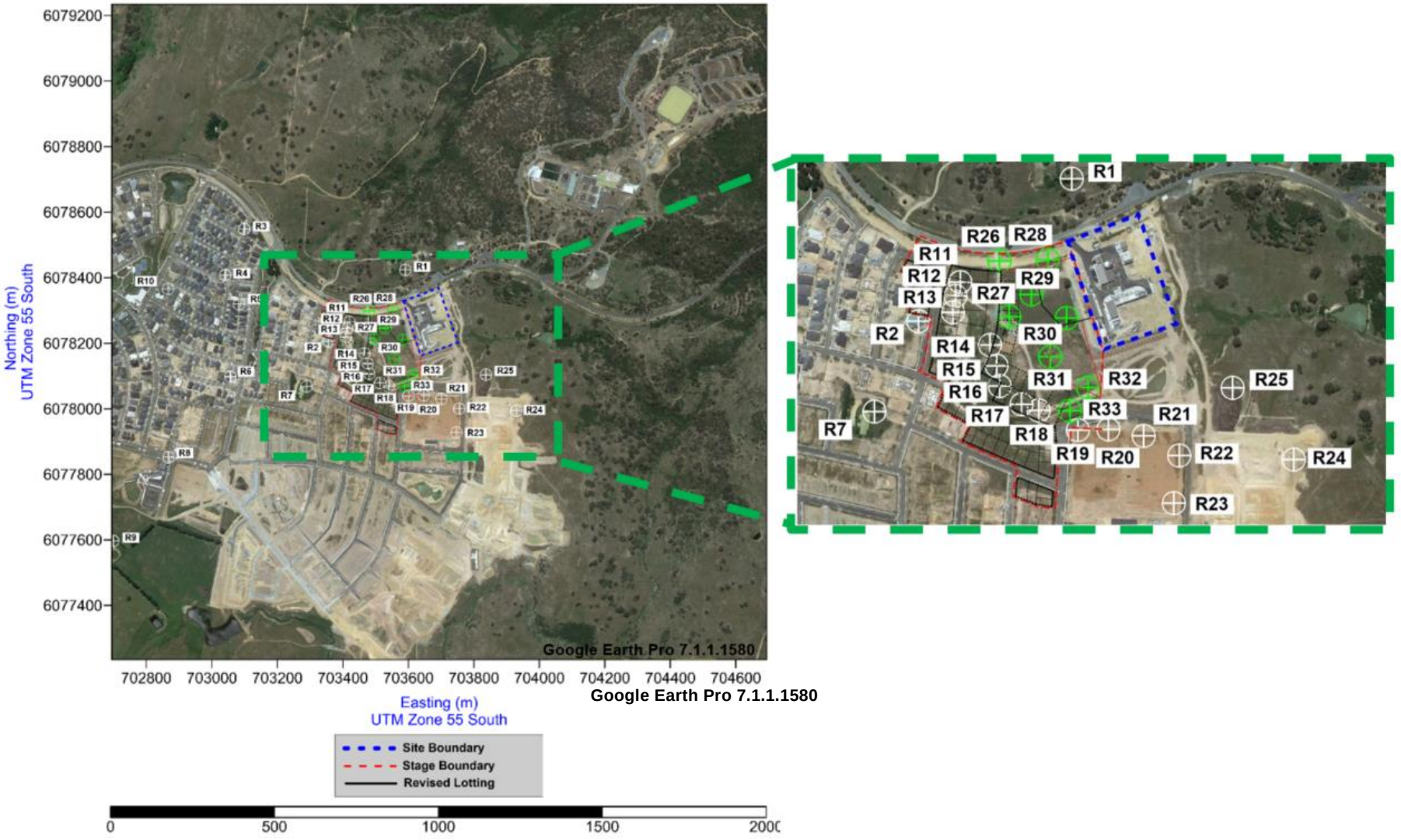
Ref.	Type	Address	UTM Zone 55 South		Distance (m) and	Elevation (m)
			Easting (m)	Northing (m)	Direction from Site Boundary	
R1	Dwelling	191 Googong Road	703591	6078424	100 / N	718
R2	Dwelling	Carraway Crescent	703356	6078206	240 / W	739
R3	Dwelling	Merlin Crescent	703099	6078549	530 / NW	734
R4	Dwelling	Bonarba Link	703041	6078408	550 / WNW	734
R5	Dwelling	Pickering Street	703083	6078319	500 / W	737
R6	Dwelling	McTavish Street	703057	6078098	560 / WSW	741
R7	Dwelling	Badgery Street	703289	6078068	340 / SW	741
R8	School	Rosa Street	702868	6077852	800 / SW	742
R9	Dwelling	44 Googong Road	702699	6077597	1000 / SW	748

Ref.	Type	Address	UTM Zone 55 South		Distance (m) and	Elevation (m)
			Easting (m)	Northing (m)	Direction from Site Boundary	
R10	Dwelling	Bonarba Link	702866	6078366	710 / WNW	731
R11	Dwelling	Carraway Crescent	703420	6078266	160 / W	734
R12	Dwelling	Carraway Crescent	703413	6078245	160 / W	735
R13	Dwelling	Carraway Crescent	703409	6078220	180 / W	737
R14	Dwelling	Unnamed Road	703466	6078170	130 / WSW	737
R15	Dwelling	Unnamed Road	703476	6078138	130 / WSW	737
R16	Dwelling	Unnamed Road	703481	6078107	140 / WSW	736
R17	Dwelling	Larkin Street	703514	6078079	120 / SW	734
R18	Dwelling	Larkin Street	703540	6078070	110 / SW	733
R19	Sports Ground	Duncan Loop	703600	6078040	120 / S	730
R20	Sports Ground	Duncan Loop	703647	6078041	110 / S	728
R21	Sports Ground	Duncan Loop	703701	6078031	140 / S	724
R22	Dwelling	Duncan Loop	703755	6078001	180 / SSE	722
R23	Dwelling	Duncan Loop	703747	6077928	250 / SE	722
R24	Dwelling	Unnamed Road	703930	6077995	270 / SE	715
R25	Open Space	Unnamed Road	703837	6078104	140 / SE	718
R26	*Dwelling*	*Unnamed Road*	*703480*	*6078298*	*98/NW*	*735*
R27	*Dwelling*	*Unnamed Road*	*703495*	*6078213*	*103/SW*	*741*
R28	*Dwelling*	*Unnamed Road*	*703554*	*6078300*	*22/NW*	*733*
R29	*Commercial*	*Unnamed Road*	*703529*	*6078247*	*61/W*	*737*
R30	*Recreational*	*Unnamed Road*	*703583*	*6078211*	*21/SW*	*734*
R31	*Recreational*	*Unnamed Road*	*703558*	*6078152*	*64/SW*	*735*
R32	*Dwelling*	*Unnamed Road*	*703616*	*6078105*	*47/SW*	*727*
R33	*Dwelling*	*Unnamed Road*	*703588*	*6078069*	*96/SW*	*726*

Italics - within the GTPL planning proposal for NH1A Stage 4D land west of the SP2 zone

Figure 2-3 shows the location of the potentially affected sensitive receptors identified in this assessment (as shown by a plus sign in the centre of a white circle). The figure shows the boundary of the Googong WRP (dashed blue line) and is based on the 2 km by 2 km CALPUFF modelling area (see Section 2.4.3).

Figure 2-3 indicates that there will be residential properties located in the Googong township (west, south-west and south of the Googong WRP) which have the potential to be impacted by odour emissions originating at the WRP. This report aims to quantify that potential impact.



Google Earth Pro 7.1.1.1580

Figure 2-3: Aerial Basemap Showing Discrete Receptor Locations R1 to R33

2.3.4 Odour Impact Assessment Criteria

2.3.4.1 Assessment Criteria

In NSW, the NSW OEH[2] has set a sliding scale of odour impact assessment criteria, based on the size of the potentially impacted population. The sliding scale is required because as the size of the potentially impacted population increases, the possibility of a person who is highly sensitive to the odour being present increases. This sliding scale, as shown in Table 2-2, is based on the reported odour impact values being expressed as the 99th percentile value of all the calculated dispersed odour concentrations and as a nose-response time-average (approximately one second).

For residential areas with a population over 2,000 people, recreational areas, or where other sensitive receptors are located, the **2 ou odour impact criterion is appropriate, and has been used in this Report**.

The equation used by the NSW OEH to determine the appropriate impact assessment criterion for complex mixtures of odorous air pollutants, as specified in the Approved Methods, is expressed as:

$$\text{Impact assessment criterion (ou)} = (\log_{10}(\text{population}) - 4.5) / -0.6$$

A summary of the impact assessment criteria given for various population densities, as drawn from the Approved Methods, is given in Table 2-2.

Table 2-2: NSW OEH Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants (nose-response-time average, 99th percentile)

Population of Affected Community	Impact Assessment Criteria (ou)
Urban area (>2,000)	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single residence (<2)	7.0

Source: The Approved Methods (OEH, 2005)[3]

The Approved Methods states that the impact assessment criteria for complex mixtures of odorous air pollutants must be applied at the nearest existing or likely future off-site sensitive receptor(s).

The incremental impact (predicted impact due to the pollutant source alone) must be reported in units consistent with the impact assessment criteria (ou), as nose response time concentrations (i.e. approximately 1 second average) and as the:

- *100th percentile* of dispersion model predictions for 'Level 1' impact assessments, or
- *99th percentile* of dispersion model predictions for 'Level 2' impact assessments (using a minimum of 1-year of site-specific meteorological data). This Report is a Level 2 impact assessment and therefore

Given the high density of potential sensitive receptor locations in the immediate vicinity of the Googong WRP (i.e. the Googong township) the odour impact assessment criterion of 2 ou is the appropriate odour impact criterion for odour emissions from the Googong WRP following the Stage D expansion.

[2] Technical Framework - Assessment and Management of Odour from Stationary Sources in New South Wales, NSW Office of Environment & Heritage (formerly the Department of Environment and Conservation (DEC) at time of publication), November 2006.

[3] Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, Department of Environment and Conservation NSW (DEC), NSW Environment Protection Authority (EPA), August, 2005 (the 'Approved Methods').

the 99th percentile has been used as accepted by the NSW EPA where site specific information is available.

Table 2-3 summarises the assessment criterion selected for this dispersion modelling assessment, which is consistent with the criteria used in Stantec's (then MWH's) 2009, 2013 and 2014 CALPUFF modelling assessments. Note that the 2009 model was used for the original Concept Approval and considered both Stage AB and ultimate (Stage D) emissions.

Table 2-3: Assessment Criteria Used in the Modelling Assessment

Authority	Averaging Period	Impact Assessment Criterion (ou)	Assessment Criteria Reference
NSW OEH	1-second (99th percentile)	2	The Approved Methods (OEH, 2005)

2.3.4.2 The Concept of Odour Units (ou)

In Australia, the strength of odours for use in odour impact assessments is expressed in odour units (ou). ou are effectively dilution ratios. 1 ou is taken to be the lowest odour strength that the average person can detect in the most stringent of laboratory conditions, and at this strength the person would only be able to say that an odour was present but nor what the odour smelled like.

As an example, an odour strength of 500 ou means that the original odour would need to be diluted approximately 500 times to reach the 1 ou concentration.

In practice, ambient odour strengths can range from tens to hundreds of ou depending on the location. By setting the odour impact criteria at ou levels of 2 to 7, the NSW EPA has set the odour impact criteria, which is the predicted impact over ambient levels, at odour strengths that are not detectable over ambient odours.

2.3.4.3 Peak-to-Mean Ratios

The Approved Methods states that peak-to-mean ratios should be incorporated when conducting atmospheric dispersion modelling of odour.

It is commonly recognised that dispersion models need to be supplemented to accurately simulate atmospheric dispersion of odours. This is because the instantaneous perception of odours by the human nose typically occurs over a time scale of approximately one second but dispersion model predictions are typically valid for time scales equivalent to minutes to one hour averaging periods.

To estimate the effects of plume meandering and concentration fluctuations perceived by the human nose, it is possible to multiply dispersion model predictions by a correction factor called a "peak-to-mean ratio" (or 'P/M60'). The peak-to-mean ratio is defined as the ratio of peak 1-second average concentrations to mean 1-hour average concentrations.

To estimate peak concentrations, this assessment has used the procedures presented in the Approved Methods. For this Report, to establish a conservatively high estimate of peak odour concentrations, a peak-to-mean ratio (P/M60) of 2.3 has been adopted, corresponding to near-field receptors. In other words, the 1-hour mean ground level odour concentrations predicted by the model have been multiplied by a factor of 2.3 to give the results presented in Section 2.5.

2.4 Assessment Methodology

2.4.1 Modelling Approach

The atmospheric dispersion modelling assessment has been undertaken using CALPUFF (Version 7.2.1, Level 150618).

CALPUFF has been used extensively in Australia and New Zealand and is a recommended model in the NSW OEH's Approved Methods (OEH, 2005)[4], particularly for sites surrounded by complex terrain and where light or low wind speed conditions are likely to occur (both of these conditions apply to the Googong site). CALPUFF was used for the 2009 Googong WRP odour dispersion modelling assessment which was used for the Concept Approval for the Googong township (and also for the 2012 and 2014 dispersion modelling assessments).

CALPUFF is a US EPA approved atmospheric dispersion model and is a non-steady state Lagrangian Gaussian puff model containing modules for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation. In other words, the model can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and removal.

In simple terms, CALPUFF models the odour emissions as "puffs" or packets of odorous air and models how these packets move, merge and disperse under the influence of the weather and the terrain hour by hour and then predicts the odour concentration at selected locations. In order to do this, CALPUFF requires significant data on the terrain, land cover, water bodies and weather (meteorological data) in the area under consideration. These data are described in the following sections.

2.4.2 Meteorological Modelling

CALMET (Version 6.4.0, Level 121203) was used in this assessment. CALMET is a meteorological model which calculates local climate large scale data sets and data collected locally. Within CALMET are facilities to address how topography and terrain impact on the local climate. CALMET forms part of the CALPUFF dispersion modelling suite (see the following section).

CALMET operates by calculating the climate conditions over a large area. CALPUFF then takes the climate data for a smaller area within the larger area to determine how odours will disperse in the area under investigation. CALPUFF requires meteorological data for both ground level and the upper atmosphere. Ground level data is generally available, but upper atmosphere data most often needs to be calculated; both of these are described below.

A 30 km by 30 km CALMET model domain at a resolution of 200 m was used. The south-west (lower-left) corner of the grid was 688694 m East, 6063235 m North (Universal Transverse Mercator, or UTM, Zone 55 South). CALMET was set up in accordance with the general guidance contained in OEH (2011)[5].

A 2 km by 2 km CALPUFF modelling area was centred on the Googong WRP. The south-west (lower-left) corner of the grid was 702694 m East, 6077235 m North (UTM Zone 55 South).

Figure 2-4 shows the CALMET domain and CALPUFF modelling area used in this assessment.

4 *Ibid.*

5 New South Wales Office of Environment and Heritage (OEH), 2011. *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia*, Sydney, Australia, March 2011.

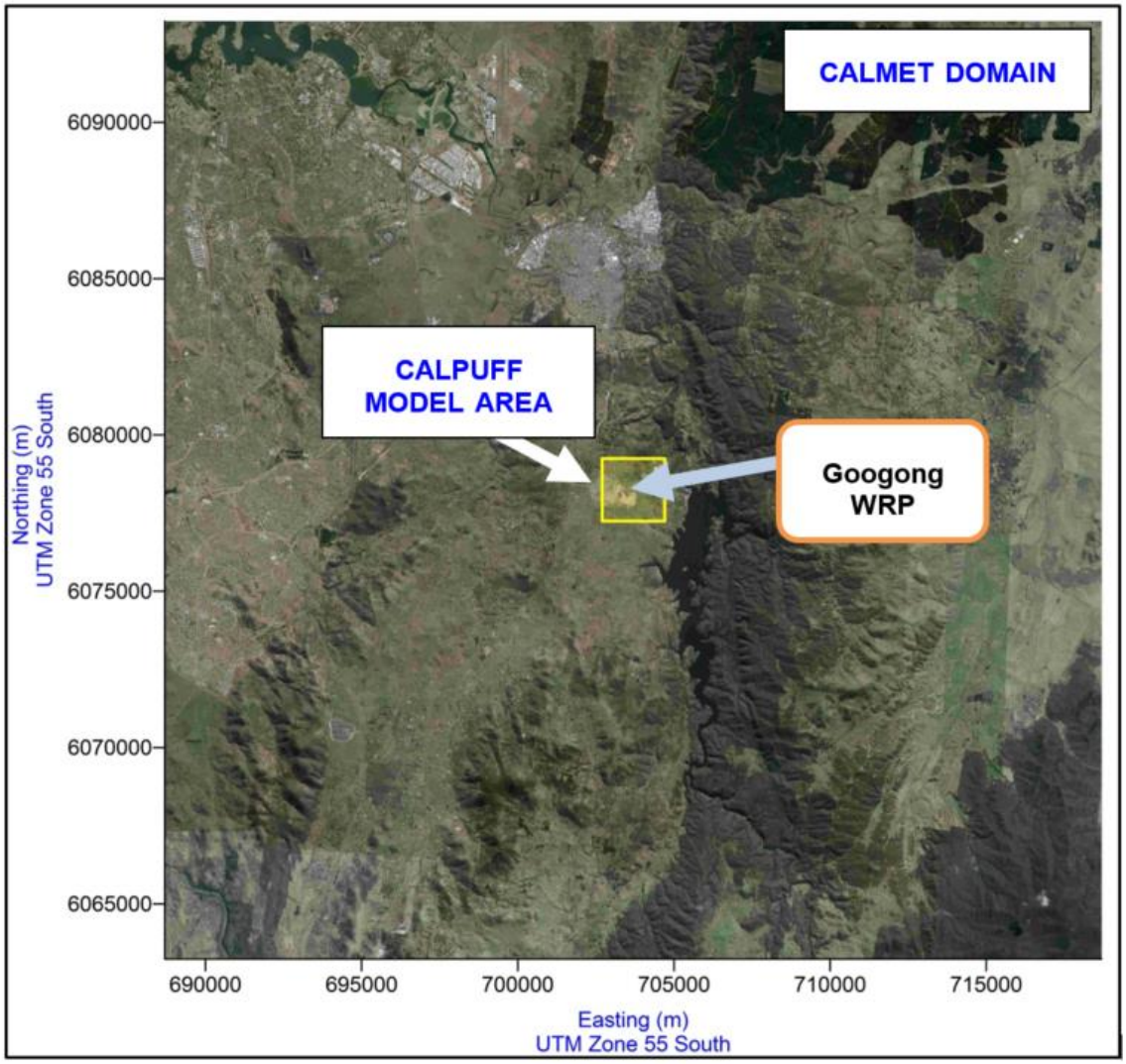


Image © 2014 CNES / Astrium, © 2014 Google, Image © 2014 DigitalGlobe (Google Earth Pro 7.1.1.1580)

Figure 2-4: CALMET Domain (outer) and CALPUFF Modelling Area (inner)

An automatic weather station (AWS) was installed onsite (referred to hereafter as the 'Googong WRP AWS') and a year's worth of baseline weather monitoring data were collected between 1 September 2013 and 31 August 2014. The Googong WRP AWS was assigned a station number of '54321' for the purposes of this assessment.

The two closest Bureau of Meteorology (BoM) AWS sites to the Googong WRP are situated at the Canberra International Airport and in Tuggeranong, which are approximately 13 km north-west and 14 km west of the WRP, respectively. The BoM station numbers for the Canberra International Airport and Tuggeranong AWS sites are '70351' and '70339', respectively.

The locations of the AWS sites are shown in Figure 2-5.

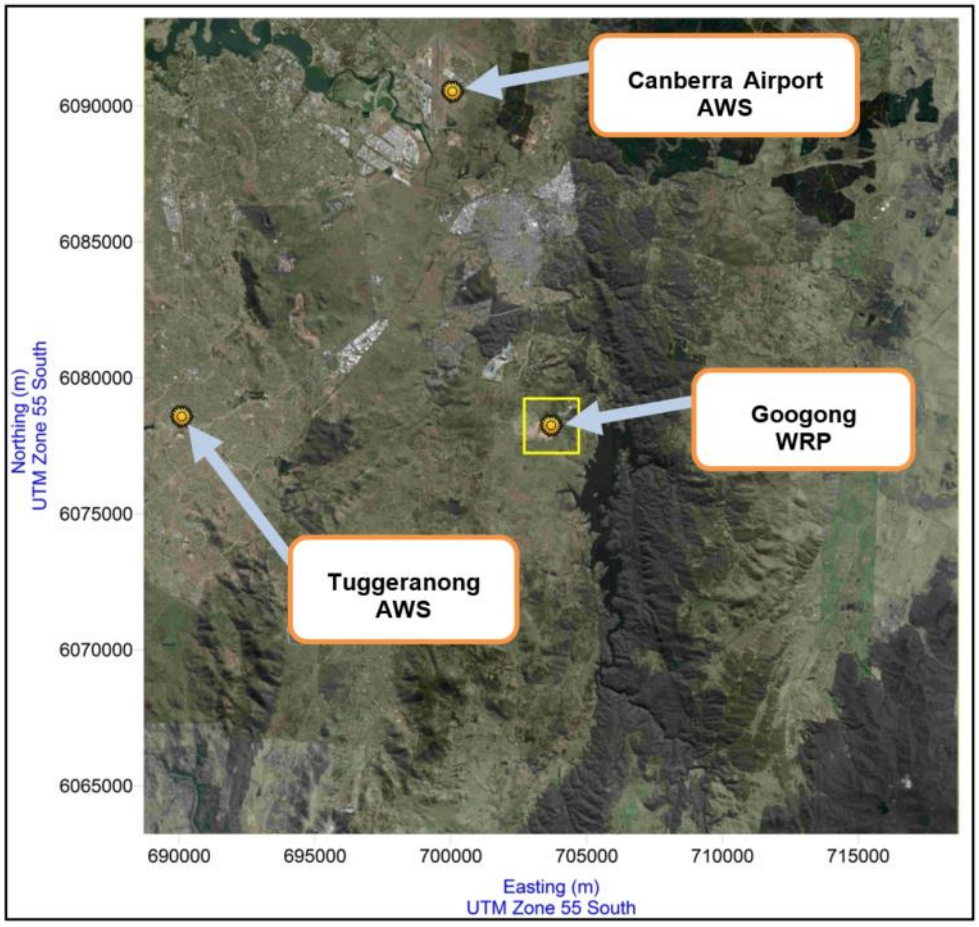


Image © 2014 CNES / Astrium, © 2014 Google, Image © 2014 DigitalGlobe (Google Earth Pro 7.1.1.1580)

Figure 2-5: Locations of the Surface Meteorological Stations

Hourly wind speed, wind direction, air temperature, atmospheric pressure, and relative humidity data for the Googong WRP AWS, the Canberra Airport AWS and the Tuggeranong AWS from 1 September 2013 (Hour 1) to 31 August 2014 (Hour 24) were analysed.

A CALMET–formatted surface meteorological data file (surf.dat) for the 1-year period for the three AWS sites was generated using SMERGE (Version 5.70, Level 121203) using hourly mean data for the following parameters: wind speed, wind direction, air temperature, relative humidity and atmospheric pressure.

The upper air data input into CALMET were generated using the Weather Research and Forecasting (WRF) model, which is a next-generation mesoscale numerical weather prediction system developed in the US by the National Centre for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration, amongst other US government agencies/departments.

CALMET-formatted WRF data (3D.dat format) for 1 September 2013 (Hour 1) to 31 August 2014 (Hour 24) were supplied by Lakes Environmental Software for this study. A 50 km by 50 km WRF modelling domain at a resolution of 4 km was centred on the Googong WRP at latitude 35.418 ºS and longitude 149.2434 ºE (703685 m E, 6078290 m N, UTM). 35 vertical levels were included in WRF.

The WRF 3D.dat data input into CALMET incorporated the diagnostic wind module, which uses a two-step approach to the computation of the wind fields. In Step 1, the initial guess wind field is adjusted for the kinematic effects of terrain, slope flows, blocking effects, and three-dimensional divergence minimisation. Step 2 combines the available wind observations with the Step 1 gridded wind field to develop the final wind field in CALMET.

The total CALMET model runtime was 54.4 hours (2.3 days).

Graphical outputs of selected wind field modelling results for the modelling domain are shown in Appendix B.

2.4.2.1 Wind Speed and Direction

The data capture achieved at the Googong WRP AWS over the 1-year period was excellent at 99% (i.e. there were only 68 missing hours out of the 8,760 hours of possible hours in the year). The Approved Methods specifies that up to 10% missing data hours (i.e. 876 hours) are permitted in any one year of meteorological data collected at a project site for input into a dispersion model for a 'Level 2' impact assessment. **The data capture achieved at the Googong WRP over the 1-year period was therefore in accordance with the Approved Methods**.

The mean wind speed for the 1-year period measured at the Googong WRP was 3.1 metres per second (m/s). The frequency of calm wind conditions (wind speeds less than or equal to 0.45 m/s) over the period was 0.43%, which was less than recorded at the other two AWSs. The following wind speed frequencies were observed over the 1-year period:

- Calms 0.43%;
- Wind speeds between 0.5 m/s and 1.5 m/s *'Light Air' or Beaufort 1* 19.37%;
- Wind speeds between 1.5 m/s and 3 m/s *'Light Breeze' or Beaufort 2* 34.82%;
- Wind speeds between 3 m/s and 5.5 m/s *'Gentle Breeze' or Beaufort 3* 31.28%;
- Wind speeds between 5.5 m/s and 8 m/s *'Moderate Breeze' or Beaufort 4* 11.43%;
- Wind speeds between 8 m/s and 10.5 m/s *'Fresh Breeze' or Beaufort 5* 1.76%;
- Wind speeds greater than or equal to 10.5 m/s *'Strong Breeze' or Beaufort 6* 0.13%; and
- Unavailable 0.78%.

Wind speed and direction data for a particular location are often represented graphically in the form of a wind rose, as shown in the following figures. In Australia, the arms of the wind rose show the direction ***from*** which the wind is blowing, and the length of the coloured arm segments show the frequency (percent of the time) with which winds of a certain speed (shown in the scale) blow from that direction.

The wind rose shown in

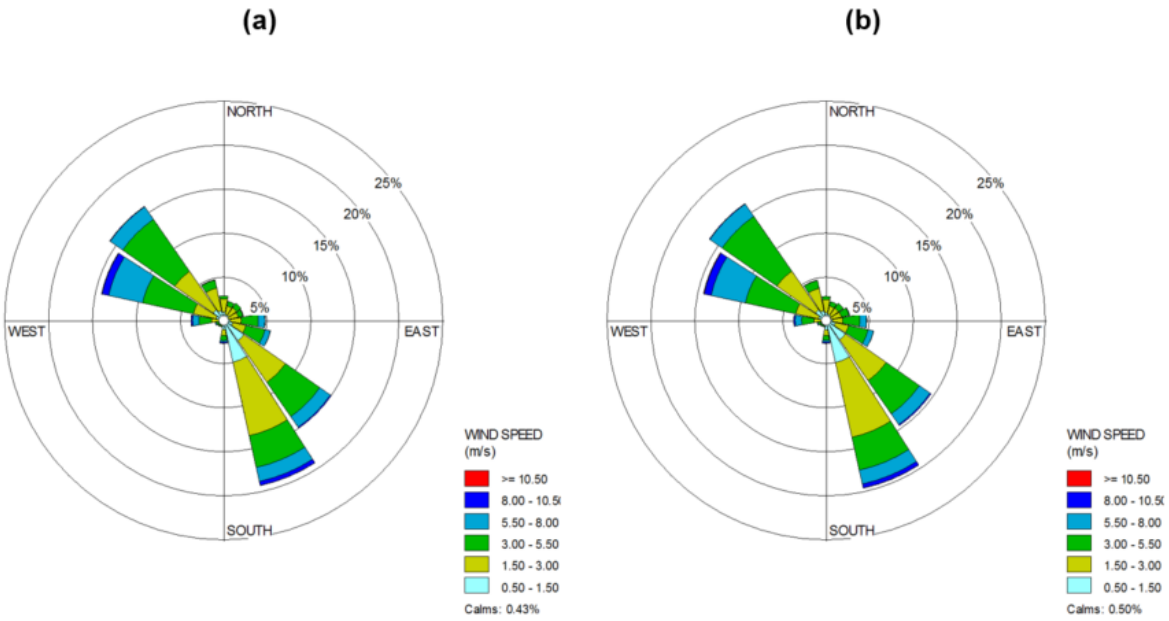


Figure 2-6(a) presents the hourly wind speed and direction data for the Googong WRP from 1 September 2013 (Hour 1) to 31 August 2014 (Hour 24), in other words the data input into CALMET

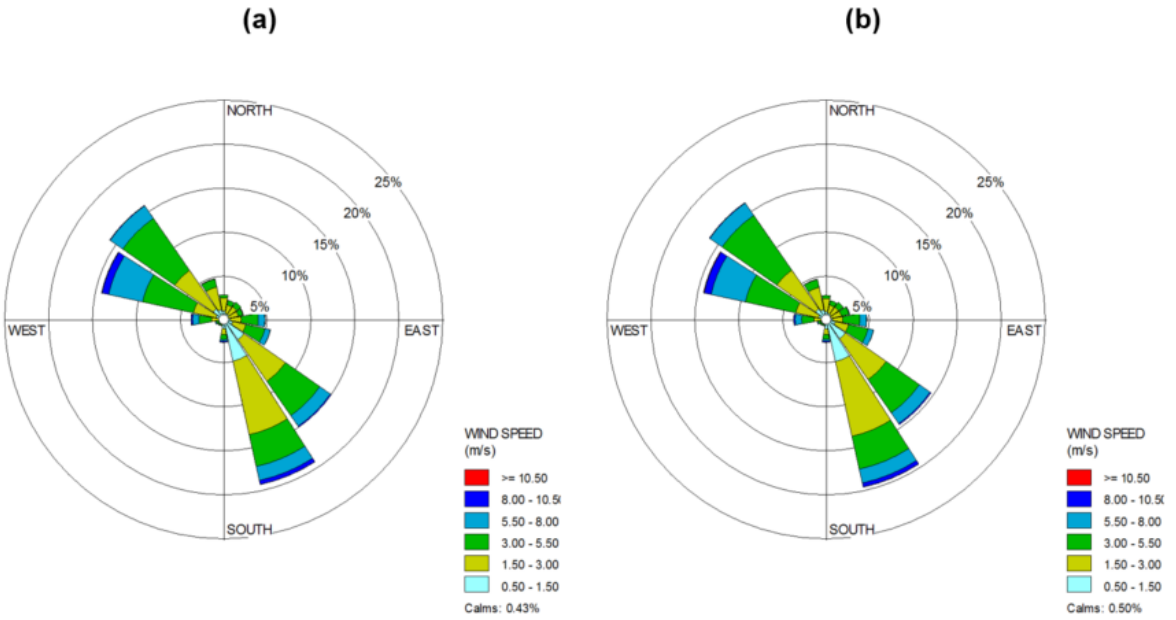


Figure 2-6(b) presents the hourly wind speed and direction data for the same period using data extracted from CALMET. The figure indicates that whilst winds from all directions were experienced at the Googong WRP, the predominant wind directions were from the south-south-east (SSE), south-east (SE), north-west (NW) and west-north-west (WNW).

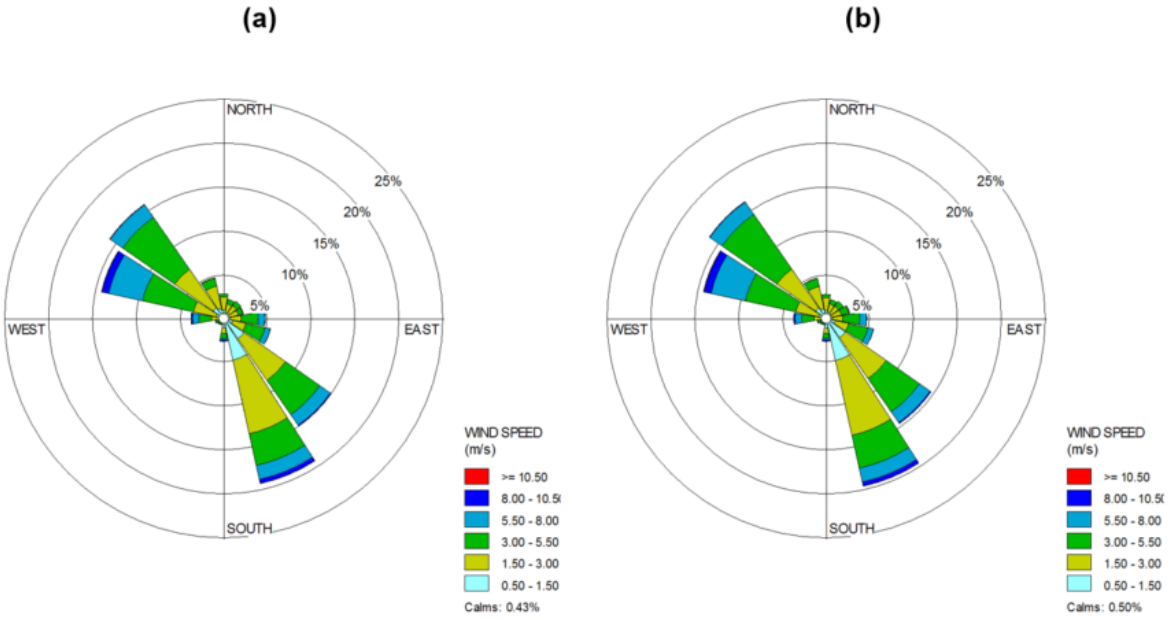


Figure 2-6(b) indicates that the wind direction and speed frequencies for the 1-year CALMET data file compare well with the actual monitoring data shown in

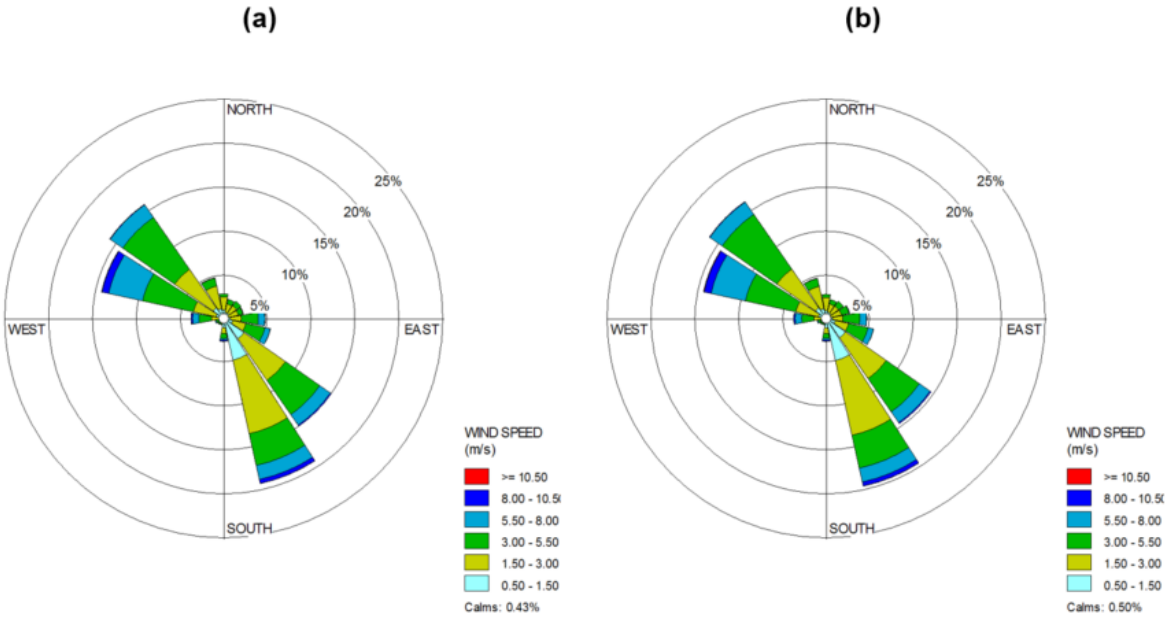


Figure 2-6(a). Furthermore, the annual mean wind speed for the Googong WRP in the CALMET data file was 3.1 m/s (i.e. the same as the actual monitoring data) and the frequency of calm wind conditions was 0.5%, which also compares well with the actual monitoring data.

The annual and seasonal wind roses for the Googong WRP AWS (using actual monitoring data and the CALMET output data), the Canberra Airport AWS and the Tuggeranong AWS for the period 1 September 2013 to 31 August 2014 are shown in Appendix A. Wind roses are also shown in Appendix A for the wind speed and direction data extracted from WRF, and for the time-of day based on measurements collected at the Googong WRP AWS.

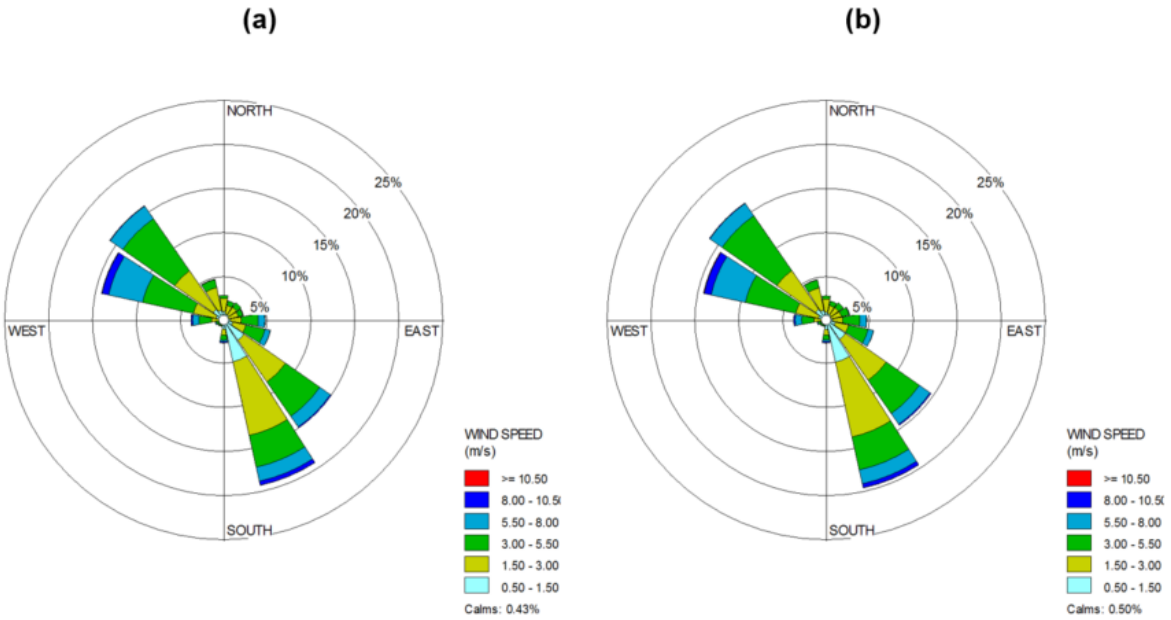


Figure 2-6: Annual Wind Roses for Googong WRP: (a) CALMET Input and (b) CALMET Output

The seasonal wind roses shown in Appendix A for the Googong WRP indicate that:

- In summer, the prevailing wind directions were from the SSE, SE, NW, WNW, E and ESE; and,
- In autumn, winter and spring, the prevailing wind directions were as per the annual wind rose (i.e. SSE, SE, NW and WNW).

The time-of-day wind roses for the Googong WRP indicate that:

- In the early morning (Hour 1 to Hour 6), the prevailing wind directions were from the SSE and SE;
- In the morning (Hour 7 to Hour 12), the prevailing wind directions were as per the annual wind rose (i.e. SSE, SE, NW and WNW);
- In the afternoon (Hour 13 to Hour 18), the prevailing wind directions were from the WNW and NW;
- In the evening (Hour 19 to Hour 24), the prevailing wind directions were as per the annual wind rose (i.e. SSE, SE, NW and WNW).

The mean wind speed for the 1-year period measured at the Canberra Airport AWS was 3.6 m/s, while the frequency of calm wind conditions was 10%. The mean wind speed for the 1-year period measured at the Tuggeranong AWS was 2.5 m/s, while the frequency of calm winds was 22%.

Another method of summarising wind speed data is to graphically summarise the wind speeds, irrespective of direction, by their frequency of occurrence.

Figure 2-7 shows the wind speed frequency distribution for the Googong WRP for the 1-year CALMET data output file. The majority of the wind speeds measured at the Googong WRP were predicted to be light to moderate: 32.6% were between 1.5 m/s and 3 m/s and 30.5% were between 3 m/s and 5.5 m/s. Only 18.6 % of winds were between 0.45 m/s and 1.5 m/s (low wind conditions) and 18.2% were above 5.5 m/s (moderate to strong wind conditions). **The wind speed frequency distribution predicted for the Googong WRP by CALMET is therefore considered to be in good agreement with the actual site-specific meteorological monitoring data.**

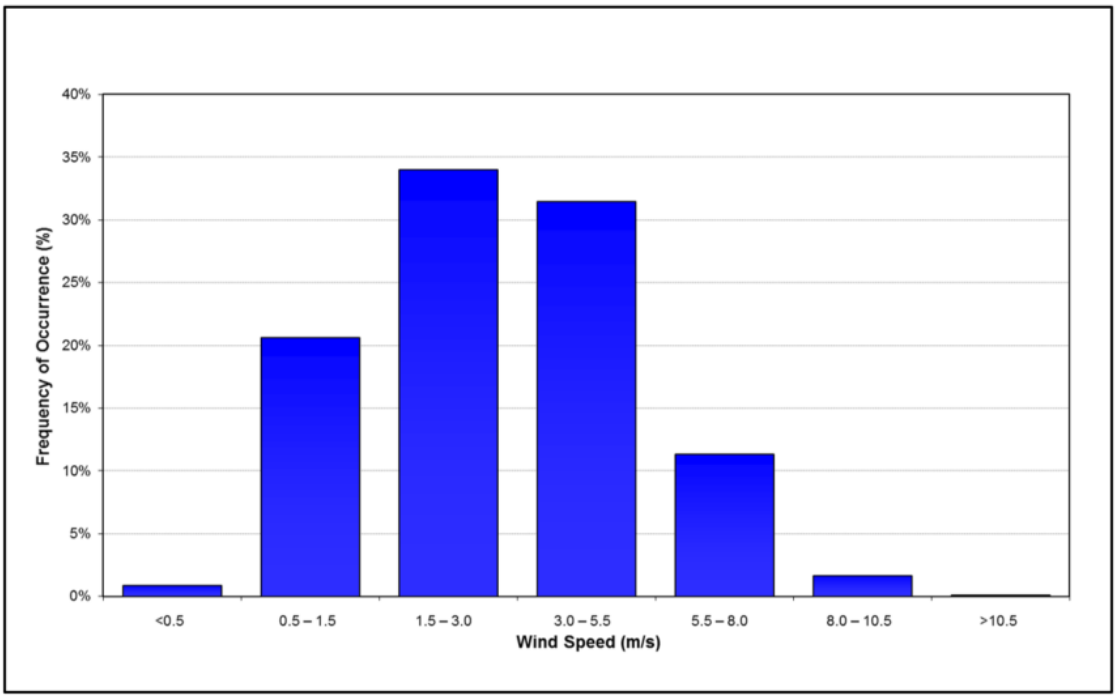


Figure 2-7: Wind Speed Frequency Distribution for the Googong WRP AWS

2.4.2.2 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The stability of the atmosphere at a certain location will be dependent on:

Climatic Conditions: For instance, the sun heating the ground causes the air in contact with the ground to warm, which will make the air more buoyant and tend to rise. This convective mixing results in less stable atmospheric conditions

"Mechanical" Conditions: In this case the term mechanical means disturbance of the air as it flows over a surface. As wind passes over the terrain, obstacles such as trees, vegetation and buildings disturb the air flow. The greater the wind speed, the more disturbance occurs, leading to less stable air flows.

The Pasquill-Gifford assignment scheme identifies six stability classes: "A" to "F", which categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions.

Stability class "A" represents highly unstable conditions that are typically found during summer, categorised by strong winds and convective conditions. Conversely, Stability class "F" relates to highly stable conditions which typically occur at night-time and are associated with clear skies, light winds and the presence of a temperature inversion. Classes "B" through to "E" represent conditions intermediate to these extremes.

The frequency of occurrence of each stability class predicted by CALMET at the Googong WRP for the 1-year period is presented in Figure 2-8. The results show a high frequency of conditions typical of stability class "D" and class "F", indicative of neutral to stable conditions which will neither enhance nor impede atmospheric pollutant dispersion. A neutral atmosphere neither enhances nor inhibits mechanical turbulence and, as a result, the vertical and lateral diffusion of a given atmospheric pollutant may be expected to be of a small to moderate scale.

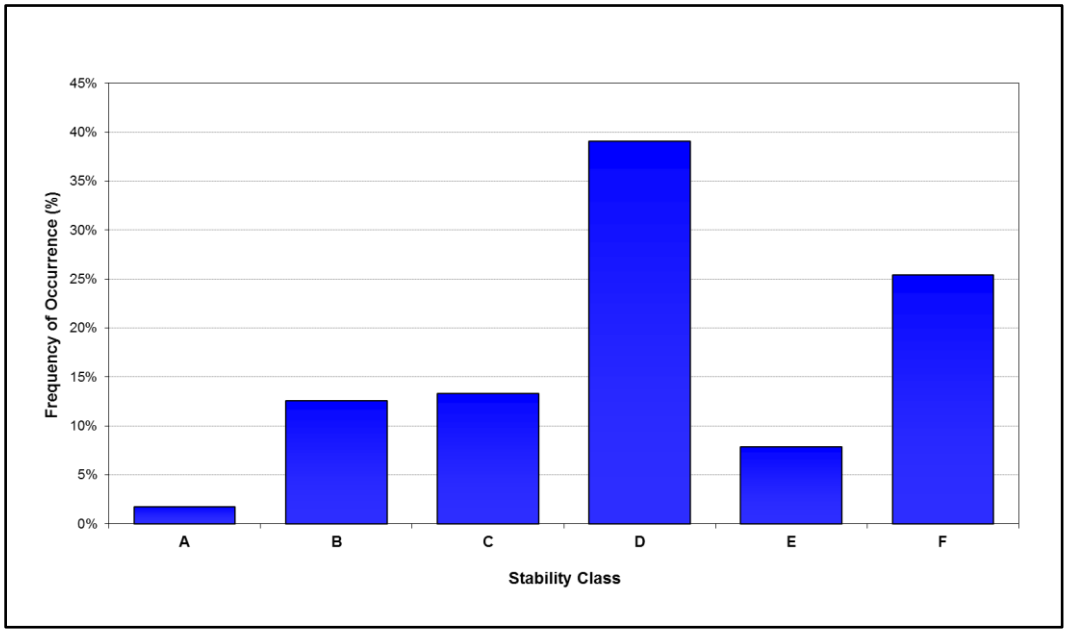


Figure 2-8: Atmospheric Stability Classes for Googong WRP taken from CALMET (1/09/2013 – 31/08/2014)

2.4.2.3 Mixing Height

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Googong WRP for the 1-year period are shown in Figure 2-9.

It can be seen that an increase in the mixing height occurs during the morning, due to the onset of vertical mixing following sunrise. The figure indicates that the maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of the convective mixing layer.

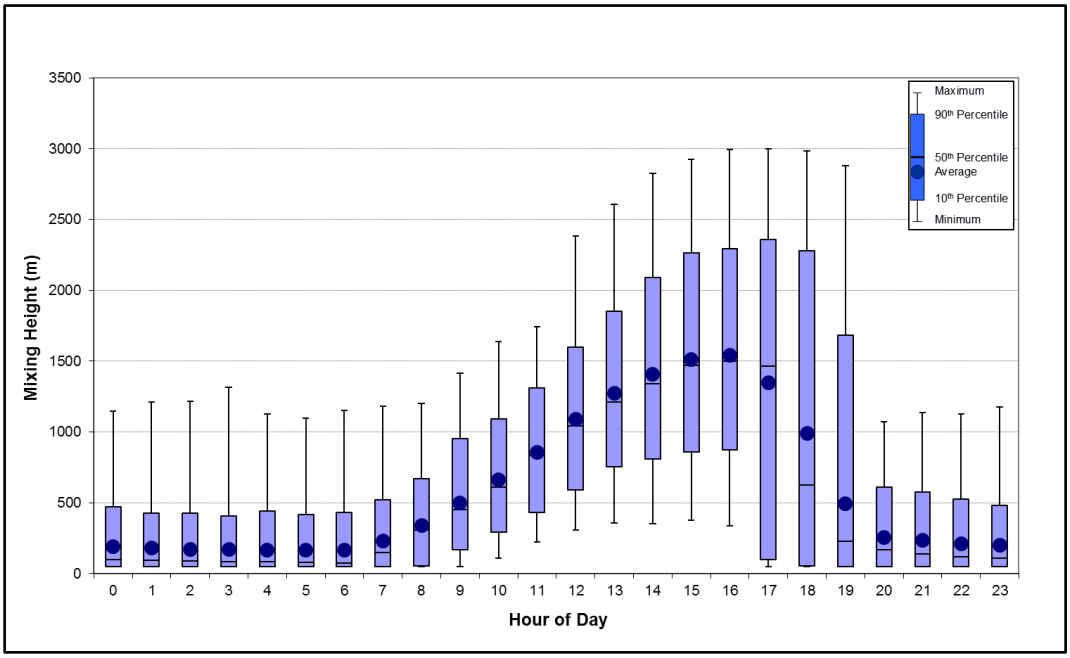


Figure 2-9: Diurnal Variation in Mixing Height for Googong WRP taken from CALMET (1/09/2013 – 31/08/2014)

2.4.2.4 Temperature

A time-series plot of the hourly air temperature data extracted from CALMET for the 1-year period at the Googong WRP is shown in Figure 2-10. As expected, the highest temperatures were predicted to occur in the summer months (December to February) and the lowest temperatures occurred in the winter months (June to August).

The review of the annual temperature data shows there is nothing unusual or unexpected in the temperature data used in the modelling.

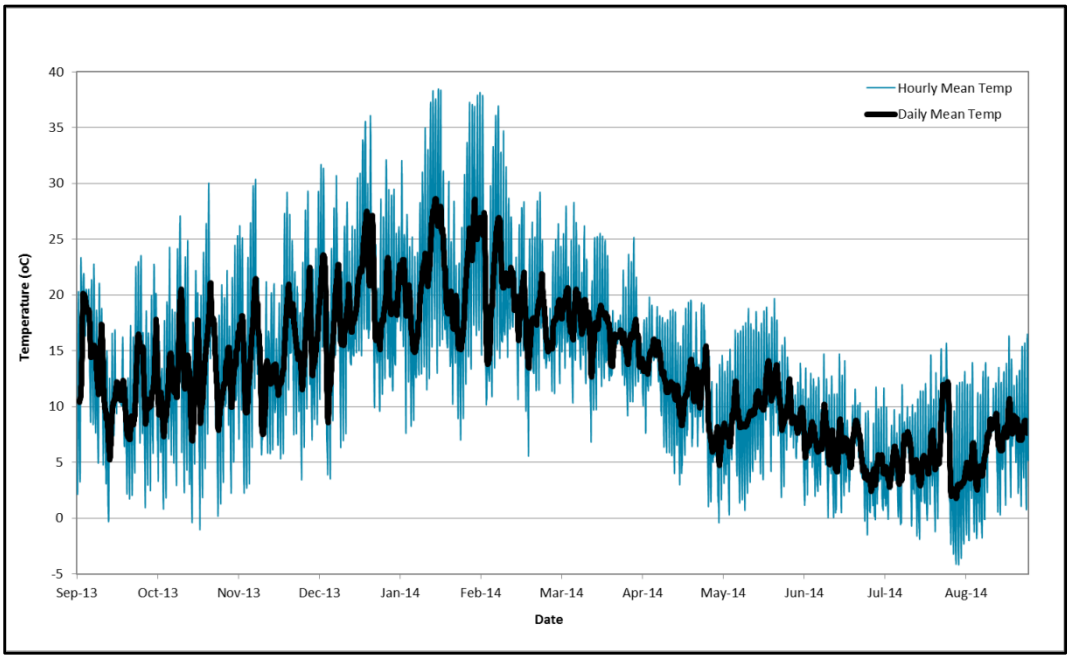


Figure 2-10: Time-series Plot of Air Temperature for Googong WRP taken from CALMET (1/09/2013 – 31/08/2014):

Diurnal variations in maximum and average air temperature predicted by CALMET at the Googong WRP for the 1-year period are shown in Figure 2-11. It can be seen that an increase in temperature occurred during the morning following sunrise, and that the maximum temperature occurred in the mid afternoon.

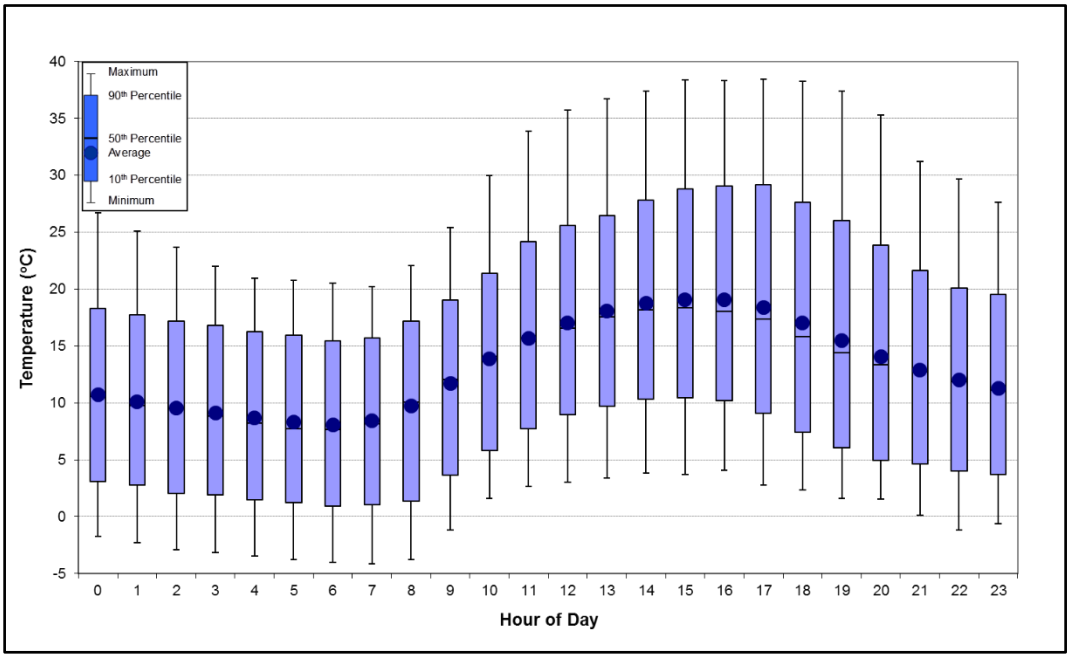


Figure 2-11: Diurnal Variation in Air Temperature for Googong WRP taken from CALMET (1/09/2013 – 31/08/2014)

The review of the diurnal temperature data shows there is nothing unusual or unexpected in the temperature data used in the modelling.

2.4.2.5 Terrain and Land Use

Geophysical (terrain and land use) data were input into the CALMET model at a resolution of 200 m. The land use data input into the model were based on the United States Geological Survey (USGS) land use and land cover classification scheme.

The surface elevation (terrain) data were taken from Lakes Environmental Software's website (www.webGIS.com), and were based on the Shuttle Radar Topography Mission (SRTM-3) digital elevation model (90 m resolution) data (Version 2) originally produced by NASA.

Figure 2-12 and Figure 2-13 show, respectively, the land use and terrain data input into CALMET. The data are superimposed on top of a Google Earth basemap (aerial photograph).

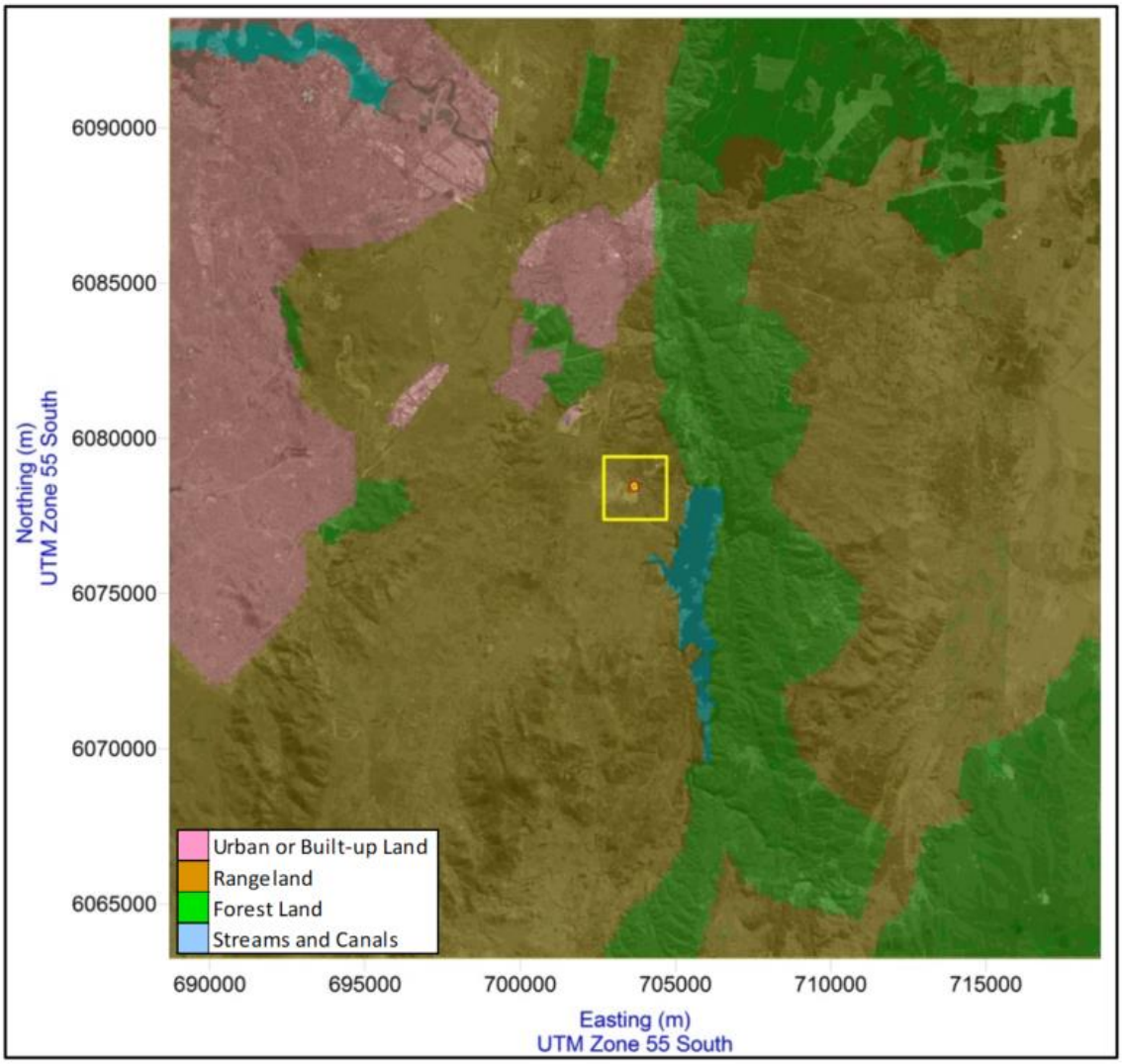


Image © 2014 CNES / Astrium, © 2014 Google, Image © 2014 DigitalGlobe (Google Earth Pro 7.1.1.1580)

Figure 2-12: Land Use Data Input into the Model

(a)

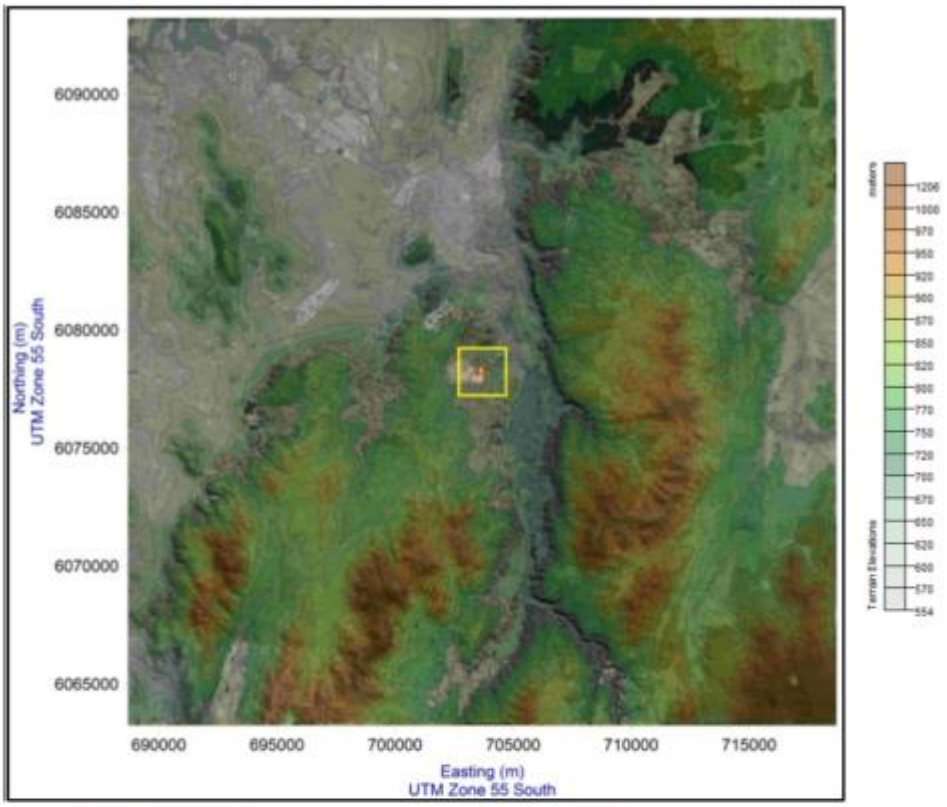


Image © 2014 CNES / Astrium, © 2014 Google, Image © 2014 DigitalGlobe (Google Earth Pro 7.1.1.1580)

(b)

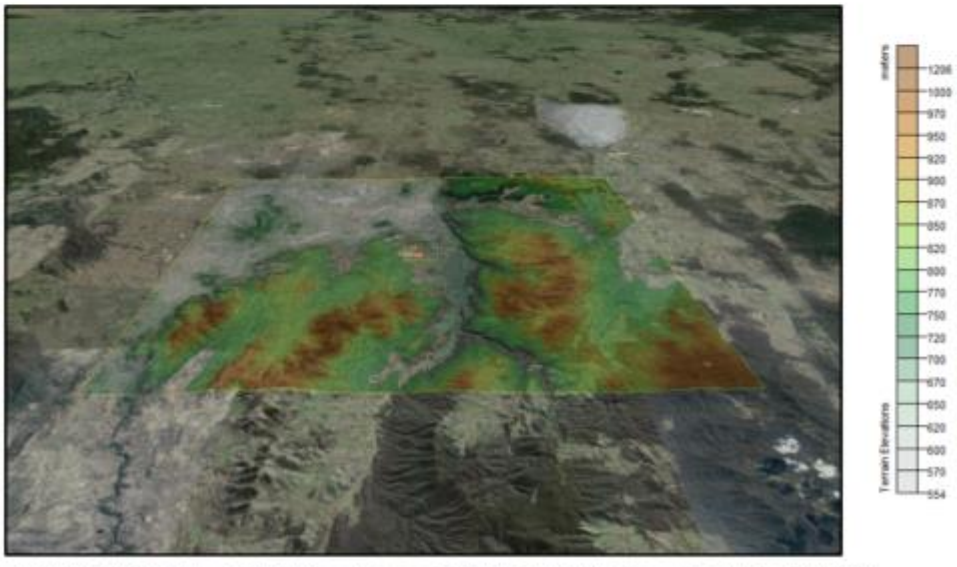


Image © 2014 CNES / Astrium, © 2014 Google, Image © 2014 DigitalGlobe (Google Earth Pro 7.1.1.1580)

Figure 2-13: Terrain Data Input into the Model: (a) aerial view and (b) oblique view

The terrain data shown in Figure 2-13 ranged from 554 m (light grey shading to the north-west of the Googong WRP) to 1,206 m (dark brown shading in the south-east corner of the CALMET domain).

2.4.3 Dispersion Modelling

2.4.3.1 CALPUFF Model Set-up

The atmospheric dispersion modelling assessment was conducted through the use of CALPUFF (Version 7.2.1, Level 150618), which is the latest version of the model. The model was set up in accordance with the general guidance contained in OEH (2011)[6]. Ground-level odour concentrations were predicted over a regular Cartesian receptor grid covering a 2 km by 2 km area (in the X and Y directions). The CALPUFF modelling area was centred on the Googong WRP at UTM 703694 m E, 6078235 m N (Zone 55 South), which was also the centre of the CALMET grid.

The modelled receptor locations were set up in the model as follows:

- 113 plant boundary (fenceline) discrete receptors were input into the model at a 5 m spacing along the WRP site boundary
- 33 sensitive receptors (see Section 2.3.3) were also input into the model
- At every 20 metres for the 1 km by 1 km area centred on the WRP location, then
- At every 50 metres up to the boundary of the 2 km by 2 km area centred on the WRP location

In other words, there were 3,975 discrete receptors in total across the 2 km by 2 km model area. The terrain data (elevations) were also imported for each discrete receptor. For each of these receptors, the predicted odour concentration for each hour of meteorological data in the year was calculated.

The CALPUFF modelling area is shown in Figure 2-14. The Googong WRP site boundary is shown by a dashed blue line and the discrete receptors are shown by a symbol with a yellow plus sign.

6 New South Wales Office of Environment and Heritage (OEH), 2011. *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia*, Sydney, Australia, March 2011.

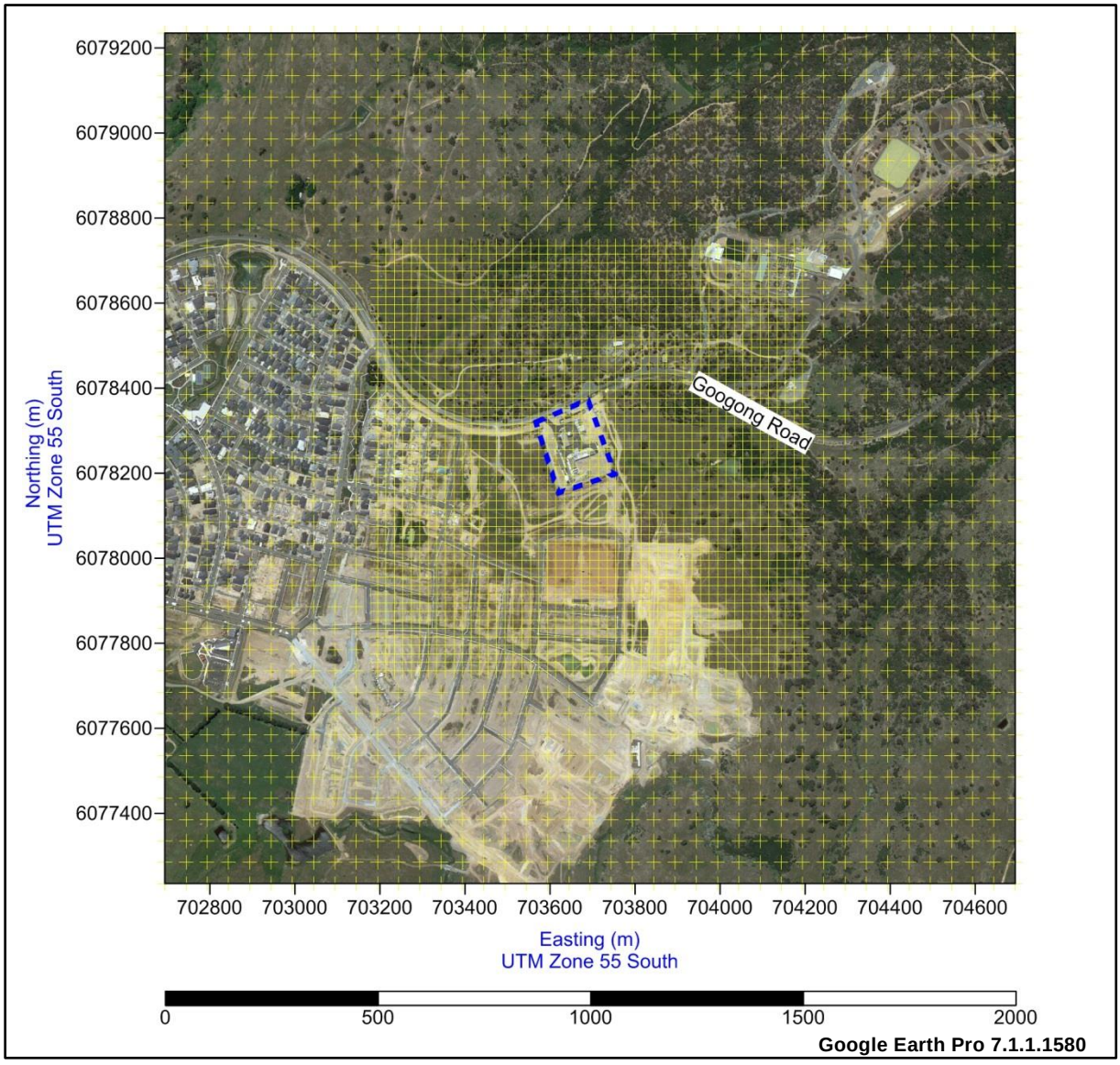


Figure 2-14: Aerial Basemap Showing the CALPUFF Modelling Area

2.4.4 Dispersion Options

OEH (2011)[7] recommends that CALPUFF should be run using the turbulence-based dispersion coefficients with the probability density function (PDF) option turned on (for calculating the σ_z (vertical dispersion) in the convective boundary layer) rather than US EPA default method, which uses the Pasquill-Gifford (PG) curves and ISC rural dispersion coefficients (computed using the ISCST3 multi-segment approximation) and McElroy-Pooler (MP) curves for urban dispersion coefficients (collectively known as the 'PG/MP dispersion coefficients'). This dispersion option is particularly important for tall stacks, which is not applicable in this assessment.

Notwithstanding the above, Stantec ran the CALPUFF model using the turbulence-based dispersion coefficients with the PDF option turned on, in accordance with OEH (2011) and the Approved Methods.

The way in which the wind "sees" or flows over buildings and structures depends on the direction of the wind. For instance, for a long narrow building, the wind will behave differently when blowing end-on or side-on or at an angle to the building long axis. A program called BPIP-PRIME is used to provide data

7 *Ibid*.

for the model to incorporate these effects. The Googong WRP buildings were input into the BPIP-PRIME building downwash model and the outputs from BPIP-PRIME were imported into CALPUFF.

The total run-time for the CALPUFF run was 7.5 days (181 hours). The CALPUFF list file is shown in Appendix D.

2.4.4.1 Odour Emission Rates And Locations

In the modelling of odour emissions, there are several types of odour emission sources used. Those relevant to this Report are:

- Point emissions, such as exhaust stacks and exhaust vents, where the odours are emitted as part of an air stream which has some velocity to it
- Volume emissions, such as buildings, where odours released inside the building exit through doors and windows
- Area emissions, such as open lagoons and tanks, where are odours are released through evaporation under the influence of the weather

2.4.4.1.1 Point Emissions (Stacks)

The location of the odour control facility (OCF) stack (point emission source) at the Googong WRP is shown in Table 2-4.

Table 2-4: Odour Control Facility Emission Source Location

Ref.	Description	UTM Zone 55 S		Elevation
		Easting (m)	Northing (m)	(m)
SRC_1	OCF Stack	703649	6078209	728.74

In developing an odour emission rate for the OCF stack, the following reasonable assumptions were made based on the design and performance guarantees of the OCF:

- The in-stack odour concentration is 500 ou, which is the maximum (i.e. worst-case) predicted concentration at peak load and aligns with current OCF design, operation and vendor's performance guarantee;
- The volumetric flow rate is 7.47 cubic metres per second (m^3/s) at actual conditions (which is the design of the OCF), which equates to a stack exit velocity of 16.9 metres per second (m/s) for a stack diameter of 0.75 m[8];
- The stack temperature is at ambient conditions (i.e. 298 Kelvin (K) or 25 degrees Celsius (°C)); and,
- The stack height is 16 m above ground level.

The odour emissions from the OCF stack were assumed to be constant (i.e. 24 hours a day, 7 days a week) throughout the 1-year model run period. This is a conservative approach as there will be times of the day when odour emissions will be less than the peak.

The odour emission rate input into the model for the wake-affected OCF stack is shown in Table 2-5.

[8] Current odour control system has discharge cone of 0.5m exit diameter which will be upgraded by Stage D to provide a discharge cone of 0.75m diameter at the larger, Stage D flows of 7.47 m^3/s.

Table 2-5: Odour Emission Data Input into the Model for the Odour Control Facility Stack

Ref.	Description	Stack Height (m)	Stack Diameter (m)	Stack Temperature (°C)	Exit Velocity (m/s)	Odour Concentration (ou)	Odour Emission Rate (ou.m^3/s)
SRC_1	OCF Stack	16.0	0.75	25	16.9	500	3,735

2.4.4.1.2 Volume Emissions (Buildings)

The sludge handling building (SHB) at the Googong WRP was input into the model as a volume source. The location of the SHB emission source is shown in Table 2-6.

Table 2-6: Sludge Handling Building Emission Source Location

Ref.	Description	UTM Zone 55 S (SW Corner)		Elevation (m)
		Easting (m)	Northing (m)	
SRC_2	SHB	703659	6078325	724.42

The odour emission rate input into the model for the SHB is shown in Table 2-7.

Table 2-7: Odour Emission Data Input into the Model for the Sludge Handling Building

Ref.	Description	Length of Side (m)	Release Height (m)	Initial Sigma *y* (m)	Initial Sigma *z* (m)	Odour Emission Rate (ou.m^3/s)
SRC_2	SHB	9.0	4.0	2.09	1.86	278

In developing an odour emission rate for the SHB, the following assumptions were made based on the design and the expected operation of the SHB:

- The odour concentration within the SHB is 200 ou, which is the maximum (i.e. **worst-case**) predicted concentration at peak load and the odour capture effectiveness of the building is 98%;
- For conservatism, it was assumed that the total area of the opening(s) on the leeward side(s) of the building is 78.32 m^2 (based on 4.4 m multiplied by 8.9 m multiplied by 2, i.e. two walls of the building). The total volumetric flow rate through the opening is 78.32 m^3/s at actual conditions, based on a wind speed of 1 m/s;
- The indoor air temperature is 298 K (or 25 °C); and,
- The release height is 4 m above ground level.

The initial lateral dimension (sigma *y*) was calculated according to the length of the side of the volume source (i.e. 9 m) divided by 4.3, in accordance with the default US EPA method. Similarly, the initial vertical dimension (sigma *z*) was calculated according to the height of the building (4 m above ground level) divided by 2.15, in accordance with the default US EPA method.

The odour emissions from the SHB were assumed to be constant (i.e. 24 hours a day, 7 days a week) throughout the 1-year model run period although in reality the emissions would only occur during normal working hours. In addition, the modelling assumed that the doors would be open when good operating practice would be to have them shut. These assumptions add conservatism to the modelling outcomes.

2.4.4.1.3 Area Emissions (Tanks, Bins, etc.)

The inlet works, grit and screening bins, bioreactor, aerobic digester and sludge storage hopper at the Googong WRP (Stage D) were modelled as area sources. As mentioned earlier, it was assumed that odour controls, as installed at Stage AB and Stage C, and proposed for Stage D, will be in place at each emission source, which will predominantly comprise of the use of covers with the odorous gases being extracted by forced air ventilation for treatment in the OCF. The Stage D bioreactor has been modelled as two bioreactors (Bioreactor 3 and Bioreactor 4) as per the original staging strategy. This strategy was revised in the Stage D Concept Design to replace Bioreactor 3 and Bioreactor 4 with a single bioreactor (known as Bioreactor 3) of equivalent surface area and odour emissions to the original Bioreactor 3 and Bioreactor 4 modelled herewith. This change will have a negligible influence on the odour emissions from site and, given its large area, would be recommended to be modelled as two separate sources anyway.

Some discussion of why these odour sources were modelled as area sources is required at this point. In reality, no cover or lid is perfectly sealed, and therefore there will always be some degree of leakage around the edges of the cover or lid, or around the edges of access hatches and other openings. We believe the leakage rates used in the modelling are conservative.

Odours released at the edges of covers or lids have been modelled as if being released over the area of the cover or lid. This approach allows the odours to be modelled as being released under the influence of the weather present at the time, which is the appropriate approach.

A total of 28 area emission sources were input into the model, as shown in Table 2-8.

Table 2-8: Area Emission Source Locations

Ref.	Description	UTM Zone 55 S (SW Corner)		Elevation (m)
		Easting (m)	Northing (m)	
SRC_3	Inlet Works	703685	6078214	726.02
SRC_4	Grit and Screenings Bins	703690	6078223	725.71
SRC_5	Bioreactor 1 - Anaerobic Zone	703665	6078235	727.30
SRC_6	Bioreactor 1 - Primary Anoxic	703659	6078230	727.65
SRC_7	Bioreactor 1 - Aerobic Zone	703655	6078236	727.23
SRC_8	Bioreactor 1 - Deaeration Zone	703673	6078233	727.03
SRC_9	Bioreactor 1 - Secondary Anoxic	703671	6078237	726.61
SRC_10	Bioreactor 1 - MBR	703666	6078240	726.75
SRC_11	Bioreactor 2 - Anaerobic Zone	703654	6078226	727.96
SRC_12	Bioreactor 2 - Primary Anoxic	703647	6078225	728.30
SRC_13	Bioreactor 2 - Aerobic Zone	703644	6078232	728.15
SRC_14	Bioreactor 2 - Deaeration Zone	703652	6078230	727.90
SRC_15	Bioreactor 2 - Secondary Anoxic	703651	6078234	727.84
SRC_16	Bioreactor 2 - MBR	703661	6078239	726.94
SRC_17	Bioreactor 3 - Anaerobic Zone	703672	6078214	726.71
SRC_18	Bioreactor 3 - Primary Anoxic	703667	6078208	727.81
SRC_19	Bioreactor 3 - Aerobic Zone	703662	6078215	727.91
SRC_20	Bioreactor 3 - Deaeration Zone	703680	6078211	726.32
SRC_21	Bioreactor 3 - Secondary Anoxic	703678	6078216	726.36

Ref.	Description	UTM Zone 55 S (SW Corner)		Elevation (m)
		Easting (m)	Northing (m)	
SRC_22	Bioreactor 3 - MBR	703673	6078219	727.22
SRC_23	Bioreactor 4 - Anaerobic Zone	703661	6078205	728.21
SRC_24	Bioreactor 4 - Primary Anoxic	703654	6078203	728.67
SRC_25	Bioreactor 4 - Aerobic Zone	703651	6078211	728.55
SRC_26	Bioreactor 4 - Deaeration Zone	703660	6078209	728.18
SRC_27	Bioreactor 4 - Secondary Anoxic	703658	6078213	728.15
SRC_28	Bioreactor 4 - MBR	703669	6078218	727.50
SRC_29	Aerobic Digester	703652	6078300	724.79
SRC_30	Sludge Storage Hopper	703658	6078315	724.54

Odour sampling and analysis was undertaken in March 2016 by AirLabs at the existing (Stage AB) Googong WRP area emission sources using a flux hood in accordance with Australian/New Zealand Standard (AS/NZS) 4323.3 (2001)[9] and AS/NZS 4323.4 (2009)[10]. AirLabs is NATA accredited (laboratory number 15463) to undertake the sampling and analysis of odour in accordance with these Standards.

Area sources are normally sampled for odours by placing an odour collection hood on the surface, allowing the air under the hood to equilibrate, then drawing an odour sample from under the hood. However, at some locations at the WRP, there was insufficient room to place the hood, and therefore a method similar to how a stack or building odour sample would be taken was used i.e. an odour sample was collected and the velocity of the air at that point was measured.

The actual site-specific odour monitoring data from March 2016 were analysed and compared to odour emission data used in the previous odour modelling for the WRP. The analysis and comparison revealed that the odour values measured in 2016 were significantly lower than the assumed values used in the previous modelling. **Therefore, in order to provide a worst-case (conservative) assessment, the odour emission rates input into the model were based on the emission rates used in the previous Stantec dispersion modelling assessment dated November 2004[11] for the ultimate (Stage D) WRP site layout**. It was not considered to be appropriate to use the actual existing (Stage AB) odour emission source data as input into the model given that the average daily flow rates to the WRP will be higher under Stage D compared with Stage AB and Stage C. A comparison of some of the data is shown in Table 2-9 by way of example.

Table 2-9: Comparison Of Odour Emission Values Used In Previous Modelling Compared To Measured Values In March 2016

Odour Source	Odour Value Used In Previous Modelling (ou.m/s)	Odour Value Measured in March 2016 (ou.m/s)
SRC_5	2.7	0.21

9 Australian/New Zealand Standard AS/NZS 4323.3 (2001) Stationary Source Emissions – Part 3: Determination of Odour Concentration by Dynamic Olfactometry.

10 Australian/New Zealand Standard AS/NZS 4323.4 (2009) Stationary Source Emissions – Method 4: Area Source Sampling—Flux Chamber Technique.

11 Technical Memorandum prepared by Stantec (then MWH) for GTPL dated 3 November 2014 entitled 'Googong WRP Odour Dispersion Modelling Assessment'.

Odour Source	Odour Value Used In Previous Modelling (ou.m/s)	Odour Value Measured in March 2016 (ou.m/s)
SRC_6	0.7	0.29
SRC_7	0.4	0.04
SRC_29	0.5	0.06

The odour emission rates input into the model assumed a high-level of odour capture efficiency at the area sources (see Table 2-10).

The odour capture efficiencies assumed in this assessment for the area emission sources are summarised in Table 2-10. These are considered reasonable based on the level of cover and extraction from these areas.

Table 2-10: Area Source Odour Capture Efficiencies

Ref.	Description	Capture Efficiency (%)
SRC_3	Inlet Works	95%
SRC_4	Grit and Screenings Bins	95%
SRC_5	Bioreactor 1 - Anaerobic Zone	99%
SRC_6	Bioreactor 1 - Primary Anoxic	99%
SRC_7	Bioreactor 1 - Aerobic Zone	99%
SRC_8	Bioreactor 1 - Deaeration Zone	99%
SRC_9	Bioreactor 1 - Secondary Anoxic	99%
SRC_10	Bioreactor 1 - MBR	99%
SRC_11	Bioreactor 2 - Anaerobic Zone	99%
SRC_12	Bioreactor 2 - Primary Anoxic	99%
SRC_13	Bioreactor 2 - Aerobic Zone	99%
SRC_14	Bioreactor 2 - Deaeration Zone	99%
SRC_15	Bioreactor 2 - Secondary Anoxic	99%
SRC_16	Bioreactor 2 - MBR	99%
SRC_17	Bioreactor 3 - Anaerobic Zone	99%
SRC_18	Bioreactor 3 - Primary Anoxic	99%
SRC_19	Bioreactor 3 - Aerobic Zone	99%
SRC_20	Bioreactor 3 - Deaeration Zone	99%
SRC_21	Bioreactor 3 - Secondary Anoxic	99%
SRC_22	Bioreactor 3 - MBR	99%
SRC_23	Bioreactor 4 - Anaerobic Zone	99%
SRC_24	Bioreactor 4 - Primary Anoxic	99%
SRC_25	Bioreactor 4 - Aerobic Zone	99%
SRC_26	Bioreactor 4 - Deaeration Zone	99%
SRC_27	Bioreactor 4 - Secondary Anoxic	99%

Ref.	Description	Capture Efficiency (%)
SRC_28	Bioreactor 4 - MBR	99%
SRC_29	Aerobic Digester	99%
SRC_30	Sludge Storage Hopper	99%

The odour emission rates input into the model for the area sources are shown in Table 2-11.

Table 2-11: Odour Emission Data Input into the Model for the Area Sources

Ref.	Description	Source Area (m^2)	Release Height (m)	Initial Sigma *z* (m)	Odour Emission Rate After Odour Capture Efficiency Applied (ou.m/s)
SRC_3	Inlet Works	40	7.4	1.0	0.280
SRC_4	Grit and Screenings Bins	12	2.5	1.0	0.280
SRC_5	Bioreactor 1 - Anaerobic Zone	36	2.9	1.0	0.027
SRC_6	Bioreactor 1 - Primary Anoxic	49	2.9	1.0	0.007
SRC_7	Bioreactor 1 - Aerobic Zone	53	2.9	1.0	0.004
SRC_8	Bioreactor 1 - Deaeration Zone	16	2.9	1.0	0.003
SRC_9	Bioreactor 1 - Secondary Anoxic	16	2.9	1.0	0.007
SRC_10	Bioreactor 1 - MBR	23	3.1	1.0	0.004
SRC_11	Bioreactor 2 - Anaerobic Zone	36	2.9	1.0	0.027
SRC_12	Bioreactor 2 - Primary Anoxic	49	2.9	1.0	0.007
SRC_13	Bioreactor 2 - Aerobic Zone	53	2.9	1.0	0.004
SRC_14	Bioreactor 2 - Deaeration Zone	16	2.9	1.0	0.003
SRC_15	Bioreactor 2 - Secondary Anoxic	16	2.9	1.0	0.007
SRC_16	Bioreactor 2 - MBR	23	3.1	1.0	0.004
SRC_17	Bioreactor 3 - Anaerobic Zone	36	2.9	1.0	0.027
SRC_18	Bioreactor 3 - Primary Anoxic	49	2.9	1.0	0.007
SRC_19	Bioreactor 3 - Aerobic Zone	53	2.9	1.0	0.004
SRC_20	Bioreactor 3 - Deaeration Zone	16	2.9	1.0	0.003
SRC_21	Bioreactor 3 - Secondary Anoxic	16	2.9	1.0	0.007
SRC_22	Bioreactor 3 - MBR	23	3.1	1.0	0.004
SRC_23	Bioreactor 4 - Anaerobic Zone	36	2.9	1.0	0.027
SRC_24	Bioreactor 4 - Primary Anoxic	49	2.9	1.0	0.007
SRC_25	Bioreactor 4 - Aerobic Zone	53	2.9	1.0	0.004
SRC_26	Bioreactor 4 - Deaeration Zone	16	2.9	1.0	0.003
SRC_27	Bioreactor 4 - Secondary Anoxic	16	2.9	1.0	0.007
SRC_28	Bioreactor 4 - MBR	23	3.1	1.0	0.004

SRC_29	Aerobic Digester	186	1.7	1.0	0.005
SRC_30	Sludge Storage Hopper	20	2.6	1.0	0.012

The odour emissions from the area sources were assumed to be constant (i.e. 24 hours a day, 7 days a week) throughout the 1-year model run period. This is a conservative approach as these worst case odour emissions would not be present on a constant basis.

2.4.4.1.4 Summary of Total Googong WRP Stage D Odour Emissions

Analysis of the odour emission rates input into the model indicates that the principal emission sources at the Googong WRP (Stage D) will be the OCF stack (SRC_1) and SHB (SRC_2), as indicated below:

- SRC_1 OCF Stack 3,735 ou.m^3/s (or 91.67% of the total site odour emissions)
- SRC_2 SHB 278 ou.m^3/s (or 7.68% of the total site odour emissions); and
- Total Area Sources 23.6 ou.m^3/s (0.65% of the total site odour emissions).

The product of the area source odour emission rate (ou.m/s) and the emission source area (m^2) is the odour emission rate in ou.m^3/s. The 28 area sources (SRC_3 to SRC_30) only contribute 23.6 ou.m^3/s in total or 0.7% of the total site odour emissions, which are 3,622 ou.m^3/s based on the current practice of covering the area odour sources being extended to the Stage D facilities

2.5 Odour Impact Assessment

The ground-level odour concentrations predicted by the model are shown in Figure 2-15 as an isopleth (odour concentration contour) plot. The discrete sensitive receptor locations are shown by the white symbol '⊕', while the WRP site boundary is shown by a dashed blue line. The odour concentration scale shown in the figure is non-linear and locations with predicted exceedances of the 2 ou odour assessment criterion are shown by filled orange contour lines. Receptors 26 to 33 (R26 to R33 shaded green in the diagram below) are locations associated with GTPL Planning proposal for NH1A stage 4D which includes for additional residential lots to the west of the WRP in future.

In Figure 2-15, the odour contours shown do ***not*** represent a snapshot of a particular moment in time but a summary of the years' worth of predictions. The contours join up those locations where the highest predicted value over the year are the same. If we take the 0.5 ou contour line, for example, at some point in the year the weather was such that a location to the north was predicted to experience 0.5 ou, and at some other hour in the year the weather conditions were such that a location to the south was predicted to experience 0.5 ou.

Figure 2-15 indicates that odour concentrations of greater than the 2 ou assessment criterion were only predicted within the boundary of the WRP site and that odour concentrations were predicted to be **well below the odour assessment criterion at all existing and future sensitive receptor locations**. Given that a **conservative** approach to odour emissions was taken both for concentrations and occurrence, it is very unlikely that odour nuisance impacts will occur under normal WRP operating conditions.

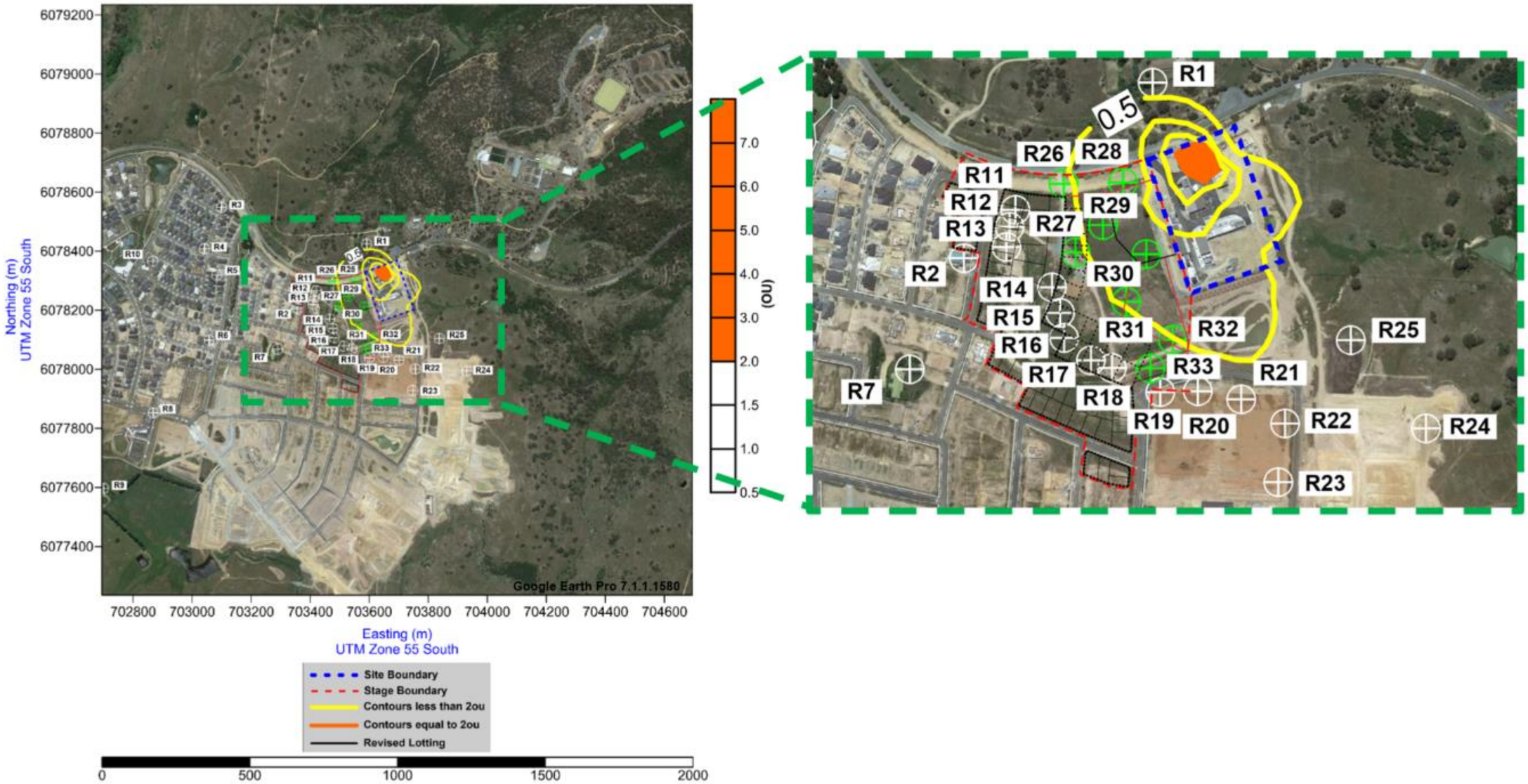


Figure 2-15: 99th percentile 1-second Mean Odour Concentrations (ou) and close up

2.6 Stage D Odour Strategy Discussion

This section has been included to provide GTPL and their stakeholders with discussion of the Stage D odour strategy. Specifically:

- A comparison of measured odour emission rates and those used in the air quality assessment
- Review and discussion of the predicted Stage C and Stage D odour impact
- Discussion of any potential buffer zone including risk associated with abnormal operation
- Discussion of the potential impact of uncovering areas of plant at Stage D

2.6.1 Review of Emission Rate Data

The odour emission rates inventory used for the Googong WRP Stage D dispersion modelling is documented in detail in Section 2.4.4.1 of this document. This text is intended to provide further discussion of the derivation of these rates including a review of emission rate estimates used in previous Googong WRP dispersion modelling exercises, actual data collected from the operational plant in March 2016, and potential future changes to these emission rates associated with future plant expansion.

2.6.1.1 2009 - 2014 Emission Rate Estimates

Odour emission rates were initially estimated for Googong WRP during the planning stage of the project in 2009, based on emission rate data observed for process units at similar plants. This data was taken from the 'Stantec Global Emissions Database' and based on an understanding of the plant configuration and proposed operation. The emission rates selected at this time were necessarily relatively conservative given the early stage of design development and lack of any wastewater characterisation data.

Further monitoring exercises were completed in 2013 and 2014 with the 2013 assessment (Googong Integrated Water Cycle, Odour Management – Maintenance Impact, Technical Memorandum, 83500349-P-TM-009) providing input to design development and the 2014 model (Googong WRP Odour Dispersion Modelling Assessment, 3 November 2014, REF M002) incorporating meteorological data collected at the Googong WRP site.

2.6.1.2 2016 Emission Rate Monitoring

The WRP began receiving sewage in late 2015 and odour monitoring was undertaken in March 2016 by AirLabs, which was as a requirement of the performance testing specification. This emission data was collected to check that the estimates previously made were reasonable and to inform emission rates for odour impact assessments for future stages of development. The WRP was fully operational and receiving and treating wastewater during this sampling period. The total load to the WRP was approximately 1,000 EP (around 21% of the design capacity of the Stage AB WRP) and as such the WRP was relatively lowly loaded. Some of the key factors relative to odour emission rates associated with this low loading are as follows:

1. Total influent wastewater flow is relatively low which, due to the pumped nature of flow to the WRP, results in shorter durations of sewage receival and inlet works operation
2. Influent wastewater rising main retention times are relatively high resulting in a higher level of septicity in the influent sewage (more odorous material)
3. Total plant organic load is significantly less than design capacity resulting in a low oxygen demand and intermittent bioreactor aeration
4. The low total plant organic load also results in a high sludge age in the bioreactor. This was estimated as upwards of 80 days at the time of odour monitoring. The design sludge age for the bioreactor is approximately 20 days. A lower sludge age can result in less stable (and potentially higher) odour emission rates in some circumstances, however there is little difference in odour emission in the 20 to 80 days sludge age range.
5. The aerobic digester solids retention time was relatively high due to low total sludge production
6. The sludge dewatering equipment was run infrequently

2.6.1.3 Review and Comparison of Area Source Data

Table 2-12 provides a summary of the previously used estimated Specific Odour Emission rates (SOER) for each area source at the plant, the 2016 measured values, and the values selected for the Stage C

and Stage D odour impact assessment. In general the measured odour emission rates were relatively low, which is in part associated with the low loads which the WRP was treating at the time of sampling. The SOER are expected to increase as the load to the WRP increases over time however it is not possible to accurately quantify this and as such the SOER used in the 2009 – 2014 modelling has generally been adopted for the Stage C and Stage D WRP impact assessment.

Table 2-12: Area Source Odour Emissions

Source	2009 – 2014 SOER Assumption	2016 Measured Data (ou.m/s) Notes 2, 3			Selected Value for Stage C & Stage D Modelling
	(ou.m/s) Notes 1, 3	50 %ile	90 %ile	Max	(ou.m/s) Note 3
Inlet Works	5.600	Not measured as an area source.		Note 4	5.600
Grit and Screenings Bins	5.600	Not measured		Note 5	5.600
Bioreactor Anaerobic Zone Note 6	2.700	0.17	0.19	0.21	2.700
Bioreactor Primary Anoxic Note 6	0.700	0.05	0.26	0.29	0.700
Bioreactor Aerobic Zone Note 6	0.400	0.03	0.04	0.04	0.400
Bioreactor Deaeration Zone	0.300	Not measured.		Note 9	0.300
Bioreactor Secondary Anoxic	0.700	Not measured		Note 9	0.700
Bioreactor Membrane Tank	0.400	Not measured		Note 9	0.400
Aerobic Digester	0.500	0.03	0.05	0.06	0.500
Sludge Storage Hopper	1.200	Not measured		Note 8	1.200

Notes

1. Estimates used for 2009 planning approval odour impact assessment
2. Data measured in March 2016 by Airlabs as part of Stage AB performance testing
3. Raw input value selected before a capture ratio has been applied
4. **Odour Measurements for the Inlet Works:** The Stage AB inlet works was measured as part of the 2016 monitoring but due to available access for equipment this was measured as a point source and as such is not directly comparable with the assumed odour emission rate used previously. The average odour concentration of 1,175 ou and a maximum measured value of 5,500 ou are relatively low concentrations, which is attributed to the effectiveness of the rising main ferric sulphate dosing and the inlet works having a relatively high level of ventilation.
   The inlet works was replaced at Stage C and the new inlet works has a different configuration resulting in different turbulence and ventilation characteristics. The sewage characteristics will also be different and raw sewage will be received for longer durations (with shorter residence times in the network) as the catchment ramps up. As such it is anticipated that the inlet works SOER may increase over time from that measured in 2016. It is not possible to accurately quantify this increase and as such the estimated SOER used in the 2009 – 2014 modelling has been adopted. Note that the value stated is that before the odour capture rate has been applied.
5. **Odour Measurements for the Grit and Screenings Bins:** The grit and screenings bins are relatively small and low odour impact sources when covered as per the design. The Stage AB SOER was not measured because this is a relatively small source and the Stage C bins will have different odour characteristics due to

changes in the raw sewage and the mechanism for removal and handling of grit and screenings. The estimated SOER used in the 2009 – 2014 modelling has been adopted for the Stage C and Stage D WRP impact assessments.

6. **Odour Measurements for The Bioreactor:** The Stage AB bioreactor SOER was measured at three different locations. The measured SOER were all significantly less than the 2009 assumed value with:

   - Peaks in the anaerobic zone being less than 10% of the estimated value
   - Peaks in the anoxic zone being around 40% of the estimated value and
   - Peaks in the aerobic zone being less than 10% of the estimated value.

   These are all relatively low SOER and this is partially attributed to the relatively low loading to the plant as discussed in Section 2.6.1.2 and associated long sludge age. The high variability noted in the anoxic zone is indicative of fluctuations in its aerobic state (i.e. moving between anoxic/anaerobic and aerobic states) due to the low loading and infrequent addition of raw sewage. The aerobic zone values appear to be generally low indicating that the mixed liquor in the bioreactor is well aerated which correlates with the low load to the plant. The emission rates from the bioreactor are likely to increase as WRP loading increases however it is not possible to accurately quantify this increase and as such the estimated SOER used in the 2009 – 2014 modelling has been adopted. The Deaeration zone, secondary anoxic and membrane tank zones were estimated based on the other measured zones as described below.
7. **Odour Measurements for the Aerobic Digester:** The measured aerobic digester emissions were significantly lower than those estimated. This process unit was lowly loaded during commissioning as the WRP sludge inventory was developed. The digester was also well aerated with the blowers operating at the lower end of their range. The emission rates from the aerobic digester are likely to increase as WRP loading increases however it is not possible to accurately quantify this increase and as such the estimated SOER used in the 2009 – 2014 modelling has been adopted for the Stage C and Stage D assessments.
8. **Odour Measurements for the Sludge Storage Hopper:** The sludge hopper emission rates were not measured due to the low volumes of dewatered sludge stored during commissioning and as such the estimated SOER used in the 2009 – 2014 modelling has been adopted for the Stage C and Stage D assessments.
9. **Odour Measurements for the Bioreactor: De-Aeration Zone, Bioreactor Secondary Anoxic Zone and Bioreactor Membrane Tank:** Experience has shown that these odour sources are relatively low strength and as such were not included in the Testing Requirements. The assumed values are based on equivalent emissions from the Primary treatment units, which are more odorous, and therefore this is a conservative approach

2.6.1.4 Review and Comparison of Point / Volume Source Data

Table 2-13 provides a summary of the estimated odour concentrations for the point (stack) and volume (building) odour sources at the WRP, along with the 2016 measured values and the values selected for the Stage C and Stage D odour impact assessment.

The OCF Exhaust Stack: The dominant emission from the entire site and that which has the highest overall Odour Emission Rate (OER) is the OCF stack. The odour concentration in the stack was estimated as 500 ou in 2009 based on the use of activated carbon adsorption (filtration) to treat the foul air. The installed system is designed based on provision of a guarantee of 500 ou at the stack and monitoring data confirms this is currently being achieved. The OCF stack discharge concentration is not anticipated to significantly increase so long as the system is operated and maintained correctly (primarily meaning activated carbon media is changed at the appropriate time) and as such the 500 ou value has also been adopted for the Stage C and Stage D assessment.

The Sludge Handling Building: Monitoring in the sludge handling building indicated relatively low odour concentrations consistent with ambient air. The samples were all taken during operation of the centrifuge and this indicates that the odour containment measures provided for the centrifuge, drains and conveyors are operating effectively. The centrifuge will operate for longer durations as the plant loading increases but the odour concentration in this building are not anticipated to change significantly so long as good housekeeping and maintenance practices are carried out. As such a value of 200 ou was adopted for the Stage C and Stage D assessment. This is over **4 times the maximum measured** value during WRP operation.

Table 2-13: Point & Volume Source Odour Emissions

Source	2009 – 2014 Odour Concentration (ou) Notes 1, 3	2016 Measured Data (ou) Notes 2, 3			Selected Value for Stage C & Stage D Modelling
		50 %ile	90 %ile	Max	(ou) Note 3
OCF Stack	500	230	397	460	500
Sludge Handling Building	500	38	43	44	200

Notes

1. Estimates used for 2009 planning approval odour impact assessment and subsequent variations
2. Data measured in March 2016 by Airlabs as part of Stage AB performance testing
3. Raw input value selected before a capture ratio has been applied

2.6.2 Predicted Odour Impact Discussion

2.6.2.1 Stage C and Stage D Impact Comparison

Figure 2-16 presents the Stage C and Stage D odour footprints. It is clear that the plots are very similar to one another. Receptors 26 to 33 (R26 to R33 shaded green in the diagram below) are locations associated with GTPL Planning proposal for NH1A stage 4D which includes for additional residential lots to the west of the WRP in future.

Review of the sources which contribute to these footprints show that the sludge handling building emissions, which are unchanged in the model between Stage C and Stage D contribute the most to ground level impacts. The impact associated with the area sources is relatively low because of the covering and ventilation provided and the impact of the Odour Control Facility discharge is mitigated through stack dispersion.

These plots are comparable with those produced during 2009, 2013 and 2014 modelling projects and indicate that there are no offsite areas which exceed the odour impact criterion of 2 ou at the sensitive receptors as, discussed in Section 2.3.4.1.

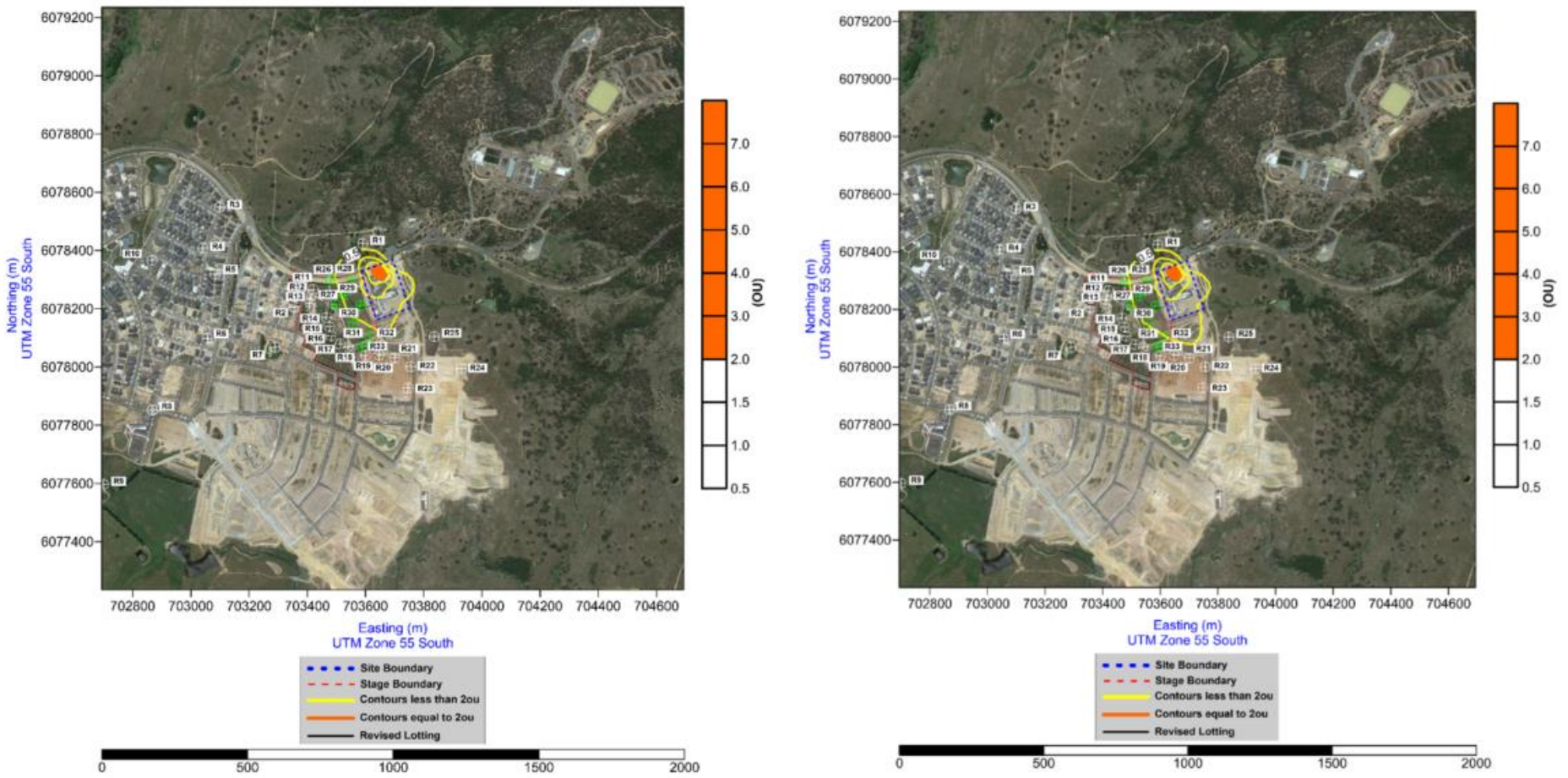


Figure 2-16: Comparison of Stage C (left) and Stage D (right) Predicted Odour Footprint - 99th percentile 1-second Mean Odour Concentrations (ou)

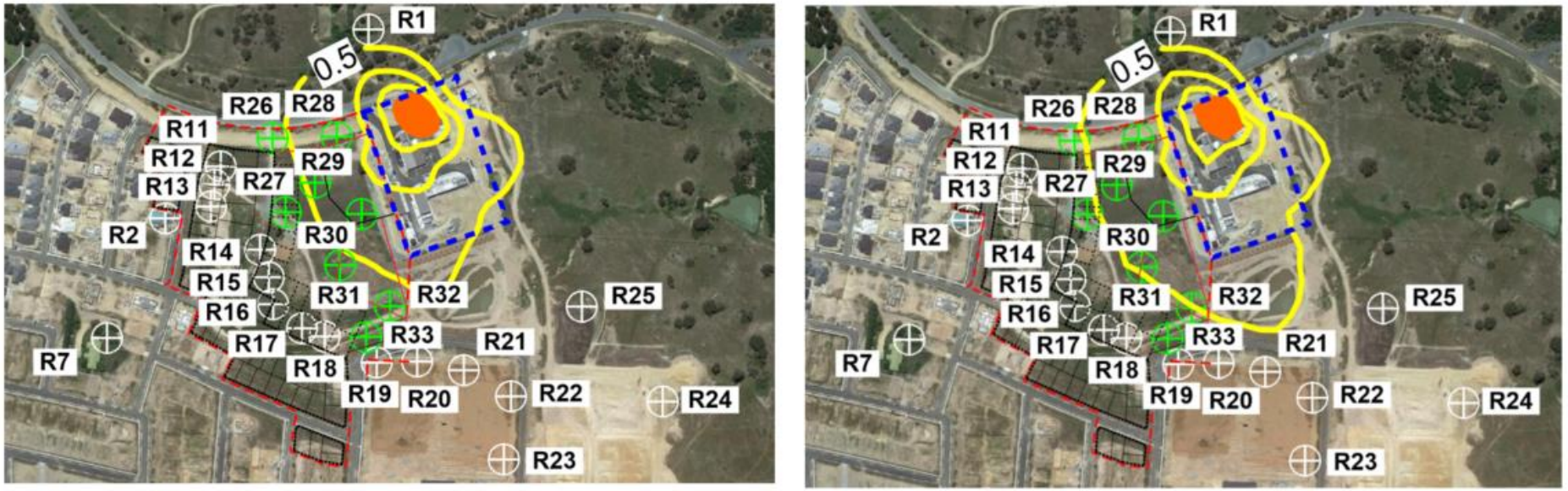


Figure 2-17: Comparison of Stage C (left) and Stage D (right) Predicted Odour Footprint - 99th percentile 1-second Mean Odour Concentrations (ou) – Close up view

2.6.3 Residual odour risk

It is generally accepted that even with good odour containment and treatment there is potential for unintended emissions associated with intermittent events such as equipment failure, abnormal operation, accidents or abnormal weather. The Googong WRP is designed with extensive odour covers and odour abatement including a high level of redundancy, however such unplanned events may still occur and have the potential to cause offsite odour impact.

2.6.3.1 Key Risks of Abnormal Odour Emissions

The odour impact assessment and dispersion modeling predicts no offsite odour impact in excess of the 2 ou odour impact criterion. This modelling takes into account conservative emission rates however it should be noted that these generally still assume normal operation and that, as noted above, there is potential for offsite odour impact to occur during abnormal events. Some of the key risks for Googong WRP are listed below. These would almost all require a combination of factors to occur to result in an off-site odour impact. Risk mitigation measures are shown in italics:

- Failure of inlet chemical dosing (pump failure or lack of available chemical) occurring concurrently with inlet works hatches being left open or open for maintenance. – *Can be addressed through thorough preventative maintenance, management of chemical supply, and work procedures requiring mandatory closing of hatches*
- Fugitive emissions from the grit and screenings bins possibly during changeover. – *Can be addressed by suitable work procedures*
- Fugitive emissions from the Emergency Detention Tank (EDT) associated with extended storage periods or presence of residual solids following a wet weather event – *Can be cleaned out after long storage times occur.*
- Abnormal conditions in the bioreactor potentially associated with blower failures or toxic shock occurring concurrently with hatches being left open. – *Can be addressed by preventative maintenance and work procedures requiring mandatory closing of hatches*
- Fugitive emissions from the Rotary Drum Thickeners associated with sludge spillage during maintenance and inspection. – *Can be addressed through suitable work procedures*
- Fugitive emissions from the aerobic digester associated with sludge spillage during maintenance, open hatches and blower failure or overflow of sludge. – *Can be addressed by preventative maintenance and work procedures requiring mandatory closing of hatches*
- Fugitive emissions in the sludge dewatering building caused by biosolids spillage from the centrifuge or conveyors, release from the centrate sump or fugitive emissions from the biosolids bin during changeover particularly if storage is for an extended period – *Can be addressed by work procedures*
- Failure of the odour control facility due to activated carbon being fully saturated. – *Can be addressed by suitable OCF management procedures*
- Fugitive emissions associated with chemical spillage (particularly acetic acid). – *Can be addressed by suitable chemical management procedures*

In summary, the risks of abnormal or unexpected odour emissions can largely be managed through the use of suitable management methods and procedures, however some residual risk remains.

2.6.3.2 Summary

Googong WRP does have extensive odour control measures including both chemical dosing to the incoming sewage and covering and ventilation throughout the potentially odorous areas of the plant combined with odour control on the ventilation exhaust stream (the OCF exhaust).

The WRP was also designed to locate areas with a highest risk of fugitive emission events, such as the inlet works and biosolids areas, away from boundaries with sensitive receptors, where possible. The odour abatement scheme also has redundancy throughout including in chemical dosing facilities, extraction fans and the activated carbon filters which provide treatment.

These factors all contribute to reducing the risk of offsite odour impact. An Odour Management Plan should be developed to reduce the risk of odour impact associated with abnormal operation and maintenance activities, as described above.

In practice, the WRP has been in operation for the past 4 years with no odour complaints received by QPRC. This included periods when the plant underwent maintenance works which required temporary removal of odour containment covers, such as during cleaning/replacement of the MBR membranes.

3 Dust Management

3.1 WRP Operation

It is not anticipated that there will be a significant risk of adverse impact on air quality associated with dust during the operation of the Stage D WRP. The expansion will not introduce any significant potential sources of dust in comparison to the existing Stage AB and Stage C WRP.

Roads, laydown areas and working areas will be sealed or landscaped. Any residual solids such as biosolids, grit and screenings are stored in dedicated sealed and ventilated bins.

3.2 Construction

The Stage D WRP expansion includes the requirement for earthworks in a number of areas including new water retaining structures, roads and retaining walls which provide a potential risk of dust generation.

Table 3-1 describes the key air quality risks (including dust generation) and proposed mitigation measures associated with construction.

These mitigation measures are consistent with those adopted for construction of the existing Stage AB and C WRP and will be developed further as the construction methodology (and particularly the Construction Environmental Management Plan (CEMP)) are developed through Detailed Design and by the future Contractor.

Table 3-1: Construction Air Quality Impact Risks & Mitigation

Risk	Mitigation
Dust generation due to general construction activities	The CEMP will include typical dust suppression measures. Nuisance dust will be minimised by: • Employment of water trucks and/or use of WRP recycled water system to reduce dust in dry, windy conditions. • Reducing speed limits during high dust conditions • Clearing vegetation and topsoil only within the designated footprint • Progressive reinstatement of disturbed areas
Dust generation due to construction activities such as rock excavation	Rock excavation will be conducted at appropriate times, with consideration of site conditions and sensitive receivers.
Adverse weather conditions and potential for dust storms	Working practices will be modified during periods of high winds by limiting the use of some machinery, particularly when in close proximity to dwellings in addition to reducing travel speeds of vehicles.
Adverse impacts on air quality due to smoke and other conditions	The burning of material on site will be prohibited on site, except under the instruction of fire services.
Emissions from vehicle use	Vehicles will be well maintained to ensure emissions are kept to the minimum practicable.

4 Recommendations and Conclusions

4.1 Odour

The dispersion modelling results presented in Section 2.5 indicate odour emissions from the proposed Stage D expansion works at the Googong WRP, with odour controls in place, are not predicted to exceed the NSW EPA odour impact criterion of 2 ou at the nearest sensitive receptor. Given this, the likelihood of odour nuisance from odour emissions from the WRP under normal operating conditions is very low.

GTPL's Planning Proposal for the NH1A Stage 4D receptors has no receptor receiving greater than the NSW EPA odour impact criterion of 2 ou and hence is compliant with the NSW EPA requirements.

With the derivation and implementation of a suitable Odour Management Plan to address abnormal or upset conditions at the WRP, the risk of odour nuisance occurring under these conditions can be minimised.

This is based on the following:

- Odour control covers, ventilation & foul air treatment consistent with the existing Stage AB and Stage C WRP and the proposed Stage D are adopted i.e. the inlet works, all bioreactor areas, the General Purpose Pump Station, the aerobic digester and the appropriate biosolids processing equipment are covered / enclosed and ventilated to an Odour Control Facility.
- Odour capture efficiencies of at least 95% at the inlet works and at the grit and screenings bins, and of at least 99% at the bioreactor, aerobic digester and sludge storage hopper are required (as per the installed Stage AB and Stage C systems). The odorous gases at each additional area source should be extracted by forced air ventilation for treatment in the OCF, as per the measures adopted for the existing Stage AB and Stage C WRP and proposed Stage D;
- The existing WRP OCF will be modified at Stage D and should be designed, operated and maintained to achieve a maximum in-stack odour concentration of 500 ou;
- The exit velocity at the OCF stack should be at least 16.9 m/s with an internal stack exit diameter of 0.75 m for the Stage D flows. This equates to an actual volumetric flow rate of 7.47 m^3/s. The OCF stack tip height should be at least 16 m above ground level; and,
- Where possible and practicable, all doors to the sludge handling building should be kept closed at all times (particularly when the centrifuge is operational), to reduce the potential release of odours from this source.

4.2 Dust Management

The dust management assessment indicates that there will not be a significant risk of adverse air quality impact associated with dust during the operation of the Stage D WRP. During construction, there is a potential for impacting on the air quality due to:

- Dust generation due to general construction activities
- Dust generation due to construction activities such as rock excavation
- Adverse weather conditions and potential for dust storms
- Adverse impacts on air quality due to smoke and other conditions
- Emissions from vehicle use

These risks can be mitigated through a number of measures and it is recommended that the risk mitigation measures are developed further as the construction methodology (and particularly the CEMP) are developed by the future Contractor.

Appendix A Wind Roses

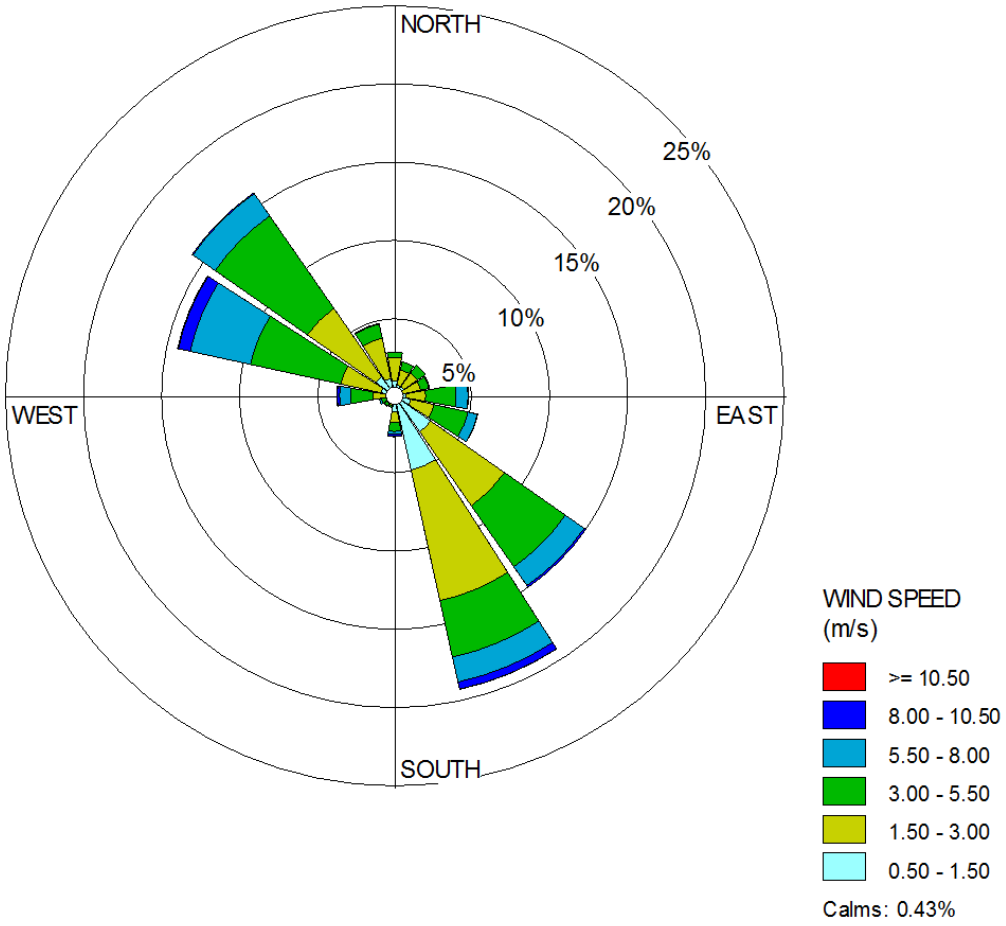


Figure A–1: Annual Wind Rose for Googong WRP (1/09/2013 – 31/08/2014)

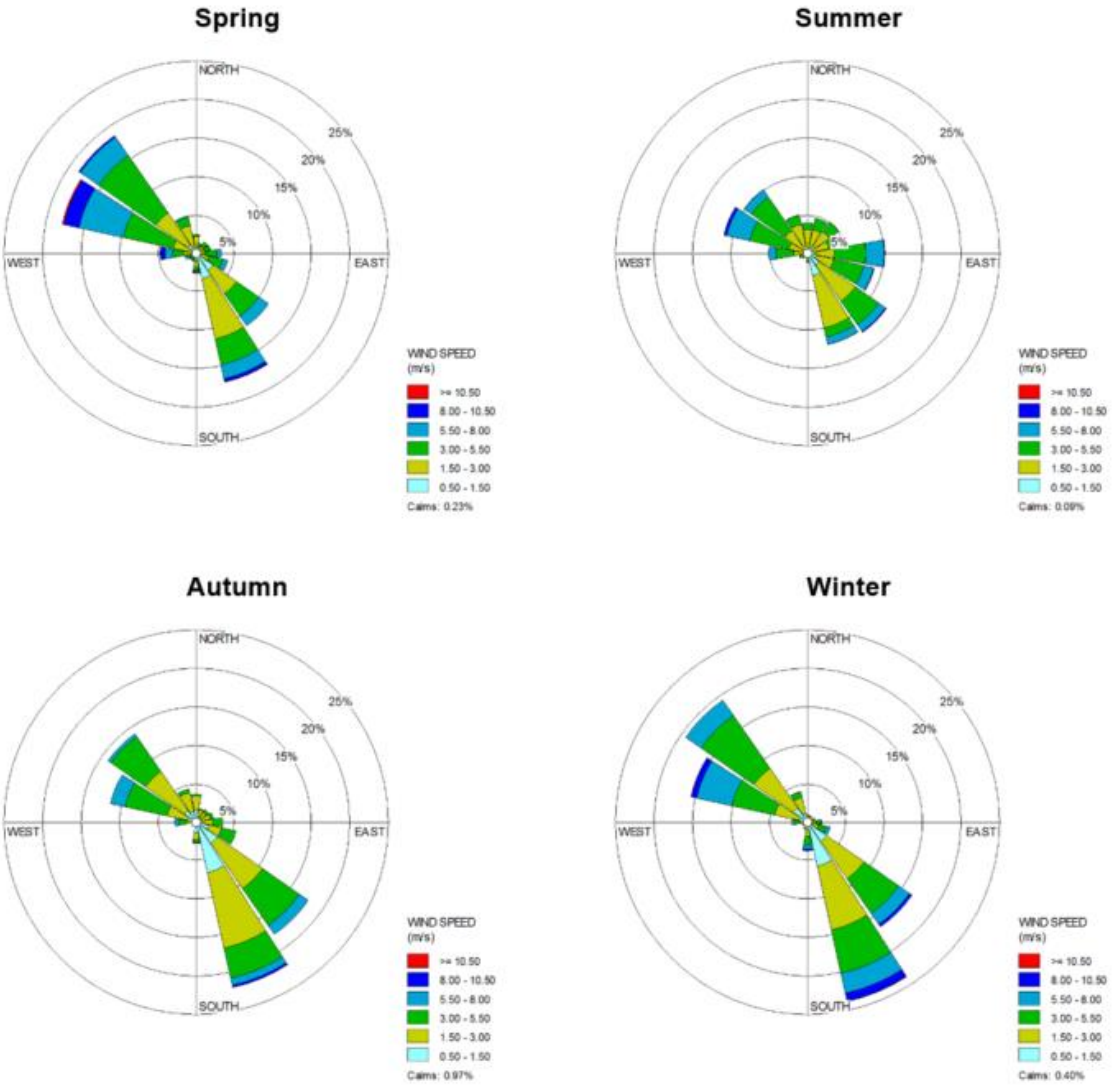


Figure A–2: Seasonal Wind Roses for Googong WRP (1/09/2013 – 31/08/2014)

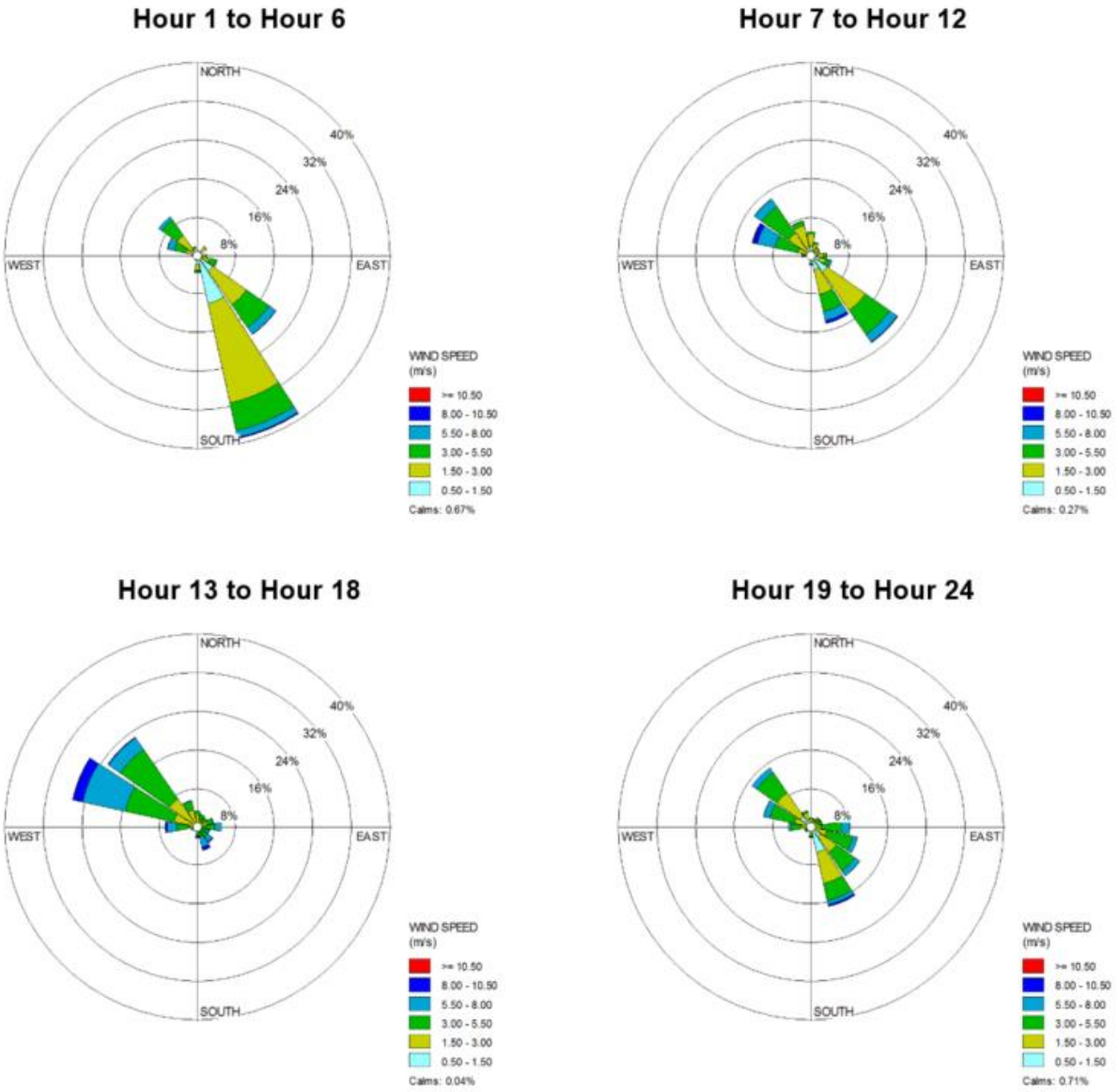


Figure A–3: Time-of-Day Wind Roses for Googong WRP (1/09/2013 – 31/08/2014)

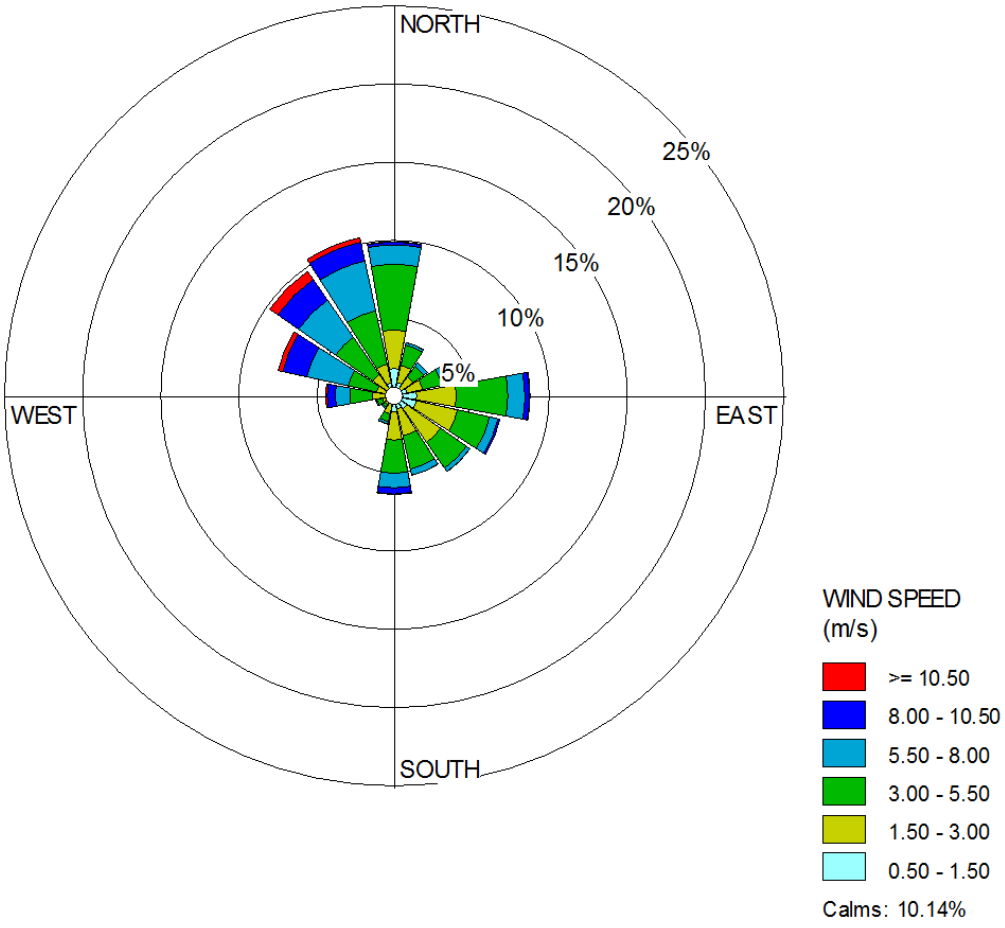


Figure A–4: Annual Wind Rose for Canberra Airport AWS (1/09/2013 – 31/08/2014)

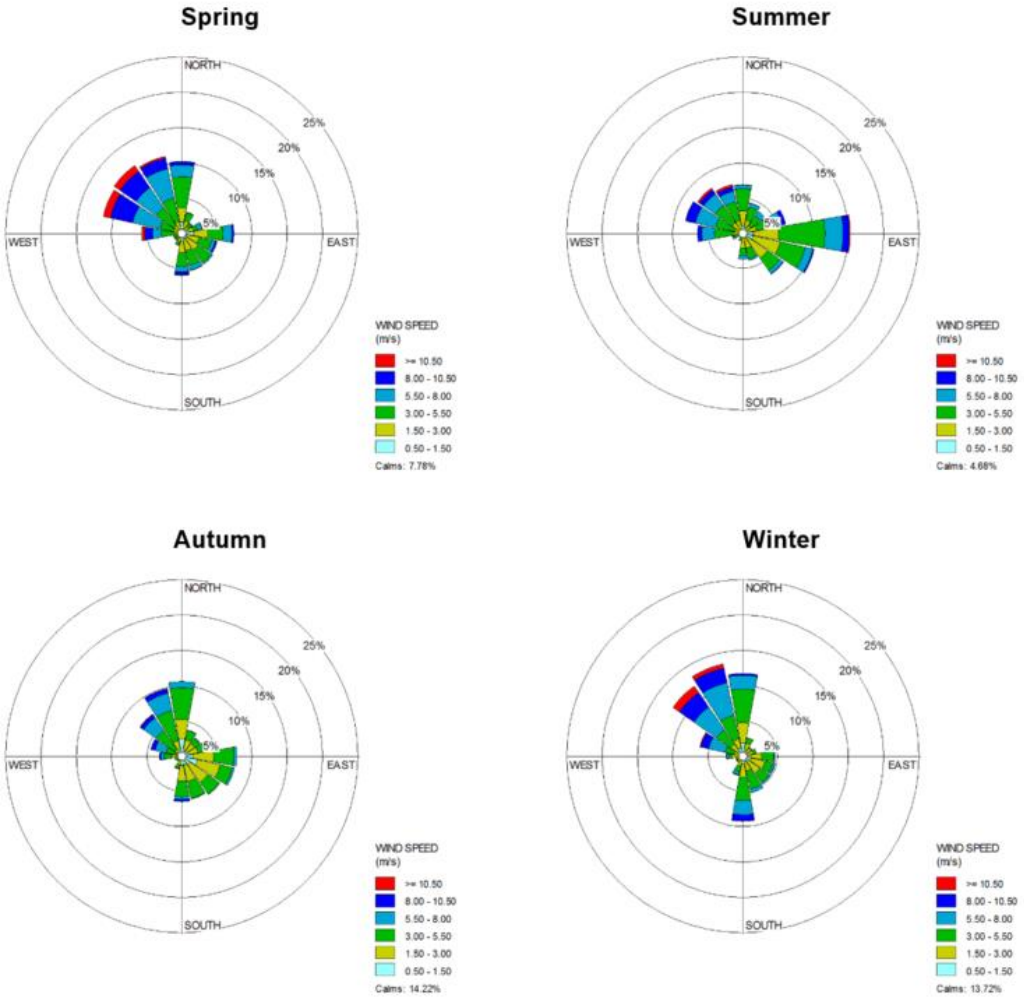


Figure A–5: Seasonal Wind Roses for Canberra Airport AWS (1/09/2013 – 31/08/2014)

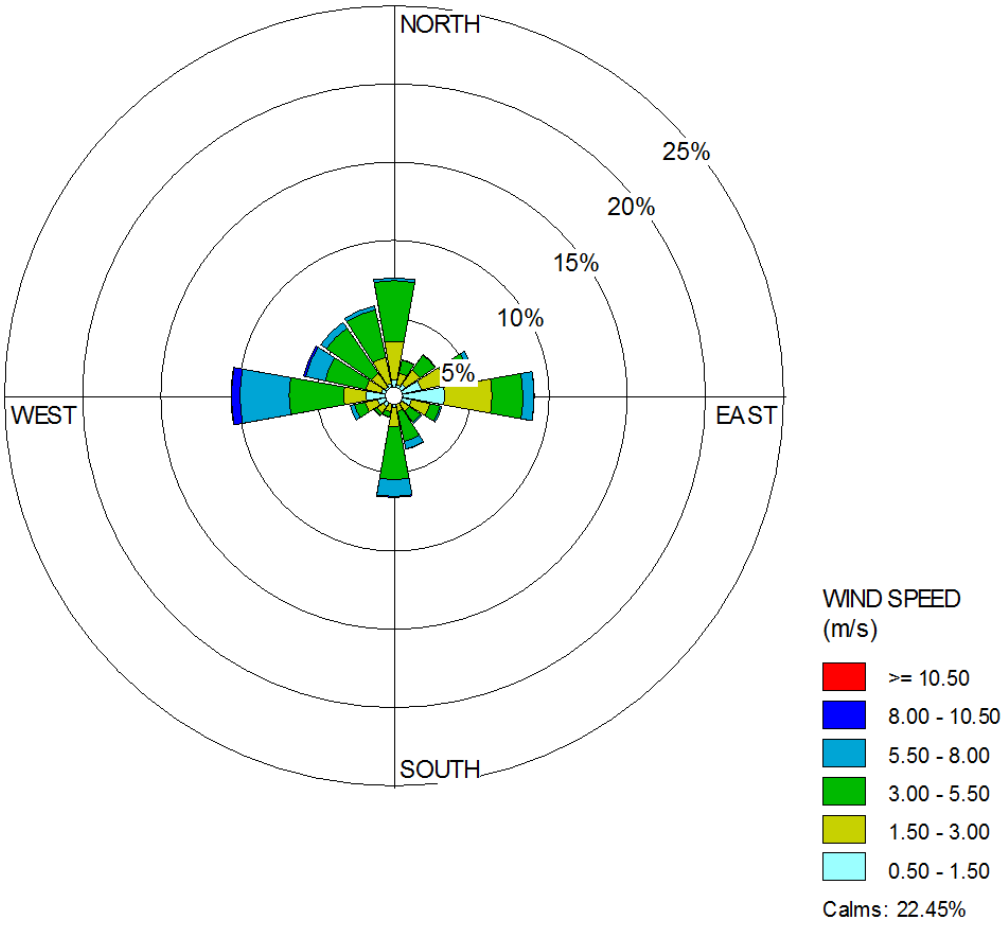


Figure A–6: Annual Wind Rose for Tuggeranong AWS (1/09/2013 – 31/08/2014)

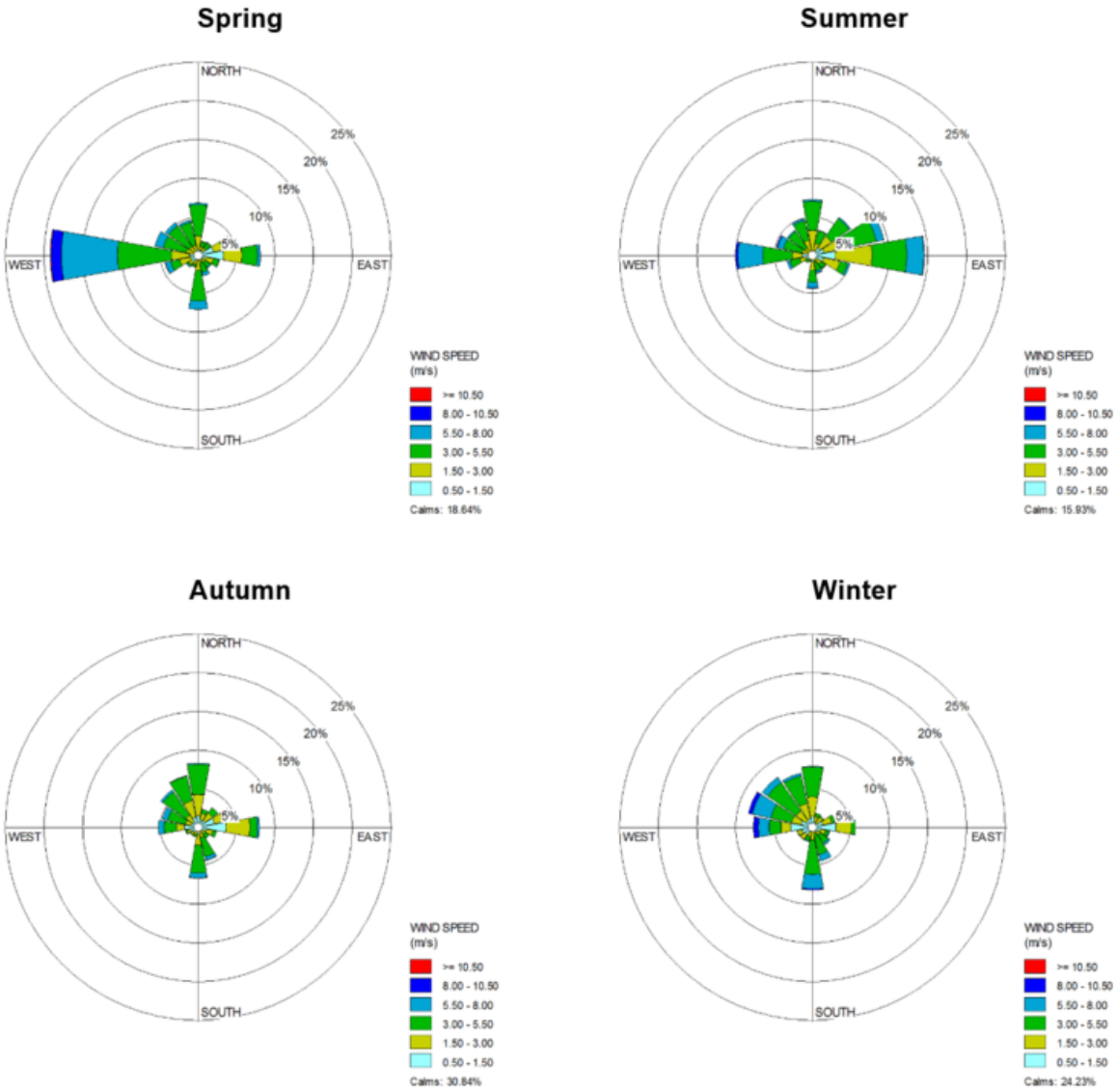


Figure A–7: Seasonal Wind Roses for Tuggeranong AWS (1/09/2013 – 31/08/2014)

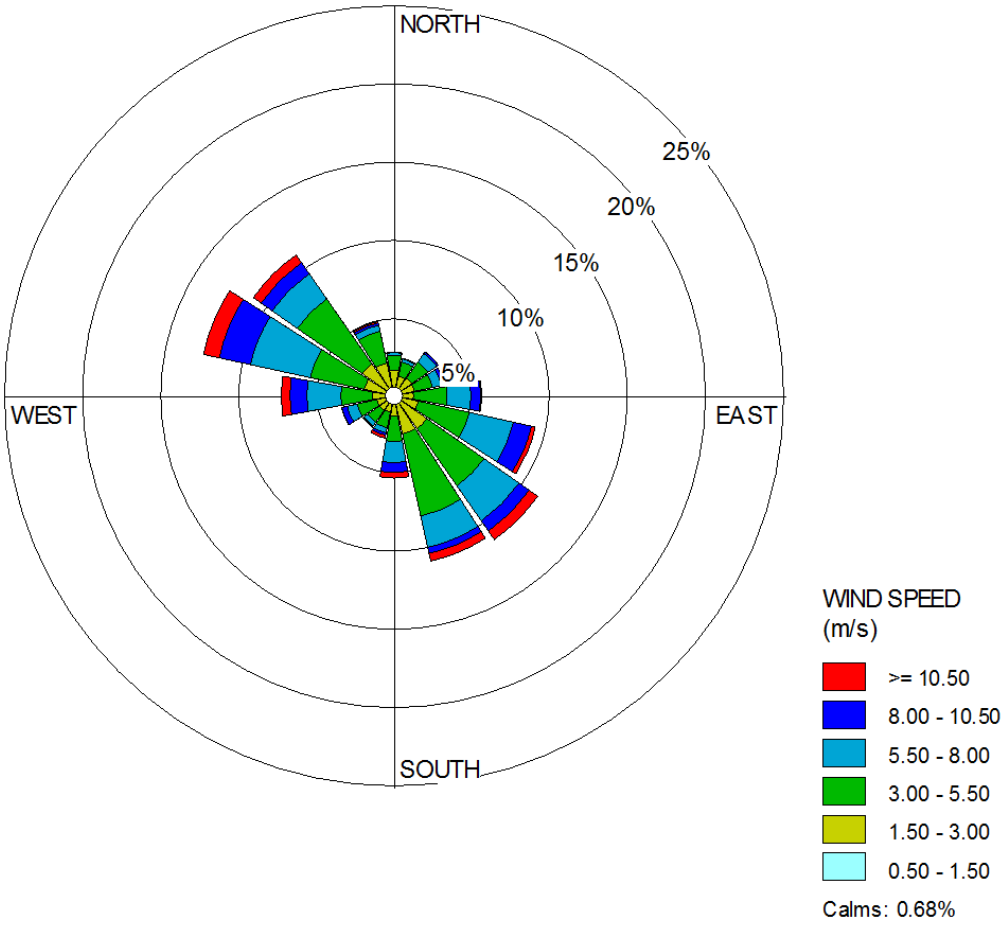


Figure A–8: Annual Wind Rose for Googong WRP from WRF (1/09/2013 – 31/08/2014)

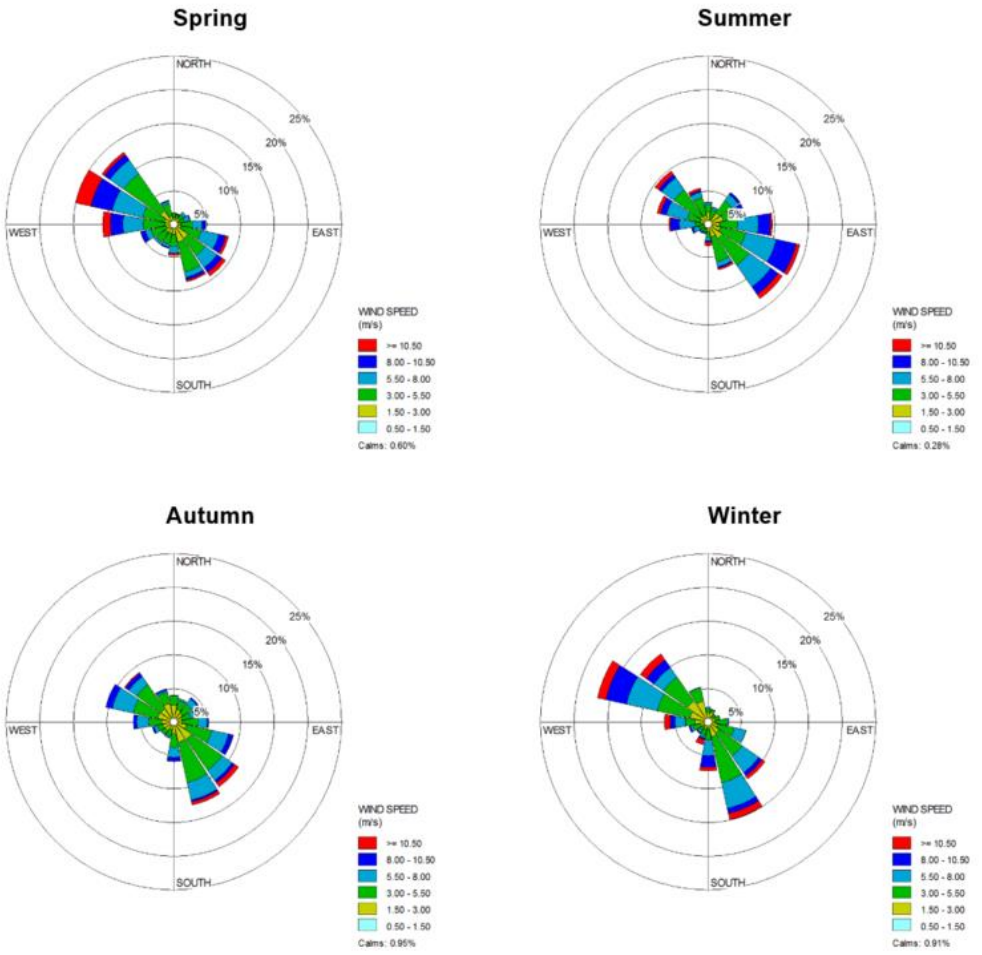


Figure A–9: Seasonal Wind Roses for Googong WRP from WRF (1/09/2013 – 31/08/2014)

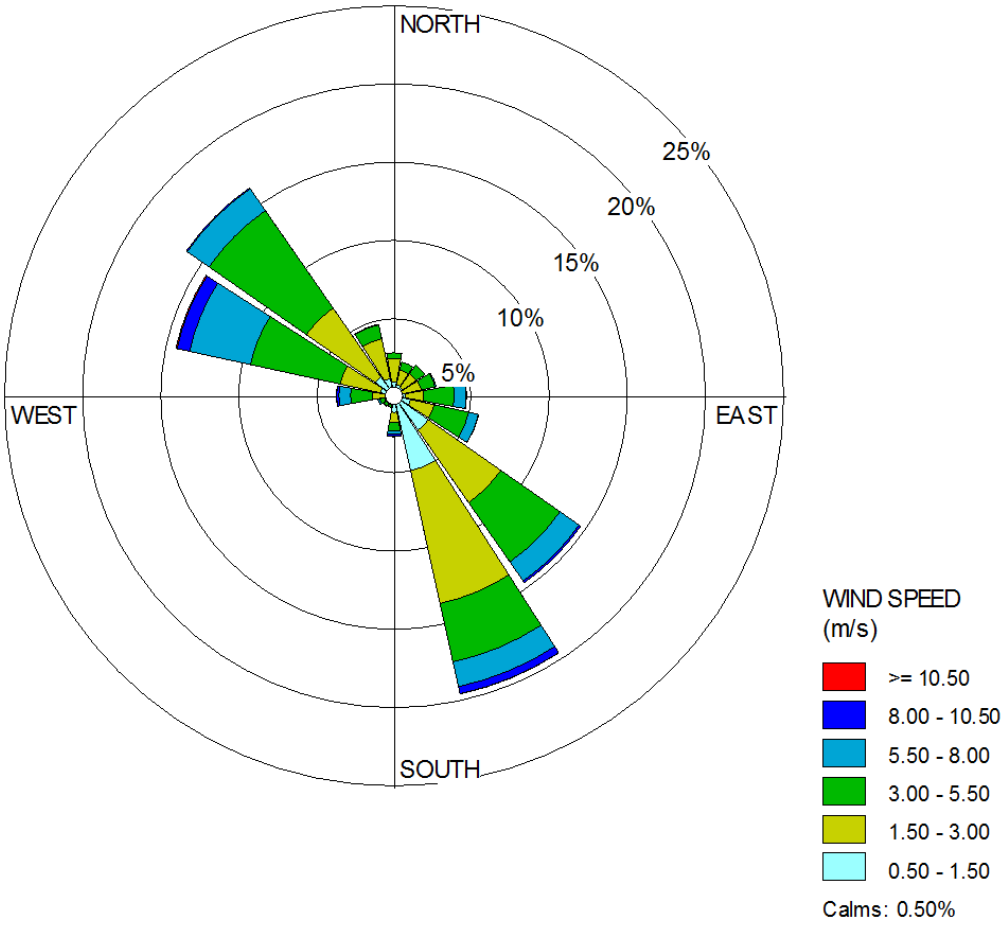


Figure A–10: Annual Wind Rose for Googong WRP from CALMET (1/09/2013 – 31/08/2014)

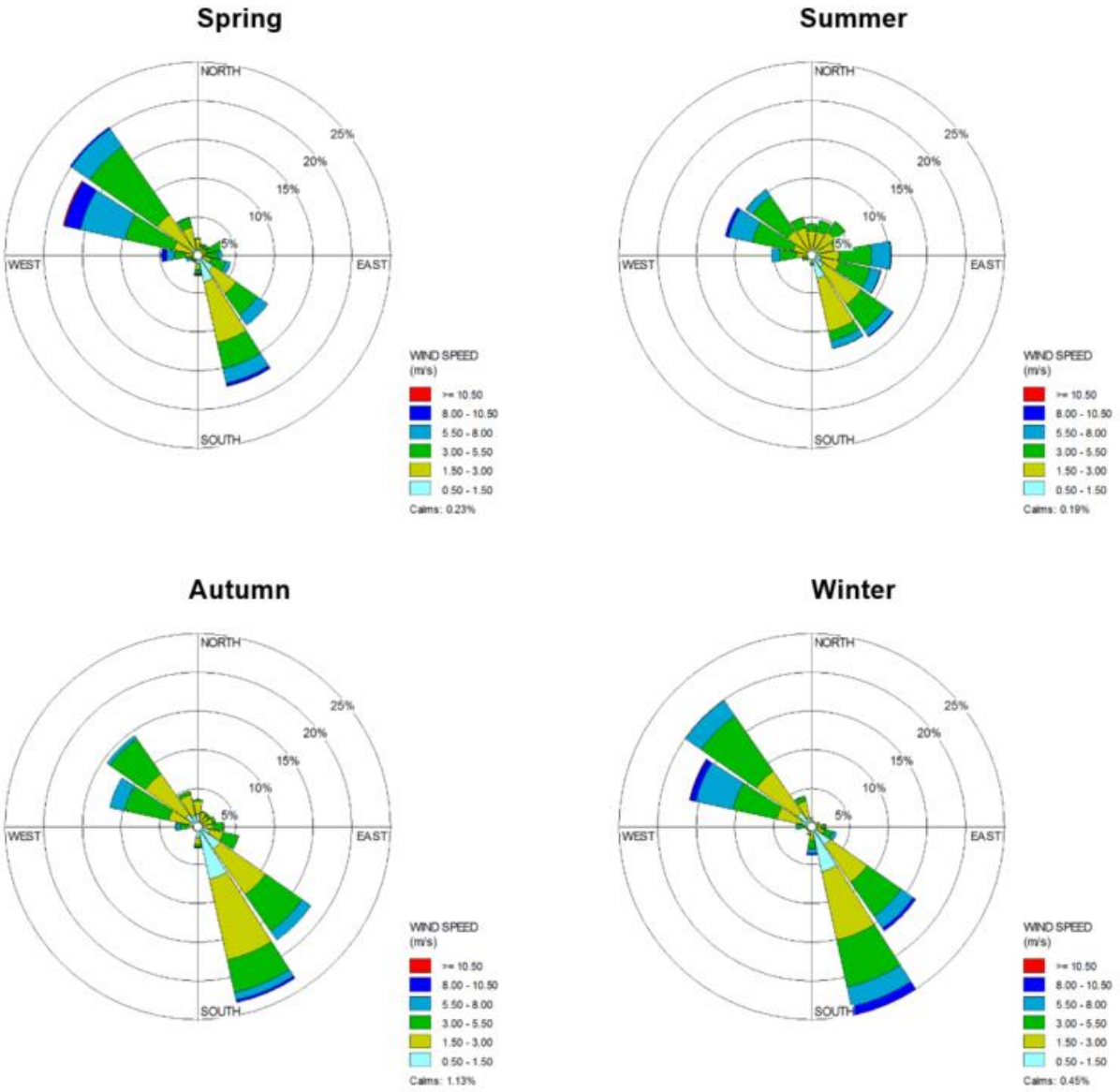
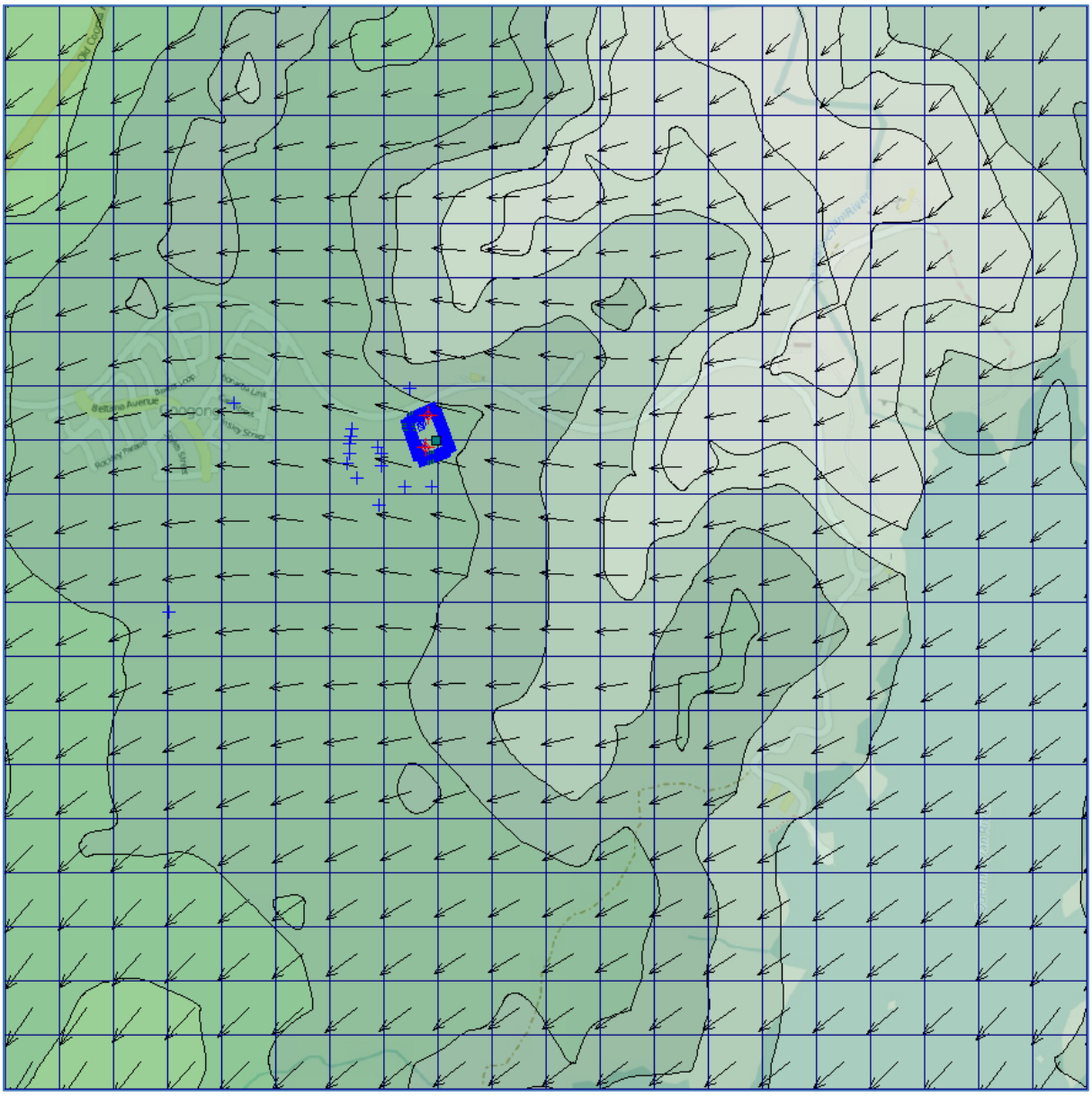


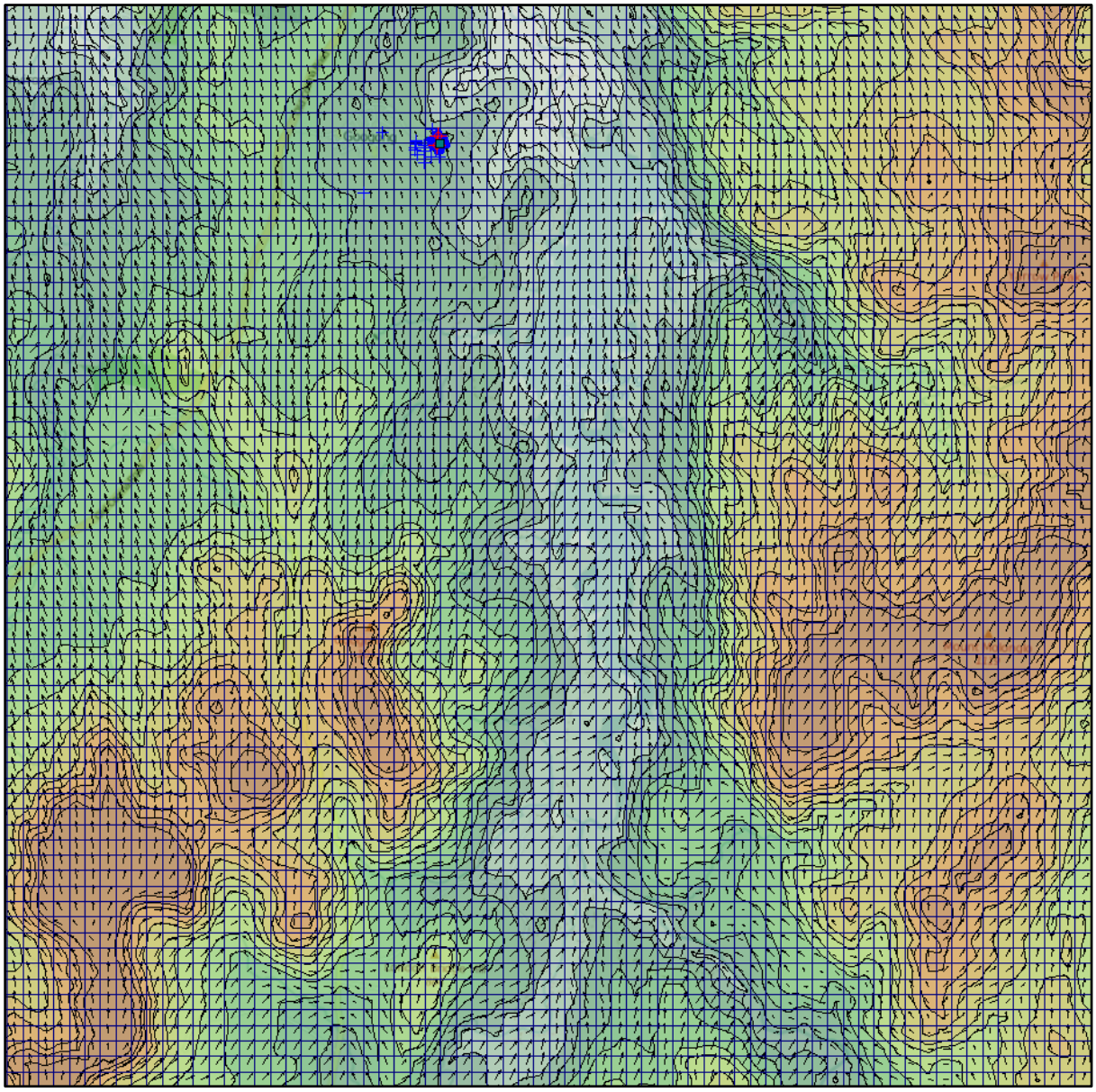
Figure A–11: Seasonal Wind Roses for Googong WRP from CALMET (1/09/2013 – 31/08/2014)

Appendix B Spatially-Varying Wind Vectors



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Figure C–1: Spatially Varying Wind Vector Plot taken from CALMET (1 March 2014, Hour 10)



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Figure C–2: Spatially Varying Wind Vector Plot taken from CALMET (1 September 2013, Hour 21)

Appendix C CALPUFF List File

Note: the CALPUFF .lst file associated with the Stage D odour dispersion model is available electronically upon request

Appendix I Visual impact assessment

GOOGONG IWC PROJECT STAGE D

VISUAL IMPACT ASSESSMENT

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VERSION	PURPOSE	AUTHOR	APPROVED	DATE
A	DRAFT	JM	MD	APR 24, 2020
B	REVISED	JM	MD	14/05/2020

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GLOSSARY

BERM – Shaped, usually mounded, earth

CUMULATIVE EFFECTS – Cumulative effects occur between projects, where the combination of effects created by multiple projects may be greater than the sum of the individual effects.

LANDSCAPE CHARACTER -A distinct recognisable and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse. *

LANDFORM – The shape and form of the land surface which is the resulted of the action and interaction of natural and/or human factors. *

MAGNITUDE OF EFFECT – A term that combines the judgements about the size and scale of the effect, the extent of the area over which it occurs, whether it is reversible or irreversible and whether it is short or long term in duration. *

SENSITIVITY – A term applied to visual receivers, combining judgements of the susceptibility of the receiver to the specific type of change or development proposed and the value related to that receptor. *

VISUAL AMENITY – The overall pleasantness of the views people enjoy of their surroundings, which provides an attractive visual setting or backdrop for the enjoyment of activities of the people living, working, recreating, visiting or travelling through an area. *

VISUAL ENVELOPE MAP – A map, usually digitally produced, showing areas of land within which a development is theoretically visible. *

VISUAL RECEIVER – Individuals and/or defined groups of people who have the potential to be affected by a proposal

FIGURES AND TABLES

FIGURES

FIGURE01 :GOOGONG STAGES WORKS UNDER THE PART 3A APPROVAL

FIGURE 02 : PROPOSED STAGE D WORK AREAS

FIGURE 03 : SITE OUTLINE OF STAGE D WRP

FIGURE 04 : STAGE D WRP PROPOSED WORKS

FIGURE 05: STAGE D HILL 800 PROPOSED WORKS

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FIGURE 07 : EXISTING VEGETATION

FIGURE 08 : VIEW POINT LOCATION

FIGURE 09 : VIEW POINT 01

FIGURE 10 : VIEW POINT 02

FIGURE 11 : VIEW POINT 03

FIGURE 12 : VIEW POINT 04

FIGURE 13: VIEW POINT 05

FIGURE 14: VIEW POINT 06

TABLES

TABLE 1- VISUAL SENSITIVITY

TABLE 2- VISUAL IMPACT

TABLE 03- VIEWPOINT SUMMARY

TERMS AND ABBREVIATIONS

	Term
4WD	Four-wheel drive vehicle
ACT	Australian Capital Territory
ADWF	Average dry weather flow
AEC	Areas of environmental concern
AGWR	Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (NRMMC, EPHC and AHMC, 2006)
AHD	Australia Height Datum
AHIMS	Aboriginal Heritage Information Management System
ARI	Annual return interval
APZ	Asset protection zone
BC Act	Biodiversity Conservation Act 2016
CCP	Critical control point
CEMP	Construction environmental management plan
CNVG	Construction Noise and Vibration Guidelines (TRMS, 2016)
CoA	Conditions of Approval
DAWE	Commonwealth Department of Agriculture, Water and the Environment
dB	Decibel
dBA	Decibels A-weighted
DCP	Development Control Plan
DPIE	NSW Department of Planning, Industry and Environment
DPIE – Water	NSW Department of Planning, Industry and Environment – Water (previously NSW Office of Water)
EA	Environmental assessment
EC	Electrical conductivity
EDT	Emergency detention tank
EES	NSW Environment, Energy and Science Division (previously Office of Environment and Heritage)
EP	Equivalent population
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPL	Environment Protection Licence
ESD	Ecologically sustainable development
FM Act	Fisheries Management Act 1994
GFIMS	Googong foreshores Interface Management Strategy
GWMP	Groundwater Monitoring Program
GTPL	Googong Township Propriety Limited
ha	Hectares
Hill 800	Permanent reservoirs
IHO	Interim heritage order
IMP	Irrigation Management Plan
INCG	Interim Construction Noise Guideline (DECC, 2009)
ISEPP	State Environmental Planning Policy (Infrastructure) 2007
IWC	Integrated Water Cycle
KL	Kilolitre
L	Litre
L/s	Litres per second
LA90	The percentile sound pressure level exceeded for 90 per cent of the measure period with 'A' frequency weighting calculated by statistical analysis
LAeq	Equivalent continuous sound pressure level with 'A' frequency weighting
LAmax	The maximum of the sound pressure levels recorded of a measurement period
LEP	Local environmental plan
LES	Local environment study
m	Metre
MBR	Membrane bioreactor
MCC	Motor control centre
ML	Megalitre
mm	Millimetre
NH	Neighbourhood
NML	Noise monitoring level
NPfI	Noise Policy for Industry (EPA, 2017)
NPW Act	National Parks and Wildlife Act 1974
NSW	New South Wales
OCF	Odour control facility
OCP	Operational control point
OEMP	Operational environmental management plan
PCS	Plant control system
PLC	Programmable Logic Controller
POEO	Protection of the Environment Operations Act 1997
Proposal	Construction and operation of Stage D WRP and Hill 800
PW	Potable water
PWWF	Peak wet weather flows
ou	Odour unit
QCC	Queanbeyan City Council (now QPRC)
QPRC	Queanbeyan-Palerang Regional Council
RBL	Rating background levels
RDT	Rotating drum thickener
REF	Review of Environmental Factors
RMS	Roads and Maritime Services
RNP	Road Noise Policy
RW	Recycled water
RWPS	Recycled water pumping station
RWST	Recycled water storage tank
RWQMP	Recycled Water Quality Management Plan
s	Seconds
SCADA	Supervisory Control and Data Acquisition
SHR	State Heritage Register
SPS	Sewage pumping station
SWL	Sound power levels
TDS	Total dissolved solids
TfNSW	Transport for NSW
TPZ	Tree protection zone
TSS	Total suspended solids
µg/L	Microgram per litre
µS/cm	Micro-Siemens per centimetre
UV	Ultra-violet
UVT	UV transmissivity
WARR Act	Waste Avoidance and Resource Recovery Act 2001
WAS	Waste activated sludge
WM Act	Water Management Act 2000
WRP	Water recycling plant

1.0 INTRODUCTION

1.1 PROPOSAL BACKGROUND

1.1.1 BACKGROUND

RPS Australia East Pty Ltd has been engaged by Googong Township Proprietary Limited (GTPL) to develop a visual impact assessment (VIA) as part of the Googong Township Integrated Water Cycle (IWC) Project stage D. The IWC project involves the construction and operation of water cycle infrastructure to deliver potable and recycled water to the new Googong township just south of Queanbeyan in NSW.

Googong Township Pty Ltd (GTPL) – a joint venture between Canberra Investment Corporation (CIC) and Mirvac – is responsible for the development of the new Googong township located in the Canberra region, around seven kilometres south of Queanbeyan in NSW. The new Googong township would be home to about 18,850 people and developed over 25 years.

The township is designed around an integrated water cycle (IWC), with a dedicated Water Recycling Plant (WRP) that would reduce the consumption of potable water in the community by around 60 per cent and recycle the township's water for non-potable use. The Googong IWC Project is being constructed and operated in stages to ensure the infrastructure is appropriately sized to meet the incremental level of demand as development of the Googong township progresses.

On 24 November 2011, the Googong Township Water Cycle Project Environmental Assessment (Manidis Roberts, 2010) was approved by the Minister for Planning under Part 3A (now repealed) of the Environment Planning and Assessment Act 1979 (EP&A Act). The approval included Concept Approval for the ultimate development (Stage 1 and 2) and the Project Approval for Stage 1 development of the Googong Township IWC Project.

Stage 1 of the IWC project was developed in three stages (Stage A – Network, Stage AB – WRP and Stage B – Network) has commenced operation. The Googong township development reached capacity of the Stage 1 IWC project by late 2016, therefore Stage 2 of the IWC project has commenced.

Stage 2 of the IWC Project would be delivered in two sub-stages, known as Stage C and Stage D, in order to provide the appropriate IWC infrastructure to accommodate the size and growth of the Googong township. Construction of Stage 2 of the IWC commenced in August 2016. Stage C has been developed, with construction of Stage C completed in August 2018. As of November 2019, all Stage C assets have been handed over from GTPL to Icon Water and Queanbeyan-Palerang Regional council (QPRC) and these assets are now operational.

Stage D (the Proposal) is the ultimate capacity of the IWC Project and planning for the final stages has commenced. The purpose of Stage D WRP is to support the ongoing development of the Googong township to increase the capacity of the existing IWC Project to 18,850 equivalent population (EP).

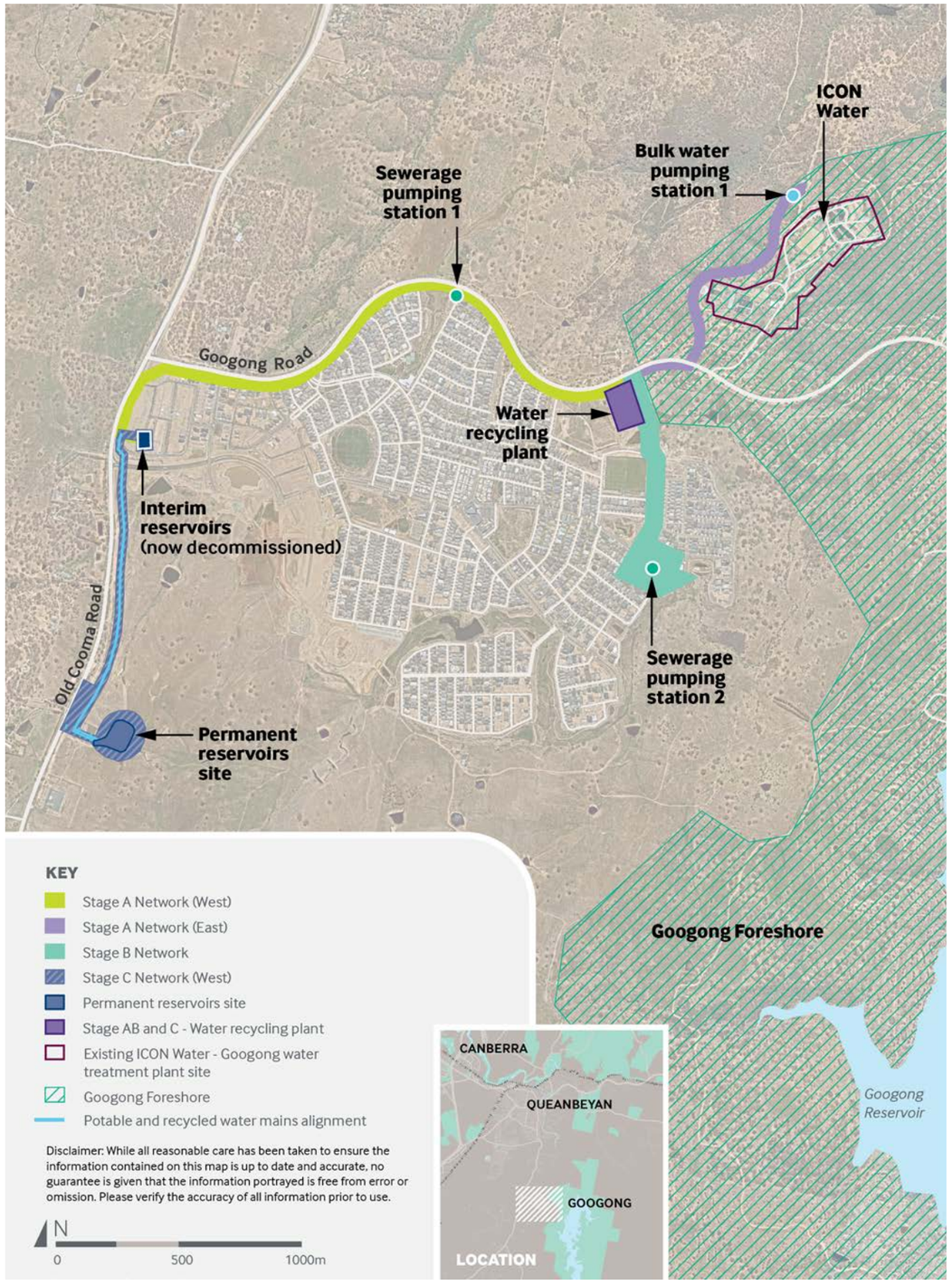


FIGURE01 :GOOGONG STAGES AB (STAGE 1) AND STAGE C (STAGE 2) WORKS UNDER THE PART 3A APPROVAL

1.2 PROPOSAL OVERVIEW

The Proposal would involve works at the following IWC components:

- Stage AB and C WRP (referred to as existing WRP)
- Permanent reservoirs located at Hill 800); and
- Associated upgrades to sewage reticulation infrastructure.

The Proposal would involve the installation of new equipment and upgrades to existing IWC infrastructure to allow for the treatment of wastewater for 18,850 EP. The Stage D upgrade works to be conducted at the WRP include:

New equipment/process units:

- Additional membrane bioreactor train with consolidated design along with associated diffusers, mixers, pumps, and pipework
- Additional tertiary filter train to provide increased tertiary treatment (chemical phosphorus removal) capacity
- Additional aerobic digester tank along with associated diffusers, pumps, and pipework
- Additional centrifuge unit to provide increased sludge dewatering capacity
- Additional chemical dosing skids for the Stage D bioreactors; and
- Addition of a fourth recycled water transfer pump.

Replacements/upgrades:

- Upgrade of blowers and/or air compressor in the blowers room
- Upgrade of one or both smaller tertiary feed pump(s)
- Upgrade of some existing chemical dosing pumps
- Upgrade of the centrifuge feed pumps with higher capacity units
- Upgrade of the biosolids bins and weighing cells; and
- General electrical and control system upgrade to cater to the upgrade works.

The Stage D upgrade works to be conducted at Hill 800 include:

- A new 9ML reservoir would be built for recycled water storage
- The existing 4.0 ML recycled water (RW) reservoir would be cleaned and re-purposed for potable water (PW), bringing the total PW storage volume up to 5.9 ML
- A new Stage D PW booster pump skid would be provided to cater to flows in the higher elevation developments of the township
- The Stage C PW booster pump skid would be decommissioned. Supply would be from the new Stage D PW booster pump skid
- Decommissioning of the Stage C sedimentation bund and associated civil works required to re-purpose the area for the new 9ML RW reservoir
- Sodium metabisulphite would be redirected to dose into the Stage D chemical dosing chamber that receives the overflow from the new reservoir
- Recycled Water sodium hypochlorite dosing pumps may need to be replaced with 40 L/h dosing pumps. This is pending review of the operating data at concept design. Potable water sodium hypochlorite dosing pumps can be retained; and
- Electrical and control system upgrade to cater for the new infrastructure.

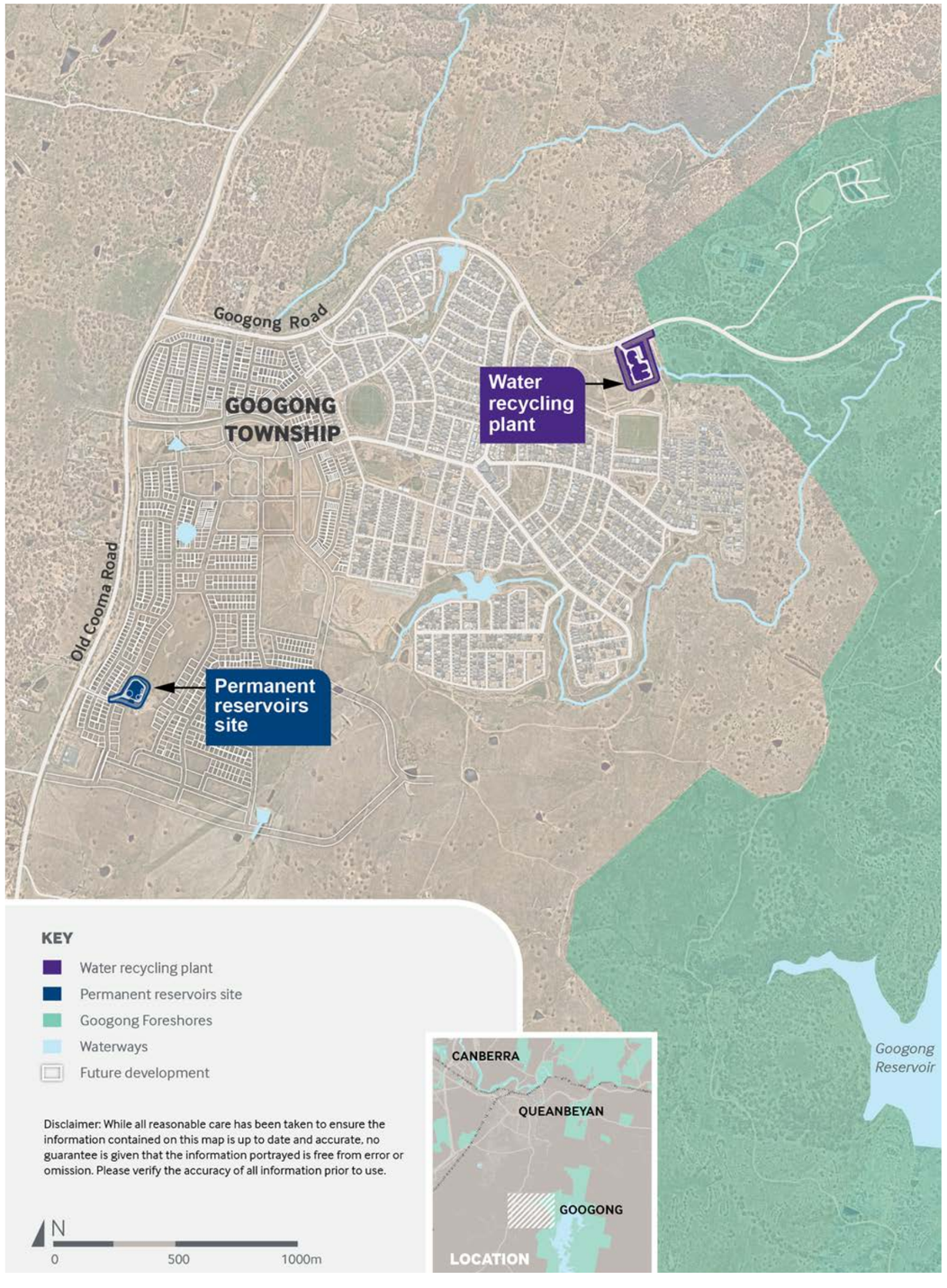


FIGURE 02 : PROPOSED STAGE D WORK AREAS

1.3 DETAILED DESCRIPTION OF THE PROPOSAL

Stage D works at the Hill 800 Reservoir site involves construction of a new recycled water reservoir and repurposing the existing recycled water reservoir into potable water storage. The Stage D works include:

- A new 9ML reservoir would be built for recycled water storage
- The existing 4.0 ML RW reservoir would be cleaned and re-purposed for PW, bringing the total PW storage volume up to 5.9 ML
- A new Stage D PW booster pump skid would be provided to cater to flows in the higher elevation developments of the township
- The Stage C PW booster pump skid would be decommissioned. Supply would be from the new Stage D PW booster pump skid
- Decommissioning of the Stage C sedimentation bund and associated civil works required to re-purpose the area for the new 9ML RW reservoir
- Sodium metabisulphite would be redirected to dose into the Stage D chemical dosing chamber that receives the overflow from the new reservoir
- Recycled Water sodium hypochlorite dosing pumps may need to be replaced with 40 L/h dosing pumps. This is pending review of the operating data at concept design. Potable water sodium hypochlorite dosing pumps can be retained; and
- Electrical and control system upgrade to cater for the new infrastructure.
- The Hill 800 areas currently identified as requiring upgrade are highlighted in Figure 3.5.

Potable water and recycled water reservoirs
The Hill 800 reservoir site layout developed during the Stage C design included provision for the Stage D infrastructure, and an area for the new reservoir is located north of the existing reservoirs. The new reservoir would be supplied with recycled water from the recycled water storage tank (RWST) at the WRP via the recycled water pumping station (RWPS).

Potable and recycled water booster pumps
The existing potable water booster pump skid would be decommissioned and replaced with a larger skid to supply potable water to the high elevation areas of the township. The new skid would be sized based on the potable water demands agreed with GTPL and would be of similar design and operation to the existing skid.

The existing recycled water pump skid would be retained to continue providing flows for irrigation of sports fields at the Googong Common. A second recycled water booster pump skid would be provided as part of Stage D works to supply recycled water to the high elevation areas of the township. The new skid would also be sized based on potable water demands agreed with GTPL and would be of similar design and operation to the existing skid. Adequate space within the existing pump station building is available to accommodate the new skids and associated pipework connections.

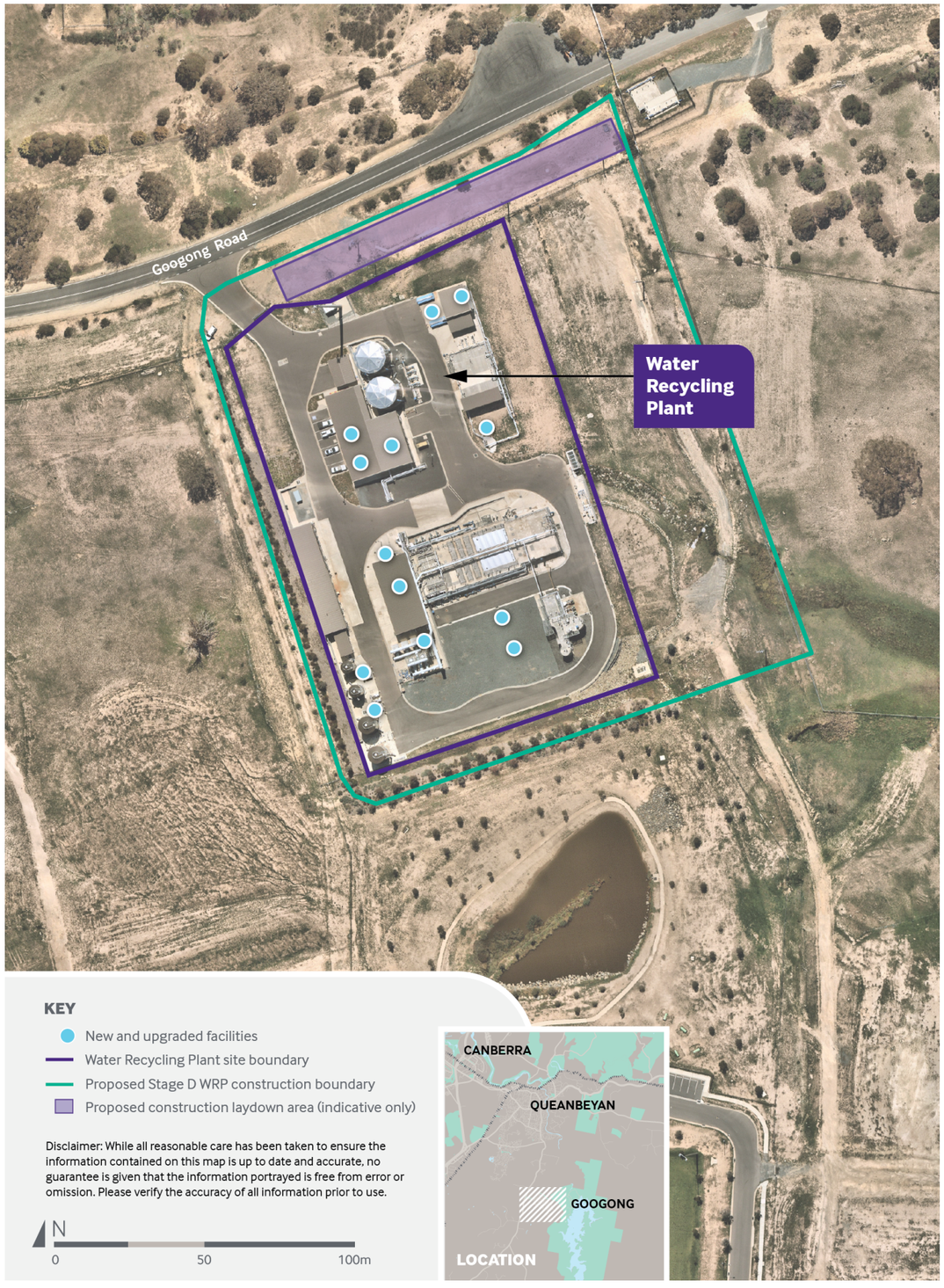
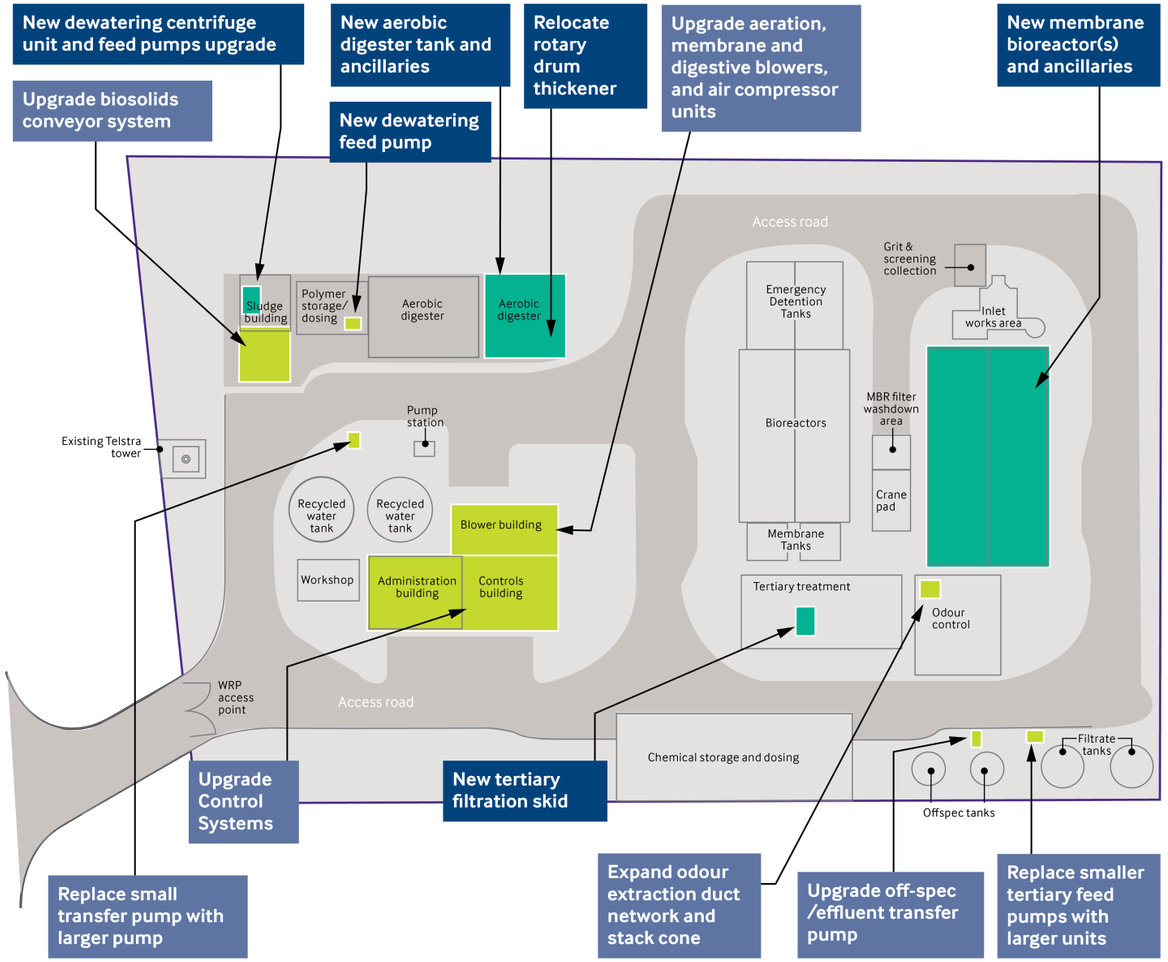
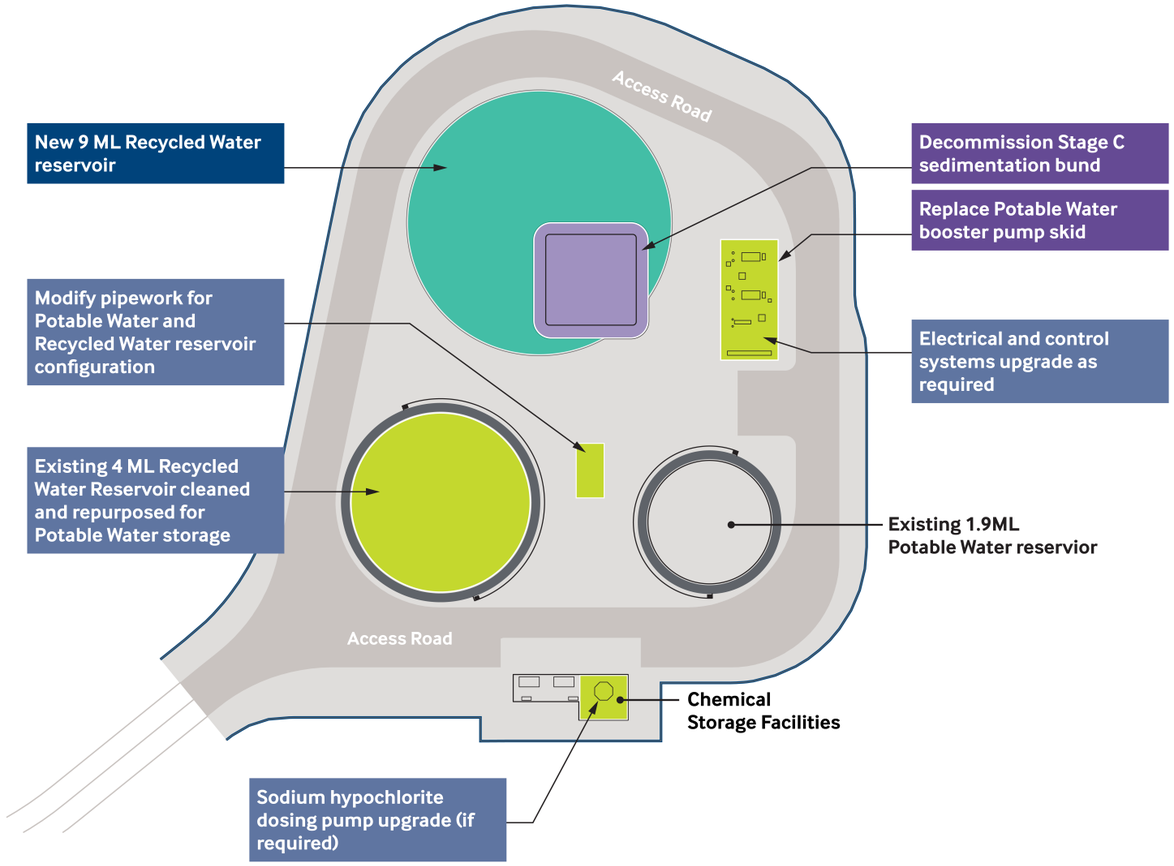


FIGURE 03 : SITE OUTLINE OF STAGE D WRP





KEY

- Water Recycling Plant site area
- New facilities
- Upgraded facilities

N

1:250

0 10 20 30m

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

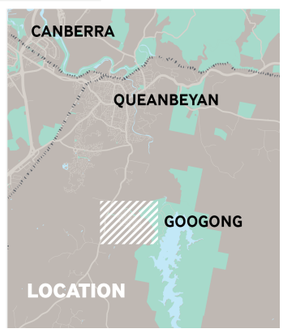


FIGURE 04 : STAGE D WRP PROPOSED WORKS

KEY

- Permanent Reservoir site area
- New facilities
- Upgraded facilities
- Decommissioned facilities

N

1:250

0 10 20 30m

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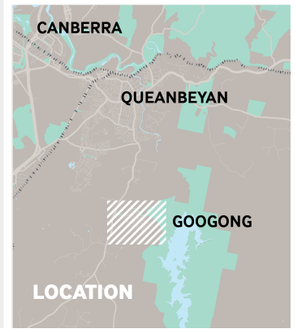


FIGURE 05: STAGE D HILL 800 PROPOSED WORKS

1.4 STUDY METHOD

1.4.1 VISUAL IMPACT ASSESSMENT

A visual impact assessment is used to identify and determine the value, significance and sensitivity of a landscape. The method applied to this study involved systematically evaluating the visual environment pertaining to the site and using judgements based on landscape values.

The assessment was undertaken in stages as noted below:

- Objective assessment of the relative aesthetic value of the landscape, defined as visual quality and expressed as high, medium or low. This assessment generally relates to variety, uniqueness, prominence and naturalness of the landform, vegetation and water forms within each character type.
- Determination of the landscape sensitivity and its ability to absorb different types of development on the basis of physical and environmental character.
- An assessment of viewer sensitivity to change. This includes how different groups of people view the landscape (for example, a resident as opposed to a tourist), and how many people are viewing and from how far.
- The undertaking of a viewpoint analysis to identify areas likely to be affected by development of the site and a photographic survey using a digital camera and a handheld GPS unit to record position and altitude.
- An assessment of visual impacts and the preparation of recommendations for impact mitigation. Suggestions are made for suitable development patterns that would maintain the areas visual quality.

The purpose of the above methodology is to reduce the amount of subjectivity entering into the visual impact assessment and to provide sufficient data to allow for third party verification of results.

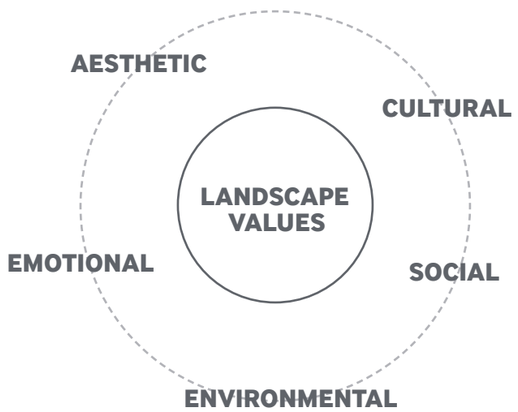


FIGURE 3 - LANDSCAPE VALUES

1.4.2 LANDSCAPE VALUES

Landscape values are the cultural attributes (social, indigenous, artistic and environmental) as well as the aesthetics of a place

1.4.3 VISUAL SENSITIVITY

Visual sensitivity is a measure of how critically a change to the existing landscape is viewed by people from different areas. The assessment is based on the number of people affected, land use, and the distance of the viewer from the proposal. For example, a significant change that is not frequently seen may result in a low visual sensitivity although its impact on a landscape may be high. Generally the following principles apply:

- Visual sensitivity decreases as the viewer distance increases.
- Visual sensitivity decreases as the viewing time decreases.
- Visual sensitivity can also be related to viewer activity (eg. a person viewing an affected site whilst engaged in recreational activities will be more strongly affected by change than someone passing a scene in a car travelling to a desired destination).

VISUAL SENSITIVITY

LAND USE	DISTANCE ZONES				
	FOREGROUND		MIDDLE-GROUND		BACKGROUND
	0-1KM	1-2KM	2-5KM	5-8KM	>8KMS
TOURISM / RECREATION	HIGH	HIGH	HIGH	MOD	LOW
RESIDENTIAL	HIGH	HIGH	HIGH	MOD	LOW
MAIN TRAVEL CORRIDOR	MOD	MOD	LOW	LOW	LOW
MINOR ROADS	MOD	MOD	LOW	LOW	LOW

TABLE 1- VISUAL SENSITIVITY

1.4.4 VISUAL EFFECT

Visual effect is the interaction between a proposal and the existing visual environment. It is often expressed as the level of visual contrast of the proposal against its setting or background in which it is viewed.

LOW VISUAL EFFECT: occurs when a proposal blends in with its existing viewed landscape due to a high level of integration of one or several of the following: form, shape, pattern, line, texture or colour. It can also result from the use of effective screening often using a combination of landform and landscaping.

MODERATE VISUAL EFFECT: occurs where a proposal is visible and contrasts with its viewed landscape however, there has been some degree of integration (eg. good siting principles employed, retention of significant existing vegetation, provision of screen landscaping, appropriate colour selection and/or suitably scaled development).

HIGH VISUAL EFFECT: results when a proposal has a high visual contrast to the surrounding landscape with little or no natural screening or integration created by vegetation or topography.

1.5.5 VISUAL QUALITY

Visual quality of an area is essentially an assessment of how viewers may respond to designated scenery. Scenes of high visual quality are those which are valued by a community for the enjoyment and improved amenity they can create. Conversely, scenes of low visual quality are of little value to the community with a preference that they be changed and improved, often through the introduction of landscape treatments.

As visual quality relates to aesthetics its assessment is largely subjective. There is evidence to suggest that certain landscapes are constantly preferred over others with preferences related to the presence or absence of certain elements. The rating of visual quality for this study has been based on scenic quality ratings and on the following generally accepted assumptions arising from scientific research (DOP, 1988):

- Visual quality increases as relative relief and topographic ruggedness increases;
- Visual quality increases as vegetation pattern variations increase;
- Visual quality increases due to the presence of natural and/or agricultural landscapes;
- Visual quality increases owing to the presence of water forms (without becoming too common) and related to water quality and associated activity; and
- Visual quality increases with increases in land use compatibility.

In addition to the above, cultural items may also endow a distinct character to an area and therefore contribute to its visual quality due to nostalgic associations and the desire to preserve items of heritage significance.

1.5.6 VISUAL IMPACT

This report adopts the industry standard in its approach to visual impact assessment that is process-driven, consistent and based on professional, value judgement of commonly accepted and adopted criteria in the industry. The methodology adopted for this report is guided by policy and guidelines outlined in *Guideline for landscape character and visual impact assessment Environmental impact assessment practice note EIA-N04 Roads and Maritime Services | December 2018*

VISUAL IMPACT

		VISUAL EFFECT ZONES		
		HIGH	MODERATE	LOW
VISUAL SENSITIVITY LENS	HIGH	HIGH IMPACT	HIGH IMPACT	MODERATE IMPACT
	MODERATE	HIGH IMPACT	MODERATE IMPACT	LOW IMPACT
	LOW	MODERATE IMPACT	LOW IMPACT	LOW IMPACT

TABLE 2- VISUAL IMPACT

1.5.7 STUDY LIMITATIONS

The VIA intends to provide an objective assessment of the visual impacts of the identified work on the future viewers (visual receptors) within the Googong Township residential subdivision based, in some cases, on indicative road and lot layouts provided and as shown in the current master plan. This VIA assumes therefore that the information provided is generally implemented as indicated however also noting that the construction of the subdivision is a continually evolving process and some areas may change or may not be constructed for many years depending on demand, economic factors and/or site constraints.

2.0 SITE ANALYSIS

2.1 SITE DESCRIPTION

In order to gain a full understanding of the site's visual character, it was first necessary to undertake a broader analysis of the visual character of the area to identify the visual "catchment" or areas that would have the predominant visual connection with the site.

The landscape character was assessed in terms of the existing built elements, landform, colour, texture and vegetation patterns. The overall study area is located in a predominantly rural setting. Land uses in the area include, cleared agricultural lands (predominantly for grazing), rural and new residential development. The surrounding areas lands largely modified through clearing, within a larger natural setting of mountain ranges and foothills.

The areas within the Township are largely open fields and rolling hills with both local and more distant views possible. Existing mature Eucalyptus species (Gum) and other remnant trees are scattered across the landscape contrasting the low pasture grasses that provide visual continuity throughout the landscape.

Hill 800 is the highest point in the overall Googong Township development and is both prominent and visible from the surrounding areas. From the top of Hill 800, views are possible in all directions to the surrounding hills and mountain ranges and conversely views to the top from surrounding areas are also possible.

The construction footprint area at the Hill 800 comprises of cleared, developed land with no trees or other notable habitat features. There are numerous scattered trees on the eastern boundary of the Hill 800, however these areas are outside of the construction footprint.

It is also possible that some weeds may be present in the construction footprint area. Land to the west of the Hill 800 site would be utilised during construction for storage, stockpiling, and site offices. This land has also been previously disturbed during the construction of the existing infrastructure at the Hill 800 site and has since been resurfaced with grass.



FIGURE 06 : STAGE D WRP TOPOGRAPHY

The majority of the Googong township, including the Hill 800 site, is located within the Burra soil landscape, while the WRP site is located within the Anembo soil landscape - the character of each landscape is detailed below:

- **Burra** This landscape is characterised by undulating to rolling hills and alluvial fans associated with the weathering of the underlying Silurian volcanic units, with the ground surface almost completely cleared of woodland. The soils are described as strongly acidic with low fertility and low available water-holding capability. Subsoils also have low permeability.
- **Anembo** This landscape is characterised by undulating rises and flats over granitic material. The ground surface typically exhibits extensively cleared, open to tall open forest with woodland and low woodland in frost hollows. The area of Anembo soil landscape has been extensively cleared. Soils are of gravely low fertility and low water-holding capacity and are prone to water logging. Some subsoils have very low permeability.

The Hill 800 site is approximately 300 metres from the nearest bushfire vegetation buffer zone.
The land surrounding the permanent reservoirs site at Hill 800 is denuded of wooded vegetation and is characteristic of the sheep grazing land of the surrounding district.





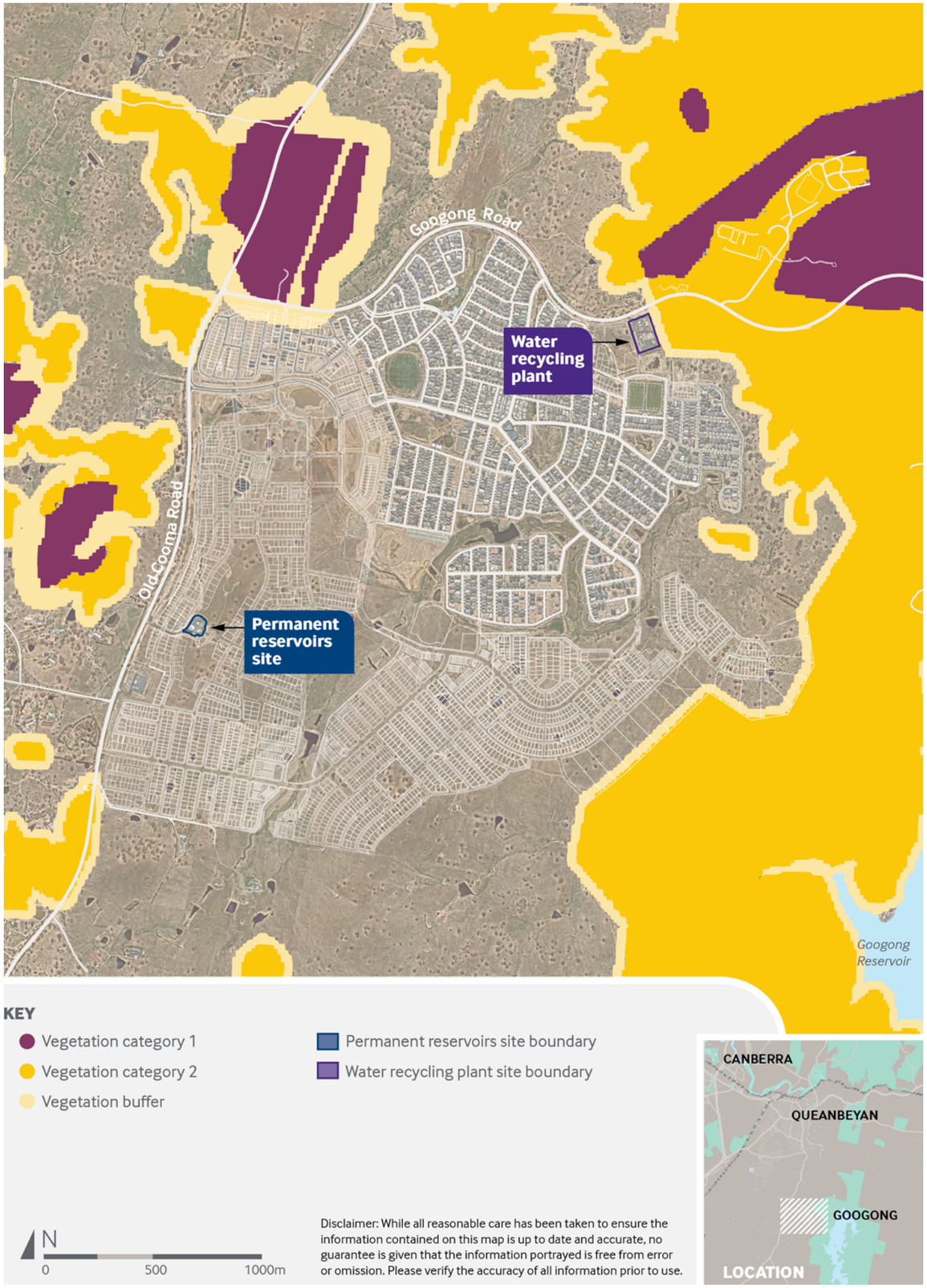


FIGURE 07 : EXISTING VEGETATION

3.0 VISUAL IMPACT ASSESSMENT

3.1 VIEW LOCATIONS

This part of the visual assessment considers the likely impact that development would have on the existing landscape character and visual amenity by selecting prominent sites, otherwise referred to as viewpoints.

VIEWPOINT SELECTION PROCESS

Viewpoints are selected to illustrate a combination of the following:

- Present landscape character types.
- Areas of high landscape or scenic value.
- Visual composition (eg. Focused or panoramic views, simple or complex landscape pattern).
- Range of distances.
- Varying aspects.
- Various elevations.
- Various extent of development visibility (full and partial visibility).
- Sequential along specific routes.

Viewpoints have been carefully selected to be representative of the range of views within the study area. The selection of viewpoints is informed by topographical maps, field work observations and other relevant influences such as access, landscape character and the popularity of vantage points.

A total of 6 viewpoints were recorded as part of the field work process. These viewpoints were taken from private and public sites surrounding the site. The viewpoints which have been included represent the areas from where the development would appear most prominent, either based on the degree of exposure or the number of people likely to be affected.

PROCESS OF VIEWPOINT ANALYSIS

Viewpoint analysis is included the following pages.

- VIEWPOINT 1 - Looking East from Lot 964
- VIEWPOINT 2 - Looking North East from Lot 6
- VIEWPOINT 3 - Looking North East from Lot 27
- VIEWPOINT 4 - Looking East from Old Cooma Rd
- VIEWPOINT 5 - Looking West from Proposed Sports Fields
- VIEWPOINT 6 - Looking South East from Old Cooma Rd

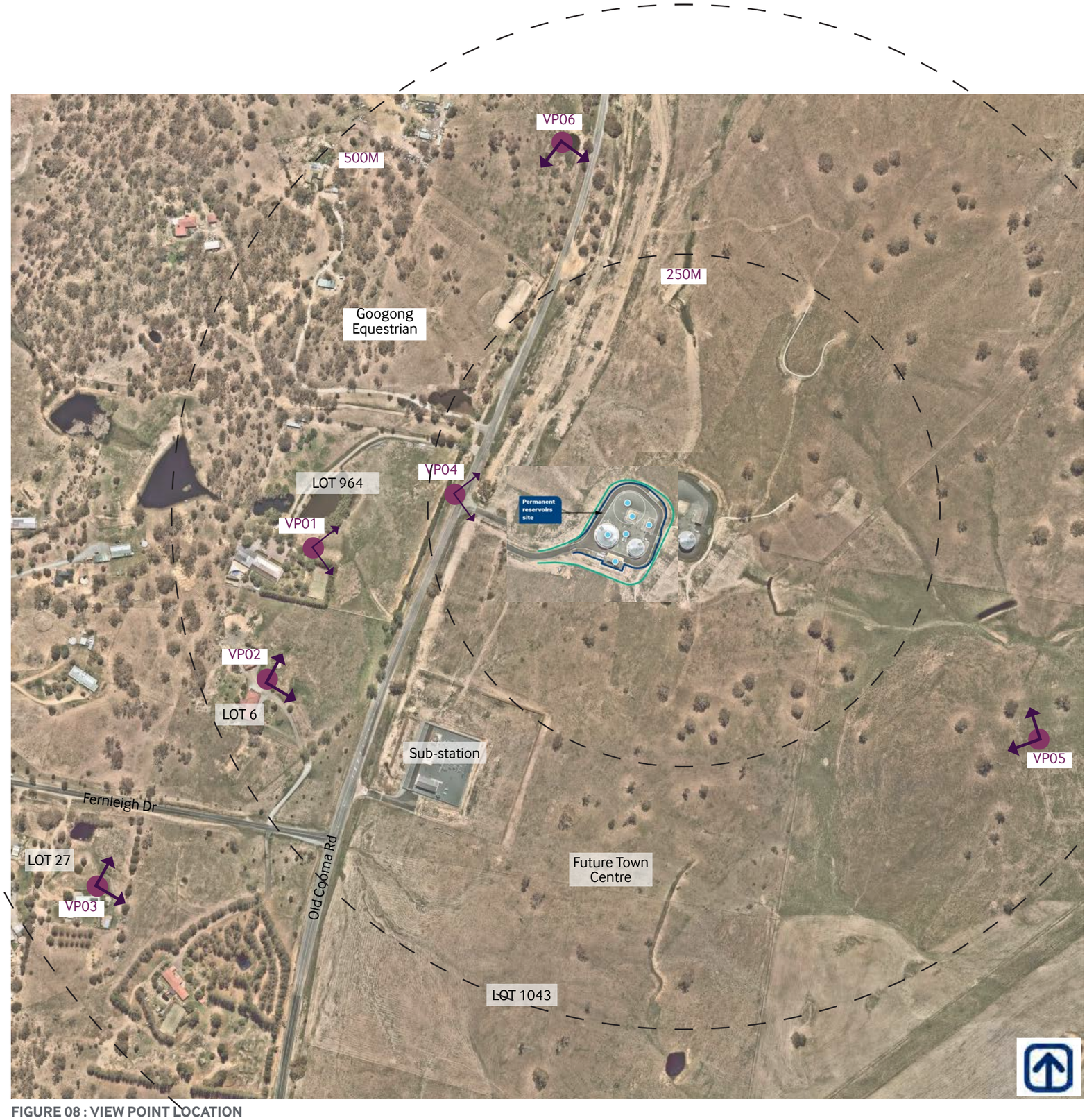


FIGURE 08 : VIEW POINT LOCATION

3.2 VIEWPOINT ANALYSIS - VP01

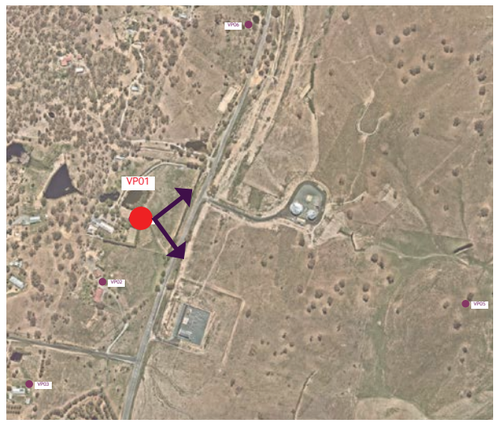


FIGURE 09 : VIEW POINT 01

SUMMARY OF VIEWPOINT	
LOCATION	LOT 964 OLD COOMA RD
COORDINATES	-35.430978, 149.216532
ELEVATION	9M
VIEWING DIRECTION	E
DISTANCE TO SITE	375 M
LAND ZONING	RURAL
VISUAL SENSITIVITY	LOW
VISUAL IMPACT	LOW

ANALYSIS

Visual receivers are assumed to be existing residents and passengers traveling Old Cooma road. Views by visual receivers may be partially or wholly blocked by the landscape berm and planting and the existing water reseviors. The magnitude of change in character that would be created by the additional water tank height within the context of the existing water reseviors is considered to be Low due to its lack of visual prominence in the overall landscape.



3.3 VIEWPOINT ANALYSIS - VP02

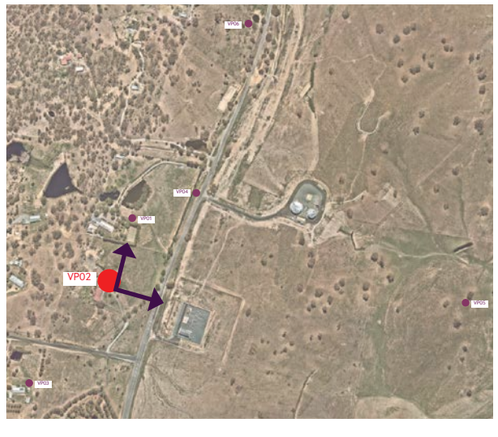


FIGURE 10 : VIEW POINT 02

SUMMARY OF VIEWPOINT	
LOCATION	LOT 964 OLD COOMA RD
COORDINATES	-35.432264, 149.216017
ELEVATION	-
VIEWING DIRECTION	NE
DISTANCE TO SITE	445 M
LAND ZONING	RURAL
VISUAL SENSITIVITY	LOW
VISUAL IMPACT	NEGLIGIBLE

ANALYSIS

Visual receivers are assumed to be existing residents and passengers traveling Old Cooma Road. Views by visual receivers may be partially or wholly blocked by the landscape berm and planting and the existing water reseviors. The magnitude of change in character that would be created by the additional water tank height within the context of the existing water reseviors is considered to be Negligible due to its lack of visual prominence in the overall landscape.



3.4 VIEWPOINT ANALYSIS - VP03

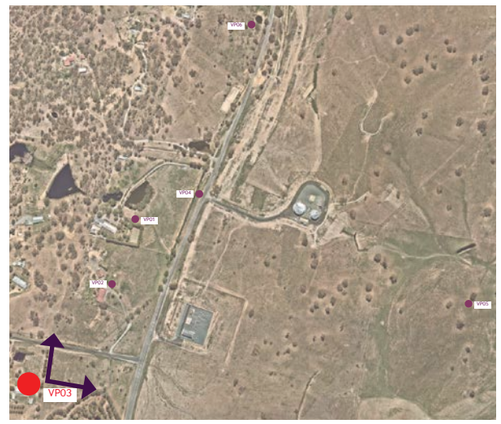


FIGURE 11 : VIEW POINT 03

SUMMARY OF VIEWPOINT	
LOCATION	LOT 27 FERNLEIGH DR
COORDINATES	-35.434521, 149.214111
ELEVATION	-
VIEWING DIRECTION	NE
DISTANCE TO SITE	726 M
LAND USE	RURAL
VISUAL EFFECT	LOW
VISUAL IMPACT	NEGLIGIBLE

ANALYSIS

Visual receivers are assumed to be existing residents and passengers traveling Old Cooma road. Views by visual receivers may be partially or wholly blocked by the landscape berm and planting and the existing water reseviors. The magnitude of change in character that would be created by the additional water tank height within the context of the existing water reseviors is considered to be Negligible due to its lack of visual prominence in the overall landscape.



3.5 VIEWPOINT ANALYSIS - VP04

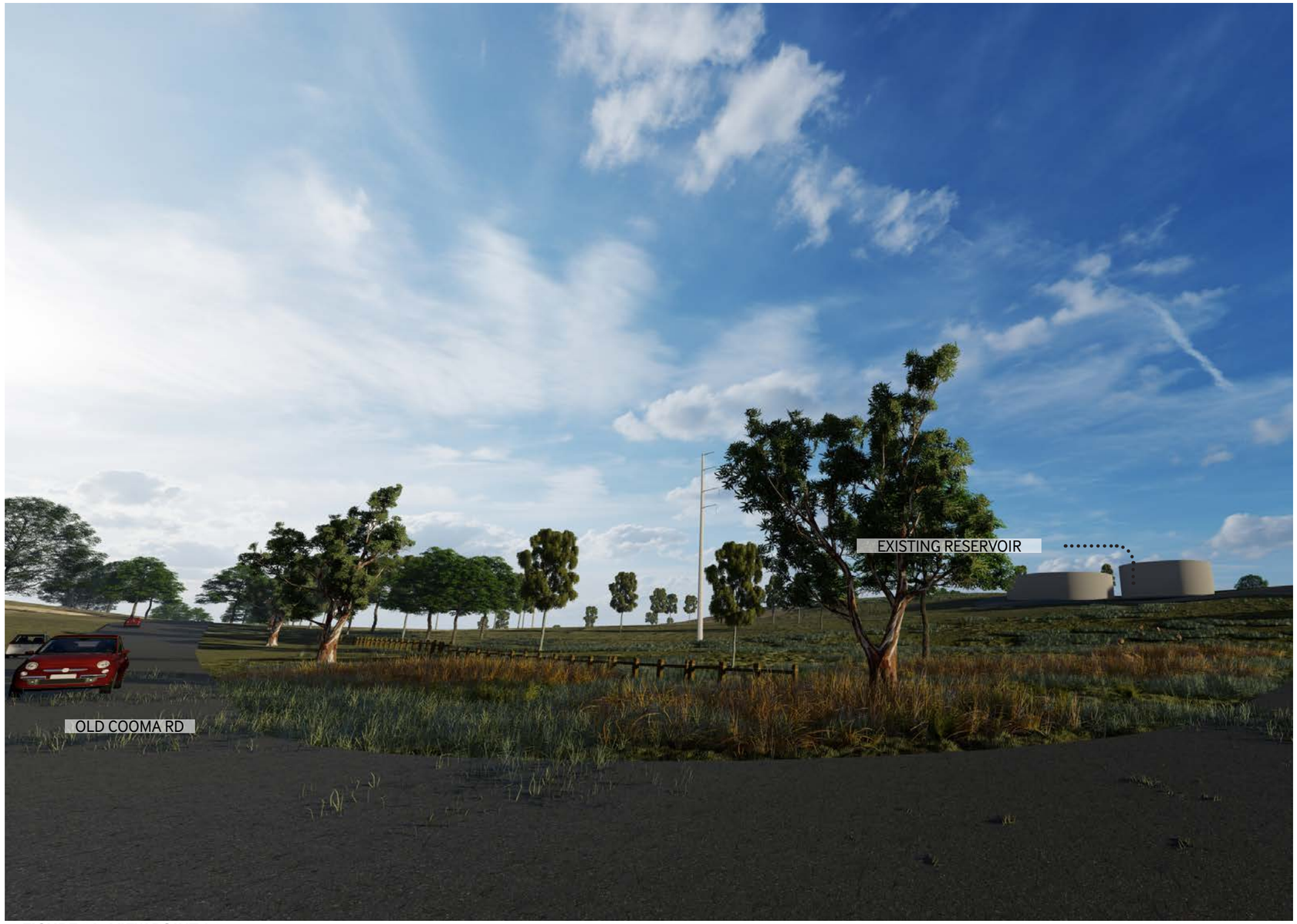
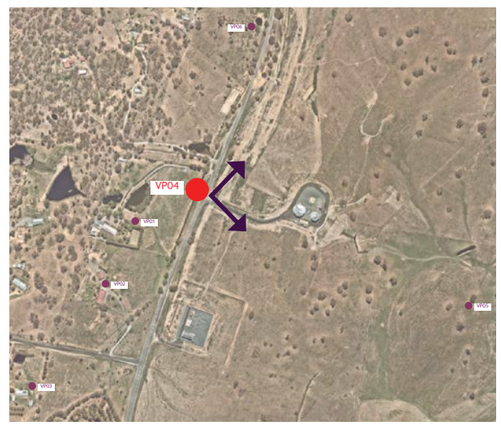


FIGURE 12 : VIEW POINT 04

SUMMARY OF VIEWPOINT	
LOCATION	LOT 27 FERNLEIGH DR
COORDINATES	-35.434521, 149.214111
ELEVATION	-
VIEWING DIRECTION	E
DISTANCE TO SITE	226 M
LAND USE	RURAL
VISUAL EFFECT	LOW
VISUAL IMPACT	MEDIUM

ANALYSIS

Visual receivers are assumed to be passengers traveling Old Cooma road. The reservoir are located in an elevated saddle above most of the surrounding landscape. Their scale, higher position relative to the residents and contrasting industrial character mean they will be prominent within the landscape. The surrounding landscape will likely have little capacity to visually absorb the structures.



3.6 VIEWPOINT ANALYSIS - VP05



FIGURE 13: VIEW POINT 05

SUMMARY OF VIEWPOINT	
LOCATION	LOT 27 FERNLEIGH DR
COORDINATES	-35.434521, 149.214111
ELEVATION	-
VIEWING DIRECTION	NW
DISTANCE TO SITE	726 M
LAND USE	RURAL
VISUAL EFFECT	LOW
VISUAL IMPACT	MEDIUM

ANALYSIS

Visual receivers are assumed to be residents in future homes and may have long viewing times from properties to the tank. Visual receivers are also residents within the development using publicly accessible areas such as streets and footpaths. The reservoir will be higher than the viewers from the east meaning they will have a strong visual presence. Their combined size and contrasting industrial character mean they will be prominent within the landscape. The surrounding landscape currently may have little capacity to visually absorb the structures.



3.7 VIEWPOINT ANALYSIS - VP06

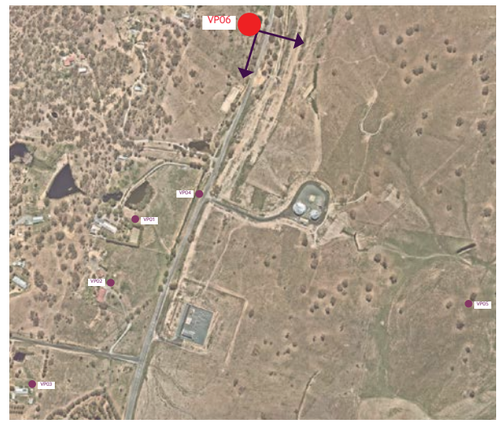


FIGURE 14: VIEW POINT 06

SUMMARY OF VIEWPOINT	
LOCATION	LOT 27 FERNLEIGH DR
COORDINATES	-35.434521, 149.214111
ELEVATION	-
VIEWING DIRECTION	SE
DISTANCE TO SITE	726 M
LAND USE	RURAL
VISUAL EFFECT	LOW
VISUAL IMPACT	MEDIUM

ANALYSIS

Visual receivers are assumed to be future residences west of the reservoirs. Residents are within 200 meters and are likely to have views to the reservoirs from their properties. Visual receivers are also residents within the development The reservoir is located in an elevated saddle above most of the surrounding landscape. Their scale, higher position relative to the residents and contrasting industrial character mean they will be prominent within the landscape. The surrounding landscape will likely have little capacity to visually absorb the structures.



3.8 VIEWPOINT SUMMARY

Viewpoint	Visual Sensitivity	Potential Impact
VP01	• LOW	• LOW
VP02	• LOW	• NEG
VP03	• LOW	• NEG
V04	• LOW	• MED
VP05	• LOW	• MED
VP06	• LOW	• MED

TABLE 03- VIEWPOINT SUMMARY

4.0 CONCLUSION & REFERENCES

4.1 CONCLUSION

SUMMARY OF MODIFIED VISUAL IMPACT ASSESSMENT

The degree to which the changes to the landscape are perceived either positively or negatively will in the end depend on the actual users/residents. The degree of importance placed on viewpoints varies according to a combination of considerations including predominantly visual prominence and visual exposure.

This visual assessment has determined that the impacts on visual amenity from the Stage D Network West infrastructure proposals will be highest near the new Permanent Water Reservoir. The immediate surrounding area will have little visual capacity to absorb the industrial character of the large, elevated tanks in the landscape. It is imperative therefore that wherever possible, measures should be implemented to visually buffer the reservoirs from the future residential areas, Hilltop Park and wider area.

The additional height of the water tank at the WRP and expanded pumping station are generally of a scale and nature that do not detract from the overall visual amenity of the future residential areas. The tank will be largely visually concealed from the surrounding area both by WRP infrastructure as well as expected landscape berm and planting to the south and west.

The recommendations for mitigation measures should be considered alongside the recommendations made in previous Visual Impact Assessments. This report provides recommendations for mitigation in light of the future residential visual amenity for the Township and does not seek to repeat those made in previous visual impact assessments.

- Effective screening of the permanent reservoirs should be implanted through the use of locally endemic vegetation close to the site. Species selection should aim to inhibit views at the ground and mid levels up to 10 meters in particular on the eastern and western sides of the reservoirs. A landscape concept plan should be prepared that demonstrates how the proposed planting treatments will address potential views of the reservoirs from surrounding areas.
- Regularly monitor the health of trees and vegetation once planted to ensure continued growth is achieved. Replace trees and vegetation that are dead or dying.
- If night lighting for security and operation is implemented, the use of light emitting diodes (LED) lighting will significantly reduce stray light. Low angle cut-off fittings should be used to mitigate the impact of lighting.
- Decrease the visual prominence of the reservoir through the use of muted colours and non-reflective surfaces.

CONSTRUCTION

Depending on timing of development and the Stage D West Visual impacts during construction are limited to construction materials, fencing, stockpiles, lighting and plant and vehicle movements. The management of these during the construction phase would require:

- Installation of temporary fencing for security and to visually delineate the area of construction.
- The site to be kept tidy and well maintained, including removal of all rubbish at regular intervals. There should be no storage of materials beyond the construction boundaries.
- Temporary hoardings, barriers, traffic management and signage would be removed when no longer required.
- Locate construction plant, machinery and vehicle parking areas away from public or sensitive viewing areas.
- Locate any night lighting needed for construction away from public or sensitive viewing areas.
- Upon completion, revegetate residual site areas.

4.2 REFERENCES

- Roads and Maritime Services 2014, Beyond the Pavement available online at < https://www.rms.nsw.gov.au/documents/projects/planning-principles/beyond-pavement.pdf>, viewed 4 September 2019.
- Roads and Maritime Services 2018, Guideline for landscape character and visual impact assessment - Environmental impact assessment practice note EIA-N04 available online at < https://www.rms.nsw.gov.au/documents/projects/planning-principles/urban-design/guideline-landscape-character-and-visual-impact.pdf
- Guidance Note for Landscape and Visual Assessment June 2018 https://www.aila.org.au/imis_prod/documents/AILA/QLD/2018/AILA_GNLVA_June_2018V2.pdf
- Colleran, JR. & Gearing D. (1980) A Visual Assessment Method for Botany Bay, Landscape Australia, 3 August.
- DOP (1988) Rural Land Evaluation, Government Printer, Department of Planning.
- EDAW (Australia) Pty Ltd (2000) 'Section 12 – Visual Assessment', The Mount Arthur North Coal Project: Environmental Impact Statement, URS Australia Pty Ltd, Prepared for Coal Operations Limited.
- The Landscape Institute with the Institute of Environmental Management and Assessment (2008) Guidelines for Landscape and Visual Assessment Second Edition, Newport, Lincoln.
- Google Maps, 2014 http://google.com/maps/
- Six Maps, 2014, http://http://maps.six.nsw.gov.au/

Appendix J Risk assessment

Reference	Risk or opportunity	Potential consequences	Original rating			Proposed risk treatment	Residual rating		
			Likelihood	Consequences	Original risk		Likelihood	Consequence	Rsedlual risk
1	**Concept design development**								
1.1	Concept design is not sufficiently developed to confidently establish a sufficient environmental footprint	Delay to REF and construction etc (additional design and environmental costs).	L	H	M	Lessons learnt from previous project stages. Ongoing liaison within the IWC team to flag design issues.	L	H	M
1.2	Changes to design will impact REF	Delay to REF and construction etc (additional design costs due to maintaining existing footprint).	M	H	H	Lessons learnt from previous project stages. Ongoing liaison within the IWC team to flag design issues.	L	H	M
1.3	Need to consider adjacent development and Master Plan	Proposal not compatible with Master Plan for township, requiring changes to design, delay to REF and additional costs.	M	H	H	Lessons learnt from previous project stages. Ongoing liaison with the IWC and subdivision team to flag any constraints as they arise.	N	N	N
1.4	Evolving nature of WMP & changes in EPA licence conditions becomes in conflict with concept design parameters for water treatment	Future amendment to operation or process of IWC and related infrastructure.	L	H	M	Detailed design to consider contingency for lower parameters	N	N	N
2	**Planning approvals**								
2.1	Proposal not approved by determining authority	Delays to program and construction Additional costs for designs and environmental assessments. Social impacts.	L	E	H	Lessons learnt from previous project stages. Confirm planning pathway with QPRC.	L	H	M
2.2	Obtaining EPL for proposed works (construction and operation)	Delay to construction pending approvals.	M	M	M	Lessons learnt from previous project stages. Consultation with EPA prior to submitting licence application to ensure all concerns are addressed.	L	M	L
2.3	Delay in approvals from planning authority	Delays to program and construction Additional costs for designs and environmental assessments. Social impacts.	M	H	H	Ongoing consultation with broader QPRC stakeholders. Lessons learnt from previous project stages. Early community consultation to identify potential community and stakeholder concerns early in the preparation of the REF.	L	L	N
3	**Site establishment and construction**								
3.1	Water quality	Pollution of receiving waters via transport of sediment.	M	H	H	All run-off from the site would be directed to appropriate sediment control structures which must be appropriately sized and maintained as per the Blue Book. If required, sediment basins would only be discharged to receiving waters once field tests/laboratory tests confirm the water quality parameters are within guideline limits.	L	H	M
3.2	Water quality	Pollution of soils and receiving waters via chemical spills.	M	H	H	Spill clean-up kits would be located in appropriate locations, based on the risk of a spill occurring and potential volume of material that might be spilled at the particular location.	L	H	M
3.3	Water quality	Pollution of soils and receiving waters via discharge of contaminated water.	M	H	H	All run-off from the site would be directed to appropriate sediment control structures which must be appropriately sized and maintained as per the Blue Book. If required, sediment basins would only be discharged to receiving waters once field tests/laboratory tests confirm the water quality parameters are within guideline limits. Vehicle wash down would take place in designated areas within the WRP and Permanent Reservoirs sites and away from drainage lines. Water from the wash down would be appropriately treated before being reused on site or discharged.	L	H	M
3.4	Water usage	Impacts to available water supplies during construction.	L	M	L	The Construction Environmental Management Plan would be prepared prior to construction activities and outline procedures for the responsible use and re-use of waters on site.	L	M	L
3.5	Flora and fauna	Considerable native vegetation loss and removal of vegetation in communities/EEC's.	N	H	L	The Contractor would be required to undertake construction of the Proposal having regard for the trees on the northern boundary of the WRP and Tree Protection Zones (TPZs) would be established in line with AS 4970-2009 Protection of Trees on Development Sites and would include exclusion fencing of TPZs.	N	H	L
3.6	Flora and fauna	Failure to adequately address environmentally sensitive areas in defining the proposed project.	L	H	M	An Environmental Controls Map would be prepared that would clearly mark no-go areas and other important environmental features/areas of sensitivity along with key environmental controls.	L	H	M
3.7	Flora and fauna	Native fauna injured or trapped by construction activities.	L	M	L	Regular site inspections and the monitoring and inspection of construction plant and material would be undertaken to identify native fauna injured or trapped by construciton activities.	L	M	L
3.8	Flora and fauna	Increased vehicle/fauna interactions due to construction traffic.	M	M	M	A Traffic Management Plan would be prepared prior to construction to outline all access routes to, from and within the construction zones, traffic control methods to be utilised and methods to minimise impacts to the local road network and surrounding environment.	M	M	M
3.9	Flora and fauna	Disturbance to native fauna, particularly nocturnal species, due to increased lighting around construction compounds and some night-time construction activities.	L	L	N	LED lighting would be used to significantly reduce stray light. Low angle cut-off fittings would also be used to migitate the impact of lighting.	L	L	N
3.10	Weeds	Encourage the spread of weeds through the construction area.	M	M	M	Weed control measures would be implemented in line with the *Noxious Weed (Control Order) 2014* and include details on the treatment, management, and disposal methods for noxious weeds.	L	M	L
3.11	Soils	Increase soil erosion and potential for soil erosion due to disturbance of topsoil and loss of vegetation.	H	H	E	Site-specific Erosion and Sediment Control Plans (ESCPs) will be prepared progressively to include the management strategies and controls for all activities with the potential to impact on sediment loss and erosion. Implementation of erosion controls measures, which includes: Stabilising where required by establishing rocks, sandbags, and/or matting to prevent scouring, ensuring that they are placed to conform as far as possible with existing contours. Re-spreading topsoil over the area from where it was removed. Installing matting that is infused with seedlings to keep the soils stable while it settles. Protecting buffer and riparian vegetation zones, and restoring these zones where required.	M	M	M
3.12	Spoil vs fill ratio	Excess spoil would need to be disposed of off-site.	H	H	E	Any spoil disposal will be outlined in the CEMP, icnluding potential spoil disposal within subdivision development areas.	M	M	M
3.13	Contaminated soils	Failure to adequately identify contaminated soils, resulting in impacts on surrounding environment once exposed.	L	M	L	Where possible, all refuelling will occur at designated fuel distribution points. Chemical transport, storage, handling and disposal procedures will be implemented in accordance with the requirements of dangerous goods and environmental legislation, and industry standards. Spill response procedures and equipment for containment and recovery will be available on site. Workforce training will be conducted on the transport, storage, handling and disposal procedures relating to chemicals. Stop all work in the area if potential or actual contamination is found during earthworks.	L	M	L
3.14	Impacts to groundwater quality	Pollution of groundwater sources as a result of drilling, excavations or discharge.	L	H	M	Treatment of surface water pumped out of excavations prior to discharge. Trenching carried out progressively to minimise the length and duration of open excavations. Sediment trap fencing to reduce sediment transport and TDS. Limiting the application of fertilisors for vegetation establishment.	L	M	L
3.15	Impacts to groundwater flows	Changes to groundwater flows due to construction activities.	L	H	M	Directing surface water runoff away from exposed trenches and managed within the current WRP surface water system. Trenching carried out progressively to minimise the length and duration of open excavations.	L	M	L
3.16	Vibration	Damage to existing WRP and permanent reservoir structures	L	E	H	Detailed design to consider and contractor to be aware of obligations	N	N	N
3.17	Noise	Noise and vibration impacts to local sensitive receivers.	H	M	H	Identification of nearby residences and other sensitive land uses, including a survey of all occupied dwellings within the Googong Township. Approved hours of work and what work would be undertaken. Construction works should be planned and carried out during standard construction hours wherever possible.	M	M	M
3.18	Noise	Resident or community complaints.	L	M	L	Ensure all staff are aware of complaint handling protocol(s).	L	L	N
3.19	Vibration	Damage to property / heritage items.	N	H	L	Identification of nearby residences and other sensitive land uses, including a survey of all occupied dwellings within the Googong Township.	N	H	L

3.20	Air quality	Emissions from construction machinery.	H	L	M	The adequate maintenance and proper use of all vehicles and machinery to minimise energy use and greenhouse gas emissions. The use of fuel-efficient and low-emission vehicles where practicable.	M	L	L
3.21	Air quality - dust emission	Generation of dust from construction activities.	H	H	E	Speed limits would be reduced during high dust/windy conditions. Clearing of vegetation and topsoil would be limited to the designated footprint required. Disturbed areas would be progressively reinstated with suitable stabilising agents or revegetation. Water trucks would be used to reduce dust in dry, windy conditions. Working practices would be modified during periods of high winds by limiting the use of some machinery and by reducing travel speeds.	L	M	L
3.22	Traffic and access	Community impacts to access to property.	L	L	N	Access to residential properties would be maintained at all times.	L	L	N
3.23	Traffic and access - construction traffic movements	Loss of local parking for local residents.	N	L	N	Construction staff and delivery vehicles would not park in public areas where supply is limited.	N	L	H
3.24	Traffic and access - construction traffic movements	Impacts to traffic flow and movement during construction of Googong Road (road diversion and/or temporary closure of roads).	L	L	N	A detailed traffic and access management plan would be prepared prior to construction to outline all access routes to, from and within the construction zones, traffic control methods to be utilised and methods to minimise impacts on the local road network. This plan would be prepared in accordance with the RMS standard Traffic Control Plan (TCP) 195 and submitted to RMS for consultation and approval.	L	L	N
3.25	Aboriginal heritage	Direct impacts on identified Aboriginal heritage sites during construction.	N	H	L	The location of nearby Aboriginal heritage sites should be clearly marked on all site plans and maps utilised for the construction of the Proposal.	N	H	L
3.26	Aboriginal heritage	Impacts to unidentified Aboriginal heritage sites during construction that may result in destruction of Aboriginal heritage sites and/or delays to construction schedule.	L	H	M	If unforeseen items/objects are uncovered during construction, work would cease in the vicinity of the find and the Environment Manager would be notified immediately to assist in co-ordinating next steps which are likely to involve consultation with an archaeologist, OEH and Local Aboriginal Land Council.	L	H	M
3.27	Non-Aboriginal heritage	Direct impacts on identified non-Aboriginal heritage items.	N	H	L	The location of nearby non-Aboriginal heritage sites should be clearly marked on all site plans and maps utilised for the construction of the Proposal.	N	H	L
3.28	Visual amenity	Impact to residents' visual amenity due to construction activities.	L	L	N	The site to be kept tidy and well maintained, including removal of all rubbish at regular intervals. There should be no storage of materials beyond the construction boundaries. Temporary hoardings, barriers, traffic management and signage would be removed when no longer required. Location of construction plant, machinery and vehicle parking areas away from public or sensitive viewing areas. Location any lighting needed for construction night-time activities away from public or sensitive viewing areas.	L	L	N
3.29	Hazards and risks	Fire impacts may result in the destruction of property.	L	H	M	The burning of material on site would be prohibited, except under the instruction of NSW Rural Fire Services.	L	H	M
3.30	Hazards and risks	Safety hazards and risks, whilst undertaking construction activities (including interference with services, trench collapse, traffic, bushfire, impact with power lines, personal safety and security).	M	E	E	A Hazards, Risk and Safety Management Plan would be prepared that would detail the following (at a minimum): - Implomentation of appropriate safety and training procedures - Risk register - Emergency access - Emergency response plan/s.	L	H	M
3.31	Use on non-renewable resources	Depletion of non-renewable resources.	H	N	L	The re-use of on-site (excavated) materials where materials are suitable and their re-use feasible. The use of low greenhouse intensity materials rather than conventional materials where appropriate. The use of locally sourced materials where feasible.	L	N	N
3.32	Energy use	Creation of greenhouse gas emissions.	H	N	L	The adequate maintenance and proper use of all vehicles and machinery to minimise energy use and greenhouse gas emissions. The use of fuel-efficient and low-emission vehicles where practicable.	M	N	N
3.33	Waste disposal	Disposal of contaminated land including asbestos.	N	H	L	Waste to be disposed of offsite will be disposed of to a waste facility that is licensed under the POEO Act to receive wastes of that type.	N	H	L
3.34	Waste disposal	General waste from construction site.	H	L	M	Waste management strategies will be developed in accordance with the WARR Act and by adopting the resource management hierarchy principles (in order of priority) of avoidance, resource recovery and disposal.	L	L	N
3.35	Socio-economic	Impacts on recreational use at various nearby sites during construction.	L	L	N	Construction staff and delivery vehicles would not park in public areas where supply is limited.	L	L	N
3.36	Adjacent projects	Impacts from adjacent subdivision projects (eg erosion and sedimentation run-off) that impacts the proposed site.	H	H	E	Site plans to clearly distinguish the project site boundaries. Ongoing liaison with subdivision teams is required to ensure all issues are resolved before incidents arise.	N	N	N
3.37	Unauthorised access to the construction site by members of the public or operational staff	Death, injury or malicious damage.	M	E	E	Construction site will be fenced.	N	N	N
3.38	Contractor management	Construction activity affecting process performance.	M	H	H	A CEMP would be prepared to manage the environmental issues assessed in this REF and ensure implementation of the identified mitigation measures where required during construction. All Contractors would be inducted on the key project environmental risks, procedures, mitigation measures and Conditions of Approval. Site inspections to monitor environmental compliance and performance would be undertaken during construction at appropriate intervals.	L	H	M
4	**Employee relations**								
4.1	General attitude to environmental management	Construction activities not complying with environmental legislation requirements.	M	H	H	Inductions and training for all site staff. The selection of competent contractor and review of QA systems.	L	H	M
4.2	Lack of knowledge of environmental issues	Non-compliance with environmental requirements and breaches of legal requirements.	M	H	H	Review of EHS system.	L	H	M
5	**Operation**								
5.1	Need to comply with all environmental and legal requirements	Breaches of approvals with potential for fines or reporting to appropriate agencies.	L	H	H	All other licences, permits and approvals for operation would be obtained and maintained (e.g. Environment Protection Licence under the PoEO Act). The existing operational management plans for the IWC Project would be also be revised and amended to reflect the increased operational capacity of the WRP and Permanent Reservoirs , additional relevant licences as well as reporting requirements for Stage D.	L	H	M
5.2	Water quality	Release of water that doesn't adhere to license requirements.	L	H	M	A Water Management Plan (WMP) (RPS, 2018) has been prepared for the IWC Project, which outlines the procedures and practices to manage potential impacts on surface water and groundwater systems during operation of the IWC Project. The WMP and associated sub-plans would be revised and amended to reflect the increased operational capacity of the WRP and Permanenent Reservoirs, and additional mitigation and management requirements. The sub-plans that would be revised include: - Surface Water and Aquatic Ecology Monitoring Program - Surface and Groundwater Response Plan - Groundwater Monitoring Program - Recycled Water Flow Release Protocol - Irrigation Management Plan	L	H	M
5.3	Water quality	Reduced water quality in receiving waters due to discharge of recycled water.	M	H	M	A Recycled Water Flow Release Protocol has been developed as part of the WMP (RPS, 2018) which describes the discharge arrangements for excess recycled water released to the environment and provides a procedure for the review of such discharges based on the outcomes of the monitoring required by other parts of the WMP, Conditions of Approval and Statement of Commitments. The RWFRP would be revised to include the operation of Stage D, updated monitoring results and discharge modelling, and additional mitigation measures to manage potentil impacts to downstream waterways.	M	H	M
5.4	Water quality	Failure in treatment system, leading to the discharge of poor quality recycled water, and consequentially reduced receiving water quality (quality related).	L	H	M	A WMP (RPS, 2018) has been prepared for the IWC Project, which outlines the procedures and practices to manage potential impacts on surface water and groundwater systems during operation of the IWC Project. The WMP and associated sub-plans would be revised and amended to reflect the increased operational capacity of the WRP and Permanenent Reservoirs, and additional mitigation and management requirements.	L	H	M
5.5	Water quality	Spills of pollutants used and/or stored for operation causing pollution of receiving waters.	L	H	M	The existing Operational Environmental Management Plan (OEMP) would be revised and amended to reflect the increased operational capacity of the WRP and Permanenent Reservoirs. The OEMP would include a revised list of pollutants stored for Stage D, and relevant procedures to manage the use and storage of these pollutants. Procedures for the clean-up of spills would also be revised for Stage D.	L	H	M

5.6	Hydrology	Changes in flows in receiving waters due to discharges of recycled water and stormwater flows.	M	H	H	A Recycled Water Flow Release Protocol has been developed as part of the WMP (RPS, 2018) which describes the discharge arrangements for excess recycled water released to the environment and provides a procedure for the review of such discharges based on the outcomes of the monitoring required by other parts of the WMP, Conditions of Approval and Statement of Commitments. The RWFRP would be revised to include the operation of Stage D, updated monitoring results and discharge modelling, and additional mitigation measures to manage potentil impacts to downstream waterways.	M	H	H
5.7	Hydrology	Changed geomorphology of receiving water beds due to recycled water discharges (increased flows).	L	H	M	A Groundwater Monitoring Program has been developed as part of the WMP (RPS, 2018) which outlines the groundwater baseline and ongoing monitoring programs and results. The GWMP also outlines the groundwater impact assessment critieria and triggers levels for groundwater quality. The GWMP would be revised to include the operation of Stage D, results of updated groundwater data and additional mitigation measures to manage potnetial impacts to groundwater and geomorphology.	L	H	M
5.8	Flora and fauna	Increased active erosion, scouring and loss of riparian vegetation in creeks due to increased flows.	L	H	M	A Recycled Water Flow Release Protocol has been developed as part of the WMP (RPS, 2018) which describes the discharge arrangements for excess recycled water released to the environment and provides a procedure for the review of such discharges based on the outcomes of the monitoring required by other parts of the WMP, Conditions of Approval and Statement of Commitments. The RWFRP would be revised to include the operation of Stage D, updated monitoring results and discharge modelling, and additional mitigation measures to manage potentil impacts to downstream waterways.	L	H	M
5.9	Flora and fauna	Impacts on downstream ecology due to changes in hydrology.	M	H	H	A Surface water (and Aquatic Ecology) Monitoring Program has been developed as part of the WMP (RPS, 2018) which outlines the surface water baseline and ongoing monitoring programs and results. The SWAEMP also outlines the monitoring requirements and trigger levels to manage potential downstream impacts of the IWC Project. The SWAEMP would be revised to include the operation of Stage D, results of updated monitoring and additional mitigation measures to manage potential impacts to downstream ecology.	M	H	H
5.10	Flora and fauna	Changes to water quality (alkalinity, conductivity and turbidity conditions) may create changes in aquatic ecology.	M	H	H	A Surface water (and Aquatic Ecology) Monitoring Program has been developed as part of the WMP (RPS, 2018) which outlines the baseline and ongoing monitoring programs, and surface water and stream health impact assessments for the IWC Project. The SWAEMP also outlines the monitoring requirements and trigger levels to manage potential downstream impacts of the IWC Project. The SWAEMP would be revised to include stage D and updated ecological data.	M	H	H
5.11	Soils	Contamination of soils due to irrigation of public areas with recycled waters	L	H	M	The treatment process has been optimised to produce recycled water with low salinity, thereby minimising adverse salinity issues. Control mechanisms have been incorporated to ensure salinity of the recycled water can be further reduced if required, either through mandating the specific types of chemicals used in the treatment process and/or reducing the quantity of chemicals used. There is a trade-off between management of phosphorus and management of salinity. If salinity is required to be reduced, changes to the way phosphorus is managed in the treatment process are possible.	L	H	M
5.12	Groundwater	Impact on quality of groundwater sources due to irrigation.	L	H	M	An Irrigation Management Plan (IMP) has been developed as part of the WMP (RPS, 2018) which outlines the procedures and practices related to the sustainable management of irrigation of public spaces for Stage 1 and 2 of the IWC Project. The IMP includes standard operating procedures that will assist in reducing the movement of salt through soil and into the groundwater system. It also provides a mechanism by which the operations can be monitored and continually assessed. The IMP will be expanded to incorporate the public spaces irrigated for Stage D of the IWC Project.	L	H	M
5.13	Noise and vibration	Noise and vibration impacts from operation of the WRP and permanent reservoirs.	H	M	H	Noise enclosure at the WRP, the enclosure should be constructed gap-free and fully sealed around all edges. Should ventilation be required for the relevant equipment, all vents should be acoustically treated and/or have the opening directed away from the sensitive receivers.	L	M	L
5.14	Air quality	Odour emissions from WRP that may impact on air quality.	H	M	H	Odour modelling to ensure control covers, ventilation and foul air treatment provides adequate odour management. Subdivision layout is managed to ensure odour emissions do not impact on township residents.	L	M	L
5.15	Air quality	Odour emissions from malfunctions anywhere in the treatment and distribution system.	L	L	N	Odour modelling to ensure control covers, ventilation and foul air treatment provides adequate odour management. Subdivision layout is managed to ensure odour emissions do not impact on township residents.	L	L	N
5.16	Traffic and access	Traffic impacts due to necessary deliveries and maintenance.	N	L	N	The existing Operational Environmental Management Plan (OEMP) would be revised and amended to reflect the increased operational capacity of the WRP and Permananent Reservoirs. The OEMP would include revised mitigation measures to address traffic impacts associated with the operation of Stage D.	N	L	N
5.17	Aboriginal heritage	Impacts on unidentified sites that are of heritage or recreational value.	N	H	L	If unforeseen items/objects are uncovered during operation, work would cease in the vicinity of the find and the Environment Manager would be notified immediately to assist in co-ordinating next steps which are likely to involve consultation with an archaeologist, OEH and Local Aboriginal Land Council.	N	H	L
5.18	Visual amenity	Negative impact on visual amenity due to presence of permanent infrastructure.	L	H	M	Selection of similar colours to the existing bioreactor and non-reflective surfaces for new elements to decrease the visual prominence. Monitoring of trees and vegetation at the WRP site to ensure the ongoing success of planting and screening. Dead or dying trees should be replaced.	N	N	N
5.19	Hazards and risk	Safety hazards and risks during operation.	L	H	M	The operation of Stage D would be undertaken in accordance with the revised OEMP, relevant maagament plans and standard operating procedures.	L	H	M
5.20	Hazards and risk	Risk to human health via pathways or exposure to recycled waters.	L	H	M	A Recycled Water Quality Management Plan (RWQMP) (QPRC, 20XX) has been prepared for the IWC Project would be revised and amended to reflect the increased operational capacity of the WRP and Permanenent Reservoirs and incorporate the Stage D assets. The update of the RWQMP would also include a review of the recycled water system analysis to capture all hazards and risks associated with recycled waters.	L	H	M
5.21	Energy use	Creation of green-house gases through continuous operation of pumps etc	H	N	L	Overall commitment to energy efficiency and sustainability throughout the Googong township. Sizing pumps and other infrastructure appropriately for each stage as the development of the Googong township progresses. Use of SCADA and telemetry during operation to minimise wastage of electricity.	M	N	N
5.22	Emergency discharge to montgomery creek	Human health impacts - swimming in the river	L	H	M	Recreational activities, such as swimming, would be restricted in areas immediately downstream of the discharge points. Additional community notificiation would be undertaken to inform the public of any potential health risks.	L	H	M
5.23	Natural Disaster	Damage to infrastructure assets.	N	H	L	Construct the Stage D components to the Australian Standards.	N	M	N
5.24	Water quality	Impacts to downstream human health	N	H	L	QPRC have never endorsed usage of Queanbeyan River as a source of drinking water.	N	H	L
5.25	Sabotage by members of the public	Damage to infrastructure assets.	N	H	L	Ensure lighting and a security system are installed and operational at WRP and permanent reservoir sites.	N	H	L

Appendix K Agency consultation

29 January 2020

«Title» «First_Name» «Last_Name»
«Organisation»
«Postal_Address»
«Suburb» «State» «Postcode»

Dear «Title» «First_Name» «Last_Name»

Googong Integrated Water Cycle Project – Invitation to comment on the Stage D expansion works

Googong Township Proprietary Limited (**GTPL**) is inviting key State and Federal agencies to provide comments on the next component of work (referred to as Stage D) of the Googong Integrated Water Cycle (**IWC**) project.

The IWC involves the construction and operation of water cycle infrastructure to deliver potable and recycled water to Googong township, to sustainably support the development as it grows.

Integrated Water Cycle project

The IWC project has been planned in four Stages (A, B, C and D) to support the progressive population growth of Googong over its 20 to 25-year development period. Concept Approval for the ultimate development of the project was granted 24 November 2011 (approval number MP 08_0236). The approval requires environmental assessments to be completed prior to the progress of each stage in line with Part 4 or Part 5 of the *Environmental Planning and Assessment Act 1979* (**EP&A Act**).

Stages A, B and C are completed and have been handed over to Queanbeyan-Palerang Regional Council (**QPRC**) for operation and we are now commencing the planning and approvals scope for Stage D in line with our concept approval. Timing for Stage D construction will be determined by the ongoing development of the Googong township.

Stage D expansion includes works at the following assets:

- Stage D Water Recycled Plant (**WRP**)
- Stage D Hill 800.

Stage D WRP

Stage D WRP will be the last stage to commence and includes the augmentation of the WRP with a new Reactor No. 3 and associated infrastructure, which would provide the remaining infrastructure to double the WRP capacity to 18,800 equivalent population (**EP**).

The scope of work for Stage C WRP is also represented in **Figure 1**.

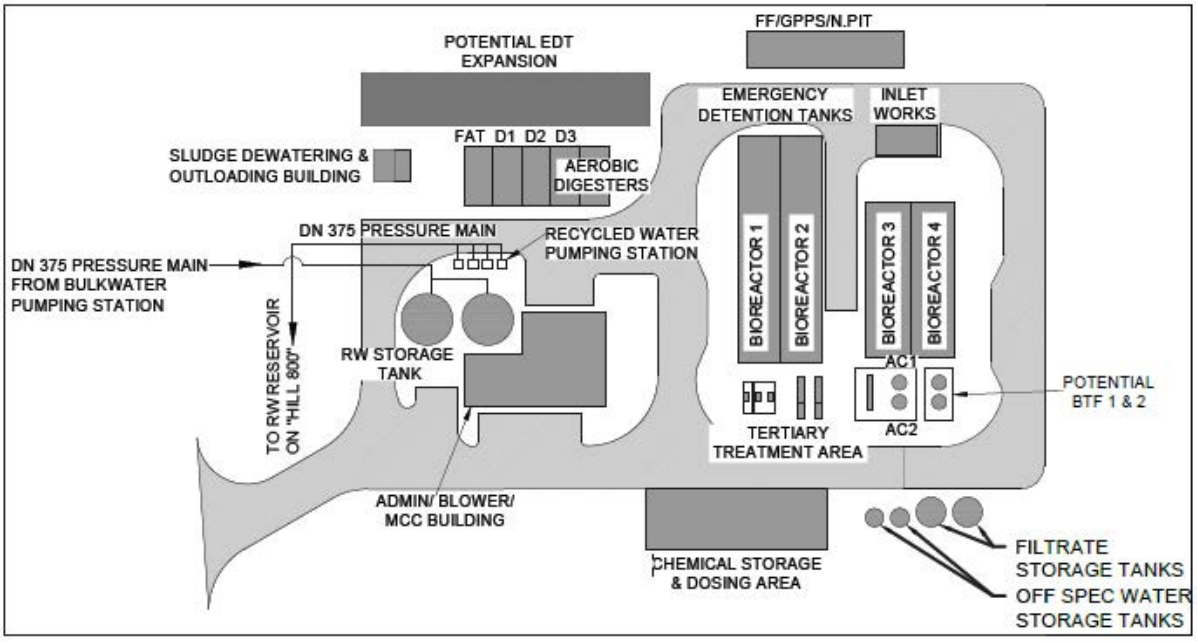


Figure 1 High level Plan of Stage D WRP upgrade works areas

Stage D Hill 800

Stage D Hill 800 works will provide the ultimate reservoir infrastructure and includes the construction of a new recycled water reservoir and repurposing of the existing recycled water reservoir into potable water storage.

The scope of work for Stage D Hill 800 is also represented in **Figure 2**.

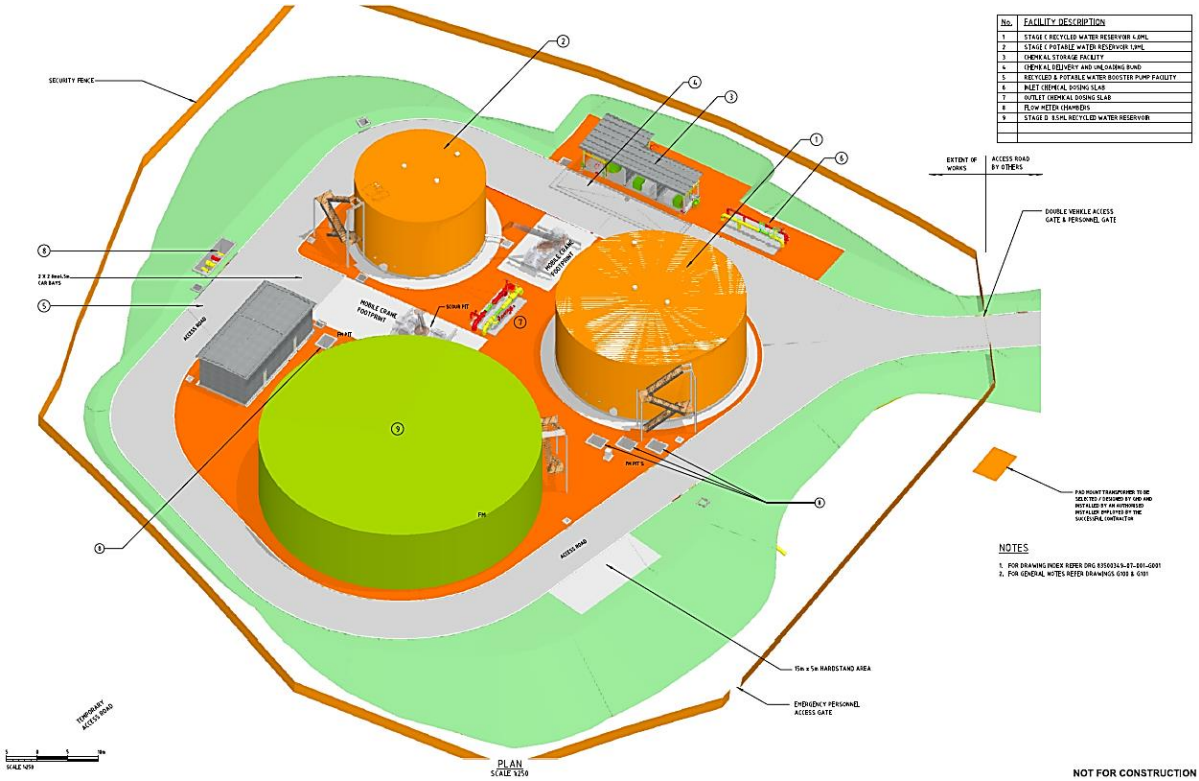


Figure 2 Concept for Stage D Reservoir at Hill 800

The Approvals

As required under the concept approval, the approval pathway for Stage D works will be undertaken under Part 5 of the EP&A Act, on behalf of QPRC (who will own and operate the asset).

GTPL will be preparing an environmental assessment in accordance with the requirements of the Concept Approval, as outlined in **Enclosure 1**.

At this time GTPL requests any issues you would like to see addressed in the REF be identified in a submission by **13 February 2020** to Belinda Bock at RPS (Belinda.bock@rpsgroup.com.au).

Should you have any further question please don't hesitate to contact myself or Belinda on 02 8099 3200.

Yours faithfully,



Craig Harris
Assistant Project Director
Googong Township Pty Ltd

Enclosure 1: Part 3A Concept Approval for future environmental assessment requirements (Section 2.1 of the Googong Township IWC Project Part 3A Concept Approval)

Enclosure 1: Table 1 Part 3A Concept Approval for future environmental assessment requirements (Section 2.1 of the Googong Township IWC Project Part 3A Concept Approval)

Part 3A Concept Approval future environmental assessment requirements (Section 2.1 of the Concept Plan approval)
(a) A detailed project description, including the design and location of ancillary infrastructure (including access roads and temporary construction compounds) and its relationship to the approved concept and approved project stages;
(b) An assessment of relevant statutory matters including land zoning, permissibility and consistency with the objects of the EP&A Act;
(c) A demonstration that the project is consistent with the requirements of this Concept Plan approval and generally consistent with the scope and intent of the Concept Plan and environmental impacts outlined in the documents under condition 1.1 of this approval;
(d) A risk assessment of the potential environmental impacts of the project, identifying the key issues for further assessment;
(e) A description of the measures that would be implemented to avoid, minimise and, if necessary, offset the potential impacts of the project, and ensure that the project is in the public interest;
(f) An assessment of the consistency of the potential impacts and proposed mitigation measures with the management plans approved under the Stage 1 Project and subsequent stages;
(g) A detailed project-specific statement of commitments;
(h) An assessment of the following key issues considering all components of the project (including temporary construction facilities) and cumulative impacts from other projects associated with the Concept Plan:
Surface Water – including potential water quality impacts on local creeks and rivers and impacts on surface water flows, as a result of construction and operation of the project;
Soils and Landscape – including potential soil contamination, erosion risks, irrigation and rehabilitation;
Groundwater – including potential impacts on local recharge levels, contamination risks, groundwater mounding, isolated waterlogging of soils and impacts on groundwater quality;
Flora and Fauna – including terrestrial riparian and aquatic, with accurate estimates of vegetation disturbance associated with the project;
Heritage – both Aboriginal and non-Aboriginal, including an assessment of Aboriginal sites affected by the proposed development, their cultural value and the significance of these values for Aboriginal people;
Human Health – including impacts arising from the application of recycled water and discharges of wastewater and recycled water.
Waste Management – including the likely waste quantities and qualities generated during the construction (including spoil generation) and operation of the project;
Hazards and Risk – including details of hazardous materials used or kept on the premises during the construction and operation phases of the project;
Air Quality – including dust and odour impacts;
Noise and Vibration – including construction and operation noise impacts in the context of planned urban development in the area;

Part 3A Concept Approval future environmental assessment requirements (Section 2.1 of the Concept Plan approval)
Visual Amenity – an assessment of the impact of the project on visual amenity, including future sensitive receptor areas, including residential;
Traffic and Access – including details of transport routes to and from construction and operational sites and associated impacts to existing activities, including safety impact;
(i) evidence of an appropriate level of consultation with (but not necessarily limited to) the following parties, including identification of the issues raised and how these have been addressed in the assessment: • Commonwealth Department of Sustainability, Environment, Water, Population and • Communities; • Office of Environment and Heritage (including its Heritage Branch); • Department of Primary Industries (including the NSW Office of Water); • Department of Trade & Investment, Regional Infrastructure & Services (including its • Primary Industries Division); • Roads and Traffic Authority; • Queanbeyan City Council; • Palerang Council; • relevant service providers; and • property owners and the local community; and
(j) the environmental assessment of the project must take into account relevant State Government guidelines, policies and plans; and
(k) the assessments of the subsequent project stages shall take into account, but not limited to the following guidelines, as relevant: • National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000); • National Water Quality Management Strategy - Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Natural Resource • Management Ministerial Council, Environment Protection and Heritage Council and Australian Health Ministers' Conference, 2006); • Environmental Guidelines: Use of Effluent by Irrigation (DEC, 2004); • NSW Industrial Noise Policy (EPA, 2000); • Interim Construction Noise Guidelines (DECC, 2009); • Environmental Noise Management - Assessing Vibration: a Technical Guideline (DECC, 2006); • Environment Criteria for Road Traffic Noise (EPA, 1999); • Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005); • Assessment and Management of Odour from Stationary Sources in NSW (DEC, 2006); and • Technical Notes: Assessment and Management of Odour from Stationary Sources in NSW (DEC, 2006).

20 March 2020

«Title» «First_Name» «Last_Name»
«Organisation»
«Postal_Address»
«Suburb» «State» «Postcode»

Dear «Title» «First_Name» «Last_Name»

Googong Integrated Water Cycle Project – Invitation to comment on the Stage D expansion works with updated figures

Recently, Googong Township Proprietary Limited (**GTPL**) invited key State and Federal agencies to provide comments on the next component of work (referred to as Stage D) of the Googong Integrated Water Cycle (**IWC**) project.

The IWC involves the construction and operation of water cycle infrastructure to deliver potable and recycled water to Googong township, to sustainably support the development as it grows.

Based on feedback received from agencies, we are now providing additional figures to more clearly outline the proposed works at the Water Recycling Plant (**WRP**) and Permanent Reservoir (**Hill 800**) sites.

The scope of work for Stage D WRP is included as **Enclosure 1**.

The scope of work for Stage D Hill 800 is included as **Enclosure 2**.

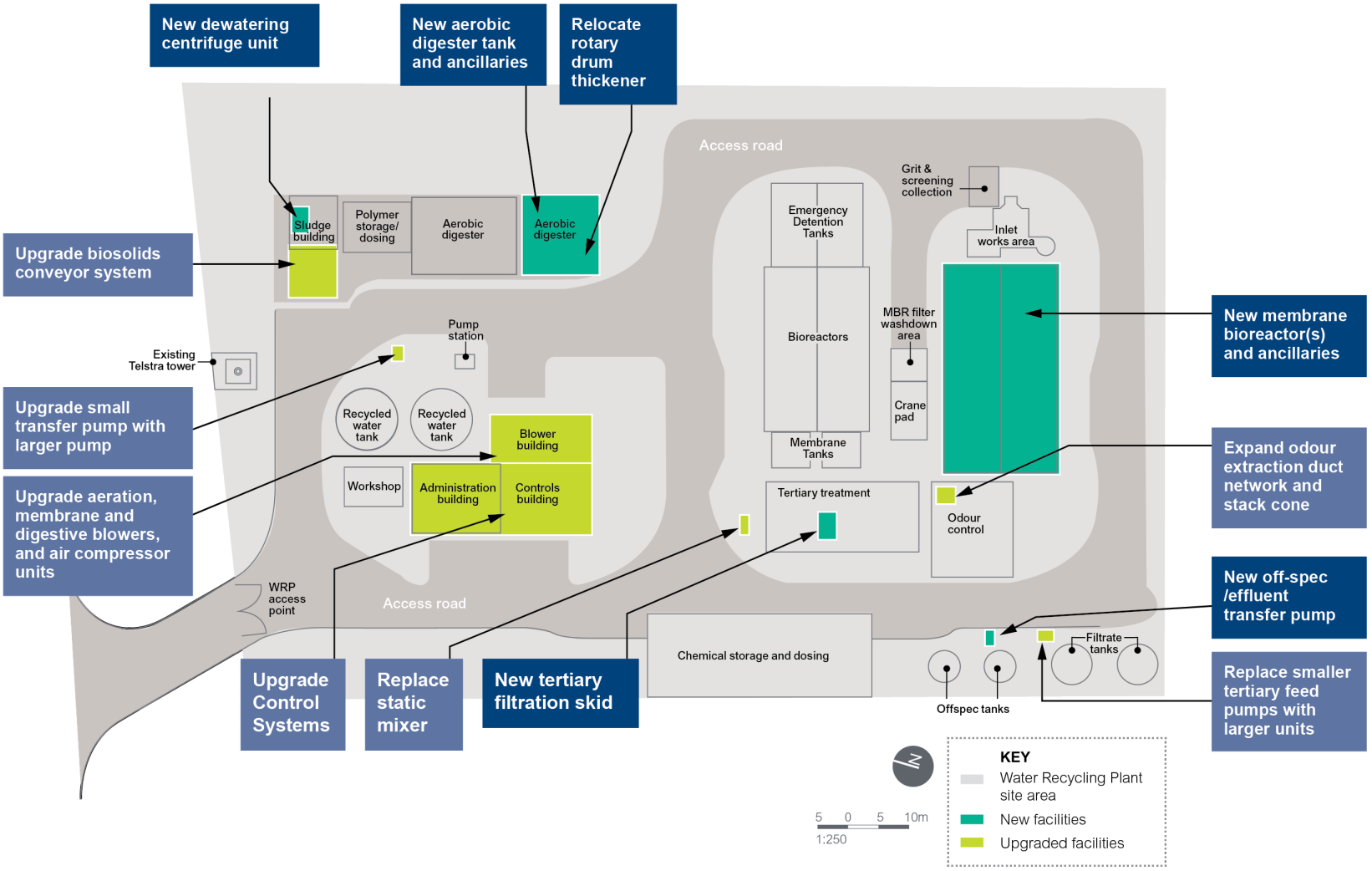
The location of proposed Stage D work sites is included as **Enclosure 3.**

Should you have any further questions or comments please don't hesitate to contact myself or Belinda Bock on 02 8099 3200 or at Belinda.bock@rpsgroup.com.au. Agencies will again have the opportunity to comment on the proposed works once the environmental assessment has been placed on public display.

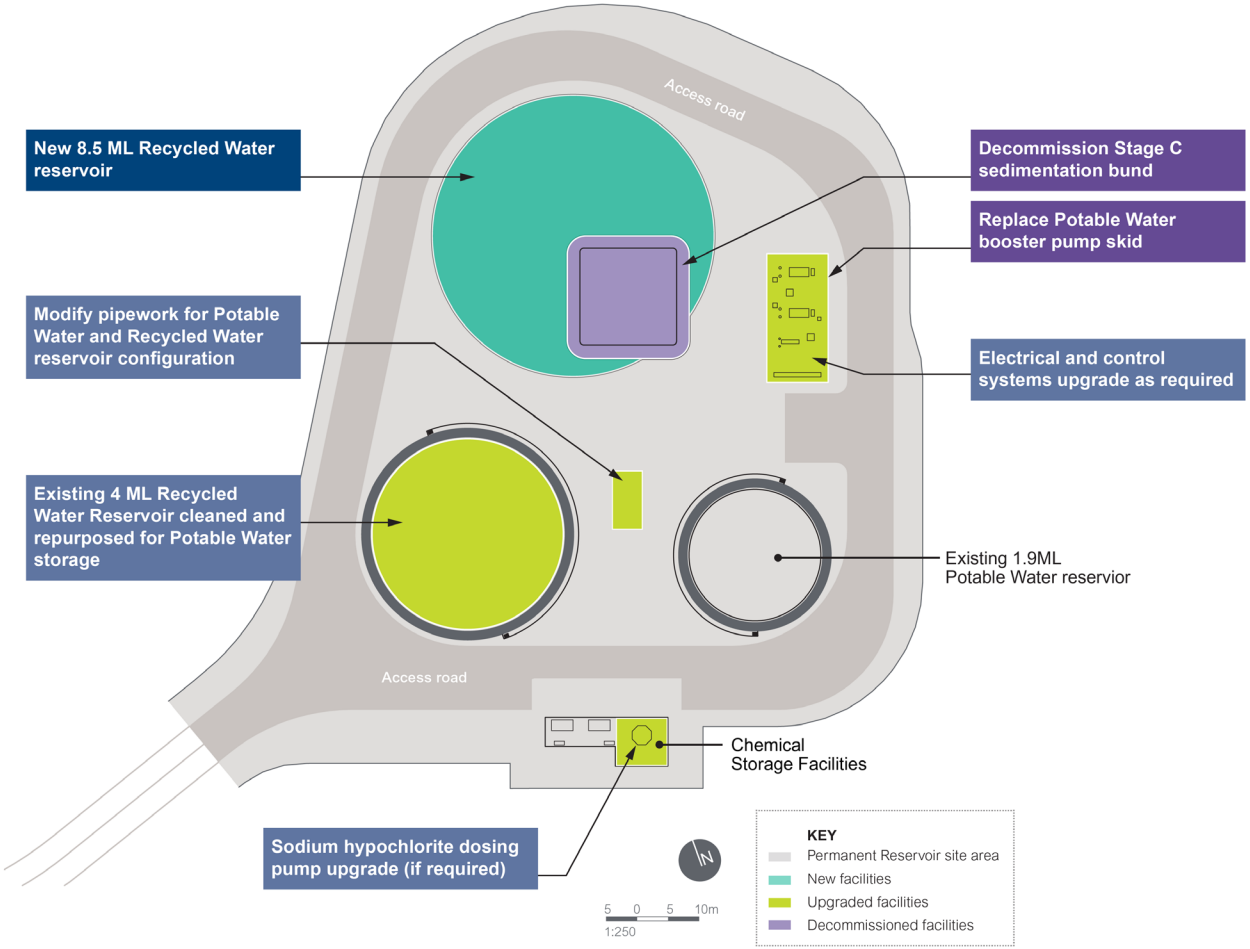
Yours faithfully,

Craig Harris
Assistant Project Director
Googong Township Pty Ltd

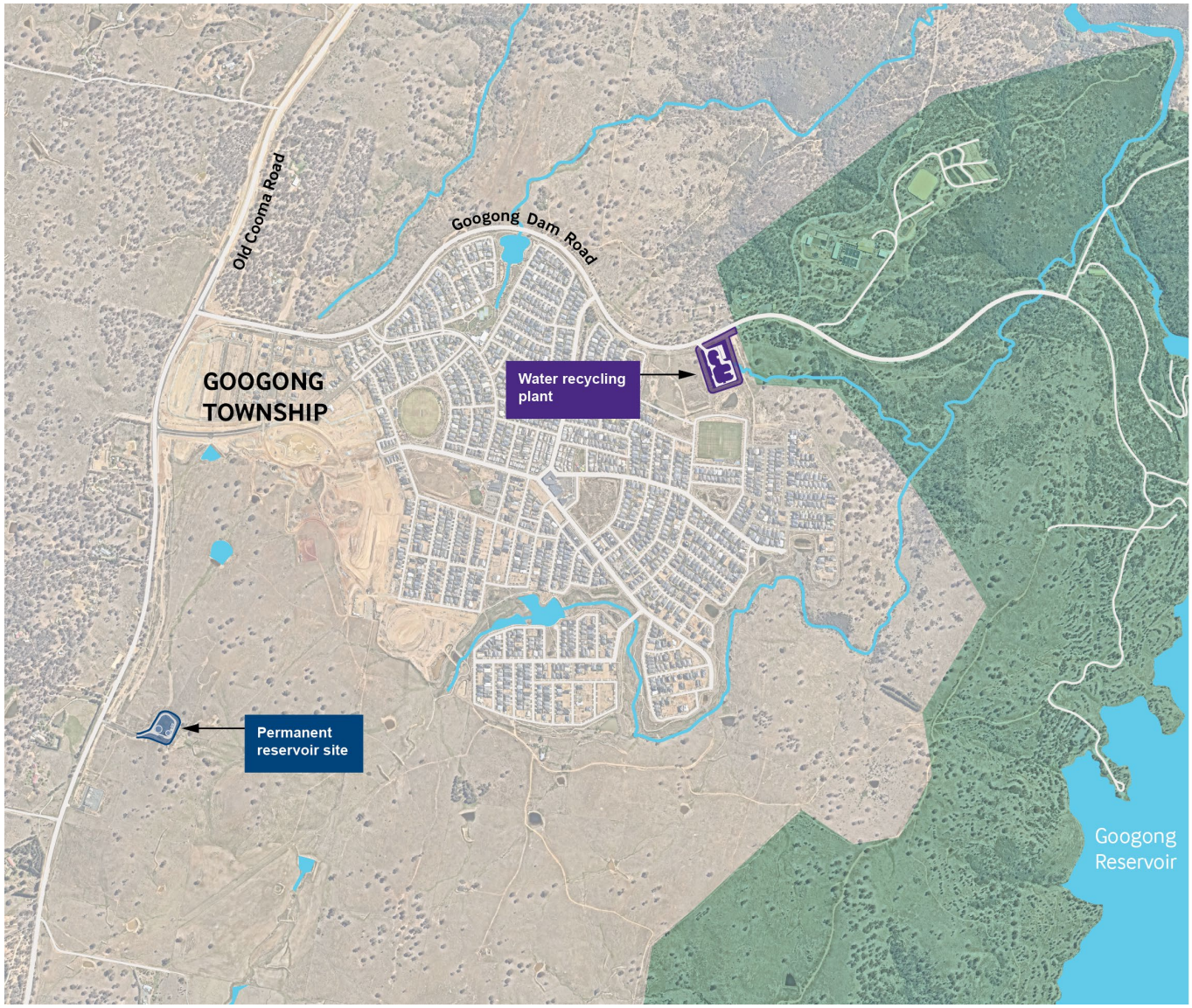
Enclosure 1: Proposed Stage D WRP upgrade works



Enclosure 2: Proposed Stage D Hill 800 upgrade works



Enclosure 3: Location of proposed Stage D work sites



Key

Waterways

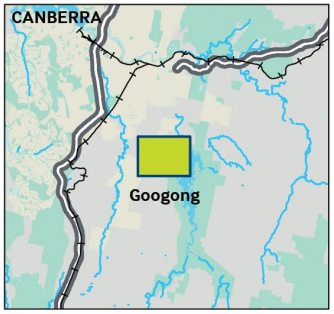
Googong Foreshores

N

0 500 1000m

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

LOCATION



Appendix L Community consultation

Googong Integrated Water Cycle Project – invitation to comment on the Stage D expansion works, 2 April 2020

We are inviting you to comment on the next component (Stage D) of Googong's Integrated Water Cycle project.

Googong's Integrated Water Cycle system delivers recycled water to every home in the township for toilet flushing and garden watering, as well as providing irrigation for parks and open spaces.

Our aim is to reduce potable water consumption by over 60% compared to a typical development.

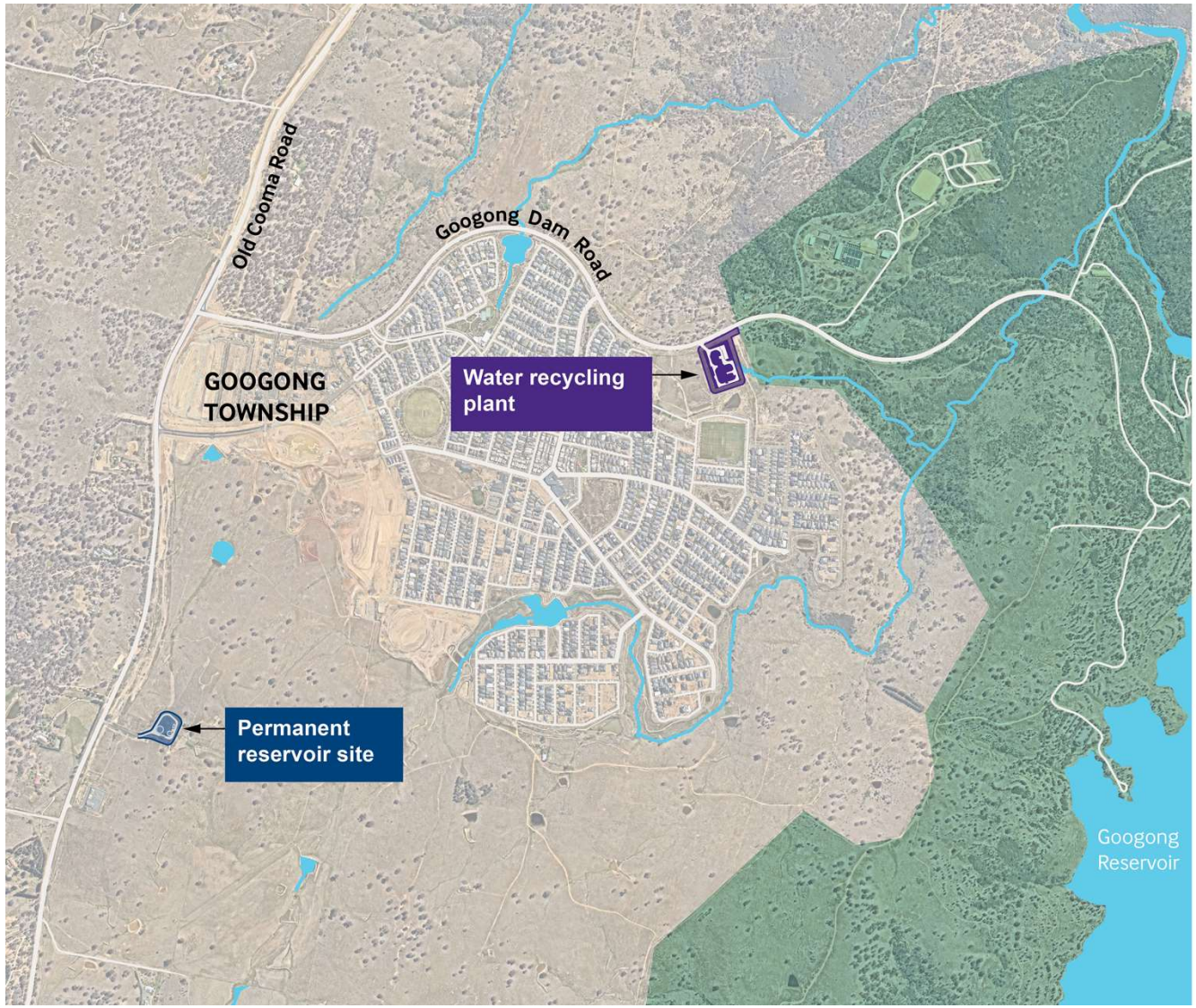
This is another step towards a more sustainable and low environmental impact Googong community.

About the project

The Integrated Water Cycle project has been planned in four stages (A, B, C and D) to progressively support Googong's development as the township grows to its full population.

Stages A, B and C of the project are complete and have been handed over to Queanbeyan-Palerang Regional Council for operation. We are now starting the planning and approvals for Stage D, which includes the preparation of a Review of Environmental Factors.

The proposed works for Stage D include an upgrade of the existing water cycle recycling plant located on Googong Dam Road and installation of a new concrete reservoir tank to hold the recycled water at the existing site on Old Cooma Road. You can see the site locations on the diagram below.



Key

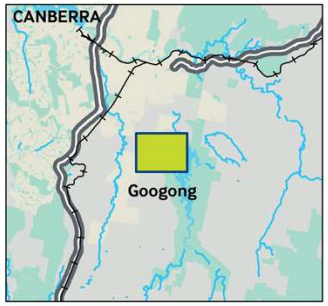
- Waterways
- Googong Foreshores

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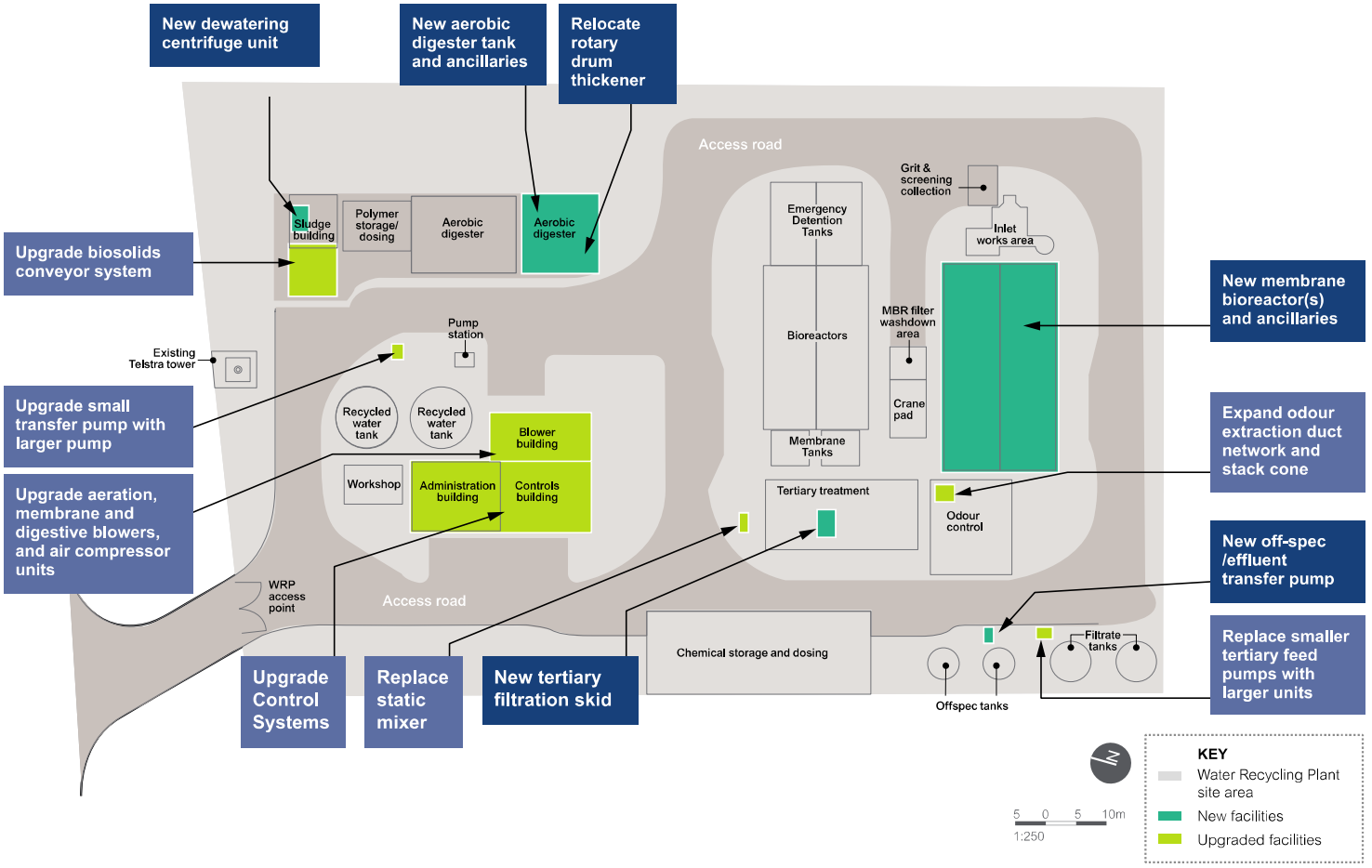
LOCATION



Stage D Water Recycling Plant – proposed works

Stage D for the water recycling plant includes the installation of infrastructure that will double the existing plant's capacity to eventually service the entire township – enough for all future Googonians.

The diagram below shows the scope of the proposed upgrade to the integrated water cycle plant.

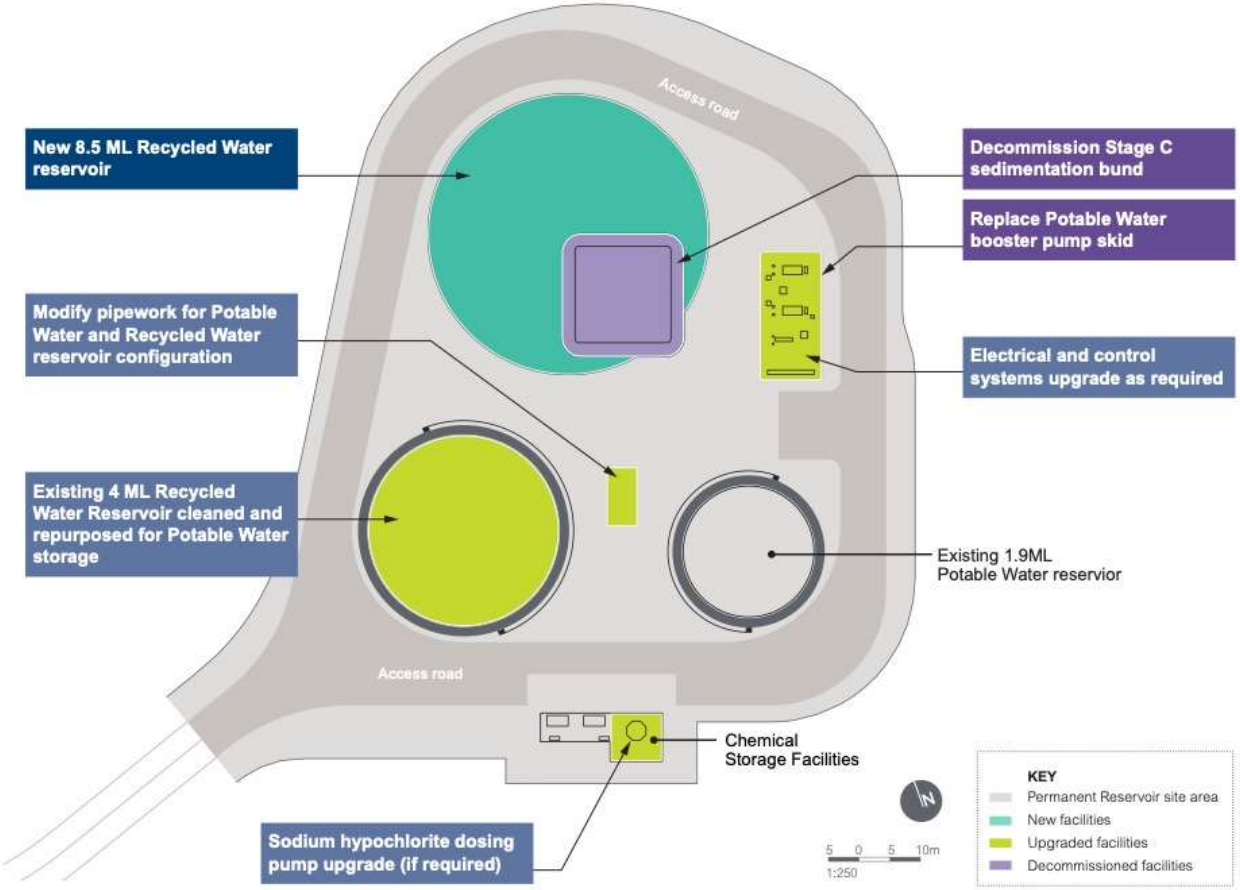


Stage D Reservoir Tank – proposed works

The Stage D works on the reservoir tank will take place at the existing site at Nangi Pimble (also called Hill 800) on Old Cooma Road.

The proposed works include the construction of a new recycled water reservoir and repurposing the existing recycled water reservoir for potable water storage.

The diagram below shows the scope of the proposed reservoir tank works.



Review of Environmental Factors

A Review of Environmental Factors is an environmental assessment that examines the significance of likely environmental impacts of a proposal and any measures needed to mitigate adverse impacts to the environment.

We are now starting the planning and approvals for Stage D of Googong's Integrated Water Cycle project, which includes the preparation of a Review of Environmental Factors.

We would like to hear any comments you have on what should be included in the Review of Environmental Factors, before Queanbeyan-Palerang Regional Council publicly exhibits the document.

We expect Council to put the draft Review of Environmental Factors on public exhibition in the second half of this year.

Approval process

The approval for the Stage D works, including the exhibition of the Review of Environmental Factors, will be undertaken under Part 5 of the *Environmental Planning & Assessment Act 1979* by Queanbeyan-Palerang Regional Council, who will own and operate the project following construction and commissioning.

Timing

The timing for Stage D construction will be confirmed as development of the Googong township progresses. We currently expect that construction will be completed before the end of 2024.

For more information or to make a comment

For more information or to make a comment about what you think should be included in the Review of Environmental Factors for Stage D of Googong's Integrated Water Cycle Project, please:

Email enquiries@googong.net

Or call 0403 297 222

You can also post your comments to:
Googong Integrated Water Cycle Project REF
PO Box 1000
Civic Square ACT 2608

Please submit your comments by 17 April 2020.