Centennial Coal

Centennial Mandalong Pty Limited

Mandalong Mine
Water Management Plan

December 2019

DOCUMENT CONTROL

DOCUMENT DETAILS	Name	Mandalong Mine: Water Management Plan
	Author	Tess Davies and Lachlan Hammersley (GHD Pty Ltd)
	Revision	5
	Document status	Final

	Revision	Trigger	Date	Brief details of change
DETAILS OF CHANGE	0		22/11/2016	Original water management plan
	1		05/05/2017	Revised to include site-specific guideline values for surface water quality in Morans Creek
	2		17/11/2017	Revised to make the water management plan consistent with relevant extraction plans, particularly with regard to watercourse stability and flooding
	3		13/06/2018	Revised following an uncontrolled discharge event at the Mandalong South Surface Site to include water management measures to minimise the risk of future incidents at the site
	4	SSD-5144 Mod 6	12/08/2019	Revised following approval for Modification 6 to development consent SSD-5144 allowing for controlled discharges from the Sediment Dam at the Mandalong South Surface Site
	5		19/12/2019	Revised to account for changes in water management activities at Mandalong Mine Access Surface Site and Mandalong South Surface Site

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Glossary

Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of calcium carbonate ($CaCO_3$).
Alluvial	Deposition from running waters.
Ambient	Pertaining to the surrounding environment or prevailing conditions.
Annual exceedance probability	The probability of a flood event occurring in any year, e.g. a large flood which may be calculated to have a 1% chance to occur in any one year is described as having a 1% annual exceedance probability.
Aquifer	An underground layer of permeable material from which groundwater can be usefully extracted.
Australian Height Datum	A common national surface level datum approximately corresponding to sea level
Average recurrence interval	A statistical estimate of the average period in years between the occurrence of a flood of a given size or larger, e.g. floods with a discharge equivalent to the 1 in 100 year average recurrence interval flood event will occur on average once every 100 years.
Baseflow	The component of flow in a watercourse that is driven from the discharge of underground water.
Baseline monitoring	Monitoring conducted over time to collect a body of information to define specific characteristics of an area (e.g. species occurrence or water quality) prior to the commencement of a specific activity.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular location.
Clean water	Water that has not come into physical contact with coal or mined carbonaceous material.
Dewatering	The removal or pumping of water from an above or below ground storage, including the mine water within the water collection system of mine workings. Water removed from mine workings is regarded as dewatering unless the workings are flooded and at equilibrium with the surrounding strata (in which case the removal is considered groundwater extraction).
Dirty water	Water that has an elevated sediment load.
Discharge	The quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Electrical conductivity	A measure of the concentration of dissolved salts in water.

Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Floodplain	Area of land that is periodically inundated by floods up to the probable maximum flood event.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report relates to the form and structure of waterways.
Goaf	The part of a mine from which the mineral has been partially or wholly removed, including the waste left in workings.
Groundwater	Water occurring naturally below ground level.
Groundwater extraction	For the purposes of this plan, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.
Guideline value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. They indicate a risk of impact if exceeded and should ‘trigger’ action to conduct further investigations or to implement management or remedial processes.
Hardness	The concentration of multivalent cations present in water. Generally, hardness is a measure of the concentration of calcium and magnesium ions in water and is expressed in units of calcium carbonate ($CaCO_3$) equivalent. Hardness may influence the toxicity and bioavailability of substances in water.
Ion	Electrically charged atom.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated within the site Environmental Protection License.
Macroinvertebrate	An animal species that does not develop a vertebral column that is large enough to be seen without the use of a microscope. These animals generally include insects, crustaceans, molluscs, arachnids and annelids.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.

Potable water	Water of a quality suitable for drinking.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Run of mine	Raw coal production (unprocessed).
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology related to the branching of streams.
Subsidence	The vertical difference between the pre-mining surface level and the post-mining surface level at a point.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Total Kjeldahl nitrogen	The sum of the concentrations of organic nitrogen, ammonia (NH_3) and ammonium (NH_4^+) in water.
Total nitrogen	A measure of organic and inorganic nitrogen forms in water. The sum of concentrations of total kjeldahl nitrogen and nitrate + nitrite.
Total phosphorus	A measure of organic and inorganic phosphorus forms in particulate and soluble forms.
Total suspended solids	A measure of the filterable matter suspended in water.
Toxicity	The inherent potential or capacity of a substance to cause adverse effects in a living organism.
Tributary	A stream or river that flows into a main river or lake.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

Abbreviations

AEP	Annual exceedance probability
AHD	Australian Height Datum
ARI	Average recurrence interval
AUSRIVAS	Australian Rivers Assessment System
BOD	Biochemical oxygen demand
BOM	Bureau of Meteorology
c/t	Cut through
CEMP	Construction environmental management plan
Centennial	Centennial Coal Company Pty Limited
Centennial Mandalong	Centennial Mandalong Pty Limited
CES	Cooranbong Entry Site
CRD	Cumulative rainfall departure
DES	Delta Entry Site
DGV	Default guideline value
DPIE	Department of Planning, Industry and Environment
DPI Water	Department of Primary Industries – Water
EC	Electrical conductivity
EIS	Environmental impact statement
EPA	Environment Protection Authority
EPL	Environment protection licence
GDE	Groundwater dependent ecosystem
GPT	Gross pollutant trap
ha	Hectare
HARTT	Hydrograph Analysis: Rainfall and Time Trends
HWC	Hunter Water Corporation
km	Kilometre
kV	Kilovolt
L/s	Litre per second

LDP	Licensed discharge point
LOR	Limit of reporting
m	Metre
m/year	Metre per year
m^3/s	Cubic metre per second
mg/L	Milligram per litre
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
mm/day	Millimetre per day
MMAS	Mandalong Mine Access Site
MSSS	Mandalong South Surface Site
Mtpa	Million tonnes per annum
NTU	Nephelometric turbidity unit
PIRMP	Pollution Incident Response Management Plan
RCE	Riparian, channel and environment
ROM	Run of mine
SILO	Scientific Information for Land Owners
SSGV	Site-specific guideline value
TARP	Trigger action response plan
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TSS	Total suspended solids
WMP	Water management plan
µS/cm	Microsiemens per centimetre

1. Introduction

Mandalong Mine is an underground coal mine located approximately 35 km south-west of Newcastle on the western side of Lake Macquarie. Centennial Mandalong Pty Limited (Centennial Mandalong) acquired Mandalong Mine in 2002, with mining operations commencing in 2005. Mandalong Mine consists of underground mine workings and surface facilities located at three sites: Mandalong Mine Access Site (MMAS), Mandalong South Surface Site (MSSS) and Delta Entry Site (DES). The location of the surface sites and the Mandalong Mine Holding Boundary are shown in Figure 1-1.

This site-specific Water Management Plan (WMP) has been prepared for Mandalong Mine as part of the *Northern Operations: Regional Water Management Plan* that encompasses the northern coal operations owned by Centennial Coal Company Limited (Centennial). These management plans apply to all operations at Mandalong Mine and include the existing and approved mining operations and associated infrastructure within the site boundary, which encompasses the mining leases of ML1443, ML1543, ML1553, ML1722 and ML1744. The WMP will be progressively developed as water management requirements change over time.

In accordance with the conditions of development consent SSD-5144 for Mandalong Mine, this WMP has been prepared by Tess Davies and Lachlan Hammersley and reviewed by Dr Stuart Gray of GHD Pty Ltd in consultation with Centennial Mandalong.

The WMP was provided to the NSW Environment Protection Authority (EPA), the former NSW Department of Primary Industries – NSW Fisheries and the former NSW Department of Primary Industries – Water (DPI Water) for consultation on 23 February 2016. Responses were received from the EPA on 2 March 2016 and DPI Water on 21 March 2016. Consultation with the regulators is provided in Appendix A. The consultation comments are provided in Appendix B, along with where these comments have been addressed in the WMP.

1.1 Overview of site operations

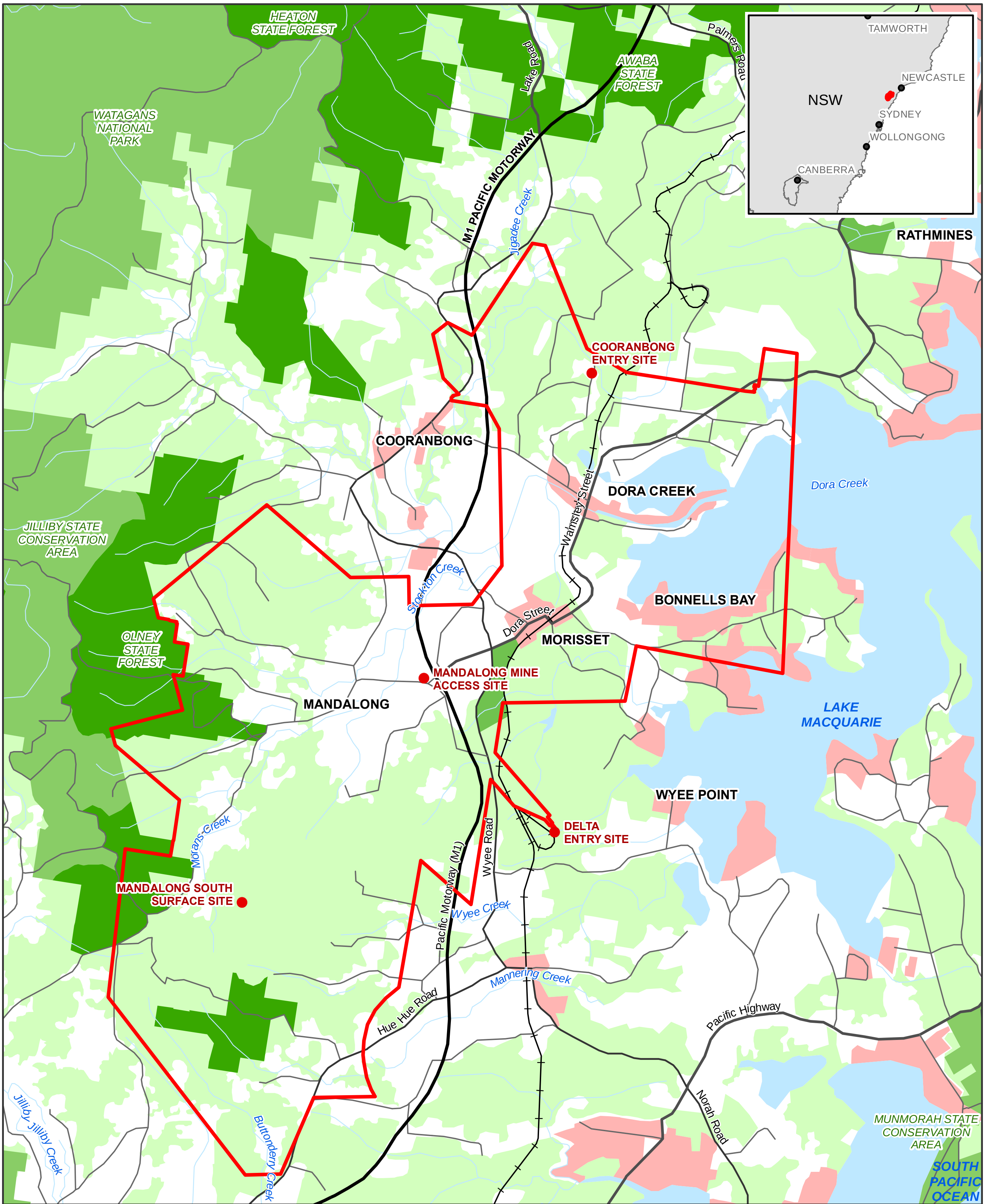
1.1.1 Site features

Mandalong Mine Access Site

The MMAS includes a decline tunnel, administration building and bathhouse, carpark, mechanical workshop and store, two mine ventilation fans, diesel refuelling station, hydrocarbon storage shed, equipment and materials storage areas, gas drainage, machinery washdown bay, fire-fighting and emergency equipment store, compressor shed, core shed, tube bundle shed, electrical sub-station and solsenic mixing plant. The site has existing connections to the Hunter Water Corporation (HWC) reticulated potable water and sewer systems. The site surface features associated with MMAS are provided in Figure 1-2.

Mandalong South Surface Site

The MSSS is located off Mandalong Road above the Mandalong Mine main headings. Construction of the MSSS commenced in 2017. The site will include a 4.5 m diameter downcast ventilation shaft and a 5.5 m diameter upcast shaft, with surface fans installed at the upcast mine shaft. Service boreholes will also be installed at the site to transfer materials and mine water as required, along with numerous other items of surface infrastructure required to service the mining operation. An access road has been constructed from Mandalong Road to the site. The proposed site surface features associated with MSSS are provided in Figure 1-3.



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0 475 950 1,900 2,850 3,800

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Existing rail
- Motorway
- Principal road
- Secondary road
- Minor road
- Watercourse
- Watercourse area
- Built up area
- Recreation areas
- Nature conservation
- State forest
- Forest or shrub

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	KS
CHECKED	TT
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Site Locality Plan

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 1-1

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP001_LocalityPlan_0.mxd

© Centennial: Boundary / mine Workings; Commonwealth of Australia (Geoscience Australia): 250K Topographic data Series 3 2006; LPMA - DCDB - 2007, DCDB - 2006; GSS: Aerial

LEGEND

- LDP
- Surface water storage

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	SM
CHECKED	TT
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Site features
Mandalong Mine Access Site

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 1-2

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP011_MandalongMineAccess_SiteFeatures_0.mxd

© LPMA - DTDB - 2007 ; Centennial: Site Layout ;

1:1,500 for A4

0 5 10 20 30 40

Metres

N

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

Site infrastructure

Surface water storage

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	TT
CHECKED	SG
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Site features
Mandalong South Surface Site

Centennial Coal
Mandalong

DATE 09 Aug 2019

Figure 1-3

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP008_MSSSite_SiteFeatures_0.mxd

© Centennial: Boundary; Commonwealth of Australia (Geoscience Australia): 250K Topographic data Series 3 2006

LPMA - DCDB - 2007, DCDB - 2006; Nearmap: Imagery, 20180715

Delta Entry Site

The DES is located on the eastern side of the M1 Motorway approximately 2.5 km north of Wyee. It comprises the Mandalong Coal Delivery System, which links the underground workings of Mandalong Mine to the Wyee coal unloader by an underground tunnel. The site includes a conveyor drift, coal transfer building and coal sizing unit. Coal is transferred from the DES to Vales Point Power Station via an overland conveyor. The site has existing connections to the HWC reticulated potable water and sewer systems. The site surface features associated with DES are provided in Figure 1-4.

1.1.2 Coal production

Mandalong Mine currently has approval to extract up to 6.5 million tonnes per annum (Mtpa) of run of mine (ROM) coal from the West Wallarah Seam utilising longwall and bord and pillar methods. ROM coal is supplied directly to the Cooranbong Entry Site (CES; part of Northern Coal Services) and the DES by an underground conveyor (termed the Mandalong Coal Delivery System). Transfer rates to the CES and DES are each up to 6 Mtpa of ROM coal.

LEGEND

- Railway
- Roads
- Surface water storage

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	SM
CHECKED	TT
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Site features
Delta Entry Site

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 1-4

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP012_DeltaAccessSite_SiteFeatures_0.mxd

1.1.3 History

A summary of the history of Mandalong Mine operations is provided in Table 1-1.

Table 1-1 History of Mandalong Mine

Date	History
1998	Original approval for Mandalong Mine (then known as Cooranbong Colliery Extension) granted.
1999	WMP first prepared.
2002	Mandalong Mine was acquired by Centennial Mandalong.
2005	Mining operations commenced at Mandalong Mine.
2006	Coal supply to Vales Point Power Station commenced.
2013	Environmental Impact Statement (EIS) for Mandalong Southern Extension Project was submitted.
2013	Construction of VAM-RAB (methane abatement) trial facility completed.
2013-2015	Significant modifications to water management system at CES completed.
October 2014	WMP was revised.
October 2015	Mandalong Southern Extension Project was approved (development consent SSD-5144).
June 2016	Modification 1 to development consent SSD-5144 was approved to relocate transmission line TL24.
September 2016	Modification 2 to development consent SSD-5144 was approved to extend the development of first workings for longwall panels 22 and 23.
November 2016	Modification 3 to development consent SSD-5144 was approved to increase the annual production limit from 6 Mtpa to 6.5 Mtpa.
March 2017	Modification 4 to development consent SSD-5144 was approved to extend longwall panels 22 and 23.
August 2017	Modification 5 to development consent SSD-5144 was approved to extend longwall panel 24 and add longwall panel 24A.
April 2019	Modification 6 to development consent SSD-5144 was approved for controlled discharge of water from the Sediment Dam at the MSSS.
July 2019	Modification 7 to development consent SSD-5144 was approved for a 33 kV powerline from the MMAS to the MSSS.

1.2 Approvals and licensing requirements

1.2.1 Development consent

The WMP addresses specific water components of the conditions of development consent SSD-5144, which was granted by the Planning and Assessment Commission on 12 October 2015 for the Mandalong Southern Extension Project. Development consent SSD-5144 has had seven modifications since October 2015 to relocate a transmission line (Modification 1), extend development of first workings for two longwall panels (Modification 2), increase the annual production limit (Modification 3), extend two longwall panels (Modification 4), extend a longwall panel and add a longwall (Modification 5), to undertake controlled discharges from the Sediment Dam (Modification 6) and for the construction of a 33 kV powerline from the MMAS to the MSSS (Modification 7).

Operations at the DES are currently regulated by two development consents. Development consent DA 35-2-2004 is held by Centennial Mandalong for the transportation of coal to the DES via the underground Mandalong Coal Delivery System. Development consent DA 2501/2004 is held by Delta Electricity for the Wyee Coal Handling Plant at the DES.

The relevant requirements of the WMP specified by development consent SSD-5144 are outlined in Table 1-2, along with the sections of the plan where these have been addressed.

Table 1-2 Development consent SSD-5144 conditions

Condition		Where addressed
Water Supply		
Schedule 3 12.	The Applicant must ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of mining operations to match its available water supply. *Note: Under the Water Act 1912 and/or the Water Management Act 2000, the Applicant is required to obtain the necessary water licences for the development.*	Section 1.2.4 Section 3.5.1
Water Pollution		
Schedule 3 13.	Unless an EPL [environment protection licence] authorises otherwise, the Applicant must comply with Section 120 of the POEO Act [*Protection of the Environment Operations Act 1997*].	Section 1.2.3
Schedule 3 14.	The Applicant must implement all reasonable and feasible measures to reduce water pollution associated with the discharge of surface water or mine-water (particularly salinity and dissolved or suspended metals associated with groundwater pumped from underground mine workings) required to comply with any EPL applying to the development.	*Northern Operations: Discharge Management Plan* *Northern Coal Services: Water Management Plan*
Water Management Performance Measures		
Schedule 3 16.	The Applicant must comply with the performance measures in Table 4 [Water Management Performance Measures], to the satisfaction of the Secretary.	Table 1-3

Condition		Where addressed
Water Management Plan		
Schedule 3 17.	The Applicant must prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must:	
Schedule 3 17. (a)	Be prepared in consultation with DPIE Water [Department of Planning, Industry and Environment – Water] and the EPA, by suitably qualified and experienced persons whose appointment has been approved by the Secretary;	Appendix A Appendix B
Schedule 3 17. (b)	Be submitted to the Secretary for approval prior to commencement of construction of the MSSS, or by 31 March 2016, whichever is sooner;	Appendix A
Schedule 3 17. (c)	Include detailed performance criteria and describe measures to ensure that the Applicant complies with the Water Management Performance Measures in Table 4;	Section 6.2 Table 1-3
Schedule 3 17. (d)	Include the following, in addition to the standard requirements for management plans (see condition 2 of Schedule 6):	
Schedule 3 17. (d) (i)	A <u>Site Water Balance</u>, that includes details of:	
	Water use and management on site;	Section 3.2 Section 3.3 Section 3.4
	Any off-site water discharges;	Section 1.2.3 Section 3.2 Section 3.5
	Reporting procedures, including the preparation of a site water balance for each calendar year of the development; and	Section 7.5 *Northern Operations: Regional Water Management Plan*
	Investigates and implements all reasonable and feasible measures to minimise potable water use and to recycle water;	Section 3.5.1
Schedule 3 17. (d) (ii)	A <u>Surface Water Management Plan</u>, that includes:	
	Detailed baseline data on water flows and quality in the watercourses that could be affected by the development;	Section 5.1

	Condition	Where addressed
	A detailed description of the development's water management systems, including the: - Clean water diversion systems; - Erosion and sediment controls; - Measures applying reasonable endeavours to reuse water held in the MSSS Sediment Dam, such as through the use of irrigation and/or evaporation, prior to discharge under condition 17A of this Schedule; and - Minewater management systems;	Section 3.2 Section 3.3 *Northern Operations: Regional Water Management Plan*
	Detailed performance criteria, including trigger levels, for investigating any potentially adverse impacts associated with: - The water management systems; - Downstream surface water quality; - Downstream watercourse channel stability; - Stream and riparian vegetation health; and - Downstream flooding impacts;	Section 6.1 Section 6.2 *Northern Operations: Regional Water Management Plan*
	A program to monitor and report on: - The effectiveness of the water management systems; - Surface water flows and water quality, and the condition of stream and riparian vegetation in the watercourses on site and downstream of the site; - Macroinvertebrate health and ecotoxicity parameters downstream of mine-water discharges; and - Downstream flooding impacts;	Section 5 *Northern Operations: Regional Water Management Plan* *Northern Operations: Discharge Management Plan*
	Reporting procedures for the results of the monitoring program;	*Northern Operations: Regional Water Management Plan*
	A plan to respond to any exceedances of the performance criteria, and mitigate any adverse surface water impacts of the development.	Section 6.3 Appendix G
	The Applicant must implement the approved management plan as approved from time to time by the Secretary.	
Temporary Discharge of Water at MSSS		
Schedule 3 17A.	The Applicant may discharge collected surface water from the MSSS Sediment Dam via Licenced Discharge Point LDP004 (EPL 365) until 30 June 2021. Any such discharge must be in accordance with conditions 14 and 17 of this Schedule.	Section 3.2.2

Condition		Where addressed
Management Plan Requirements		
Schedule 6 2.	The Applicant must ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include:	
Schedule 6 2. (a)	Detailed baseline data;	Section 5
Schedule 6 2. (b)	A description of: - The relevant statutory requirements (including any relevant approval, licence or lease conditions); - Any relevant limits or performance measures/criteria; and - The specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development of any management measures;	Section 1.2 Section 6.1 Section 6.2 *Northern Operations: Regional Water Management Plan*
Schedule 6 2. (c)	A description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Section 3.2 Section 3.3 *Northern Operations: Regional Water Management Plan*
Schedule 6 2. (d)	A program to monitor and report on the: - Impacts and environmental performance of the development; and - Effectiveness of any management measures.	*Northern Operations: Regional Water Management Plan*
Schedule 6 2. (e)	A contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 6.3 Appendix G
Schedule 6 2. (f)	A program to investigate and implement ways to improve the environmental performance of the development over time;	*Northern Operations: Regional Water Management Plan*
Schedule 6 2. (g)	A protocol for managing and reporting any: - Incidents; - Complaints; - Non-compliances with statutory requirements; and - Exceedances of the impact assessment criteria and/or performance criteria; and	*Northern Operations: Regional Water Management Plan*

Condition		Where addressed
Schedule 6 2. (h)	A protocol for periodic review of the plan.	*Northern Operations: Regional Water Management Plan*

The water management performance measures specified by development consent SSD-5144 (Table 4: Water Management Performance Measures) are presented in Table 1-3, along with the sections of the WMP where these have been addressed.

Table 1-3 Water management performance measures specified by SSD-5144

Feature	Performance measure	Where addressed
Potable water	Minimise the use of potable water from the public supply for purposes where non-potable water is acceptable.	Section 6.2.1
MMAS MSSS	Design, install and maintain erosion and sediment controls generally in accordance with the series *Managing Urban Stormwater: Soils and Construction* including *Volume 1*, *Volume 2A – Installation of Services* and *Volume 2C – Unsealed Roads*.	Section 6.2.1
	Design, install and maintain any infrastructure within 40 m of watercourses generally in accordance with the *Guidelines for Controlled Activities on Waterfront Land* (DPI 2007), or the latest version.	Section 6.2.2
	Design, install and maintain creek crossings generally in accordance with the *Policy and Guidelines for Fish Friendly Waterway Crossings* (DPI Fisheries 2003) and *Why Do Fish Need To Cross The Road? Fish Passage Requirements for Waterway Crossings* (DPI Fisheries 2003), or the latest versions.	Section 6.2.2
Sediment dams	Maintain dams generally in accordance with the series *Managing Urban Stormwater: Soils and Construction – Volume 1* and *Volume 2E – Mines and Quarries*.	Section 6.2.1
Clean water diversions	Design, install and maintain new clean water diversion structures to convey the 100 year ARI [average recurrence interval] flood.	Section 6.2.1
	Maximise as far as reasonable and feasible the diversion of clean water around disturbed areas on site.	Section 6.2.1

Feature	Performance measure	Where addressed
Mine water storages	Design, install and maintain mine water storage infrastructure to ensure no unlicensed or uncontrolled discharge of mine water off-site.	No mine water storages exist at MMAS, MSSS or DES.
Aquatic and riparian ecosystems (including affected sections of unnamed watercourses receiving discharges from the CES, Muddy Creek and Muddy Lake)	Maintain or improve baseline channel stability.	These measures are specific to the management of the CES and is covered in *Northern Coal Services: Water Management Plan*
	Develop site-specific in-stream water quality and aquatic ecology (macroinvertebrate health and ecotoxicity assessment) objectives and criteria in consultation with the EPA and in accordance with any EPL applying to the CES.	
Chemical and hydrocarbon storage	Chemical and hydrocarbon products to be stored in bunded areas in accordance with the relevant Australian Standards.	Section 6.2.1

1.2.2 Mandalong Southern Extension Project Statement of Commitments

In addition to the conditions of development consent SSD-5144 indicated in Table 1-2, Centennial Mandalong also committed to the management strategies and monitoring activities outlined in Table 1-4 as part of the Mandalong Southern Extension Project and subsequent modifications.

Table 1-4 Statement of commitments

Commitment	Where addressed
Environmental management and reporting	
Centennial Mandalong will include a process to review the groundwater, surface water and flood models as part of the Water Management Plan.	Section 7
Centennial will consult with NSW Fisheries in the development of the Water Management Plan.	Appendix A
Groundwater	
Centennial Mandalong will commit to implement “make good provisions” to any water supply work where the drawdown impacts exceed the 2 m criteria as specified by the NSW Aquifer Interference Policy.	Section 6.2.3 Appendix G
Each year, Centennial Mandalong will engage a specialist to undertake an analysis of alluvial groundwater levels to identify non-rainfall related trends.	Section 7.4
Surface water	
Centennial Mandalong will undertake any works within watercourses and on the floodplain in accordance with the *Guidelines for Controlled Activities on Waterfront Land* (2012).	Section 6.2.2

Commitment	Where addressed
Water management	
If the quality of mine water collected in the Borehole Dam is not suitable for discharge from the CES, the water will be pumped back underground for recirculation (additional filtration and sediment settlement) through the Cooranbong Colliery goaf storage area before returning to the Borehole Dam. The storage volume of the Borehole Dam at the CES will be increased to increase the settling capacity. In addition, baffles will be retrofitted in the Borehole Dam to provide increased residence time and a flocculent will be introduced. Aquatic macroinvertebrate monitoring and sediment sampling will be undertaken every six months (spring and autumn).	This commitment is specific to the management of water at the CES. *Northern Operations: Discharge Management Plan* *Northern Coal Services: Water Management Plan*
Modification 6	
Establish additional water quality monitoring locations (Sediment Dam and MCUS) and undertake water quality monitoring in accordance with Table 4 of the SEE [Statement of Environmental Effects].	Section 4.2.1 Section 4.4
Implement quarterly water quality and annual aquatic ecology monitoring in Morans Creek upstream and downstream of the confluence of the unnamed creek to assess any downstream impacts due to discharges.	Section 4.2.1 Section 4.5.2
Undertake weekly site inspections at MSSS and following 40 mm of rainfall in the preceding 24 hours to inspect the capacity, structural integrity and effectiveness of the Gross Pollutant Trap and Sediment Dam.	Section 4.1
Review and revise where necessary the site's Water Management Plan to reflect the outcomes of the modification.	Revision 4 to this WMP
Undertake six-monthly visual and photographic inspections of the unnamed creek on Centennial-owned land to assess for evidence of scouring. Implement appropriate mitigation measures should evidence of scouring be detected.	Section 4.5.1 Appendix G

1.2.3 Environment protection licence

Mandalong Mine currently holds EPL 365, with water currently licensed to be discharged through the following licensed discharge points (LDPs):

- LDP001 – Located at the CES, at the end of the discharge pipeline adjacent to an unnamed tributary of Muddy Lake. The pipeline receives mine water from the Borehole Dam or surface water from Sediment Dams 1 and 2.
- LDP002 – Located at the CES, at the outlet of the 5 ML Dam which discharges into the unnamed tributary of Muddy Lake.
- LDP003 – Located at the MMAS, at the outlet of the Sediment Control Dam which discharges into low-lying vegetation.
- LDP004 – Located at the MSSS, at the outlet of the Sediment Dam which discharges into an unnamed tributary of Morans Creek.

Both LDP001 and LDP002 at the CES are now associated with Northern Coal Services and management requirements are covered in the WMP for that site (refer to Section 1.4.4).

1.2.4 Groundwater bore licences

The *North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan* commenced on 1 July 2016 and regulates the interception and extraction of groundwater from the fractured and porous rock aquifer within the water sharing plan boundary, which includes Mandalong Mine.

Centennial Mandalong currently holds one water access licence (WAL 39767) to extract up to 1825 ML/year via the Cooranbong bore (water supply works approval 20WA218789) from the Cooranbong underground storage area into the Borehole Dam at the CES. The annual groundwater take from the fractured and porous rock groundwater sources via the Cooranbong bore is calculated annually and reported in the annual water balance review for Mandalong Mine.

A number of licences are held by Centennial Mandalong under the *Water Act 1912* for groundwater monitoring bores. The details of these bores are provided in Section 4.2.3.

1.3 Water Management Plan objectives

The WMP has been developed to address the legislative, approvals and licensing requirements presented in Section 1.2. The objectives of the WMP are:

- Collate and review existing information and studies relating to the operation of the water management system at Mandalong Mine.
- Establish an understanding of the water management system at the site.
- Categorise the existing conditions that are specific to water management requirements.
- Develop catchment plans for both the existing and the approved site layouts.
- Identify and maximise the separation of the clean, dirty and coal-contact water management systems.
- Undertake a review of the capacity of dirty and contaminate surface water storages in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008).
- Determine the suitability of flooding management and waterway conditions.
- Undertake a surface water quality assessment and review existing water quality assessment criteria.
- Minimise water discharges from the site by maximising, where practicable, opportunities for the reuse and recycling of water on site.
- Manage discharges to natural waterways in accordance with relevant EPL conditions or as agreed with the EPA.
- Determine the future water management requirements.
- Review and develop water monitoring requirements.

1.4 Relationship to other plans

Water management at Mandalong Mine is covered by three separate scales of management plan, which encompass a regional, site-specific and mine workings level. Water is managed regionally via the implementation of the *Northern Operations: Regional Water Management Plan* and at an operational-level via implementation of the site-specific WMP (this document). Development consent SSD-5144 requires an extraction plan for all second workings at Mandalong Mine, which must include a WMP.

Figure 1-5 presents the relationship between these plan types with respect to water management.

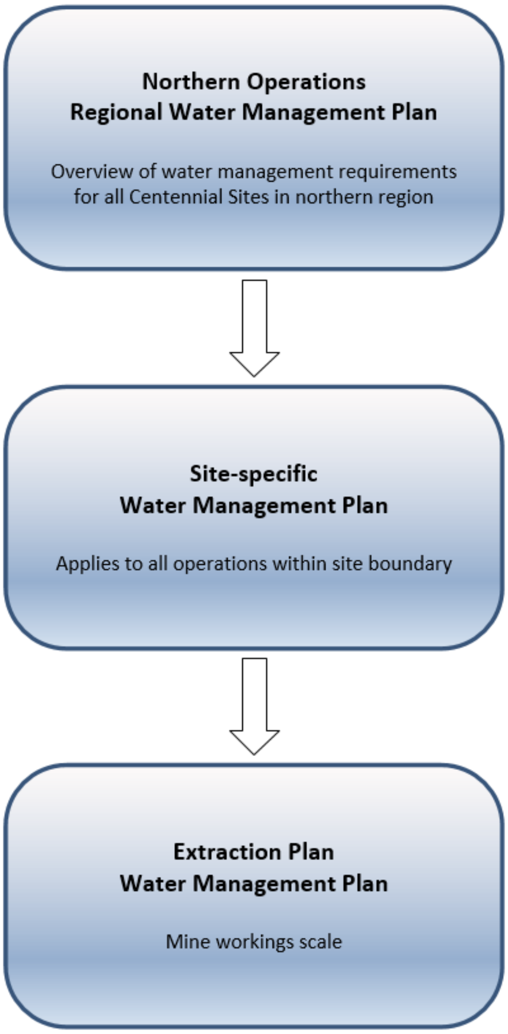


Figure 1-5 Water management plans at Mandalong Mine

1.4.1 Northern Operations: Regional Water Management Plan

The *Northern Operations: Regional Water Management Plan* has been developed to provide an overview of the water management requirements across Centennial sites within the Lake Macquarie catchment and to standardise the management of water. Site-specific WMPs, such as this plan, address specific development approval conditions and water management requirements for individual sites.

1.4.2 Northern Operations: Discharge Management Plan

The *Northern Operations: Discharge Management Plan* was prepared to outline the requirements for the control and management of mine water discharge from each of Centennial's northern operations. The management plan focuses primarily on the management of discharges of underground mine water from LDPs at Myuna Colliery and the CES and the Newstan Colliery Surface Site (both part of Northern Coal Services operations).

1.4.3 Extraction plans

Extraction plans are developed for all secondary workings of each longwall panel prior to mining. Generally, extraction plans describe the applicable regulatory framework, mine planning and management and monitoring measures to be implemented to ensure the protection of all surface/subsurface natural and built features and the protection of public safety during extraction. Each extraction plan for Mandalong Mine includes a WMP to manage potential subsidence-related impacts to water resources. A biodiversity management plan is also included as a sub-plan to each extraction plan.

1.4.4 Northern Coal Services: Water Management Plan

The *Northern Coal Services: Water Management Plan* was prepared to outline the requirements for water management at Northern Coal Services. This plan is part of the *Northern Operations: Regional Water Management Plan*. Northern Coal Services integrates the coal processing, handling and transport operations from Mandalong Mine and Newstan Colliery. Northern Coal Services utilises infrastructure at the CES and the Newstan Colliery Surface Site, along with private haul roads and rail loading infrastructure. Groundwater inflows into the underground workings at Mandalong Mine are managed by transfer to the Cooranbong underground storage, with water then transferred to the Borehole Dam at the CES prior to discharge via LDP001. All water management requirements associated with mine water discharges from the CES are detailed by the *Northern Coal Services: Water Management Plan*.

1.4.5 Mandalong Mine: Groundwater Monitoring and Modelling Plan

The *Mandalong Mine: Groundwater Monitoring and Modelling Plan* was developed for Exploration Lease 6317 to ensure that sufficient groundwater data exists so that the hydrogeological model adequately predicts impacts of mining on groundwater resources. The plan describes the existing hydrogeological environment of the area, the hydrogeological model and monitoring program.

2. Environment

2.1 Climate

2.1.1 Rainfall

Mandalong Mine has one site-based rainfall and weather station located at the CES, approximately 0.8 km north-west of the MMAS. Site-specific rainfall data has been collected on a daily basis since 2010. For assessments requiring a large historical set of rainfall data (i.e. greater than 50 years), patched point data is obtained from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Environment and Science. SILO patched point data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolation with nearby stations.

For this assessment, SILO data was obtained for the Cooranbong (Avondale) Station (BOM station number 61012), which is located approximately 2.4 km north of the site-specific weather station at CES. Figure 2-1 presents the historical SILO patched point daily rainfall data from the Cooranbong (Avondale) Station between 1889 and 2018 and site-based rainfall recorded between 2014 and 2018.

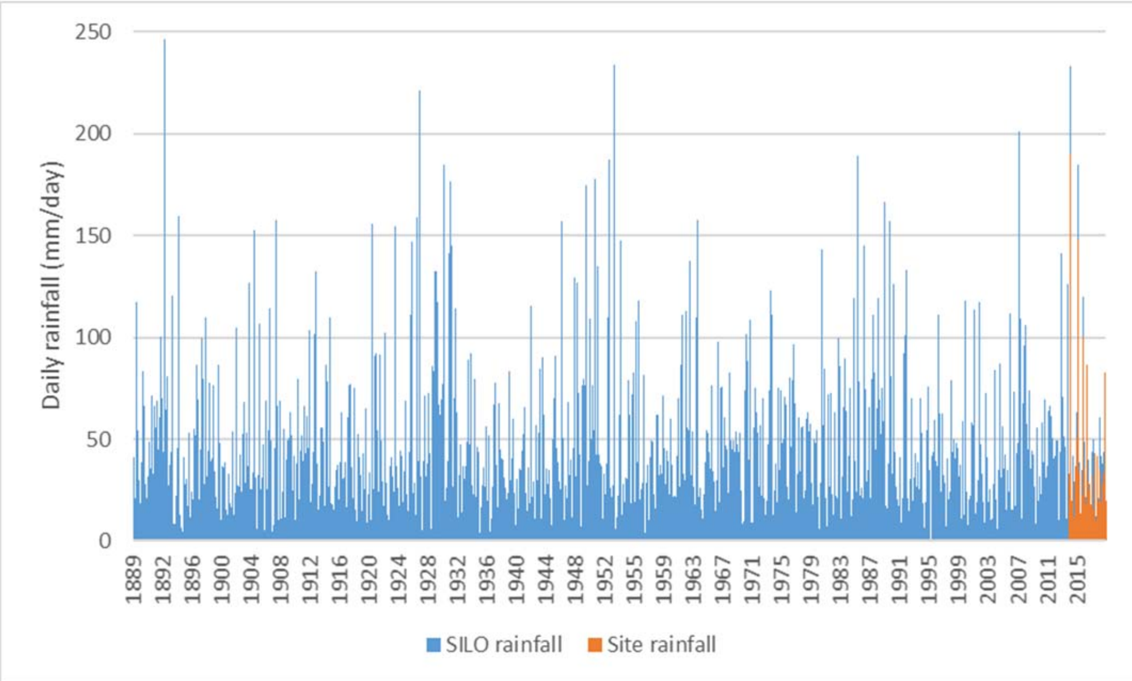


Figure 2-1 Historical daily rainfall at Cooranbong (Avondale) Station and Mandalong Mine

The annual statistics associated with the SILO patched point daily rainfall data from the Cooranbong (Avondale) Station presented in Figure 2-1 are:

- Minimum rainfall total – 531 mm in 1944.
- Average rainfall total – 1120 mm.
- Median rainfall total – 1070 mm.
- Maximum rainfall total – 1994 mm in 1950.

2.1.2 Evaporation

Evaporation estimates are not collected by Mandalong Mine. Evapotranspiration has been collected historically however no basis for this data has been detailed.

Information provided at the closest BOM station which records evaporation, Peats Ridge (Waratah Road) Station (station number 61351), was reviewed and average monthly evaporation rates were determined. The average daily evaporation rates are presented in Figure 2-2, based on 31 years of data from 1981 to 2012.

Total average annual evaporation is approximately 1172 mm, compared to the annual average rainfall total of approximately 1120 mm. This gives an annual deficit (difference between annual rainfall and annual evaporation) of approximately 52 mm.

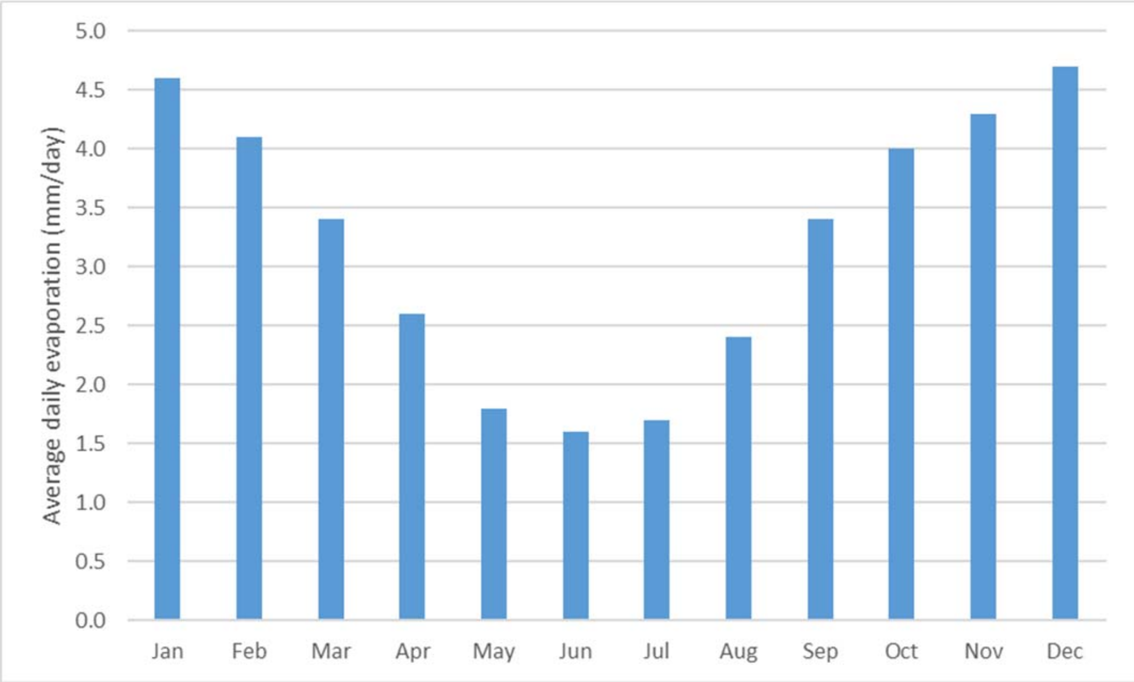


Figure 2-2 Average daily evaporation each month from Peats Ridge (Waratah Road) Station

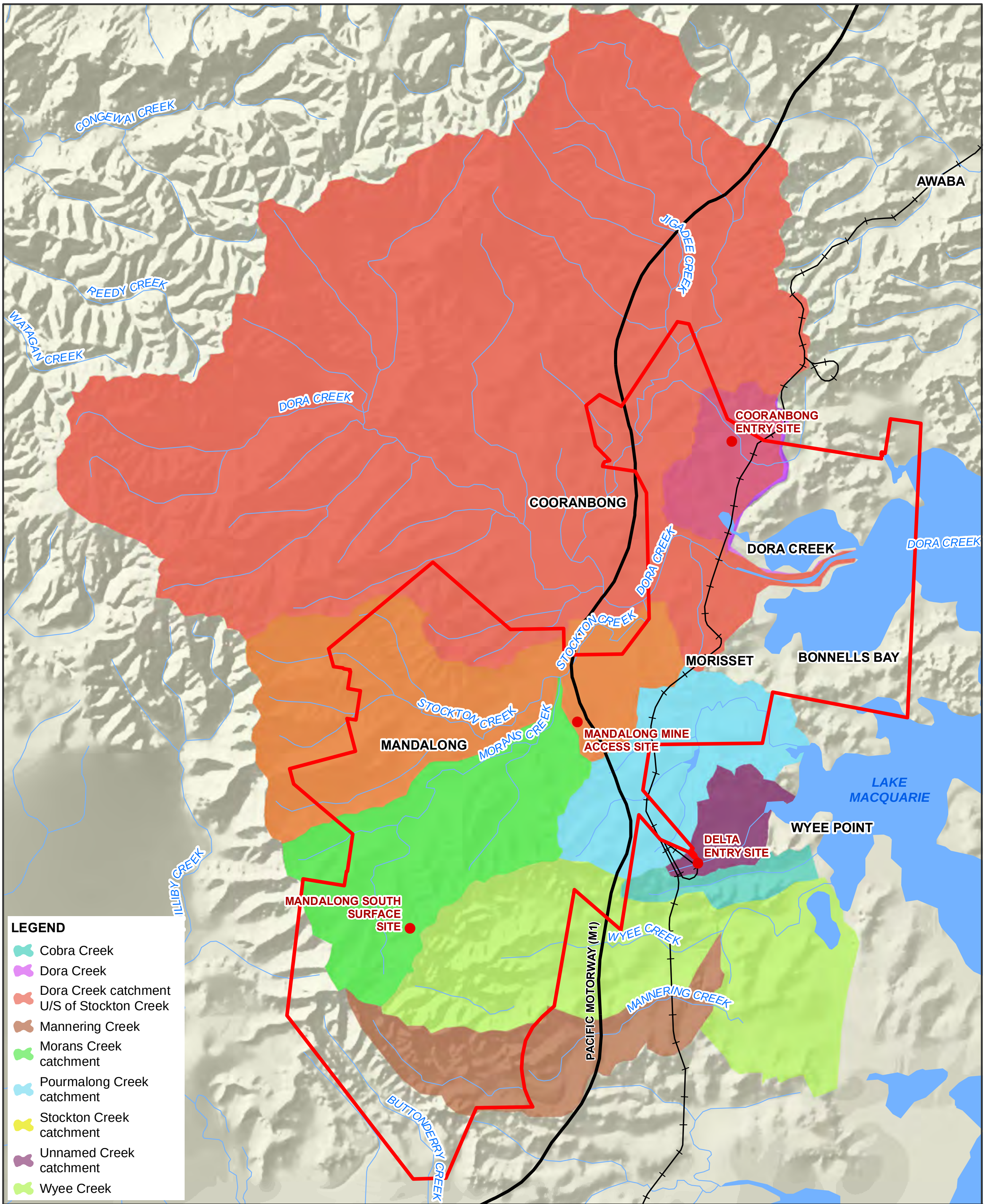
2.2 Topography and hydrology

The topography of the Mandalong Mine site includes several ridgelines and creek valleys, with elevations ranging from 0 m Australian Height Datum (AHD) adjacent to Lake Macquarie to over 200 m AHD at the peak of hills to the south-west.

Each of the surface facilities sites associated with Mandalong Mine are located in catchments that contribute to Lake Macquarie. Figure 2-3 indicates the watercourses and catchments that each of the sites interact with.

The MMAS and MSSS are located within the Morans Creek catchment. Morans Creek generally flows in a north-easterly direction, with its upper reaches receiving runoff from the MSSS. In the lower reaches, approximately 600 m from the confluence with Stockton Creek, Morans Creek receives runoff from the MMAS. Stockton Creek flows in a north-easterly direction to join Dora Creek, which is a major tributary of Lake Macquarie and flows easterly into the lake at the village of Dora Creek.

The DES is located to the south of the Dora Creek catchment and drains to an unnamed tributary that flows into Lake Macquarie to the west of the village of Wyee Point.



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0 500 1,000 2,000 3,000 4,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Existing rail
- Freeway
- Watercourse

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	TT
CHECKED	SG
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Watercourses and catchments

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 2-3

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP013_TopographyandWatercourses_0.mxd

LPMA - DCDB - 2007, DCDB - 2006; Centennial: Landform

2.3 Geology

Mandalong Mine is located in the Newcastle Coalfield, which occupies the north-eastern portion of the Sydney Basin. The Mandalong Mine site is underlain by Triassic claystone, sandstone and conglomerate, as well as Quaternary alluvial sediments along watercourses. The Triassic rocks are underlain by the Permian Newcastle Coal Measures, which regionally dips to the south at approximately 1 to 2 degrees.

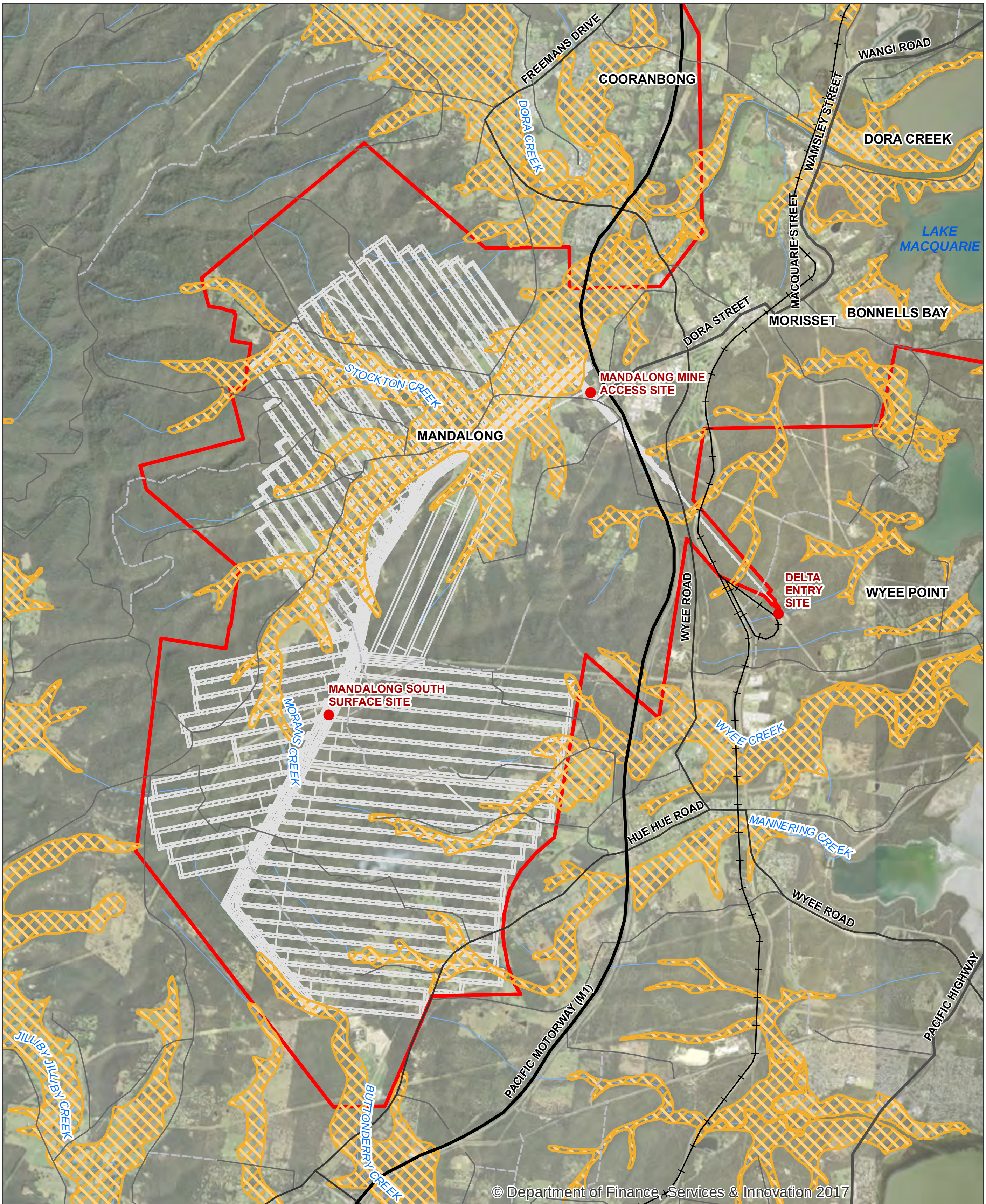
The stratigraphy at Mandalong Mine is summarised in Table 2-1. This information has been sourced from the *Newcastle Coalfield Regional Geology 1:100,000* map (Hawley et al. 1995) and exploration logs for Mandalong Mine.

Table 2-1 Stratigraphic sequence

Period	Stratigraphy		Formation	Lithology
	Group	Subgroup		
Quaternary				Alluvium
Triassic	Narrabeen	Clifton	Patonga Claystone Tuggerah Formation Munmorah Conglomerate Dooralong Shale	Conglomerate, sandstone, siltstone, claystone
Permian	Newcastle Coal Measures	Moon Island Beach	West Wallarah Seam	Conglomerate, sandstone, siltstone, tuff, coal

The approximate boundaries of the Quaternary alluvial sediments in the vicinity of the Mandalong Mine site are shown in Figure 2-4 and have been derived from the *Soil landscapes of the Newcastle 1:100,000 Sheet* (Matthei 1995) and the *Soil Landscapes of the Gosford-Lake Macquarie 1:100,000 Sheet* (Murphy 1993).

The Newcastle Coal Measures are overlain by the Triassic Narrabeen Group. The Narrabeen Group comprises variable sequences of interbedded claystones, siltstones and fine to coarse grained sandstones. The Munmorah Conglomerate is a sandstone-dominated formation within the Narrabeen Group which typically occurs between 60 m and 140 m above the Newcastle Coal Measures (or a depth of approximately 40 m to 340 m below ground level). The Munmorah Conglomerate at Mandalong Mine has been found to contain a thick pebbly sandstone/ conglomerate layer which is geotechnically important in reducing surface subsidence impacts over longwall panels.



1:80,000 for A4

0 325 650 1,300 1,950 2,600

Metres

N

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

- Site location
- Project application area
- Existing Rail
- Freeway
- Watercourse
- Approved mine working
- Alluvial Soils (Lake Macquarie)

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	R.T.
CHECKED	G.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Location of Alluvium

Centennial Coal
Mandalong

DATE 14/12/2019 Figure 2-4

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP003_LocationOfAlluvium_0.mxd

© LPMA: DTDB - 2007 ; Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3 - 2006 ; Centennial: Application Area, EL6317 Boundary, Mine Workings - 2012; GSS: Imagery;

2.4 Hydrogeology

2.4.1 Groundwater sources

The groundwater sources in the vicinity of the Mandalong Mine site are generally low yielding and predominantly within the Quaternary alluvium, weathered and/or fractured sandstone and coal seams. They would be classified as 'less productive', in accordance with the NSW Aquifer Interference Policy as yields are generally less than 5 L/s and/or the total dissolved solids (TDS) concentration is typically greater than 1500 mg/L.

Within the alluvial water sources:

- Water table depths range from less than 1 m and up to 3 m below ground level with an aquifer thickness less than 20 m.
- Water quality is moderately acidic to slightly alkaline, brackish to saline, extremely hard and of sodium chloride type.
- The environmental value of the alluvial groundwater is considered to be 'primary industry', with the saline groundwater suitable for stock watering.

Within the porous and fractured rock water sources:

- The coal seams generally reflect natural topography and the orientation of the seams.
- In areas of no depressurisation, the groundwater head of the seam is typically 0 m AHD due to the coastal environment.
- Great Northern Seam is hydraulically connected to the West Wallarah Seam and subcrops to the north of Mandalong Mine.
- A variable hydraulic conductivity exists for the seam, ranging from 10^{-9} m/s to 10^{-5} m/s (0.03 m/year to 300 m/year). Areas of higher hydraulic conductivity coincide with areas where the coal is more intensively jointed or fractured. (Pacific Power International 1997).
- Groundwater inflows into the existing Mandalong Mine workings are slightly alkaline and brackish to saline.
- The overburden and inter-seam strata within the Newcastle Coalfield tend to have very low hydraulic conductivities (in the order of 0.0003 m/year to 0.03 m/year), unless joints or fracturing creates a secondary permeability (Pacific Power International 1997).
- Groundwater within the sandstone/siltstone of the Tuggerah Formation and Munmorah Conglomerate has been found to be saline and slightly acidic to strongly alkaline.

2.4.2 Groundwater users

From previous searches of the NSW groundwater bore database operated by the NSW Department of Planning, Industry and Environment – Water, the following characteristics of groundwater users within the influenced groundwater sources have been determined:

- Approximately 140 bores within a 5 km radius of the existing and approved Mandalong Mine workings with 64 registered as monitoring/test bores, one bore registered for monitoring/town water supply, 13 did not have a registered use and the remaining 62 bores registered for domestic, irrigation and/or stock use.
- The registered domestic and stock bores primarily extract groundwater from the Triassic sandstone and conglomerate formations, with yields generally less than 1 L/s.
- Domestic and stock bores are mostly located to the south and east of ML1722 and to the north of the existing Mandalong Mine workings.

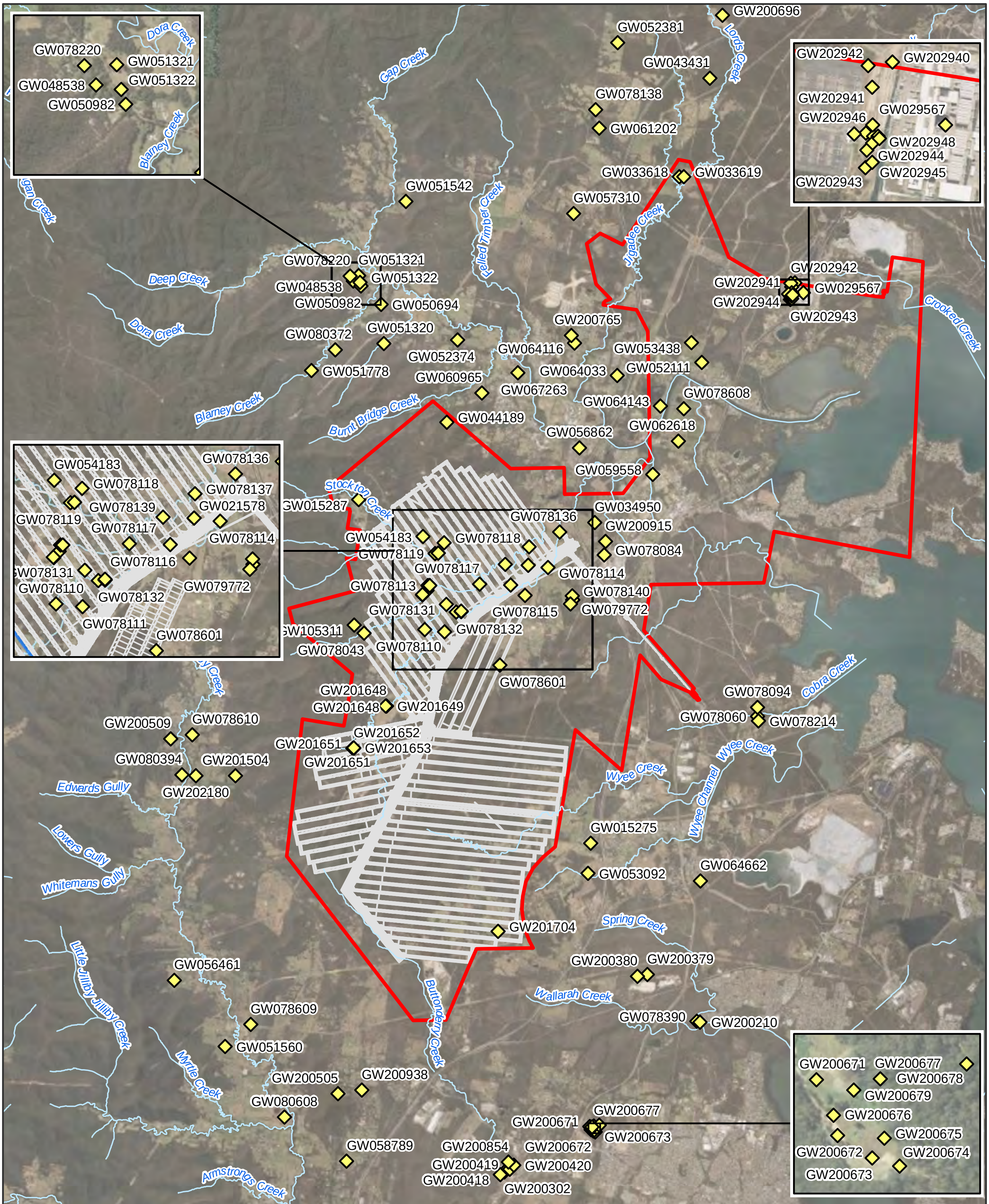
Approximate groundwater bore locations identified from searches of the NSW groundwater bore database are shown in Figure 2-5. Bore details are provided in the *Northern Operations: Regional Water Management Plan*.

2.4.3 Groundwater dependent ecosystems

The potential vegetation groundwater dependent ecosystems (GDEs) within the Mandalong Mine site include:

- Alluvial Tall Moist Forest.
- Coastal Narrabeen Forest.
- Swamp Oak Sedge Forest.
- Riparian Melaleuca Swamp Woodland.
- Wyong Paperbark Swamp Forest.
- Coastal Wet Gully Forest.
- Freshwater Wetland Complex.
- Alluvial Floodplain Cabbage Gum Forest.

These potential GDEs generally coincide with the creeks and drainage lines within the Mandalong Mine site.



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0 500 1,000 2,000 3,000 4,000

Metres

N

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

- Registered bore
- Project application area
- Waterway
- Approved mine working

LOCATION	Mandalong
DRAWN	K.S.
CHECKED	T.T.
APPROVED	S.G.
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

NSW Bore Database
Search Results

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 2-5

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP004_NSWGroundwaterBores_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. OOW: Pinneena, Registered Bore, 2010. Created by: smacdonald, kpsroba

3. Water management

3.1 Water management overview

The water management system at Mandalong Mine site is comprised of clean and dirty surface, potable, waste and underground elements. Sources of water at the three surface sites include potable water supply, rainfall, runoff and groundwater inflow to the underground mine workings. The primary water demands are for underground operations, surface dust suppression, machinery washdown, fire-fighting storage and staff amenities.

Surface water runoff from areas where there is no coal storage, transportation, handling or processing or any disturbance is considered to be clean water, as it is unlikely to be contaminated with coal fines or sediment. Runoff is diverted around dirty water and coal-contact catchments to avoid mixing with clean water runoff. Clean water runoff is typically from natural and impervious catchments such as areas of vegetation, sealed roads and sealed car parks.

Dirty water is runoff from disturbed areas and areas likely to contain suspended sediment, oils, grease and hydrocarbons. This typically includes workshop and fuel storage areas. Coal-contact water is runoff from catchments where coal storage, transportation, handling or processing occurs and is managed within the dirty water management systems.

It should be noted that the Borehole Dam, located upslope of the main CES, is considered to be part of Mandalong Mine. This dam receives mine water extracted from the Cooranbong underground storage via the dewatering bore. The Borehole Dam and discharges of mine water through LDP001 are managed in accordance with the requirements of the *Northern Coal Services: Water Management Plan* and the *Northern Operations: Discharge Management Plan*.

Schematics of the overall water management systems at the MMAS, MSSS and DES are provided in Figure 3-1.

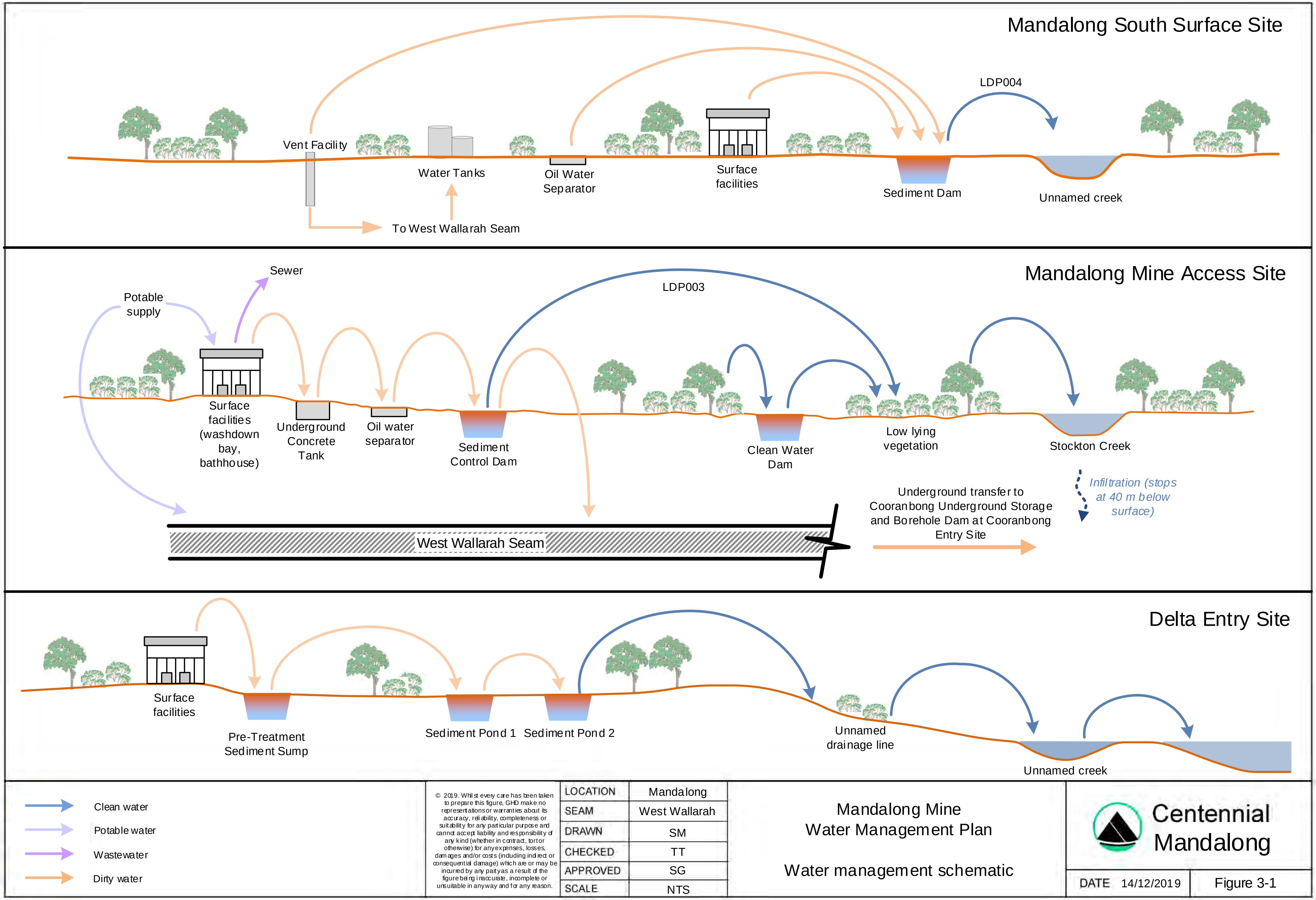
3.2 Surface water management

3.2.1 Mandalong Mine Access Site

The surface water management features for the MMAS are presented on Figure 3-2. Both clean and dirty surface water runoff is managed at the MMAS. Due to all coal being processed and managed at the CES, there is no coal-contact water managed at the MMAS. Also, there is no discharge of water from the underground workings to the surface.

Clean water management

Diversion drains to the east and west of the MMAS divert clean runoff from external catchments around the site. This includes runoff from vegetated areas to the south and west, which is diverted around the western perimeter of the site and runoff from Mandalong Road and the M1 Motorway on-ramps, which is diverted around the eastern perimeter of the site. Rain falling on vegetated and sealed surfaces in the western part of the site generates clean water runoff that is directed to the Clean Water Dam on the western side of the site. Runoff from the south-eastern portion of the site including vegetated areas and the contractors' carpark and runoff from the main carpark is diverted via a pit and pipe around dirty water catchments and discharged downstream of the Sediment Control Dam.



LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	SM
CHECKED	TT
APPROVED	SG
SCALE	NTS

Mandalong Mine
Water Management Plan

Water management schematic

Centennial Mandalong

DATE 14/12/2019

Figure 3-1

LEGEND

- Clean water surface channel
- Clean water pipe network
- Dirty water surface channel
- Dirty water pipe network
- 2 m contour
- Surface water storage
- Licensed discharge point
- Catchments
  - Clean Water Dam
  - Divert to creek
- GPT

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	KS
CHECKED	TT
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Surface Water Management System
Mandalong Mine Access Site

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 3-2

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Table 3-1 summarises the features of the clean water diversions in place at the MMAS.

Table 3-1 Clean water diversions – Mandalong Mine Access Site

Location	Type	Catchment area diverted	Channel top width	Depth	Required capacity	Design compliance
East and west diversion	Open channel	4.09 ha	4.0 m	0.5 m	1.4 m^3/s	5% annual exceedance probability (AEP)
Carpark and roof network	Pipe network	3.27 ha	N/A	N/A	1.2 m^3/s	5% AEP

Table 3-2 summarises the features of the clean water storages in place at the MMAS.

Table 3-2 Clean water storages – Mandalong Mine Access Site

Dam	Maximum capacity at outlet level	Re-use function	Overflow type	Discharge to
Clean Water Dam	0.9 ML	Fire-fighting	Weir	Stockton Creek catchment

Dirty water management

Runoff from disturbed and/or workshop areas is categorised as dirty water. This runoff is directed to a number of dirty water management structures, including a gross pollutant trap (GPT) and oil-water separator, with runoff then directed to the Sediment Control Dam.

The oil-water separator on the GPT removes hydrocarbons from runoff that originates at the fuel/oil storage, workshop, washdown buildings and equipment yard.

The Sediment Control Dam receives treated water from the GPT and oil-water separator and remaining surface catchment of the pit top. The Sediment Control Dam treats dirty water through a process of retention and settling. Dewatering of the dam is undergoing an upgrade. This upgrade will consist of a pump and pipeline, injecting capture water underground via an existing borehole where water is retained and filtered further within the underground goaf areas. Irrigation of surrounding vegetated areas also occur using water captured from the dam, when required. These works will be completed in March 2020 and forms the basis for all existing condition modelling in Section 3.5.

In the event that the dewatering capacity is exceeded, discharges from the dam will occur via a low-flow pipe outlet through LDP003 to low-lying vegetation.

Table 3-3 summarises the features of the dirty water storages in place at the MMAS.

Table 3-3 Dirty water storages – Mandalong Mine Access Site

Storage	Maximum capacity at outlet level	Function	Treatment	Required capacity	Overflow type	Discharge to
Sediment Control Dam	2.0 ML	Sediment control	Settlement through gravity and chemical dosing	95th percentile, five day rainfall depth	Pipe and spillway	Morans Creek catchment via LDP003
GPT and Oil-water separator	0.18 ML	Oil-water separation and capture coarse material	Coalescing plate	95th percentile, five day rainfall depth	Pipe	Sediment Control Dam

3.2.2 Mandalong South Surface Site

The conceptual surface water management features for the future MSSS are presented on Figure 3 3. As discussed, construction of the MSSS commenced in 2017. Drilling of the two ventilation shafts commenced in August 2018 using a blind boring construction method. At completion, the surface facilities at this site will comprise infrastructure for mine ventilation, storage and underground delivery of stone dust, concrete and ballast and hydrocarbon storage.

Both clean and dirty water is managed at the MSSS. There is no discharge of water from the underground workings to the surface at the MSSS. The MSSS does not contain any coal handling or processing facilities.

Clean water management

Clean water diversion drains are located along the eastern perimeter of the site, to divert clean water runoff from upstream vegetated areas around the site and contribute to the Morans Creek catchment. The diversion drain has been designed with the capacity to cater for the peak 100 year ARI rainfall event (equivalent to the 1% AEP event). The drain has also been constructed and lined such that it is stable under these conditions.

Table 3-4 summarises the features of the clean water diversions to be constructed at the MSSS.

Table 3-4 Clean water diversions – Mandalong South Surface Site

Diversion	Type	Catchment area diverted	Channel top width	Depth	Required capacity	Design compliance
North-east diversion	Open channel	0.3 ha	2.5 m	0.5 m	0.2 m^3/s	1% AEP
South-east diversion	Open channel	0.1 ha	2.5 m	0.5 m	0.1 m^3/s	1% AEP

Dirty water management

Runoff from disturbed and/or workshop areas is categorised as dirty water. This runoff is directed to a number of dirty water management structures, including a GPT, with runoff then directed to a Sediment Dam.

1:1,901 for A4

0 10 20 30 40

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Planned site features
- Clean drain
- Clean pipe
- Dirty drain
- Dirtty pipe
- Surface water storage
- 2m Contours
- Licensed discharge point

Catchments
- Lower pad
- NE diversion
- SE diversion
- Sediment Dam
- Upper pad

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	TM
CHECKED	TT
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Mandalong South Surface Site
Surface Water Management System

Centennial Coal
Mandalong

DATE 09 Aug 2019

Figure 3-3

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP010_MSSSCatchment_WaterMgmt_0.mxd

© Centennial: Boundary; Commonwealth of Australia (Geoscience Australia): 250K Topographic data Series 3 2006

LPMA - DCDB - 2007, DCDB - 2006; Nearmap: Imagry, 20180715.

The northern pad (ventilation out-take pad) drains to the south-west corner where a GPT is located. The southern pad drains to the northern corner of the pad down a rock chute and into the GPT. From the GPT, water flows by gravity to the Sediment Dam, which also receives runoff from the remaining surface catchment within the facility boundary. A valve between the GPT and Sediment Dam is closed when the dam reaches a level of 75% capacity.

Sediment and material collected in the GPT and Sediment Dam at the MSSS is transported to the CES, where it is stored on the 1500 tonne coal stockpile and managed in accordance with the coal handling system approved by the Northern Coal Logistics Project.

An oil-water separator will be installed at the GPT following completion of construction of the MSSS to remove hydrocarbons from runoff prior to transfer to the Sediment Dam.

Water stored within the Sediment Dam is managed through the controlled release of stored water following rainfall events via a stabilised spillway through LDP004. Controlled releases of water occur following rainfall into the unnamed creek that flows into the upper reaches of Morans Creek. Discharges are minimised by disposal of water by irrigation of surrounding vegetated areas or evaporation systems where possible. Irrigation and evaporation are carefully managed to prevent migration of water off-site. The discharge permit presented in Appendix C is used to manage and record the process of discharges from the Sediment Dam at the MSSS.

Controlled discharges from the Sediment Dam through LDP004 is a temporary arrangement that will occur until the underground workings reach the MSSS and associated surface and underground infrastructure is installed to enable water to be redirected underground. Surface water stored in the Sediment Dam will be directed into the underground water management system by no later than 30 June 2021.

During construction of the MSSS, water management (with the exception of the Sediment Dam) is undertaken in accordance with the construction environmental management plan (CEMP). The CEMP details the construction activities to be undertaken and provides mitigation measures and controls to avoid or minimise environmental impacts, including procedures for the management of surface water and erosion and sedimentation. The Contractor for the shaft drilling is responsible for the installation, maintenance and operation of the water management system during construction, with Centennial maintaining responsibility for the management of the Sediment Dam.

Table 3-5 summarises the features of the dirty water storages at the MSSS.

Table 3-5 Dirty water storages – Mandalong South Surface Site

Storage	Maximum capacity at outlet level	Re-use Function	Treatment	Required capacity	Overflow type	Discharge to
Sediment Dam	1.3 ML (extended storage of 0.4 ML)	Sediment control	Settlement through gravity and chemical dosing	95th percentile, five day rainfall depth	Stabilised spillway	Unnamed creek via LDP004
GPT	0.3 ML	Capture coarse material	N/A	N/A	Gravity overflow	Sediment Dam

Site Water Treatment

Water discharged via LDP004 is required to achieve specific quality criteria under EPL365. To achieve this criteria a water treatment system has been developed and installed. This system consists of dosing and monitoring equipment such that all water discharged via LDP004 achieves the discharge quality criteria or is diverted back into the sediment dam for storage or further treatment.

Water is dosed with a polyDADMAC to remove sediment through coagulation. The treatment system is such that in the event of either a treatment failure or inappropriate water quality, water is discharged back to the Sediment Dam.

3.2.3 Delta Entry Site

The surface water management features for the DES are presented on Figure 3-4. Both clean, dirty and coal-contact water is managed at the DES. There is no discharge of water from the underground workings to the surface at the DES.

Clean water management

Diversion drains to the north and east of the DES divert clean runoff from external catchments around the site. Some small sections of a pit and pipe network exist through the site to convey runoff from clean catchments across dirty or coal-contact catchment areas.

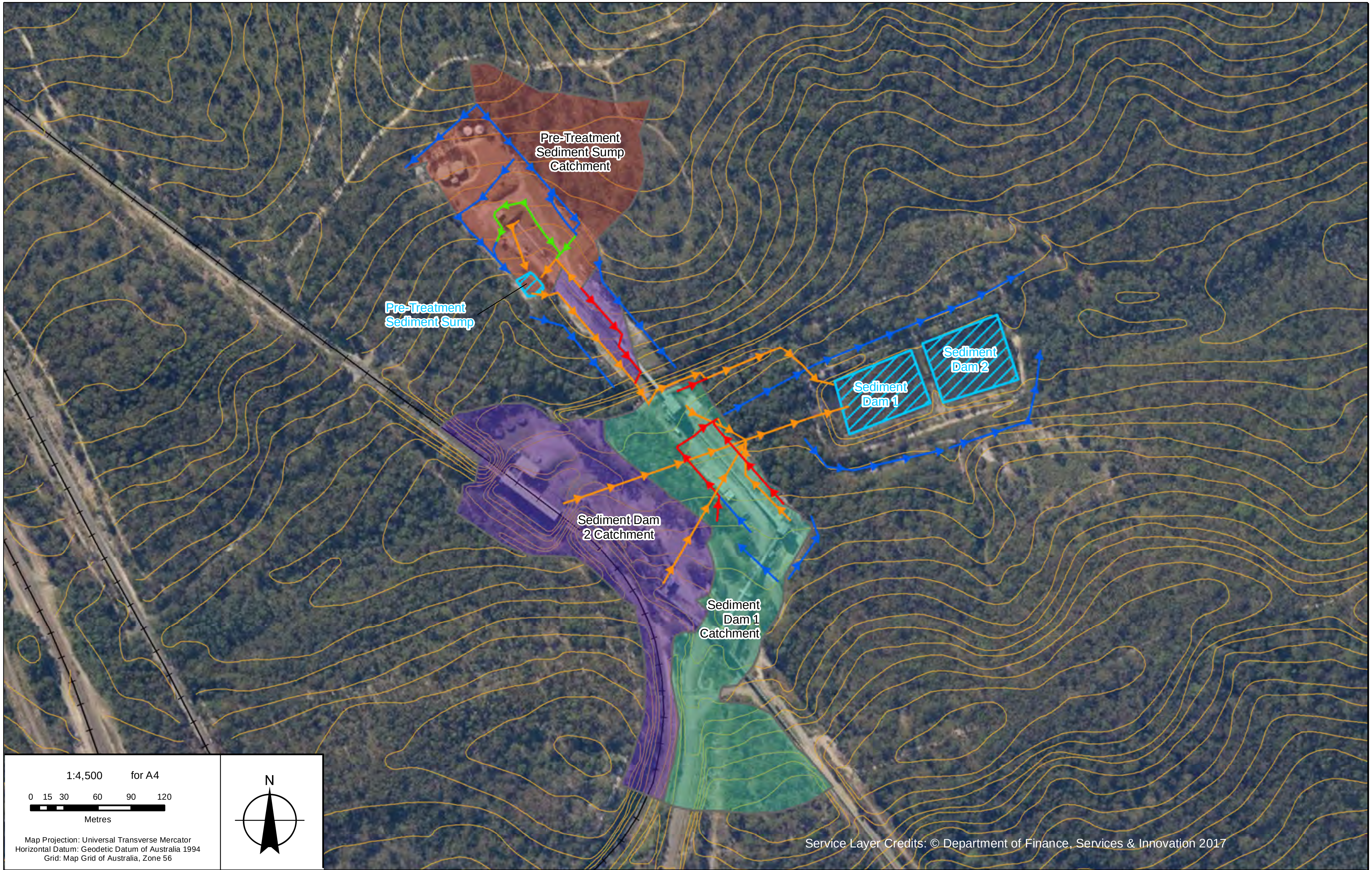
Table 3-6 Clean water diversions – Delta Entry Site

Diversion	Type	Catchment area diverted	Channel top width	Depth	Required capacity	Design compliance
North and east	Open channel	22.34 ha	Varies (min 6.0 m)	Varies (min 0.9 m)	4.3 m^3/s	5% AEP

Dirty and coal-contact water management

Runoff from disturbed and coal-contact areas is directed to a number of dirty water management structures. Dirty water is collected by the Delta drift sediment control dam and final sediment sump before being directed offsite to the 9 ML Sediment Control Dam. The 9 ML Sediment Control Dam is the final storage volume at the end of the dirty water treatment system and treats dirty water through settling prior to discharge from the outlet.

The 9 ML Sediment Control Dam (also known as Settlement Ponds 1 and 2) is operated by Delta Electricity. Centennial Mandalong maintains this dam in accordance with a Variation Agreement dated 30 June 2004.



LEGEND

- Clean Water Surface Channel
- Clean Water Pipe Network
- Dirty Water Surface Channel
- Dirty Water Pipe Network
- 2 m contours
- Railway
- Roads

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	SM
CHECKED	TT
APPROVED	SG
SCALE	Refer to scalebar

Mandalong Mine
Water Management Plan

Surface water mangement system
Delta Entry Site

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 3-4

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP009_DeltaAccessSite_WaterCatch_0.mxd

© LPMA - DTDB - 2007 ; Centennial: Site Layout; Nearmap: Imagery 2010 ; ESRI : Imagery 2016

Coal-contact runoff is directed to treatment structures that promote the settling of coal fines. These structures are sediment control sumps at the transfer building and conveyor gantry.

Table 3-7 summarises the features of the dirty water storages in place at the DES.

Table 3-7 Dirty water storages – Delta Entry Site

Storage	Maximum capacity at outlet level	Re-use Function	Treatment	Required capacity	Overflow type	Discharge to
Pre-treatment Sump	0.3 ML	Sediment capture	Gravity separation	95th percentile, five day rainfall depth	Pipe	Settlement Ponds 1 and 2
9 ML Sediment Control Dam (Settlement Ponds 1 and 2)	9.0 ML	Sediment capture	Gravity separation	95th percentile, five day rainfall depth	Weir	Unnamed creek

3.3 Underground water management

3.3.1 Underground water management system

The underground water management system receives water from the Mandalong, Cooranbong and Delta underground workings. This water is transferred to a goaf (the Cooranbong underground storage) via a series of collection points and pumps from various working areas underground. The goaf has a large volume and provides a filtration and sediment settlement function prior to being pumped to the Borehole Dam at the CES.

The inputs to the underground water management system consists of the following:

- Groundwater seepage from the coal seam and adjacent strata.
- Supply of potable water to mining equipment within the Mandalong workings (approximately 0.7 ML/day) and subsequent transfer of dirty mine water to the Cooranbong underground storage area (approximately 0.4 ML/day to 0.7 ML/day).
- Transfer of surface water from Sediment Dams 1 and 2 at the CES (approximately 80 ML/year).
- Transfer of surface water from the 5 ML Dam at the CES (approximately 50 ML/year).
- Transfer of water from the GPT at the CES (also referred to as Coal Handling Plant Settlement Tank).
- Transfer of water from the Sediment Dam at MMAS (up to 2.2 ML/day).

As shown in Figure 3-6, dirty water from the Mandalong workings is pumped at a rate of approximately 0.4 ML/day from the 69 cut through (c/t) area into the Cooranbong underground storage. Some of the water within the Mandalong workings (originating from potable supply and groundwater seepage) remains within the longwall goaf areas.

The water transferred from the Mandalong workings is allowed to settle at the Cooranbong settlement area. Water is then pumped at a rate of approximately 0.4 ML/day to 0.7 ML/day from 151 c/t pump station to the Cooranbong underground storage dam. The Cooranbong dewatering bore extracts water from this underground storage dam, which is transferred to the Borehole Dam at the CES.

Water that is transferred from the CES enters the Cooranbong underground storage via a series of passive infiltration bores. The location of this transfer is shown in Figure 3-6. This water then drains under gravity to the Cooranbong underground storage dam.

3.3.2 Hydrogeological predictions

A hydrogeological model was developed as part of the Mandalong Southern Extension Project. The hydrogeological model has been re-calibrated to updated groundwater inflow estimates at Mandalong Mine (GHD 2016). The re-calibrated hydrogeological model has been updated to reflect the current approved mine plan and schedule (GHD 2017). The model predicted the lateral zone of impact through depressurisation of aquifers from current and future mining activities and future groundwater inflow.

Figure 3-6 presents the groundwater inflows predicted by hydrogeological modelling for Mandalong Mine. Current groundwater inflows into the active mining areas are estimated to be approximately 1.1 ML/day (GHD 2019). Predicted inflows into the mine are expected to peak in January 2036 at approximately 2.1 ML/day (GHD 2017).

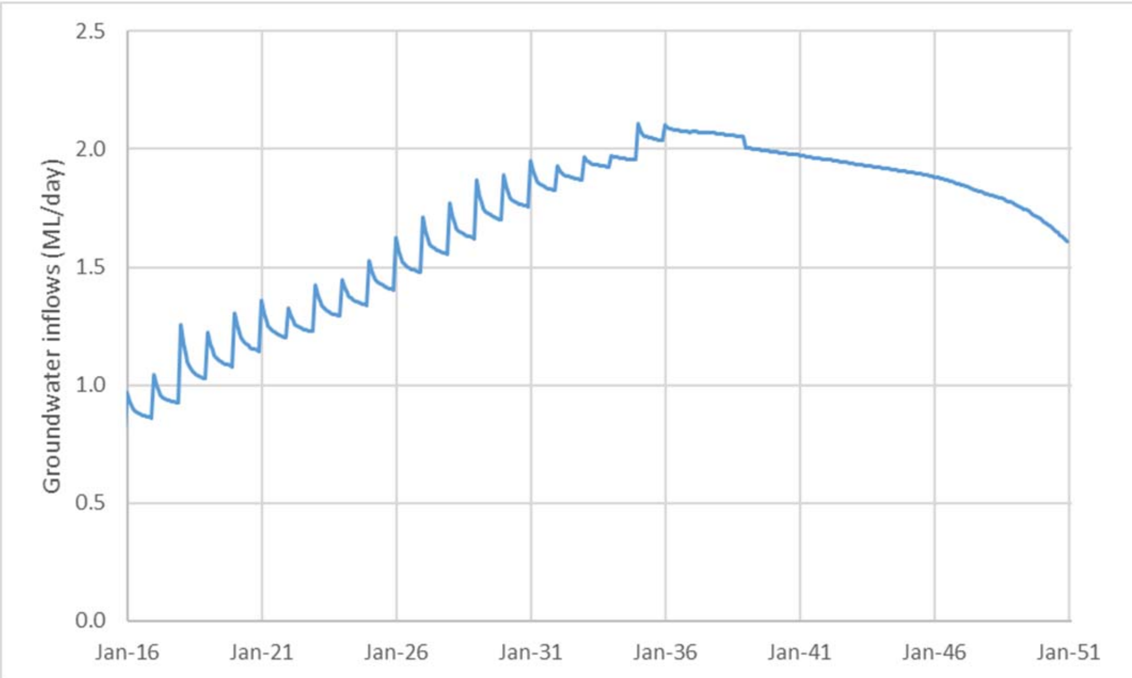
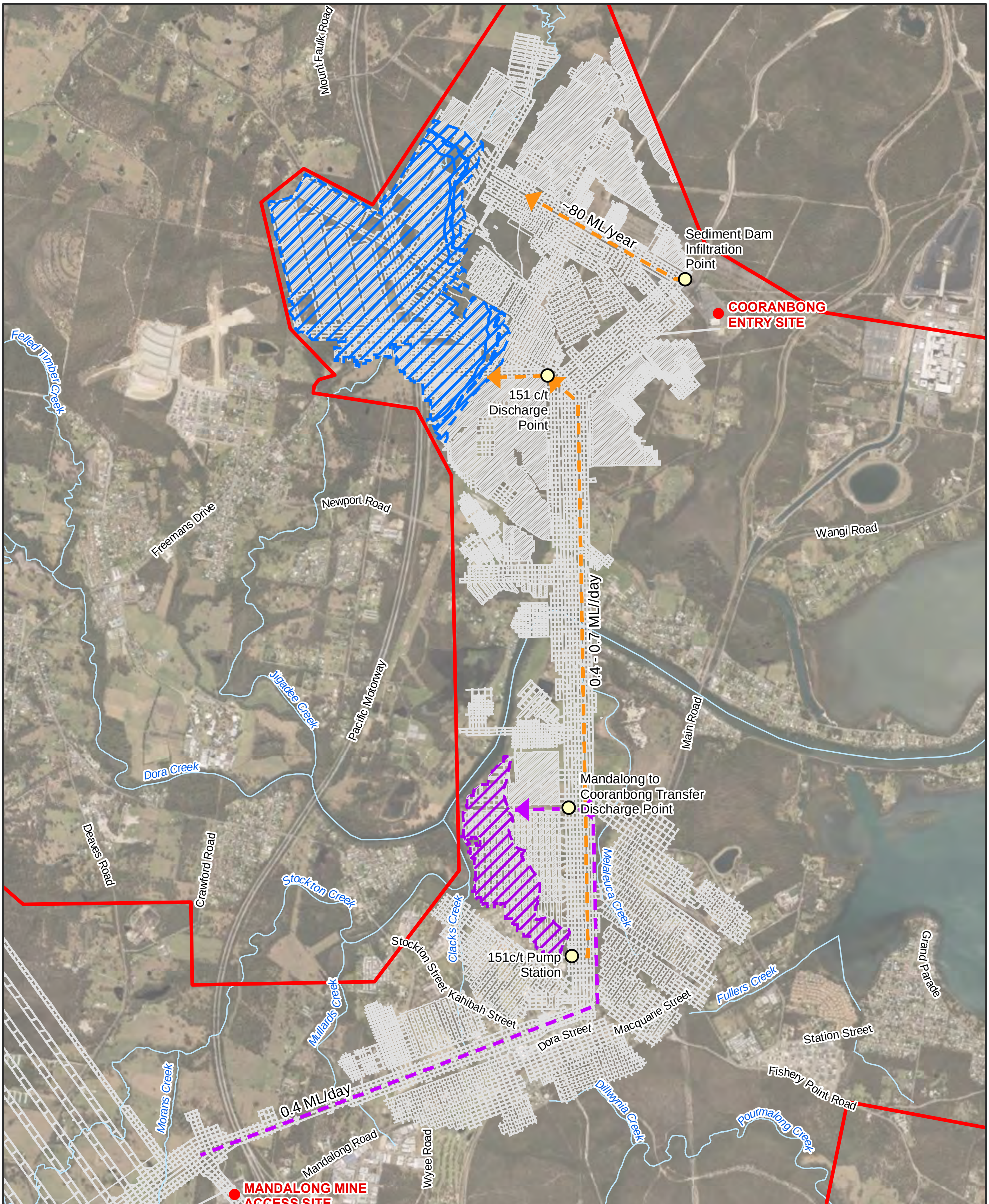


Figure 3-5 Predicted groundwater inflows into underground workings



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0 150 300 600 900 1,200

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Approved Mine Workings
- Cooranbong Transfer Locations
- Cooranbong Goaf
- Cooranbong Settling Area
- Mandalong Mine Dirty Water Pump Transfer
- Water Transfer
- Waterway

LOCATION	Mandalong
DRAWN	K.S.
CHECKED	T.T.
APPROVED	S.G.
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

Cooranbong Underground
Water Management

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 3-6

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP005_CooranbongWaterManagement_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba

3.4 Potable and wastewater systems

Potable water is provided via connections to HWC's reticulated potable water supply system at the MMAS. From the surface, potable water is transferred underground where it is used for process water. Grey water and sewage generated by onsite staff amenities at the MMAS is serviced via connection to HWC's reticulated sewer system.

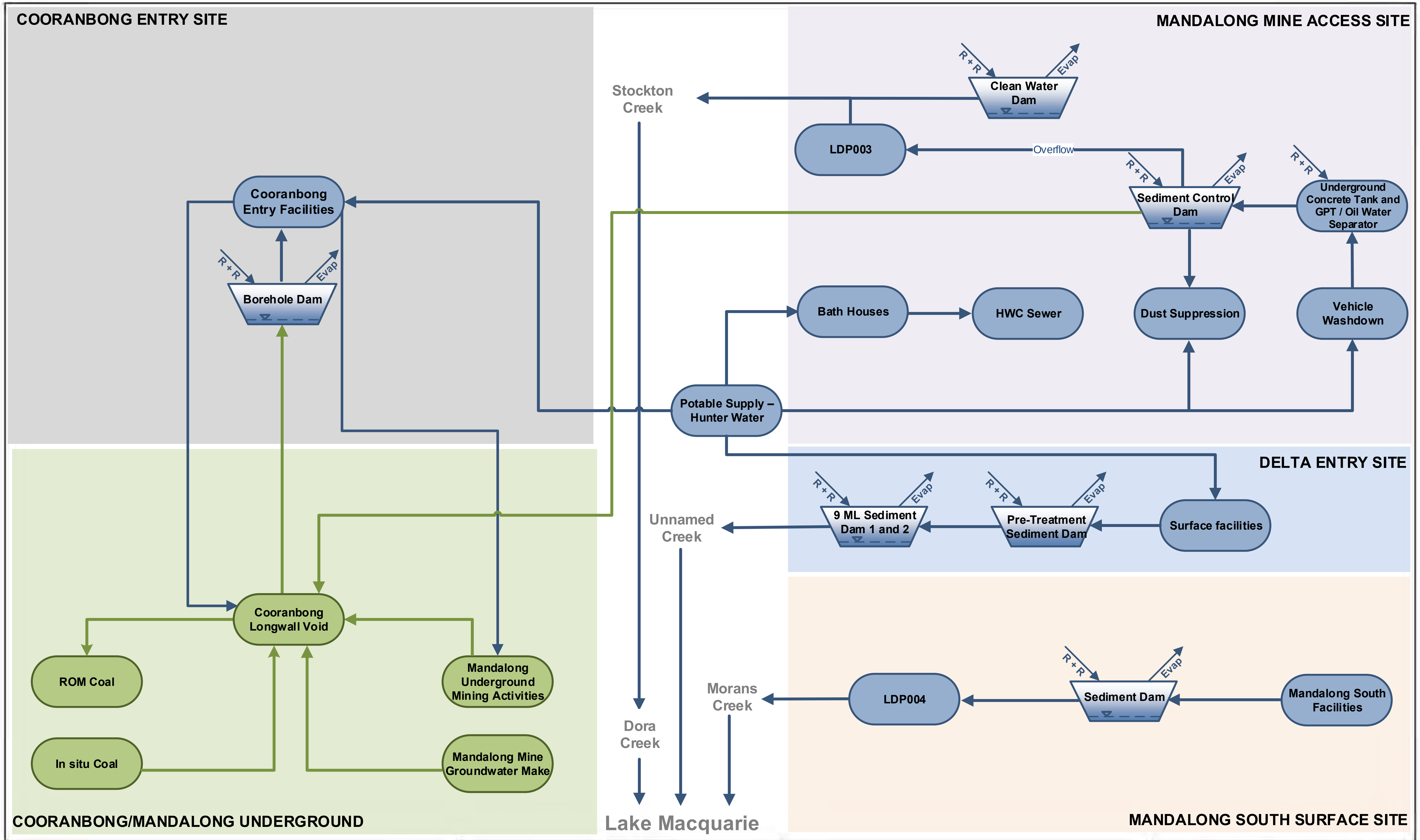
Drinking water at MSSS will be sourced from truck deliveries of bottled water. No bathhouse facilities will be available at the site. Non-potable water will be available from tanks at the site supplied by underground mine water. This water will predominately supply fire-fighting requirements and other activities. Wastewater is serviced by an on-site septic system.

Potable water is provided via connections to HWC's reticulated potable water supply system at the DES. Grey water and sewage generated by onsite staff amenities at the DES is serviced via connection to HWC's reticulated sewer system.

3.5 Site water balance

A site water balance model was previously developed for Mandalong Mine as part of the Mandalong Southern Extension Project (GHD 2013) to quantify water transfers within the site under existing and future operational conditions using various rainfall patterns. The site water balance is reviewed on an annual basis to assist in the management and reporting of water use at the site. The site water balance was updated to reflect the current approved mine plan and schedule (GHD 2017; GHD 2018). A schematic of the overall water management system is presented in Figure 3-7.

A summary of the predicted average annual inputs and outputs for the Mandalong Mine water management system for existing and future conditions is provided in Table 3-8. The future conditions for the water balance model were based on the predicted site conditions in 2036 when groundwater inflows into the active underground workings are predicted to peak.



Surface Transfers

Underground Transfers

Rainfall and Runoff

Storages

LOCATION	Mandalong
SEAM	NA
DRAWN	SM
CHECKED	TT
APPROVED	SG
SCALE	NTS

Mandalong Mine
Water Management Plan

Water cycle schematic

Centennial Mandalong

DATE 14/12/2019

Figure 3-7

\\ghdnet\ghd\AU\Newcastle\Projects\22\12510634\Tech\Visio\2219489_Mandalong_FIG3-7_Water Cycle Schematic.vsd

Table 3-8 Summary of site water balance results

	Existing conditions (ML/year)	Future conditions (ML/year)
INPUTS		
Direct rainfall onto storages and catchment runoff	112	137
Potable water supply	428	430
Groundwater inflows into underground workings	395	762
Transfers from CES water management system (part of Northern Coal Services)	95	95
TOTAL INPUTS	**1030**	**1424**
OUTPUTS		
Evaporation	12	12
Spray irrigation	21	21
Sewage to HWC	36	36
Transfers to CES water management system (part of Northern Coal Services)	876	1291
Discharge from MMAS via LDP003	1	1
Discharge from MSSS via LDP004	22	0
Discharge from DES	62	62
TOTAL OUTPUTS	**1030**	**1423**
CHANGE IN STORAGE		
Cooranbong underground storage	0	0
Surface water storages	0	0
TOTAL CHANGE IN STORAGE	**0**	**0**
BALANCE		
Inputs –outputs – change in storage*	0	1

* Balance due to rounding.

3.5.1 Water supply security

Water is supplied primarily by potable water from HWC's reticulated potable water supply system. External water supply is minimised by reuse and recirculation of water. However, potable water is required for some processes, such as underground mining equipment use and washdown, as recycled water generally has unsuitable and inconsistent quality. Given the security of potable water from HWC, there are no significant water supply risks associated with achieving appropriate environmental management requirements.

3.5.2 Discharge frequency

Figure 3-8 presents the daily discharge percentiles from LDP003 via the outlet of the Sediment Control Dam at the MMAS predicted by the site water balance for existing conditions. Discharges were modelled to occur on less than 1% of days in the year. The maximum predicted discharge was approximately 6 ML/day. The maximum discharge was modelled to occur on less than 0.1% of days.

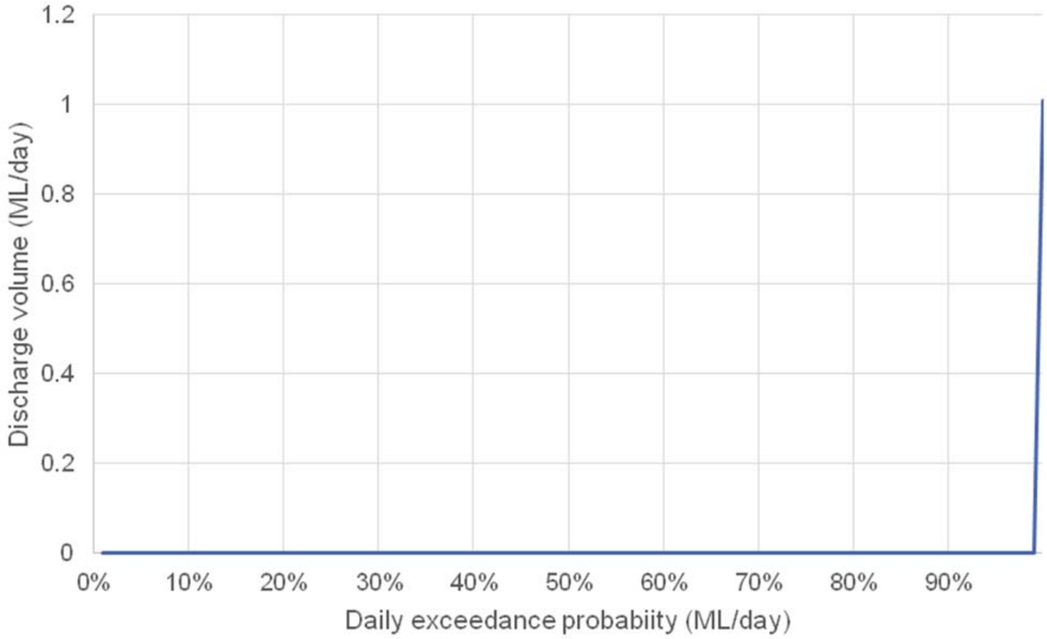


Figure 3-8 Predicted daily discharge from LDP003 at Mandalong Mine Access Site

Figure 3-9 presents the daily discharge percentiles from LDP004 via the outlet of the Sediment Dam at the MSSS predicted by the site water balance for existing conditions. The modelling indicates that controlled discharges are expected to occur on less than 6% of days (less than 22 days a year). The maximum controlled discharge predicted to occur was 1.7 ML/day, which was modelled to occur for 1.3% of days (less than five days a year).

Uncontrolled discharges were modelled to occur on less than 0.05% of days (less than one day a year). The maximum uncontrolled discharge predicted to occur was 5.9 ML/day, which was modelled to occur for less than 0.01% of days. Uncontrolled discharges were modelled to occur only when rainfall exceeded the Sediment Dam design criteria of 95th percentile, five day rainfall event.

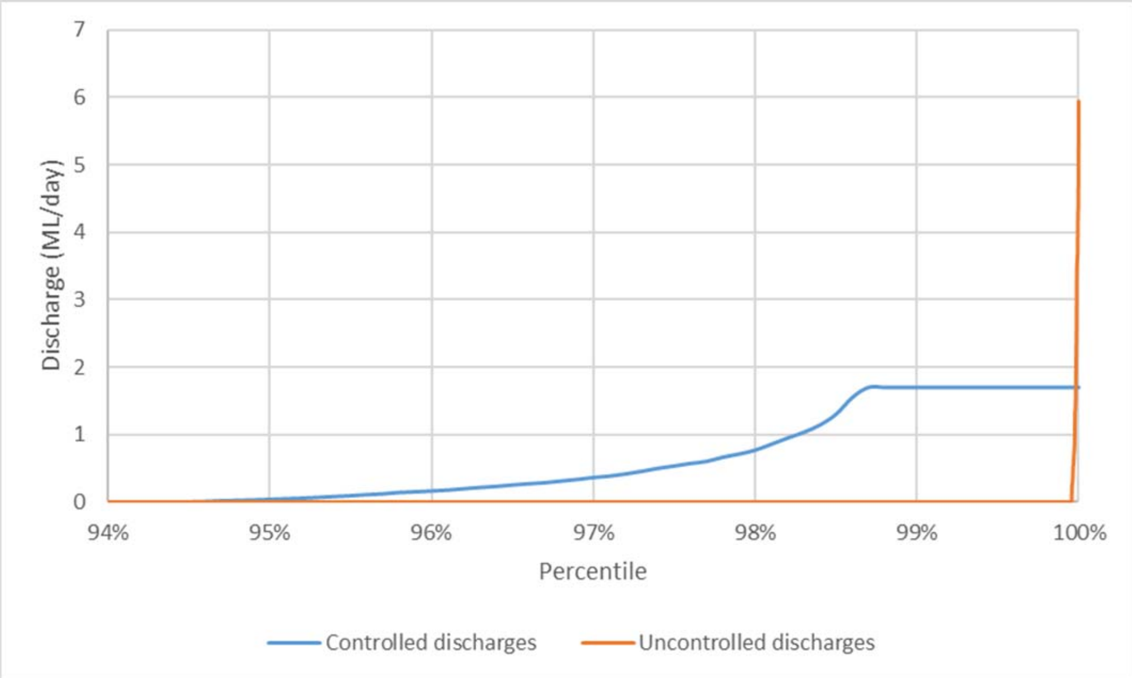


Figure 3-9 Predicated daily discharge from LDP004 at Mandalong South Surface Site

3.6 Mandalong Valley flooding

Umwelt (2013) characterised the Mandalong Valley Floodplain as part of the Mandalong Southern Extension Project EIS. Flooding is well experienced within the valley. Within the Mandalong Valley it is estimated that the June 2007 flood event was between a 50 year and 100 year ARI flood event (equivalent to the 2% and 1% AEP events respectively). Umwelt (2013) summarised a number of anecdotal pieces of evidence (in the form of photographs) from the 2007 event:

- Properties adjacent to Mandalong Road and Chapmans Road would experience flooding.
- Flooding occurs over Mandalong Road where it crosses a tributary of Morans Creek.
- Overbank flooding experienced down Morans Creek.

A flood model has been developed for the Mandalong Valley to identify and quantify the potential changes to the nature of flooding as a result of mining activities at Mandalong Mine. An outcome from recent studies into the southern extension of the underground workings indicated there is no expected change in flood behaviour from major events that may pose a risk to habitable areas.

4. Monitoring requirements

4.1 Inspections

Mandalong Mine undertake site inspections on the water management structures at MMAS, MSSS and DES. Site inspections are completed by the Environment and Community Coordinator or their delegate and occur at a minimum:

- Weekly at the MMAS and MSSS and monthly at the DES.
- As soon as practicable following rainfall events that exceed 40 mm in 24 hours.

An example of an inspection is undertaking the following activities:

- Inspecting water management and sediment control structures for capacity, structural integrity and effectiveness.
- Recording and reporting on the condition of each water management and sediment control structure in place.
- Recording where around the site sediment is deposited.

Maintenance of the water management and sediment control structures will be implemented when visual defects are observed.

4.2 Surface water monitoring

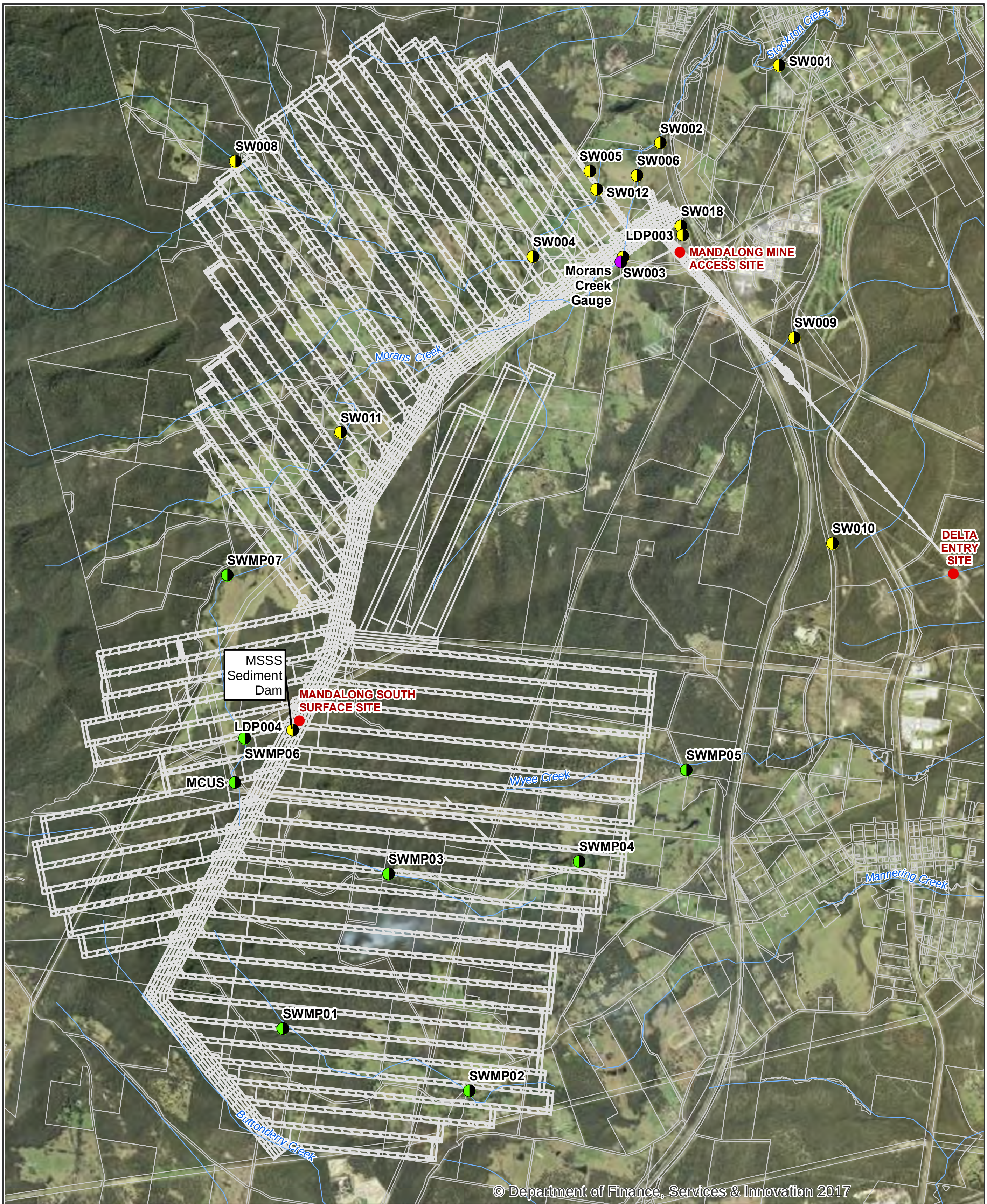
4.2.1 Surface water quality

Surface water quality monitoring points are located in the Mandalong Valley within the upper, mid and lower reaches of Morans Creek and Stockton Creek. Regular monitoring of these locations has been undertaken since August 1999. In addition to these primary surface water sampling locations, surface water monitoring is also undertaken at locations in Pourmalong Creek on the north and south arm. As part of potential subsidence related impacts surface water monitoring is also undertaken within Mannering Creek and Wyee Creek. Sampling of these locations began in June 2011.

No surface water quality monitoring has been undertaken at DES.

The sampling locations for surface water quality are provided in Figure 4 1, with the details of each location provided in Table 4-1.

Water quality sampling frequency and monitored parameters for each location is summarised in Table 4-2.



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Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Cadastre
- Mandalong South Surface water monitoring locations
- Mandalong Surface water monitoring locations
- Morans Creek Gauge
- Watercourse
- Approved mine working

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	S.M.
CHECKED	T.M.
APPROVED	S.G.
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

Surface Water
Monitoring Locations

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 4-1

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP006_SurfaceWaterMonitoring_0.mxd

© LPMA: DTDB - 2007 ; Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3 - 2006 ; Centennial: Application Area, EL6317 Boundary, Mine Workings - 2012; GSS: Imagery;

Table 4-1 Surface water monitoring locations

Site	Location and creek catchment	X coordinate	Y coordinate
Associated with mine sites and historical subsidence areas			
SW001	Downstream reach of Stockton Creek	357598.74	6336487.07
SW002	Downstream of confluence of Morans Creek and Stockton Creek	356366.22	6335679
SW003	Mid Morans Creek	355978.32	6334492.08
SW004	Mid Stockton Creek	355043.18	6334499.14
SW006	Lower Morans Creek	356122.92	6335341.95
SW008	Upper Stockton Creek	351952.94	6335489.09
SW009	South Pourmalong Creek	357760.1	6333657.25
SW010	North Pourmalong Creek	358155	6331519
SW011	Upper Morans Creek	353047.26	6332671.8
SW012	Lower Stockton Creek	355704.06	6335196.53
SW018	Lower Stockton Creek catchment	356581.38	6334816.13
MCUS	Upper Morans Creek catchment	351946.46	6329032.56
Associated with future subsidence area			
SWMP01	Mannering Creek within Olney State Forest	352446.22	6326476.57
SWMP02	Mannering Creek at Hue Road	354382.97	6325830.98
SWMP03	Wyee Creek at Wyee Farms Road	353546.89	6328085.24
SWMP04	Wyee Creek at Wyee Farms Road Bridge	355525.98	6328212.24
SWMP05	Wyee Creek at junction of Schofield Road and Manhire Road	356637.23	6329164.74
SWMP06	Morans Creek at Mandalong Road	351880.35	6331191.14
SWMP07	Upper Morans Creek catchment	352012.3	6329439.91

Table 4-2 Surface water quality monitoring frequency and parameters

Location	Frequency	Parameters
SW001, SW002, SW003, SW004, SW010, SW011, SW012	Quarterly	**Physicochemical parameters:** electrical conductivity (EC), oil and grease, pH, TDS*, total suspended solids (TSS), turbidity.
	Annually	**Major ions:** Chloride, sulfate, hardness. **Nutrients:** ammonia, nitrate + nitrite. **Metals (filtered and total):** arsenic, barium, boron, cadmium, hexavalent chromium**, copper, iron, lead, manganese, mercury, selenium, silver, zinc. **Other parameters:** fluoride, cyanide.
SW006, SW008, SW009	Quarterly	**Physicochemical parameters:** EC, oil and grease^, pH, TSS, turbidity.
SW018	Monthly	**Physicochemical parameters:** EC, oil and grease, pH, TDS, TSS, turbidity.
	Annually	**Major ions:** alkalinity, calcium, chloride, hardness, magnesium, potassium, sodium, sulfate. **Nutrients:** ammonia, biochemical oxygen demand (BOD), nitrate + nitrite, total Kjeldahl nitrogen (TKN), total nitrogen, total phosphorus. **Metals (filtered and total):** aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, zinc. **Others:** cyanide, fluoride.
MCUS	Quarterly	**Physicochemical parameters:** EC, oil and grease, pH, TSS, turbidity. **Nutrients:** ammonia, total nitrogen, total phosphorus. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. **Metals (filtered and total):** aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, zinc.

Location	Frequency	Parameters
SWMP01–SWMP07	Quarterly	**Physicochemical parameters:** EC, oil and grease, pH, TDS, TSS, turbidity. **Major ions:** alkalinity, calcium, chloride, hardness, magnesium, potassium, sodium, sulfate. **Nutrients:** ammonia, BOD, nitrate + nitrite, TKN, total nitrogen, total phosphorus. **Metals (filtered and total):** aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, zinc. **Others:** cyanide, fluoride.

* TDS monitoring at SW002 and SW012.
** Filtered hexavalent chromium only.
^ No oil and grease monitoring at SW006.

4.2.2 Surface water flow

There exists two public watercourse stream gauges located on Jilliby Creek (ID 211010) and Wyee Creek (ID 211001). Both are not continuously monitored sites and the data is considered to be unreliable. Centennial Mandalong installed a flow and level gauge on Morans Creek in 2006 and recorded data up until 2009. The gauge is located adjacent to monitoring point SW003, as shown in Figure 4-1. Centennial Mandalong has replaced this flow gauge in August 2017 to continue monitoring flows within Morans Creek during longwall development and extraction.

Field flow monitoring on various creeks is undertaken as part of visual inspections during water quality sampling. Flow monitoring is undertaken with a hand held impeller on Wyee Creek, Morans Creek, Mannering Creek and Buttonderry Creek. Flow monitoring of Wyee Creek, Mannering Creek and Buttonderry Creek will occur for two years prior to mining.

4.2.3 Tunnel erosion

Areas of very high to extreme risk of erodibility have been identified within the Gorokan soil landscape which is present within the southern portion of the mining area. GSS (2013) identified both the top soil and subsoil within the Gorokan landscape as being sodic (i.e. high in sodium) with a poor structure. As the soil profile deepens, the sodic nature increases (based on exchangeable sodium percentage) (GSS 2013).

The field survey of existing and high risk areas of active tunnel erosion is to be undertaken prior to the commencement of any surface disturbance activities or predicted subsidence. This will be managed as part of each extraction plan WMP.

The remediation of areas of tunnel erosion are to occur where the extent of severity of the occurrence is increased. Remediation activities within sodic soil areas should consider:

- Removal of sodic soils and replace with appropriate top soil.
- Addition of ameliorants such as gypsum.
- Using a geotextile to protect the soil and backfill over the affected area.
- Backfill impacted areas with placed rock and geotextile underlay.
- Locally change the configuration of disturbance activities to avoid area following remediation of any effected areas.

4.2.4 Flooding and flood monitoring programs

The condition of major flood paths is inspected every six months or following a flood event. The flood paths of the Mandalong Valley were identified *Flood Study Mandalong Coal Mine* (Hughes Trueman 2004) and more recently in the *Surface Water Assessment: Mandalong Southern Extension Project* (Umwelt 2013). The flood study encompassed the Stockton Creek and Morans Creek catchments (and their associated tributaries and floodplains) upstream of the M1 Motorway.

Monitoring of flooding occurs following rainfall events that exceed 100 mm in 24 hours, which is equivalent to the 1% AEP, 24 hour storm event. Monitoring includes photographic records of flood depth indicators (including estimated flood levels from debris marks) at the locations presented in Figure 4-2 as well as recording of road closures in the area and any anecdotal evidence from community consultation. The coordinates of flood monitoring locations are provided in

Table 4-3 Flood monitoring locations

Location	X coordinate	Y coordinate
Browns Road Location 1	353796	6333831
Browns Road Location 2	353772	6333707
Browns Road Location 3	353763	6333658
Mandalong Road Location 1	352879	6333062
Mandalong Road Location 2	352734	6332405
Mandalong Road Location 3	352692	6332256
Mandalong Road Location 4	351551	6330555

4.3 Groundwater monitoring

4.3.1 Groundwater levels and quality

The groundwater monitoring network at Mandalong Mine has been progressively established since 1997 and includes monitoring bores installed in alluvial and fractured and porous rock groundwater sources. The groundwater monitoring network also includes monitoring of landholder bore GW078043. The bores are monitored quarterly for groundwater levels and quality (EC and pH) while some bores contain water level loggers for continuous monitoring of groundwater levels.

Monitoring bore locations are shown in Figure 4-3. Details of the groundwater bores at Mandalong Mine are summarised in Table 4-4. As indicated in Table 4-4 there are some bores that are now dry or blocked, monitoring has ceased or the bore has been decommissioned.

Additional monitoring bores will be installed as part of future extraction plans in the vicinity of GDEs where depth of cover is less than 200 m.

There are a number of bores at which monitoring has ceased. These bores will be decommissioned in accordance with *Minimum Construction Requirements for Water Bores in Australia* (ADIA 2012). The decommissioned boreholes will be fully grouted from the bottom of the hole to the surface to avoid cross contamination between the surface and the screened strata.

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Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Cadastre
- Existing flood monitoring location
- Watercourse
- Approved mine working

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	S.M.
CHECKED	T.M.
APPROVED	S.G.
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

Flood monitoring locations

Centennial Coal
Mandalong

DATE 14/12/2019 Figure 4-2

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP017_FloodMonitoring_0.mxd

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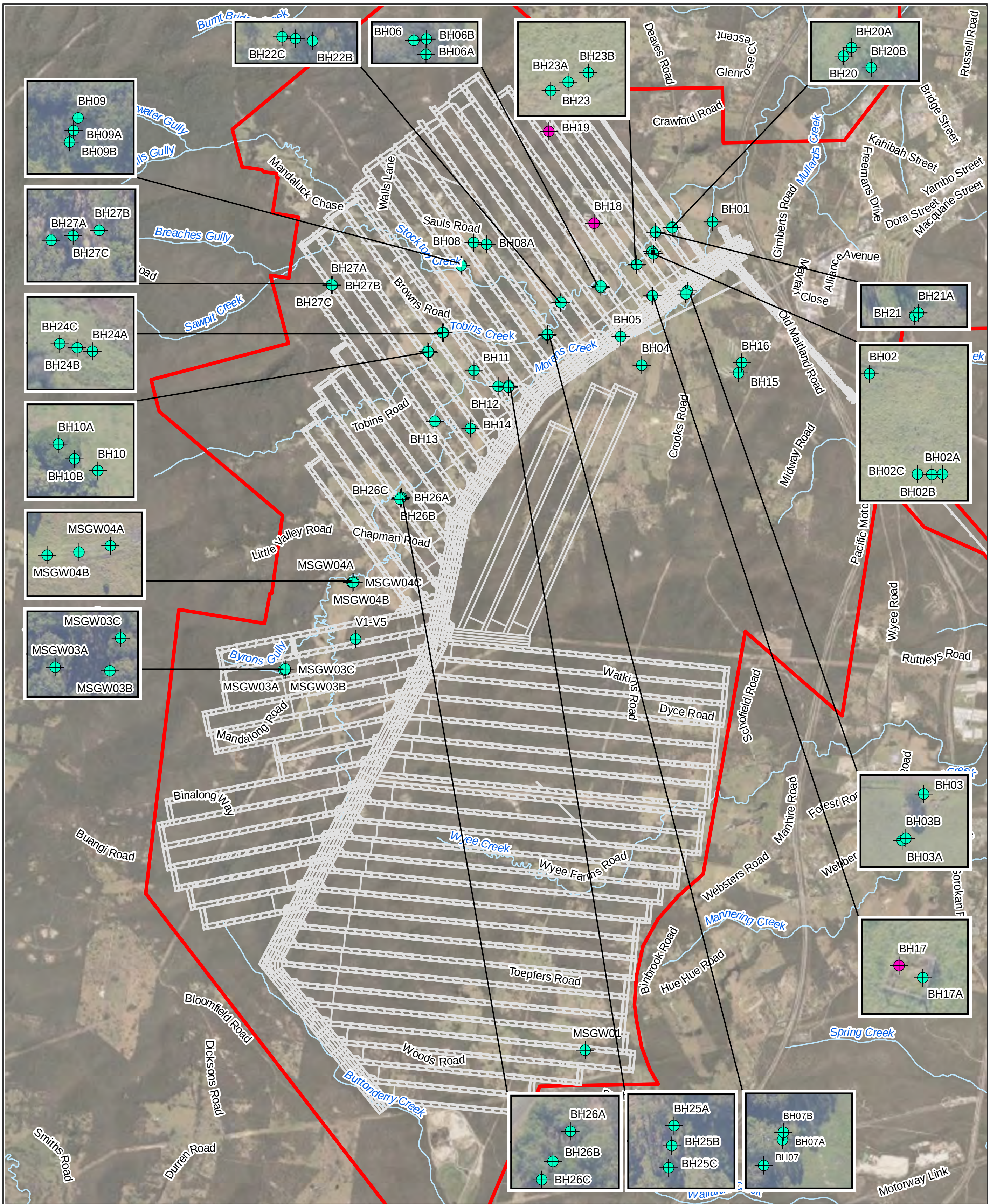

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Meters

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Groundwater Monitoring Bore
- Decommissioned Groundwater Monitoring Bore
- Project application area
- Waterway
- Approved mine working

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	KS
CHECKED	TT
APPROVED	SG
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

Groundwater Monitoring Locations

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 4-3

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP007_GroundwaterMonitoring_0.mxd

Table 4-4 Groundwater monitoring bore details

Bore	Monitoring period	Lithology	Longwall area
BH01	Aug 1997 – present	Alluvium	–
BH02A	Oct 2005 – present	Sandstone	LW3
BH03	Aug 1997 – present	Alluvium	–
BH03A	Nov 2005 – present	Alluvium	–
BH03B	Dec 2005 – present	Sandstone	–
BH04	Aug 1997 – present	Alluvium	–
BH05	Aug 1997 – present	Alluvium	–
BH06A	Nov 2005 – present	Sandstone	LW7
BH07B	Jan 2006 – present	Siltstone	LW10/11
BH09	Aug 1997 – present	Alluvium	LW12
BH09A	Jun 2010 – present	Mudstone/sandstone	LW12
BH09B	July 2010 – present	Mudstone/sandstone	LW12
BH10	Aug 1997 – present	Alluvium	LW16
BH10A	Jun 2010 – present	Mudstone/sandstone	LW16
BH10B	Jun 2010 – present	Sandstone	LW16
BH11	Aug 1997 – present	Alluvium	LW15
BH12	Aug 1997 – present	Alluvium	LW14/15
BH13	Aug 1997 – present	Alluvium	LW18
BH14	Aug 1997 – present	Alluvium	LW17
BH20	Dec 2003 – present	Conglomerate	LW1
BH21	Dec 2003 – present	Conglomerate	LW2
BH23A	Jan 2006 – present	Mudstone	LW4/5
BH24A	Jun 2010 – present	Alluvium	LW15
BH24B	Jun 2010 – present	Sandstone	LW15
BH24C	Jun 2010 – present	Mudstone/sandstone	LW15
BH25A	Jun 2010 – present	Alluvium	LW14
BH25B	Jun 2010 – present	Sandstone	LW14
BH25C	Jun 2010 – present	Mudstone/sandstone	LW14
BH26A	Oct 2011 – present	Alluvium	LW22

Bore	Monitoring period	Lithology	Longwall area
BH26B	Oct 2011 – present	Sandstone	LW22
BH26C	Oct 2011 – present (blocked at 35 m at Jan 2018)	Conglomerate	LW22
BH27A	Oct 2011 – present	Alluvium	LW18/19
BH27B	Oct 2011 – present	Sandstone	LW18/19
BH27C	Oct 2011 – present	Conglomerate	LW18/19
MSGW01	September 2011 – present	Mannering Creek alluvium	–
MSGW03A	September 2011 – present	Morans Creek alluvium	LW26
MSGW03B	September 2011 – present	Sandstone (Tuggerah)	LW26
MSGW03C	September 2011 – present	Conglomerate (Munmorah)	LW26
MSGW04A	September 2011 – present	Morans Creek alluvium	–
MSGW04B	September 2011 – present	Sandstone (Tuggerah)	–
MSGW04C	September 2011 – present	Conglomerate (Munmorah)	–
GW078043	July 2017 – present	Sandstone/Conglomerate	LW24A

4.3.2 Underground water transfers

Daily monitoring of the following underground water transfers is undertaken:

- Supply of potable water to mining equipment within the Mandalong workings.
- Transfer of dirty mine water from the 69 c/t area to the Cooranbong underground storage.
- Transfer of water from the 151 c/t area to the Cooranbong underground storage area.
- Transfer of surface water from Sediment Dams 1 and 2 at the CES to the Cooranbong underground storage.
- Transfer of surface water from the 5 ML Dam at the CES to the Cooranbong underground storage.
- Transfer of surface water from the GPT at the CES (also referred to as Coal Handling Plant Settlement Tank) to the Cooranbong underground storage.
- Extraction of water from the Cooranbong underground storage area via the Cooranbong bore and transfer to the Borehole Dam at the CES.
- Transfer of water from the Sediment Dam at MMAS (up to 2.2 ML/day).

In addition, monitoring of water levels within the Cooranbong underground storage area is undertaken as required.

4.4 Discharge water monitoring

Discharge water quality monitoring is undertaken at LDP003 at the MMAS and LDP004 at the MSSS in accordance with the requirements of EPL 365. Additional water quality monitoring of the Sediment

Dam at the MSSS is undertaken during discharge. Table 4-5 outlines the discharge water quality monitoring requirements.

Table 4-5 Discharge water quality monitoring frequency and parameters

Location	Frequency	Parameters
LDP003 (MMAS Sediment Control Dam outlet)	Daily during discharge	Oil and grease, pH, TSS.
LDP004 (MSSS Sediment Dam outlet)		
MSSS Sediment Dam	Daily during discharge	**Physicochemical parameters:** EC, pH, oil and grease, TSS, turbidity.
	Monthly during discharge	**Nutrients:** ammonia, total nitrogen, total phosphorus. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. **Metals (filtered and total):** aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, zinc.

4.5 Stream health monitoring

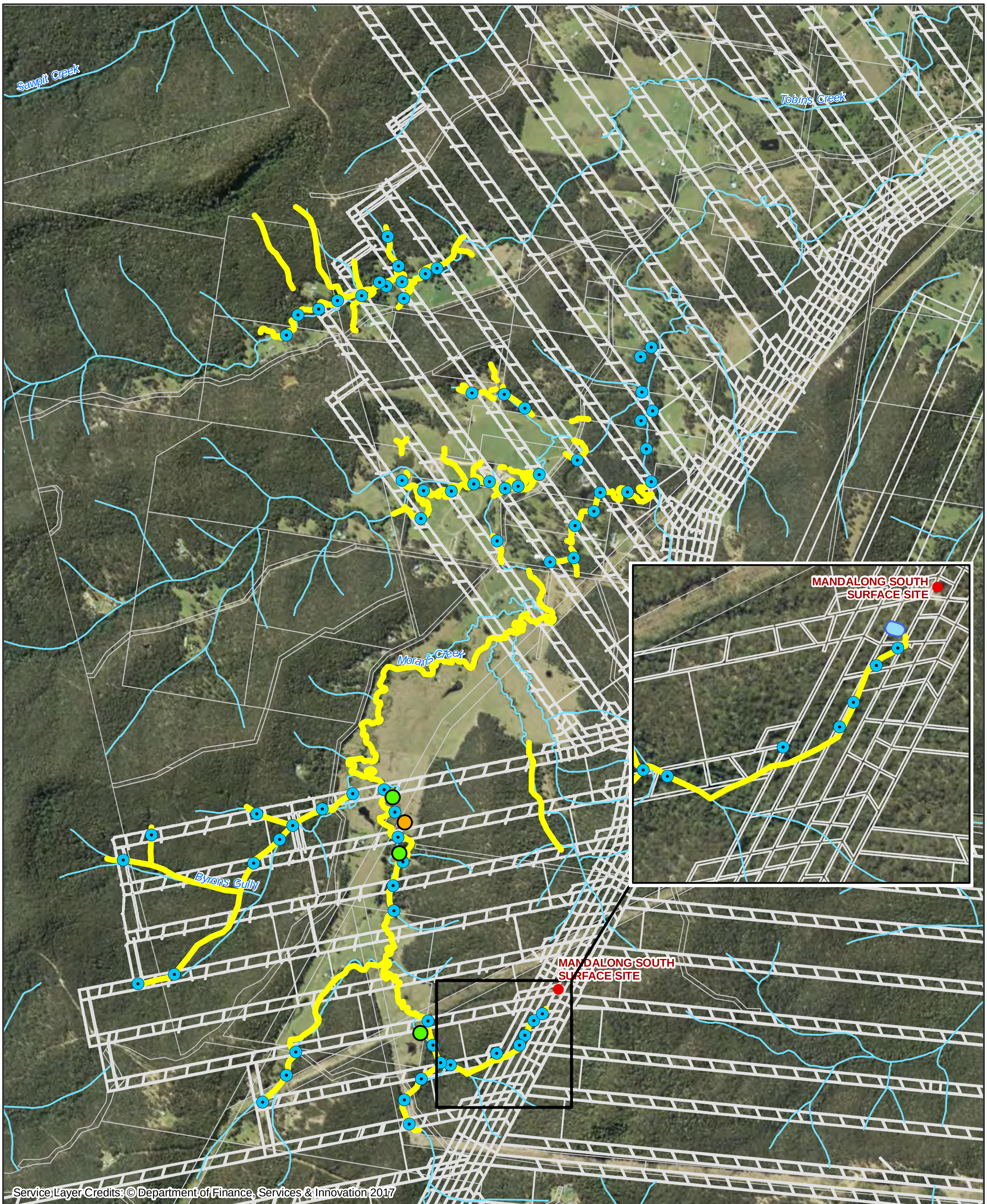
4.5.1 Geomorphic condition and watercourse stability

The predicted subsidence-related changes to stream channel conditions are assessed by floodpath monitoring for each reach above longwall panels to define the pre-mining channel condition and subsidence induced changes to stream characteristics. The monitoring locations for assessing watercourse stability are presented in Figure 4-4 and Figure 4-5. The coordinates of monitoring locations are provided in Appendix D.

Visual monitoring of watercourses is carried out by suitably qualified professionals and is generally undertaken:

- Immediately prior to longwall extraction.
- Immediately after a longwall extraction and before the following longwall extraction.
- Six to 12 months following longwall extraction.

The assessment methodology consists of surveying subsidence along waterways to measure vertical subsidence movement to derive longitudinal grades. Stream condition surveys are undertaken at photographic monitoring points. These monitoring points are located in areas of highest potential differential subsidence, typically above the centre of the longwall panels and intersection with creek beds, to monitor the effects of subsidence on stream condition and changes in stream grade. Observations on the stream's condition recorded at these points include stream geomorphology (including subsidence, scouring and ponding), bank height and width, bed condition (where observable), erosion, channel flood brake out, vegetation community and subsidence deformation.



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Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Cadastre
- Existing photographic monitoring points
- Existing visual monitoring program
- Predicted Ponding Location (Umwelt 2013)
- Predicted Scour Location (Umwelt 2013)
- Watercourse
- Approved mine working

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	S.M.
CHECKED	T.M.
APPROVED	S.G.
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

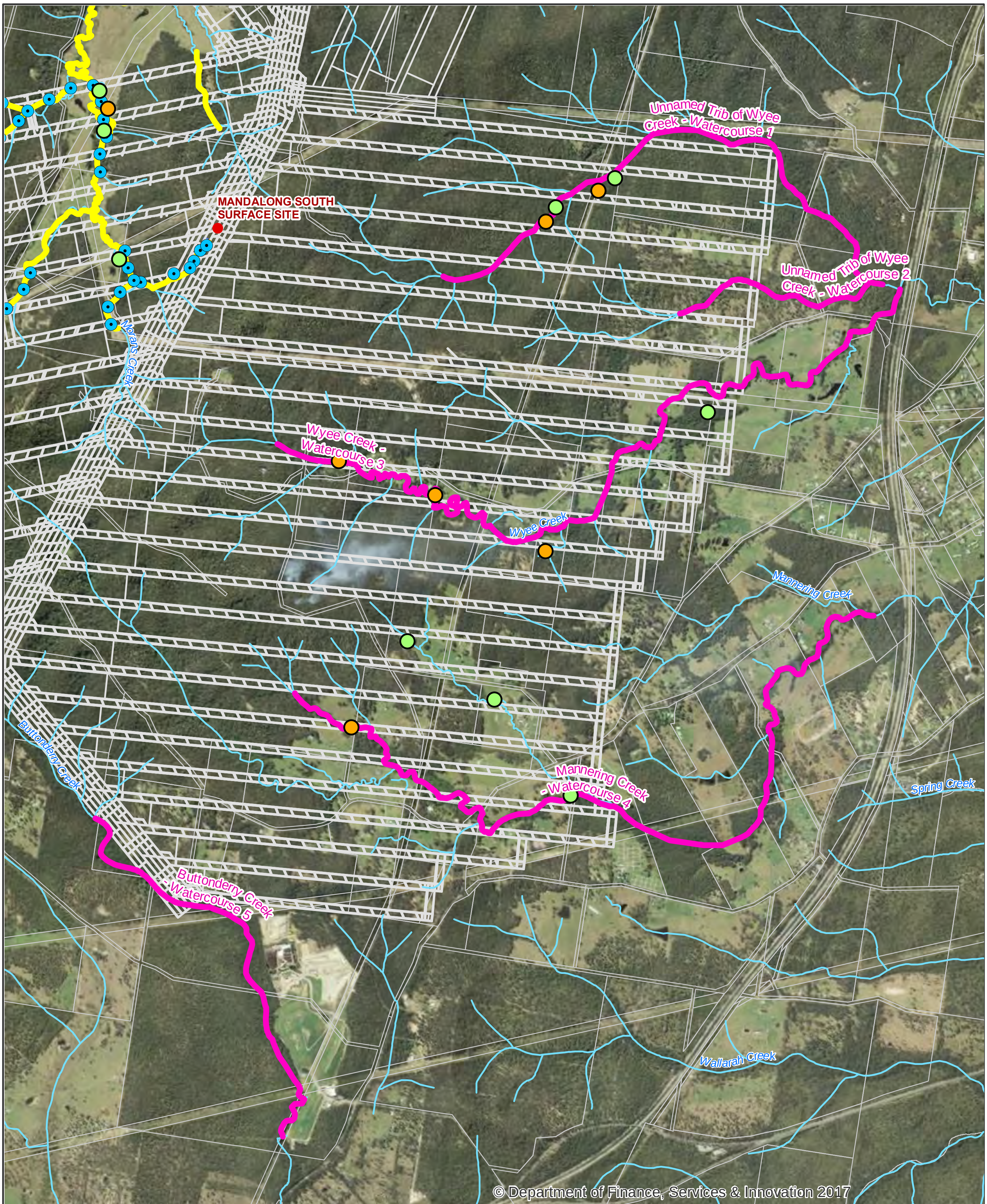
Watercourse stability
existing monitoring locations

Centennial Coal
Mandalong

DATE 16/12/2019 Figure 4-4

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP014_WatercourseMonitoring_Existing_0.mxd

© LPMA: DTDB - 2007 ; Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3 - 2006 ; Centennial: Application Area, EL6317 Boundary, Mine Workings - 2012; GSS: Imagery;



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Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Cadastre
- Existing photographic monitoring points
- Existing visual monitoring program
- Predicted Ponding Location (Umwelt 2013)
- Predicted Scour Location (Umwelt 2013)
- Future monitored watercourses
- Watercourse
- Approved mine working

LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	S.M.
CHECKED	T.M.
APPROVED	S.G.
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

Watercourse stability
future monitoring locations

Centennial Coal
Mandalong

DATE 14/12/2019 Figure 4-5

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP015_WatercourseMonitoring_Future_0.mxd

© LPMA: DTDB - 2007 ; Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3 - 2006 ; Centennial: Application Area, EL6317 Boundary, Mine Workings - 2012; GSS: Imagery;

Pre-mining surveys are conducted prior to the commencement of each longwall panel. The stream condition surveys are undertaken biannually or following a flood event. Annual floodpath condition reports are prepared with the key findings reported in the Annual Review for Mandalong Mine. The biannual Mandalong Mine flood path inspections aim to identify the impacts which may trigger mitigation.

Watercourse stability monitoring is also undertaken for the unnamed creek downstream of discharges from the Sediment Dam at the MSSS to assess for evidence of scouring. Visual and photographic monitoring is undertaken six monthly at the locations presented in Figure 4-4.

4.5.2 Aquatic ecology monitoring

Aquatic ecology monitoring occurs annually in spring at the following locations, as shown in Figure 4-6:

- MCTDS – on the unnamed creek downstream of LDP004 discharges from the MSSS Sediment Dam.
- MCUS – on Morans Creek upstream from the confluence with the unnamed creek.
- MCDS – on Morans Creek downstream from the confluence with the unnamed creek.

The aquatic ecology monitoring methodology includes:

- Sampling, sorting and identification of macroinvertebrates collected from edge habitat in accordance with the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak et al. 2004).
- Assessment of the condition of the aquatic habitat using modified NSW AUSRIVAS field sheets and riparian, channel and environmental (RCE) inventory (Peterson 1992).
- Measurement of dissolved oxygen, EC, pH and temperature just below the surface of the water column and at depth where sufficient water is available.
- Collection of surface water and sediment grab samples for water and sediment quality analysis.

1:10,000 for A4

0 0.06 0.12 0.18 0.24 0.3
Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND
- Site location
- MSSS aquatic ecology site
- MSSS Sediment dam
- Watercourse

LOCATION	Mandalong
DRAWN	TM
CHECKED	TT
APPROVED	AW
SCALE	refer to scalebar

Mandalong Mine
Water Management Plan

Aquatic ecology
monitoring locations

Centennial Coal
Mandalong

DATE 14/12/2019

Figure 4-6

GIS Filename: \\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Hunter\Regional\12510634\Mandalong WMP\2219489_MWMP016_AEMonitoringLocations_MSSS_0.mxd

Data source: Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006; Centennial: Holdings Boundary, 2016. Nearmap: Imagery, 20180715. Created by: smacdonald, kpsroba

5. Baseline data

5.1 Surface water monitoring

5.1.1 Surface water quality

Appendix E presents the baseline data for water quality within Stockton Creek, Wyee Creek, Mannering Creek and Morans Creek. Table 5-1 presents the extent of baseline data recorded within these watercourse catchments.

Where the analytical result was below the limit of reporting (LOR) for a particular parameter, then the detection limit was used. Note that monitoring points SW001 and SW002 on Stockton Creek are influenced by tidal ingress from Warners Bay.

Table 5-1 Period of recorded water quality data

Site	Period from	Period to	Count
SW001–SW012	02/03/2011	11/03/2019	51
SW018	23/08/2012	11/03/2019	36
SWMP01–SWMP07	20/06/2011	15/03/2019	54

5.1.2 Surface water flow

Figure 5-1 and Figure **5-2** presents the level and flow rate recorded by the flow gauge on Morans Creek since it was installed in August 2017.

Water levels within Morans Creek indicate a general creek response of up to 0.5 m to rainfall greater than 50 mm/day. Due to inconsistent gauging recordings, a reliable correlation between rainfall and level was not possible.

5.2 Groundwater

5.2.1 Groundwater levels and quality

Appendix F presents the baseline groundwater level and quality data for monitoring bores. Data has been considered from August 1997 to October 2018.

As discussed in the Mandalong Southern Extension Project response to submissions, there was variability in groundwater EC at a number of monitoring bores at Mandalong Mine. As part of the response to submissions process it was identified that this variability in EC was attributable to sampling of bores by bailing. Since January 2015, monitoring bores at Mandalong Mine have been sampled using low flow techniques where possible (i.e. peristaltic pump or Micro-purge pump). Additionally, bores that were identified as being regularly inundated with surface water have been purged prior to sampling to remove any influence of surface water on monitoring results. Following the update of groundwater monitoring methodology, variability in observed EC has reduced.

HARTT (Hydrograph Analysis: Rainfall and Time Trends) analysis was undertaken for each alluvial groundwater level dataset. The HARTT analysis was used to establish the relationship between groundwater levels and rainfall and detect underlying trends in groundwater level that are independent of rainfall.

A cumulative rainfall departure (CRD) curve is also presented with the groundwater level hydrographs. The CRD curve depicts the monthly accumulation of the difference between the observed monthly rainfall and the long-term average monthly rainfall.

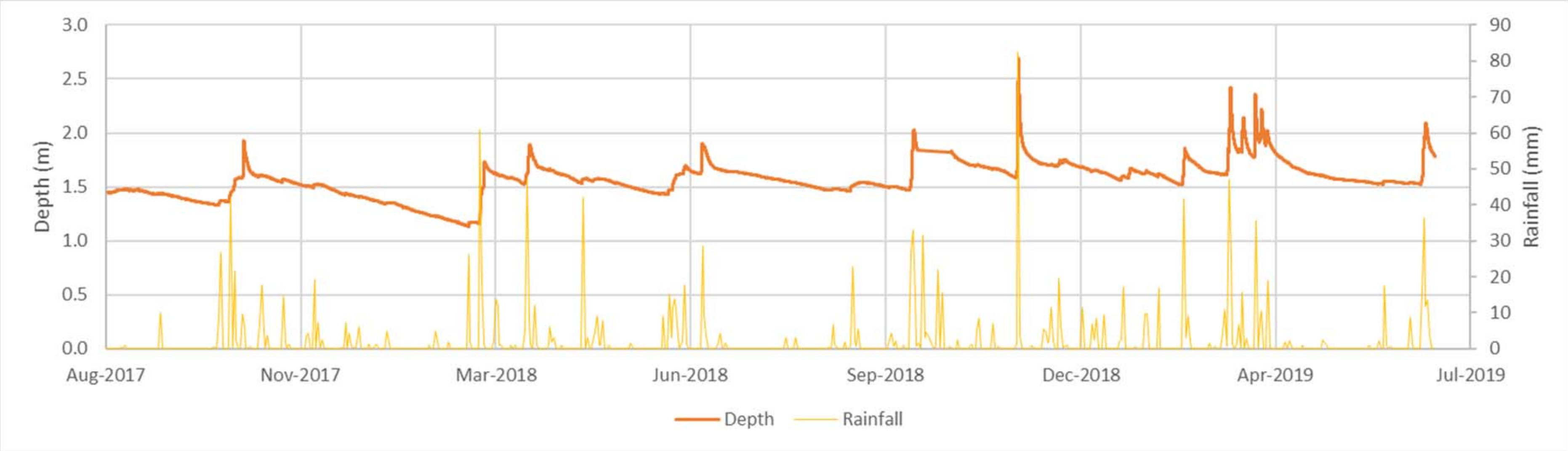

Figure 5-1 Level gauging within Morans Creek from August 2017 to June 2019

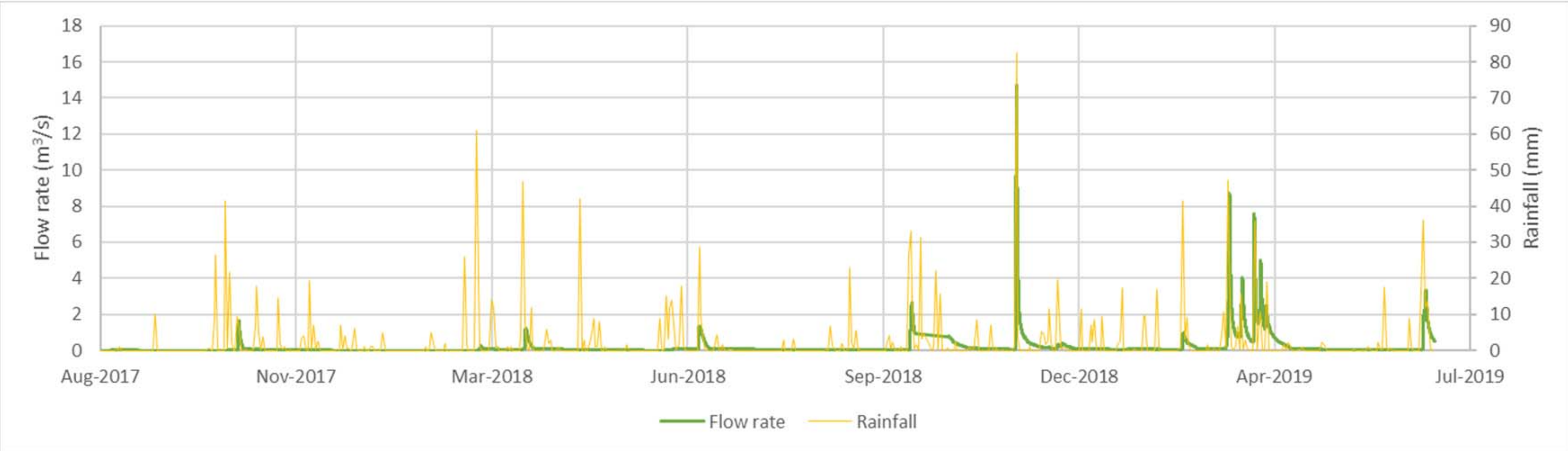

Figure 5-2 Flow rate gauging within Morans Creek from August 2017 to June 2019

5.2.2 Underground water levels

Water levels in the Cooranbong underground storage area have been monitored by Centennial Mandalong since December 2011. The measured water levels (corrected to AHD) between December 2011 and March 2019 are shown in Figure 5-3.

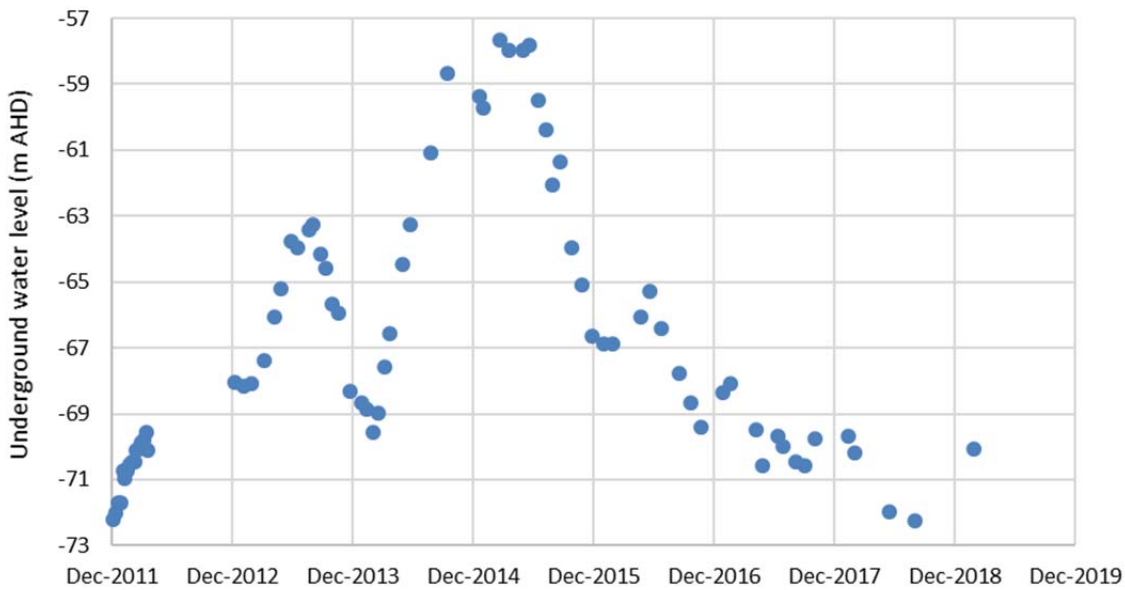

Figure 5-3 Cooranbong underground storage water levels

The following observations have been made over this period:

- For the period prior to March 2013, the average rate of dewatering of the Cooranbong underground storage dam was 1.5 ML/day and the water level rose by approximately 5 m over this period.
- Over the period March to August 2013, the underground water level rose by a further 4 m since the pump was not in operation for most of this time.
- Between mid-August 2013 and February 2014, the average extraction rate was approximately 2.6 ML/day and the water level reduced by 6 m.
- Between February and September 2014, there was no extraction of water from the Cooranbong Underground Storage and the water level rose by approximately 11 m.
- Between October 2014 and January 2015, the average extraction rate was approximately 1.9 ML/day and the water level reduced by 1 m.
- Between January and March 2015 there was no pumping for most of this time and the water level rose 2 m.
- Between March and May 2015, the average extraction rate was approximately 2 ML/day and the water level dropped 0.15 m.
- Between June 2015 and January 2016, the average extraction rate was 3.0 ML/day and the water level reduced by 9.05 m.
- Between February 2016 and May 2016, the average extraction rate was 1.6 ML/day and the water level rose 1.6 m. This included a period where pumping ceased between April to May 2016 for LDP001 upgrade at CES.
- Between June 2016 and October 2016, the average extraction rate was 3.0 ML/day and the water level reduced by 4.1 m.

- Between November 2016 and January 2018, the average extraction rate was 1.8 ML/day and the water level remained relatively constant.
- Between February 2018 and August 2018, the average extraction rate was 2.1 ML/day and the water level reduced by 2.56 m.
- Between August 2018 and February 2019, the average extraction rate was 2.0 ML/day and the water level rose 2.16 m.

Based on an assessment of the floor contours of the Cooranbong workings, the underground water storage area has a capacity of approximately 4200 ML (assuming void height of 3 m and void ratio of 0.4). Once the underground water storage reaches full capacity, the water spills to the south back towards the active Mandalong workings.

5.3 Discharge water monitoring

Discharges are currently estimated via LDP003 and LDP004 based on the water balance modelling. Discharge volumes are reported as part of monthly and annual reporting. Online telemetry is being installed in 2020 at both LDP003 and LDP004 to record daily volumes.

6. Response plans

6.1 Triggers

6.1.1 Watercourses quality triggers

Site-specific guideline values (SSGVs) have been derived following ANZG (2018) guidelines and are applied to watercourse monitoring within Morans Creek downstream of discharges. SSGVs have been selected based on a review of default guideline values (DGVs) presented by ANZG (2018) and data collected at upstream monitoring locations SWMP06 and SWMP07. Table 6-1 presents the recommended SSGV, as well as the DGVs and results for SWMP06 and SWMP07. The values in bold have been selected as the SSGVs. The 80th percentile values for water quality data at SWMP06 and SWMP07 have been calculated from the entire dataset available between June 2011 and June 2016. As samples have been collected for over two years, the dataset covers a range of seasonal, climatic and flow conditions.

SSGVs for Wyee Creek and Mannering Creek catchments will be derived as part of WMPs for the relevant extraction plans.

Table 6-1 Watercourse quality trigger values

Parameter	Units	DGV	SWMP06 80th percentile	SWMP07 80th percentile	Recommended SSGV
Physicochemical parameters					
EC	µS/cm	200	**940**	755	940
pH	pH units	6.5–**9.0**	**6.2**[1]–6.7	6.5[1]–7.0	6.2–9.0
TSS	mg/L	6	**47**	16	47
Turbidity	NTU	6	**58**	53	58
Nutrients					
Ammonia	mg/L	**0.9**	0.07	0.15	0.9
Total nitrogen	mg/L	0.35	1.18	**1.52**	1.52
Total phosphorus	mg/L	0.025	0.08	**0.11**	0.11
Dissolved metals					
Aluminium	mg/L	0.055	0.70	**0.78**	0.78
Arsenic	mg/L	**0.024**	0.001	0.001	0.024
Barium	mg/L	–	**0.083**	0.066	0.083
Boron	mg/L	**0.37**	0.05	0.05	0.37
Cadmium	mg/L	**0.0002**	0.0001	0.0001	0.0002
Chromium	mg/L	**0.001**	**0.001**	**0.001**	0.001
Cobalt	mg/L	0.0025	**0.009**	0.001	0.009

Parameter	Units	DGV	SWMP06 80th percentile	SWMP07 80th percentile	Recommended SSGV
Copper	mg/L	0.0014	0.001	**0.002**	0.002
Iron	mg/L	0.3	**3.61**	3.11	3.61
Lead	mg/L	**0.0034**	0.001	0.001	0.0034
Manganese	mg/L	**1.9**	0.828	1.744	1.9
Mercury	mg/L	**0.0006**	0.0001	0.0001	0.0006
Nickel	mg/L	**0.011**	0.006	0.004	0.011
Selenium	mg/L	**0.011**	0.01	0.01	0.011
Silver	mg/L	0.00005	**0.001**	**0.001**	0.001
Zinc	mg/L	**0.008**	0.007	0.006	0.008
Other parameters					
Cyanide (total)	mg/L	**0.007**	0.004	0.004	0.007

1. 20th percentile value.

6.1.2 Groundwater levels

Based on the statistical analysis of alluvial groundwater levels, alluvial groundwater is highly responsive to rainfall and generally not impacted by mining. The exception to this is at bores BH24A and BH25A where alluvial groundwater levels appear to have had a temporary response to mining.

For bores BH24A and BH25A, adopted trigger values are the minimum recorded depth to groundwater prior to impact by mining. Groundwater levels at BH26A and MSGW04A have generally varied by 2 m and therefore the groundwater trigger level for alluvial bore BH26A and MSGW04A has been defined as 2 m below the minimum observed groundwater level. Groundwater levels at MSGW01 have varied by 1.5 m and therefore the groundwater trigger level for alluvial bore MSGW01 has been set as 1.5 m below the minimum observed groundwater level.

Monitoring bore MSGW03A is periodically dry following low or below average rainfall. Therefore no groundwater level trigger is recommended for MSGW03A, although responses in groundwater level to rainfall will be analysed annually. For alluvial bores not listed above (i.e. those bores that have already been undermined), the adopted trigger value for groundwater level is the minimum recorded groundwater level in the historical dataset. Trigger values are shown in Table 6-2.

Groundwater level data for all monitoring bores are shown in Appendix F.

Table 6-2 Groundwater level trigger values for alluvial bores

Bore	Trigger (m AHD)
MSGW04A	21.192
BH26A	16.86
BH01	2.104

Bore	Trigger (m AHD)
BH03	4.087
BH03A	4.181
BH04	7.009
BH05	6.202
BH09	14.52
BH10	17.176
BH11	13.837
BH12	11.625
BH13	13.899
BH14	13.923
BH24A	14.118
BH25A	11.279
MSGW01	38.601

Water pressure drop within porous and fractured groundwater sources is generally expected up to approximately 230 m above mine workings based on monitoring data to date. Hydrographs within these sources will be reviewed annually in combination with a review of subsidence parameters.

Groundwater level trigger values for bores in the porous and fractured groundwater sources are defined in the WMPs of relevant extraction plans using predictions of the hydrogeological model. These trigger values are summarised in Table 6-3. Further investigations within these sources are triggered if an adjacent landholder complains about declining groundwater levels in their bore.

Table 6-3 Groundwater level trigger values for porous and fractured rock bores

Bore	Trigger (m AHD)
BH26B	17.36
BH26C	-95
MSGW03B	26.625
MSGW04C	Bore dry (-97.5)

6.1.3 Groundwater quality

There is considerable natural variability in groundwater pH and EC in both alluvial and porous and fractured rock groundwater sources. In addition, the beneficial uses of this groundwater are limited due to the high EC.

Groundwater quality trigger values provided in Table 6-4 have been developed with reference to historical monitoring data. Groundwater trigger values have been defined for bores in the vicinity of active mining. Monitoring bores BH26C, MSGW03C and MSGW04C are no longer monitored for groundwater quality and therefore no triggers have been assigned for these bores. Minor trigger values have been based on 80th percentile values (and 20th percentile for pH) and major trigger values have been based on maximum values (and minimum values for pH).

Table 6-4 Groundwater quality trigger values

Bore	pH		EC (µS/cm)	
	Minor trigger	Major trigger	Minor trigger	Major trigger
BH26A	5.6–6.3	4.9–10.6	13,544	15,770
BH26B	6.9–7.2	6.6–8.1	7063	8066
MSGW03A	5.6–6.0	5.0–6.4	4995	6370
MSGW03B	7.1–7.5	5.3–8.0	6472	7250
MSGW04A	6.3–6.5	5.7–7.2	9674	14,230
MSGW04B	6.7–7.1	6.6–7.9	8216	8970

6.1.4 Underground water management

The spill level of the Cooranbong underground storage area is approximately -50 m AHD. Based on the observed rate of rise in water levels, a 5 m buffer is to be maintained. Hence, the adopted trigger value for the Cooranbong underground storage area is -55 m AHD. Should this trigger level be exceeded, it will be necessary to reduce inputs to the storage and/or increase the extraction rate.

No trigger is defined for underground water transfers. An annual water balance is undertaken to verify that the licensed volume of groundwater extraction has not been exceeded.

6.1.5 Discharge water quality triggers

Water quality concentration limits LDP003 at the MMAS and LDP004 at the MSSS specified by EPL 365 are summarised in Table 6-5. Monitoring of these parameters is required daily during discharge. No volumetric limits for LDP003 or LDP004 are specified by EPL 365.

Table 6-5 LDP water quality concentration limits

Parameter	Units	100 percent concentration limit
Oil and grease	mg/L	10
pH	pH units	6.5–8.5
TSS	mg/L	50

6.2 Performance criteria

Performance criteria has been developed from baseline information and the water management performance measures specified by Table 4 of development consent SSD-5144 presented in Table 1-3. The performance criteria have been developed to ensure that impacts as a result of mining operations are not greater than those predicted by the environmental impact assessments for the approved Mandalong Southern Extension Project and subsequent modifications. The triggers presented in Section 6.1 have been developed to prompt specific actions (identified in the trigger action response plans (TARPs) provided in Appendix G) to prevent exceedance of the performance criteria. Further information on the approach used to develop performance criteria is provided in the *Northern Operations: Regional Water Management Plan*.

6.2.1 Surface site operations

Surface site operations cover a variety of aspects when considering water management. The performance criteria for surface water management is outlined in Table 6-6.

Table 6-6 Surface site operations criteria

Aspect	Criteria
Potable water usage	Minimise the use of potable water from the public supply for purposes where non-potable water is acceptable and available.
Surface storages	Storages sized in accordance with Landcom (2004) and DECC (2008) and maintained within the capacity of each storage.
Water quality management	Existing clean water diversion structures to be maintained to convey 5% AEP storm event. New clean water diversion structures to be designed, installed and maintained to convey 1% AEP storm event. Dirty water diversion structures to be designed, installed and maintained to convey 5% AEP storm event. Maximise as far as reasonable and feasible the diversion of clean water around disturbed areas on site.
Erosion and sediment control	Minimise disturbance area. Pit top disturbance and other construction activities is to be managed in accordance with the approach and guidelines outlined in the *Northern Operations: Regional Water Management Plan*. Design, install and maintain erosion and sediment controls in accordance with Landcom (2004) and DECC (2008). Where construction works are significant an erosion and sediment control plan and construction environmental management plan will be prepared.
Hydrocarbon management	Chemical and hydrocarbon storage to be in accordance Australian Standard AS1940:2004.

6.2.2 Watercourses

Watercourses are to be managed for water quality and flow volume. Criteria for these aspects are provided in Table 6-7. The geomorphic condition and stability for watercourses are further discussed in Section 6.2.5.

Table 6-7 Watercourse criteria

Aspect	Criteria
Waterfront land and watercourses	Design, install and maintain any infrastructure within 40 m of watercourses generally in accordance with NRAR (2018). Design, install and maintain creek crossings in accordance with NSW Fisheries (2003a; 2033b).
Watercourse quality	Within or below SSGVs provided in Table 6-1 for Morans Creek monitoring points downstream of the MMAS and MSSS.
Flooding	Subsidence levels and post-mining out-of-channel flood depths are within predicted levels (as defined by the Flood Assessment Report undertaken for each extraction plan).

6.2.3 Groundwater environment

Based on the triggers derived in Section 6.1.2 and Section 6.1.3, Table 6-8 presents the groundwater environment management criteria for Mandalong Mine.

Table 6-8 Groundwater environment criteria

Aspect	Criteria
Groundwater level	Groundwater level is above levels provided in Table 6-2 and Table 6-3. Maximum 2 m drawdown at any water supply work.
Groundwater quality	Groundwater quality is within or below trigger values provided in Table 6-4. No complaints from landholders regarding groundwater quality.
Underground water level/storage	Water level is maintained below -55 m AHD.

6.2.4 Discharge management

Discharge management includes both discharge volume and quality. The criteria applied for Mandalong is presented in Table 6-9.

Table 6-9 Discharge management criteria

Aspect	Criteria
Discharge event	Discharge is to be undertaken in accordance with EPL 365 requirements.
LDP004 discharge at MSSS	Discharge is to only occur following reasonable efforts to reuse water held in the Sediment Dam through irrigation and/or evaporation.
Discharge quality	Within or below EPL 365 limits provided in Table 6-5.

6.2.5 Stream health

To manage stream health criteria has been developed based on geomorphic condition and waterway stability. The criteria are applicable to the watercourse stability of potentially impacted reaches of Morans Creek, Wyee Creek and Mannering Creek. Table 6-10 presents the criteria for stream health.

Table 6-10 Stream health criteria

Aspect	Criteria
Geomorphic condition and watercourse stability	
Incisional processes and instabilities Waterway bed condition	Occurrence of erosional processes does not occur as a result of subsidence.
Waterway cross sectional area Stream gradient	Change in cross sectional area and stream gradient does not vary beyond the predictions of the subsidence modelling.
Watercourse subsidence	
Third order and above streams GDEs	No connective cracking between the surface, or the base of the alluvium, and the underground workings. No subsidence impact or environmental consequence greater than minor.
First and second order streams	No subsidence impact or environmental consequences greater than predicted. No connective cracking between the surface and the underground workings.
Aquatic ecology	
Instream/riparian vegetation	No change in vegetation type and density from pervious monitoring rounds.
In situ water quality	No significant change in impact sites when compared to reference/baseline sites.
Macroinvertebrate metrics	No significant change in impact sites when compared to reference/baseline sites.

Notes:

- Classification of streams in accordance with Strahler stream order system.
- Detailed performance indicators (including impact assessment criteria) for each of these performance measures will be detailed in the various management plans that are required under this consent.
- Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.

6.3 Trigger action response plans

TARPs are provided in Appendix G for:

- Surface site operation.
- Watercourses.
- Groundwater environment.
- Discharge management.
- Stream health.

7. Site-specific reviews and reports

7.1 Flood modelling

A flood model has been developed for the Mandalong Valley to identify and quantify the potential changes to the nature of flooding as a result of mining activities at Mandalong Mine. The two-dimensional hydrodynamic flood model is updated as part of each extraction plan to determine the impacts of mine subsidence on flood levels, creek stability and ponding.

The flood model is validated by comparing flood monitoring results with the modelled predictions. The model results are reviewed against the monitoring data annually, with model recalibration undertaken as required as part of each extraction plan.

7.2 Flood assessment reports

Flood assessment reports are completed for each extraction plan by an independent environmental consultant. The flood assessment report provides a pre- and post-mining flood assessment for the study area and for each property within the study area. The flood assessment report details the predictions associated with post-mining conditions for each extraction plan that will allow for the assessment against the flooding performance criteria in Table 6-7.

7.3 Hydrogeological model

The groundwater model validation program compares groundwater monitoring results with modelled groundwater level predictions on an annual basis. Where the validation process identifies significant variances between monitored and predicted results or that the hydrogeological model is underestimating drawdown in groundwater level, then a recalibration process may be required to be undertaken in consultation with an independent reviewer.

7.4 Groundwater monitoring review

A review of groundwater level and quality monitoring results is prepared annually by a specialist and summarised in the Annual Review. Results are analysed with reference to historical trends, trigger values specified in Section 6.1 and meteorological monitoring data.

7.5 Site water balance

The site water balance will be reviewed and revised annually as a minimum or as necessary when there are changes to operations. The results of the site water balance will be reported in the Annual Review for Mandalong Mine.

8. References

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Petersen, RC (1992), The RCE: A Riparian, Channel, and Environment Inventory for small streams in the agricultural landscape, *Freshwater Biology*, 27(2), 295–306.

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APPENDIX A – Correspondence with regulators

SUBMISSION FOR APPROVAL DETAILS	Revision	Circulation date	Feedback date	Approval date
	0	24 March 2016		
	1	24 November 2016	10 October 2017	
	2	17 November 2017		6 December 2017
	3	13 June 2018		15 November 2018
	4	12 August 2019		5 November 2019
	5	19 December 2019		

CONSULTATION DETAILS	Department	Circulation date	Feedback date
	Environment Protection Authority	23 February 2016	2 March 2016
	Department of Primary Industries – Water	23 February 2016	16 August 2016
	Department of Primary Industries – NSW Fisheries	23 February 2016	

APPENDIX B – Consultation outcomes

Comment	Response
Department of Primary Industries – Water (16 August 2016)	
The Environmental Impact Statement identified that groundwater inflows are predicted to increase from 712ML/yr at the existing operation to a maximum of 2158ML/yr with the southern extension. The proponent currently has a licence to take groundwater from the fractured rock and porous rock aquifer under the *Water Act 1912* for 1825ML/yr. The proposal to increase the maximum groundwater take to 5.9ML/d (2154ML/yr) will require the proponent to obtain additional entitlement. There is no discussion within the WMP on how or when this additional entitlement will be sought. DPI Water notes that an embargo order was made on 5 February 2016 covering groundwater within the Hunter water shortage zone, which includes the area of the Mandalong Mine (http://www.water.nsw.gov.au/__data/assets/pdf_file/0008/590921/160205-huntergroundwater-embargo-order.pdf). The proponent is requested to liaise with DPI Water to discuss options for obtaining the necessary entitlement.	As discussed in Section 3.3, the hydrogeological model developed as part of the Mandalong Southern Extension Project has been re-calibrated to updated calculated groundwater make. The re-calibrated model predicts inflows to the mine to peak in 2036 at approximately 2.1 ML/day (GHD 2017). These hydrogeological model predictions were used in the water balance to predict the volume of water transferred from the Cooranbong underground storage, which requires licensing (refer Section 3.5). The peak annual volume of groundwater extracted from the Cooranbong underground storage is predicted to be 1265 ML, which is below the current licensed volume of 1825 ML held by Centennial Mandalong under water access licence 39767. As such, no additional entitlements are required for Mandalong Mine.
Surface water flow monitoring detailed within the WMP should be improved. Surface flow is only monitored quarterly with a handheld device at surface monitoring locations. This is insufficient to assess against performance criteria and possible impacts related to both subsidence and water discharges. The monitoring plan should be updated to include appropriate surface flow monitoring to enable assessment against performance criteria.	Centennial have installed new gauging equipment in Morans Creek as discussed in Section 4.2.2.
The development consent requires development of detailed performance criteria, including trigger levels, for downstream flooding impacts. This has not been addressed in the WMP. The only monitoring proposed is that the condition of major flood paths is inspected every six months or following a flood event. The monitoring program associated with flooding should address downstream flooding impacts.	The WMP has been updated with the a TARP for flooding impacts, presented in Appendix G.

Comment	Response
The development consent requires "a program to monitor and report on macroinvertebrate health and ecotoxicity parameters downstream of mine-water discharges." The WMP does not address this condition and states that "as no aquatic ecology monitoring is undertaken at Mandalong Mine, there is no consideration of TARPs covering this aspect with respect to stream health."	This development consent condition specifically applies to CES and LDP001 discharges of mine water from that site (which were previously managed by Mandalong Mine and are now managed as part of Northern Coal Services). Further detail on the aquatic ecology and ecotoxicology monitoring program for CES is provided in the *Northern Coal Services: Water Management Plan*.
DPI Water notes that as part of development of the Extraction Plan there are additional requirements that need to be addressed within the Water Management Plan, including additional information on groundwater monitoring and responses and flooding assessments. The proponent notes that flooding assessments will be undertaken as part of extraction plans. DPI Water requests that all additional requirements are addressed in an updated WMP as part of the Extraction Plan and this is submitted for further review.	Extraction plans are required to be developed for all secondary workings. Each extraction plan includes a WMP with specific requirements, including on groundwater monitoring and responses and flooding assessments. Refer to specific extraction plans for more information.
With regards to DPI Water concerns regarding water quality, these concerns were addressed by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) in their report "Groundwater RTS Support – Mandalong Mine" (G1445B). Recommendations were proposed by AGE to reduce any human induced sampling error in the future monitoring of the network and to confirm the cause of historical erratic records. DPI Water requests information on whether the recommendations have been implemented.	As discussed in Section 5.2.1, historical variability in EC was attributable to sampling of bores by bailing without initial purging. Since January 2015, monitoring of bores has been undertaken low flow techniques where possible with initial purging until EC and pH stabilise. Additionally, bores that were identified as being regularly submerged by surface water have been frequently purged to remove potential influence of surface water on monitoring results. Following the update of the groundwater monitoring methodology, variability in observed EC has reduced.
Centennial Mandalong committed to installing additional groundwater monitoring bores within areas of groundwater dependant ecosystems. DPI Water requests information about the progress towards fulfilling this commitment.	As discussed in Section 4.3.1, monitoring bores in the vicinity of GDEs where depth of cover is less than 200 m will be established as part of the relevant extraction plan WMP. Refer to specific extraction plans for more information.

<table>
<tr><th>Comment</th><th>Response</th></tr>
<tr><td>Centennial Mandalong committed to augmenting the existing groundwater monitoring network within the Southern Extension Area with nested monitored bores at locations where the depth of cover is less than 250 m. This is primarily throughout the north -eastern area within the Wyee and Mannering Creek catchments. Bores are to be monitored for groundwater levels, pH and EC. DPI Water requests information about the progress towards fulfilling this commitment.</td><td rowspan="2">Additional monitoring bores are recommended above the Mandalong South workings. The final locations of these monitoring bores are dependent on the final location of exploration drilling, but are recommended to include areas where the depth of cover is less than 250 m.</td></tr>
<tr><td>Centennial Mandalong committed to installing additional groundwater monitoring bores and/or vibrating wire piezometers within the Southern Extension Area to monitor the height of groundwater depressurization prior to extraction of longwalls with lower depth of cover. DPI Water requests information about the progress towards fulfilling this commitment.</td></tr>
<tr><td>Dr Noel Merrick of Hydroalgorithmics Pty Ltd provided several recommendations in the Mandalong Groundwater Review of 18 Mar 2014 (HA2014/4). DPI Water requests information on whether these recommendations have been implemented.</td><td>Outcomes from the review undertaken by Dr Noel Merrick have been addressed as part of the Mandalong Production Tonnage Project: Groundwater and Water Balance Modelling Report (GHD 2016). This document included refinement of the model grid to allow declining enhanced permeability with height above the mine workings. The comment from Dr Noel Merrick regarding radius of inflow have been addressed as part of Mandalong Longwall Panel 22 to 23 Modification: Water Resources Impact Assessment (GHD 2016) where the updated modelled radius of drawdown has been presented. Other comments from Dr Noel Merrick have been addressed as part of the response to submission process as noted in Mandalong Groundwater Review of 18 March 2014 (HA2014/4).</td></tr>
<tr><td>The report text and Figure 3-7 Water Cycle Schematic introduces uncertainty with regards to the final destination of water that has been pumped from the underground workings via bore 20BL173524 into the Borehole Dam. It is uncertain under what conditions water is discharged back into the mine or, as stated in the EIS, discharged into LDP001.</td><td>All water from the underground that is pumped to the Borehole Dam is discharged via LDP001, which is part of the CES. Refer to Northern Coal Services: Water Management Plan for further information.</td></tr>
</table>

Comment	Response
In section 6.1.2 of the report it was mentioned that monitoring of BH22A (Alluvium) would cease. It was noted that a decreasing trend of water levels was observed at this bore. DPI Water considers this bore to be important and insists that monitoring should continue at this bore to confirm stabilisation of the alluvial aquifer water levels as a result of subsidence. Reasonable justification should otherwise be provided by the proponent to show why monitoring could cease at this location.	Visual inspection of the hydrograph for BH22A indicates that over the past two years, levels have stabilised and have been within the range of pre-mining levels. Therefore, monitoring of this bore will cease in 2016.
There is uncertainty if the high electrical conductivity values for surface water monitoring points SW001 and SW002 in Stockton Creek are related to tidal ingress salt water from Warners Bay.	The text in Section 5.1.1 has been amended to make it clear that the water quality at monitoring points SW001 and SW002 are influenced by tidal ingress from Warners Bay.
Implement the recommendations by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) and Hydroalgorithmics.	Refer to previous response regarding the recommendations by AGE and Hydroalgorithmics.
Advise about the progress made towards installing additional groundwater monitoring bores in the Southern Extension area and in the vicinity of Groundwater Dependent Ecosystems as per prior commitments by Centennial Mandalong.	Refer to previous response regarding the installation of additional monitoring bores.
It is recommended that water quality analysis (as per parameters in Table 4-4) be performed monthly for an initial 24 month period on water produced by Bore 20BL173524 and discharged from the mine offsite. The pumping and discharge is to be adequately metered.	Water extracted from the Cooranbong bore includes water from a variety of sources as discussed in the WMP and would not be representative of groundwater inflow quality. Therefore, it is considered that monitoring of water extracted by the bore would provide minimal benefit. Monitoring of water quality from discharge locations is currently undertaken.
The relationships between pumping volumes from Bore 20BL173524, inflow volumes underground and water levels in the underground workings to be monitored and studied further to better understand the underground storage capacity and inflows at the various underground workings.	As specified in Section 4.3.2, underground water transfers and monitoring of underground water levels is undertaken at Mandalong Mine.
That the water quality graph reporting show the water quality trigger limit values for each parameter.	Water quality trigger values have been added to the baseline water quality graphs for downstream sites in Appendix E.

Comment	Response
Confirm tidal influence on water quality influence. Correct the description of these points to be labelled "downstream" and not "upstream".	Appendix E has been amended to correctly refer to SW001 and SW002 as downstream monitoring points.
NSW Department of Planning and Environment – letter dated 10 October 2017 (responses to components deemed as not satisfactory)	
Section 5 of the Mandalong WMP describes the baseline water quality (72 monitoring sites). Baseline water quality presented in Appendix C. No baseline data on flow monitoring provided in the WMP. It is noted that flow monitoring results for Morans Creek are provided in the Longwall 22-23 Extraction Plan. Section 4.2.1 indicates that flow low monitoring using a hand held impeller will be undertaken on various creeks, including Wyee Creek, Mannering Creek and Buttonderry Creek, which will occur for two years prior to mining. *Include baseline flow monitoring data in the Mandalong WMP*	Information on baseline flow monitoring at Morans Creek is provided in Section 5.1.

Comment	Response
Table 4-1 of the RWMP summarises the performance criteria for surface water management across all sites. These are in-line with Table 4 of the Mandalong consent. Section 6.2 of the Mandalong WMP provides performance criteria for surface site operations, watercourses, groundwater, discharge management and stream health. Performance criteria form the basis of the TARPs in Appendix E of the Mandalong WMP. Table 6-3 does not include required sizing for new clean water diversion structures (i.e. to convey 100 year ARI storm event). Water quality default trigger values (DTVs) included in Table 6-1. Section 6.1.1 indicates that site-specific trigger values (SSTVs) will be derived within 2 years or 24 points of data. It is noted that water quality monitoring for Morans and Stockton Creeks has been undertaken since 1999 and for Wyee and Mannering Creeks since 2011. SSTVs should therefore be able to be derived for these creek systems. Criteria for watercourse flow is based on the 50th percentile historical dry weather flow volume. As noted above, Mandalong WMP does not provide any baseline flows for watercourses upon which this criteria could be assessed. Criteria for flooding is based on predicted post-mining out-of-channel flood depths. The Mandalong WMP does not provide data on these predicted depths. No criteria is included for stream and riparian vegetation health. It is noted that this information is included in Table 5-5 of the DMP. *Include sizing requirements for new clean water diversion structures (i.e. to convey 100 year ARI storm event) in Table 6-3 of the Mandalong WMP.* *Include SSTVs for Morans, Stockton, Wyee and Mannering Creeks in Table 6-1 of the Mandalong WMP.* *In order to allow assessment of performance criteria for water flows and flooding, include data on baseline flows for watercourses and predicted post-mining out-of-channel flood depths in the Mandalong WMP.* *Include performance criteria for stream and riparian health in the Mandalong WMP (refer to Table 5-5 of the DMP).*	Table 6-6 updated with performance criteria stated within *Northern Operations: Regional Water Management Plan*. Section 6.1 includes the SSGVs derived for the operations currently with a commitment to include any further SSGVs as part of extraction plan WMPs. Flow monitoring is currently undertaken at Morans Creek. Data for this is provided in Section 5.1.2. Predictions for post-mining out-of-channel flood depths are determined at each extraction plan as part of the Flood Assessment Report. This is further detailed in Section 7.2. Relevant information from Table 5-5 of *Northern Operations: Discharge Management Plan* is considered within this WMP. Section 6.2.5 includes the necessary performance criteria for stream and riparian health.

Comment	Response
A high level summary of the surface and groundwater monitoring across all sites is provided in Section 5.7 of the RWMP. Site-specific surface water monitoring program described in detail in Section 4.2 of the Mandalong WMP. Program includes weekly inspections for water management structures, quarterly water quality monitoring at all sites and visual watercourse stability monitoring. It is noted that the Extraction Plan for Longwalls 22-23 (April, 2017) also indicates that photographic monitoring would be undertaken to monitor stream conditions. This is not reflected in the Mandalong WMP. Section 4.2.1 indicates that flow monitoring using a hand held impeller will be undertaken on various creeks, including Wyee Creek, Mannering Creek and Buttonderry Creek, which will occur for two years prior to mining. In response to concerns raised by DPIWater, Centennial has indicated that it is currently installing new gauging equipment associated with the waterways potentially impacted by underground mining (Appendix A). No detail of this monitoring is provided in the Mandalong WMP. The Mandalong WMP does not include a program to monitor or report on the condition of stream and riparian vegetation in the watercourses on site and downstream of the site. It is noted that the LDP001 is now managed as part of the Northern Coal Services site and that the aquatic ecology and ecotoxicology monitoring program is described in the site specific WMP. Section 4.2.3 of the Mandalong WMP discusses what remediation of tunnel erosion “should” consider and “recommends” tunnel erosion surveys of active existing areas prior to disturbance. No clear commitment of what will be done is included. Site-specific groundwater monitoring program described in detail in Section 4.3 of the Mandalong WMP. It is noted that DPI-Water requested information on the status of installation of additional groundwater bores within the Southern Extension Area. The Department is satisfied that this information will be included in future EPs and updates to the Mandalong WMP as mine progresses into this area. *Include photographic monitoring to monitor stream conditions (in accordance with the EP for*	Additional details added to Figure 4-4, Figure 4-4 and Figure 4-5, including the existing programs on visual monitoring and photographic points presented as part of the WMP for the extraction plan for longwall 22 to longwall 24A. Flow monitoring is discussed in Section 4.2.2 with baseline flow data presented in Section 5.1.2. Section 4.5 includes additional details on monitoring and reporting systems in place for stream health and riparian vegetation within areas of extraction and downstream. Section 4.2.3 updated to provide clear commitments regarding tunnel erosion.

Comment	Response
longwalls 22-23). *Include more detailed information of water flow monitoring in the Mandalong WMP.* *Include a program to monitor and report on the condition of stream and riparian vegetation in the watercourses on site and downstream of the site.* *Include clear commitments to manage tunnel erosion areas, including pre-disturbance surveys and remediation. Indicate under what circumstances remediation would be undertaken.*	
Section 6.2 of the RWMP provides high-level emergency response procedures for unforeseen impacts and pollution incidents. Section 6.3.4 includes incident reporting requirements for the EPA. No incident reporting in accordance with condition 10, Schedule 6 of the Mandalong consent (SSD-5144) included. Appendix E of the Mandalong WMP includes TARPs. - Define “PIRMP” in the first instance. - The Watercourse TARP refers to SSTVs, however these are not included in Section 6.1.1 of the Mandalong WMP (only DTVs listed in Table 6-1). - Trigger 2 of the Watercourse TARP (water quality and flooding) should include notification of the Department in accordance with condition 10, Schedule 6 of the consent. - Trigger 2 of the Groundwater TARP (quality and levels) should include notification of the Department in accordance with condition 10, Schedule 6 of the consent. - TARP response for any exceedances should include preparation of an incident report in accordance with condition 10, Schedule 6 of the consent. *Include incident reporting requirements of consent SSD-5144 in the RWMP and the TARPS with the Mandalong WMP* *Define PIRMP and include in abbreviations list* *Include SSTVs in the Mandalong WMP and refer to relevant SSTVs and DTVs in the watercourse TARP.*	Comments addressed regarding the definition of PIRMP and incident reporting in the *Northern Operations: Regional Water Management Plan*. SSGVs have been included in Section 6.1.1 with references to TARPs where relevant.

Comment	Response
Both the RWMP and the Mandalong WMP should include a document control register to record the document, approval and circulation details.	Document control register has been added at the start of this document.
Update the figures in the Mandalong WMP to reflect the latest mine plan (ie. showing Longwalls 22-24).	Figure 2-4, Figure 2-5, Figure 3-6, Figure 4-1, Figure 4-2, Figure 4-3, Figure 4-4 and Figure 4-5 have been updated with the most recent mine plan.
Update the Mandalong WMP to reflect the water monitoring (including visual monitoring of streams, etc) relevant to Longwalls 22-23, as described in the EP for Longwalls 22-23.	Section 4 has been updated to be consistent with the monitoring requirements of the extraction plan.

APPENDIX C – Mandalong South Surface Site Sediment Dam Discharge Permit

D.1 Water reuse

Prior to the discharge of any water off-site, reasonable attempts must be made to reuse water held in the Sediment Dam through irrigation and/or evaporation.

<table>
<tr><td>Sediment Dam level</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Has irrigation occurred?</td><td>Y/N
Comment:</td><td>Irrigation of vegetated areas within the site boundary should occur when possible.
Cease irrigation if runoff is visible to prevent uncontrolled off-site discharge.</td></tr>
<tr><td colspan="2">Estimated volume irrigated:</td></tr>
<tr><td colspan="2">Date/time of irrigation:</td></tr>
<tr><td rowspan="3">Has evaporation occurred?</td><td>Y/N
Comment:</td><td>No evaporation should occur if wind speeds are likely to result in evaporative mist drift.</td></tr>
<tr><td colspan="2">Estimated volume evaporated:</td></tr>
<tr><td colspan="2">Date/time of evaporation:</td></tr>
</table>

D.2 Discharge water quality

Prior to the discharge of any water off-site, the water quality must be tested and recorded below. If the water quality meets all the conditions detailed below, then release is permitted. If one of the conditions is not met, then the water must be treated further prior to discharge off-site.

<table>
<tr><td>Rainfall recorded for five days prior to discharge</td><td></td></tr>
<tr><td rowspan="4">Has the water been treated (e.g. with flocculants)?</td><td>Y/N</td></tr>
<tr><td>Type:</td></tr>
<tr><td>Amount:</td></tr>
<tr><td>Date/time treated:</td></tr>
</table>

Turbidity (NTU)		
Total suspended solids (mg/L)		Must be less than 50 mg/L for discharge.
pH (pH units)		Must be between 6.5 and 9.0 for release.
Is there any visible oil and grease?		Must not be any visible oil and grease for release.

D.3 Receiving environment water quality

Water quality monitoring of the downstream receiving environment at point MCUS (coordinates 351946.46, 6329032.56) should be undertaken prior to discharge.

Turbidity (NTU)	
Total suspended solids (mg/L)	
pH (pH units)	

D.4 Off-site discharge details

Volume of water discharged	
Method of discharge off-site	
Date/time of discharge	
Rainfall recorded for 24 hours prior to discharge	
Additional comments	

D.4 Discharge approval

Requested by	
Position	
Signature	
Date/time	

Approved by	
Position	
Signature	
Date/time	

APPENDIX D – Watercourse stability monitoring locations

Location	X coordinate	Y coordinate	Location	X coordinate	Y coordinate
1	351646	6330599	58	353429	6332972
2	351504	6330527	59	353304	6332958
3	351362	6330449	60	353252	6332918
4	351194	6330504	61	353207	6332880
5	351302	6330383	62	353149	6332788
6	351178	6330270	63	353055	6332706
10	350696	6330403	64	353006	6332661
11	350564	6330285	65	353012	6332495
14	350805	6329745	66	353007	6332359
15	350633	6329701	67	353062	6332405
16	351795	6330617	68	353033	6332225
17	351846	6330511	69	353056	6332070
18	351860	6330394	70	352943	6332022
19	351883	6330276	71	352815	6332021
20	351838	6330165	72	352785	6331932
21	351840	6330047	73	352697	6331864
27	351378	6329380	74	352690	6331712
28	351333	6329270	75	352578	6331692
29	351222	6329143	DS1	352543	6329560
32	352003	6329525	DS2	352502	6329527
33	352025	6329412	DS3	352459	6329457
34	352062	6329329	DS4	352433	6329411
35	351971	6329253	DS5	352326	6329372
36	351890	6329153	DS6	352107	6329318
37	351913	6329040	MCT1	352209	6332490
55	353717	6333093	MCT10	352111	6332026
56	353613	6333045	MCT11	351981	6332028
57	353508	6333021	MCT12	351880	6332078

Location	X coordinate	Y coordinate	Location	X coordinate	Y coordinate
MCT13	351969	6331897	TC2	351989	6333053
MCT14	352328	6331791	TC3	351879	6333014
MCT2	352363	6332484	TC4	351806	6332994
MCT3	352460	6332418	TC5	351774	6333013
MCT4	352706	6332172	TC6	351688	6332949
MCT5	352527	6332105	TC7	351575	6332925
MCT6	352427	6332051	TC8	351486	6332885
MCT7	352367	6332040	TC9	351388	6332859
MCT8	352292	6332070	TCT1	351812	6333229
MCT9	352217	6332060	TCT2	351862	6333090
TC1	352044	6333078	TCT3	351887	6332937
TC10	351334	6332763			

APPENDIX E – Baseline surface water quality data

E.1 Mandalong Mine Access Site

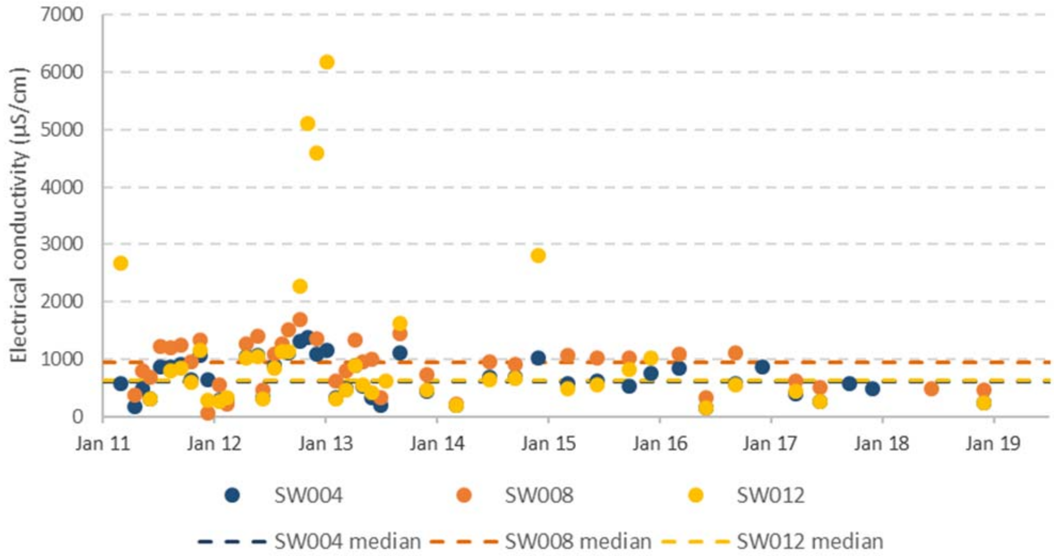
E.1.1 Upstream Stockton Creek

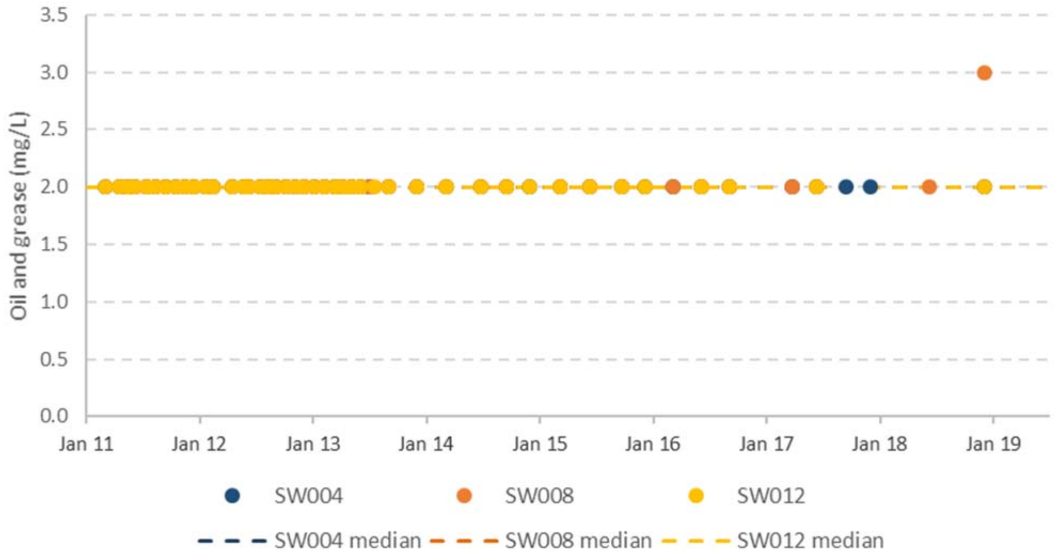
Median water quality results

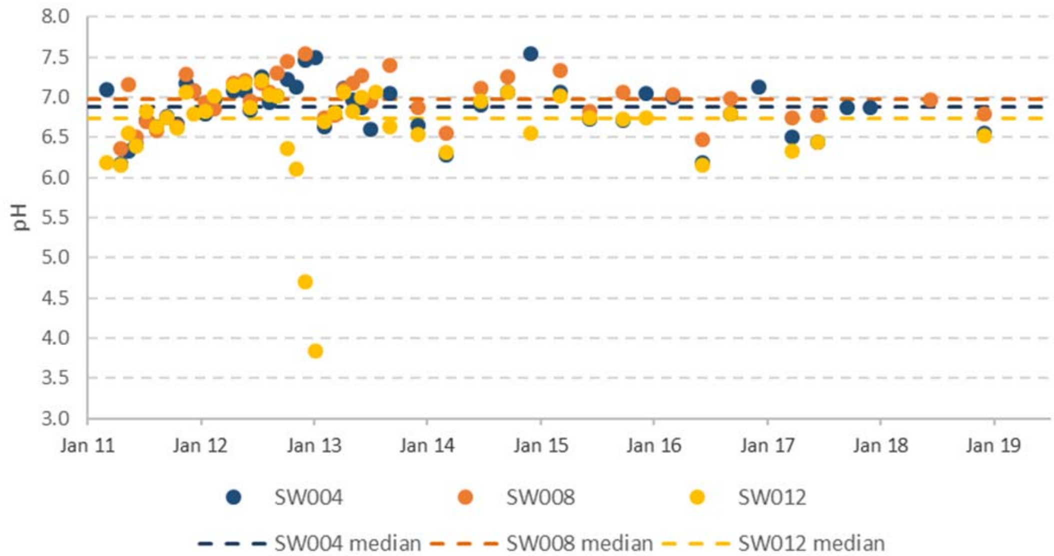
Parameter	Units	SW004		SW008		SW012	
		Count	Median	Count	Median	Count	Median
Physicochemical parameters							
EC	µS/cm	47	621	40	950	40	634
Oil and grease	mg/L	46	2	39	2	42	2
pH	pH units	47	6.88	40	6.98	43	6.74
TDS	mg/L					42	351
TSS	mg/L	47	11	40	8	43	12
Turbidity	NTU	28	21.5	22	26.2	41	33.7
Major ions							
Chloride	mg/L	6	127			5	112
Sulfate	mg/L	6	10			5	10
Total hardness	mg/L	6	81			5	60
Nutrients							
Ammonia	mg/L	6	0.11			5	0.03
Nitrate + nitrite	mg/L	6	0.01			5	0.04
Dissolved metals							
Arsenic	mg/L	6	0.001			5	0.001
Barium	mg/L	6	0.062			5	0.052
Boron	mg/L	6	0.05			5	0.05
Cadmium	mg/L	6	0.0001			5	0.0001
Hexavalent chromium	mg/L	5	0.01			4	0.01
Copper	mg/L	6	0.001			5	0.001
Iron	mg/L	6	2.20			5	1.60
Lead	mg/L	5	0.001			5	0.001
Manganese	mg/L	6	0.991			5	0.177

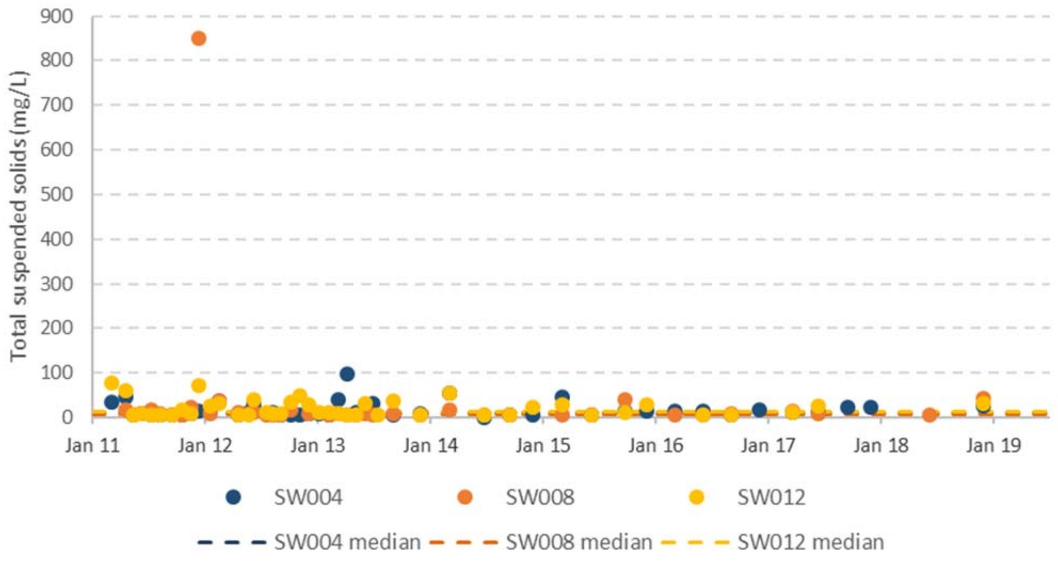
Parameter	Units	SW004		SW008		SW012	
		Count	Median	Count	Median	Count	Median
Mercury	mg/L	6	0.0001			5	0.0001
Selenium	mg/L	6	0.01			5	0.01
Silver	mg/L	6	0.001			5	0.001
Zinc	mg/L	6	0.005			5	0.010
Total metals							
Arsenic	mg/L	6	0.002			5	0.001
Barium	mg/L	6	0.106			5	0.061
Boron	mg/L	6	0.05			5	0.05
Cadmium	mg/L	6	0.0001			5	0.0001
Copper	mg/L	6	0.002			5	0.003
Iron	mg/L	5	4.94			4	4.39
Lead	mg/L	6	0.001			5	0.001
Manganese	mg/L	6	0.452			5	0.177
Mercury	mg/L	5	0.0001			4	0.0001
Selenium	mg/L	5	0.01			4	0.01
Silver	mg/L	6	0.001			5	0.001
Zinc	mg/L	5	0.015			4	0.019
Other parameters							
Cyanide	mg/L	6	0.004			5	0.004
Fluoride	mg/L	6	0.1			5	0.1

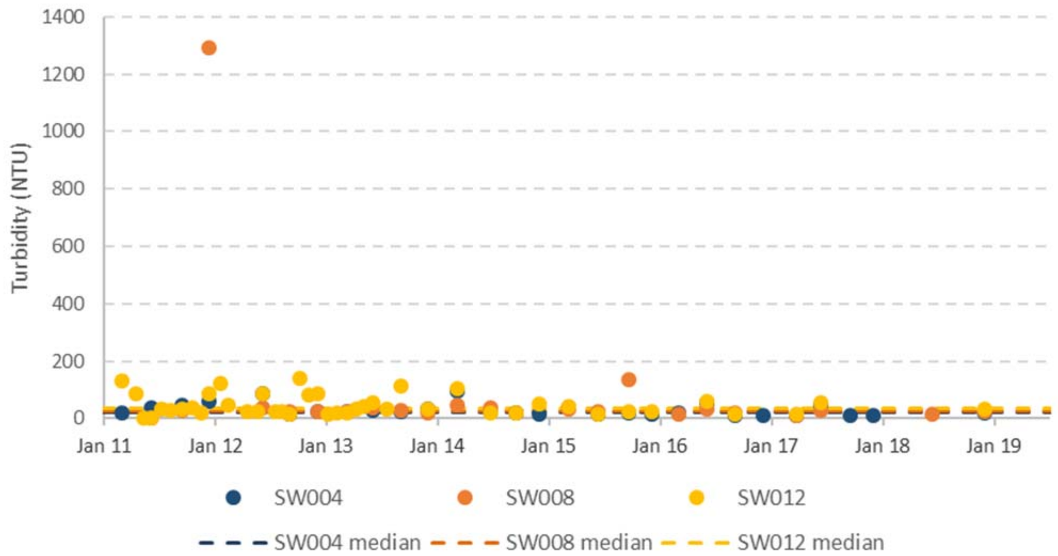
Time series graphs

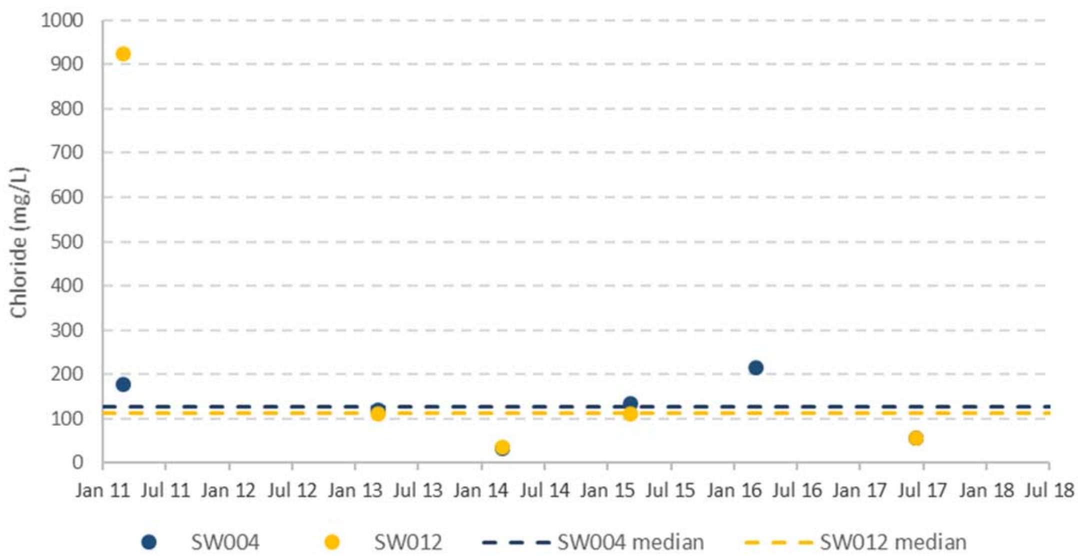




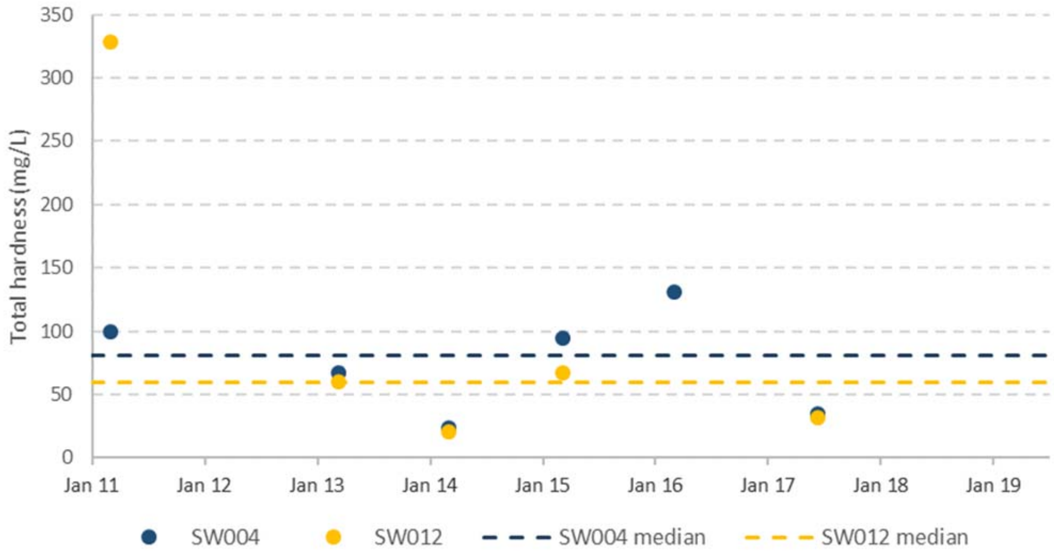


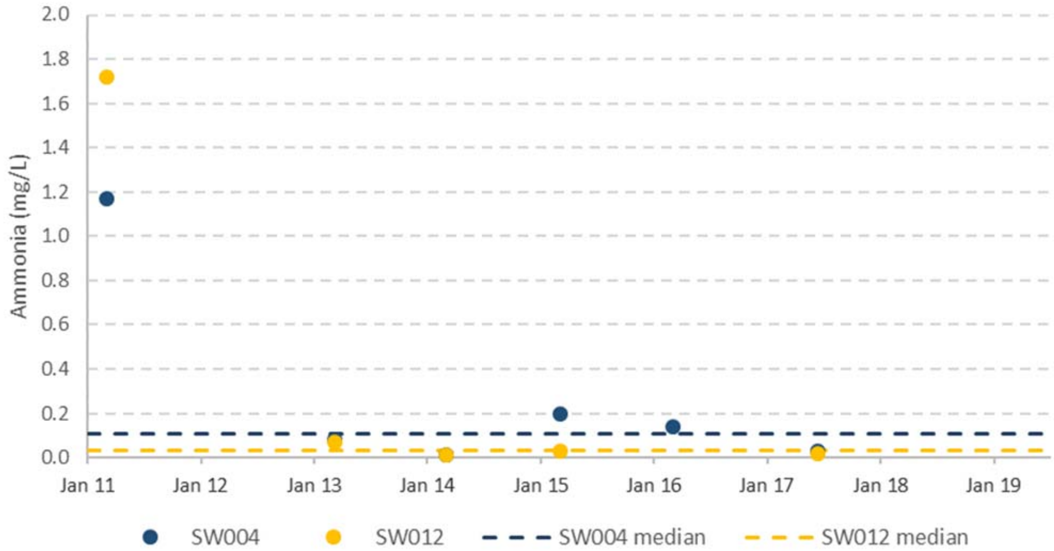

Total suspended solids (mg/L)
900
800
700
600
500
400
300
200
100
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW008
SW012
SW004 median
SW008 median
SW012 median

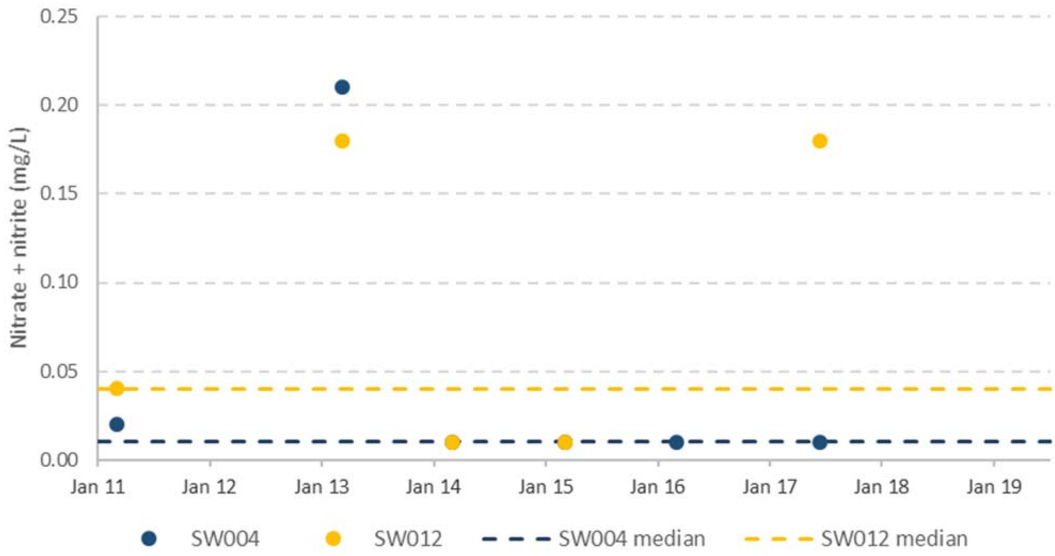

Turbidity (NTU)
1400
1200
1000
800
600
400
200
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW008
SW012
SW004 median
SW008 median
SW012 median

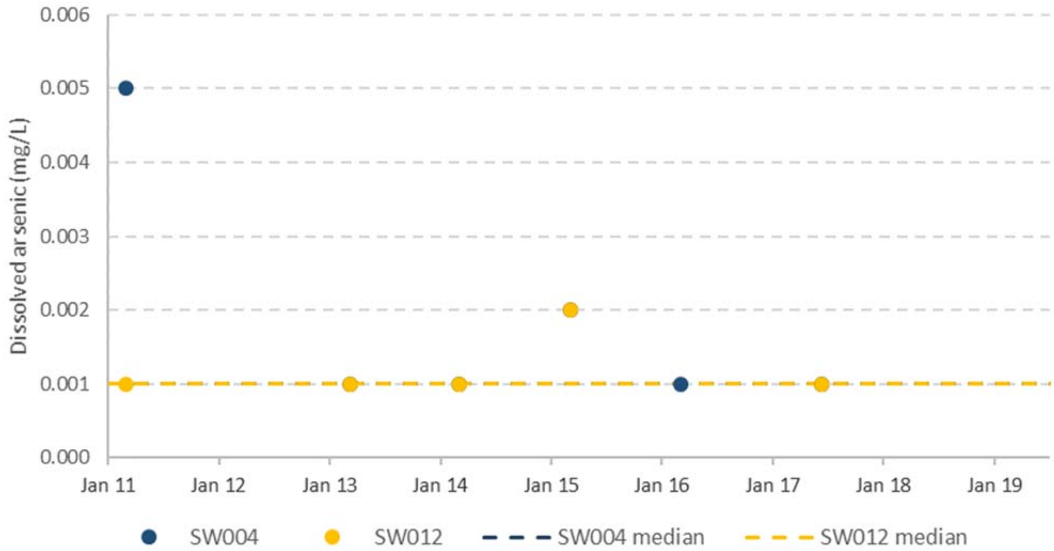

Chloride (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
Jan 11
Jul 11
Jan 12
Jul 12
Jan 13
Jul 13
Jan 14
Jul 14
Jan 15
Jul 15
Jan 16
Jul 16
Jan 17
Jul 17
Jan 18
Jul 18
SW004
SW012
SW004 median
SW012 median

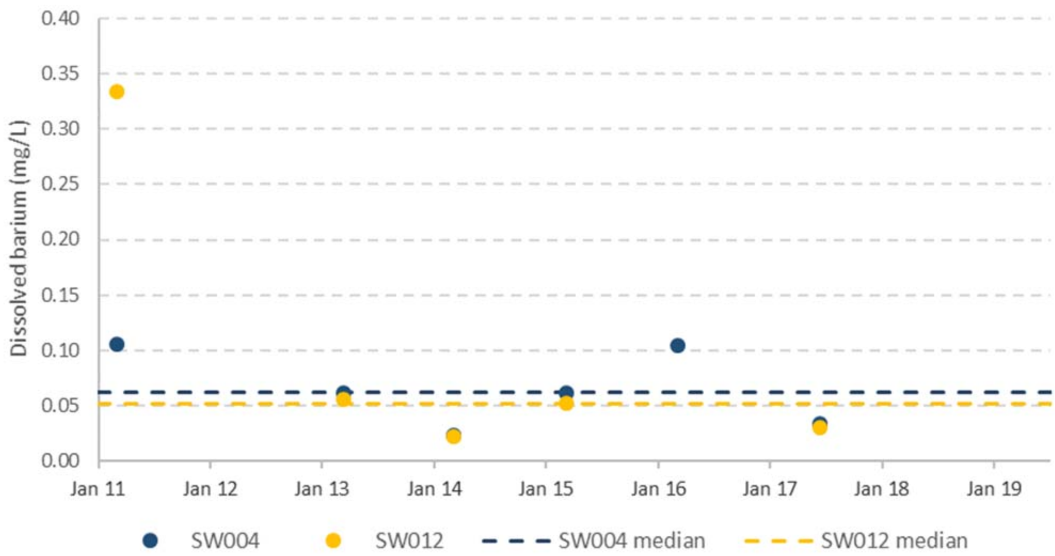

Sulfate (mg/L)
0
2
4
6
8
10
12
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

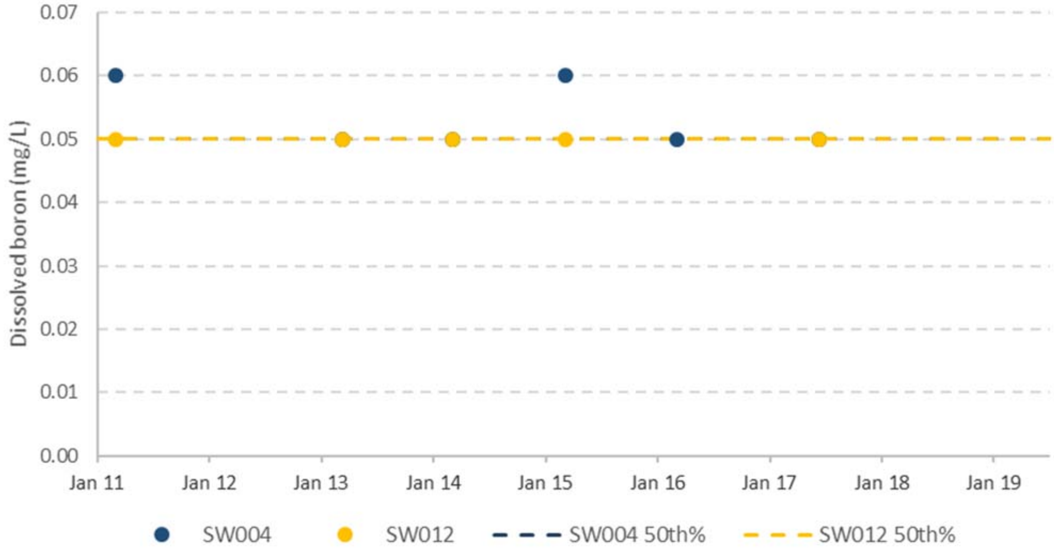

Total hardness (mg/L)
0
50
100
150
200
250
300
350
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

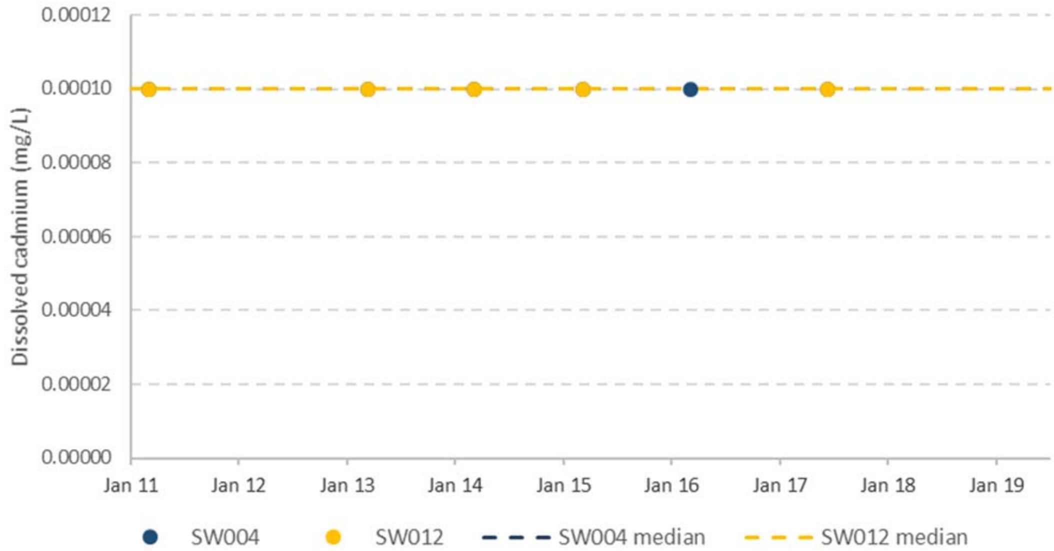

Ammonia (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

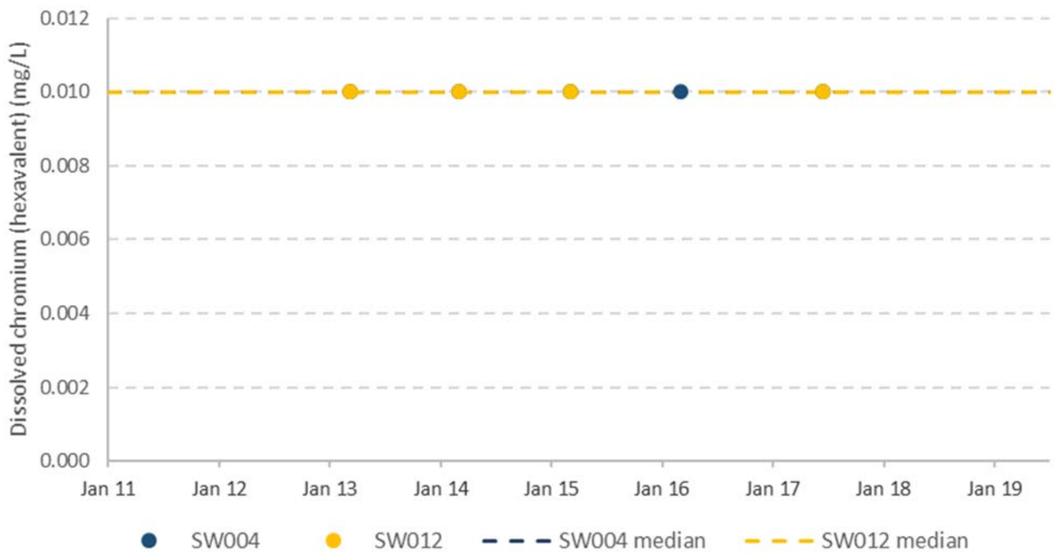

0.25
0.20
0.15
0.10
0.05
0.00
Nitrate + nitrite (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

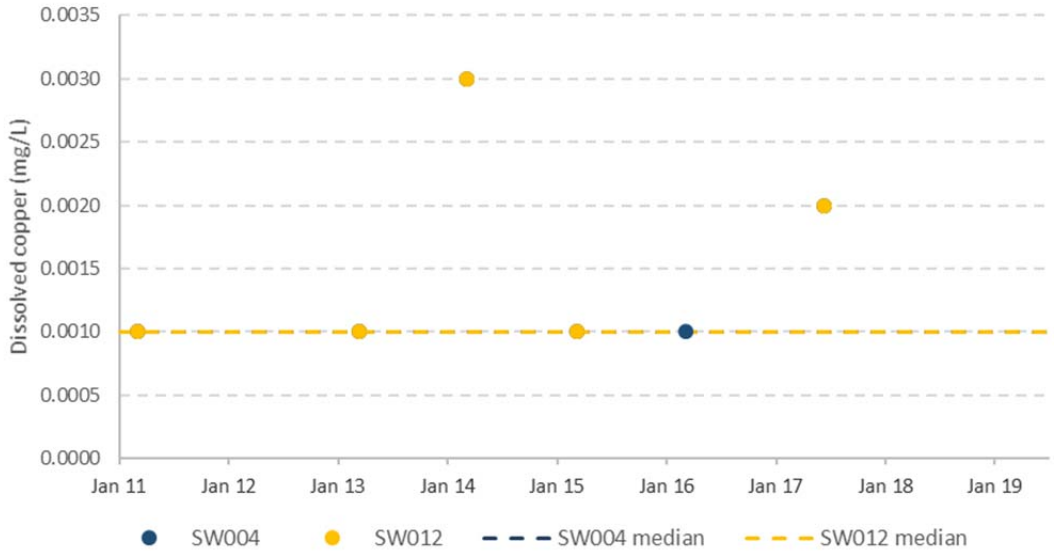

0.006
0.005
0.004
0.003
0.002
0.001
0.000
Dissolved arsenic (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median


0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dissolved barium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

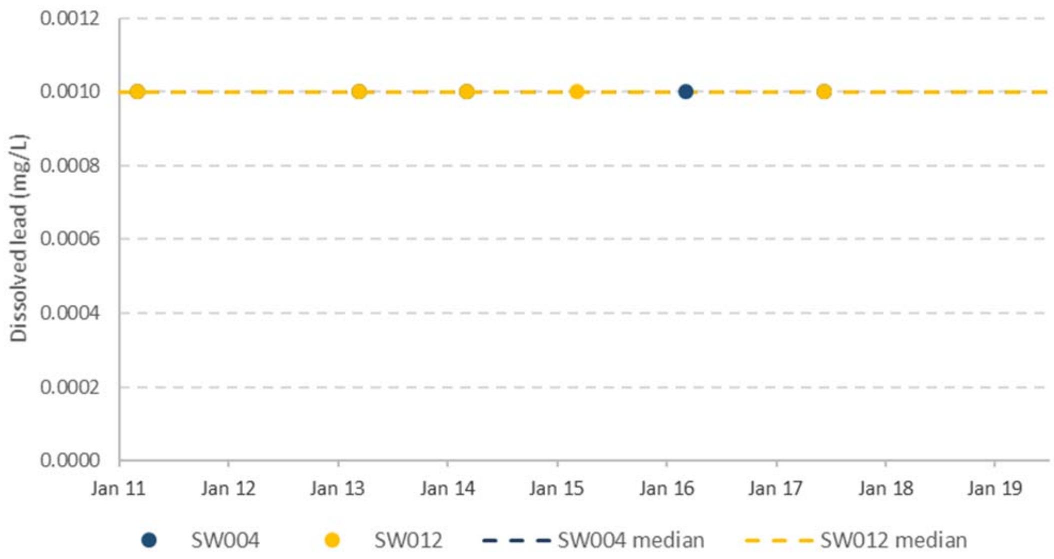

Dissolved boron (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 50th%
SW012 50th%

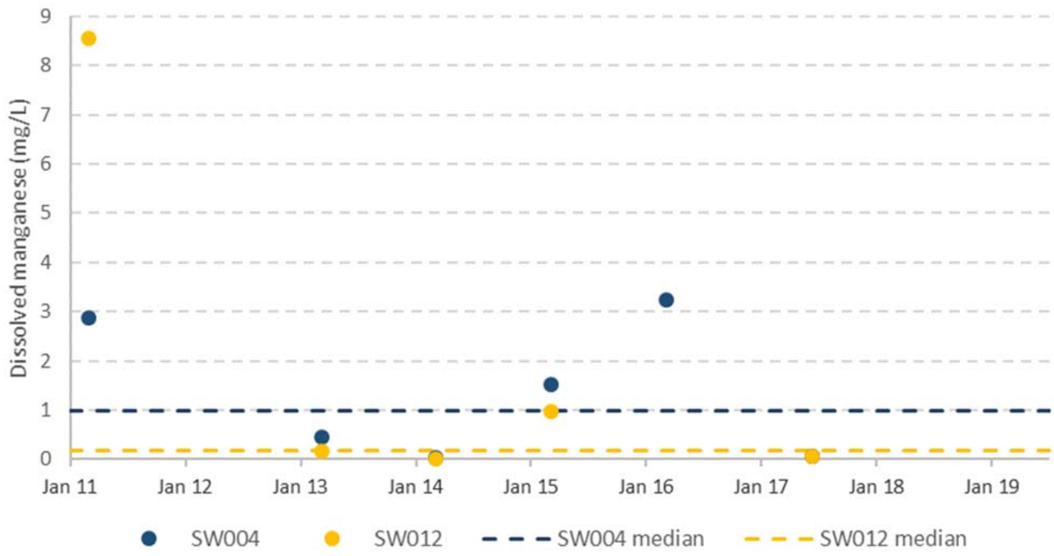

Dissolved cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

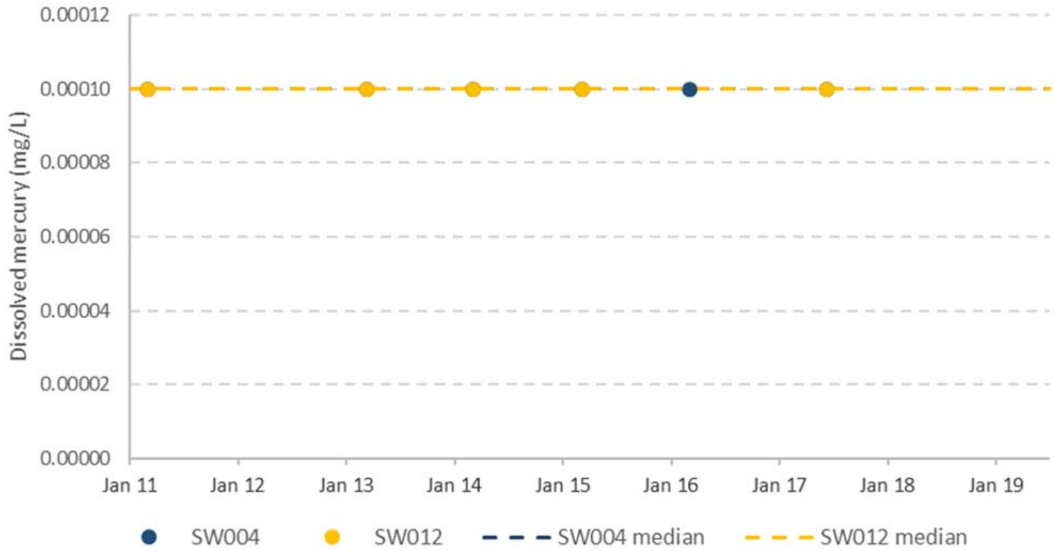

Dissolved chromium (hexavalent) (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

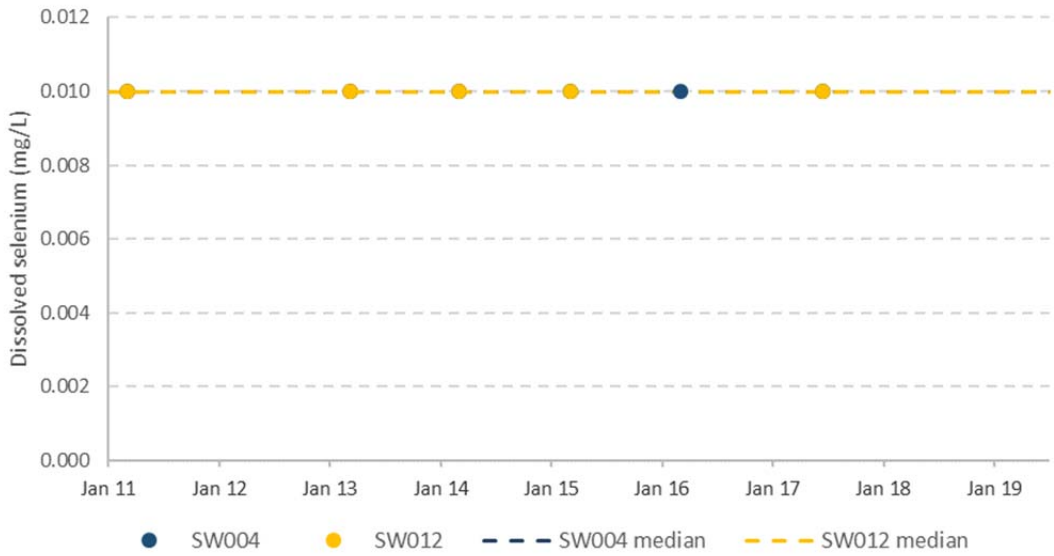

0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved copper (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

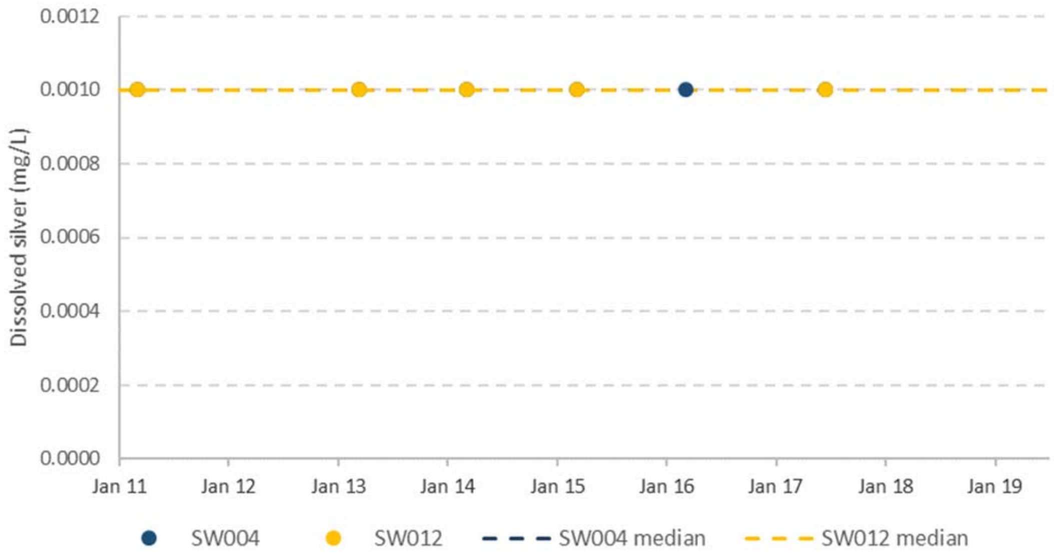

5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dissolved iron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved lead (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

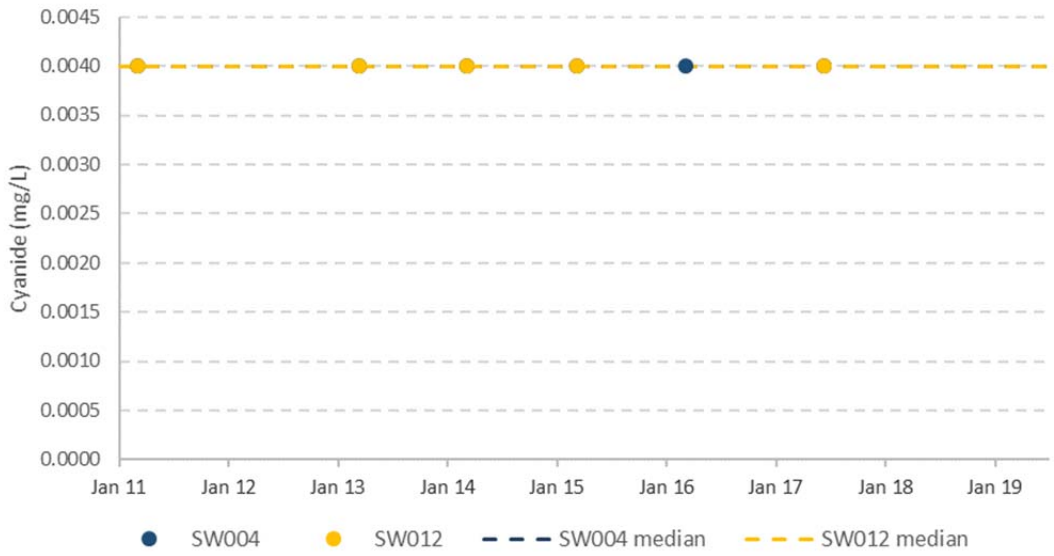

9
8
7
6
5
4
3
2
1
0
Dissolved manganese (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

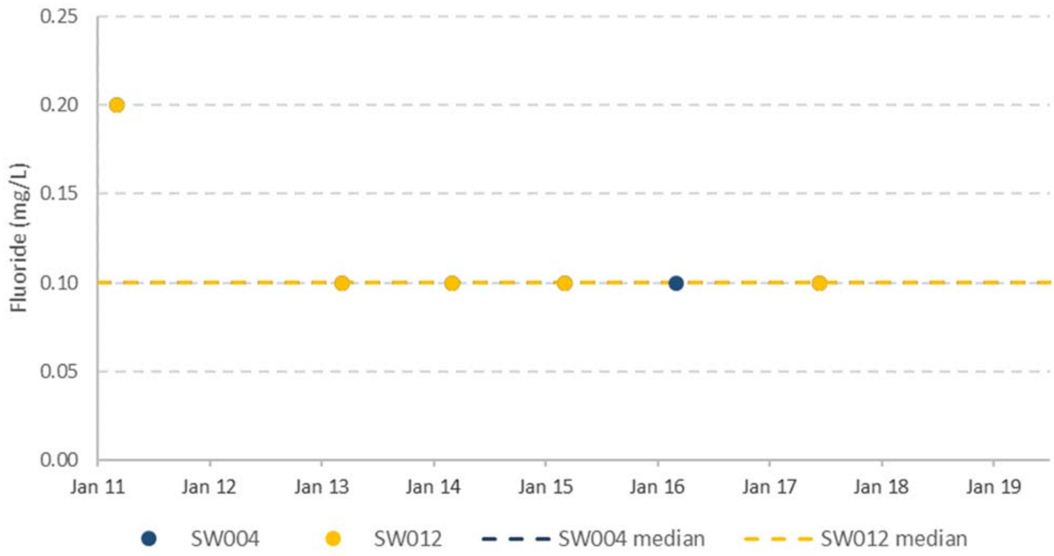

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median


0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median


0.25
0.20
0.15
0.10
0.05
0.00
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW004
SW012
SW004 median
SW012 median

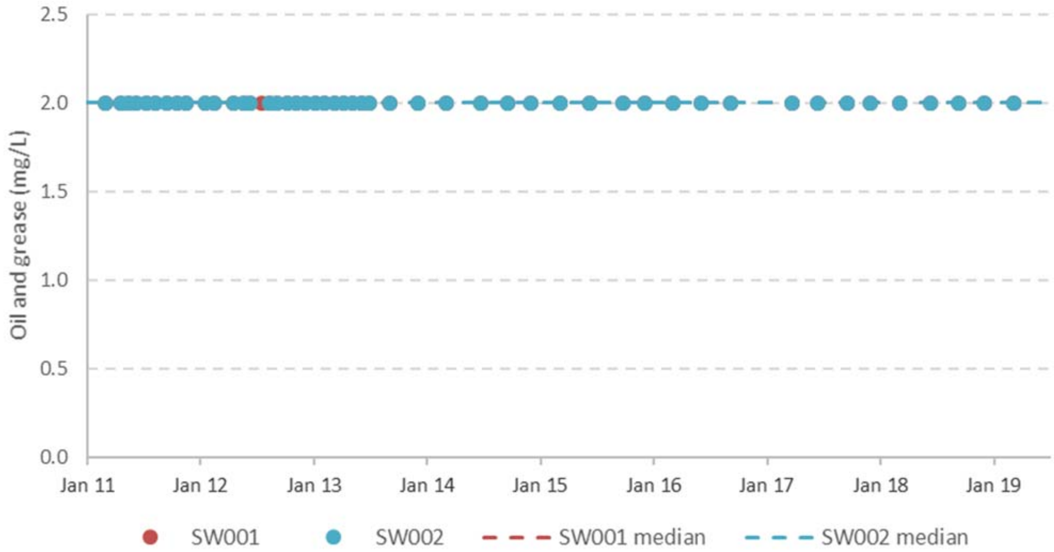
E.1.2 Downstream Stockton Creek

Median water quality results

Parameter	Units	SW001		SW002	
		Count	Median	Count	Median
Physicochemical parameters					
EC	µS/cm	50	28,550	49	3210
Oil and grease	mg/L	49	2	48	2
pH	pH units	50	7.11	49	6.90
TDS	mg/L			49	1580
TSS	mg/L	50	6	49	10
Turbidity	NTU	31	4.5	49	30.1
Major ions					
Chloride	mg/L	8	8645	8	4095
Sulfate	mg/L	8	1419	8	552
Total hardness	mg/L	8	2930	8	1287
Nutrients					
Ammonia	mg/L	8	0.07	8	0.09
Nitrate + nitrite	mg/L	8	0.05	8	0.04
Dissolved metals					
Arsenic	mg/L	8	0.001	8	0.002
Barium	mg/L	8	0.037	8	0.092
Boron	mg/L	8	2.08	8	0.895
Cadmium	mg/L	8	0.0001	8	0.0001
Hexavalent chromium	mg/L	7	0.01	7	0.01
Copper	mg/L	7	0.001	8	0.001
Iron	mg/L	8	0.63	8	0.70
Lead	mg/L	8	0.001	8	0.001
Manganese	mg/L	8	0.061	8	0.495
Mercury	mg/L	8	0.0001	8	0.0001

Parameter	Units	SW001		SW002	
		Count	Median	Count	Median
Selenium	mg/L	7	0.01	8	0.01
Silver	mg/L	8	0.001	8	0.001
Zinc	mg/L	8	0.039	8	0.020
Total metals					
Arsenic	mg/L	8	0.001	8	0.002
Barium	mg/L	8	0.041	8	0.096
Boron	mg/L	8	2.14	8	0.875
Cadmium	mg/L	8	0.0001	8	0.0001
Copper	mg/L	8	0.003	8	0.003
Iron	mg/L	7	1.24	8	3.78
Lead	mg/L	8	0.001	8	0.001
Manganese	mg/L	8	0.079	8	0.201
Mercury	mg/L	7	0.0001	7	0.0001
Selenium	mg/L	8	0.01	7	0.01
Silver	mg/L	8	0.001	8	0.002
Zinc	mg/L	7	0.033	7	0.018
Other parameters					
Cyanide	mg/L	8	0.004	8	0.004
Fluoride	mg/L	8	0.6	8	0.4

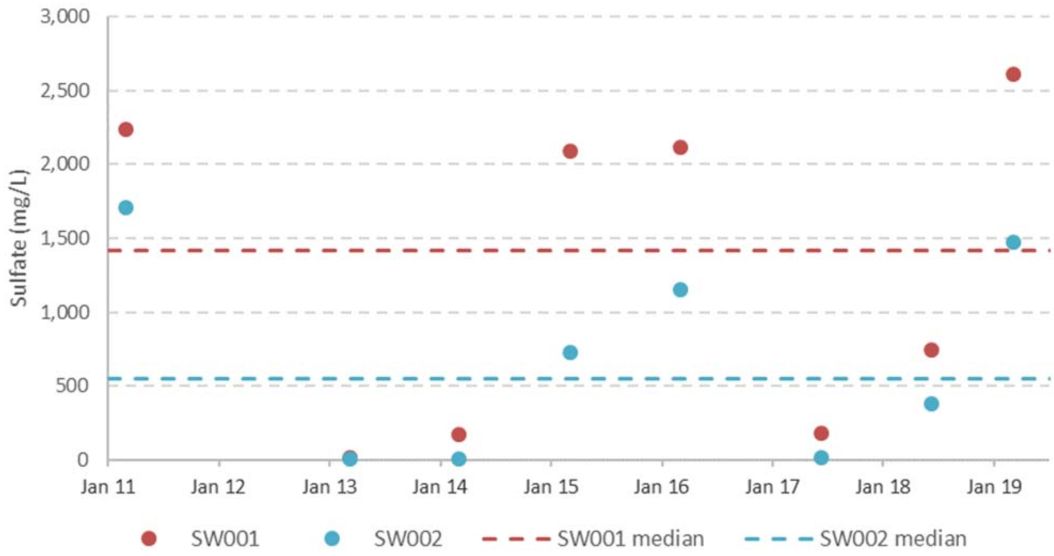
Time series graphs



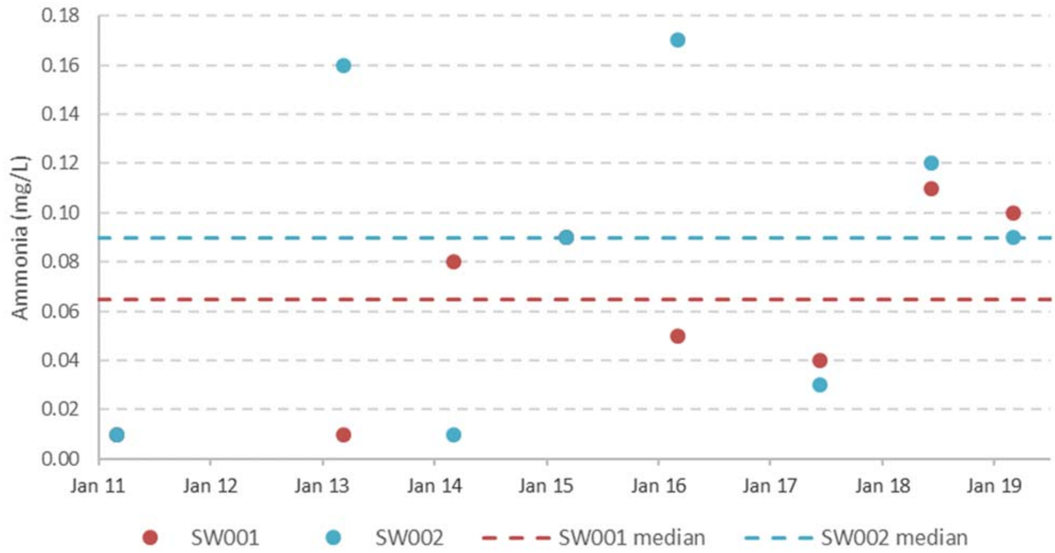

Total suspended solids (mg/L)
70
60
50
40
30
20
10
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


Turbidity (NTU)
70
60
50
40
30
20
10
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


Chloride (mg/L)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


3,000
2,500
2,000
1,500
1,000
500
0
Sulfate (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

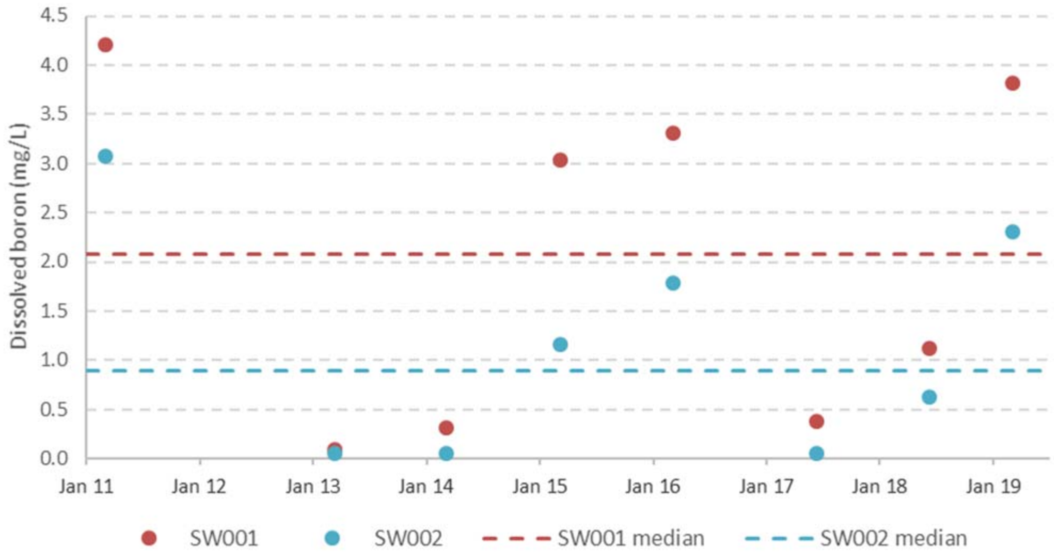

7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Total hardness (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

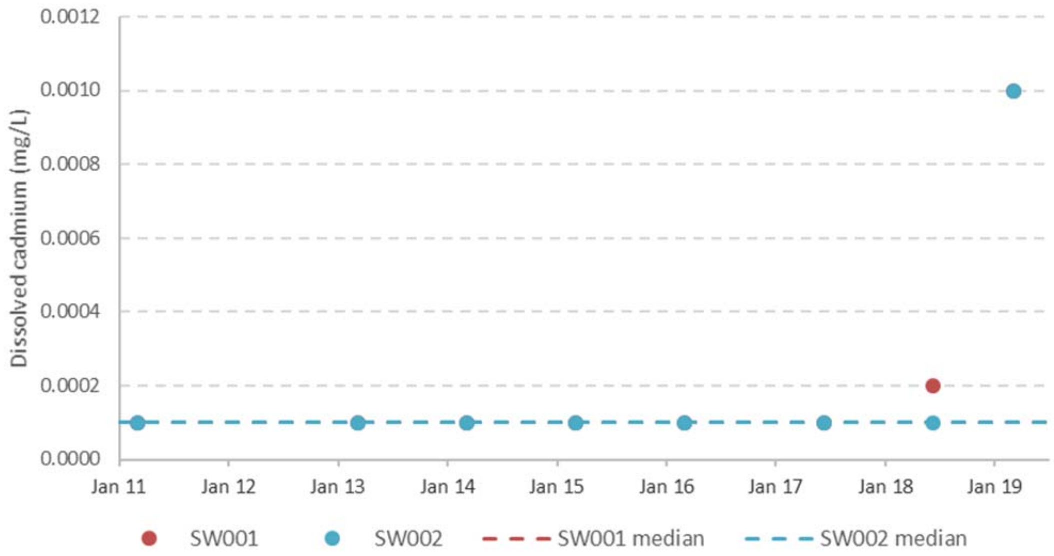

0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Ammonia (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

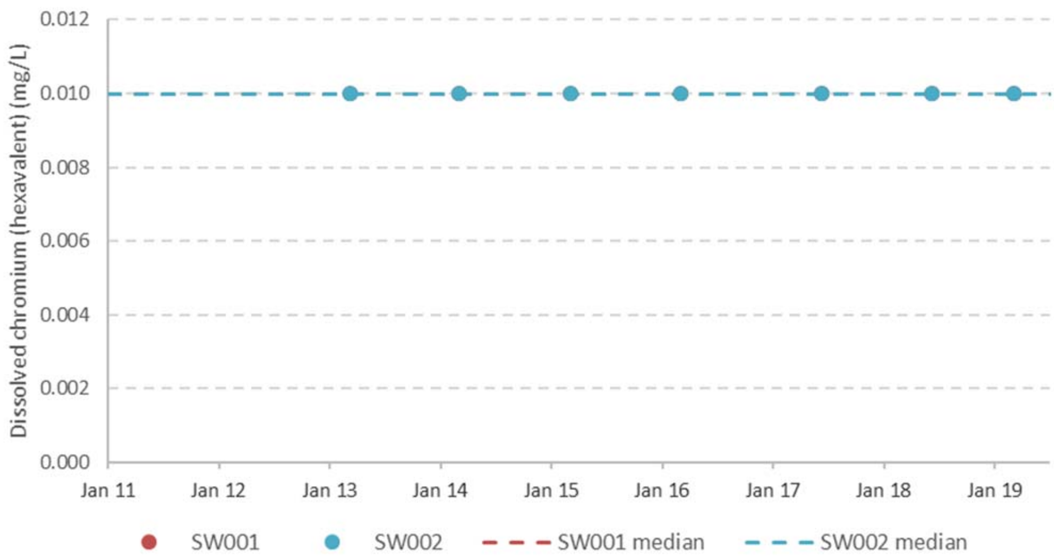

Nitrate + nitrite (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

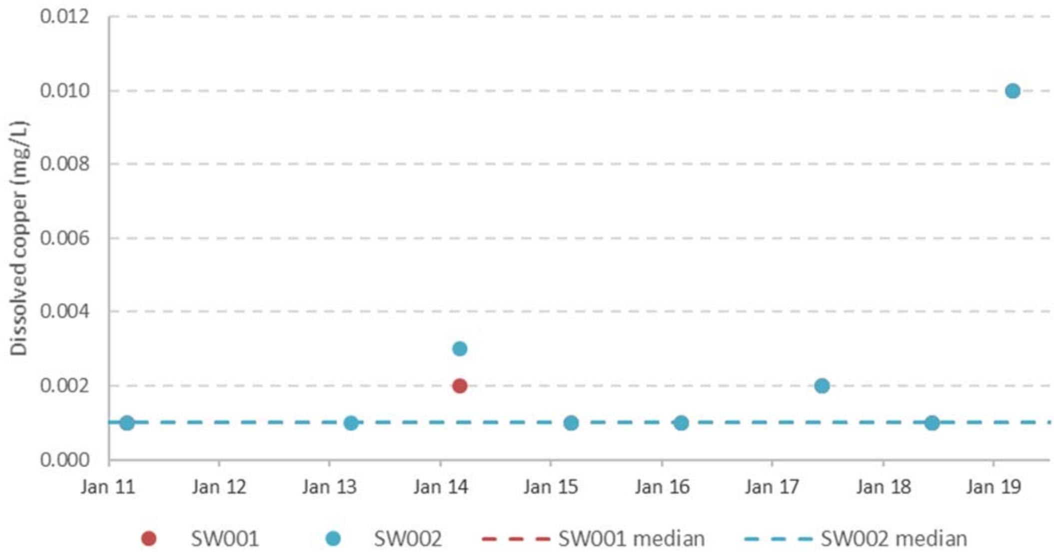

Dissolved arsenic (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


Dissolved barium (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

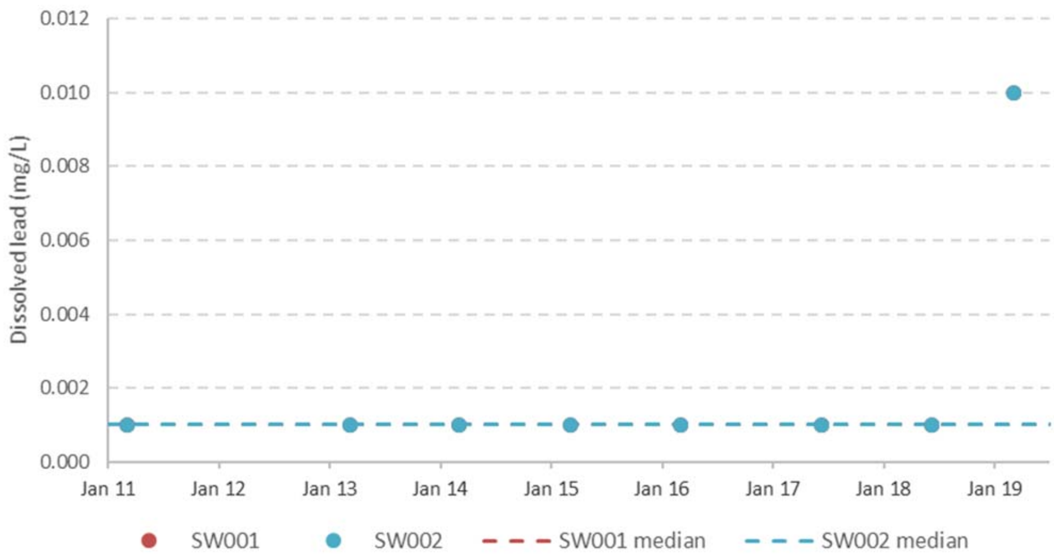

4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dissolved boron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

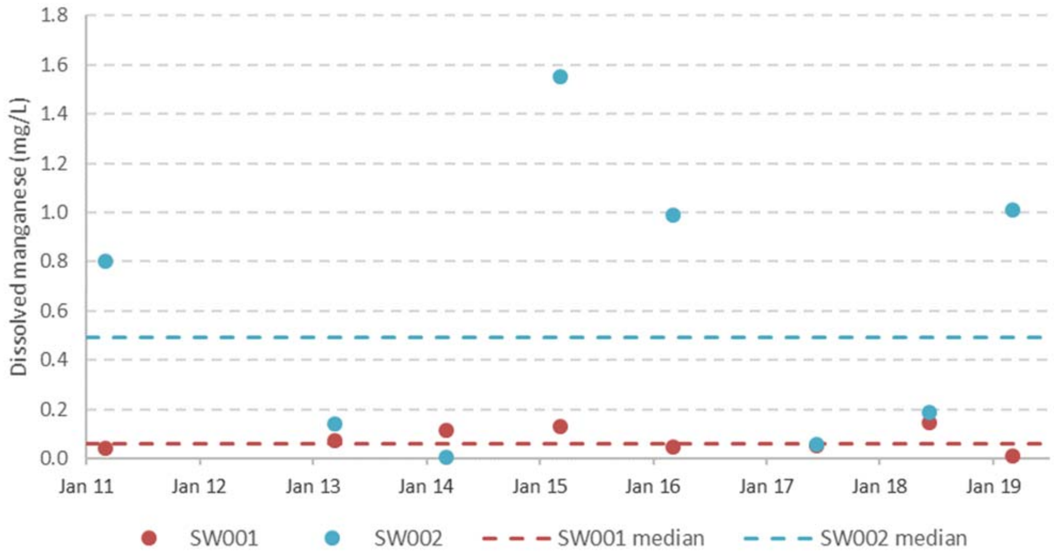

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved cadmium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

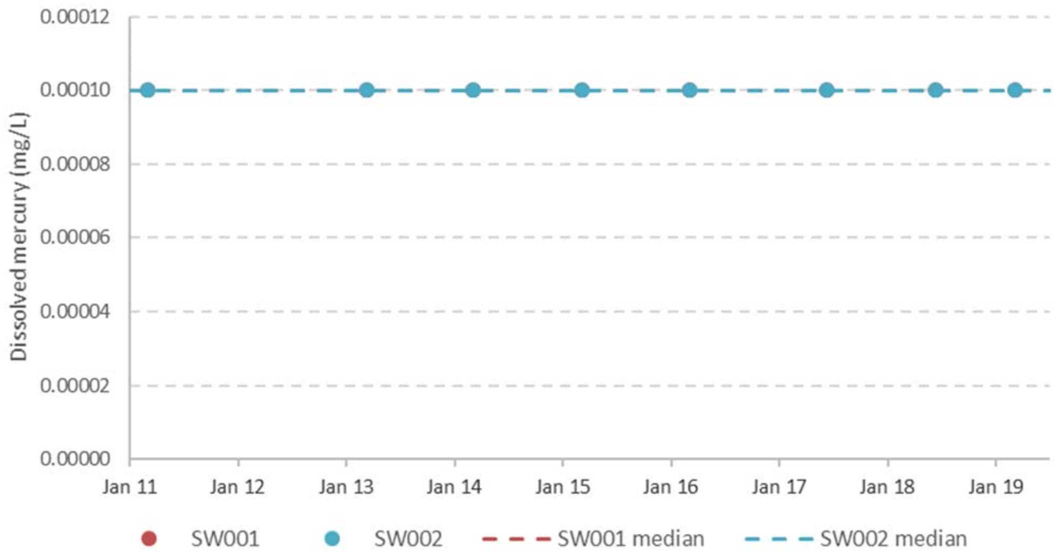

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved chromium (hexavalent) (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

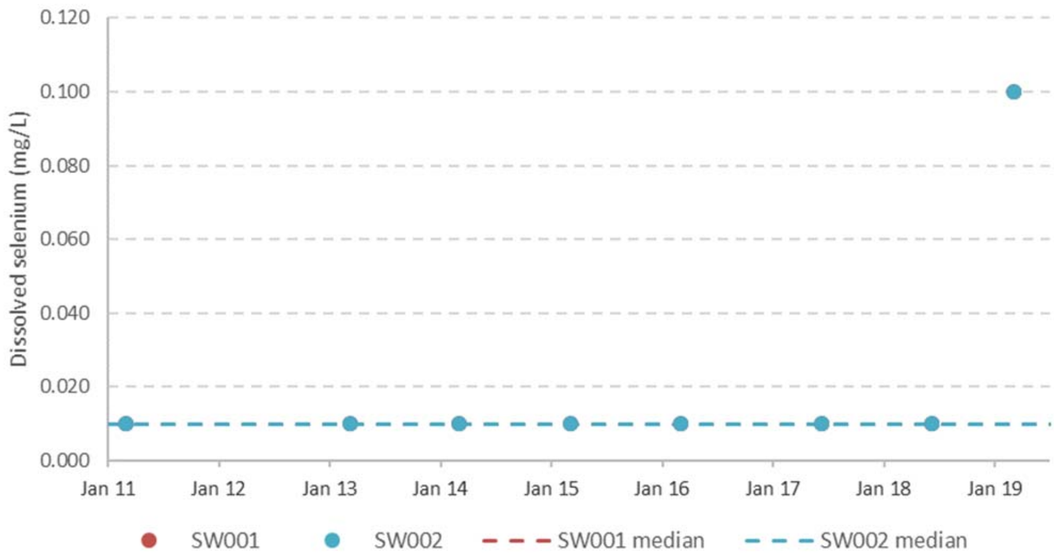

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved copper (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

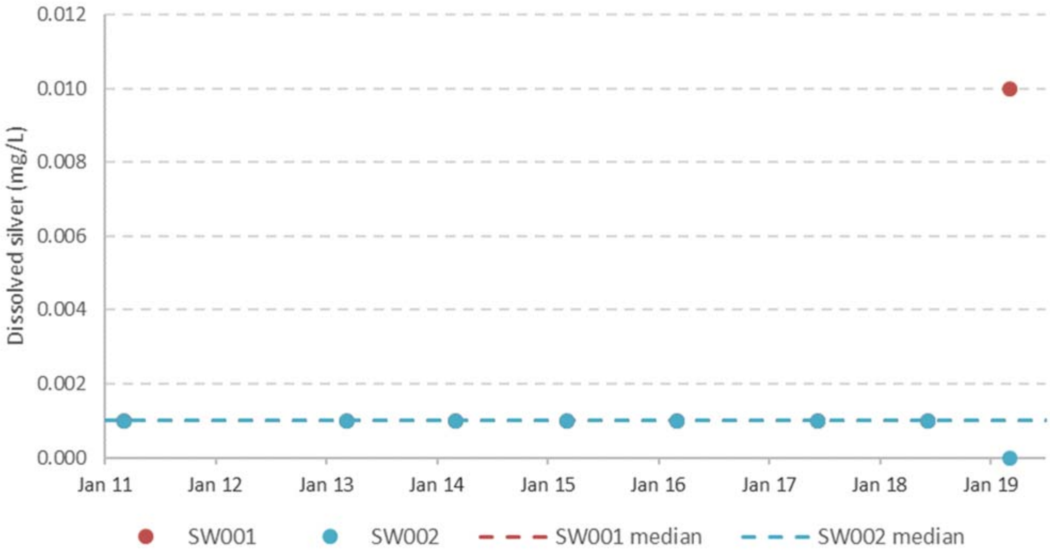

2.5
2.0
1.5
1.0
0.5
0.0
Dissolved iron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

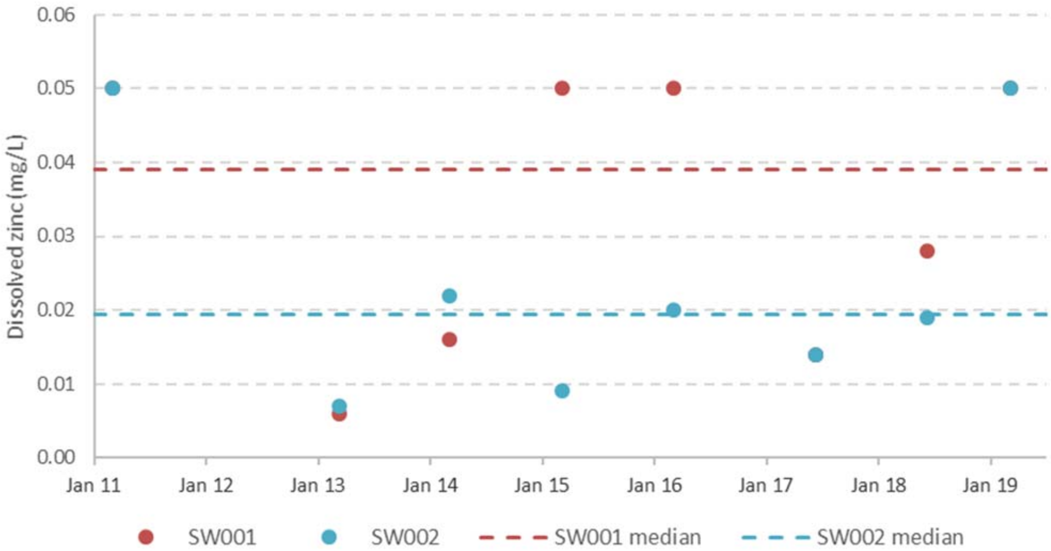

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved lead (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Dissolved manganese (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

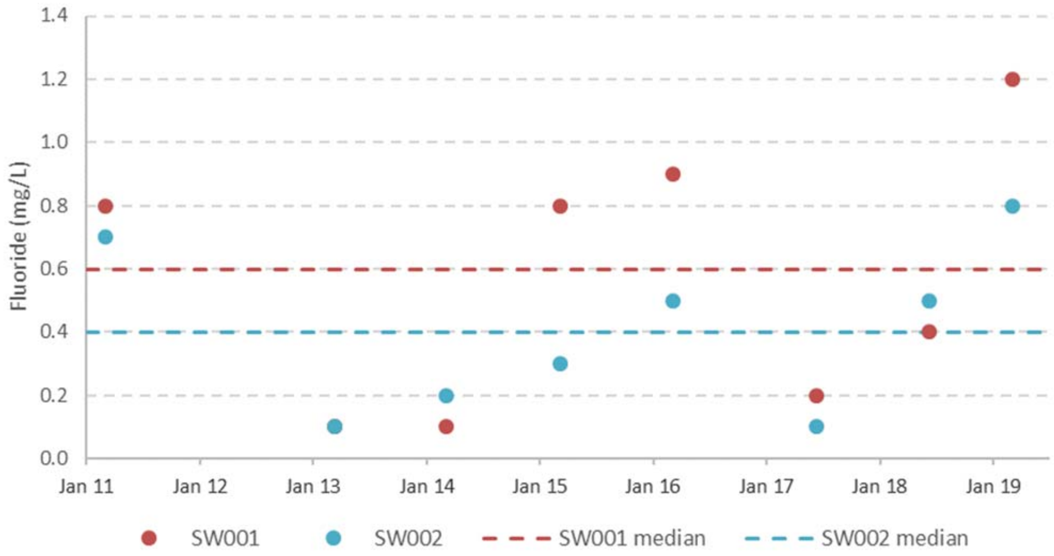

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


0.120
0.100
0.080
0.060
0.040
0.020
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median


1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW001
SW002
SW001 median
SW002 median

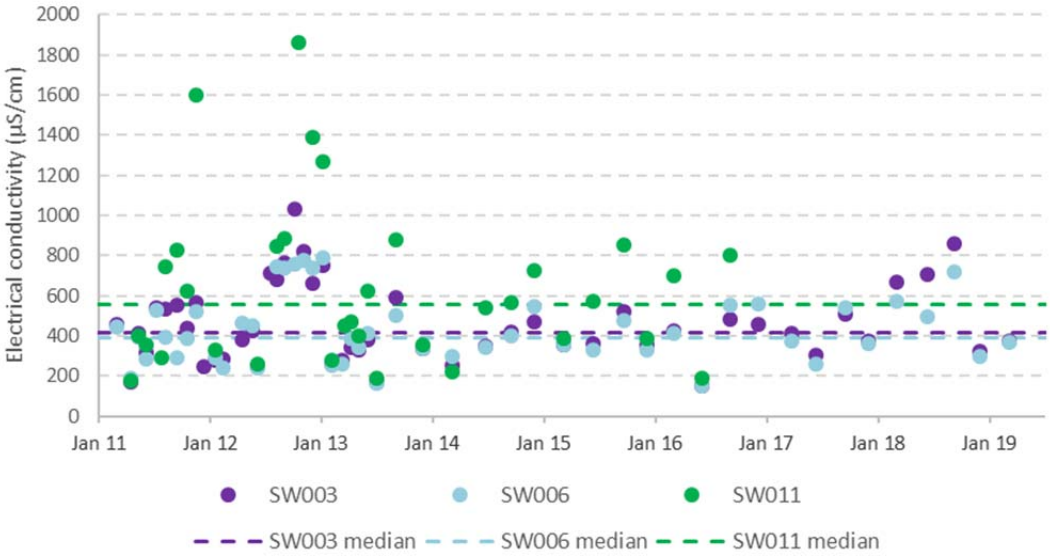
E.1.3 Morans Creek

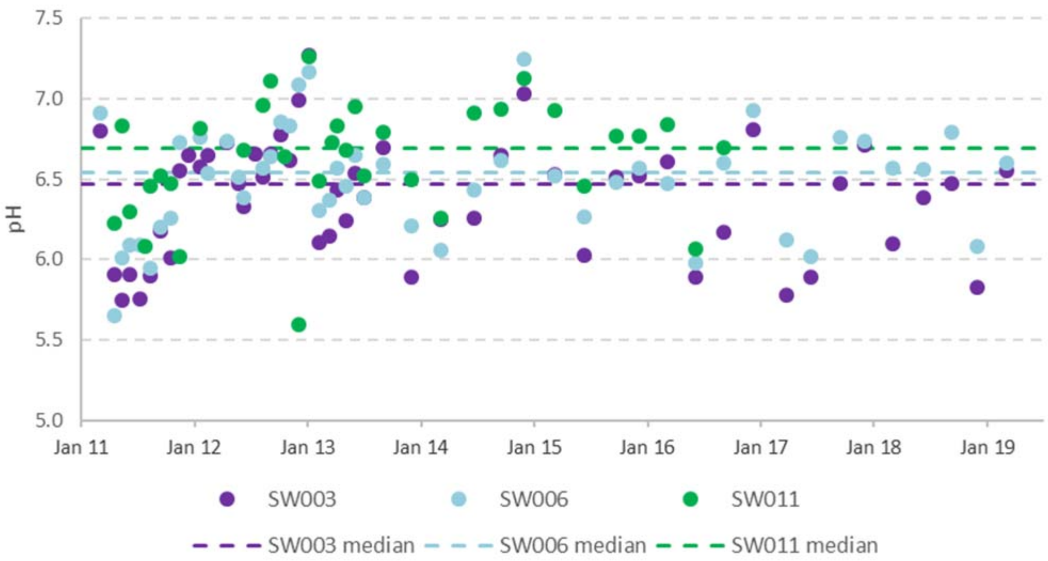
Median water quality results

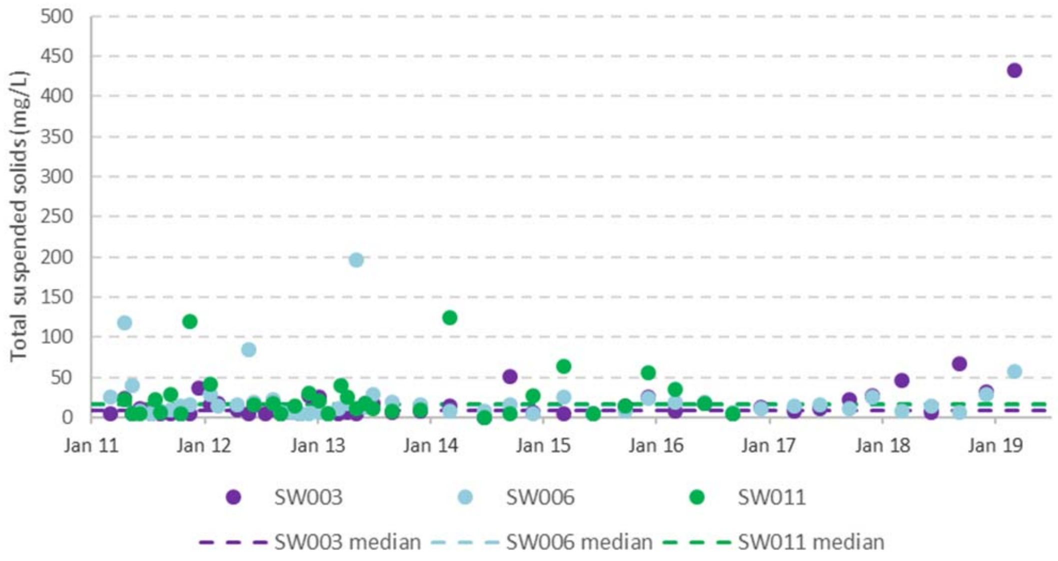
Parameter	Units	SW003		SW006		SW011	
		Count	Median	Count	Median	Count	Median
Physicochemical parameters							
EC	µS/cm	51	416	49	392	34	556
Oil and grease	mg/L	50	2			34	2
pH	pH units	51	6.47	49	6.54	34	6.69
TSS	mg/L	51	9	49	15	34	17
Turbidity	NTU	32	19.3	31	23.7	19	28.0
Major ions							
Chloride	mg/L	8	82			4	104
Sulfate	mg/L	8	12			4	4
Total hardness	mg/L	8	47			4	47
Nutrients							
Ammonia	mg/L	8	0.03			4	0.02
Nitrate + nitrite	mg/L	8	0.02			4	0.02
Dissolved metals							
Arsenic	mg/L	8	0.001			4	0.001
Barium	mg/L	8	0.046			4	0.039
Boron	mg/L	8	0.05			4	0.05
Cadmium	mg/L	8	0.0001			4	0.0001
Hexavalent chromium	mg/L	7	0.01			4	0.01
Copper	mg/L	8	0.001			4	0.001
Iron	mg/L	8	1.18			4	2.00
Lead	mg/L	8	0.001			4	0.001
Manganese	mg/L	8	0.149			4	0.635
Mercury	mg/L	8	0.0001			4	0.0001
Selenium	mg/L	8	0.01			4	0.01

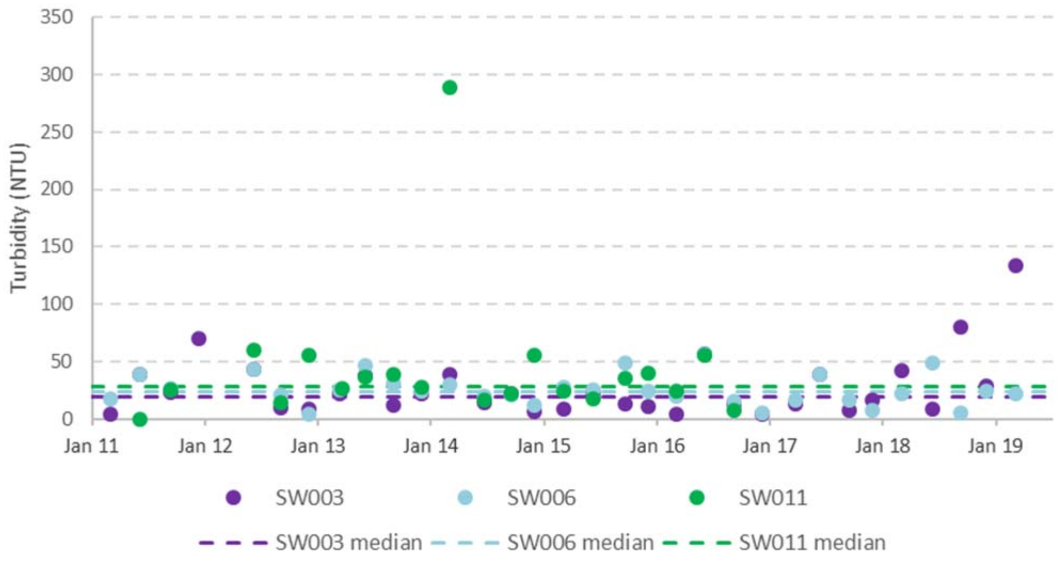
Parameter	Units	SW003		SW006		SW011	
		Count	Median	Count	Median	Count	Median
Silver	mg/L	8	0.001			4	0.001
Zinc	mg/L	8	0.008			4	0.006
Total metals							
Arsenic	mg/L	8	0.001			4	0.003
Barium	mg/L	8	0.063			4	0.083
Boron	mg/L	8	0.05			3	0.05
Cadmium	mg/L	8	0.0001			4	0.0001
Copper	mg/L	8	0.003			4	0.002
Iron	mg/L	7	2.47			4	7.61
Lead	mg/L	8	0.001			4	0.001
Manganese	mg/L	8	0.195			4	1.635
Mercury	mg/L	7	0.0001			4	0.0001
Selenium	mg/L	7	0.01			4	0.01
Silver	mg/L	8	0.001			4	0.001
Zinc	mg/L	7	0.020			4	0.013
Other parameters							
Cyanide	mg/L	8	0.004			4	0.004
Fluoride	mg/L	8	0.1			4	0.1

Time series graphs

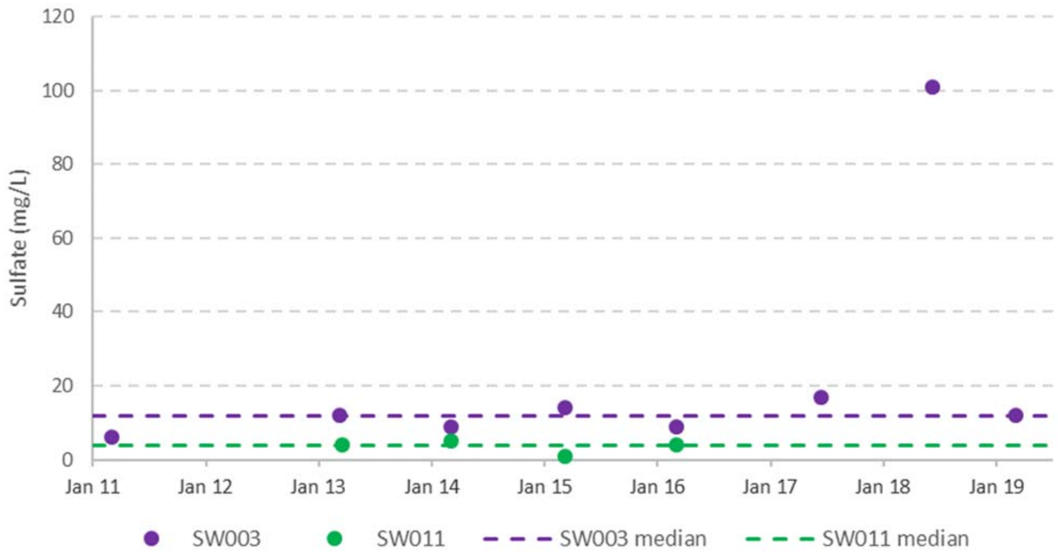




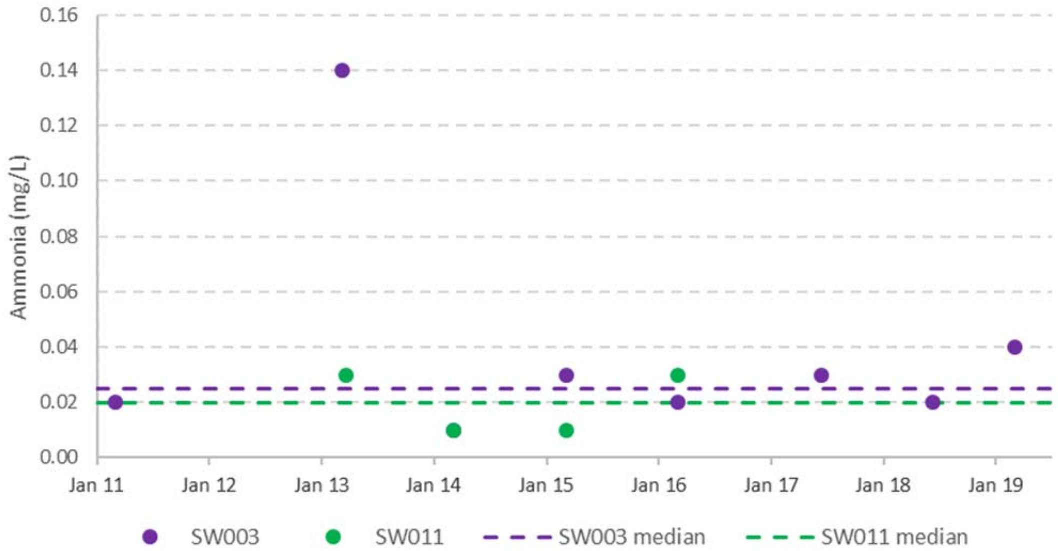

500
450
400
350
300
250
200
150
100
50
0
Total suspended solids (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW006
SW011
SW003 median
SW006 median
SW011 median


350
300
250
200
150
100
50
0
Turbidity (NTU)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW006
SW011
SW003 median
SW006 median
SW011 median


200
180
160
140
120
100
80
60
40
20
0
Chloride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


120
100
80
60
40
20
0
Sulfate (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

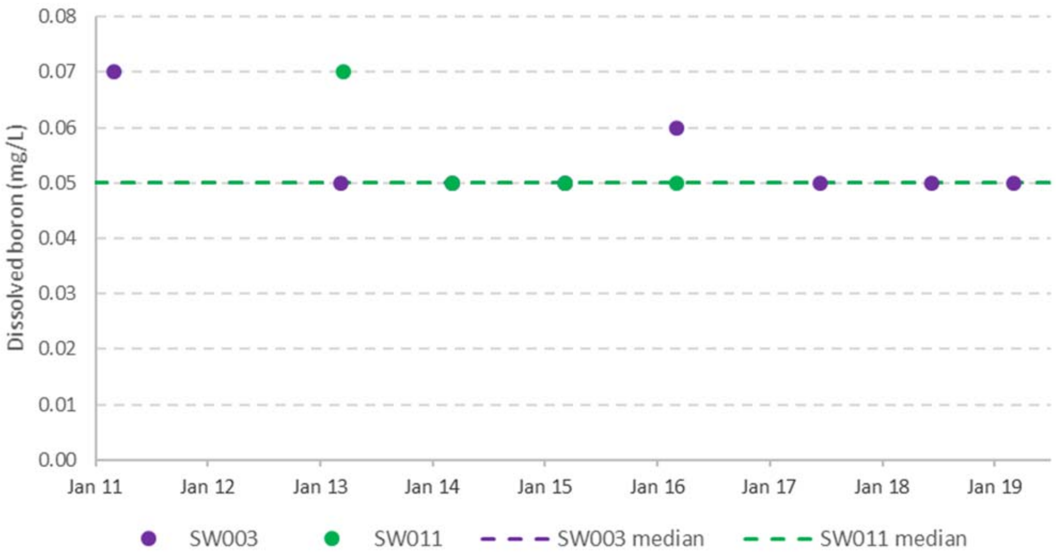

120
100
80
60
40
20
0
Total hardness (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

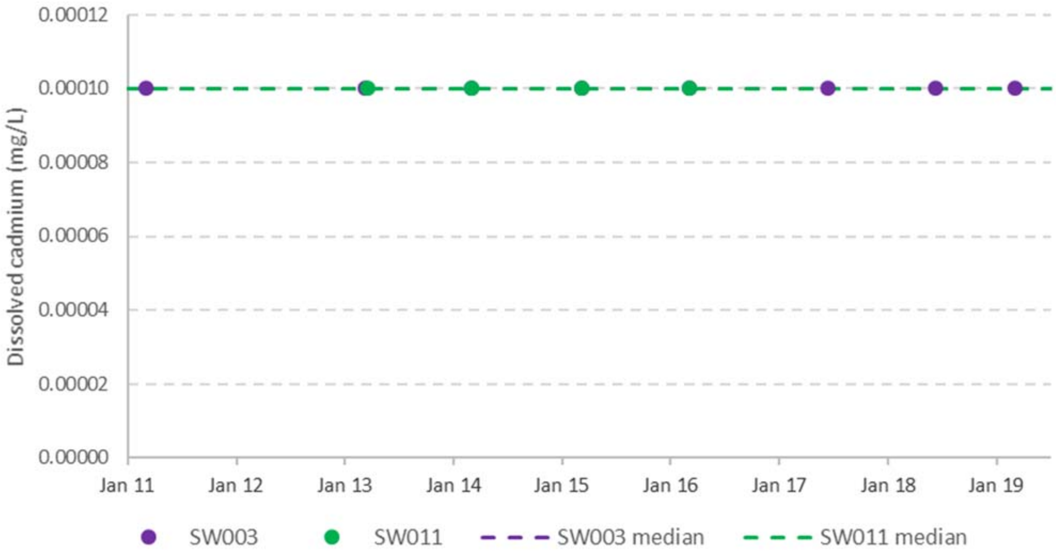

0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Ammonia (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Nitrate + nitrite (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved arsenic (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved barium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


Dissolved boron (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

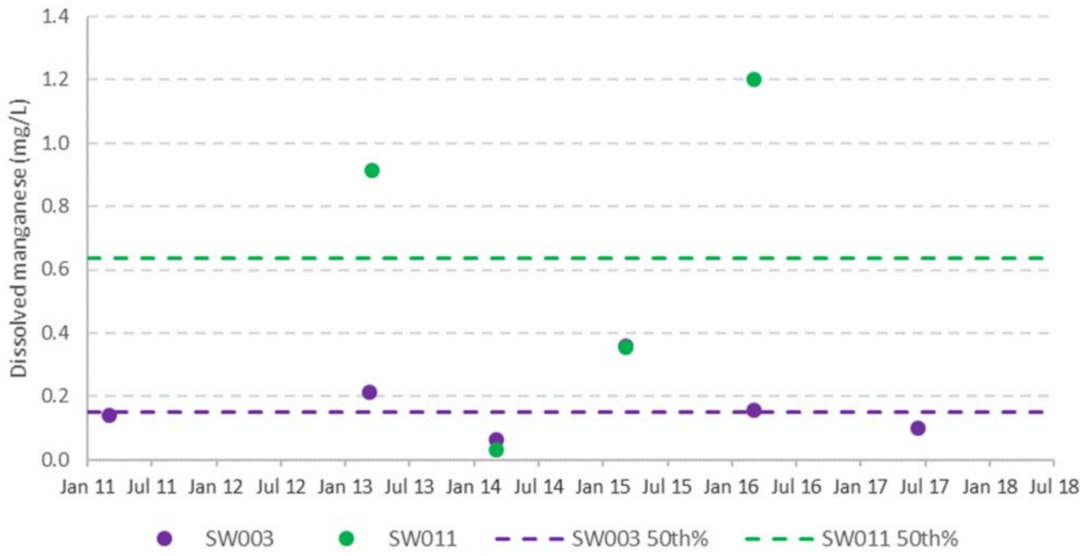

Dissolved cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

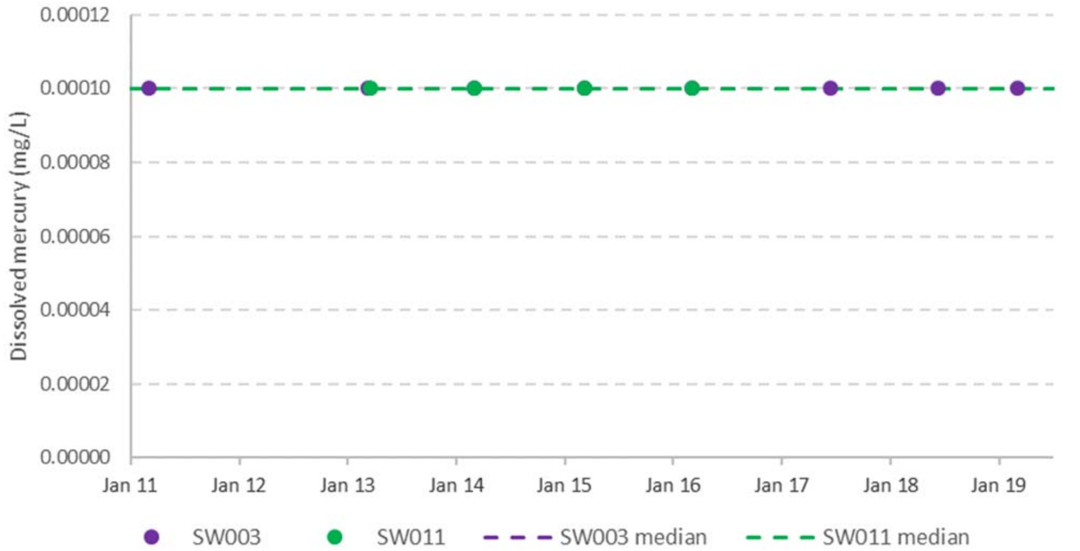

Dissolved chromium (hexavalent) (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

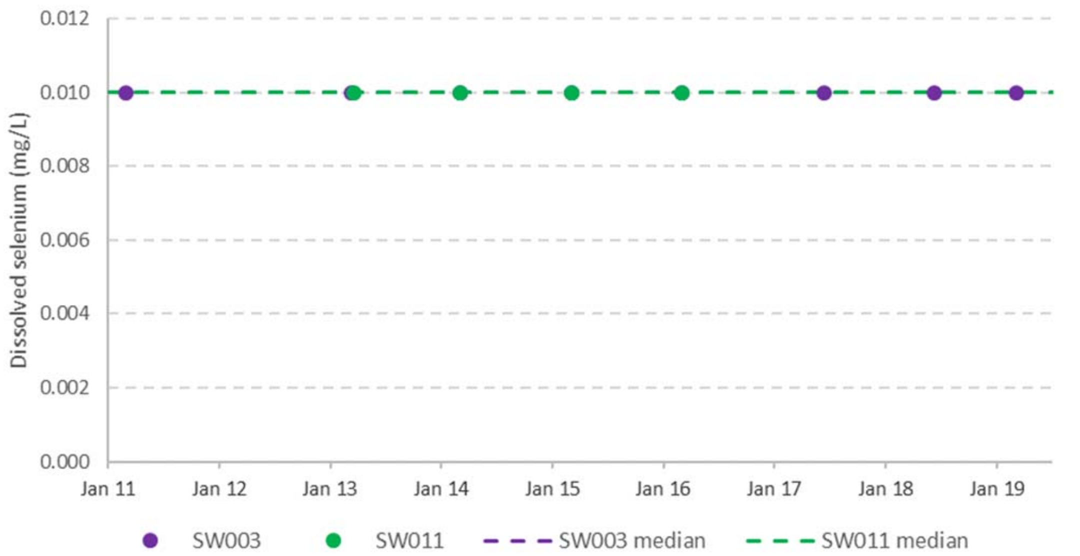

Dissolved copper (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

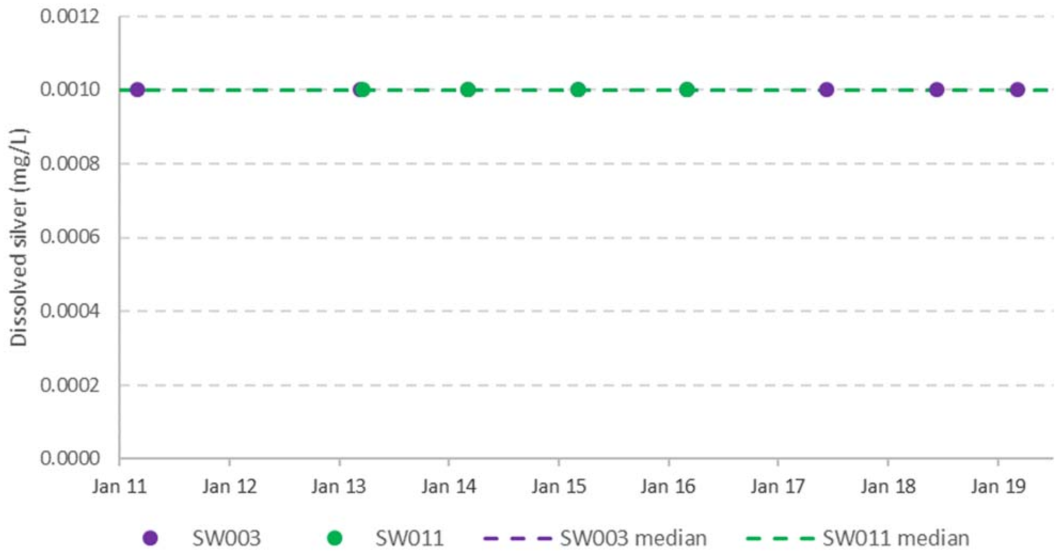

Dissolved iron (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

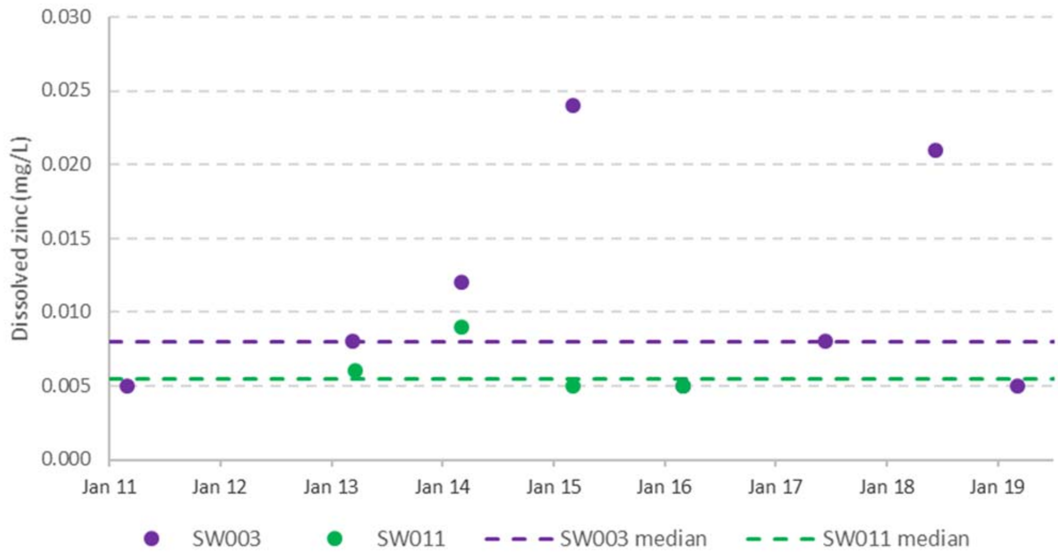

Dissolved lead (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

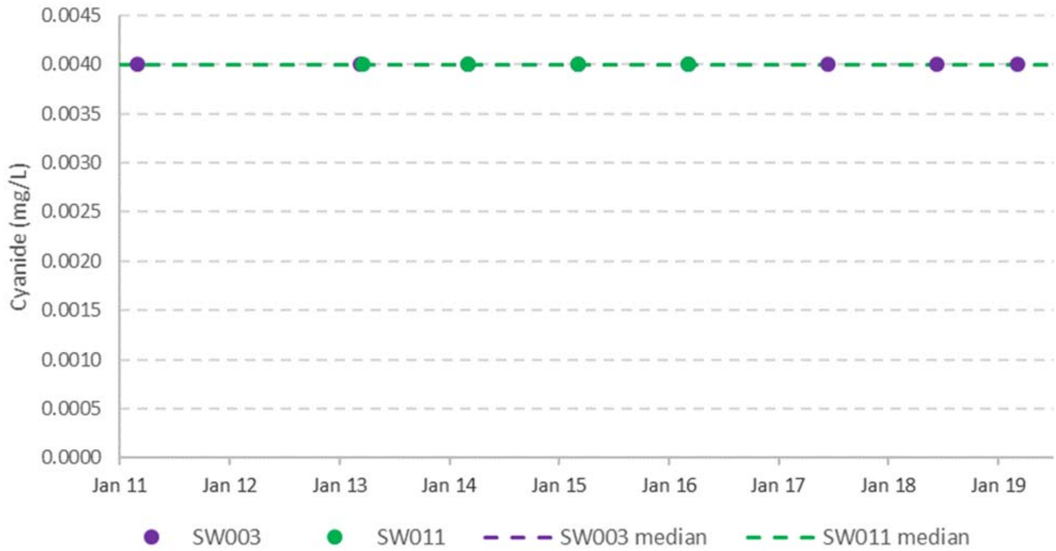

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Dissolved manganese (mg/L)
Jan 11 Jul 11 Jan 12 Jul 12 Jan 13 Jul 13 Jan 14 Jul 14 Jan 15 Jul 15 Jan 16 Jul 16 Jan 17 Jul 17 Jan 18 Jul 18
SW003
SW011
SW003 50th%
SW011 50th%

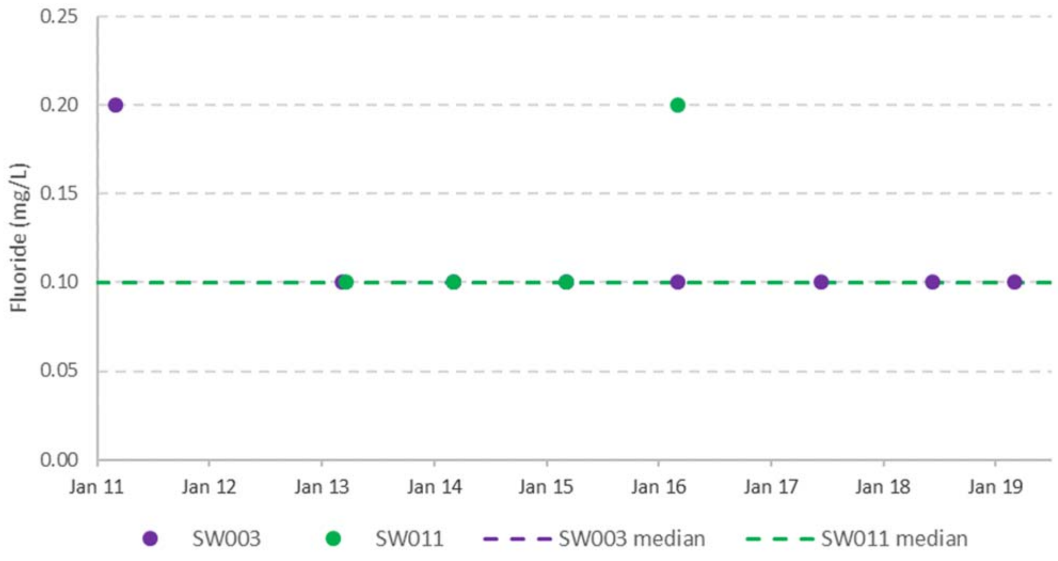

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11 Jan 12 Jan 13 Jan 14 Jan 15 Jan 16 Jan 17 Jan 18 Jan 19
SW003
SW011
SW003 median
SW011 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11 Jan 12 Jan 13 Jan 14 Jan 15 Jan 16 Jan 17 Jan 18 Jan 19
SW003
SW011
SW003 median
SW011 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median


0.25
0.20
0.15
0.10
0.05
0.00
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW003
SW011
SW003 median
SW011 median

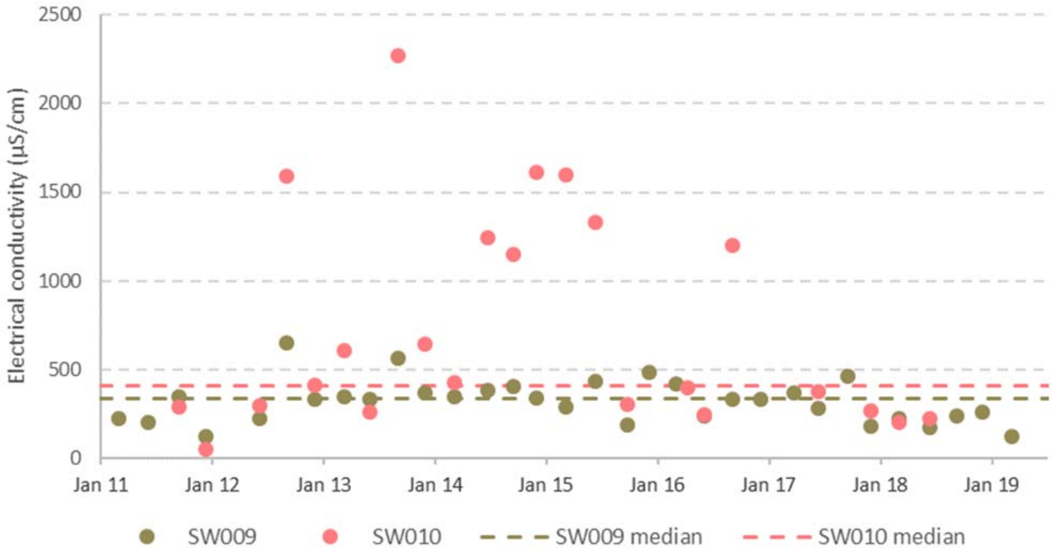
E.1.4 Pourmalong Creek

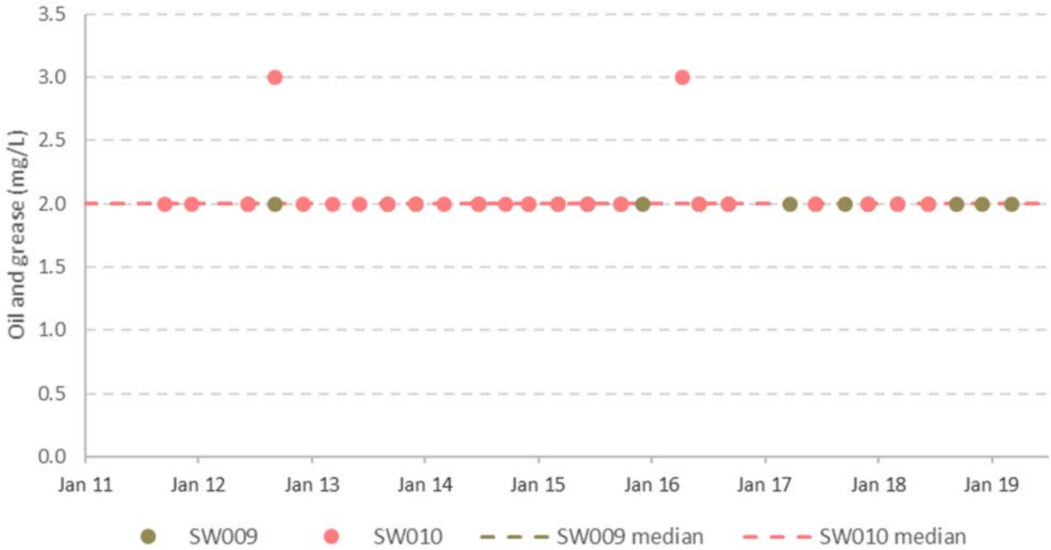
Median water quality results

Parameter	Units	SW009		SW010	
		Count	Median	Count	Median
Physicochemical parameters					
EC	µS/cm	32	334	23	409
Oil and grease	mg/L	21	2	23	2
pH	pH units	32	6.65	23	5,81
TSS	mg/L	32	12	23	11
Turbidity	NTU	31	20.4	23	25
Major ions					
Chloride	mg/L			5	104
Sulfate	mg/L			5	22
Total hardness	mg/L			5	43
Nutrients					
Ammonia	mg/L			5	0.01
Nitrate + nitrite	mg/L			5	0.01
Dissolved metals					
Arsenic	mg/L			5	0.001
Barium	mg/L			5	0.037
Boron	mg/L			5	0.05
Cadmium	mg/L			5	0.0001
Hexavalent chromium	mg/L			5	0.01
Copper	mg/L			5	0.001
Iron	mg/L			5	1.81
Lead	mg/L			5	0.001
Manganese	mg/L			5	0.094
Mercury	mg/L			5	0.0001
Selenium	mg/L			5	0.01

Parameter	Units	SW009		SW010	
		Count	Median	Count	Median
Silver	mg/L			5	0.001
Zinc	mg/L			5	0.022
Total metals					
Arsenic	mg/L			5	0.001
Barium	mg/L			5	0.051
Boron	mg/L			5	0.05
Cadmium	mg/L			5	0.0001
Copper	mg/L			5	0.004
Iron	mg/L			5	3.82
Lead	mg/L			5	0.007
Manganese	mg/L			5	0.115
Mercury	mg/L			5	0.0001
Selenium	mg/L			5	0.01
Silver	mg/L			5	0.001
Zinc	mg/L			5	0.034
Other parameters					
Cyanide	mg/L			5	0.004
Fluoride	mg/L			5	0.1

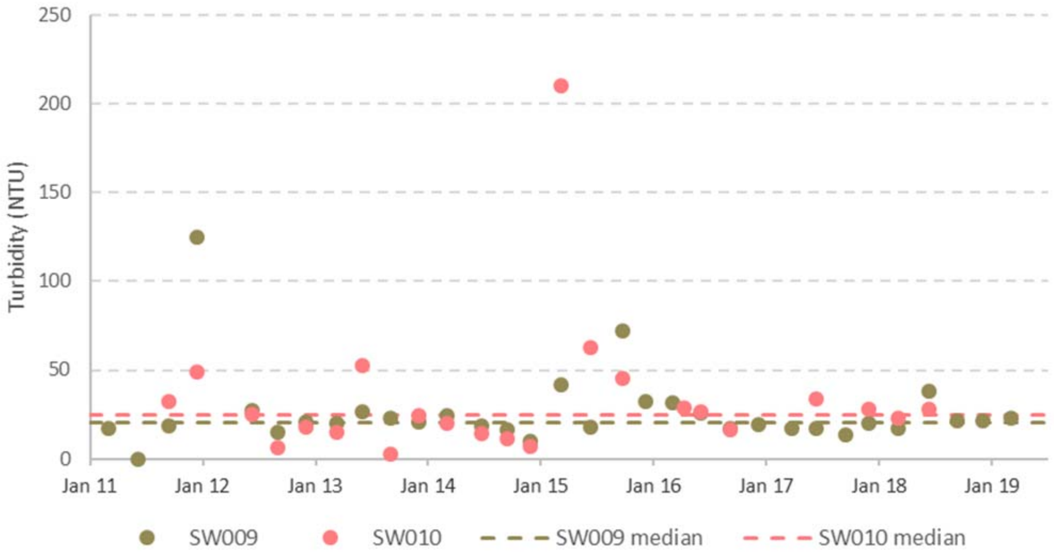
Time series graphs

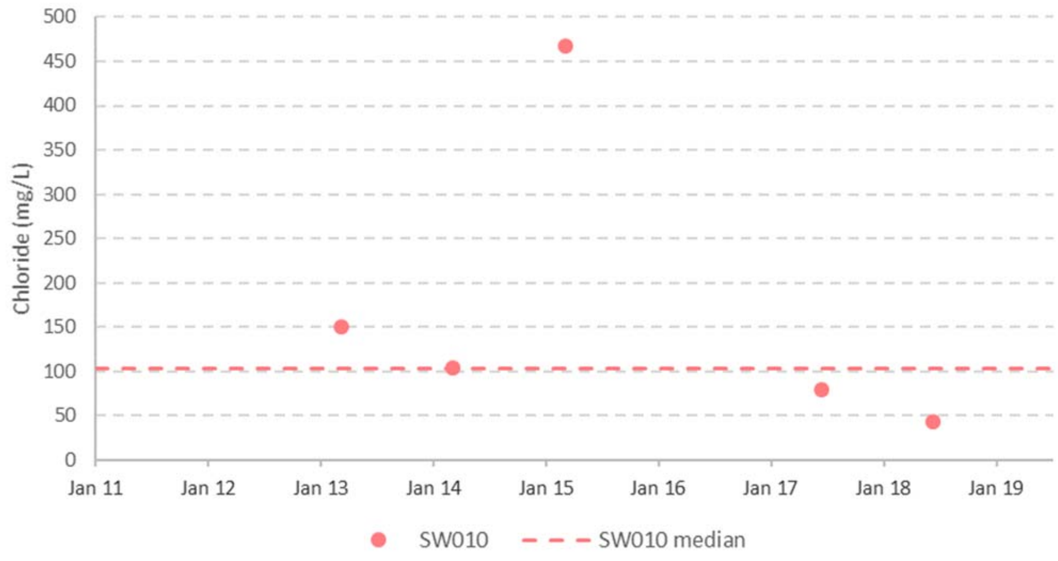





pH units
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW009
SW010
SW009 median
SW010 median

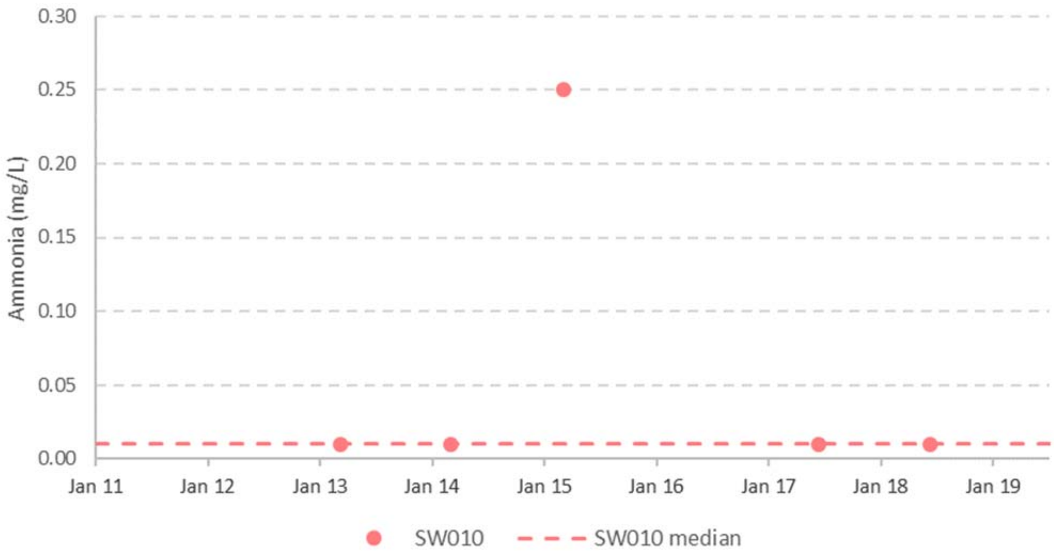

Total suspended solids (mg/L)
600
500
400
300
200
100
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW009
SW010
SW009 median
SW010 median

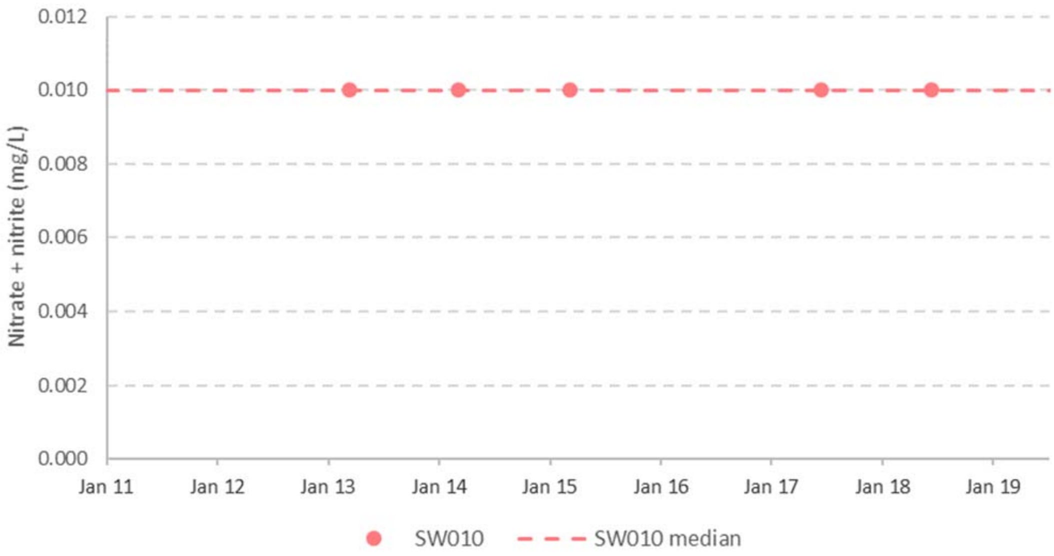

Turbidity (NTU)
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW009
SW010
SW009 median
SW010 median

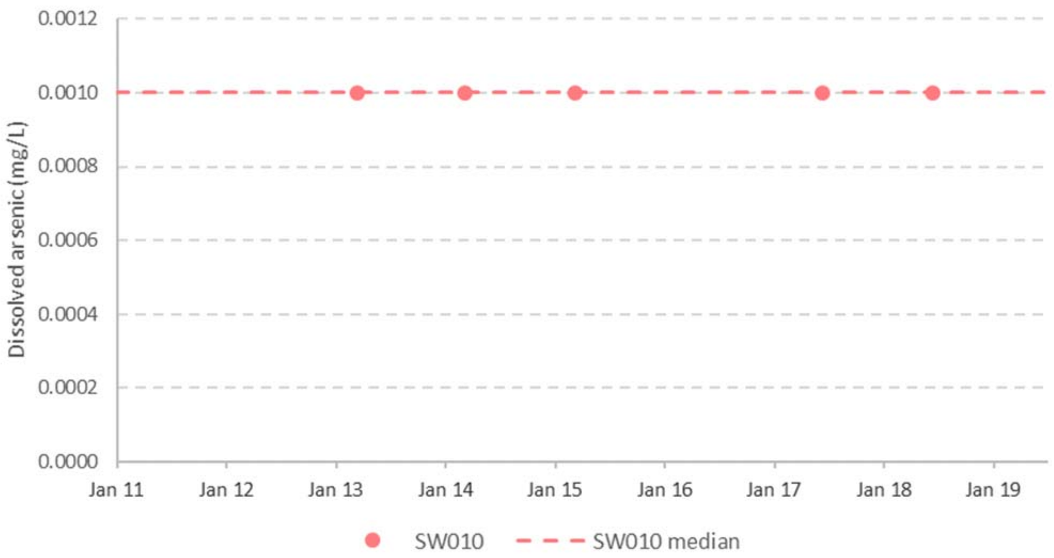

Chloride (mg/L)
500
450
400
350
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


Sulfate (mg/L)
35
30
25
20
15
10
5
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

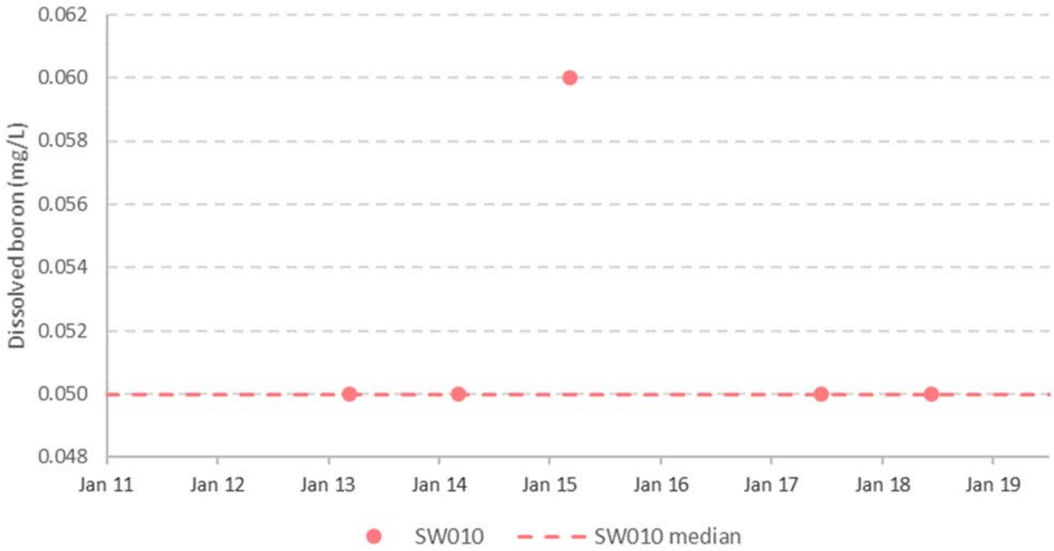

Total hardness (mg/L)
160
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

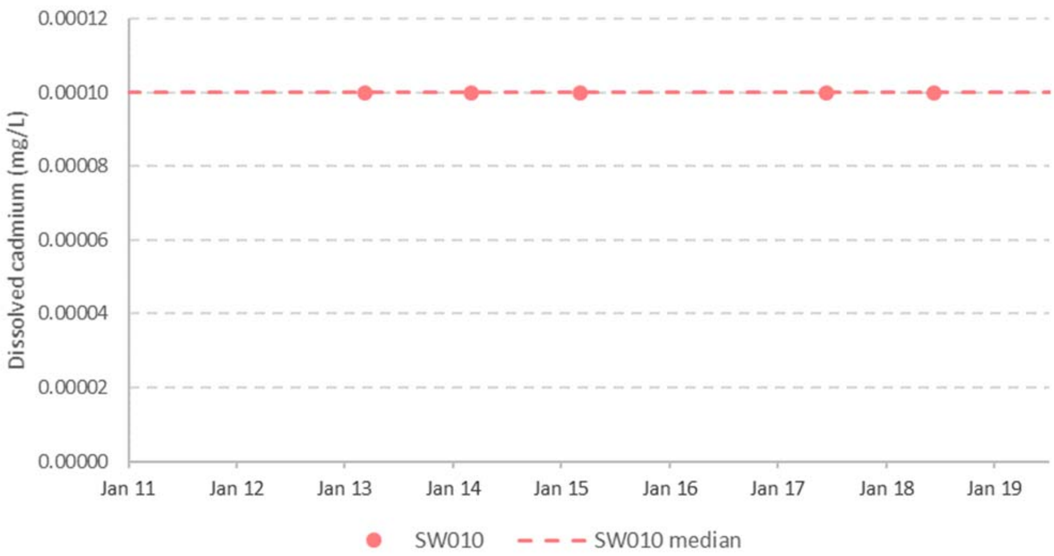

0.30
0.25
0.20
0.15
0.10
0.05
0.00
Ammonia (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

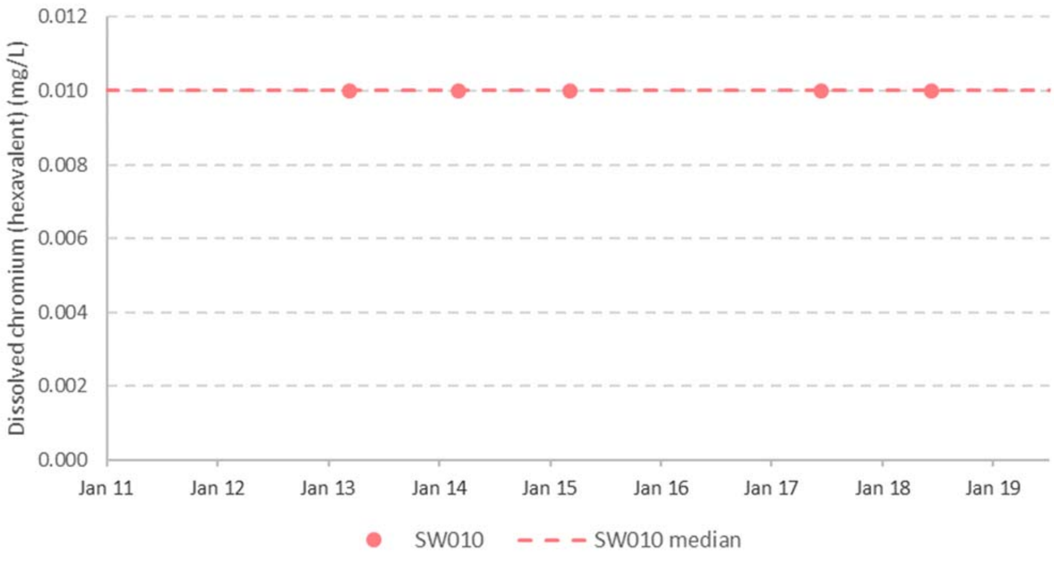

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Nitrate + nitrite (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

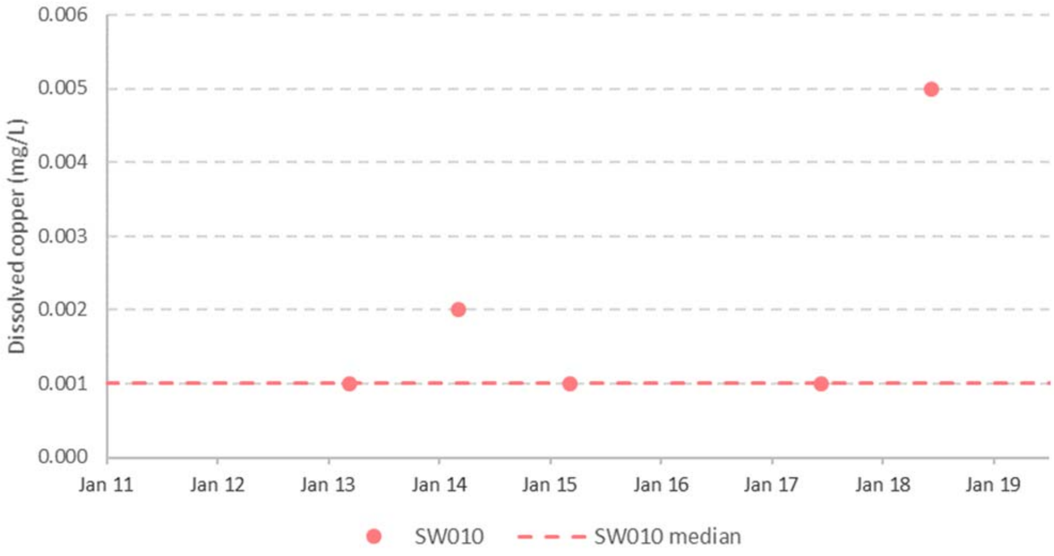

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved arsenic (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


Dissolved barium (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

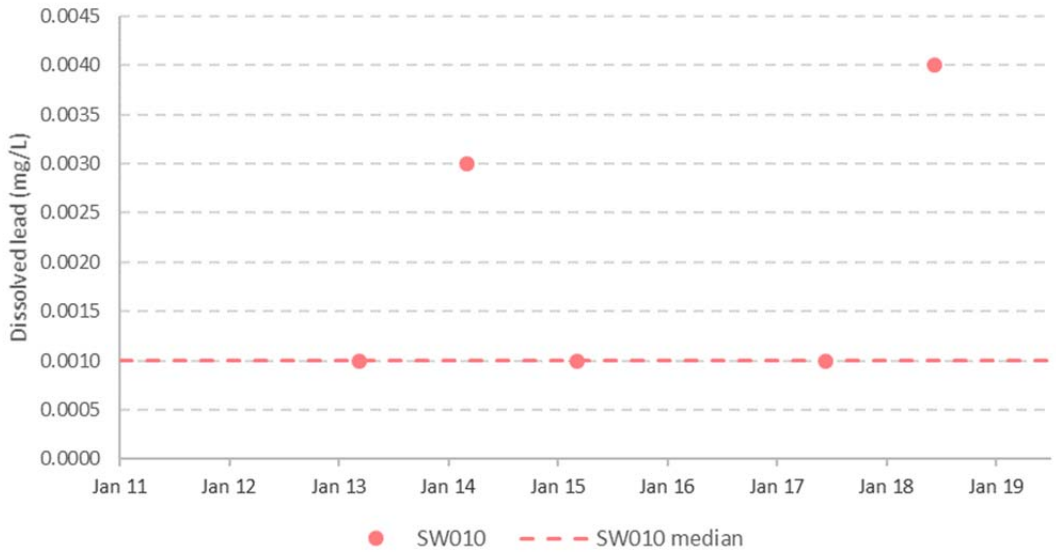

Dissolved boron (mg/L)
0.062
0.060
0.058
0.056
0.054
0.052
0.050
0.048
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


Dissolved cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


Dissolved chromium (hexavalent) (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

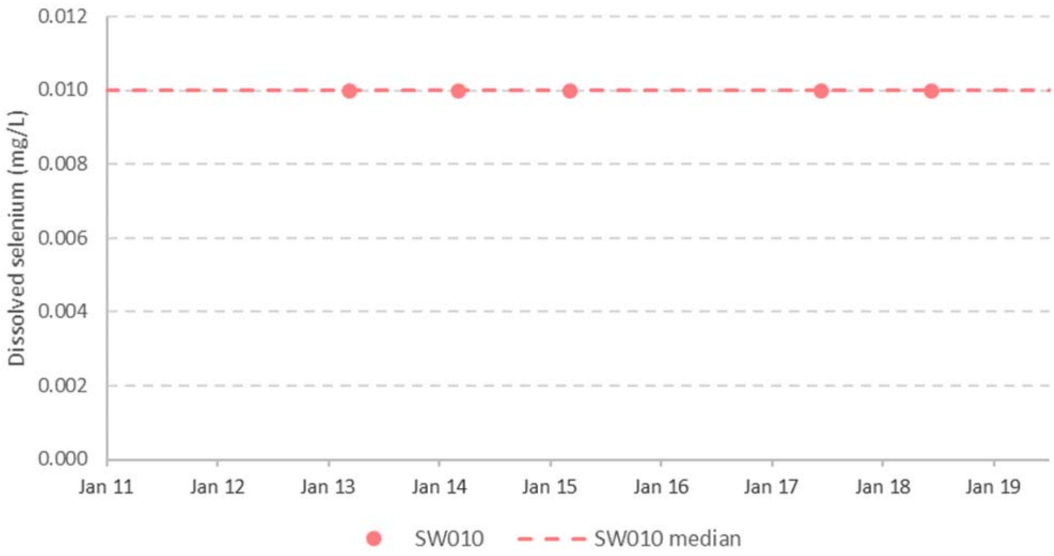

Dissolved copper (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

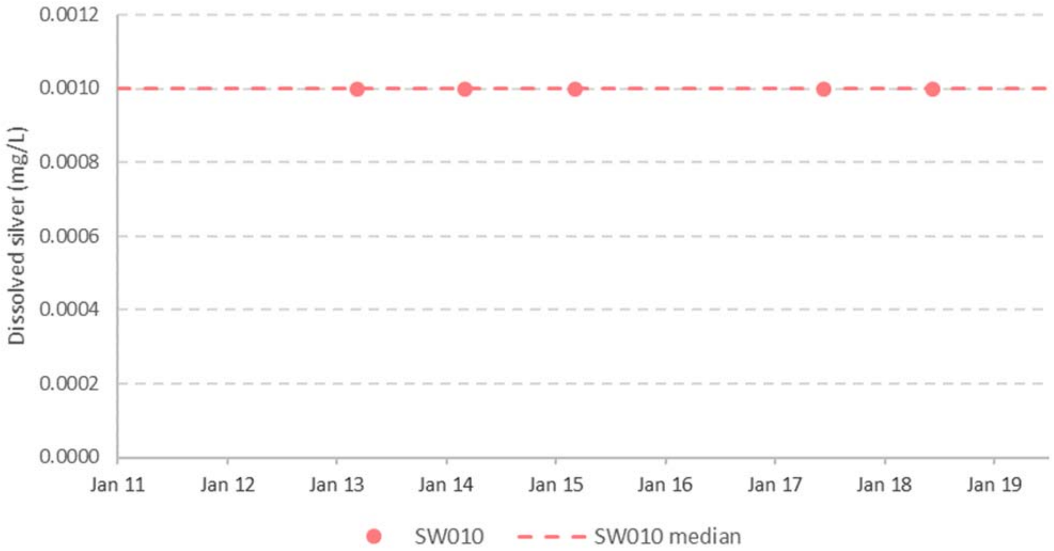

Dissolved iron (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

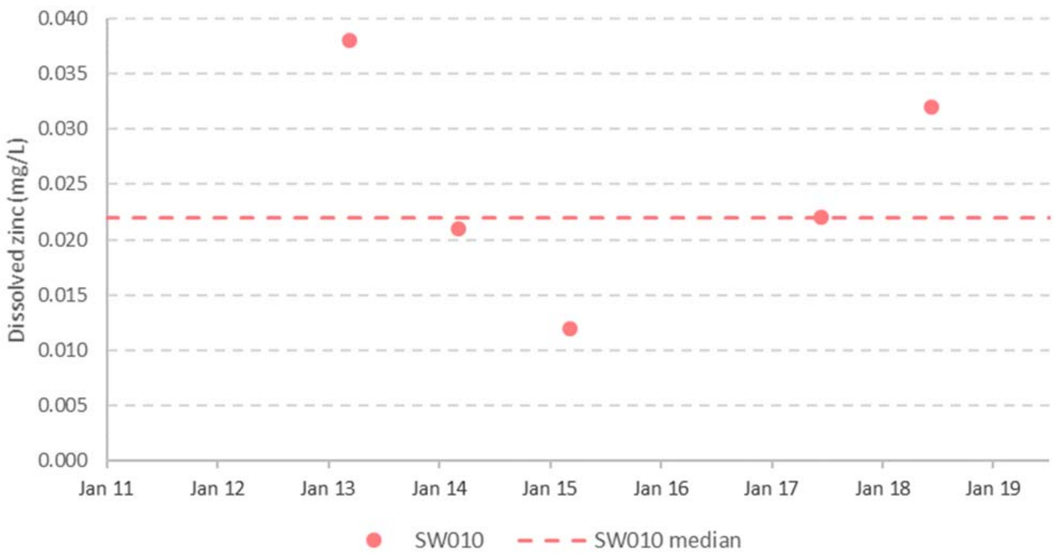

0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved lead (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

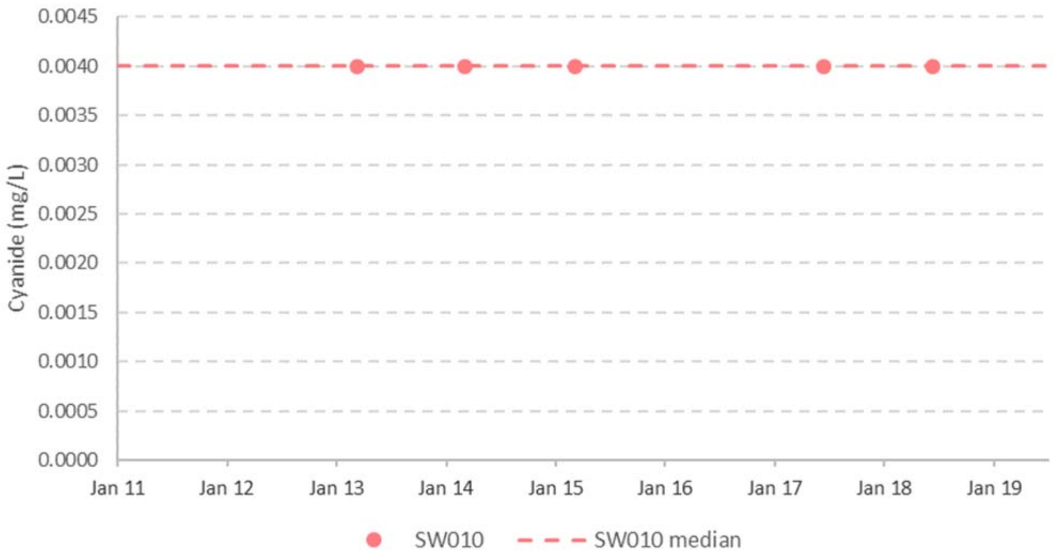

0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dissolved manganese (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

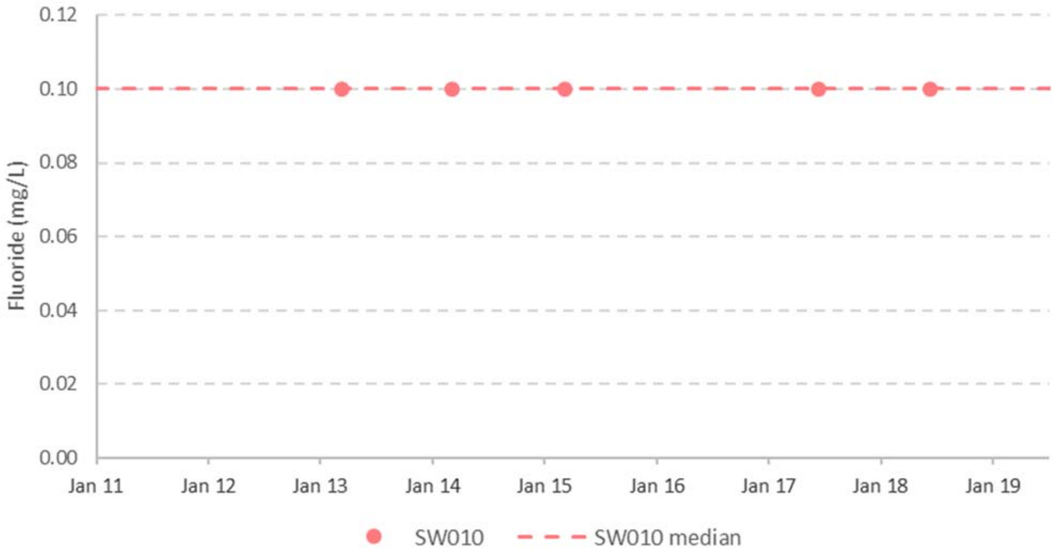

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median


0.12
0.10
0.08
0.06
0.04
0.02
0.00
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW010
SW010 median

E.1.5 Mullards Creek

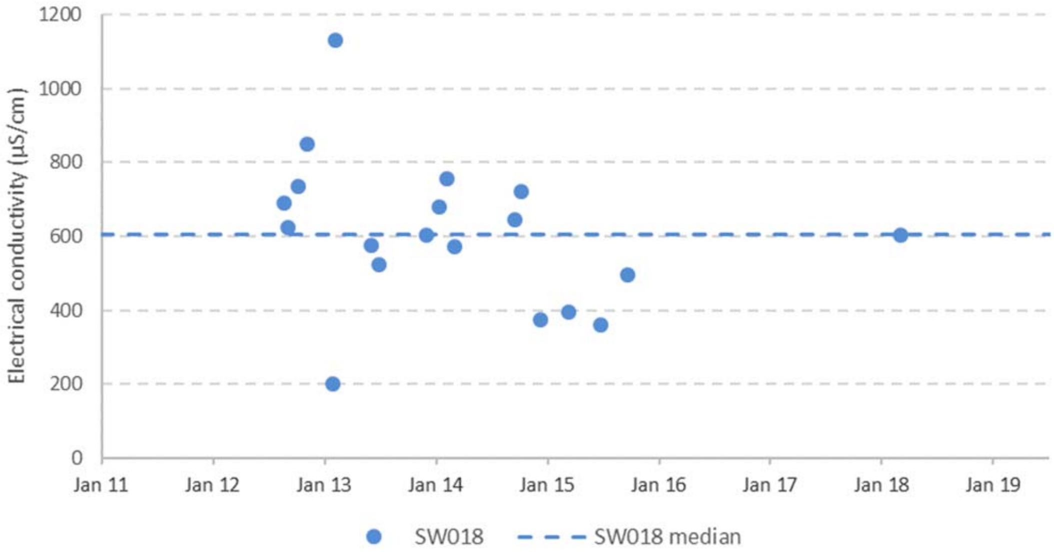
Median water quality results

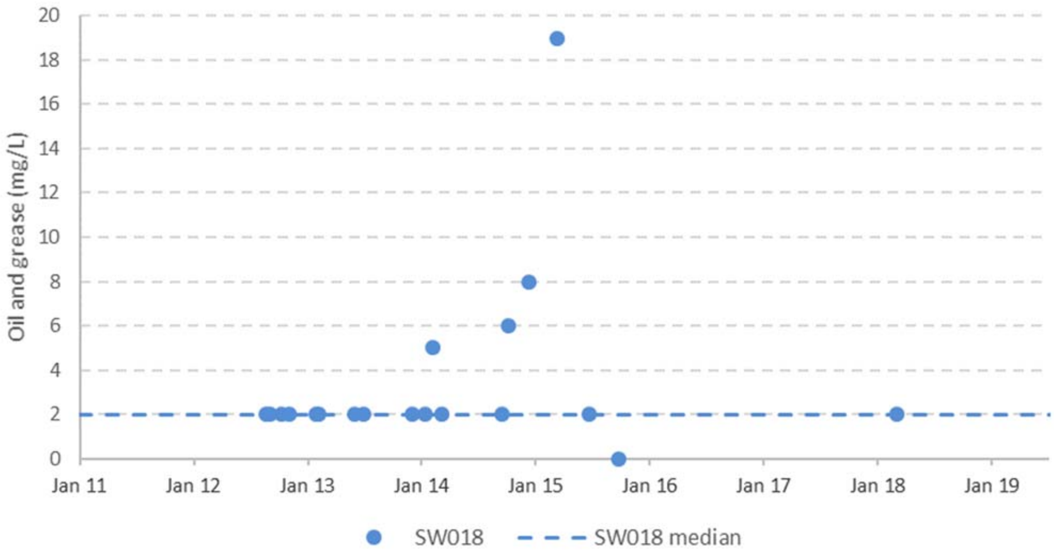
Parameter	Units	SW018	
		Count	Median
Physicochemical parameters			
EC	µS/cm	19	604
Oil and grease	mg/L	19	2
pH	pH units	19	7.30
TDS	mg/L	19	386
TSS	mg/L	19	24
Turbidity	NTU	19	46.6
Major ions			
Bicarbonate alkalinity	mg/L	16	179
Carbonate alkalinity	mg/L	16	1
Hydroxide alkalinity	mg/L	16	1
Total alkalinity	mg/L	16	179
Calcium	mg/L	17	46
Chloride	mg/L	16	38
Magnesium	mg/L	17	6
Potassium	mg/L	17	8
Sodium	mg/L	17	66
Sulfate	mg/L	16	20
Total hardness	mg/L	19	144
Nutrients			
Ammonia	mg/L	19	0.29
BOD	mg/L	19	9
Nitrate + nitrite	mg/L	19	0.01
TKN	mg/L	19	3.4
Total nitrogen	mg/L	19	3.4

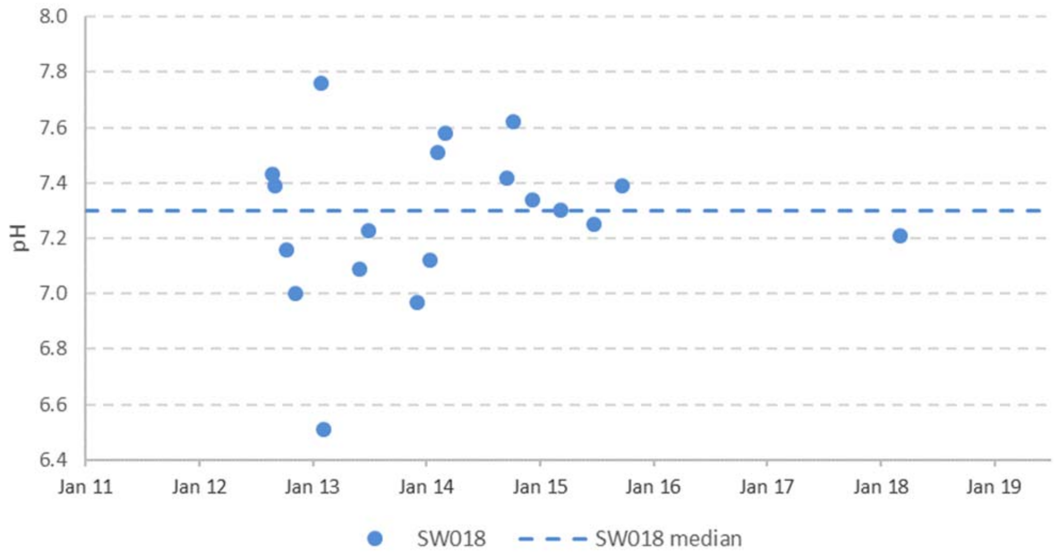
Parameter	Units	SW018	
		Count	Median
Total phosphorus	mg/L	19	2.53
Dissolved metals			
Aluminium	mg/L	18	0.07
Arsenic	mg/L	19	0.002
Barium	mg/L	19	0.026
Boron	mg/L	19	0.14
Cadmium	mg/L	19	0.0001
Chromium	mg/L	18	0.001
Cobalt	mg/L	18	0.002
Copper	mg/L	19	0.001
Iron	mg/L	19	1.84
Lead	mg/L	19	0.001
Manganese	mg/L	19	0.266
Mercury	mg/L	19	0.0001
Nickel	mg/L	18	0.009
Selenium	mg/L	19	0.01
Silver	mg/L	19	0.001
Zinc	mg/L	19	0.021
Total metals			
Aluminium	mg/L	18	0.375
Arsenic	mg/L	19	0.002
Barium	mg/L	19	0.047
Boron	mg/L	19	0.12
Cadmium	mg/L	19	0.0001
Chromium	mg/L	18	0.003
Cobalt	mg/L	18	0.002
Copper	mg/L	19	0.003

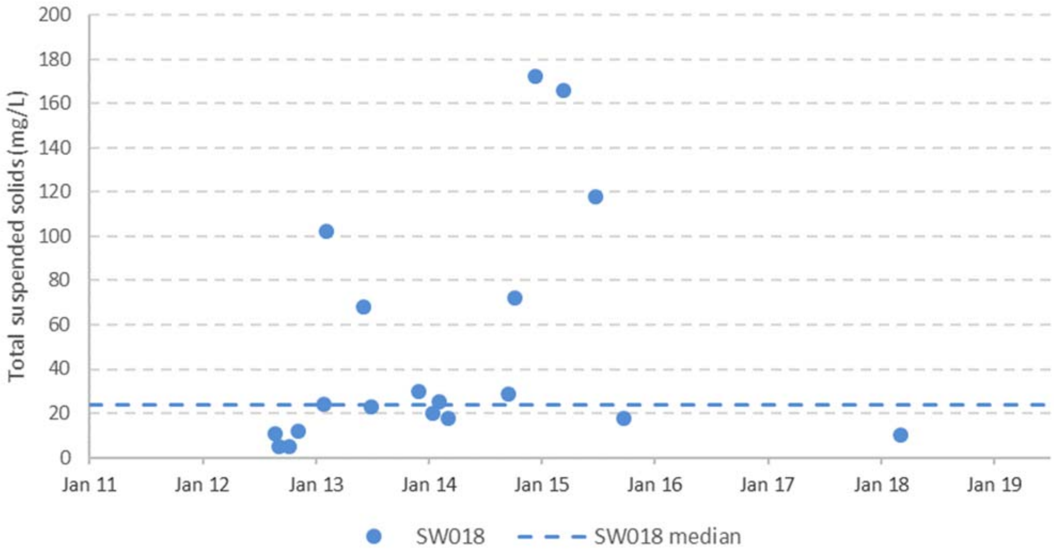
Parameter	Units	SW018	
		Count	Median
Iron	mg/L	19	5.39
Lead	mg/L	19	0.002
Manganese	mg/L	19	0.321
Mercury	mg/L	19	0.0001
Nickel	mg/L	18	0.009
Selenium	mg/L	19	0.01
Silver	mg/L	19	0.001
Zinc	mg/L	19	0.057
Other parameters			
Cyanide	mg/L	19	0.004
Fluoride	mg/L	19	0.5

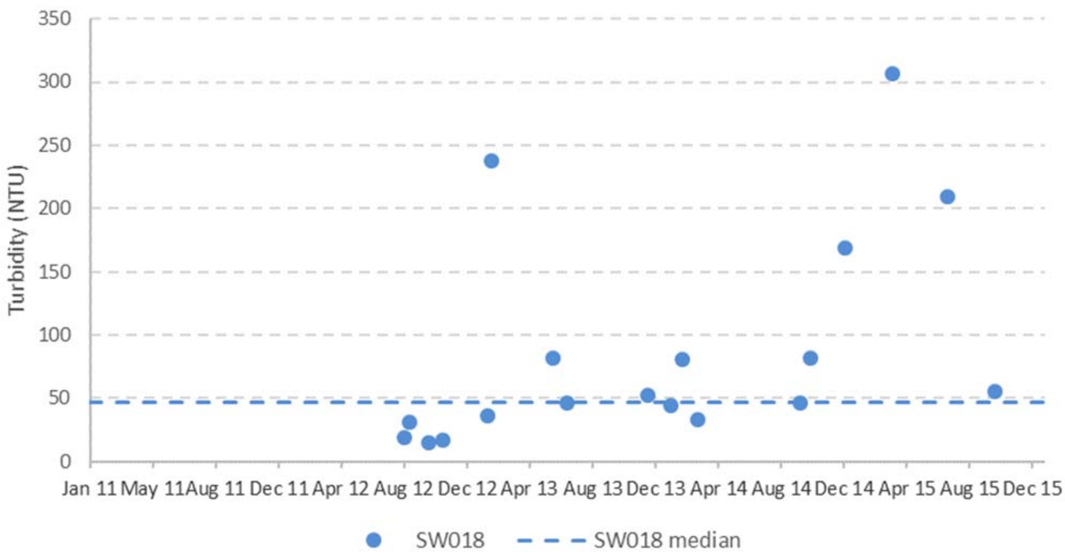
Time series graphs

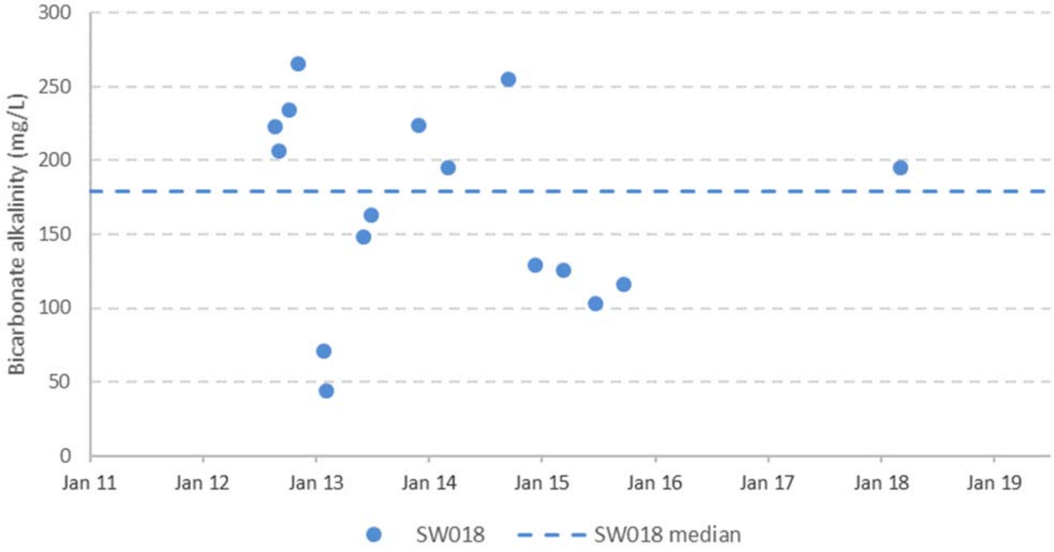


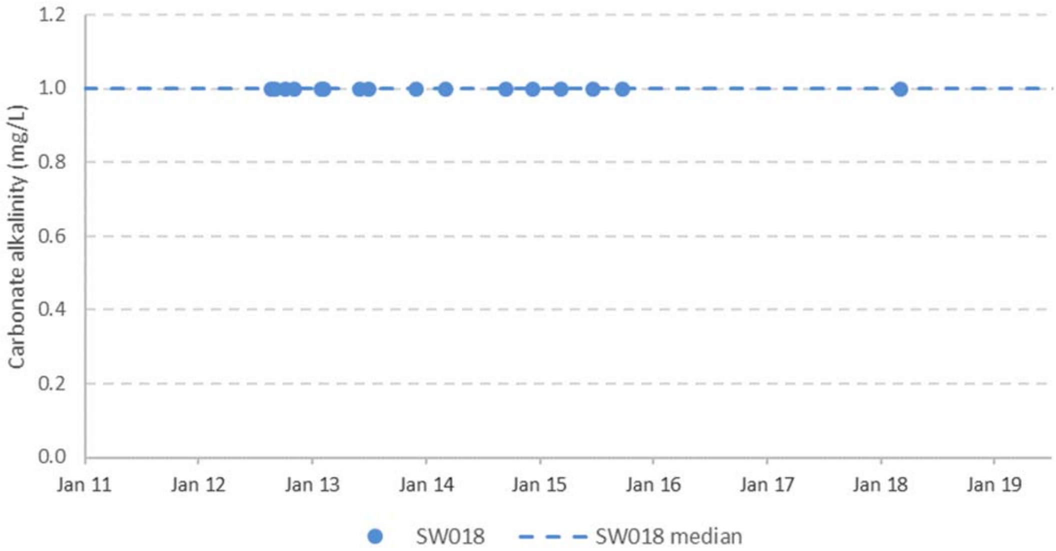


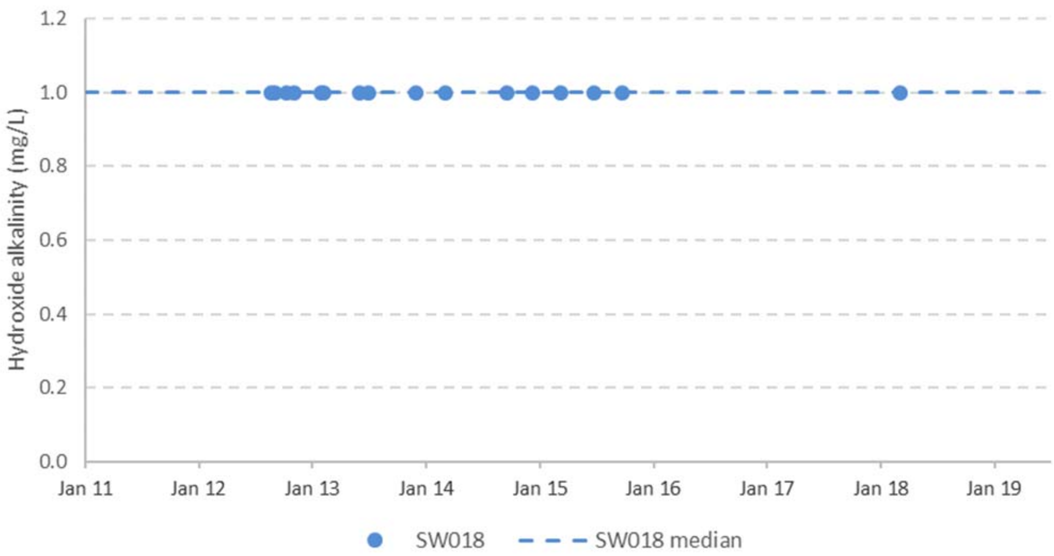

pH
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

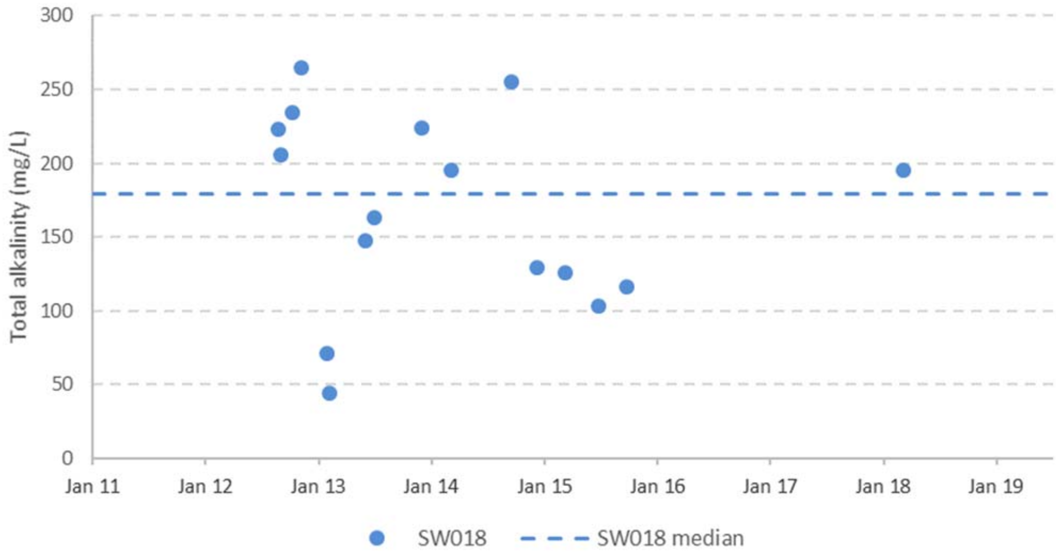

Total suspended solids (mg/L)
200
180
160
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

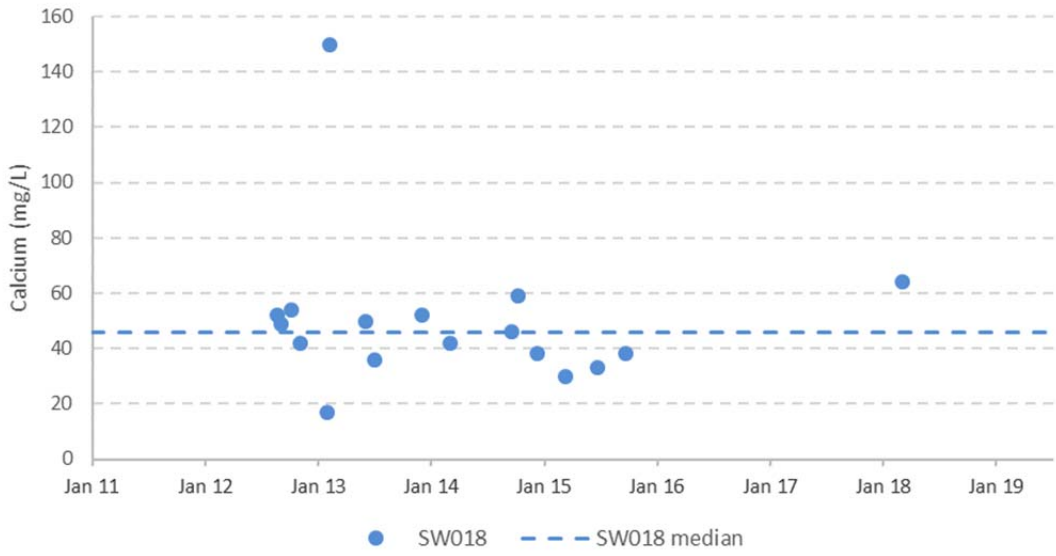

Turbidity (NTU)
350
300
250
200
150
100
50
0
Jan 11
May 11
Aug 11
Dec 11
Apr 12
Aug 12
Dec 12
Apr 13
Aug 13
Dec 13
Apr 14
Aug 14
Dec 14
Apr 15
Aug 15
Dec 15
SW018
SW018 median

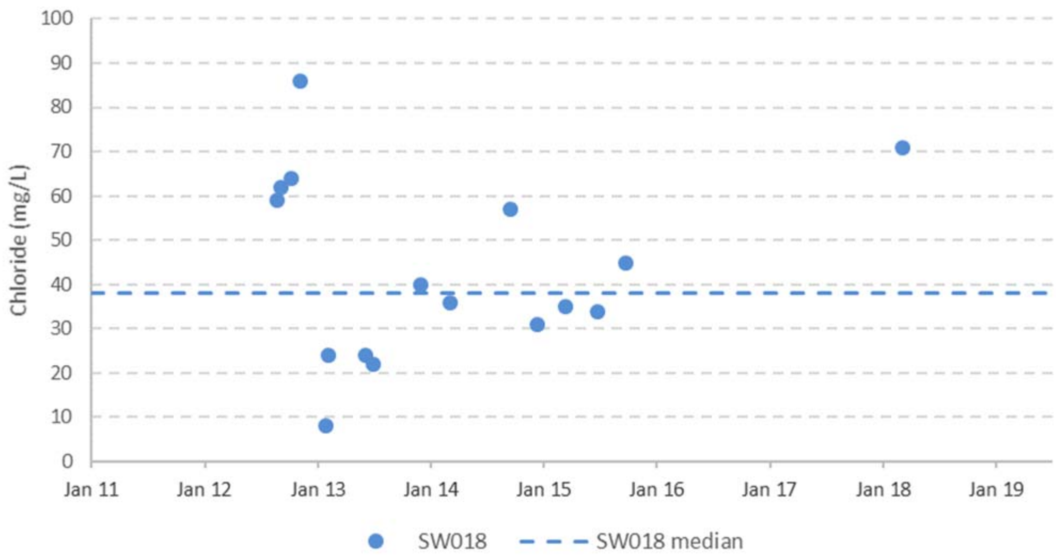

300
250
200
150
100
50
0
Bicarbonate alkalinity (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

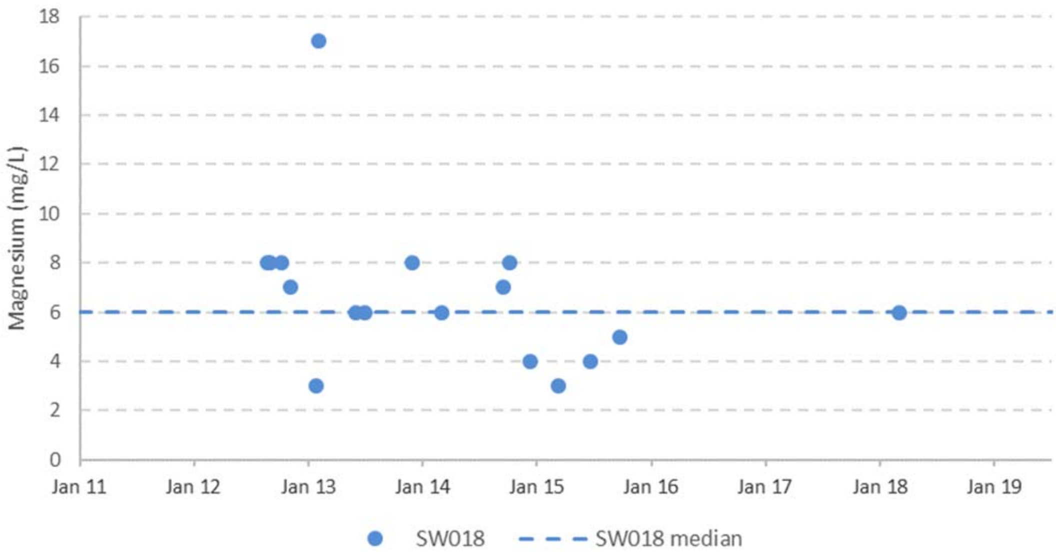

1.2
1.0
0.8
0.6
0.4
0.2
0.0
Carbonate alkalinity (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

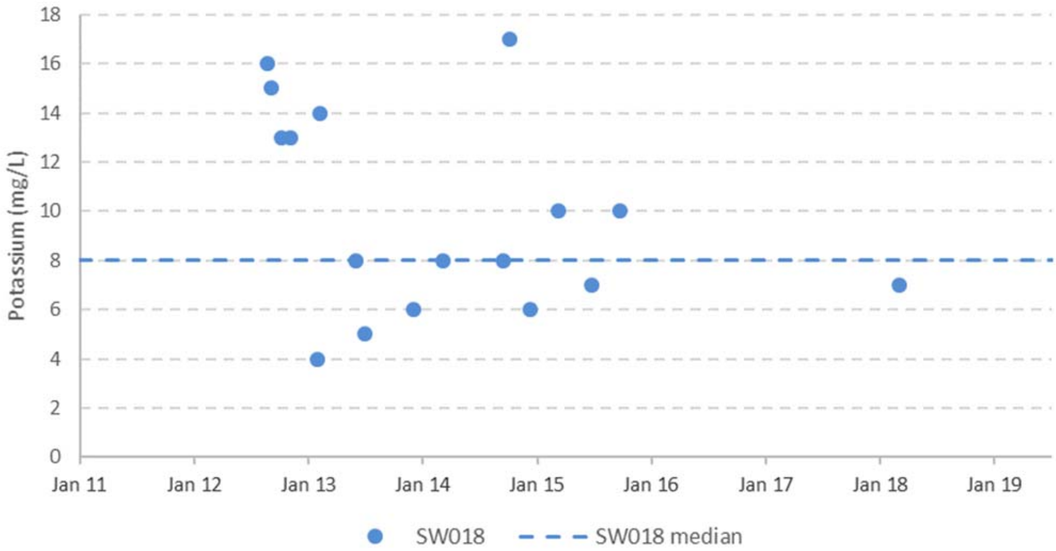

1.2
1.0
0.8
0.6
0.4
0.2
0.0
Hydroxide alkalinity (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median


Total alkalinity (mg/L)
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

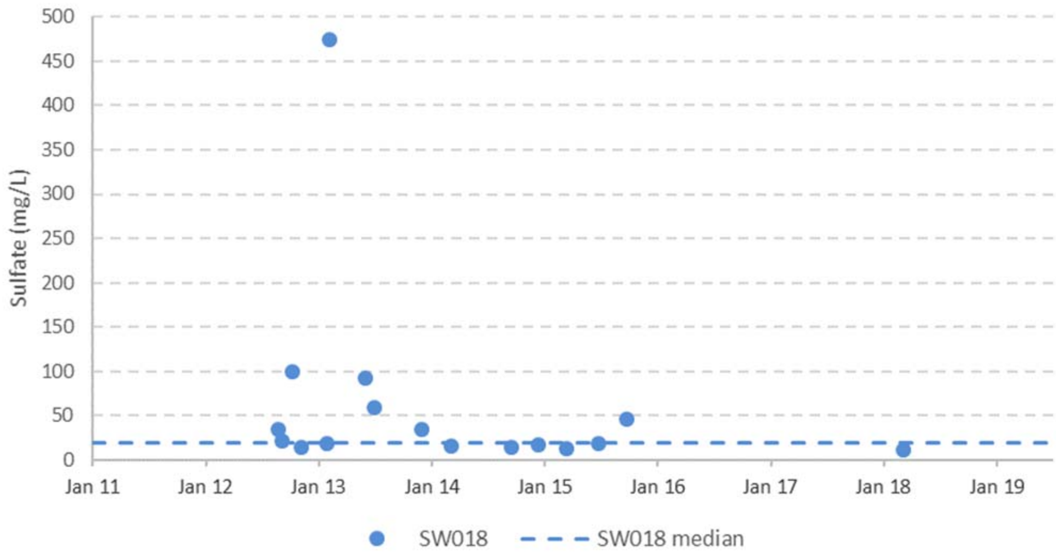

Calcium (mg/L)
160
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

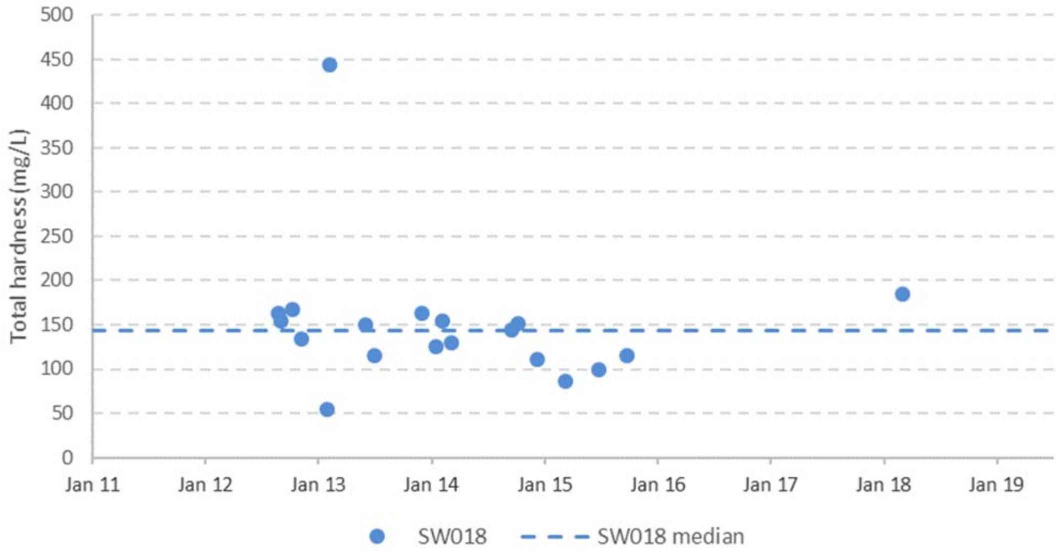

Chloride (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

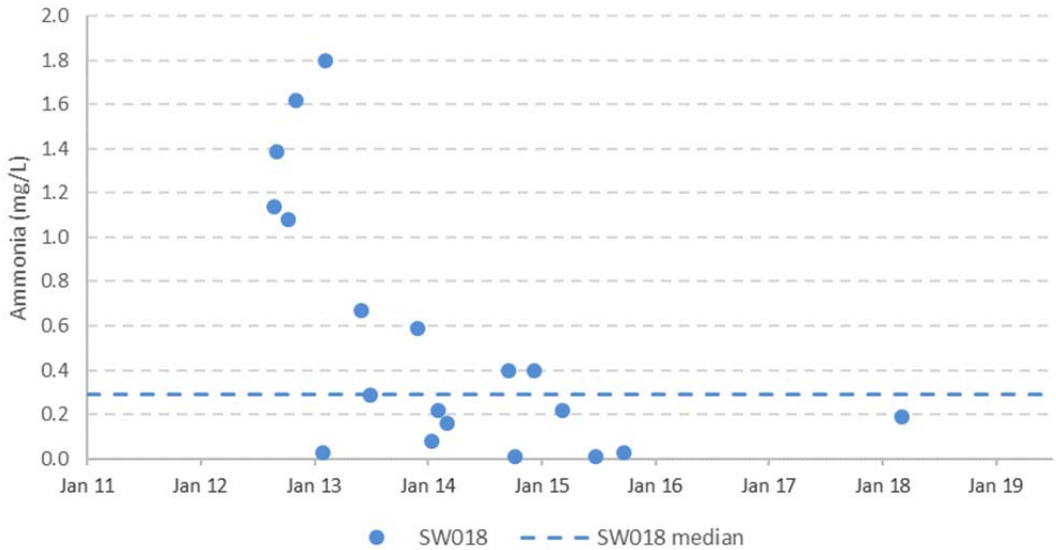

Magnesium (mg/L)
18
16
14
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

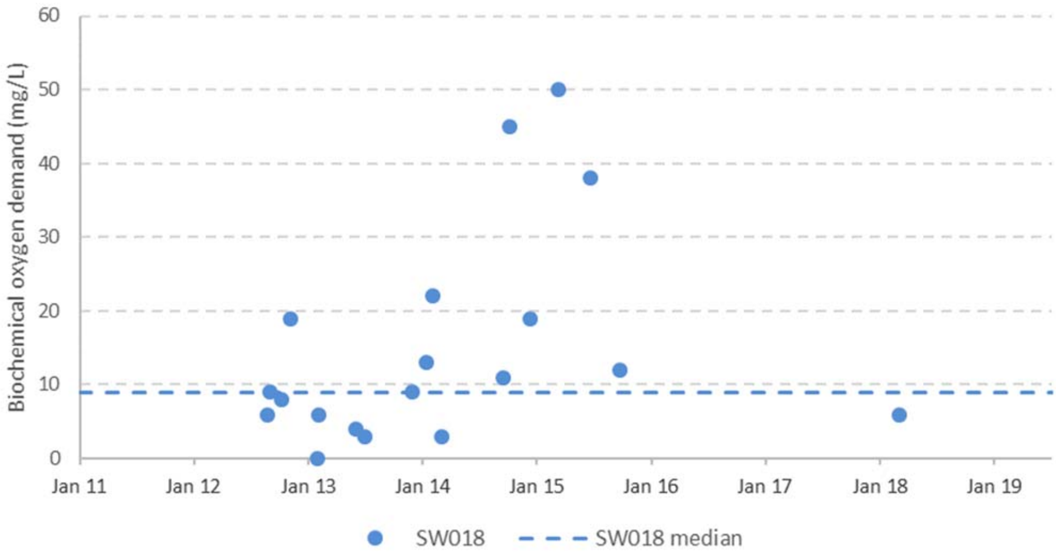

Potassium (mg/L)
18
16
14
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

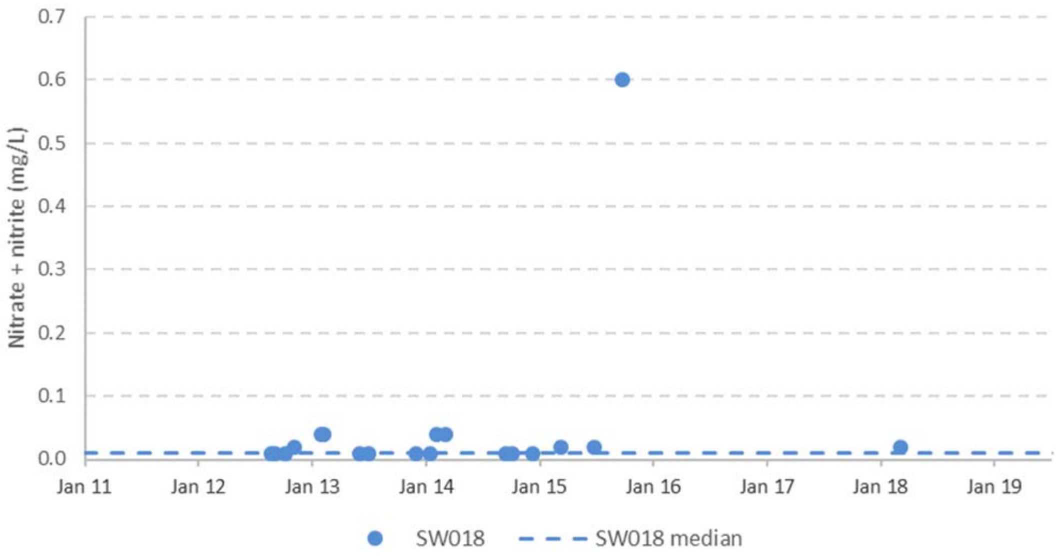

Sodium (mg/L)
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

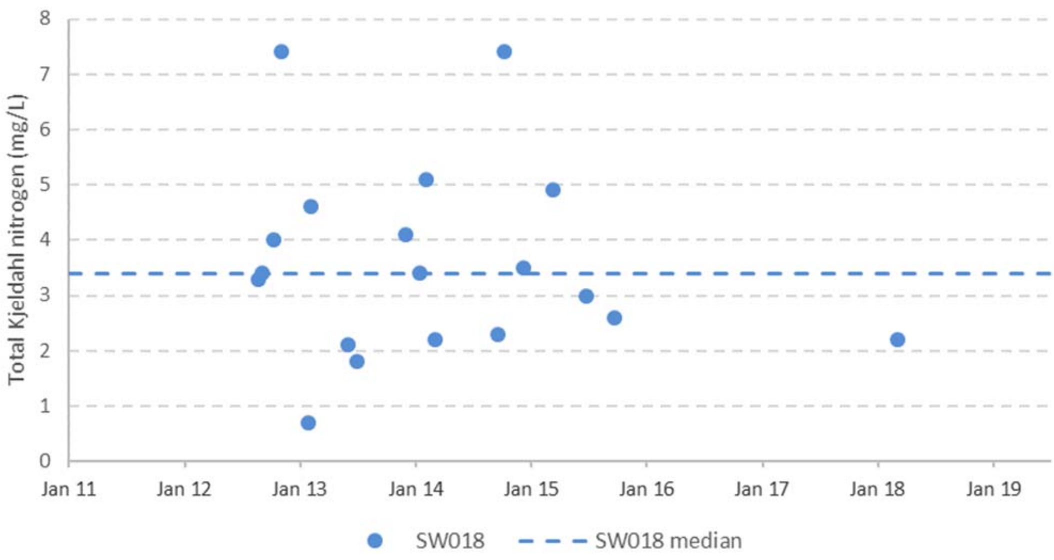

500
450
400
350
300
250
200
150
100
50
0
Sulfate (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median


500
450
400
350
300
250
200
150
100
50
0
Total hardness (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

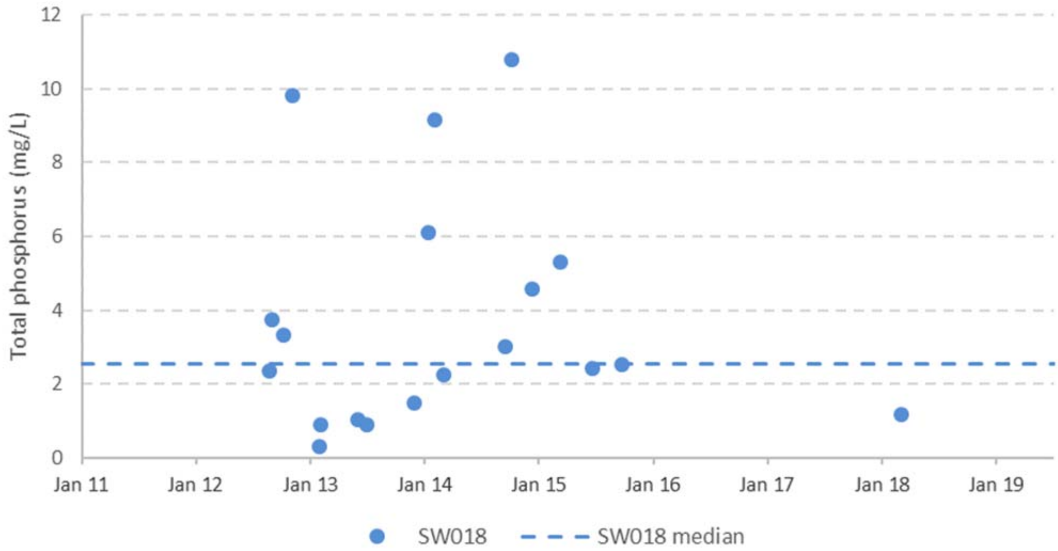

2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Ammonia (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

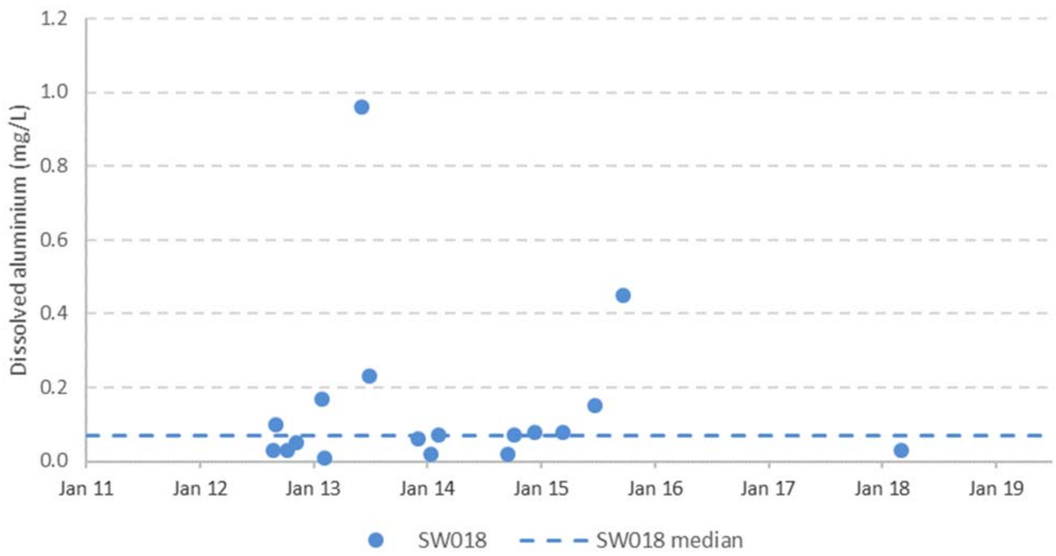

Biochemical oxygen demand (mg/L)
0
10
20
30
40
50
60
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

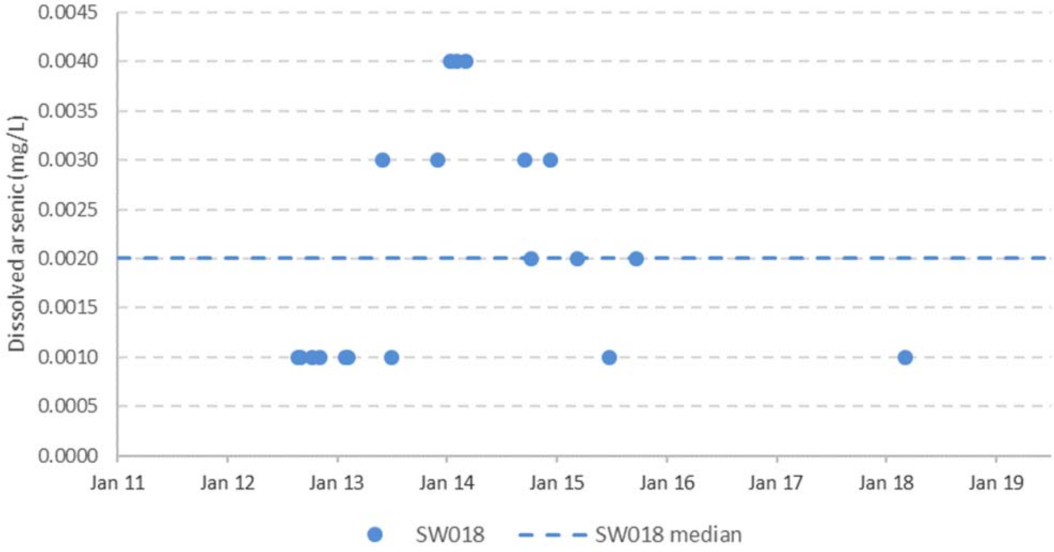

Nitrate + nitrite (mg/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

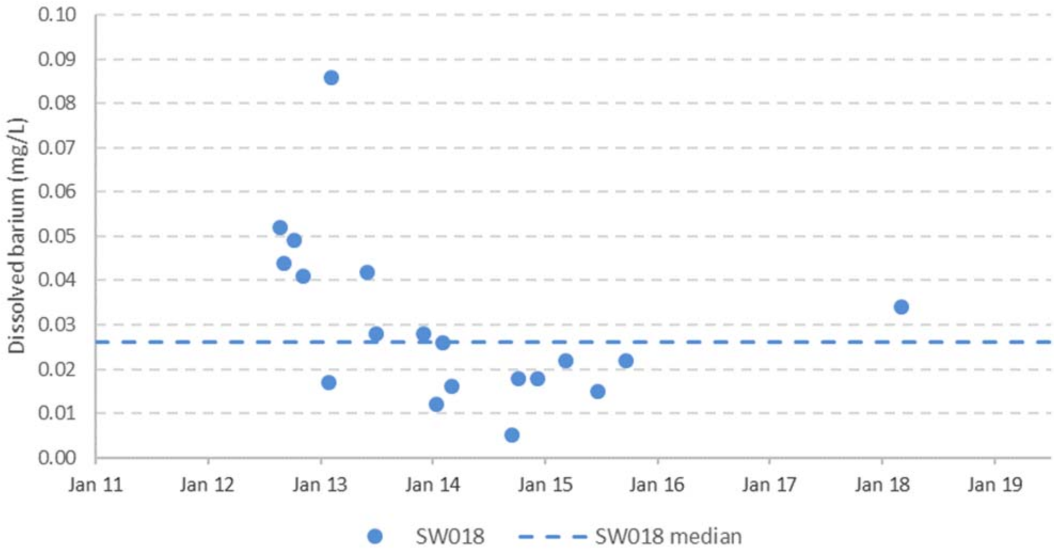

Total Kjeldahl nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

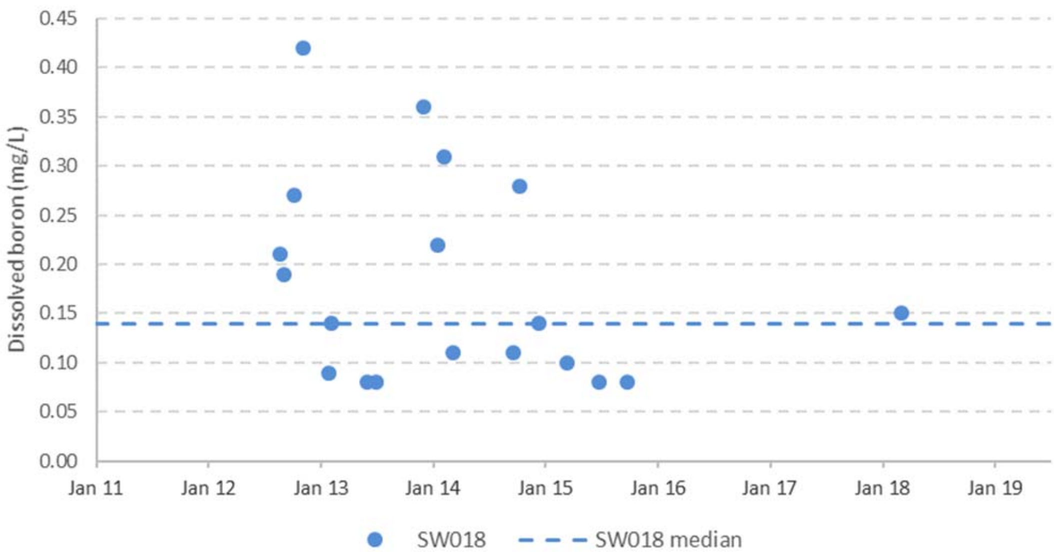

Total nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

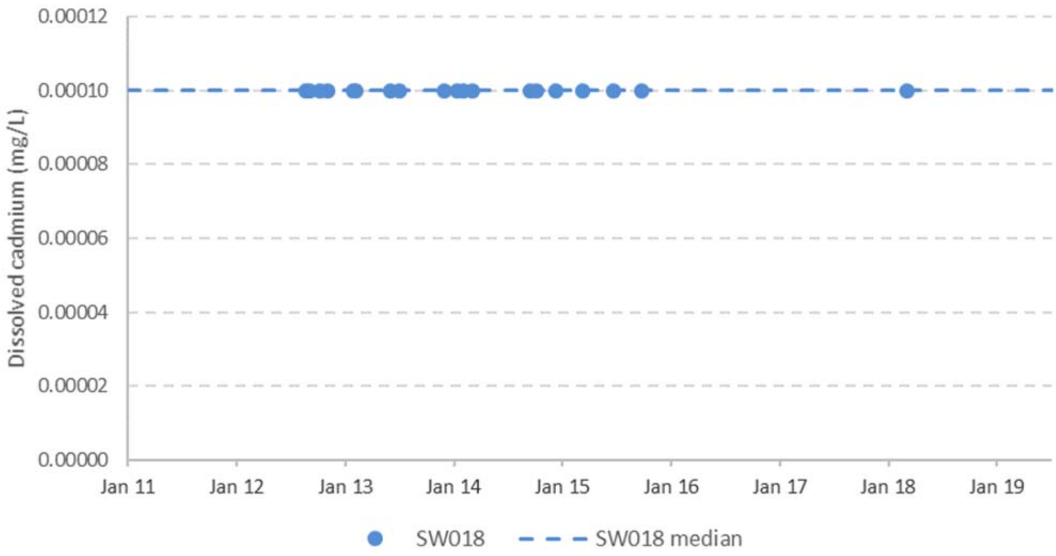

Total phosphorus (mg/L)
0
2
4
6
8
10
12
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

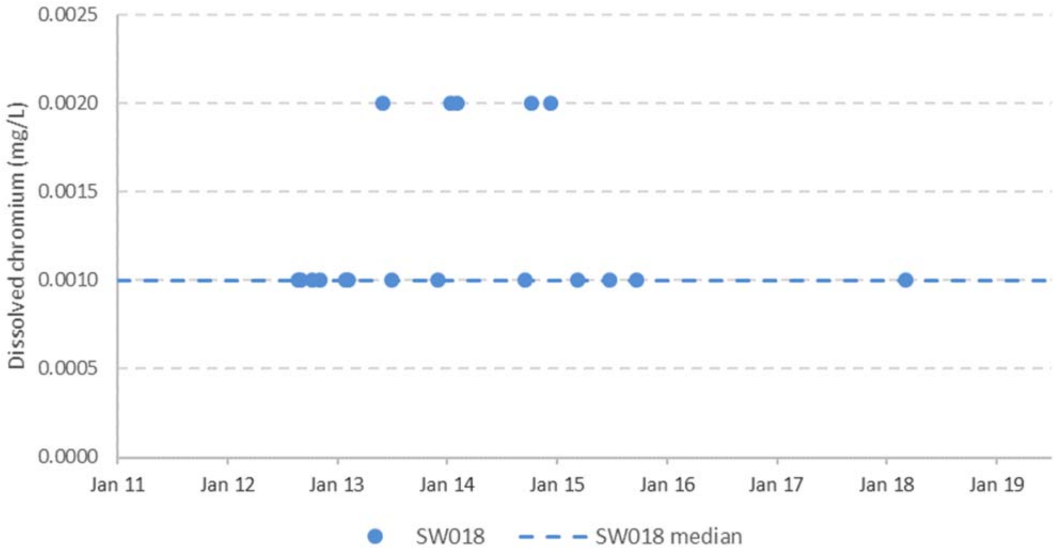

Dissolved aluminium (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

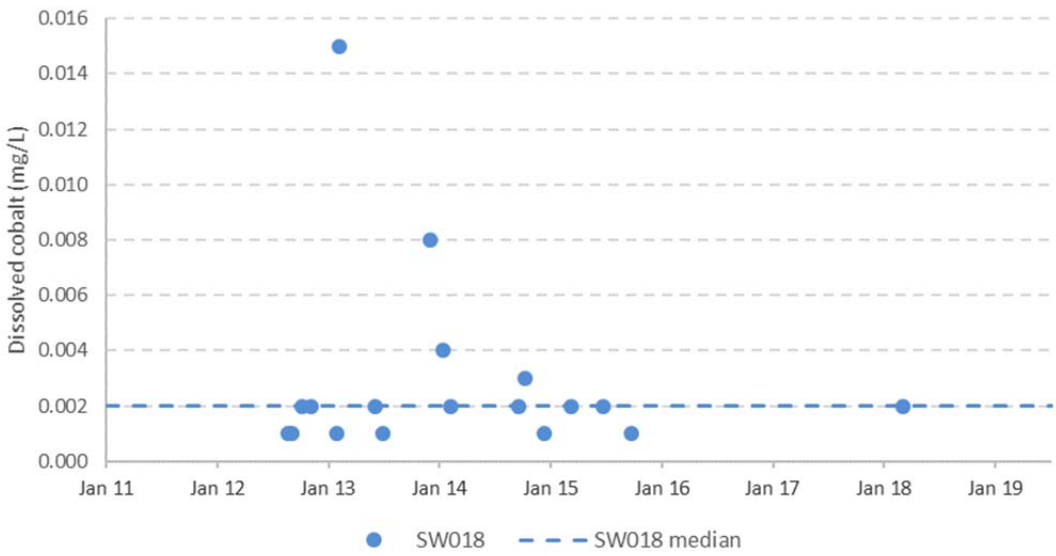

0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved arsenic (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

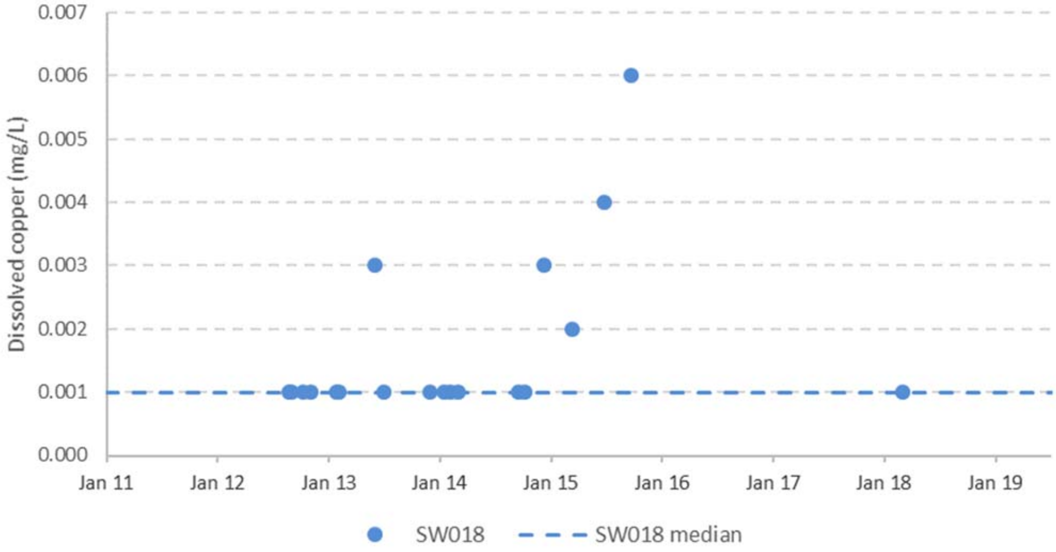

0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved barium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

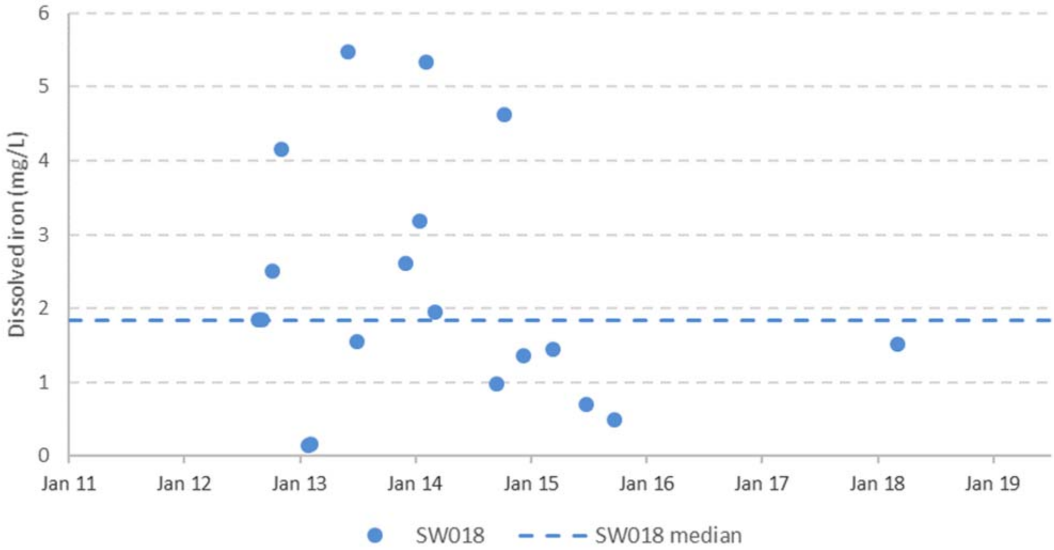

0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dissolved boron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

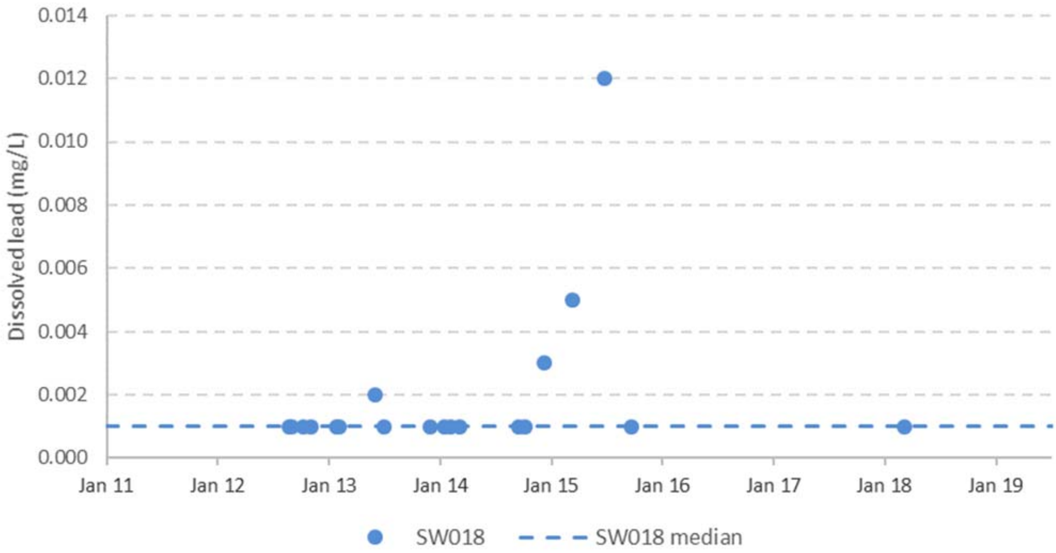

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved cadmium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

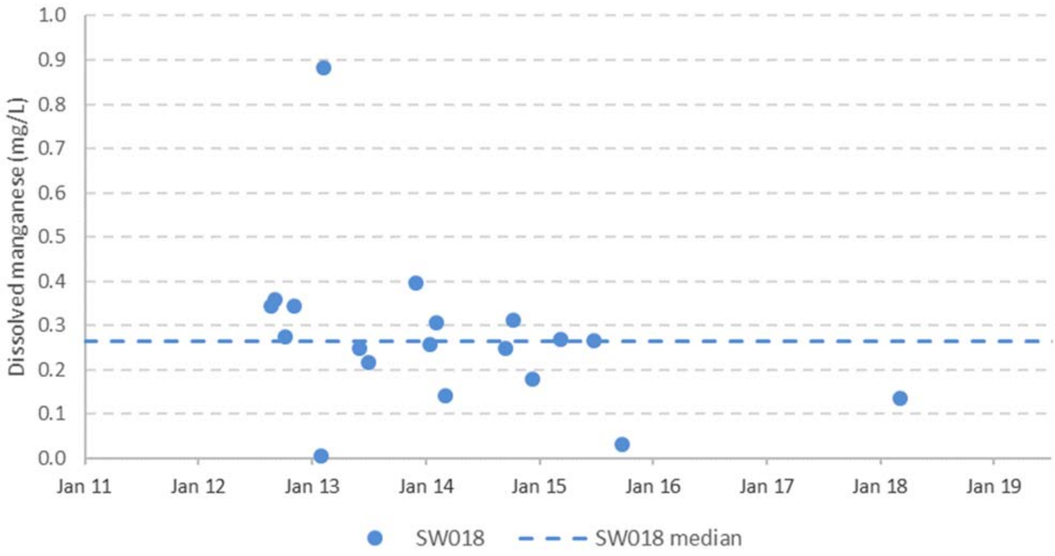

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved chromium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

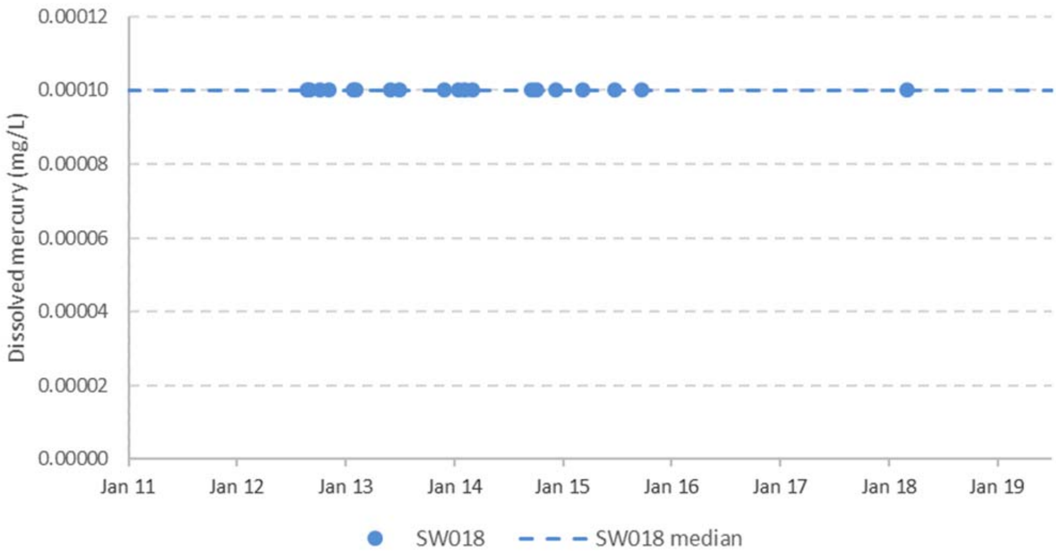

0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved cobalt (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

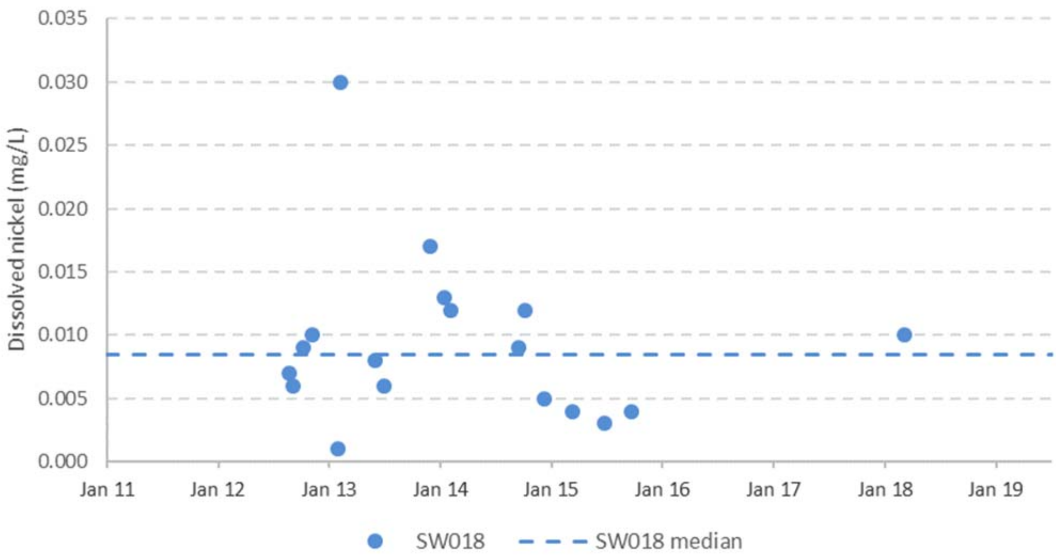

0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Dissolved copper (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

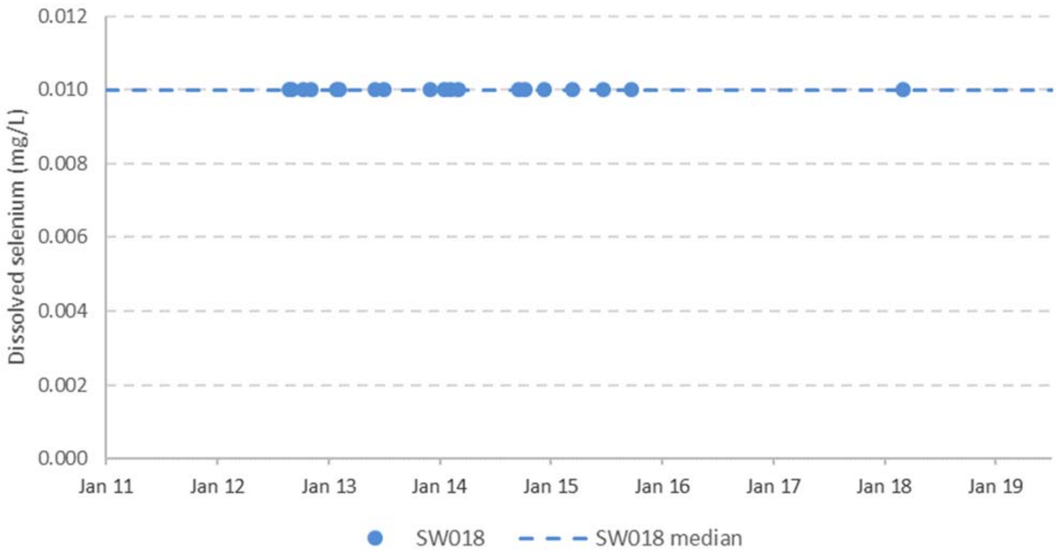

6
5
4
3
2
1
0
Dissolved iron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

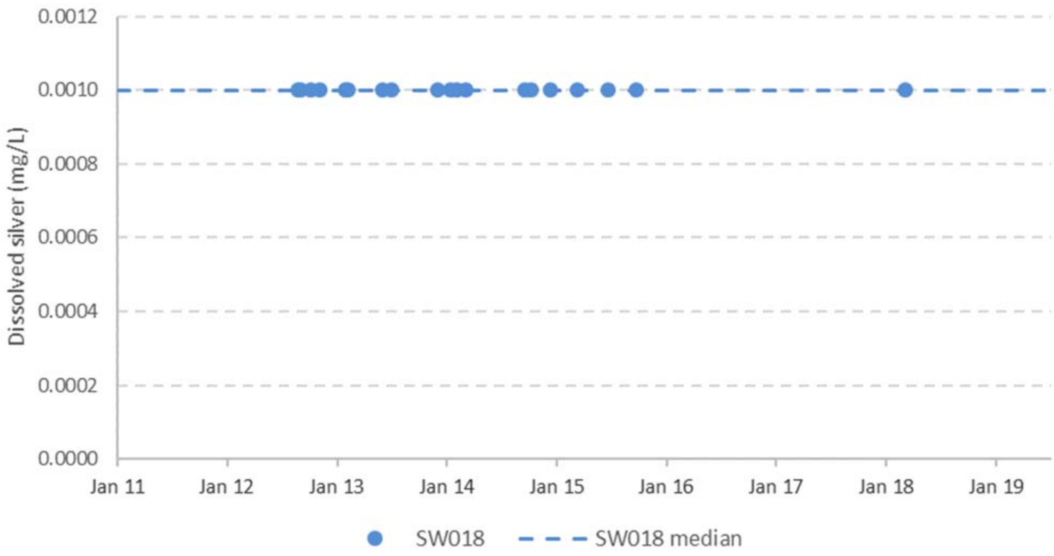

0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved lead (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

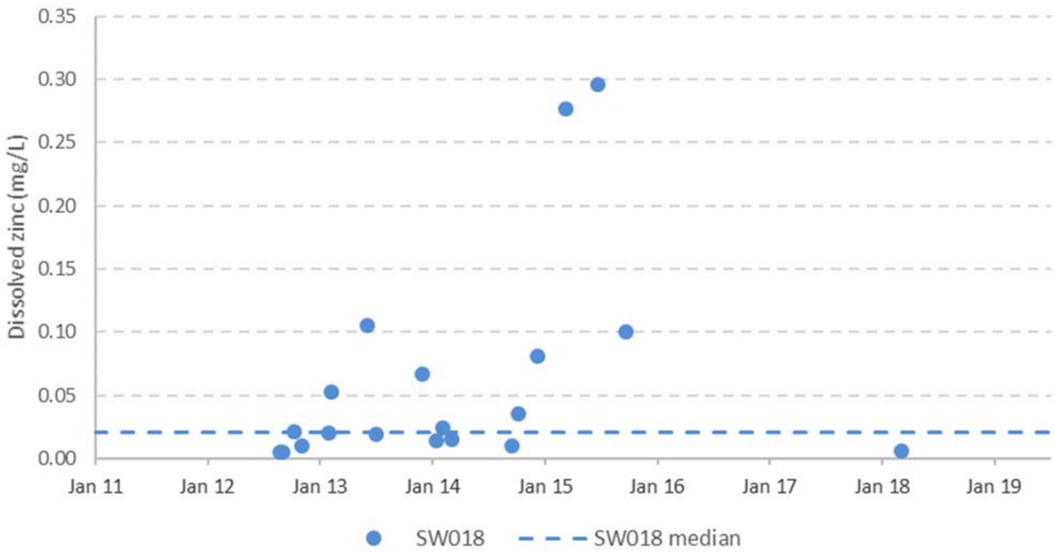

Dissolved manganese (mg/L)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

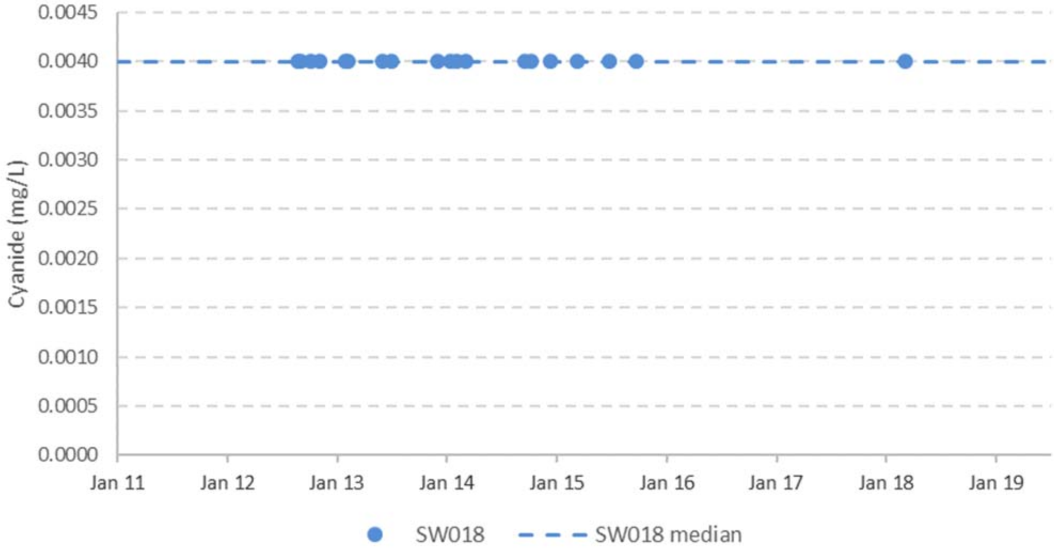

Dissolved mercury (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

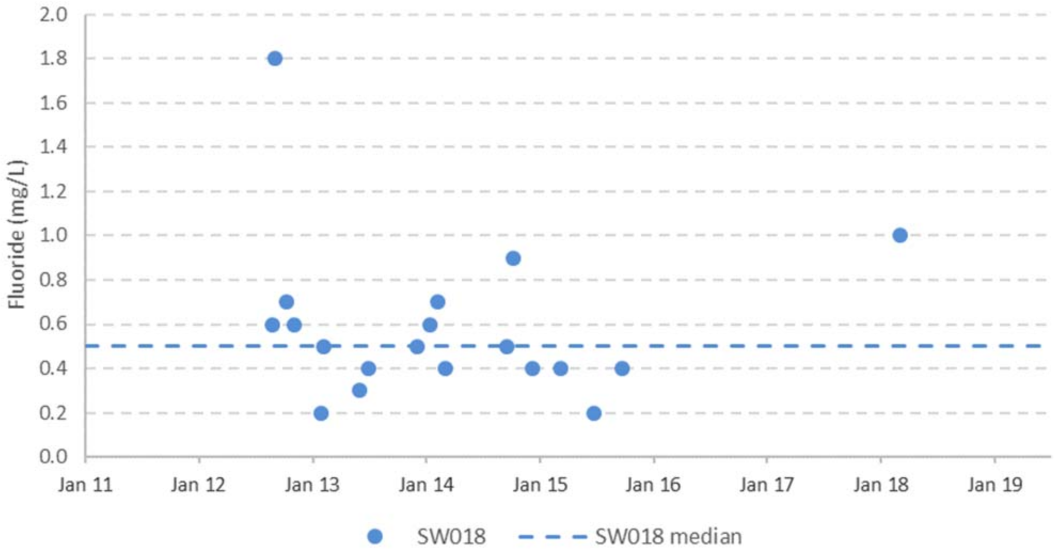

Dissolved nickel (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median


0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median


0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median


2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SW018
SW018 median

E.2 Mandalong South Surface Site

E.2.1 Mannering Creek

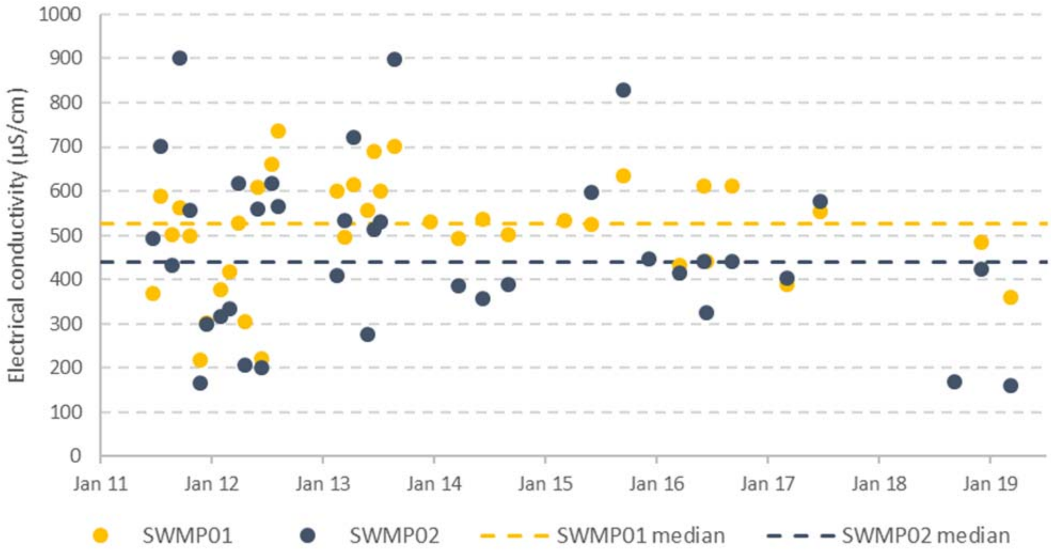
Median water quality results

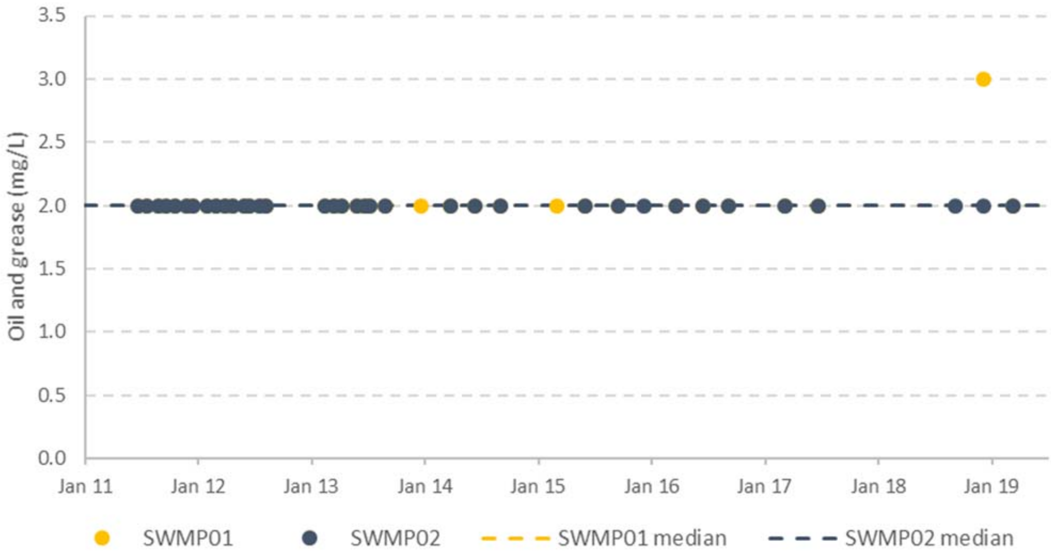
Parameter	Units	SWMP01		SWMP02	
		Count	Median	Count	Median
Physicochemical parameters					
EC	µS/cm	37	527	37	440
Oil and grease	mg/L	36	2	36	2
pH	pH units	37	6.73	37	6.56
TDS	mg/L	37	291	37	296
TSS	mg/L	37	5	37	11
Turbidity	NTU	37	16.0	37	29.6
Major ions					
Bicarbonate alkalinity	mg/L	37	29	37	29
Carbonate alkalinity	mg/L	37	1	37	1
Hydroxide alkalinity	mg/L	37	1	37	1
Total alkalinity	mg/L	37	29	37	29
Calcium	mg/L	37	7	37	5
Chloride	mg/L	37	126	37	105
Magnesium	mg/L	37	11	37	9
Potassium	mg/L	37	3	37	4
Sodium	mg/L	27	72	37	61
Sulfate	mg/L	37	16	37	11
Total hardness	mg/L	37	65	37	50
Nutrients					
Ammonia	mg/L	36	0.02	36	0.06
BOD	mg/L	37	2	37	2
Nitrate + nitrite	mg/L	37	0.02	37	0.02
TKN	mg/L	37	0.3	37	1.0

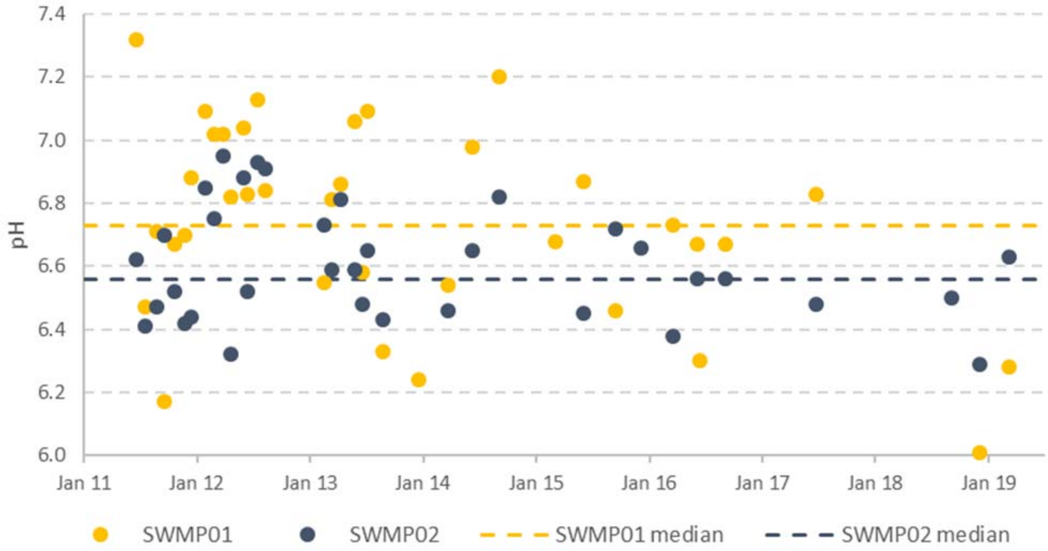
Parameter	Units	SWMP01		SWMP02	
		Count	Median	Count	Median
Total nitrogen	mg/L	37	0.3	37	1.1
Total phosphorus	mg/L	37	0.02	37	0.09
Dissolved metals					
Aluminium	mg/L	37	0.12	37	0.44
Arsenic	mg/L	37	0.001	37	0.001
Barium	mg/L	37	0.051	37	0.058
Boron	mg/L	37	0.05	37	0.05
Cadmium	mg/L	37	0.0001	37	0.0001
Chromium	mg/L	37	0.001	37	0.001
Cobalt	mg/L	37	0.001	37	0.004
Copper	mg/L	37	0.001	37	0.001
Iron	mg/L	36	1.28	36	29.6
Lead	mg/L	37	0.001	37	0.001
Manganese	mg/L	36	0.130	36	0.514
Mercury	mg/L	37	0.0001	37	0.0001
Nickel	mg/L	37	0.002	37	0.003
Selenium	mg/L	37	0.01	37	0.01
Silver	mg/L	37	0.001	37	0.001
Zinc	mg/L	37	0.005	37	0.006
Total metals					
Aluminium	mg/L	37	0.23	37	0.79
Arsenic	mg/L	37	0.001	37	0.001
Barium	mg/L	36	0.056	36	0.064
Boron	mg/L	37	0.05	37	0.05
Cadmium	mg/L	37	0.0001	37	0.0001
Chromium	mg/L	37	0.001	37	0.001
Cobalt	mg/L	36	0.001	36	0.004

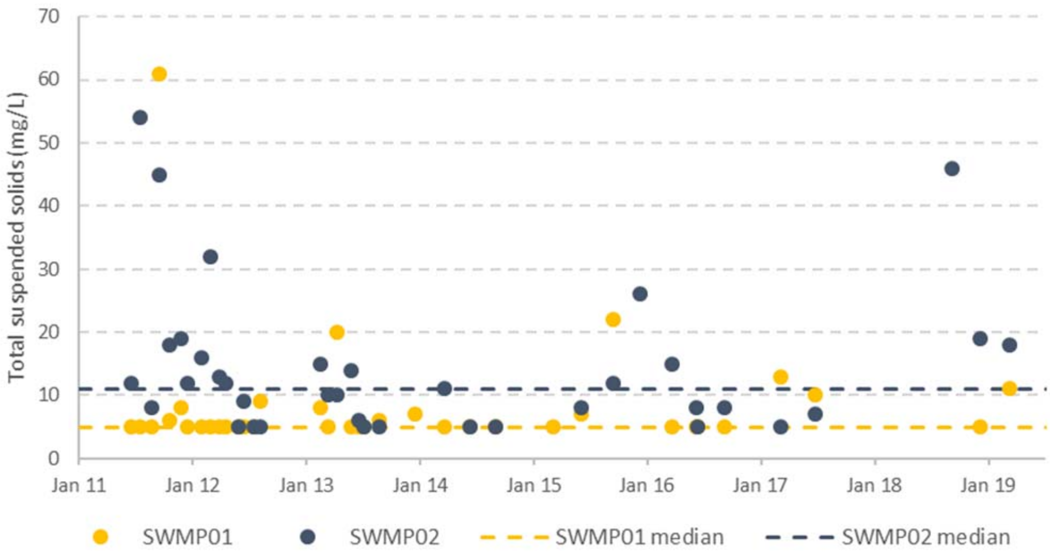
Parameter	Units	SWMP01		SWMP02	
		Count	Median	Count	Median
Copper	mg/L	37	0.001	37	0.002
Iron	mg/L	37	2.73	37	6.00
Lead	mg/L	37	0.001	37	0.001
Manganese	mg/L	37	0.137	37	0.596
Mercury	mg/L	37	0.0001	37	0.0001
Nickel	mg/L	37	0.002	37	0.004
Selenium	mg/L	37	0.01	37	0.01
Silver	mg/L	37	0.001	37	0.001
Zinc	mg/L	37	0.005	37	0.010
Other parameters					
Cyanide	mg/L	37	0.004	37	0.004
Fluoride	mg/L	37	0.1	37	0.1

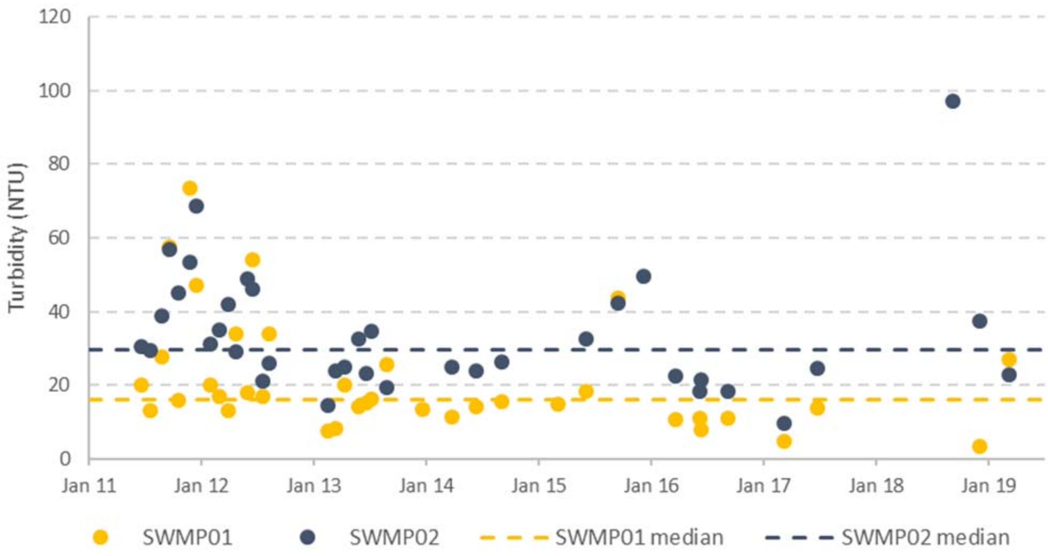
Time series graphs

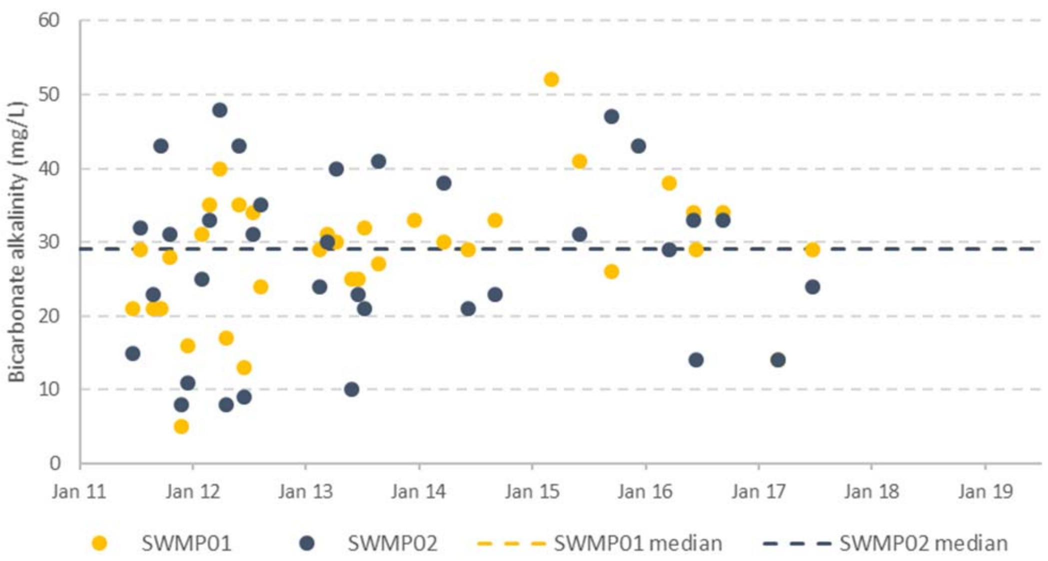


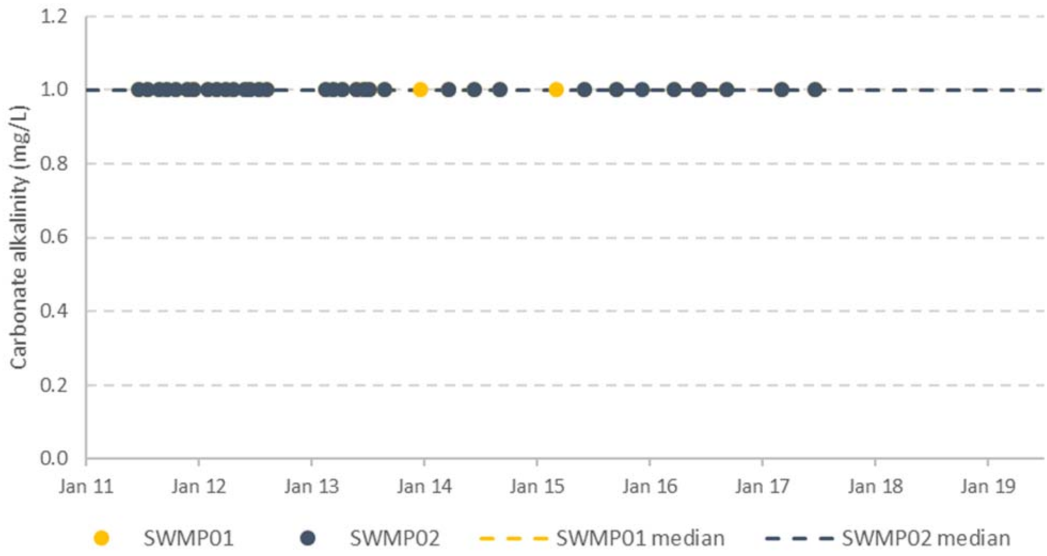


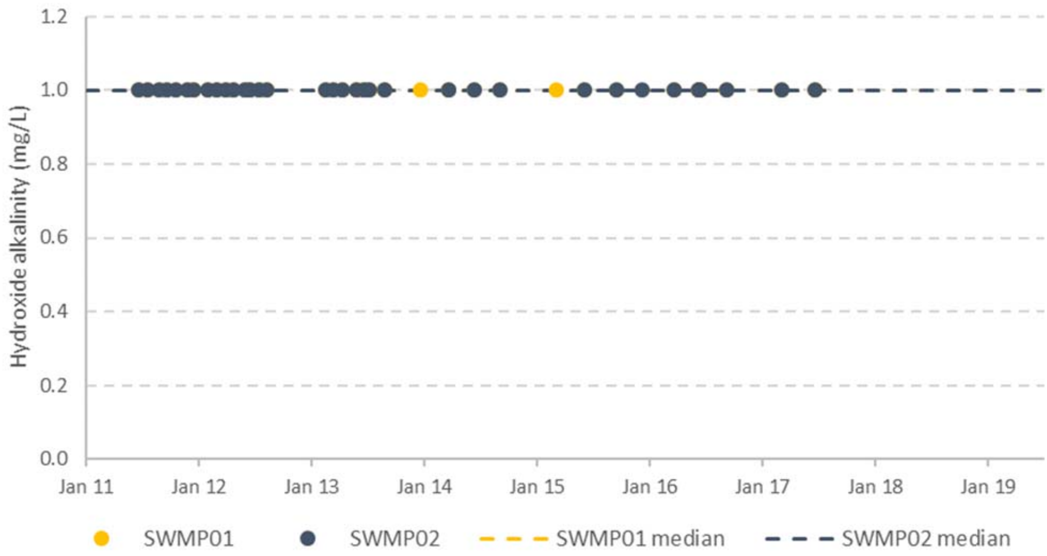


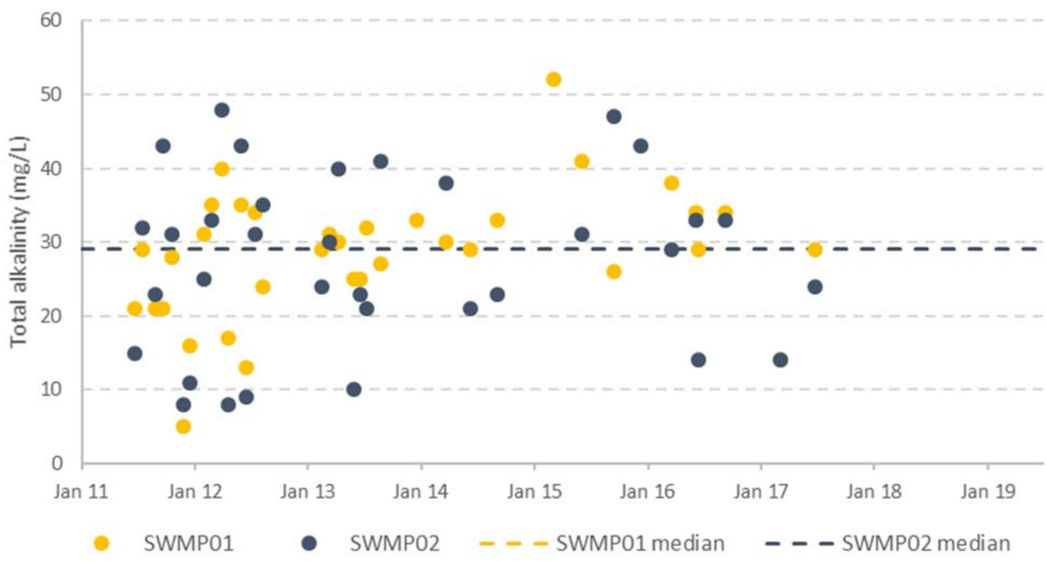

70
60
50
40
30
20
10
0
Total suspended solids (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

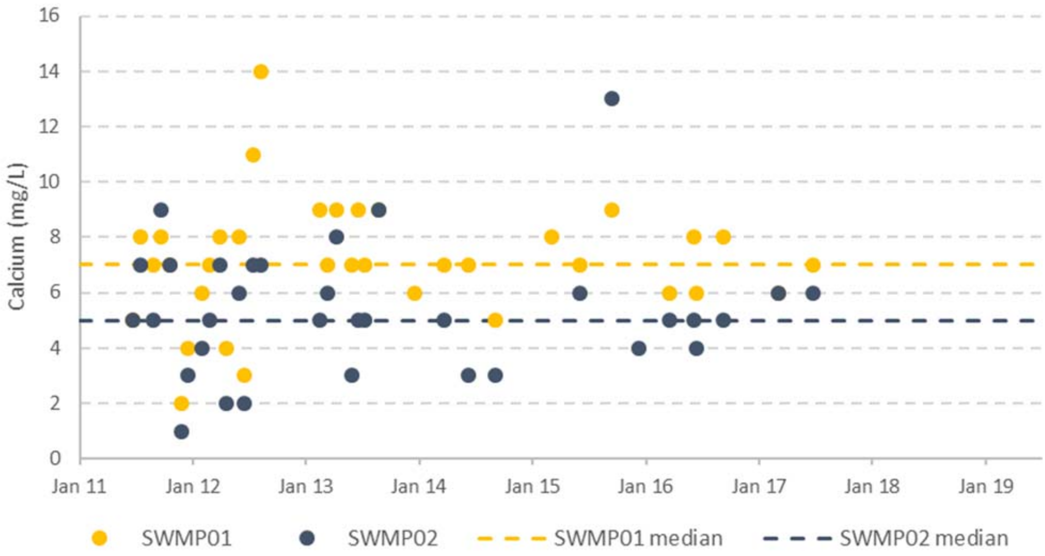

120
100
80
60
40
20
0
Turbidity (NTU)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

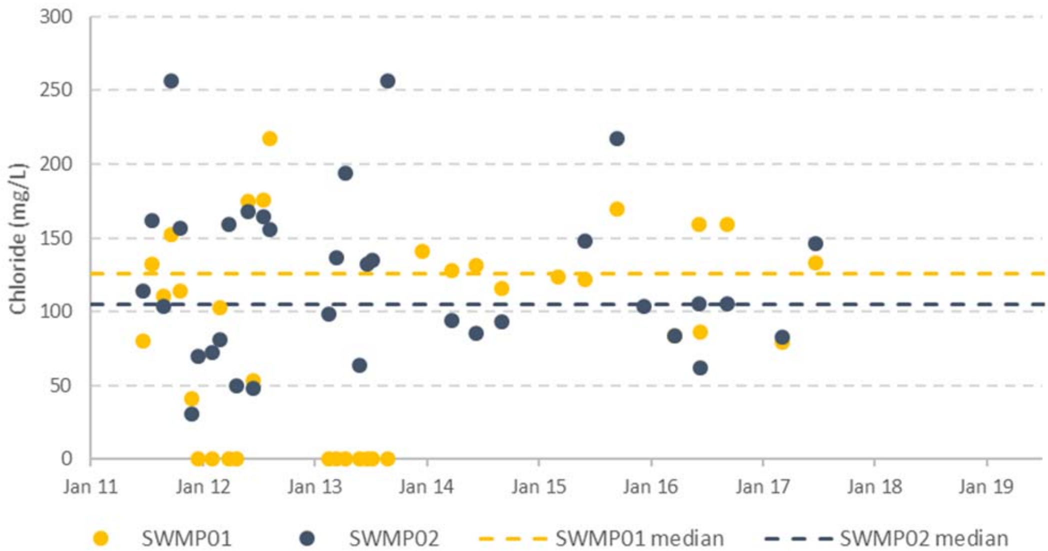

60
50
40
30
20
10
0
Bicarbonate alkalinity (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

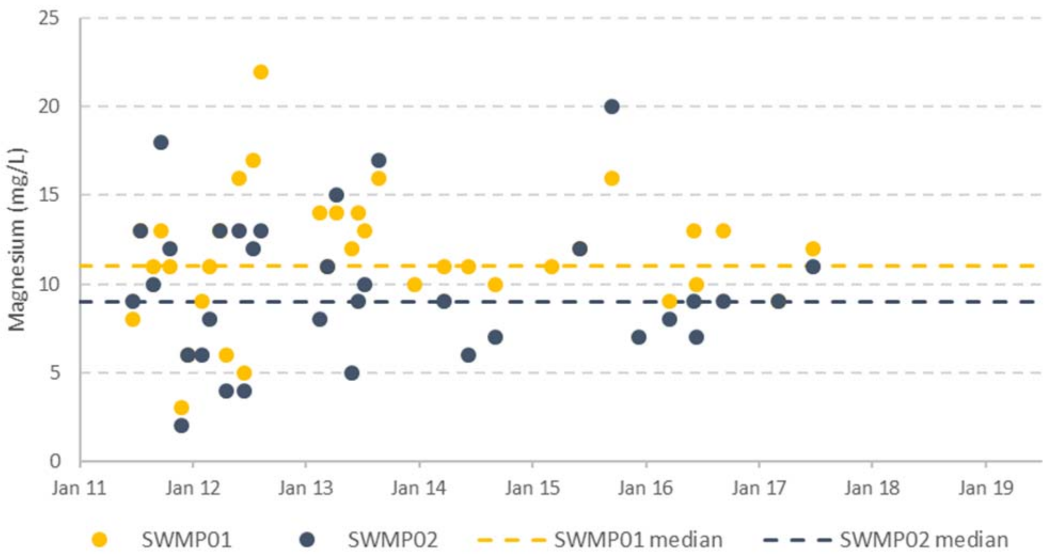

Carbonate alkalinity (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

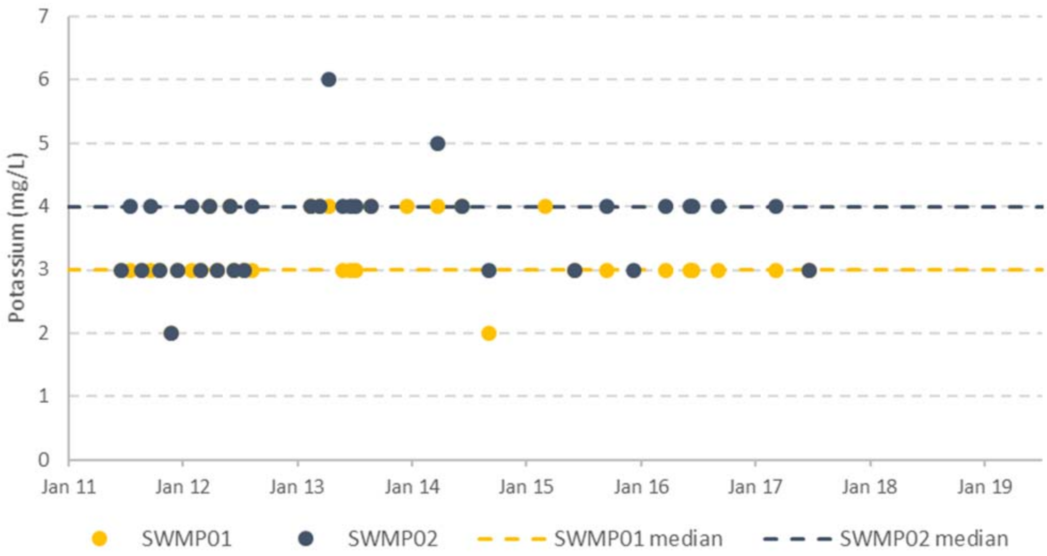

Hydroxide alkalinity (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

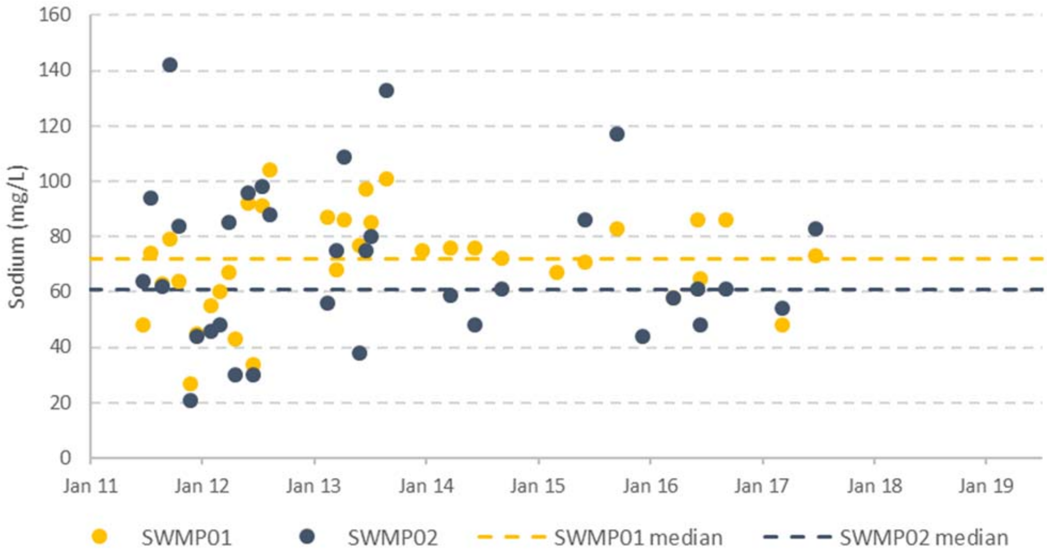

Total alkalinity (mg/L)
60
50
40
30
20
10
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

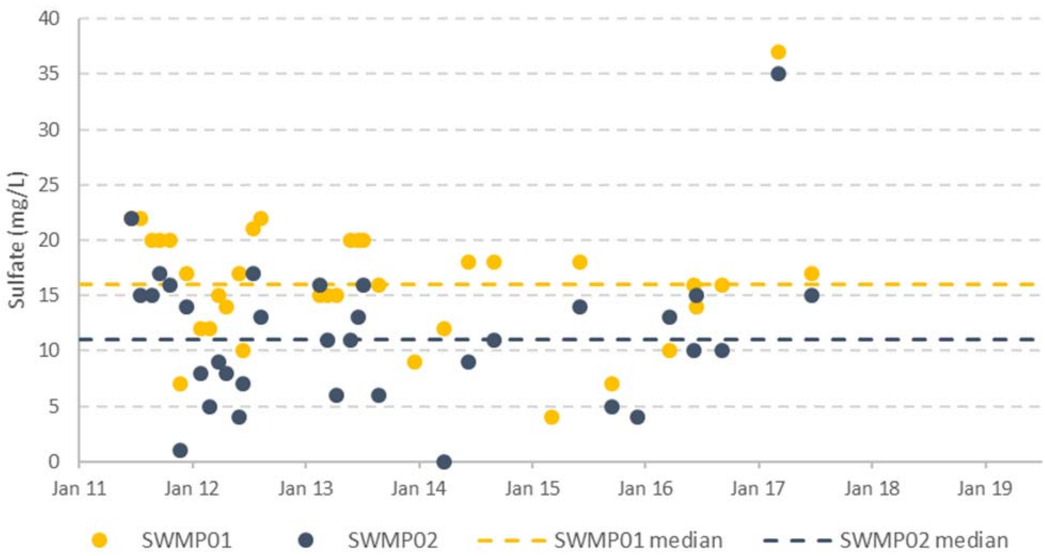

Calcium (mg/L)
16
14
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

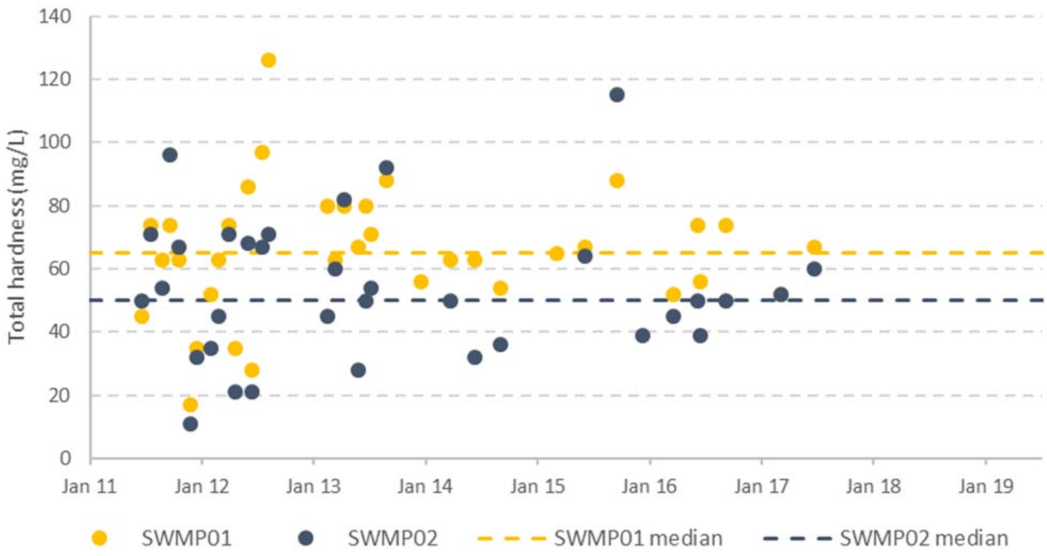

Chloride (mg/L)
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

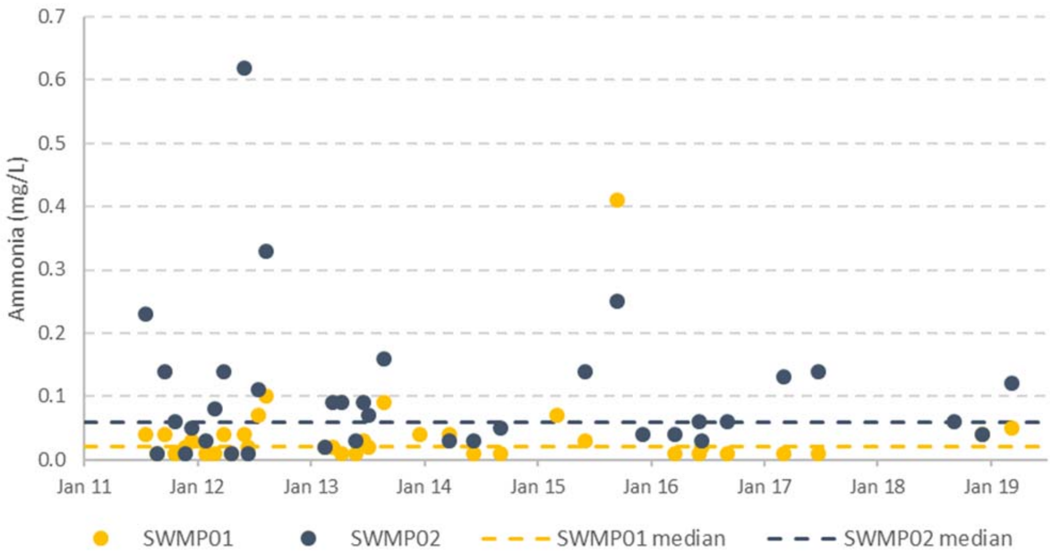

Magnesium (mg/L)
25
20
15
10
5
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

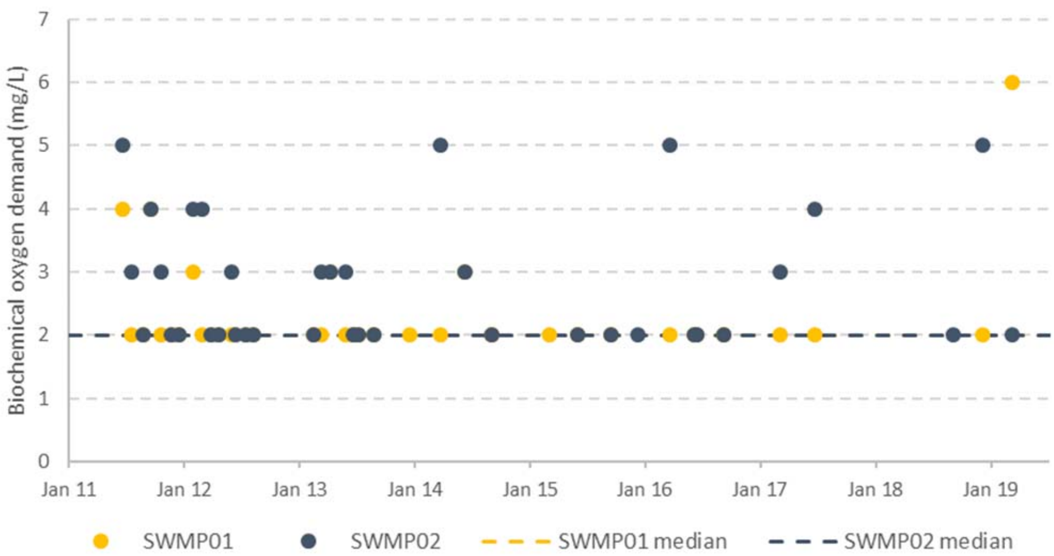

Potassium (mg/L)
0
1
2
3
4
5
6
7
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

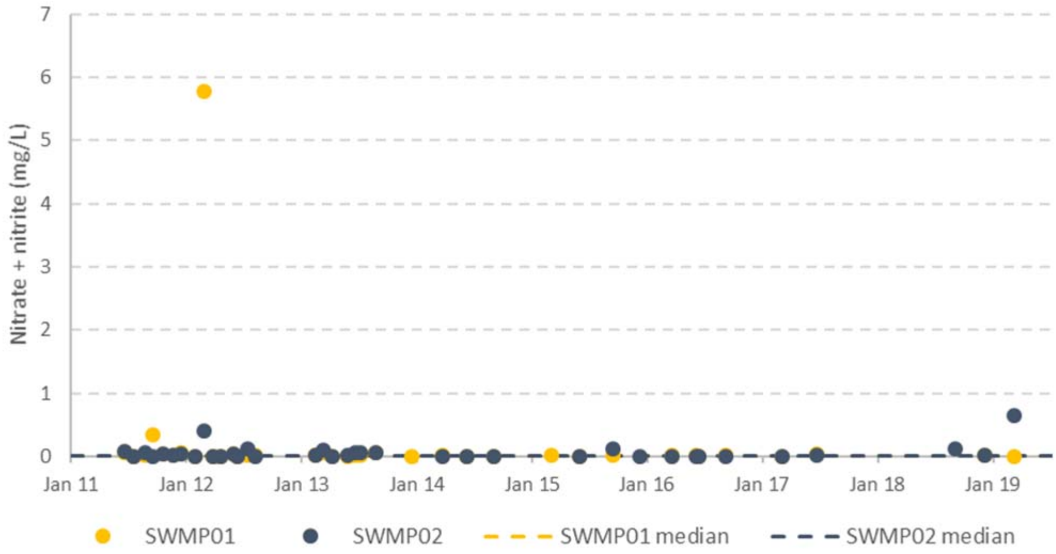

Sodium (mg/L)
0
20
40
60
80
100
120
140
160
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

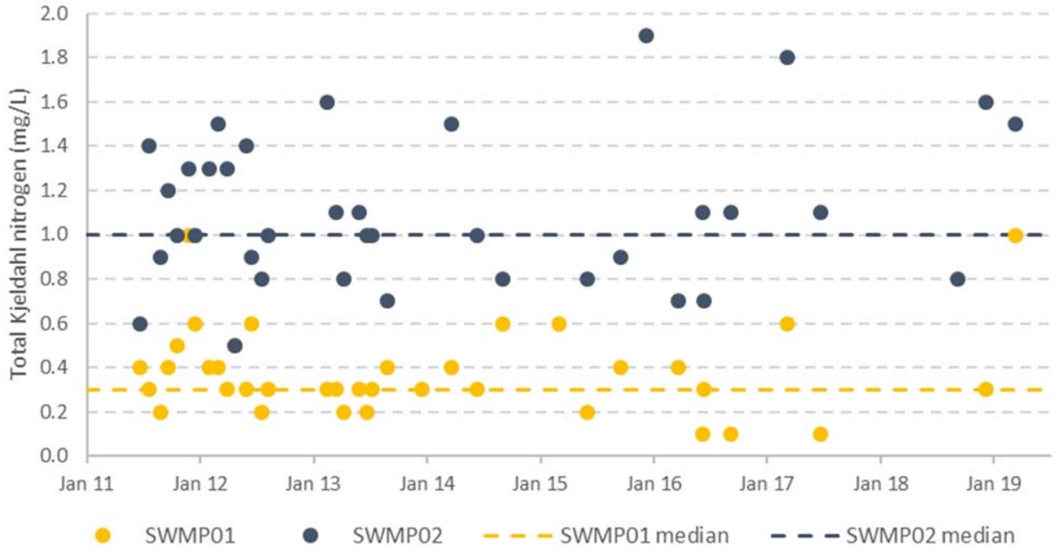

Sulfate (mg/L)
0
5
10
15
20
25
30
35
40
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

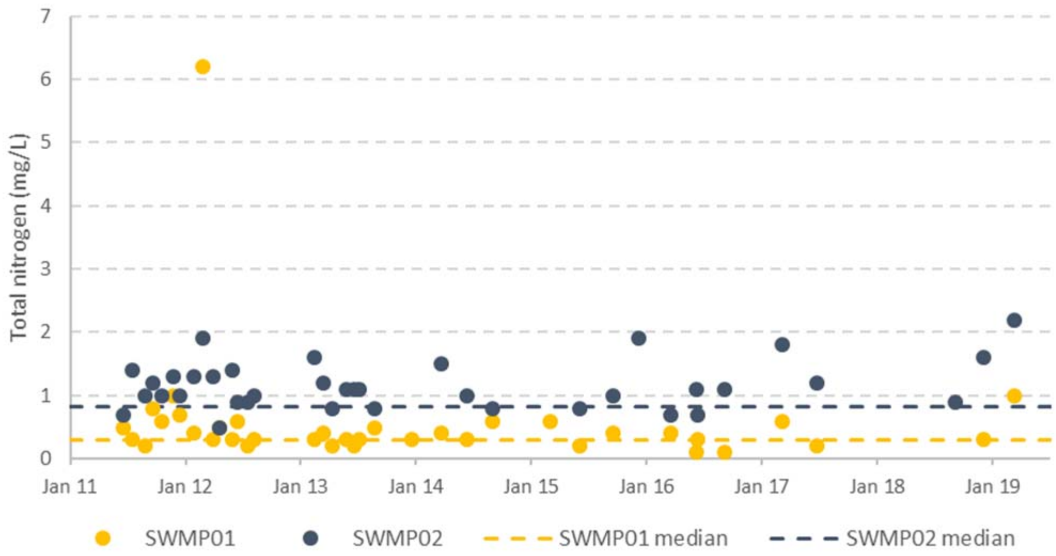

Total hardness (mg/L)
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

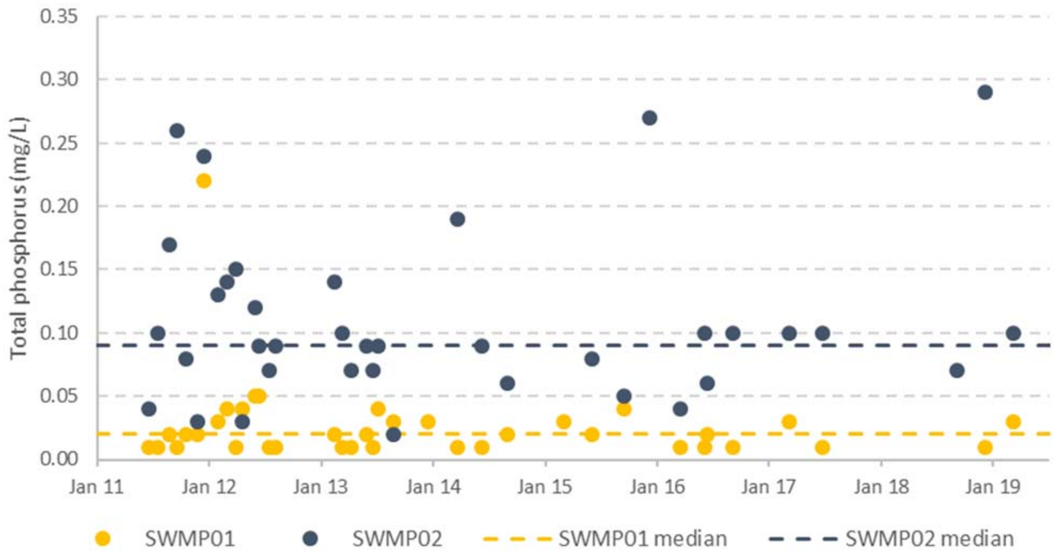

Ammonia (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

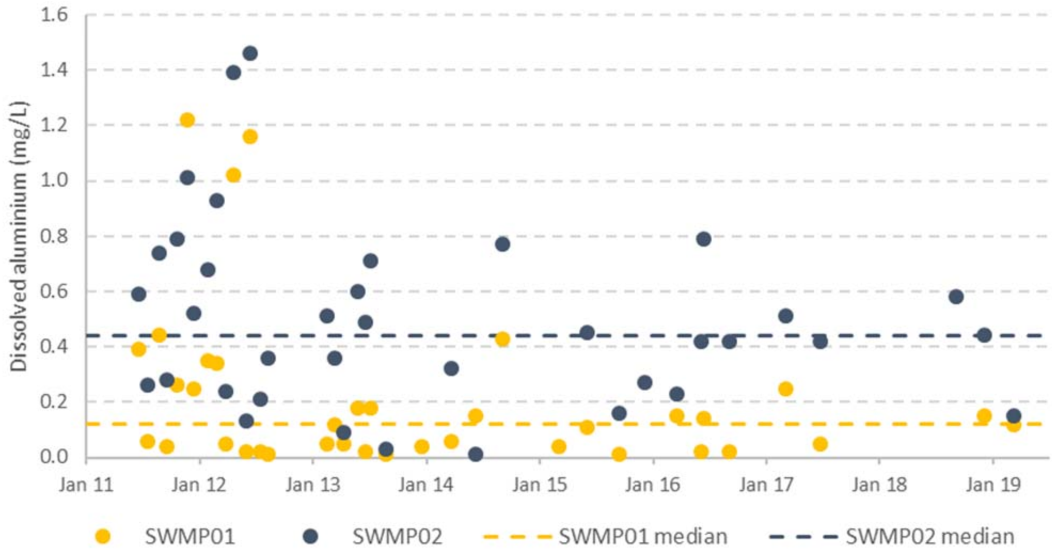

Biochemical oxygen demand (mg/L)
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

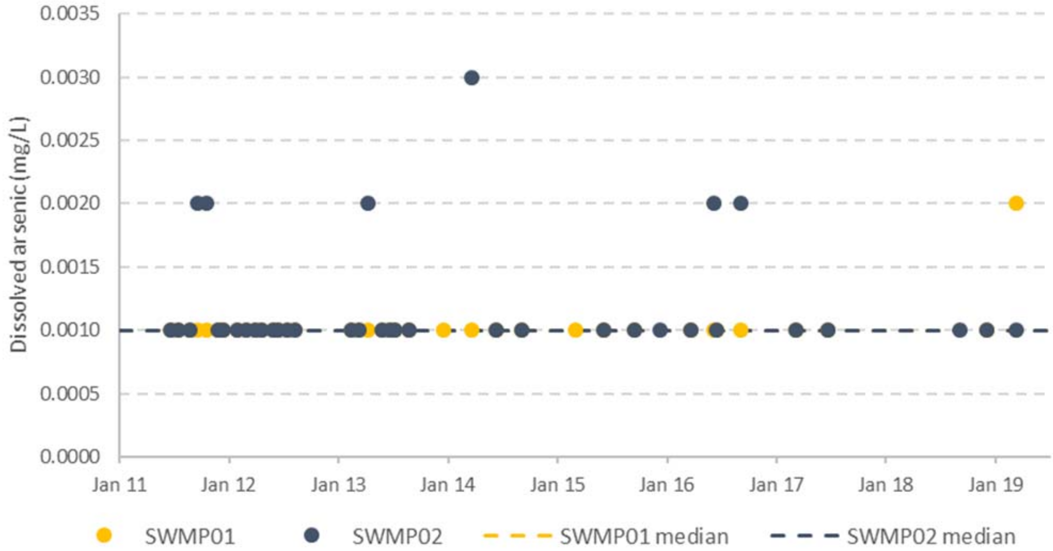

Nitrate + nitrite (mg/L)
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

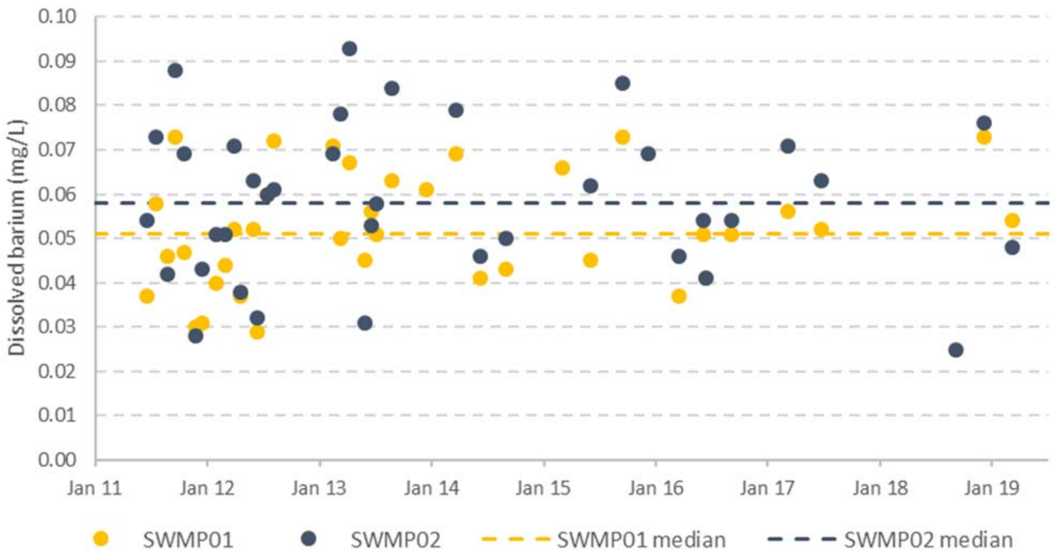

Total Kjeldahl nitrogen (mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

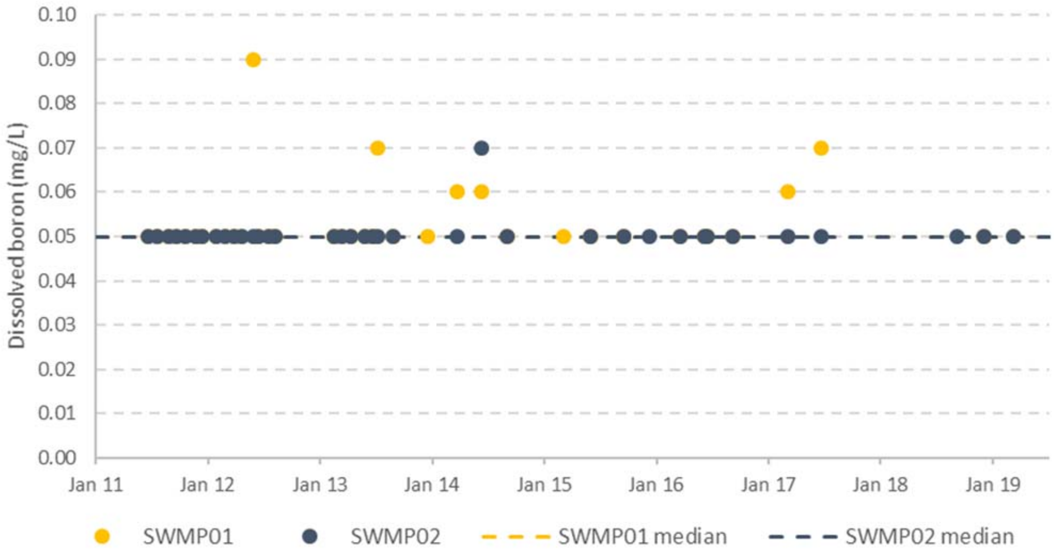

Total nitrogen (mg/L)
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

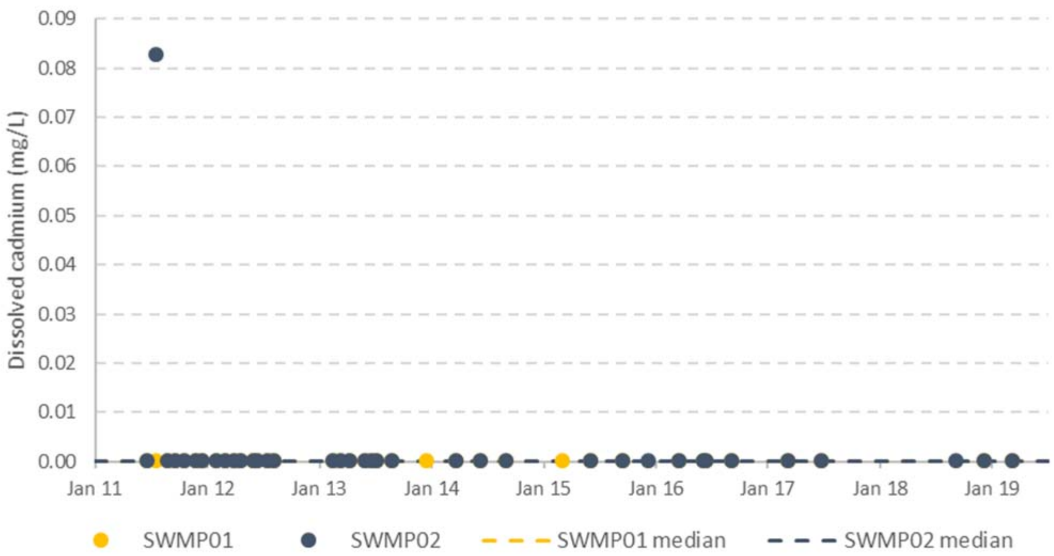

0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Total phosphorus (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

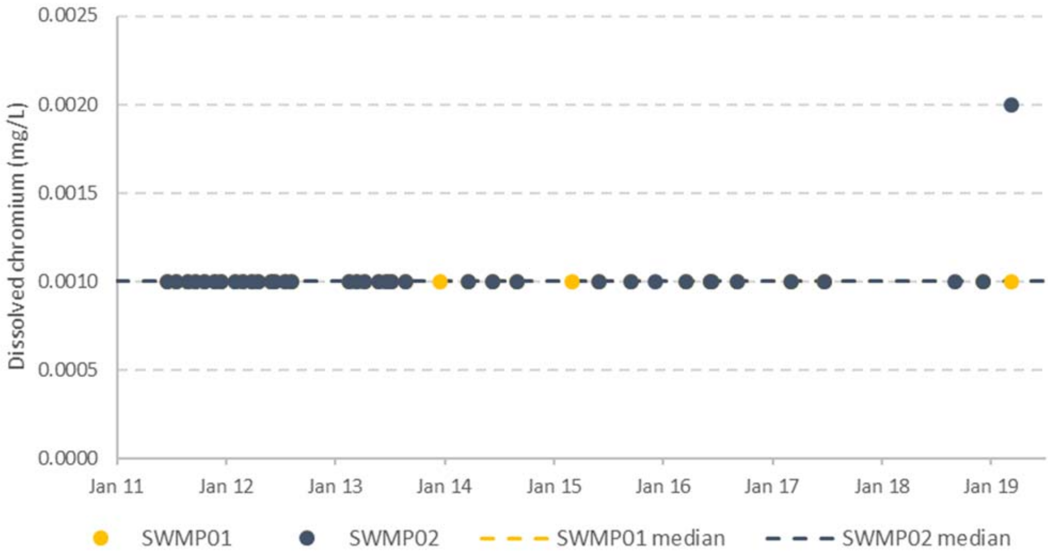

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Dissolved aluminium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

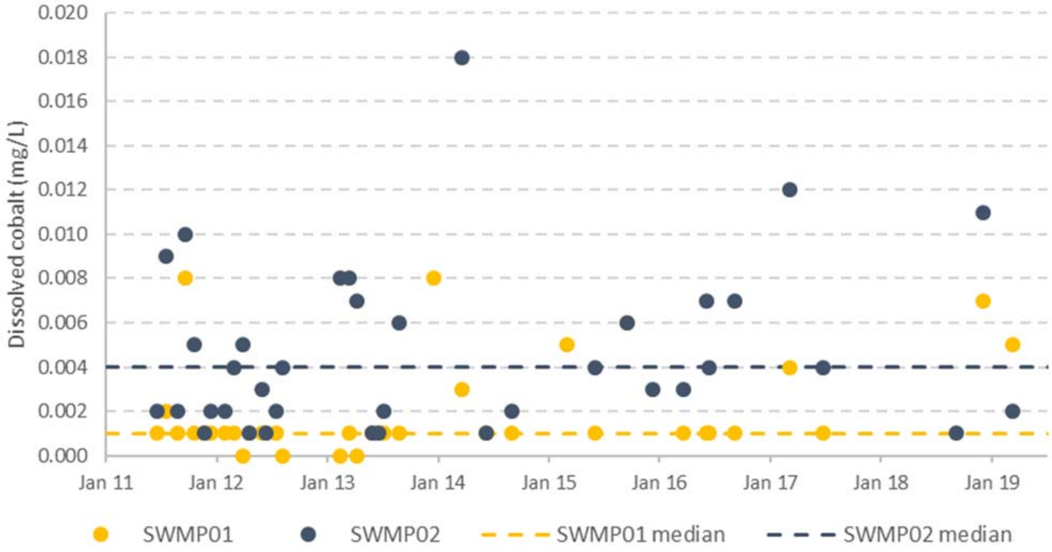

0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved arsenic (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

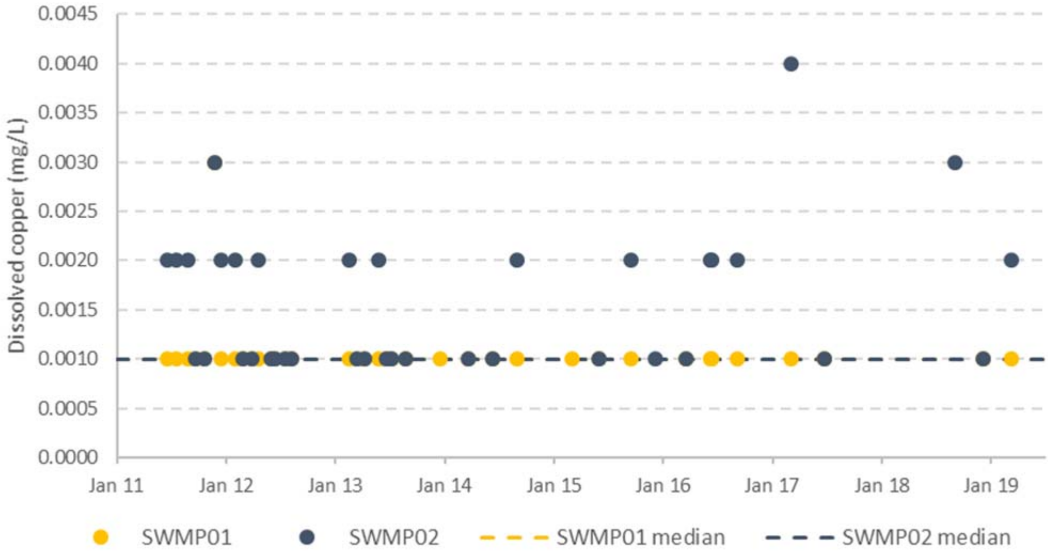

0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved barium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

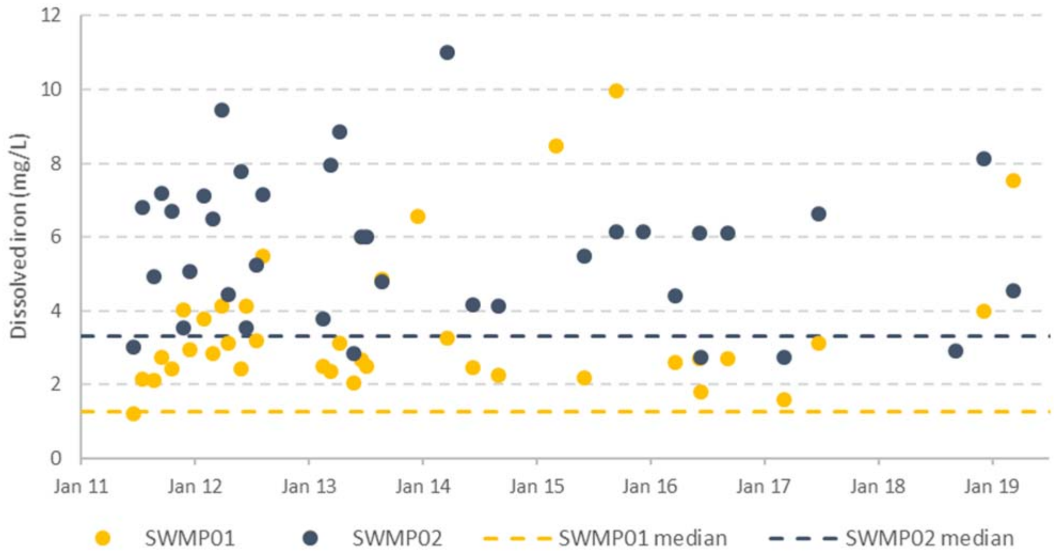

0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved boron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

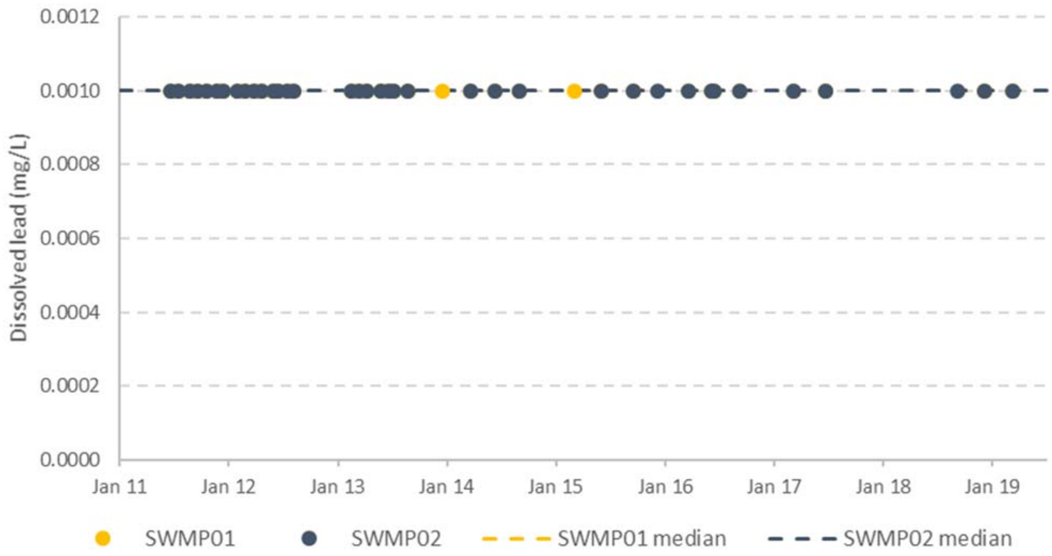

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved cadmium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

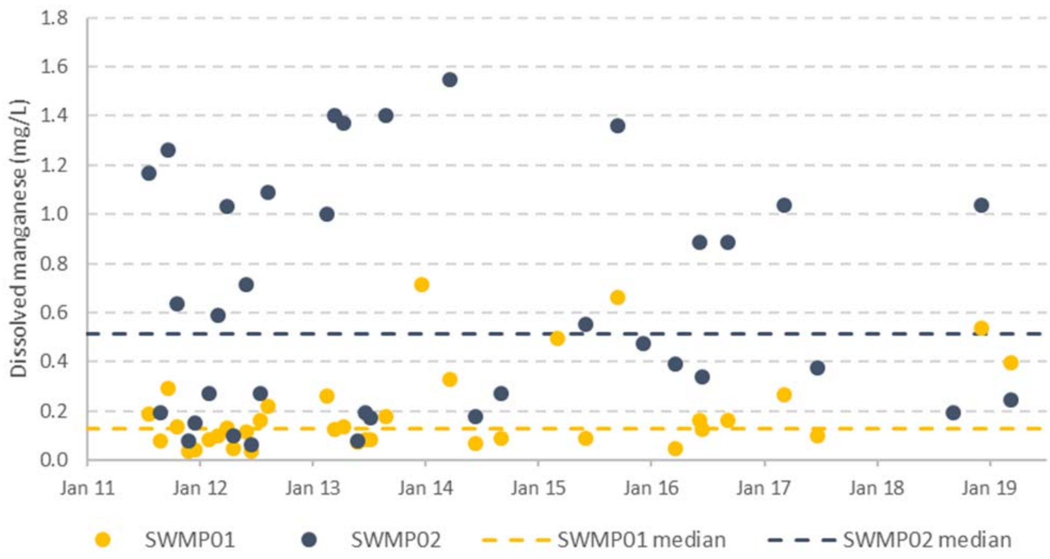

Dissolved chromium (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

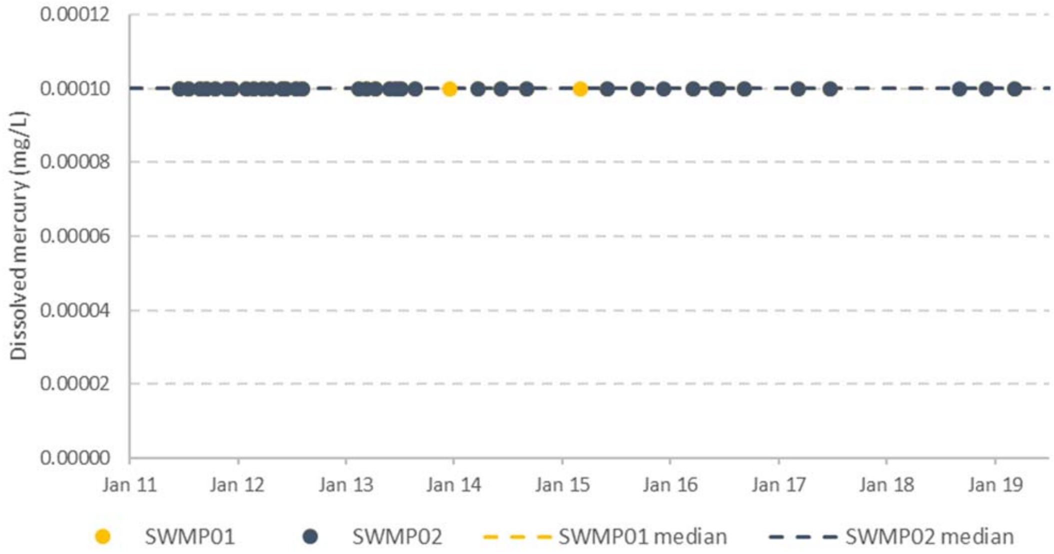

Dissolved cobalt (mg/L)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

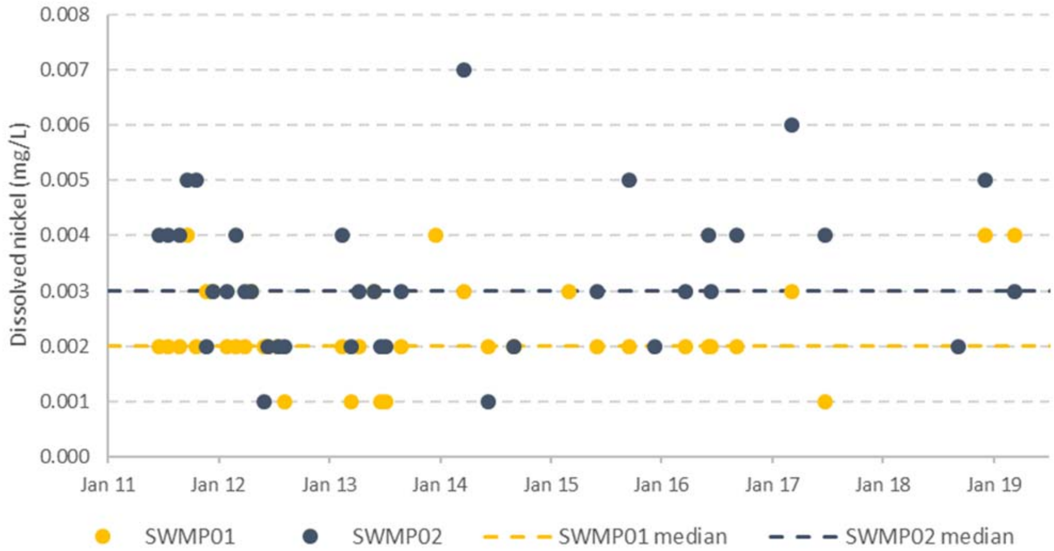

Dissolved copper (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

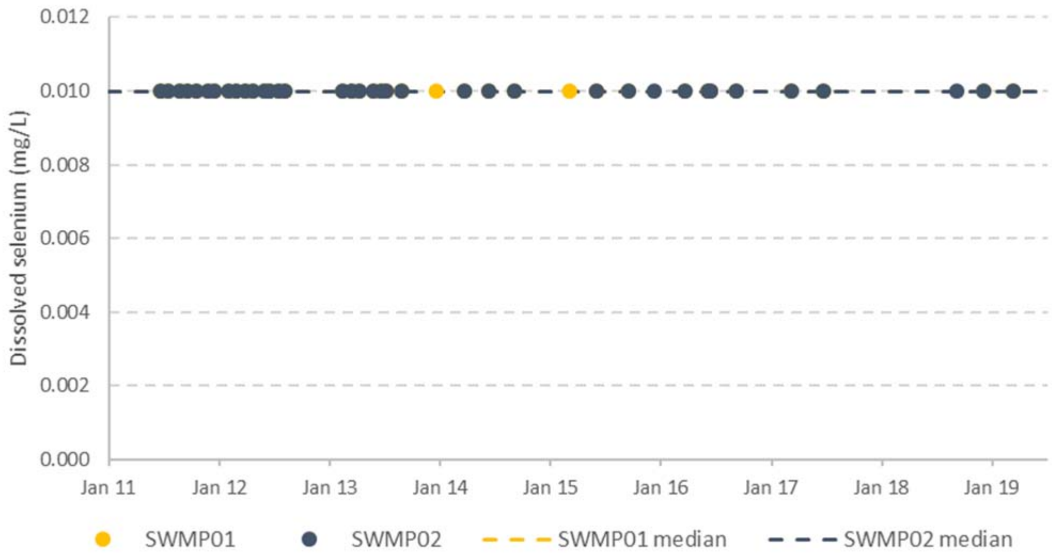

Dissolved iron (mg/L)
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

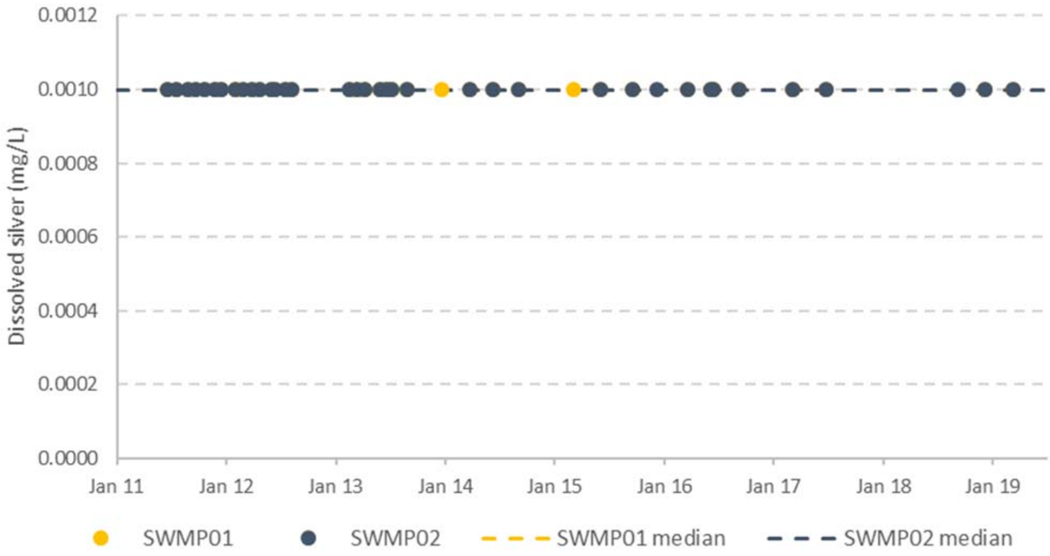

Dissolved lead (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

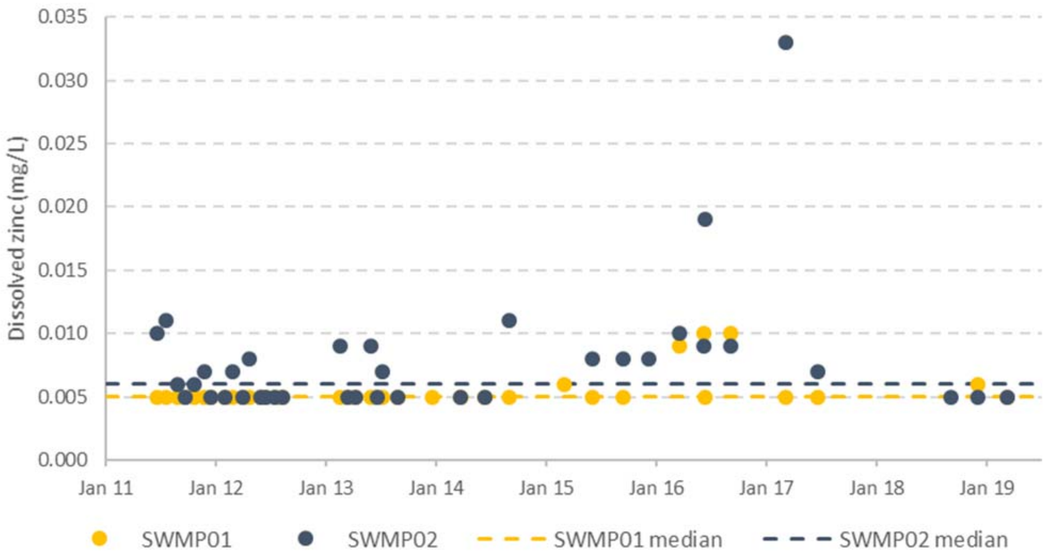

Dissolved manganese (mg/L)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

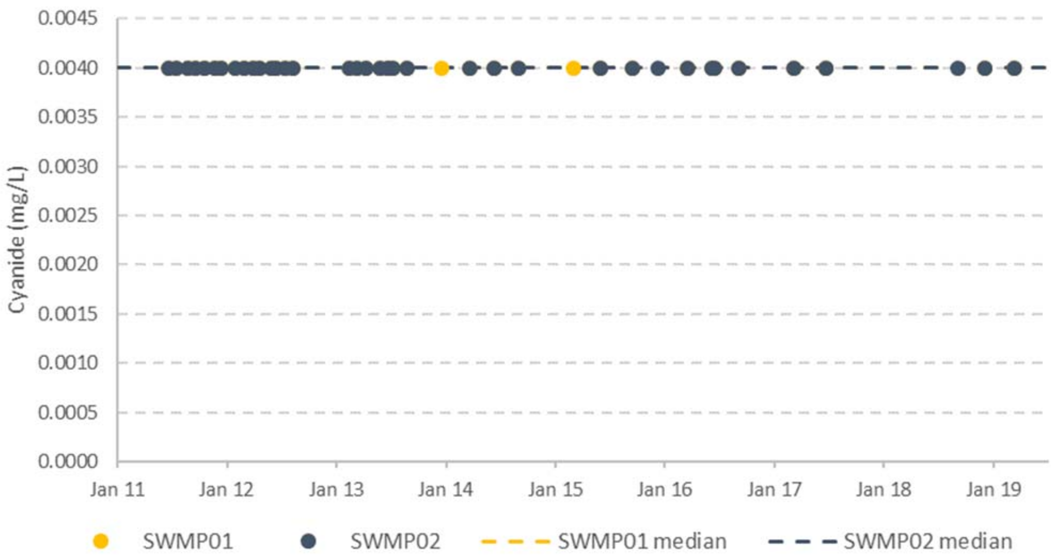

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

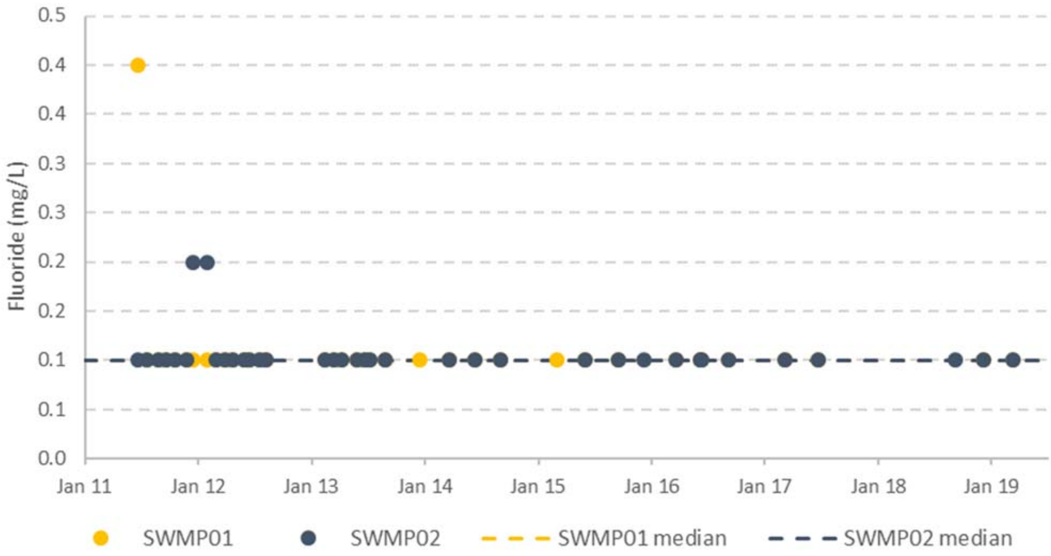

0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Dissolved nickel (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median


0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median


0.5
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP01
SWMP02
SWMP01 median
SWMP02 median

E.2.2 Wyee Creek

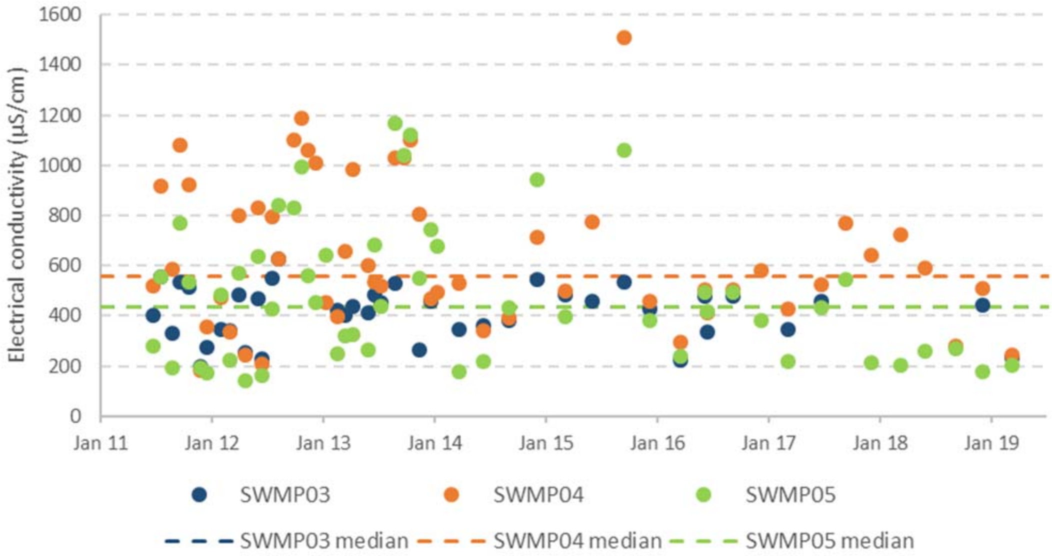
Median water quality results

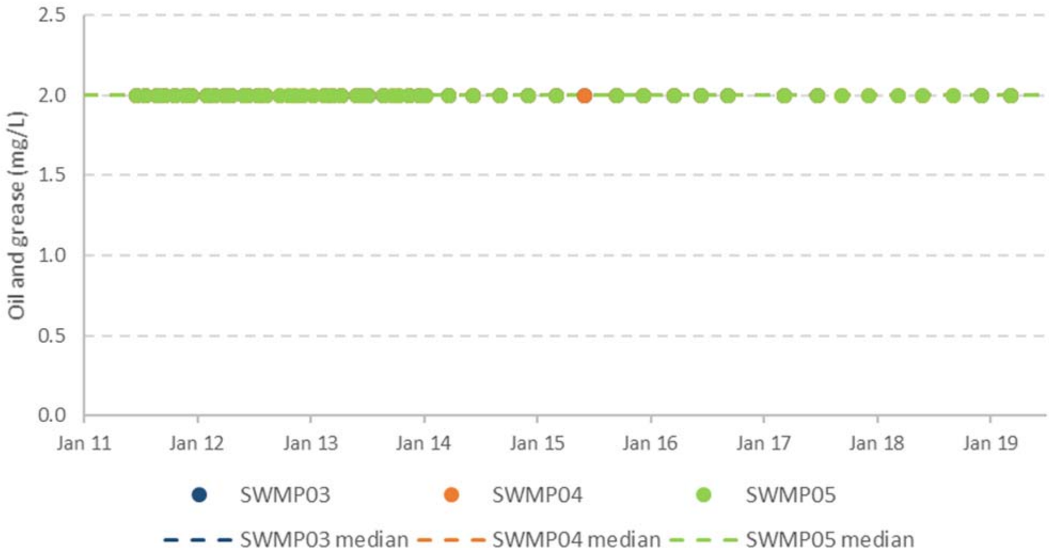
Parameter	Units	SWMP03		SWMP04		SWMP05	
		Count	Median	Count	Median	Count	Median
Physicochemical parameters							
EC	µS/cm	40	434	54	558	53	433
Oil and grease	mg/L	39	2	52	2	51	2
pH	pH units	40	6.66	54	6.75	53	6.53
TDS	mg/L	40	276	54	372	53	306
TSS	mg/L	40	10	54	13	53	16
Turbidity	NTU	40	30.8	54	29.6	53	34
Major ions							
Bicarbonate alkalinity	mg/L	40	40	54	38	53	24
Carbonate alkalinity	mg/L	40	1	54	1	53	1
Hydroxide alkalinity	mg/L	40	1	54	1	53	1
Total alkalinity	mg/L	40	40	54	38	53	24
Calcium	mg/L	40	7	54	6	53	7
Chloride	mg/L	40	100	54	139	53	106
Magnesium	mg/L	40	10	54	12	53	9
Potassium	mg/L	40	3	54	4	53	4
Sodium	mg/L	40	58	54	82	53	59
Sulfate	mg/L	40	12	54	10	53	8
Total hardness	mg/L	40	61	54	65	53	53
Nutrients							
Ammonia	mg/L	39	0.05	53	0.16	52	0.01
BOD	mg/L	40	2	54	3	53	2
Nitrate + nitrite	mg/L	40	0.02	54	0.01	53	0.01
TKN	mg/L	40	0.7	54	1.5	53	1.1
Total nitrogen	mg/L	40	0.8	54	1.5	53	1.1

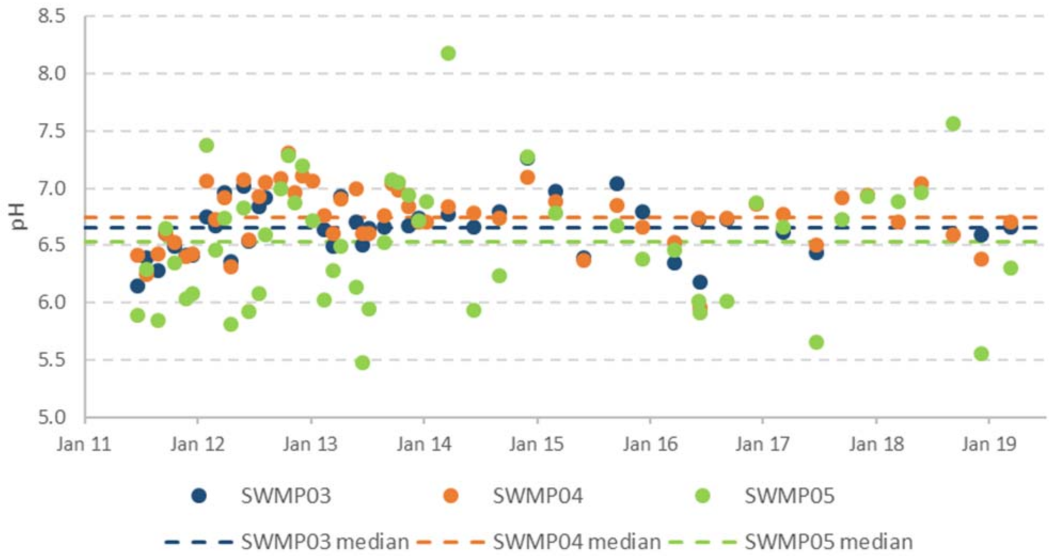
Parameter	Units	SWMP03		SWMP04		SWMP05	
		Count	Median	Count	Median	Count	Median
Total phosphorus	mg/L	40	0.06	54	0.18	53	0.08
Dissolved metals							
Aluminium	mg/L	40	0.29	54	0.305	53	0.53
Arsenic	mg/L	40	0.001	54	0.001	53	0.001
Barium	mg/L	40	0.058	54	0.051	53	0.033
Boron	mg/L	40	0.05	54	0.05	53	0.05
Cadmium	mg/L	40	0.0001	54	0.0001	53	0.0001
Chromium	mg/L	40	0.001	54	0.001	53	0.001
Cobalt	mg/L	40	0.002	54	0.002	53	0.001
Copper	mg/L	40	0.001	54	0.002	53	0.001
Iron	mg/L	39	2.32	53	3.17	52	1.62
Lead	mg/L	40	0.001	54	0.001	53	0.001
Manganese	mg/L	39	0.314	53	0.516	52	0.138
Mercury	mg/L	40	0.0001	54	0.0001	53	0.0001
Nickel	mg/L	40	0.004	54	0.003	53	0.002
Selenium	mg/L	40	0.01	54	0.01	53	0.01
Silver	mg/L	40	0.001	54	0.001	53	0.001
Zinc	mg/L	40	0.005	54	0.008	53	0.009
Total metals							
Aluminium	mg/L	40	0.74	54	0.77	53	1.85
Arsenic	mg/L	40	0.001	54	0.001	53	0.002
Barium	mg/L	39	0.065	53	0.080	52	0.046
Boron	mg/L	40	0.05	54	0.05	53	0.05
Cadmium	mg/L	40	0.0001	54	0.0001	53	0.0001
Chromium	mg/L	40	0.001	54	0.001	53	0.002
Cobalt	mg/L	39	0.001	54	0.003	52	0.002
Copper	mg/L	40	0.004	54	0.002	53	0.002

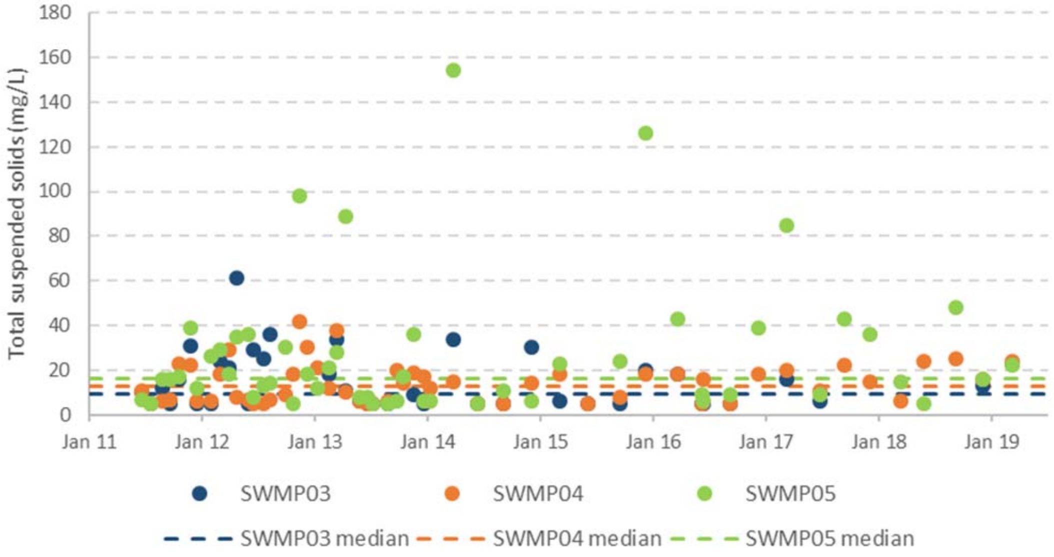
Parameter	Units	SWMP03		SWMP04		SWMP05	
		Count	Median	Count	Median	Count	Median
Iron	mg/L	40	4.98	54	6.29	53	3.75
Lead	mg/L	40	0.001	54	0.001	53	0.001
Manganese	mg/L	40	0.398	54	1.050	53	0.23
Mercury	mg/L	40	0.0001	54	0.0001	53	0.0001
Nickel	mg/L	40	0.005	54	0.004	53	0.003
Selenium	mg/L	40	0.01	54	0.01	53	0.01
Silver	mg/L	40	0.001	54	0.001	53	0.001
Zinc	mg/L	40	0.008	54	0.015	53	0.019
Other parameters							
Cyanide	mg/L	40	0.004	54	0.004	53	0.004
Fluoride	mg/L	40	0.1	54	0.1	53	0.1

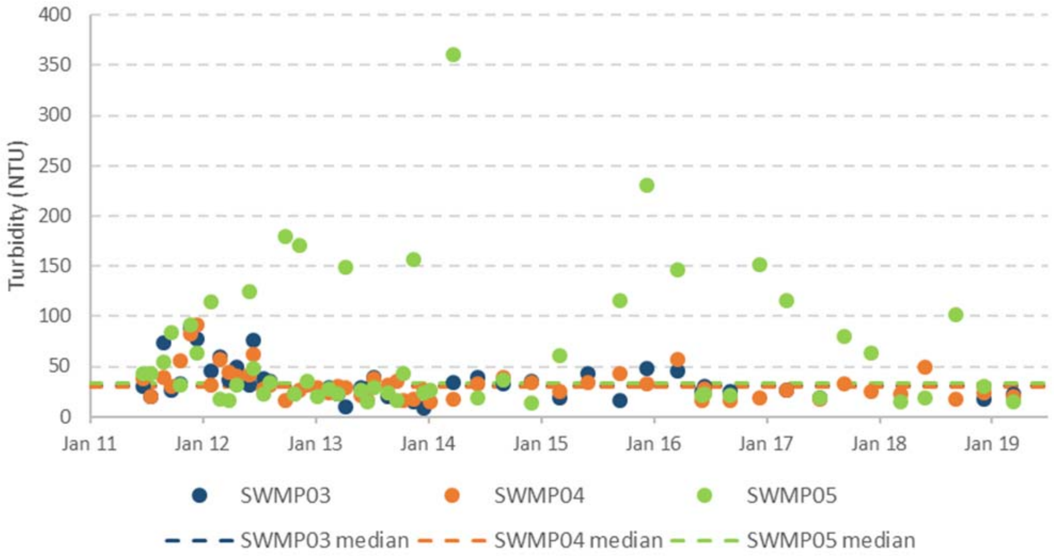
Time series graphs

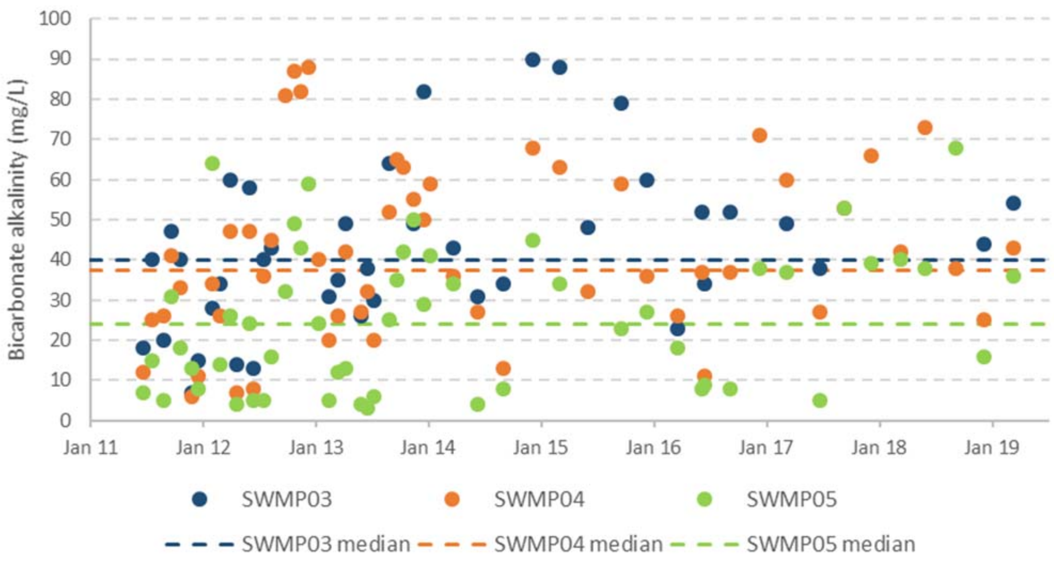


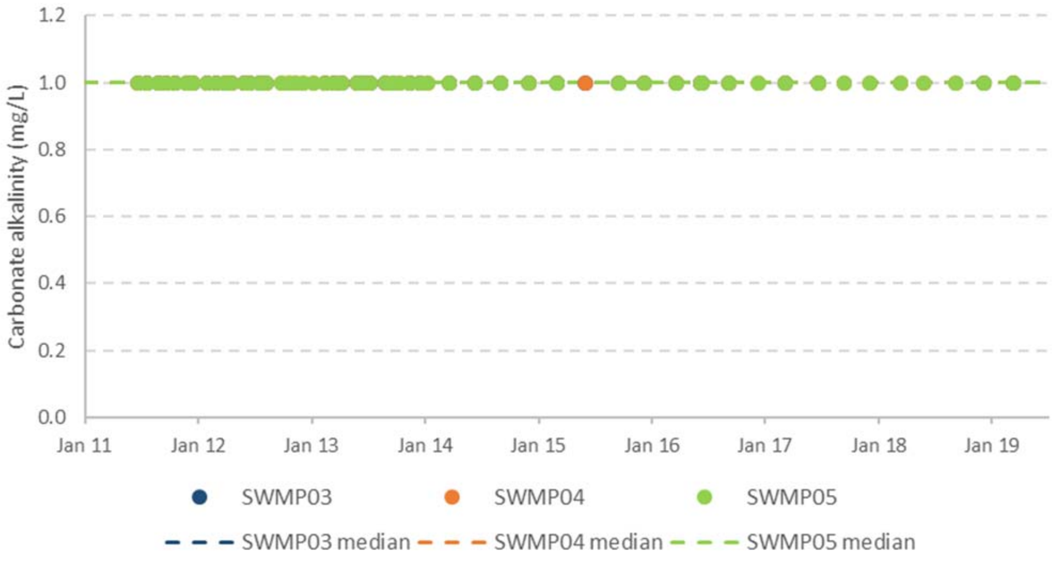


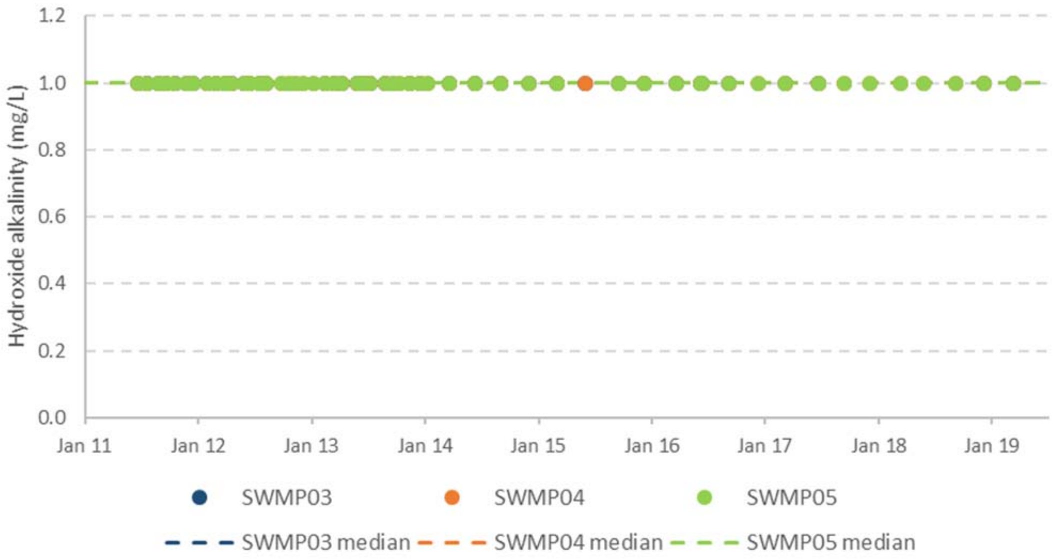


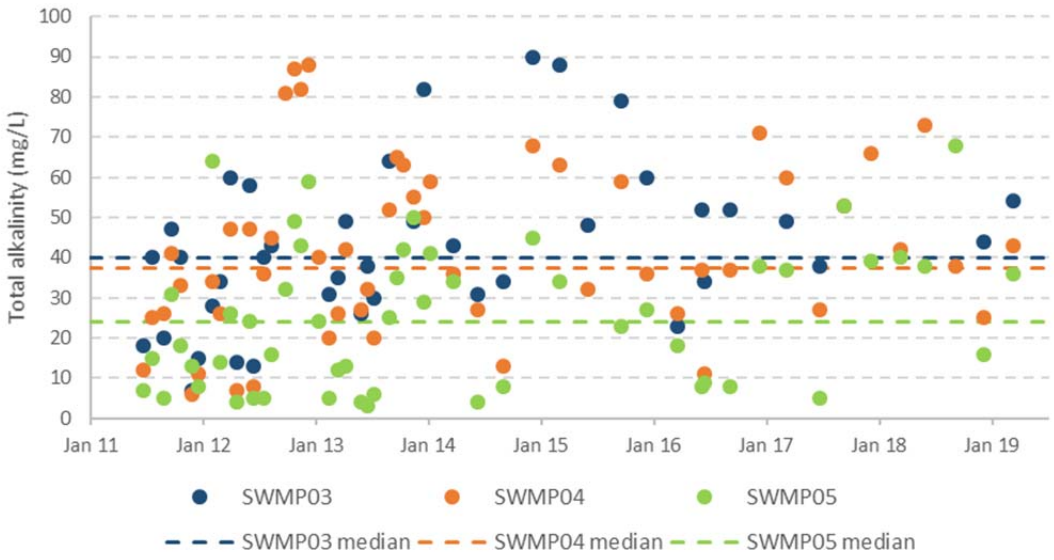

Total suspended solids (mg/L)
180
160
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

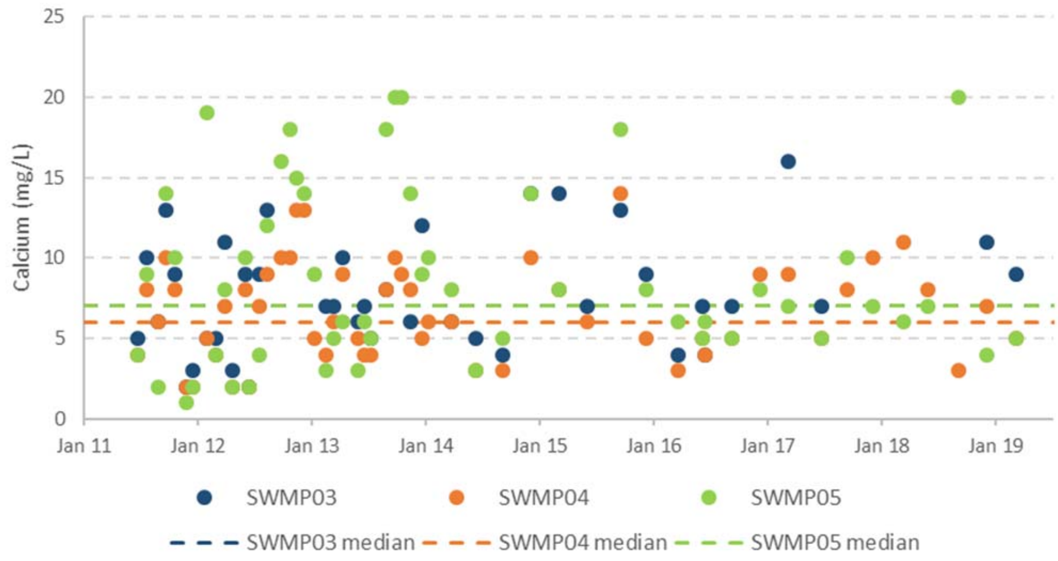

Turbidity (NTU)
400
350
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

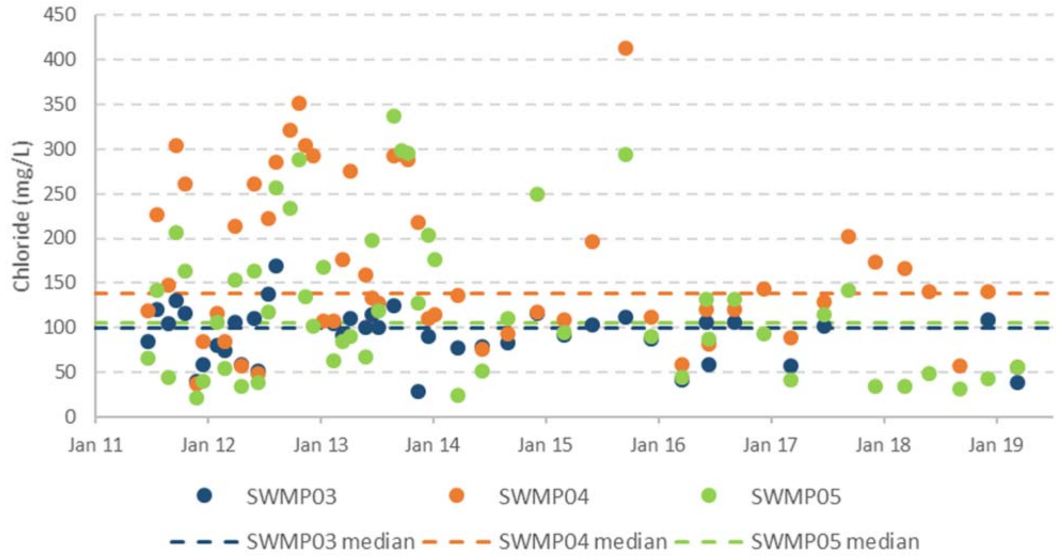

Bicarbonate alkalinity (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

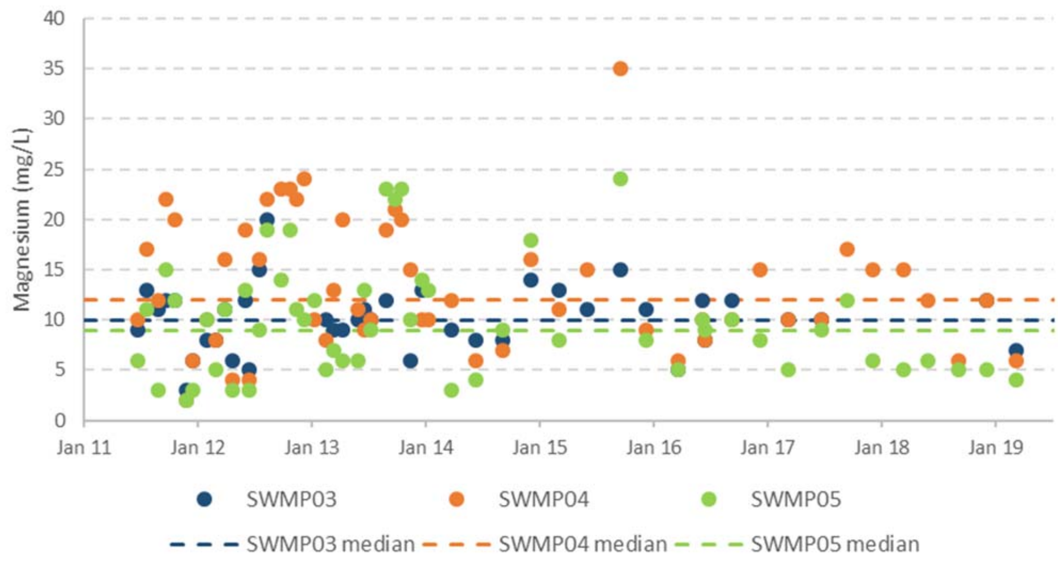

1.2
1.0
0.8
0.6
0.4
0.2
0.0
Carbonate alkalinity (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

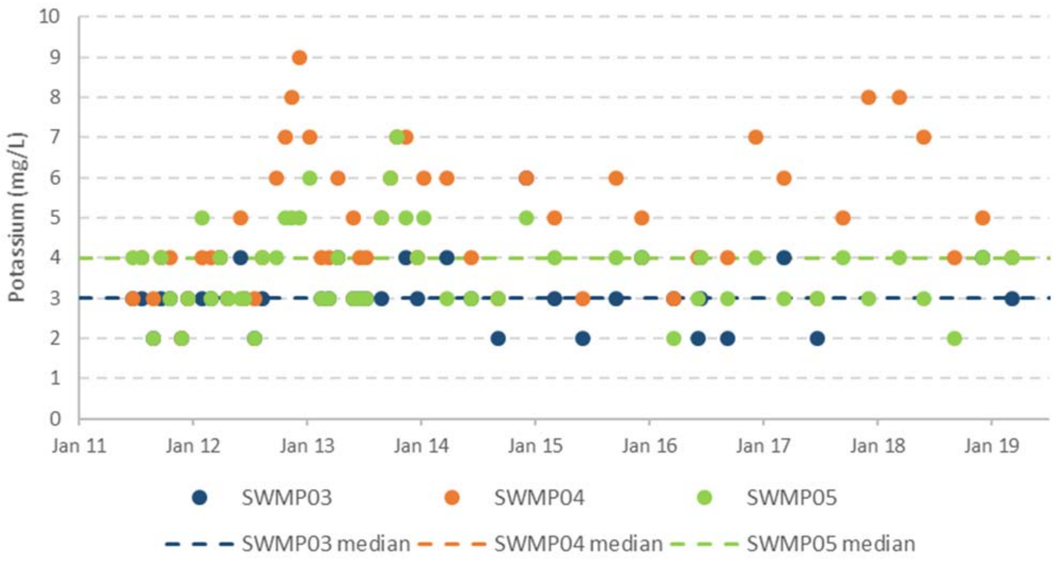

1.2
1.0
0.8
0.6
0.4
0.2
0.0
Hydroxide alkalinity (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

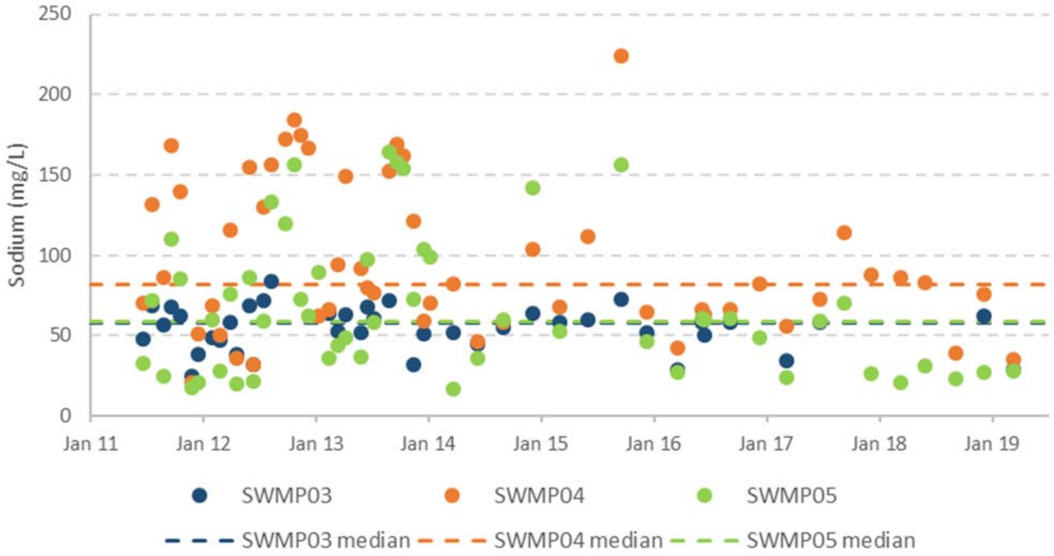

100
90
80
70
60
50
40
30
20
10
0
Total alkalinity (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

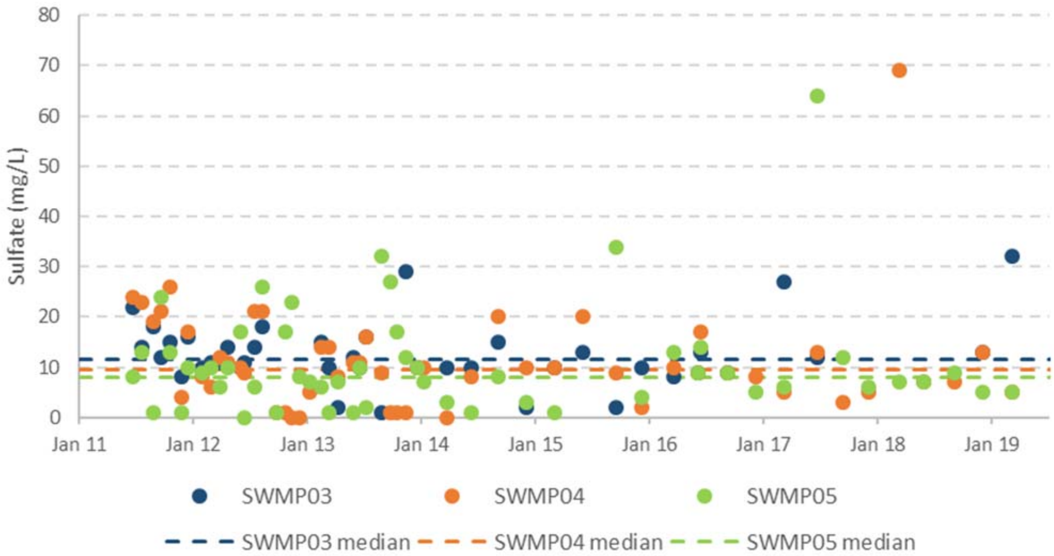

Calcium (mg/L)
0
5
10
15
20
25
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

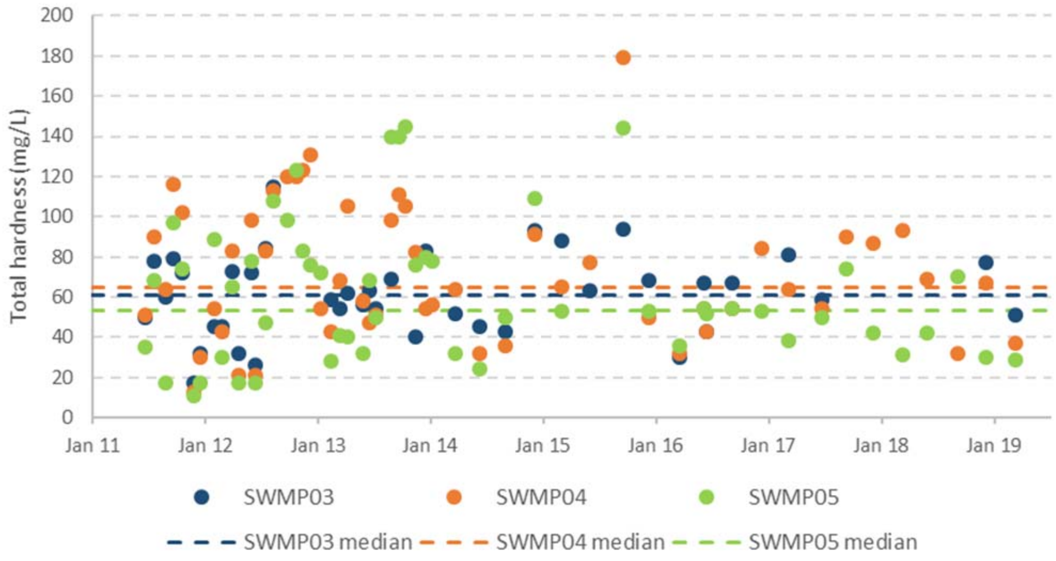

Chloride (mg/L)
0
50
100
150
200
250
300
350
400
450
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

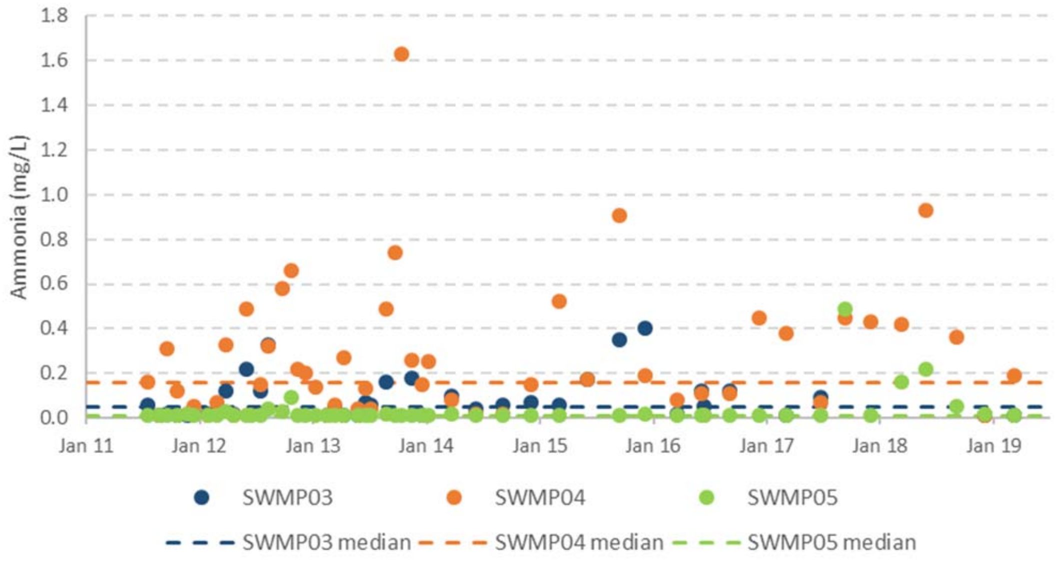

Magnesium (mg/L)
0
5
10
15
20
25
30
35
40
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

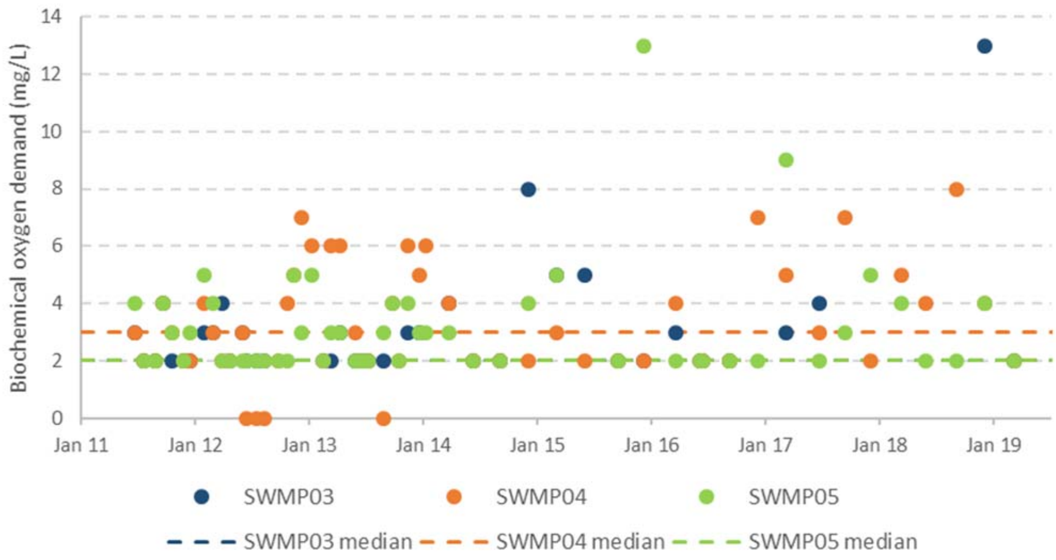

Potassium (mg/L)
0
1
2
3
4
5
6
7
8
9
10
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

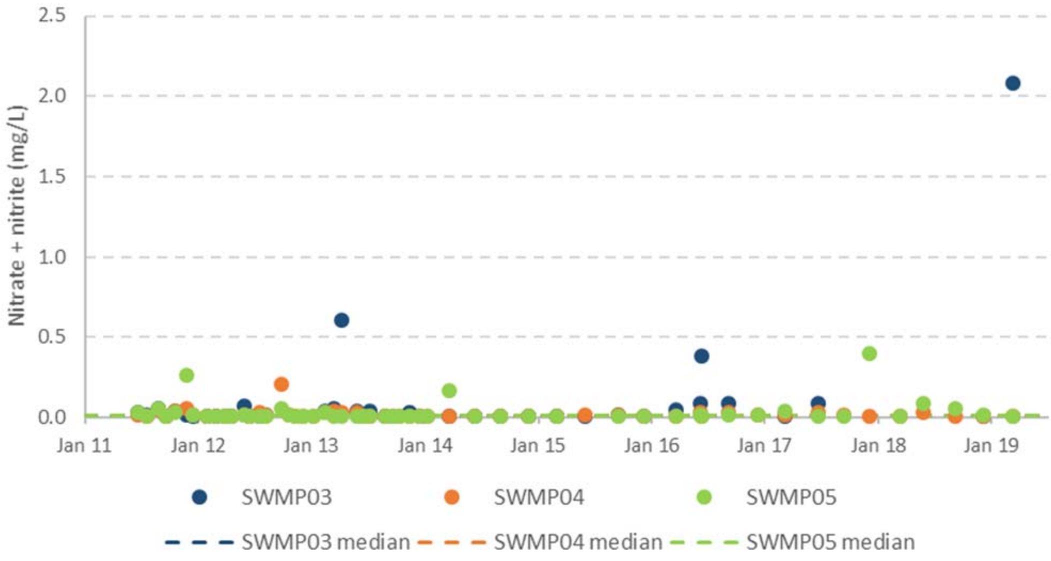

Sodium (mg/L)
0
50
100
150
200
250
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

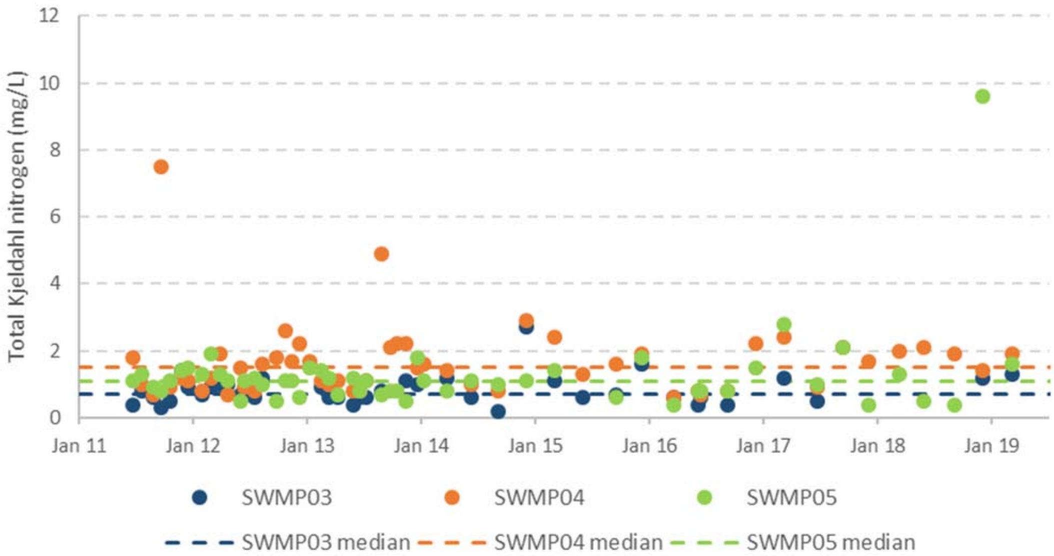

Sulfate (mg/L)
0
10
20
30
40
50
60
70
80
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

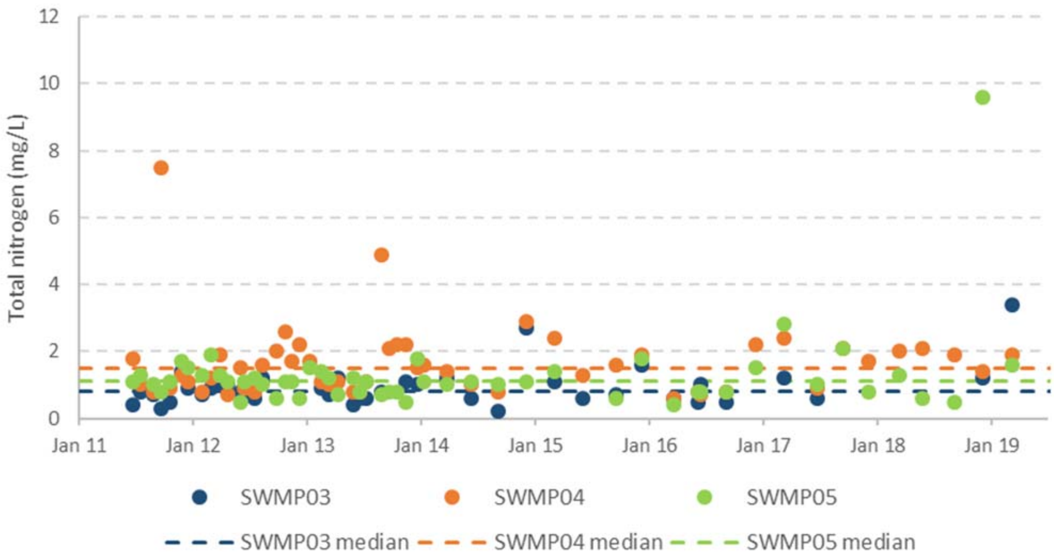

Total hardness (mg/L)
200
180
160
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

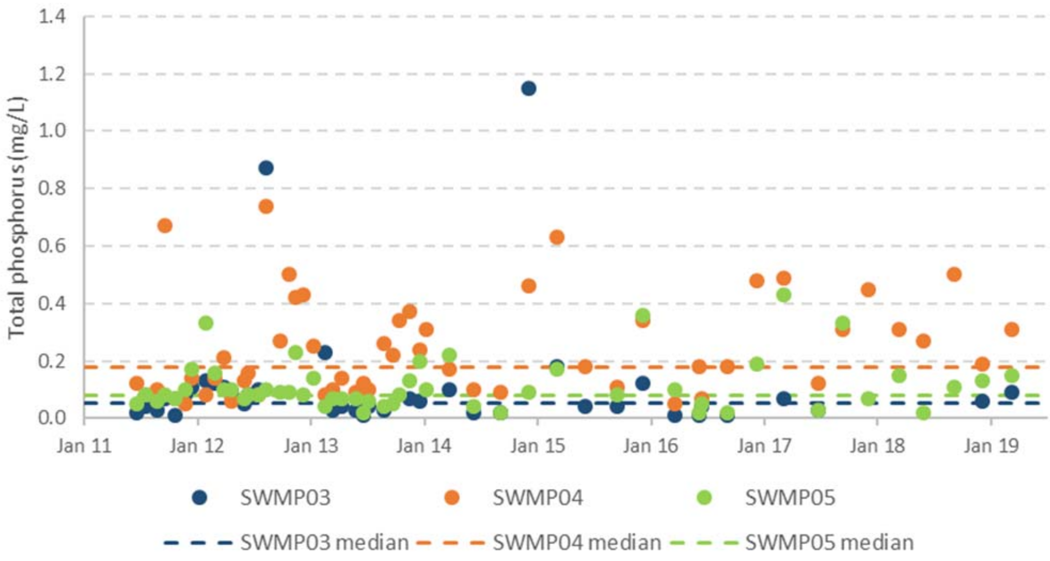

Ammonia (mg/L)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

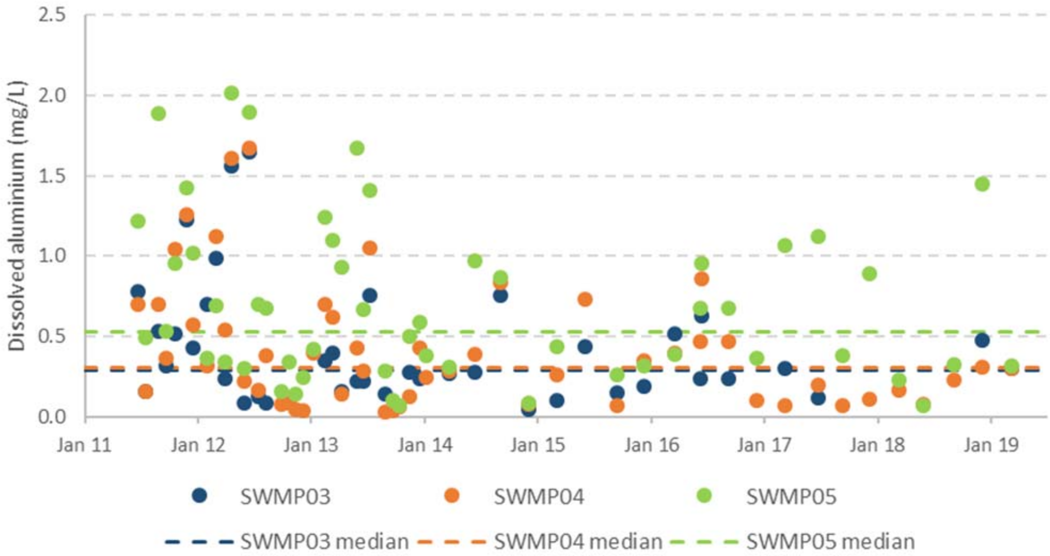

Biochemical oxygen demand (mg/L)
14
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

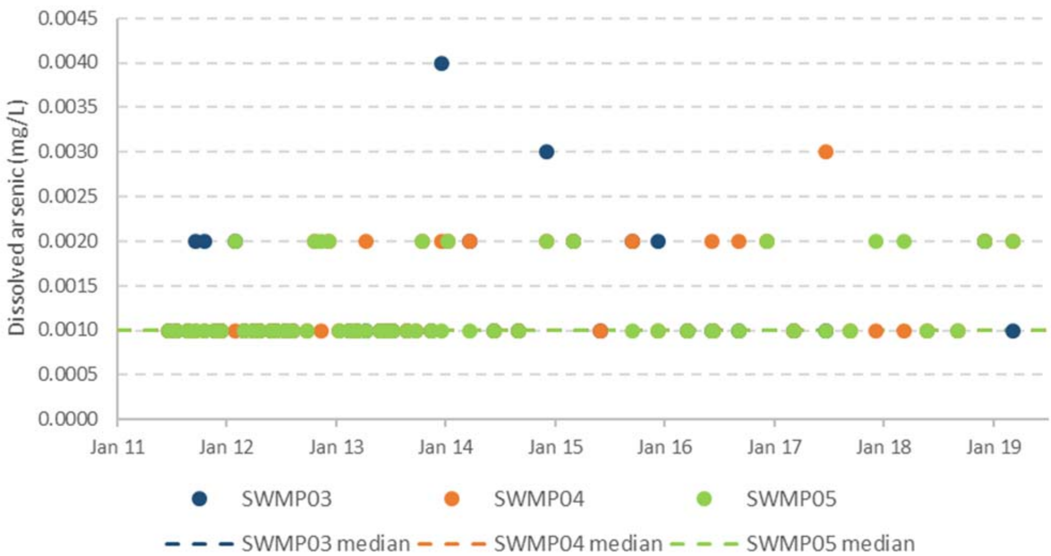

Nitrate + nitrite (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

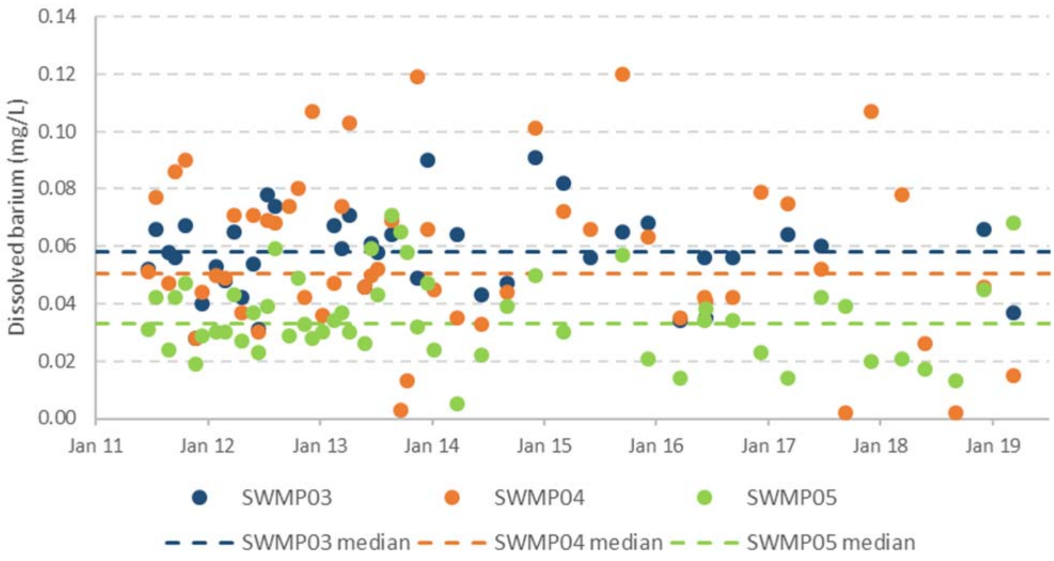

Total Kjeldahl nitrogen (mg/L)
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

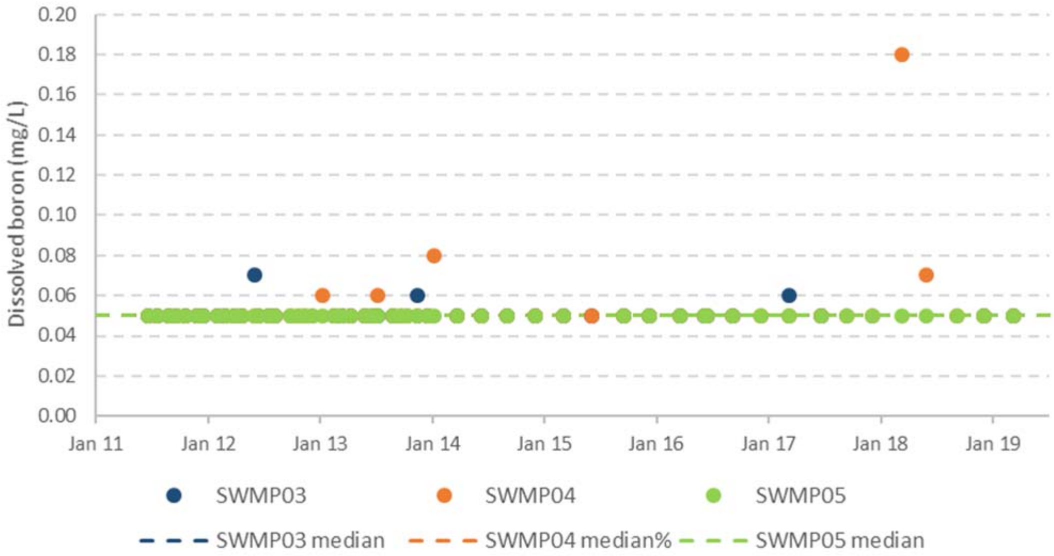

Total nitrogen (mg/L)
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

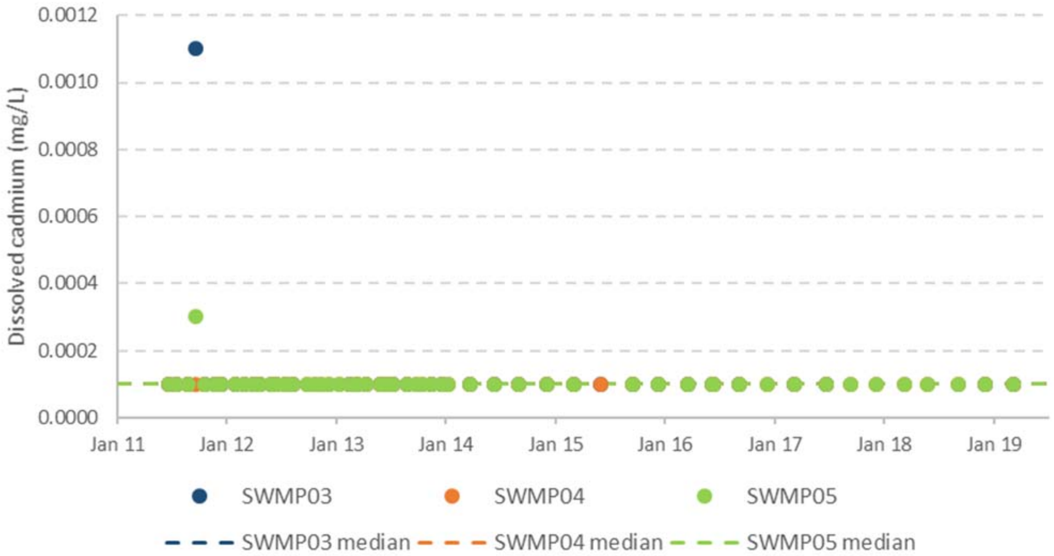

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Total phosphorus (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

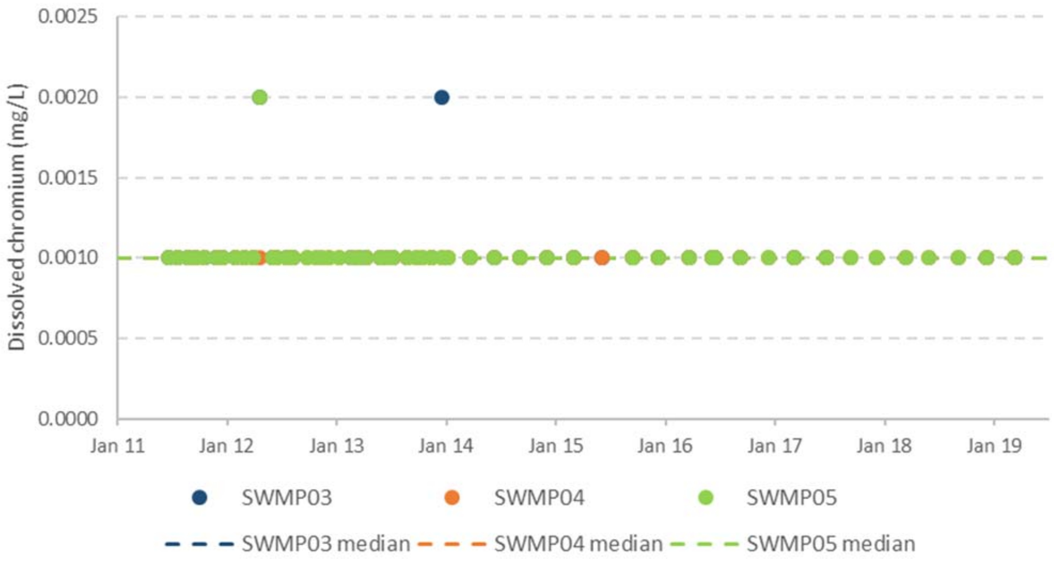

2.5
2.0
1.5
1.0
0.5
0.0
Dissolved aluminium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

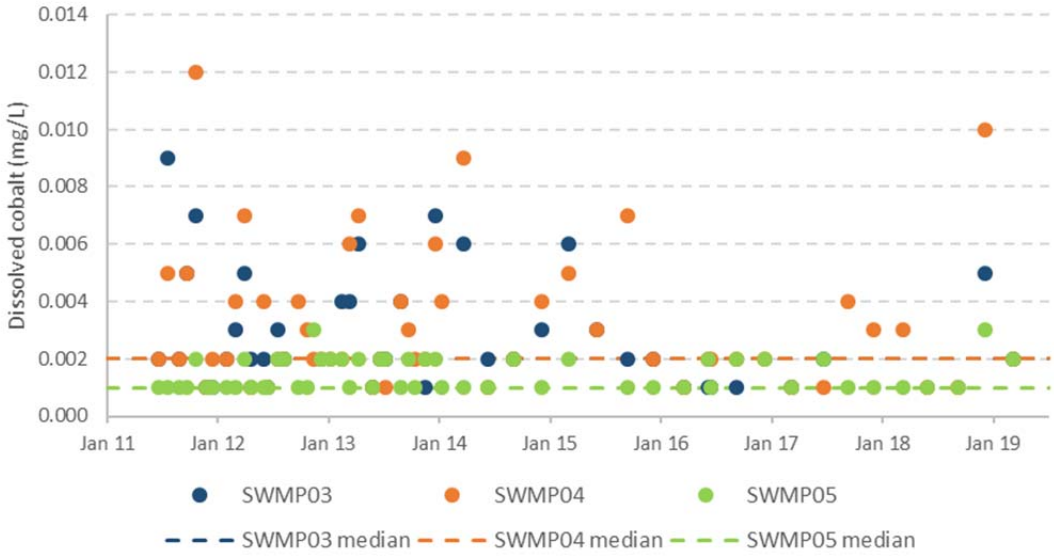

0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved arsenic (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

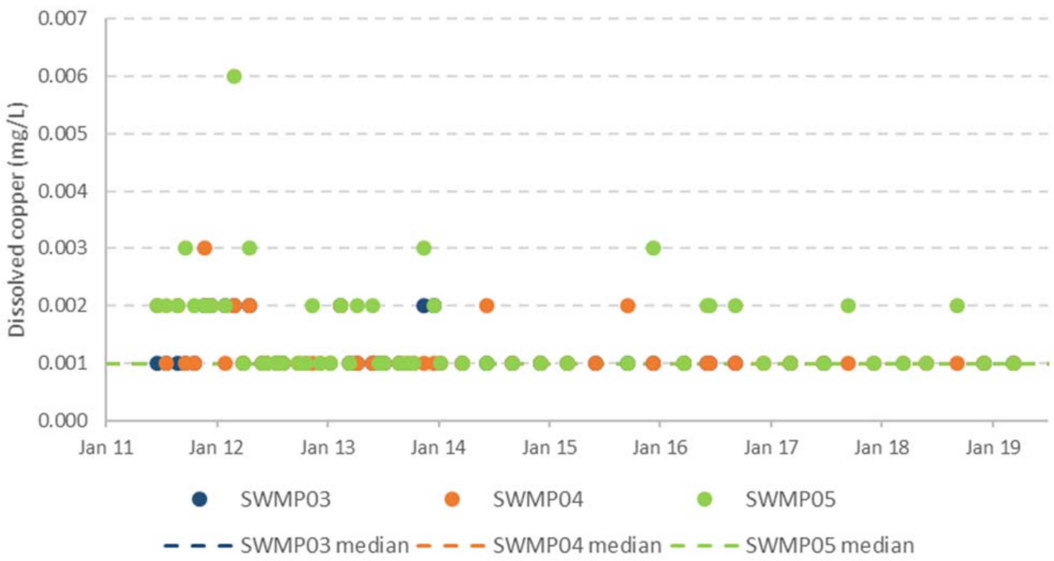

0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved barium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

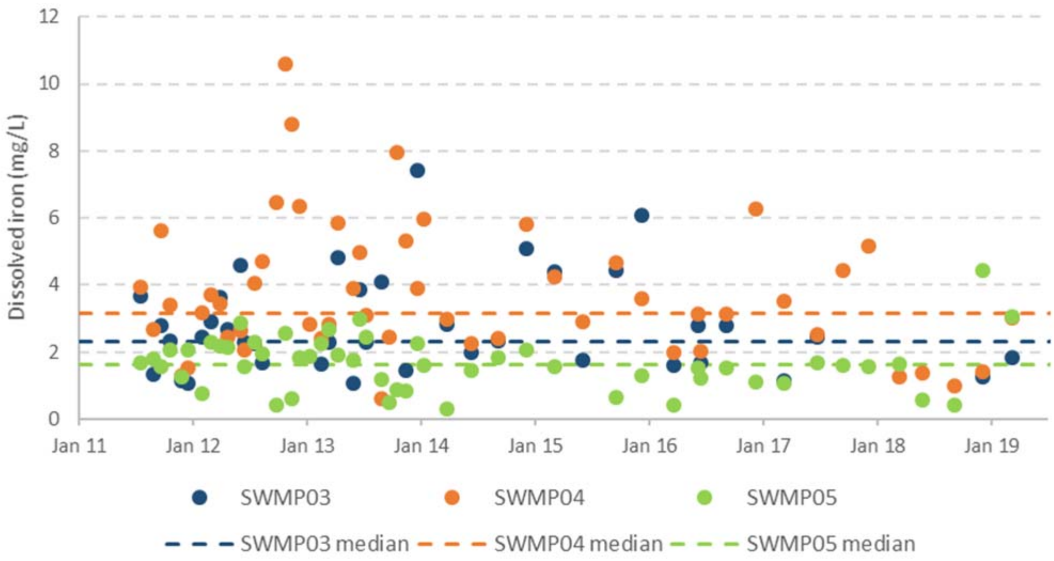

0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved boron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median%
SWMP05 median

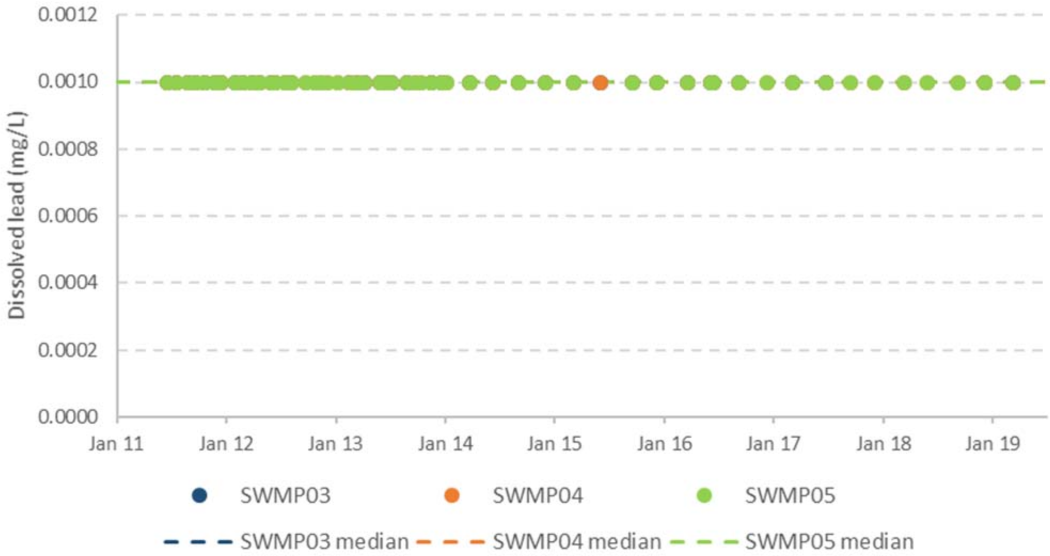

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved cadmium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

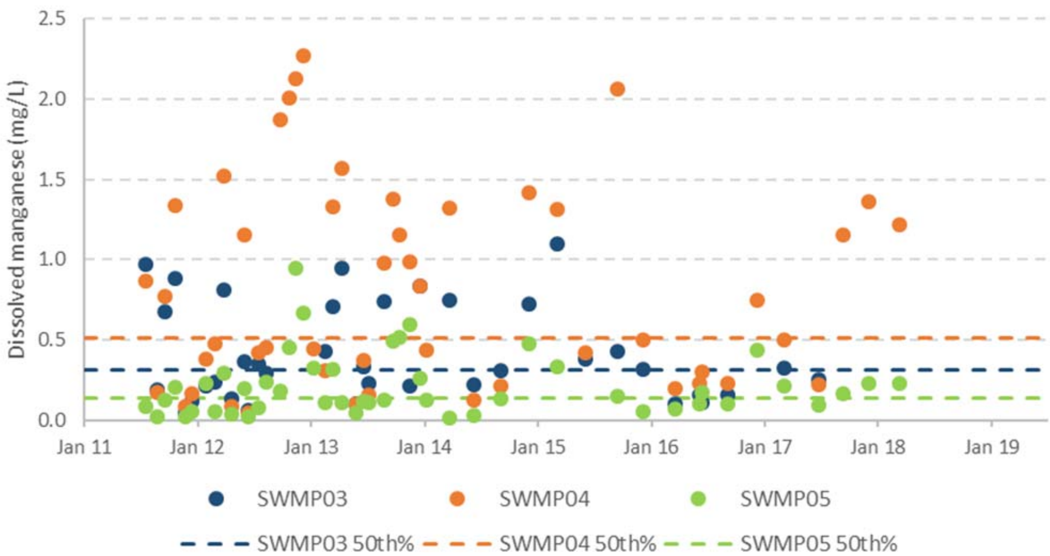

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved chromium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

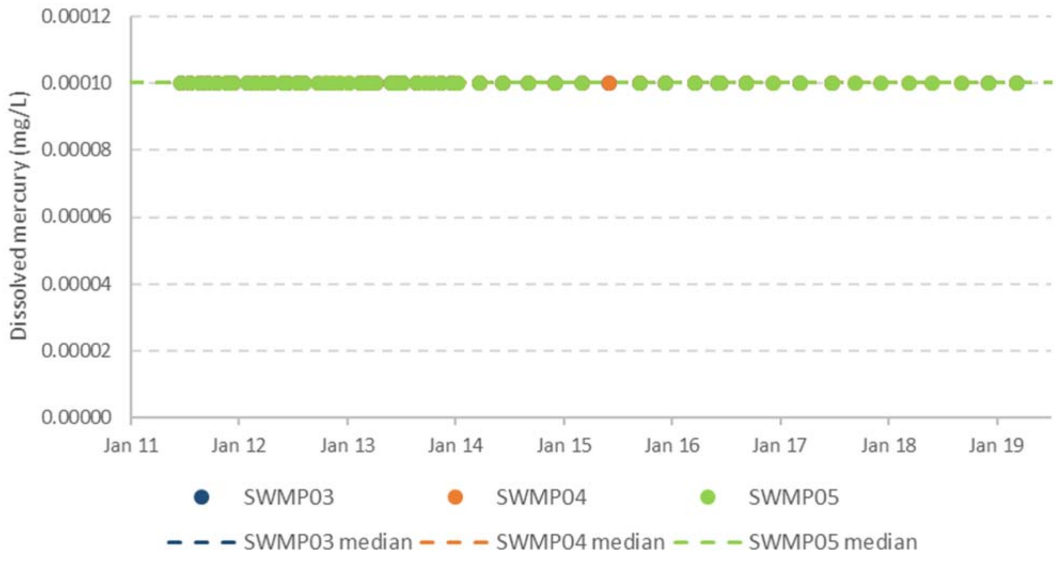

0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved cobalt (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

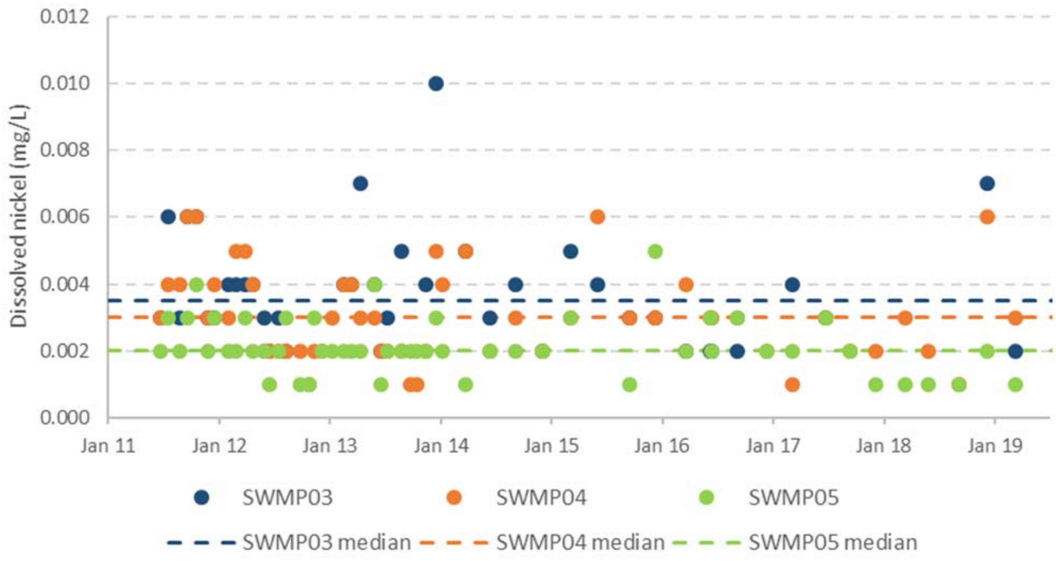

0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Dissolved copper (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

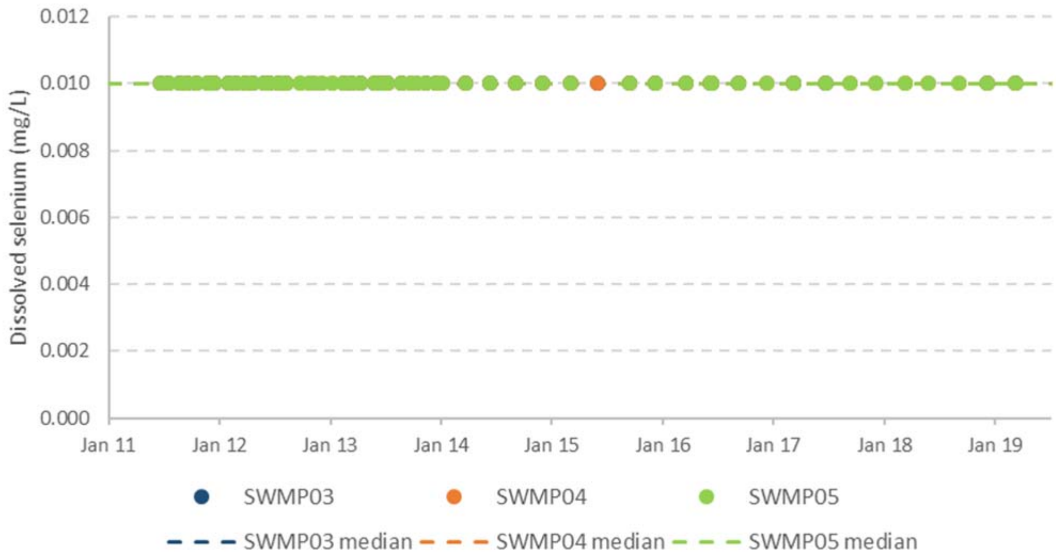

12
10
8
6
4
2
0
Dissolved iron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

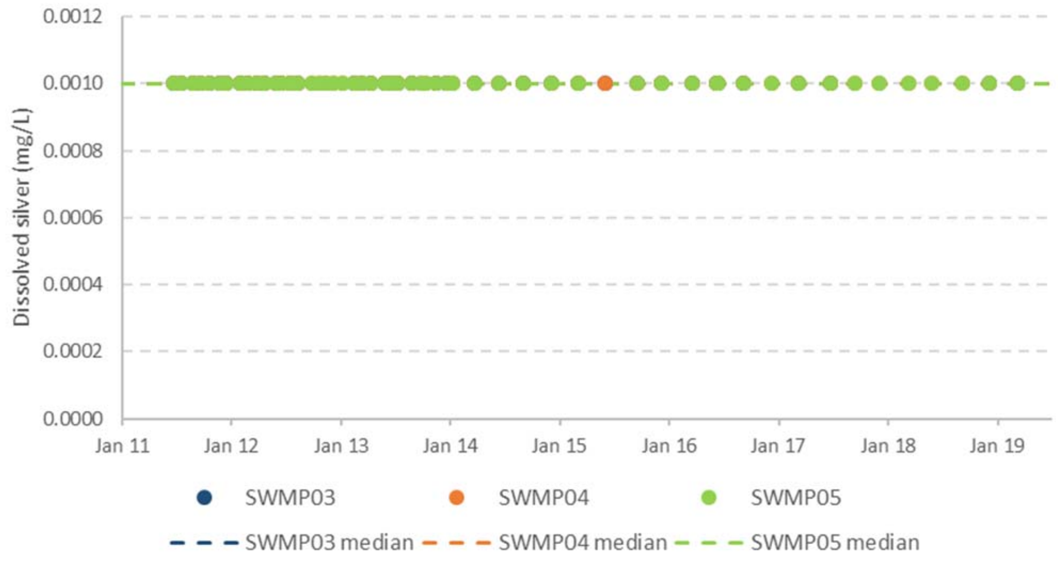

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved lead (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

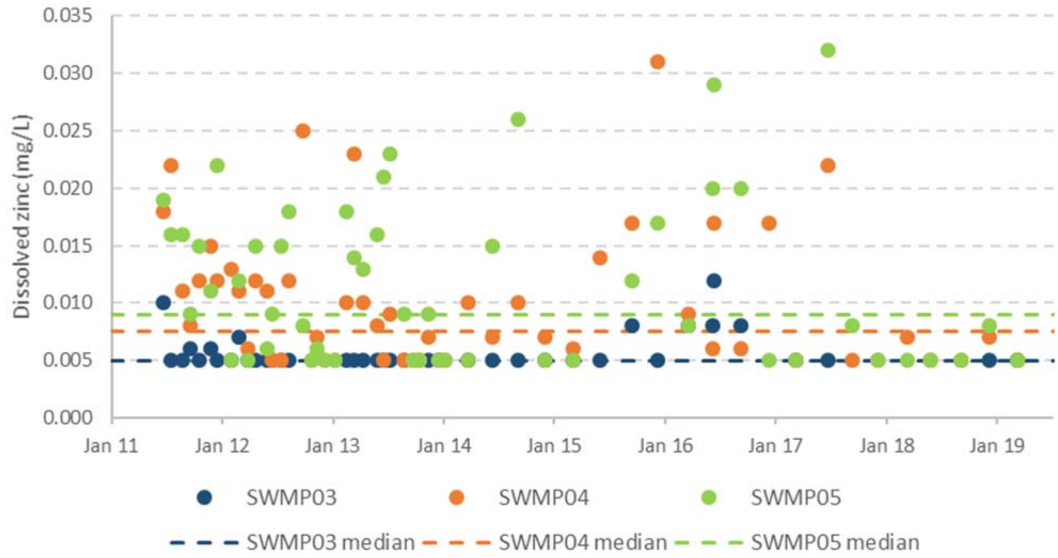

2.5
2.0
1.5
1.0
0.5
0.0
Dissolved manganese (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 50th%
SWMP04 50th%
SWMP05 50th%

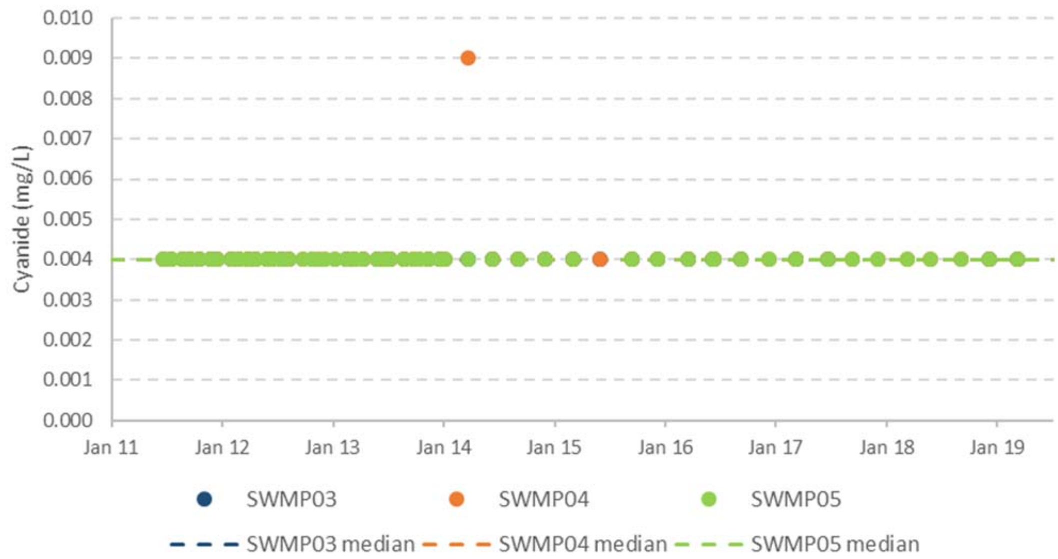

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

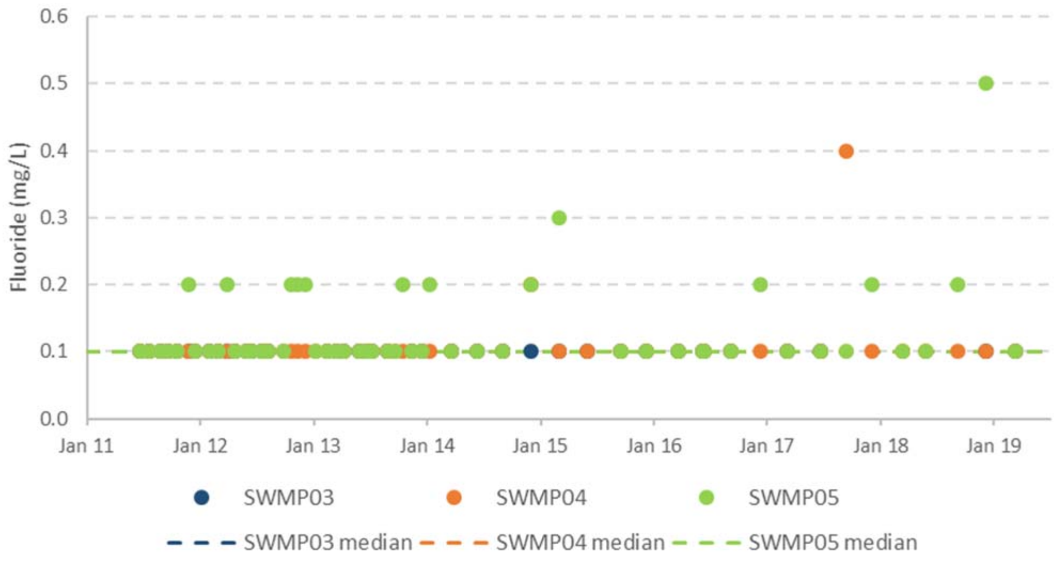

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved nickel (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median


0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median


0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP03
SWMP04
SWMP05
SWMP03 median
SWMP04 median
SWMP05 median

E.2.3 Morans Creek

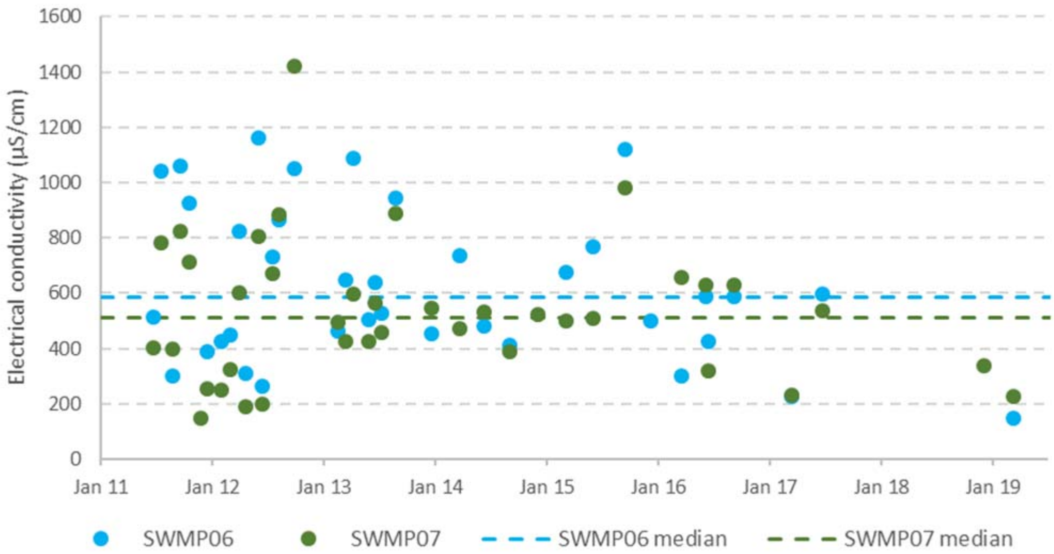
Median water quality results

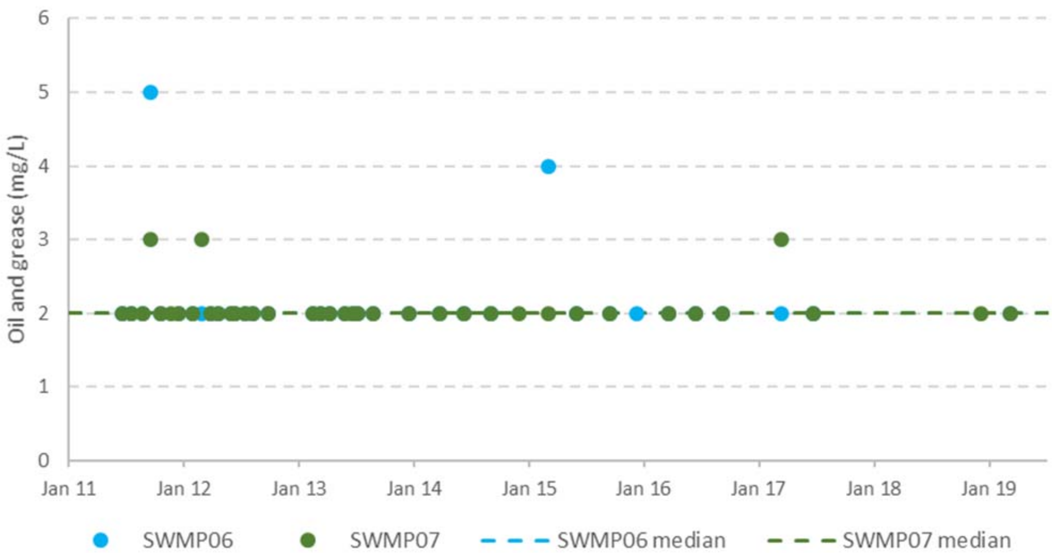
Parameter	Units	SWMP06		SWMP07	
		Count	Median	Count	Median
Physicochemical parameters					
EC	µS/cm	37	586	39	510
Oil and grease	mg/L	37	2	38	2
pH	pH units	37	6.51	39	6.80
TDS	mg/L	37	354	39	302
TSS	mg/L	37	22	39	8
Turbidity	NTU	37	31.7	39	28
Major ions					
Bicarbonate alkalinity	mg/L	37	26	39	40
Carbonate alkalinity	mg/L	37	1	39	1
Hydroxide alkalinity	mg/L	37	1	39	1
Total alkalinity	mg/L	37	26	39	40
Calcium	mg/L	37	5	39	5
Chloride	mg/L	37	148	39	119
Magnesium	mg/L	37	12	39	10
Potassium	mg/L	37	3	39	4
Sodium	mg/L	37	76	39	76
Sulfate	mg/L	37	12	39	10
Total hardness	mg/L	37	62	39	54
Nutrients					
Ammonia	mg/L	37	0.02	38	0.04
BOD	mg/L	37	2	39	2
Nitrate + nitrite	mg/L	37	0.02	39	0.02
TKN	mg/L	37	0.7	39	0.8
Total nitrogen	mg/L	37	0.8	39	0.9

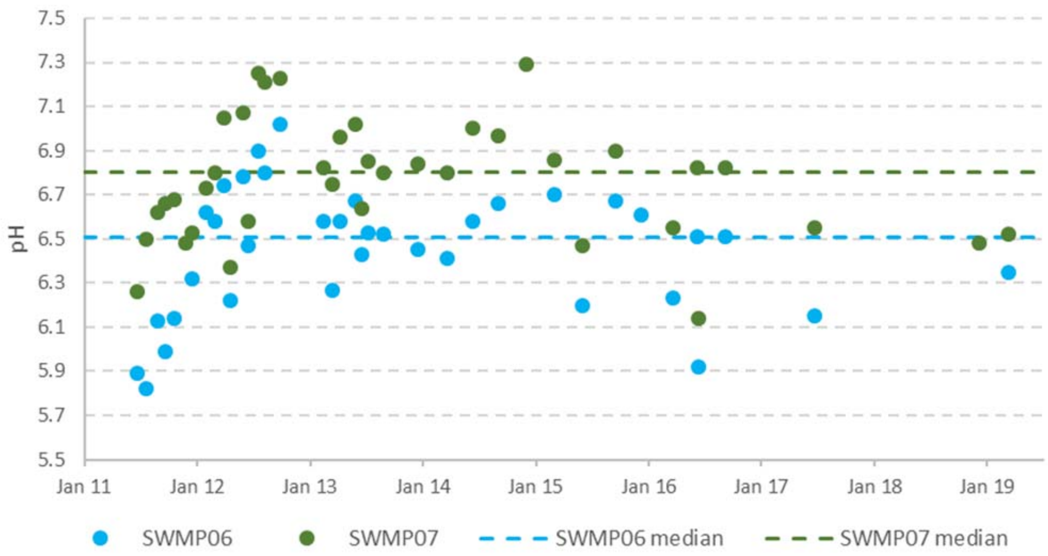
Parameter	Units	SWMP06		SWMP07	
		Count	Median	Count	Median
Total phosphorus	mg/L	37	0.04	39	0.06
Dissolved metals					
Aluminium	mg/L	37	0.32	39	0.32
Arsenic	mg/L	37	0.001	39	0.001
Barium	mg/L	37	0.062	39	0.045
Boron	mg/L	37	0.05	39	0.05
Cadmium	mg/L	37	0.0001	39	0.0001
Chromium	mg/L	37	0.001	39	0.001
Cobalt	mg/L	37	0.004	39	0.001
Copper	mg/L	37	0.001	39	0.001
Iron	mg/L	36	2.60	38	2.17
Lead	mg/L	37	0.001	39	0.001
Manganese	mg/L	36	0.296	38	0.306
Mercury	mg/L	37	0.0001	39	0.0001
Nickel	mg/L	37	0.005	39	0.003
Selenium	mg/L	37	0.01	39	0.01
Silver	mg/L	37	0.001	39	0.001
Zinc	mg/L	37	0.005	39	0.005
Total metals					
Aluminium	mg/L	37	0.83	39	0.74
Arsenic	mg/L	37	0.001	39	0.001
Barium	mg/L	36	0.076	38	0.057
Boron	mg/L	37	0.05	39	0.05
Cadmium	mg/L	37	0.0001	39	0.0001
Chromium	mg/L	37	0.001	39	0.001
Cobalt	mg/L	36	0.007	39	0.002
Copper	mg/L	37	0.001	39	0.002

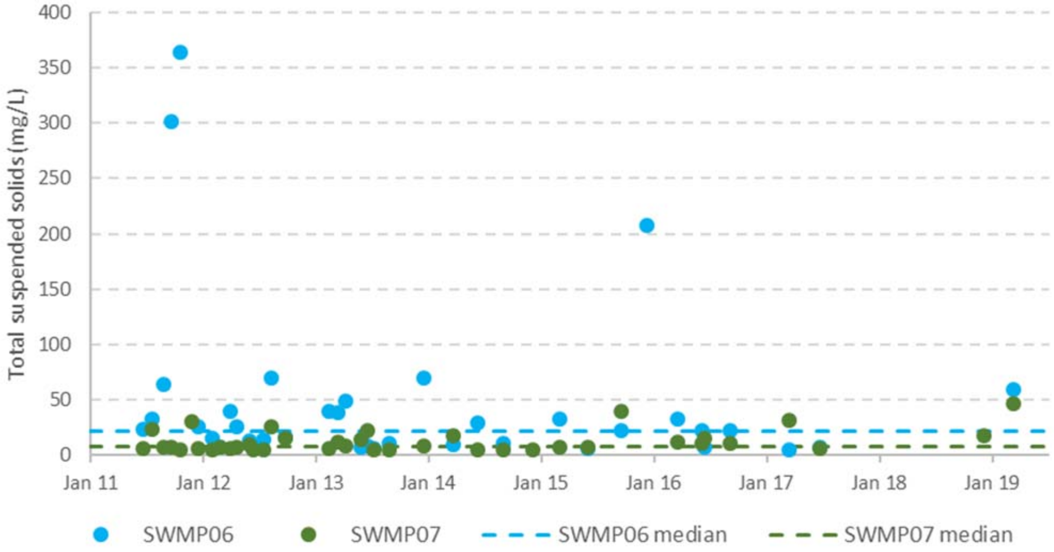
Parameter	Units	SWMP06		SWMP07	
		Count	Median	Count	Median
Iron	mg/L	37	5.32	39	4.32
Lead	mg/L	37	0.001	39	0.001
Manganese	mg/L	37	0.430	39	0.347
Mercury	mg/L	37	0.0001	39	0.0001
Nickel	mg/L	37	0.006	39	0.004
Selenium	mg/L	37	0.01	39	0.01
Silver	mg/L	37	0.001	39	0.001
Zinc	mg/L	37	0.009	39	0.008
Other parameters					
Cyanide	mg/L	37	0.004	39	0.004
Fluoride	mg/L	37	0.1	39	0.1

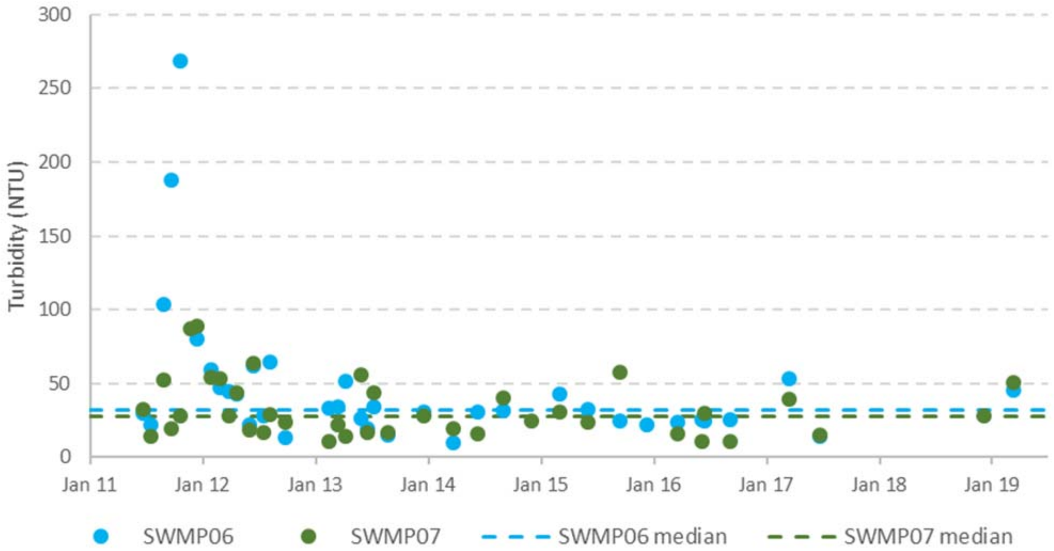
Time series graphs

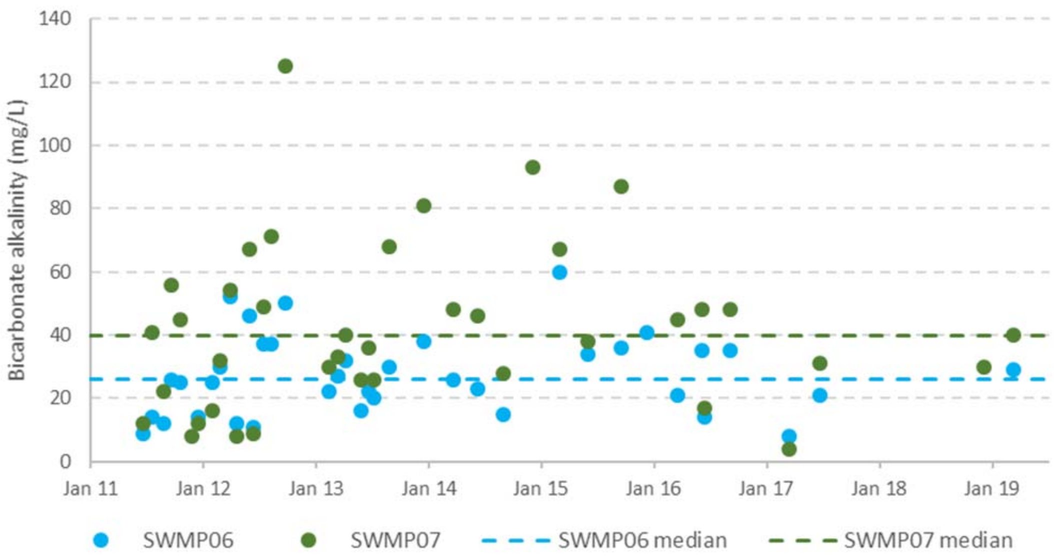


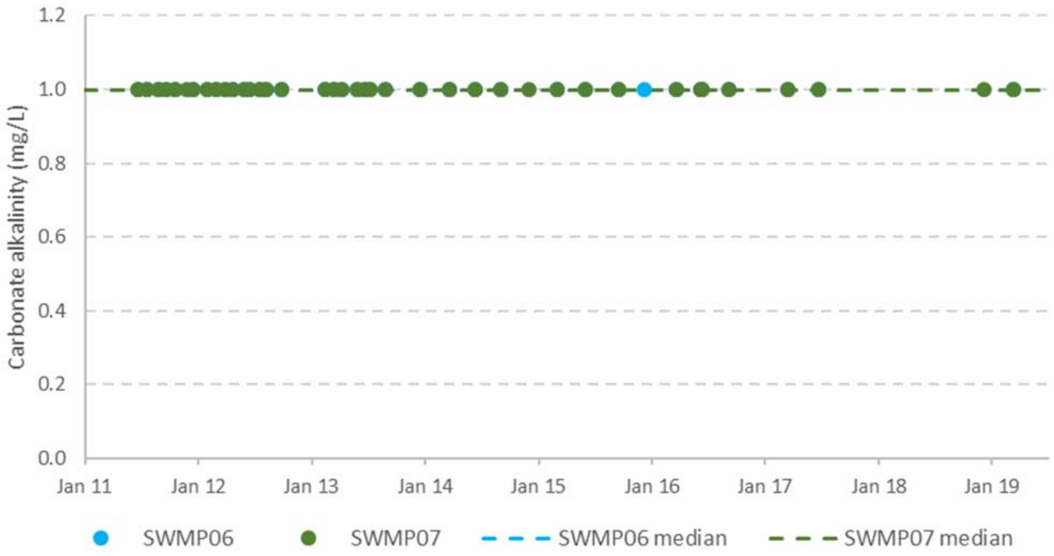


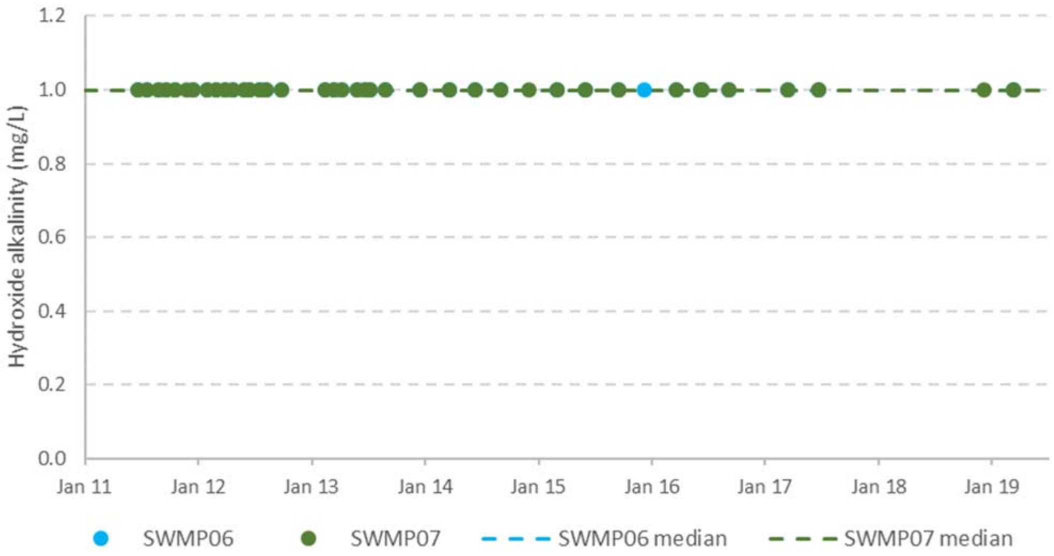


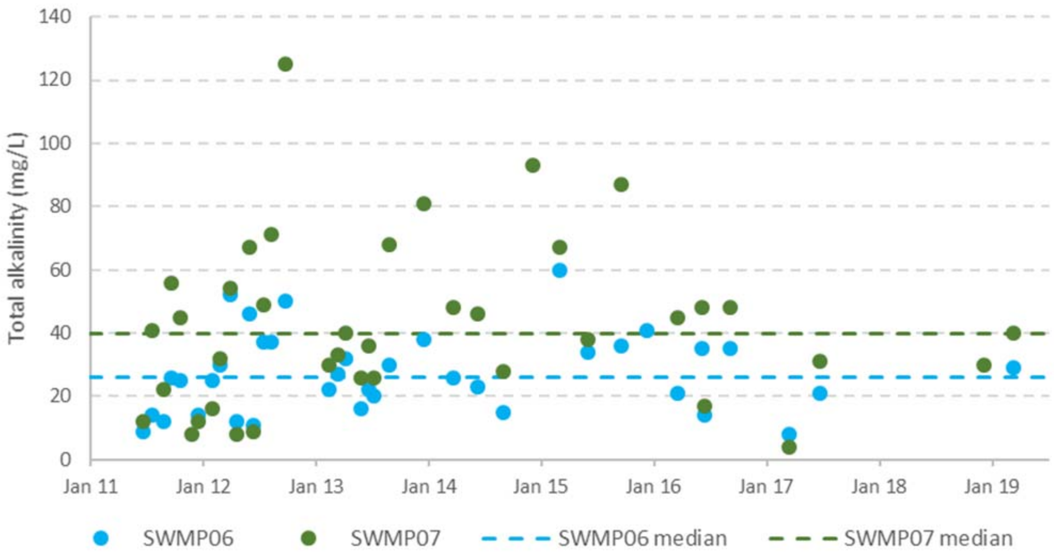

Total suspended solids (mg/L)
400
350
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

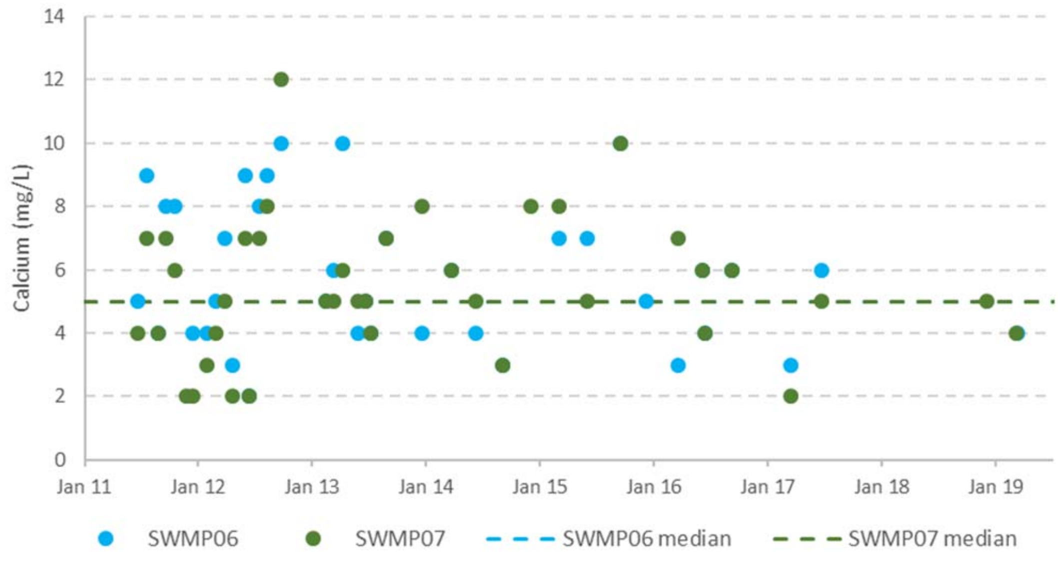

Turbidity (NTU)
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

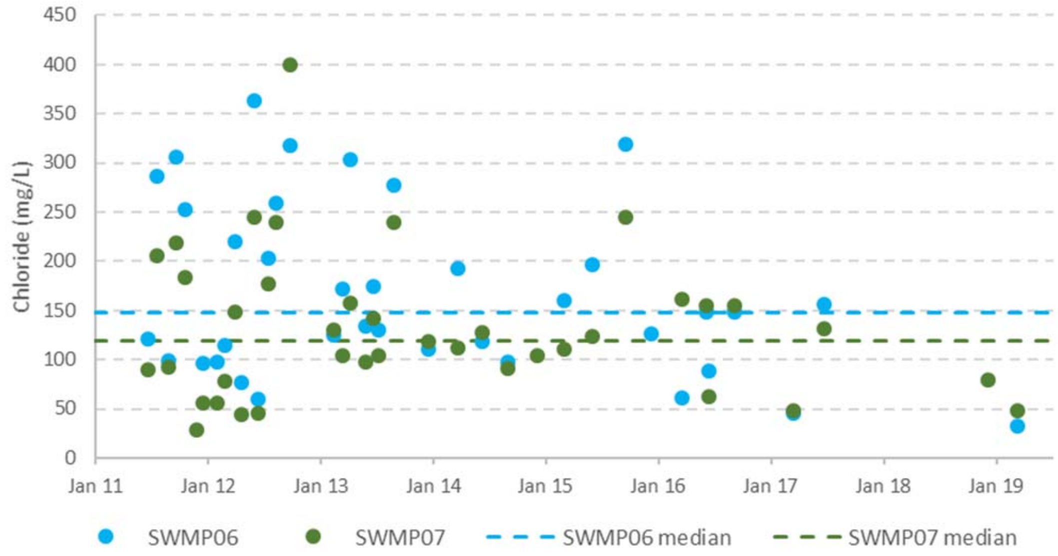

Bicarbonate alkalinity (mg/L)
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

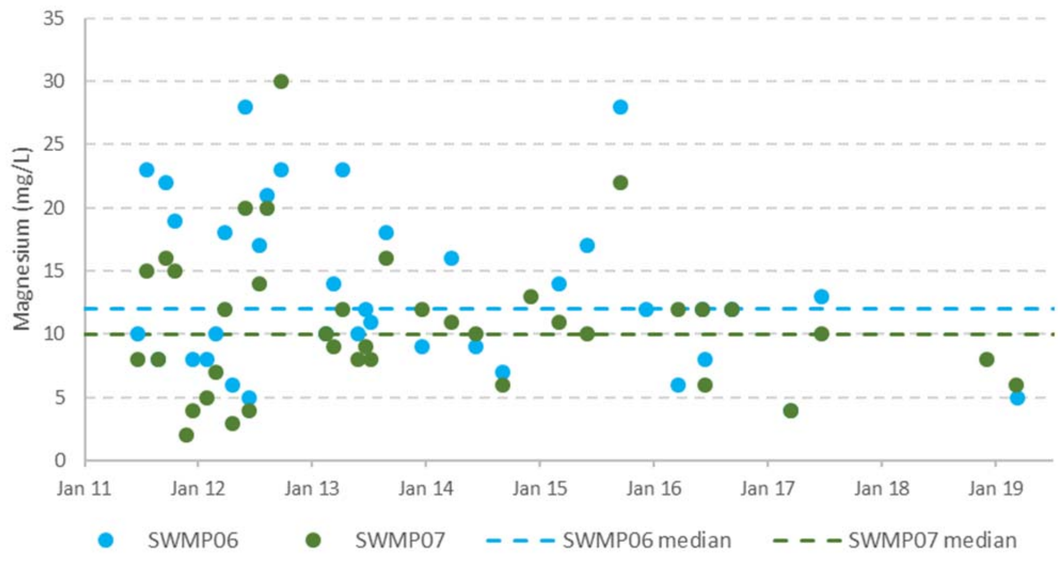

Carbonate alkalinity (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

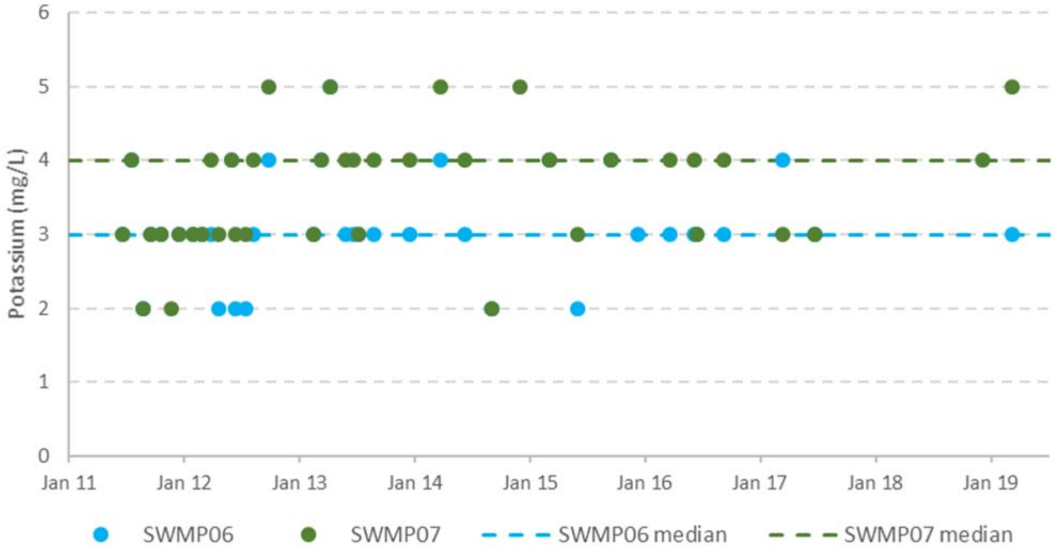

Hydroxide alkalinity (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

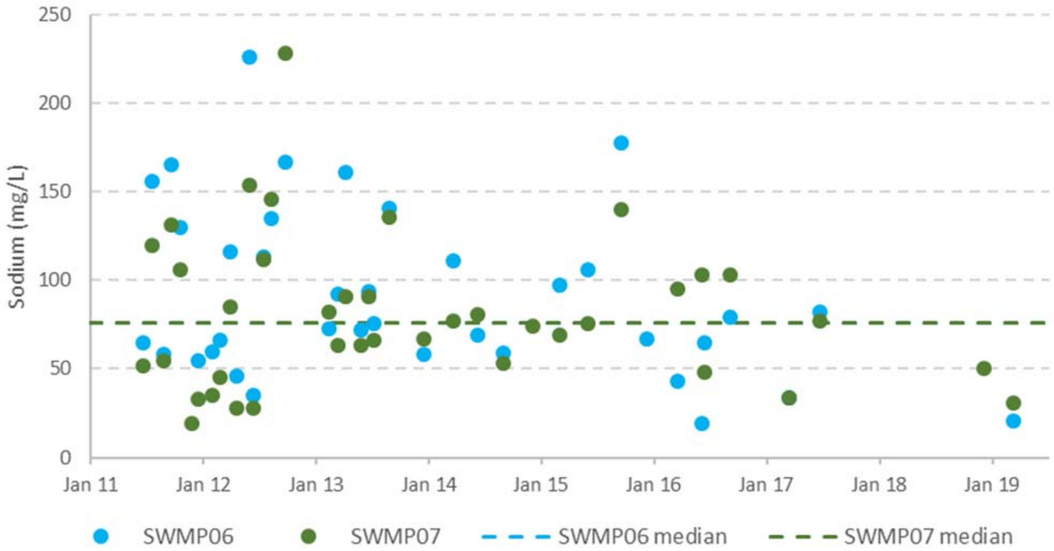

Total alkalinity (mg/L)
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

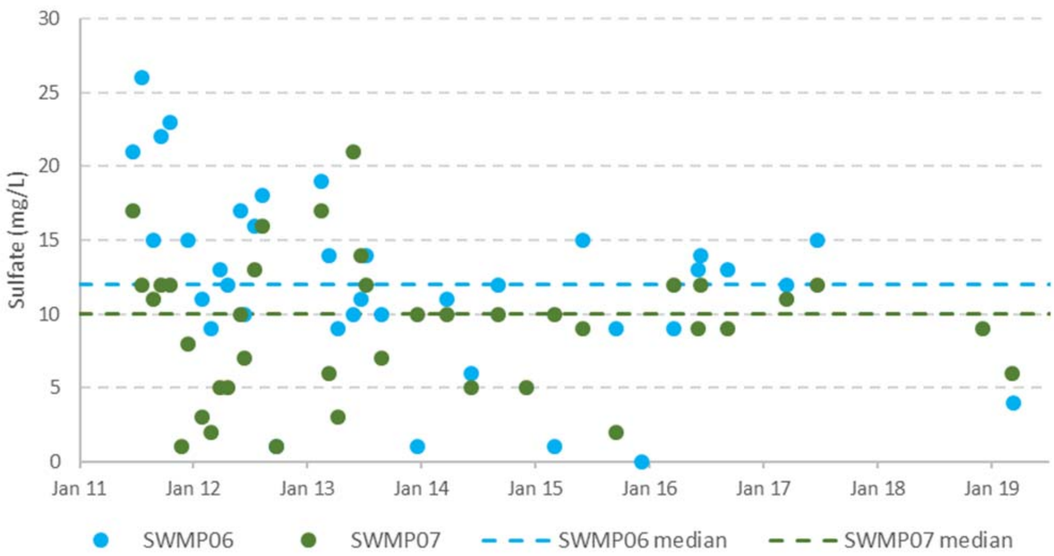

Calcium (mg/L)
14
12
10
8
6
4
2
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

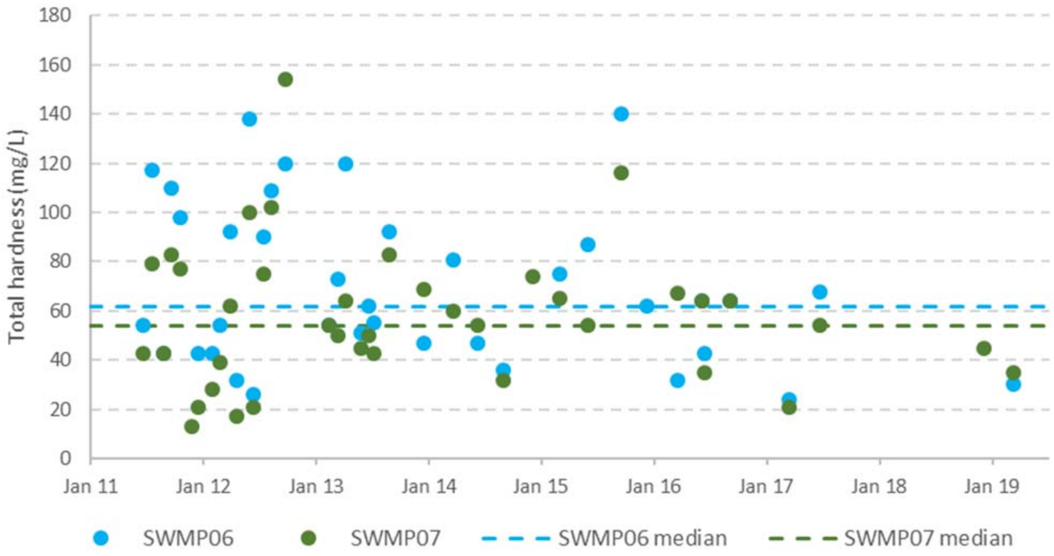

Chloride (mg/L)
450
400
350
300
250
200
150
100
50
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

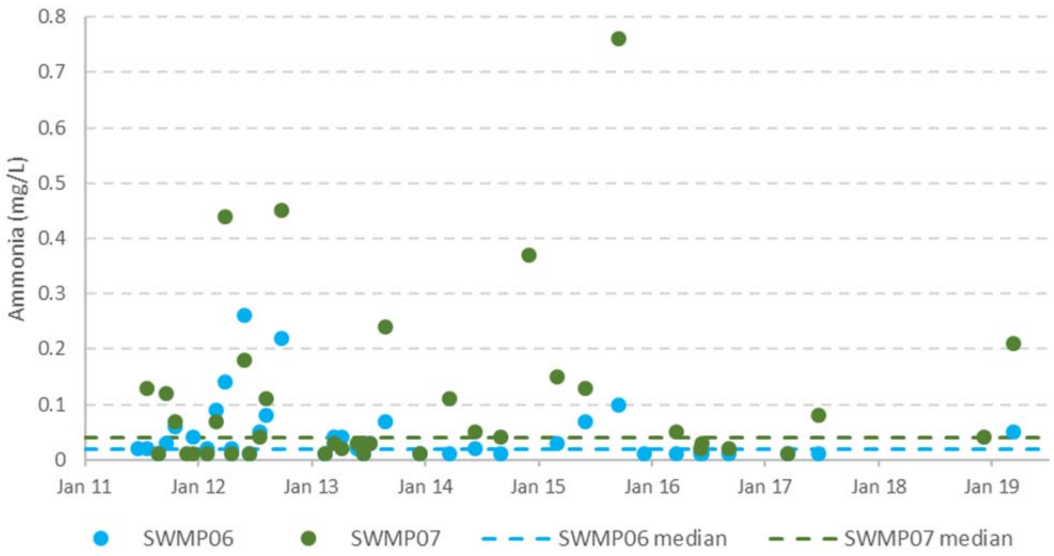

Magnesium (mg/L)
35
30
25
20
15
10
5
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

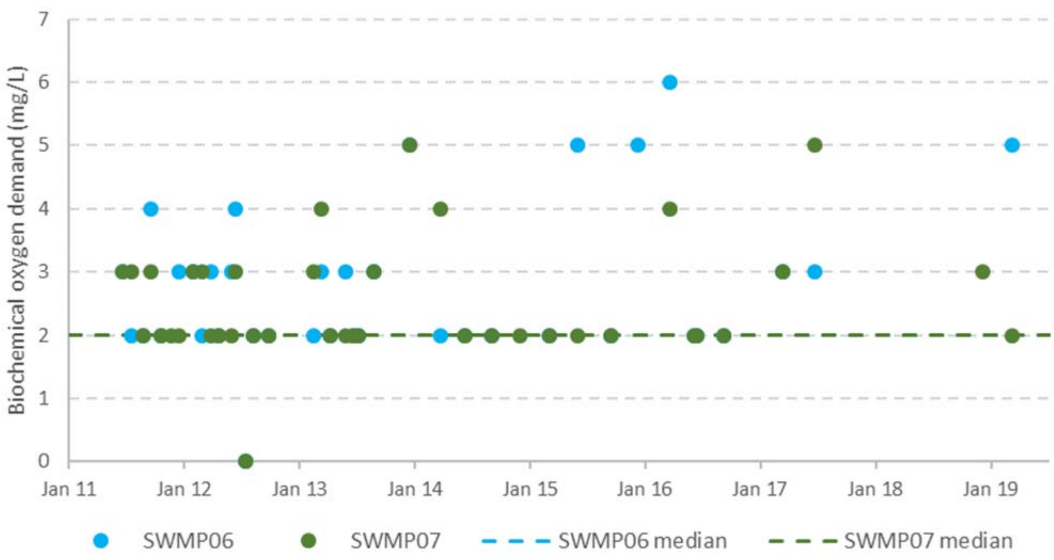

Potassium (mg/L)
0
1
2
3
4
5
6
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

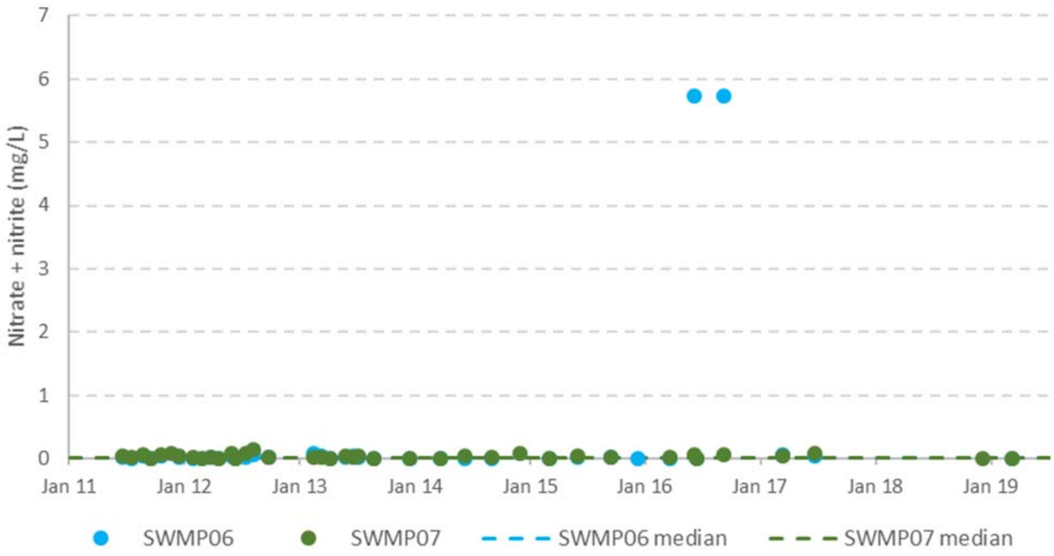

Sodium (mg/L)
0
50
100
150
200
250
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

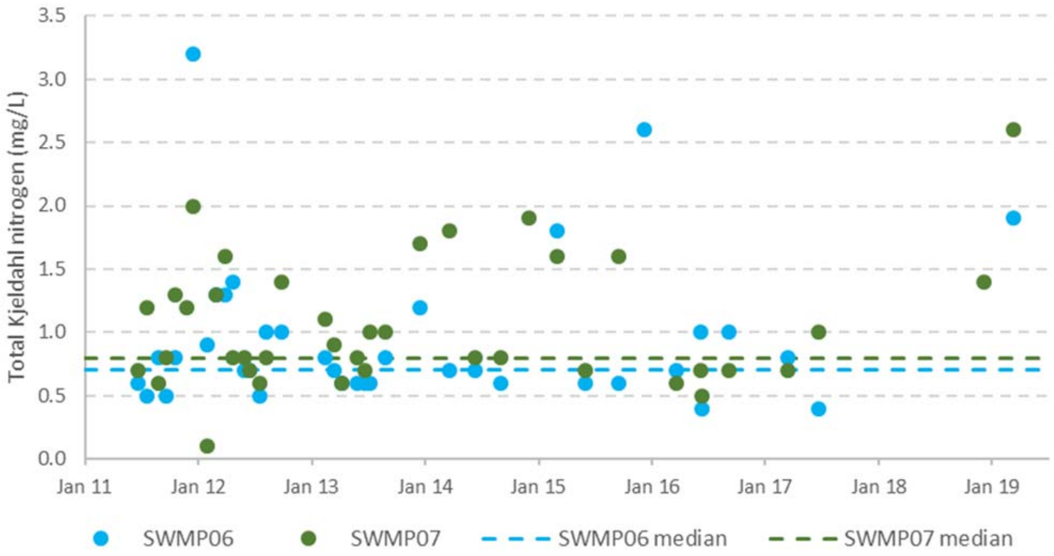

Sulfate (mg/L)
0
5
10
15
20
25
30
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

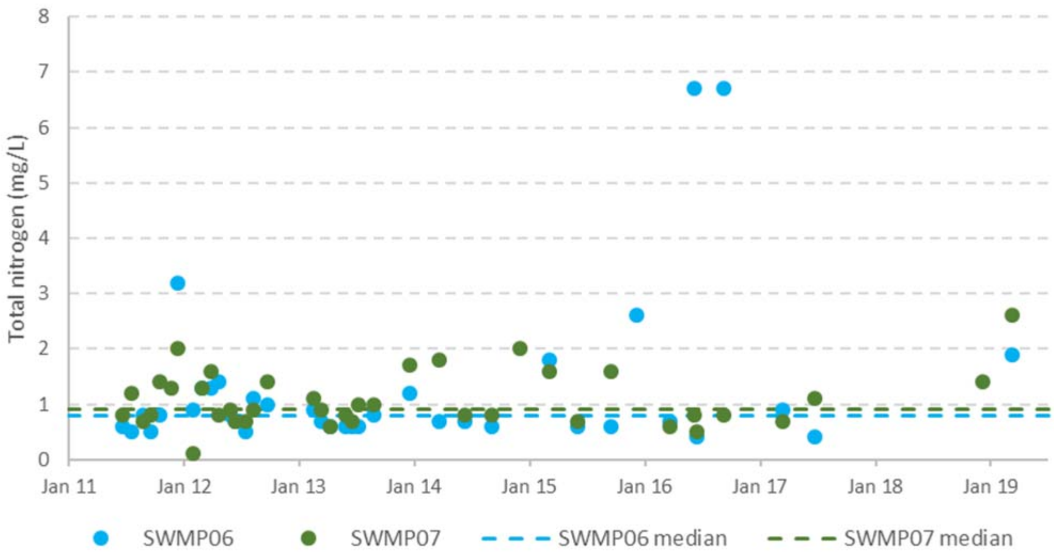

Total hardness (mg/L)
180
160
140
120
100
80
60
40
20
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

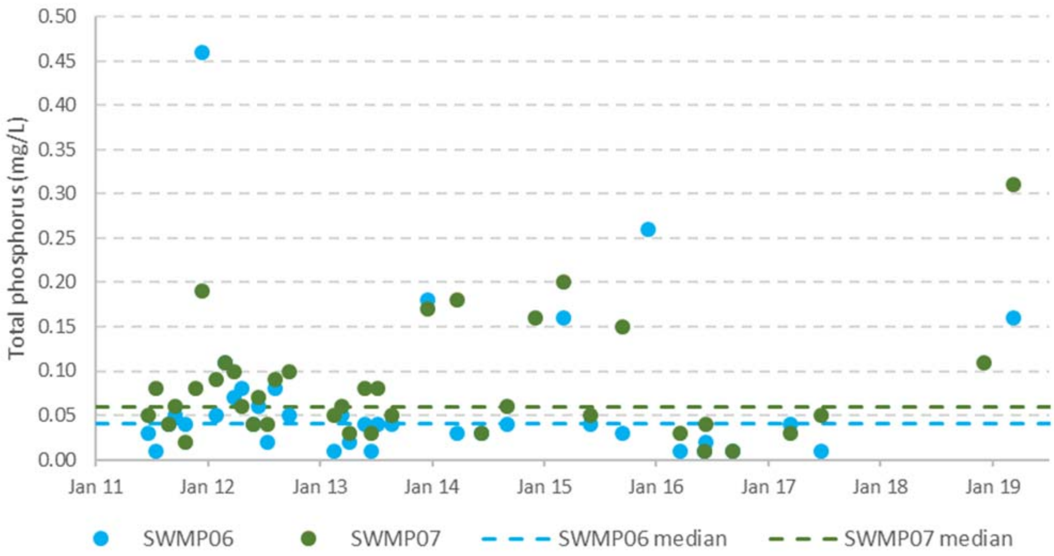

Ammonia (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

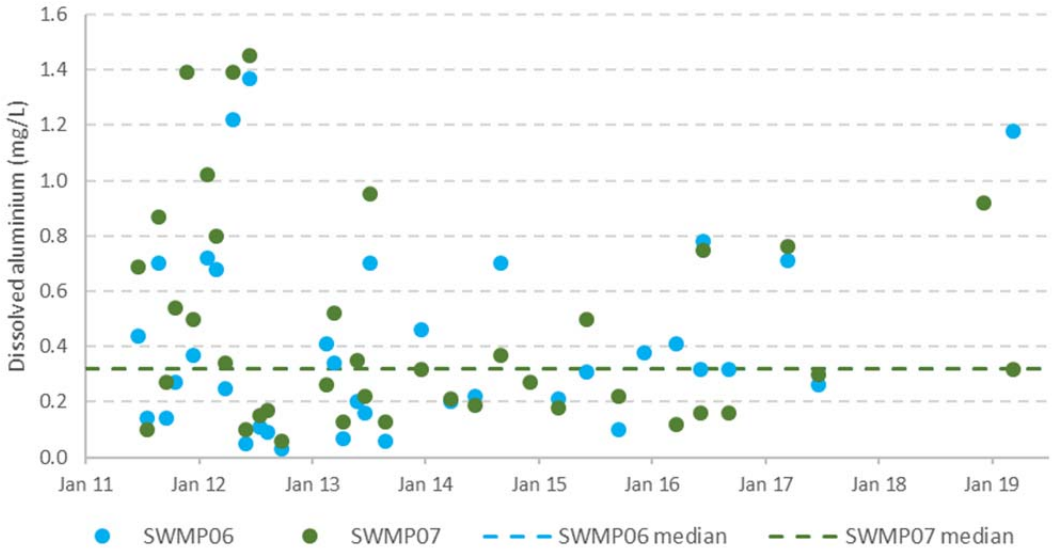

Biochemical oxygen demand (mg/L)
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

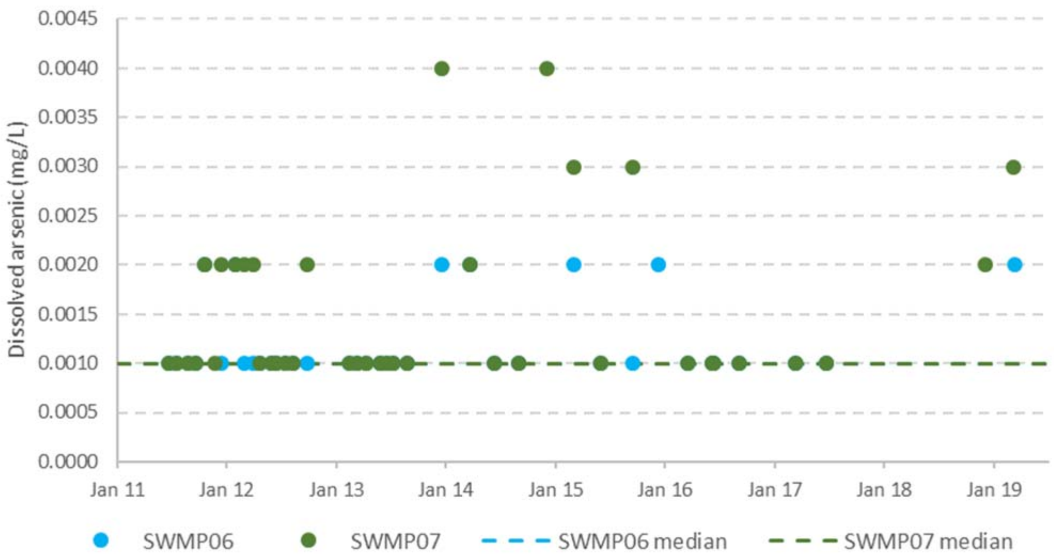

Nitrate + nitrite (mg/L)
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

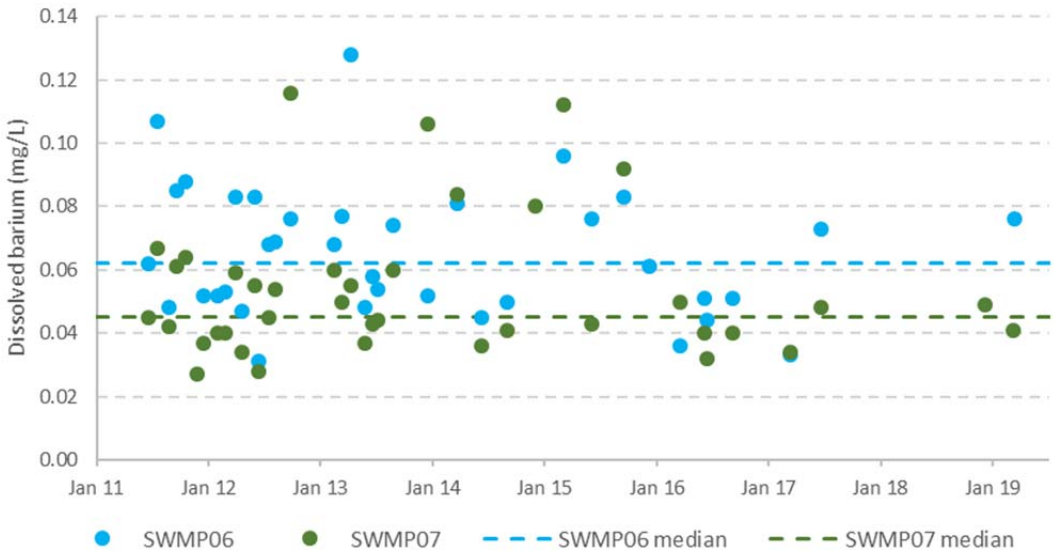

Total Kjeldahl nitrogen (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

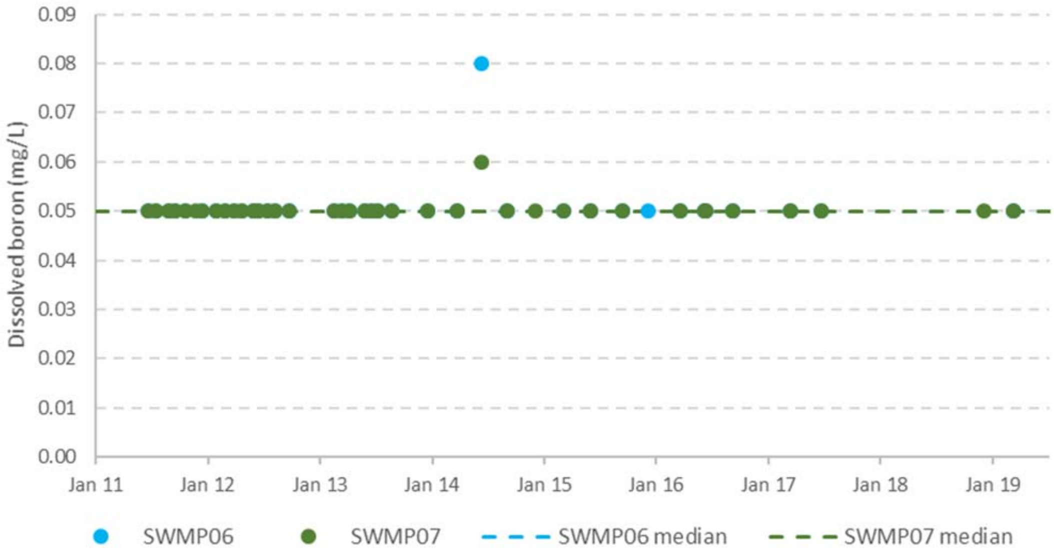

Total nitrogen (mg/L)
8
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

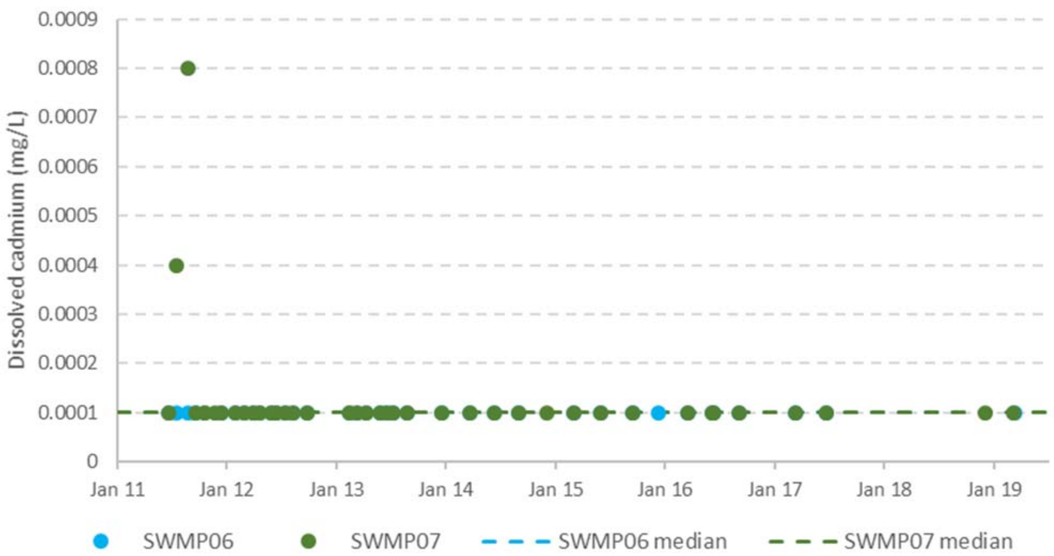

Total phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

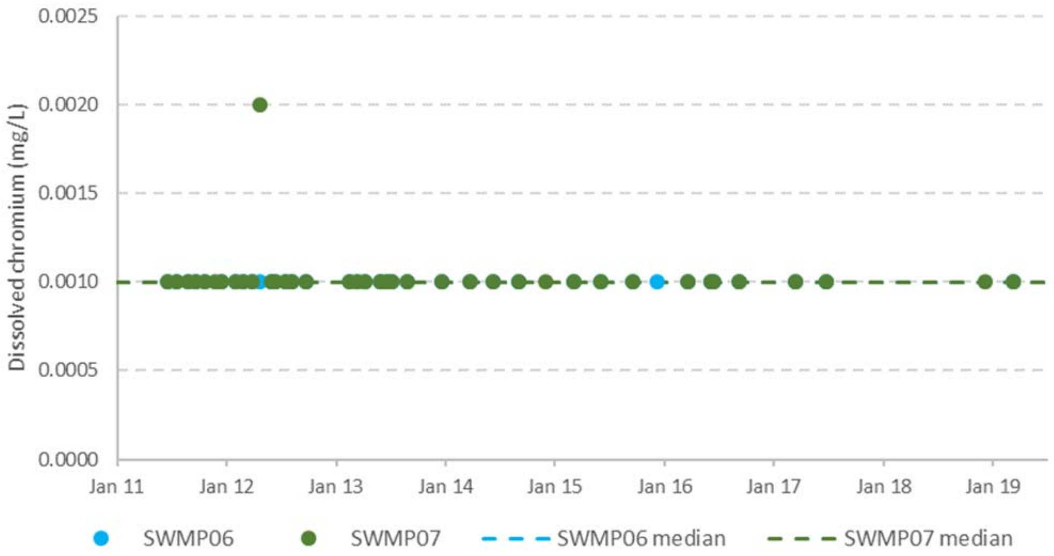

Dissolved aluminium (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

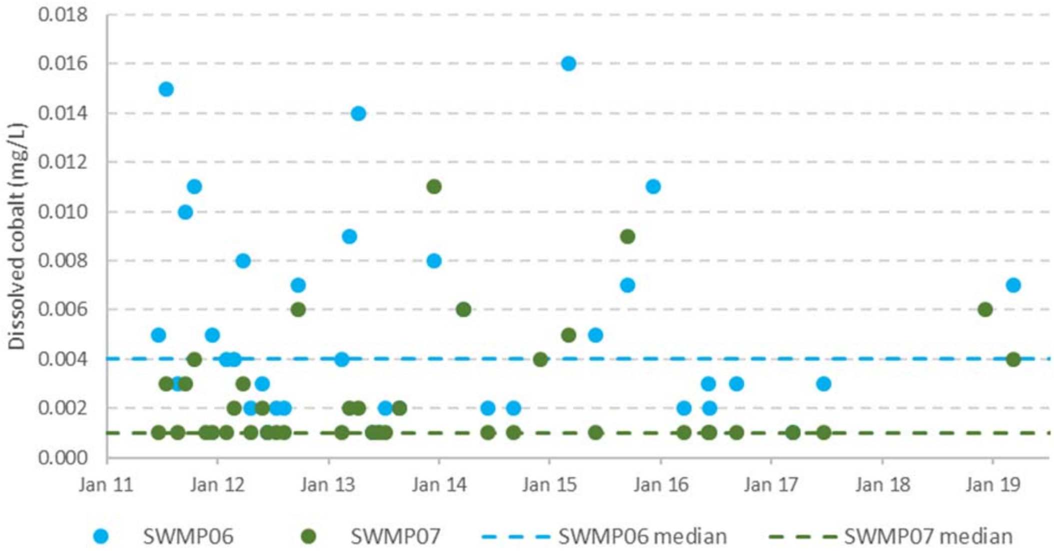

Dissolved arsenic (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

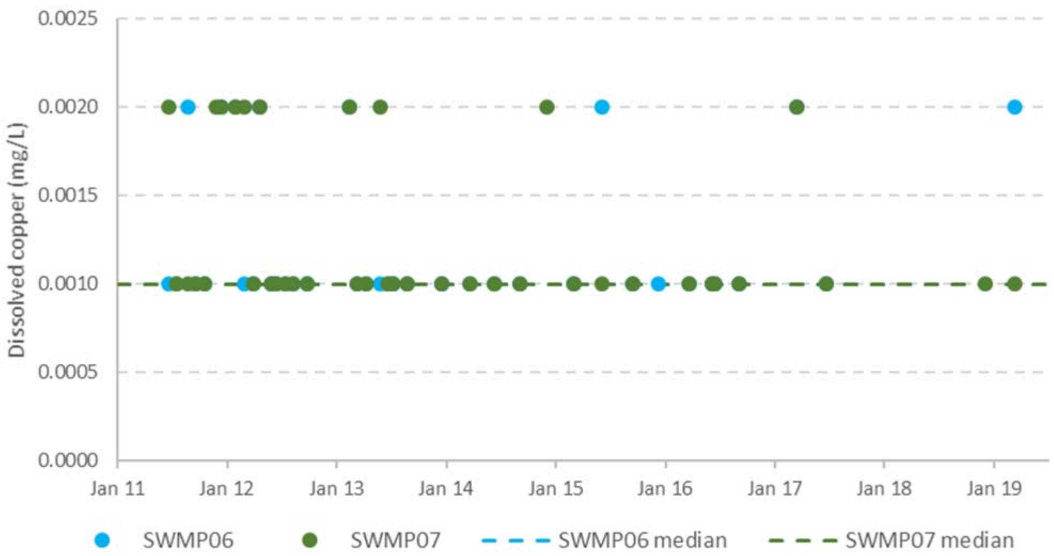

0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved barium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

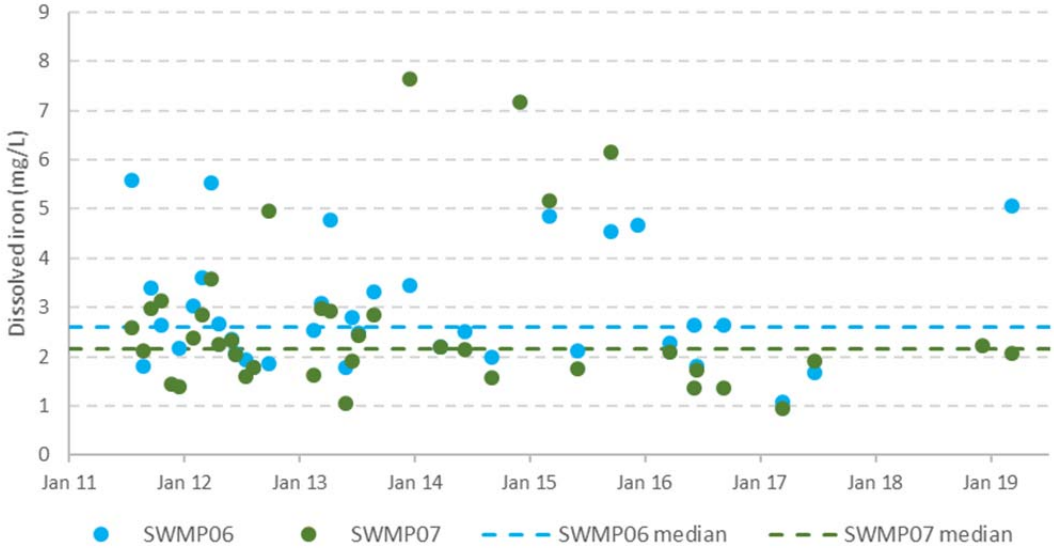

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved boron (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

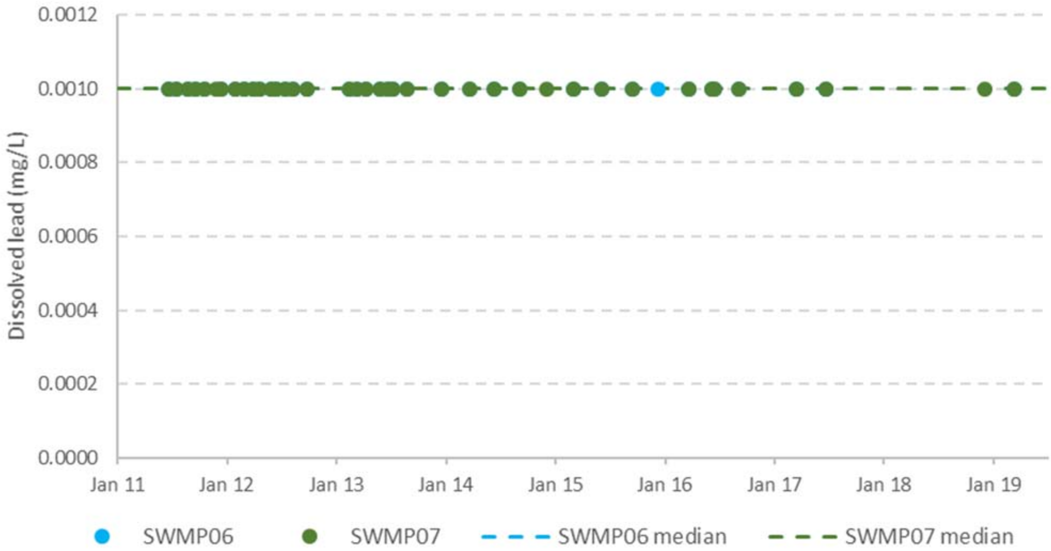

0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
Dissolved cadmium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

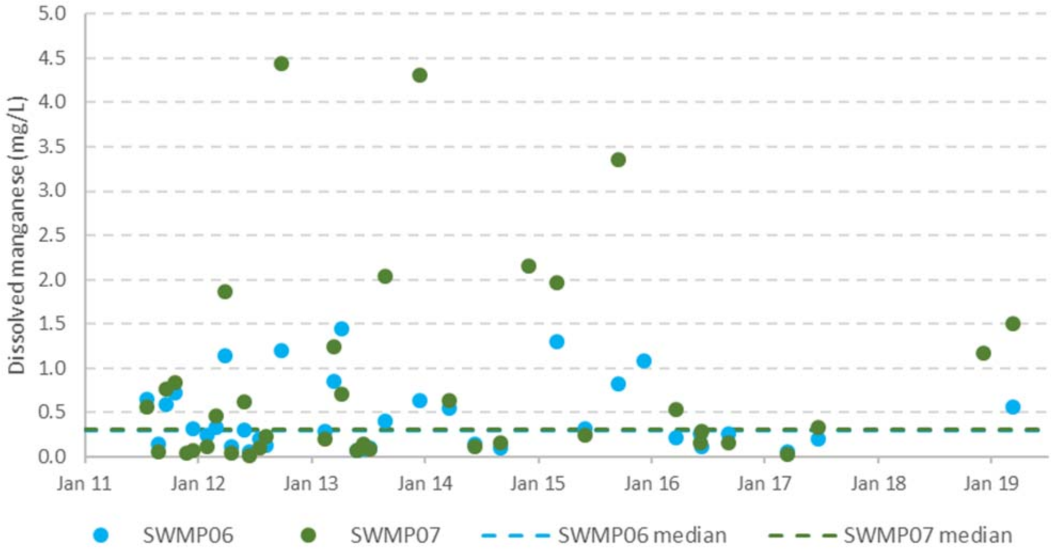

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved chromium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

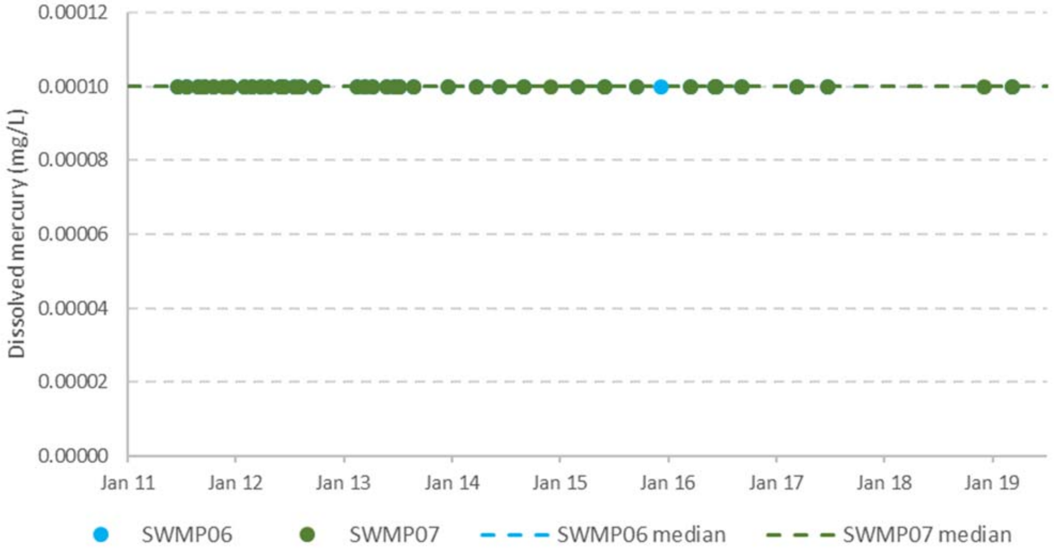

0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved cobalt (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

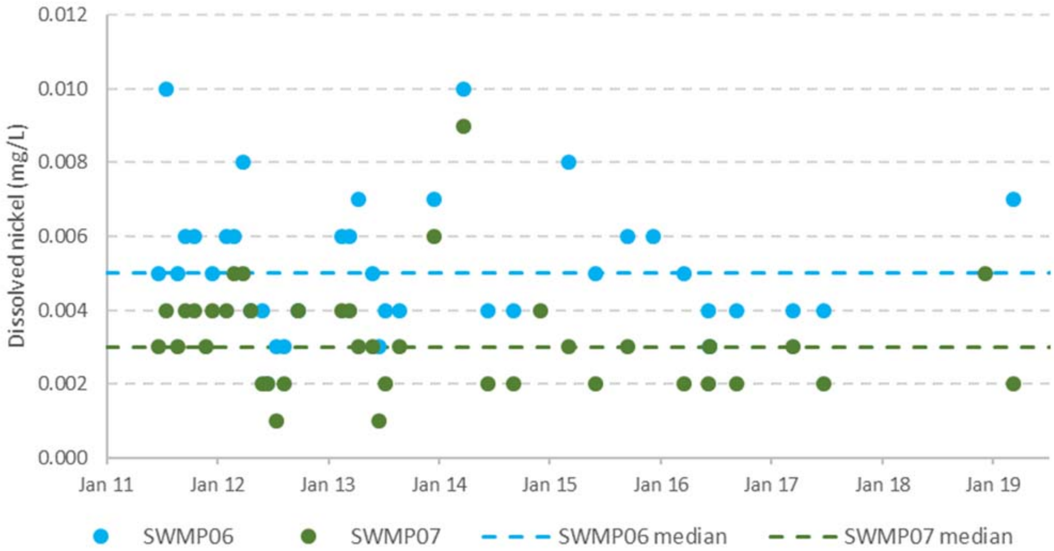

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved copper (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

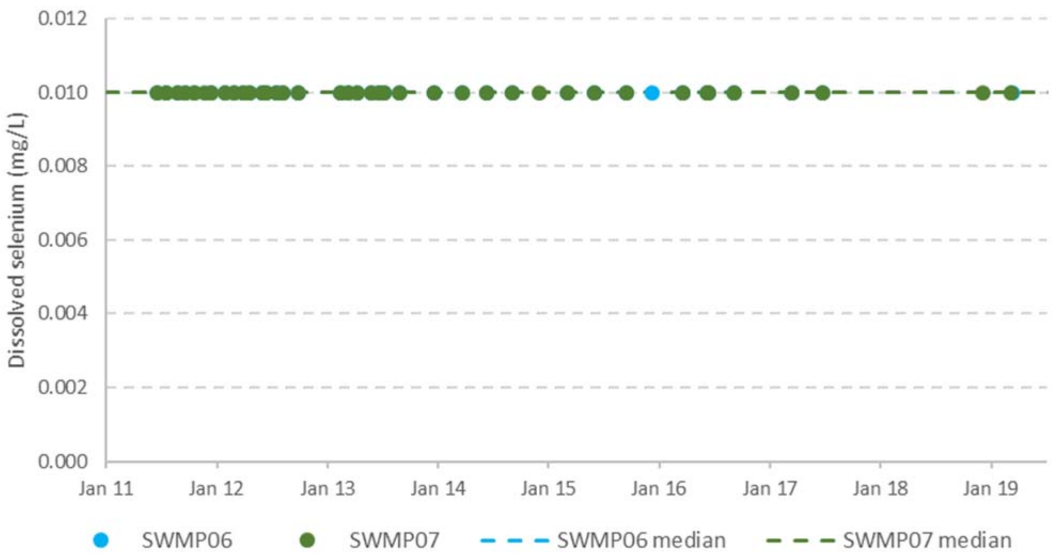

Dissolved iron (mg/L)
9
8
7
6
5
4
3
2
1
0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

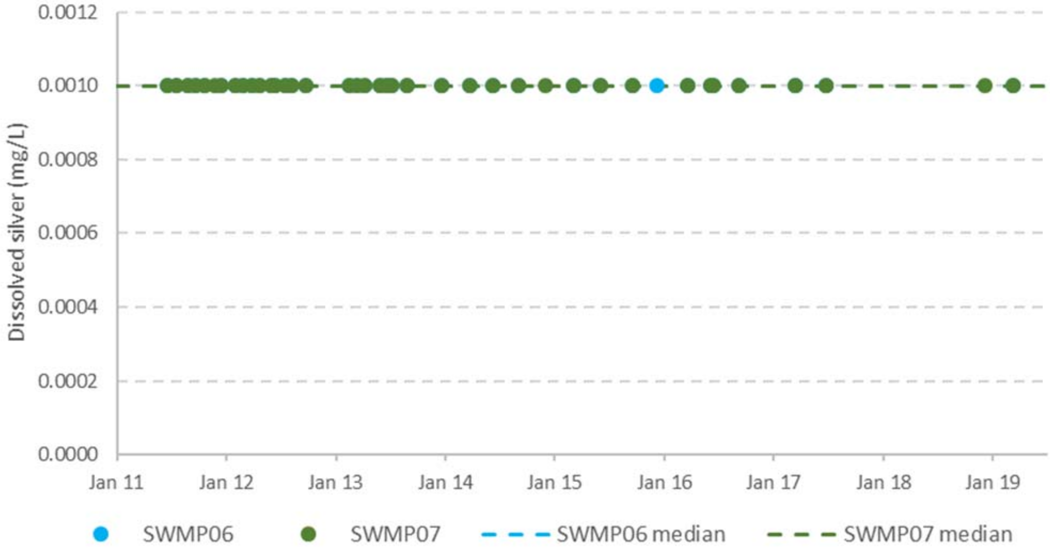

Dissolved lead (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

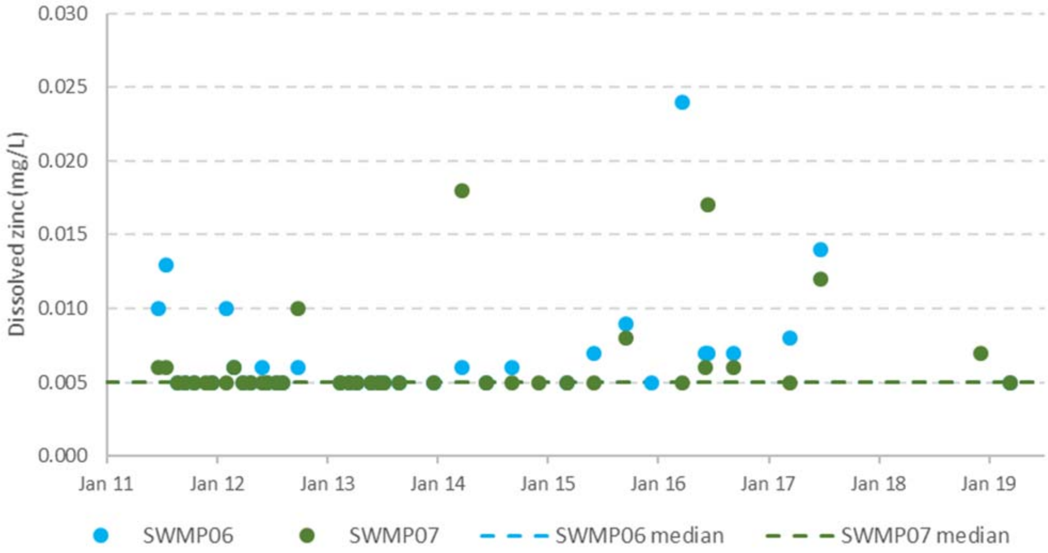

Dissolved manganese (mg/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

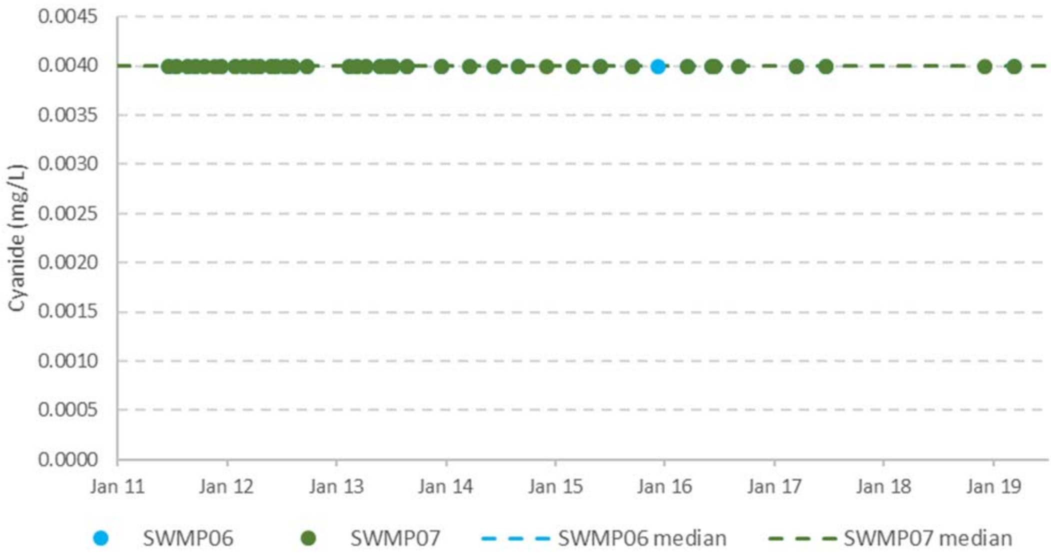

0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Dissolved mercury (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

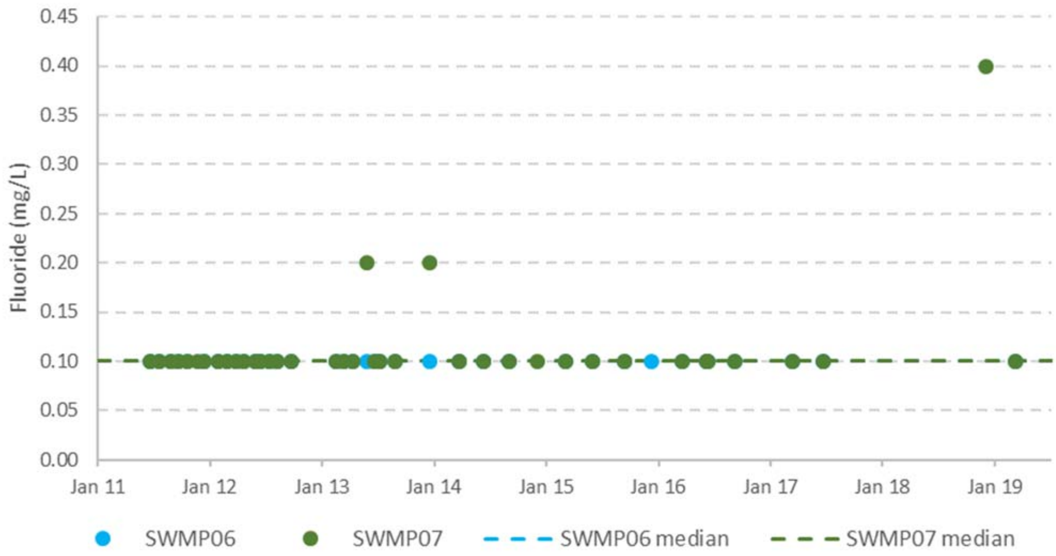

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved nickel (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median


0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved selenium (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median


0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved silver (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

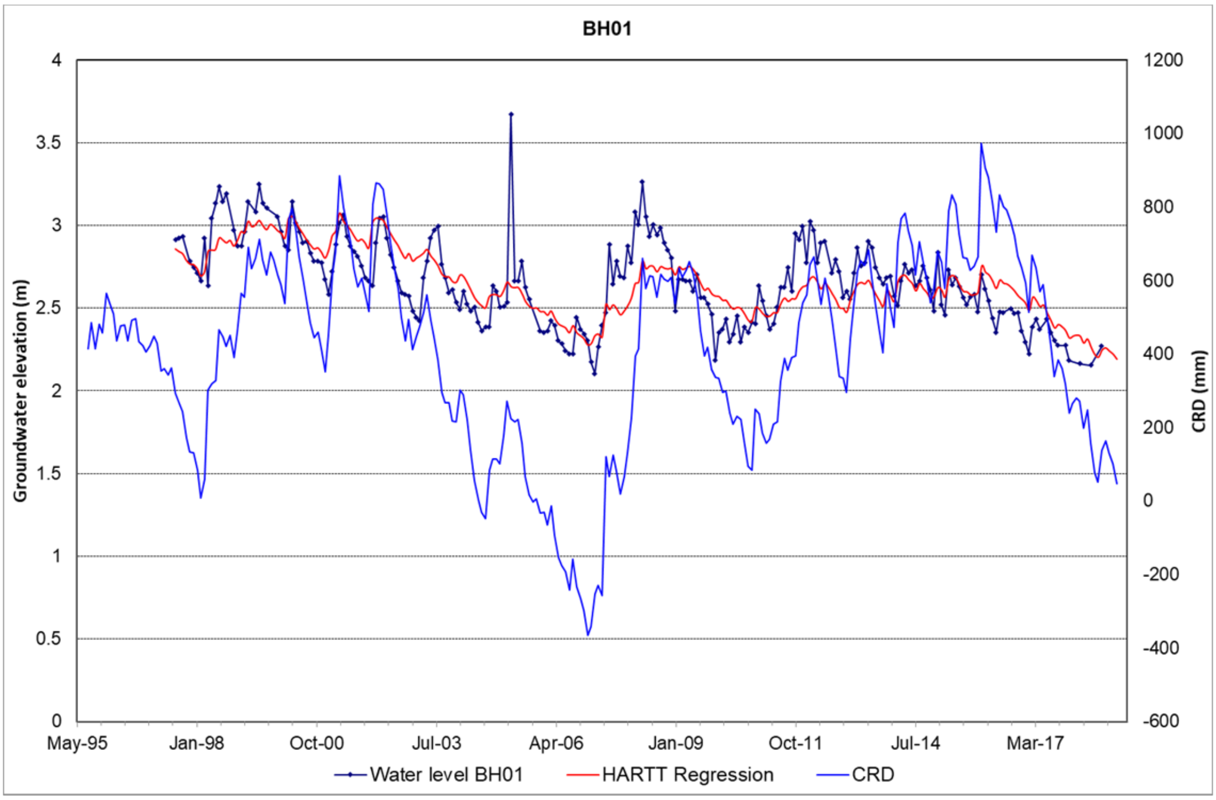

0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved zinc (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

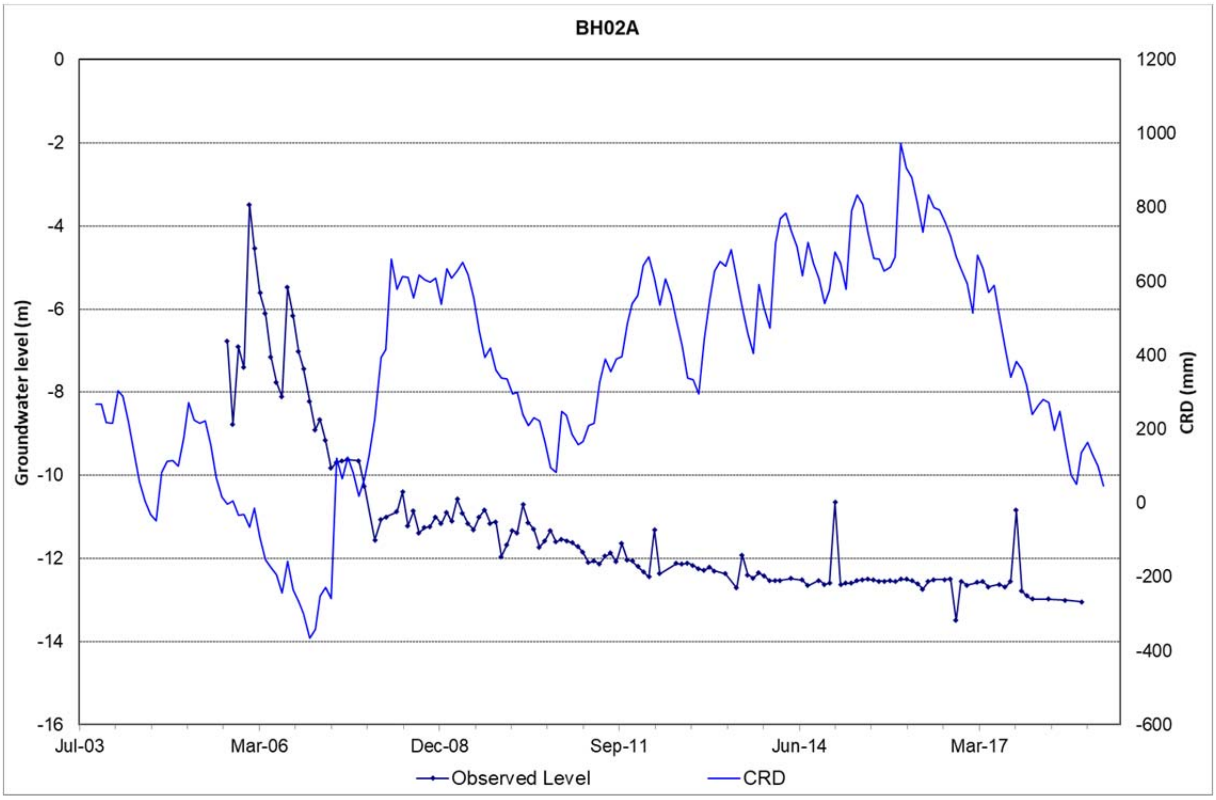

0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Cyanide (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

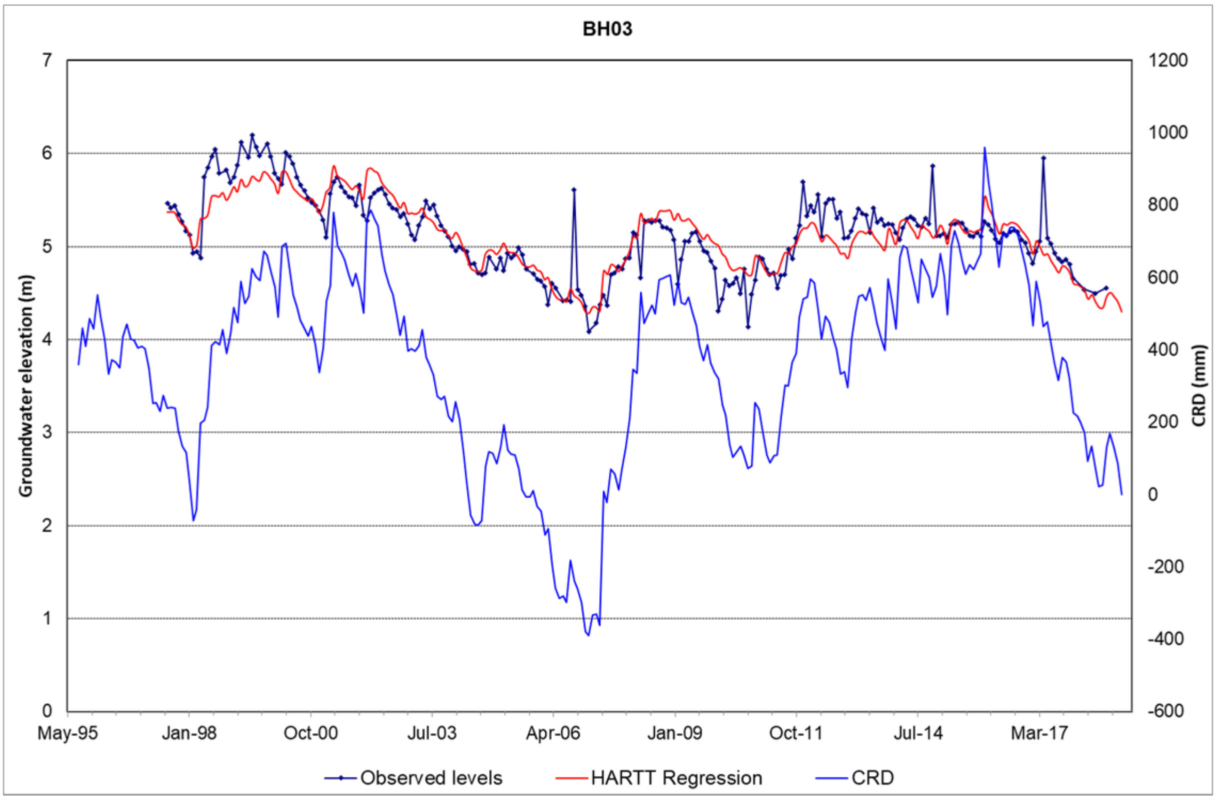

0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Fluoride (mg/L)
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
SWMP06
SWMP07
SWMP06 median
SWMP07 median

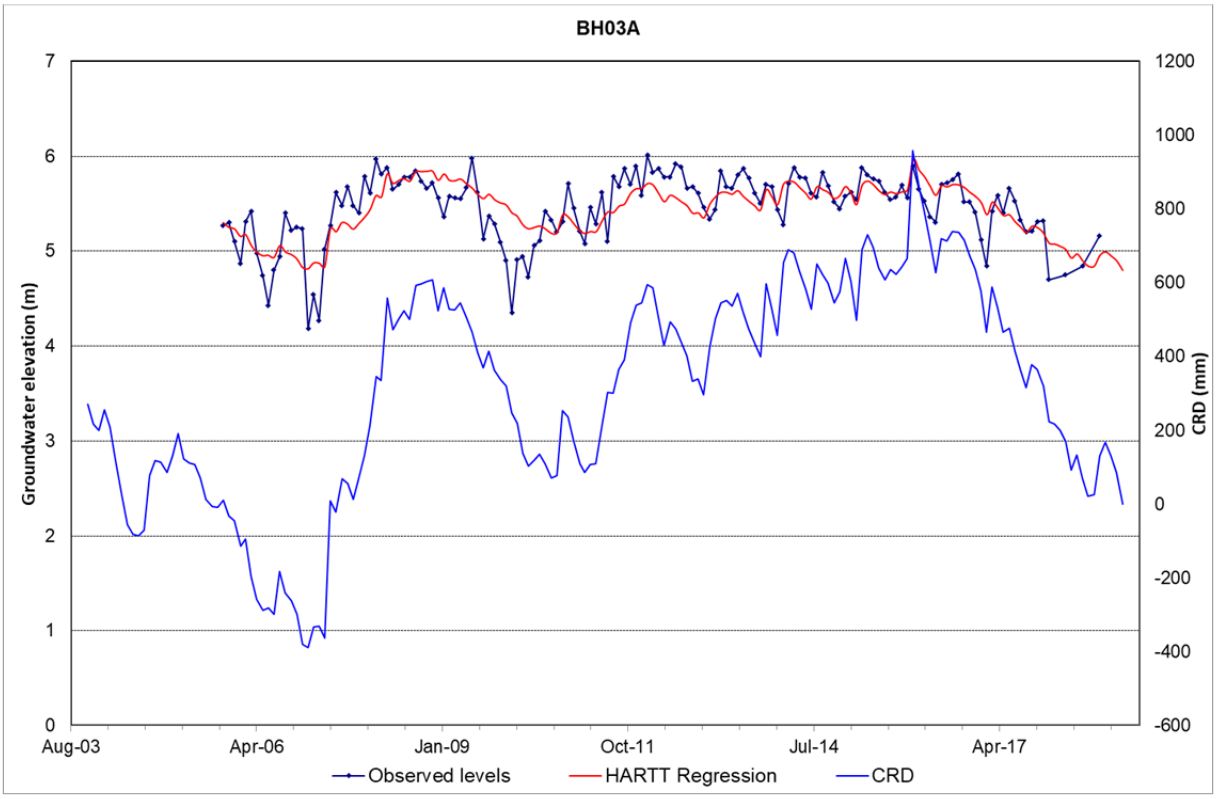
APPENDIX F – Baseline groundwater level and quality data

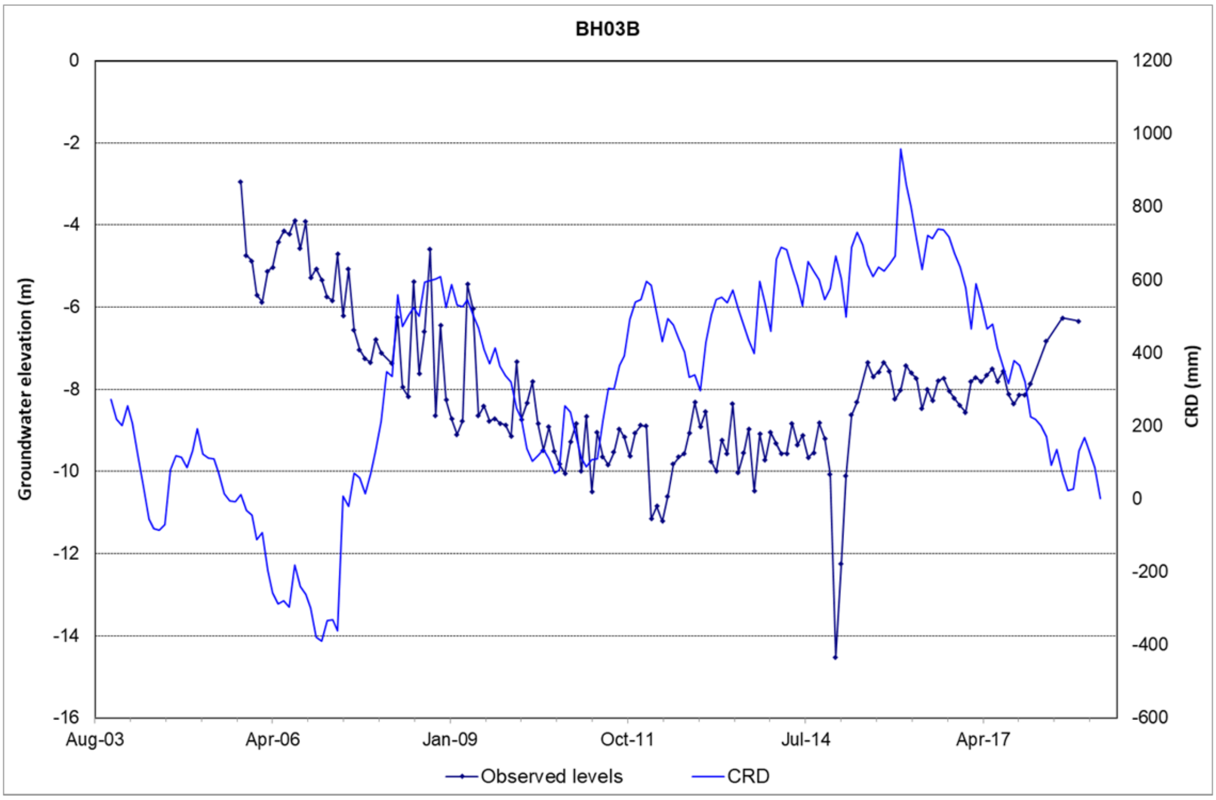
F.1 Groundwater level hydrographs

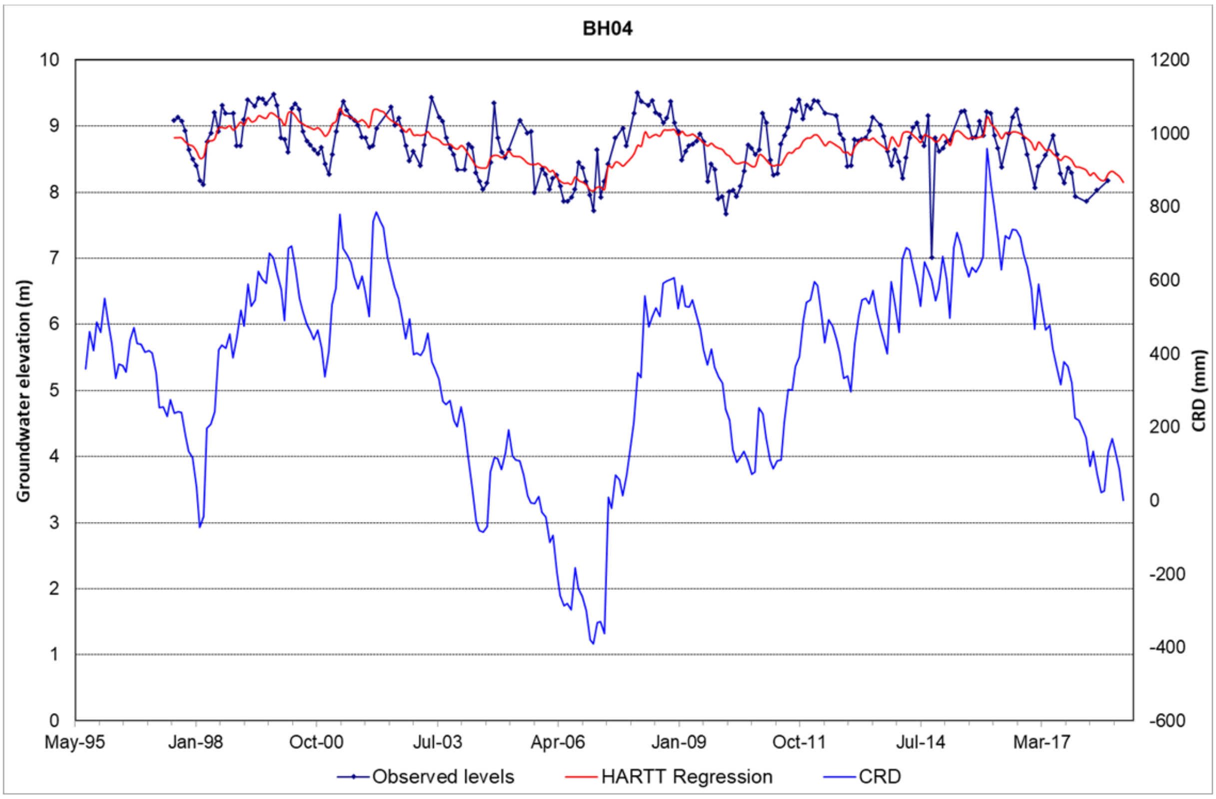


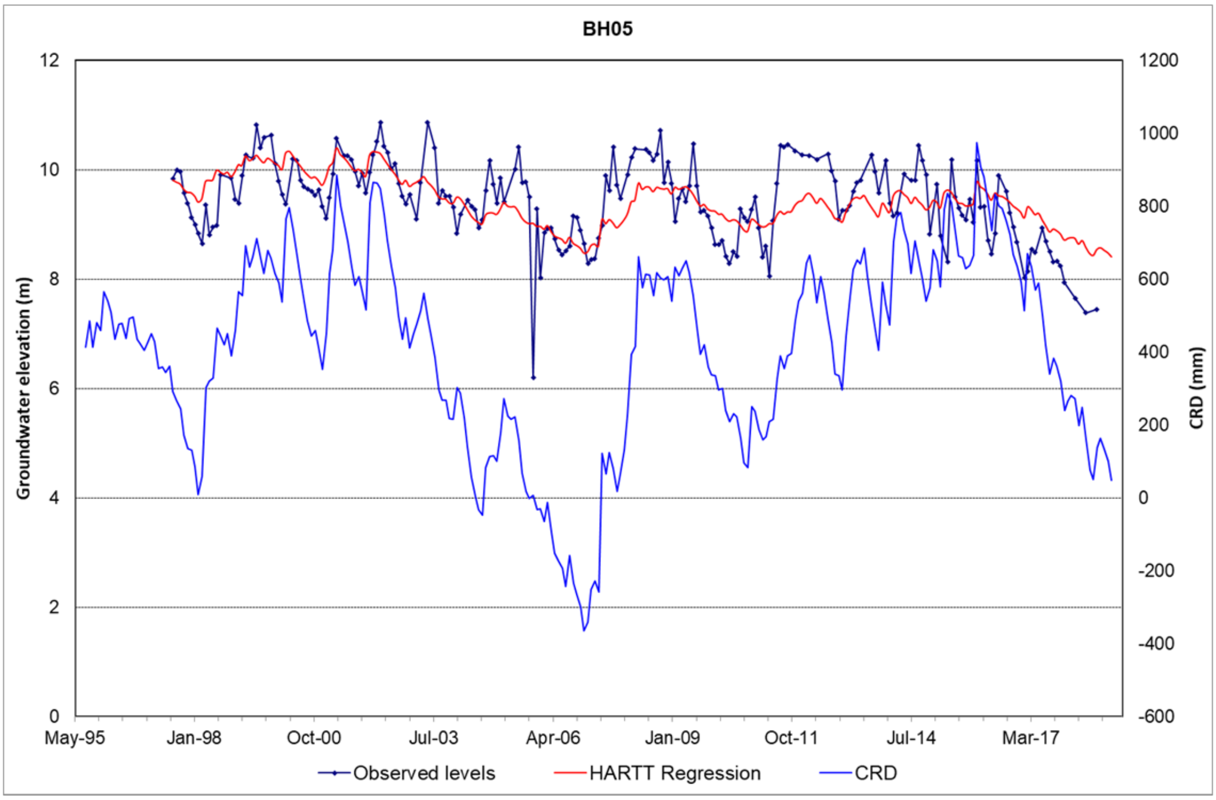


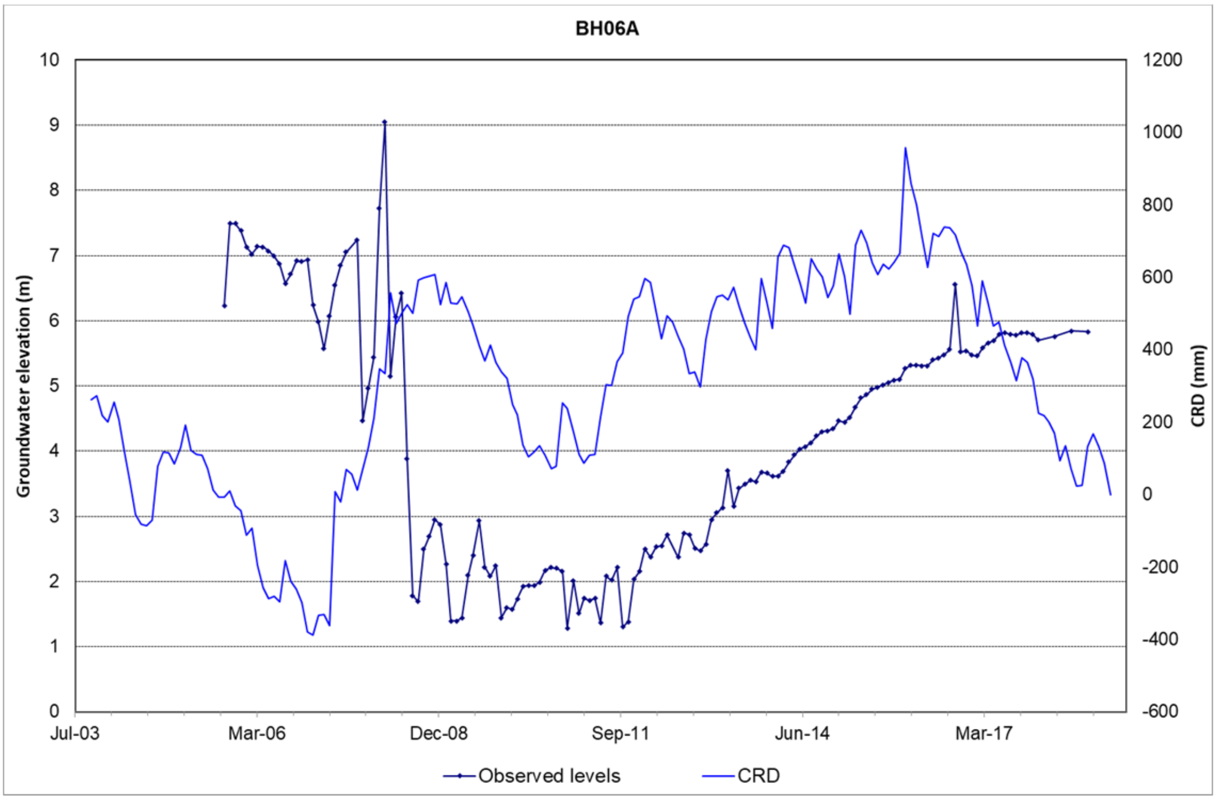

BH03
Groundwater elevation (m)
CRD (mm)
0
1
2
3
4
5
6
7
-600
-400
-200
0
200
400
600
800
1000
1200
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed levels
HARTT Regression
CRD

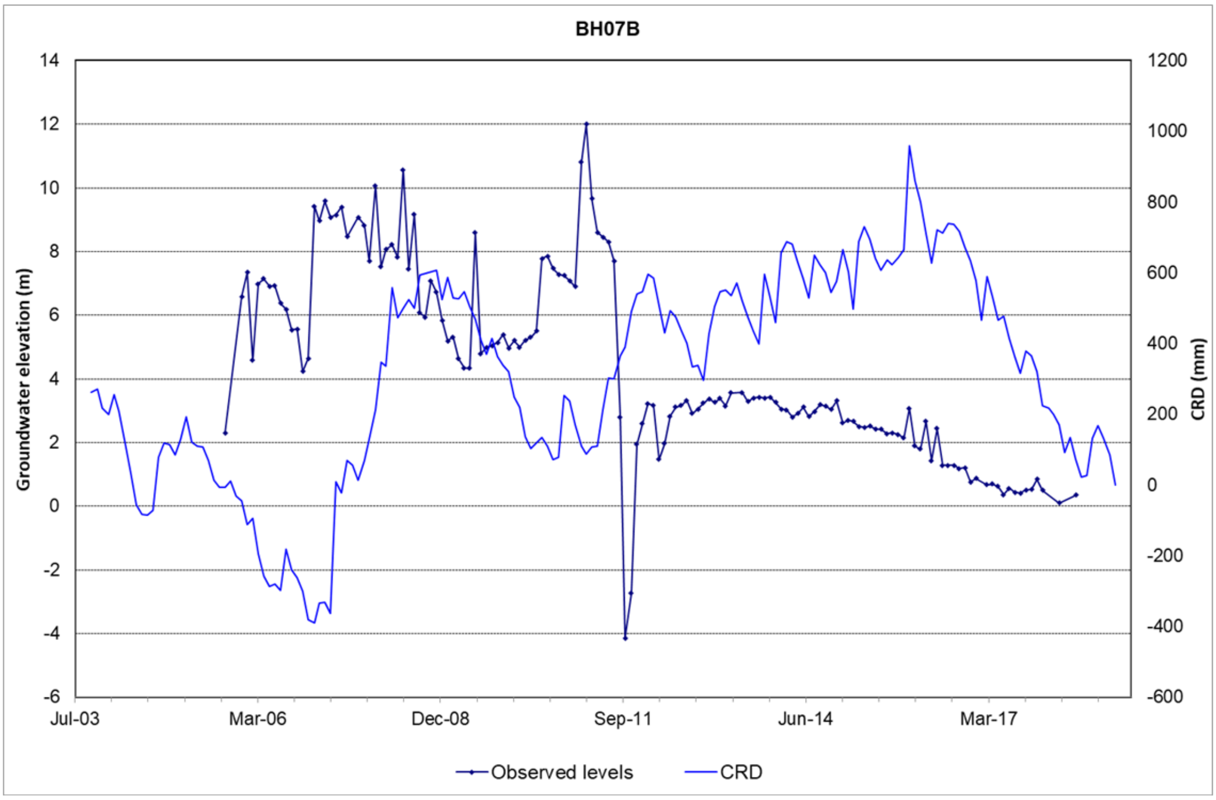

BH03A
Groundwater elevation (m)
CRD (mm)
0
1
2
3
4
5
6
7
-600
-400
-200
0
200
400
600
800
1000
1200
Aug-03
Apr-06
Jan-09
Oct-11
Jul-14
Apr-17
Observed levels
HARTT Regression
CRD

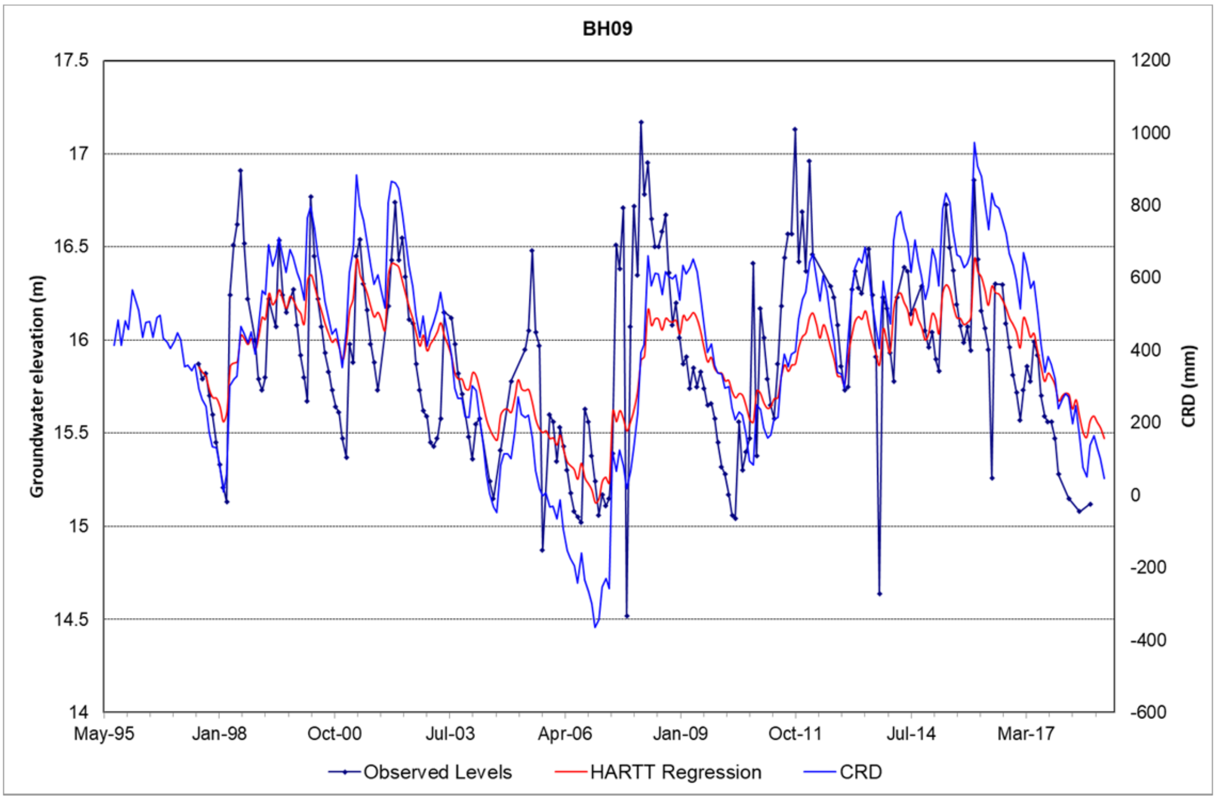

BH03B
Groundwater elevation (m)
CRD (mm)
0
-2
-4
-6
-8
-10
-12
-14
-16
1200
1000
800
600
400
200
0
-200
-400
-600
Aug-03
Apr-06
Jan-09
Oct-11
Jul-14
Apr-17
Observed levels
CRD

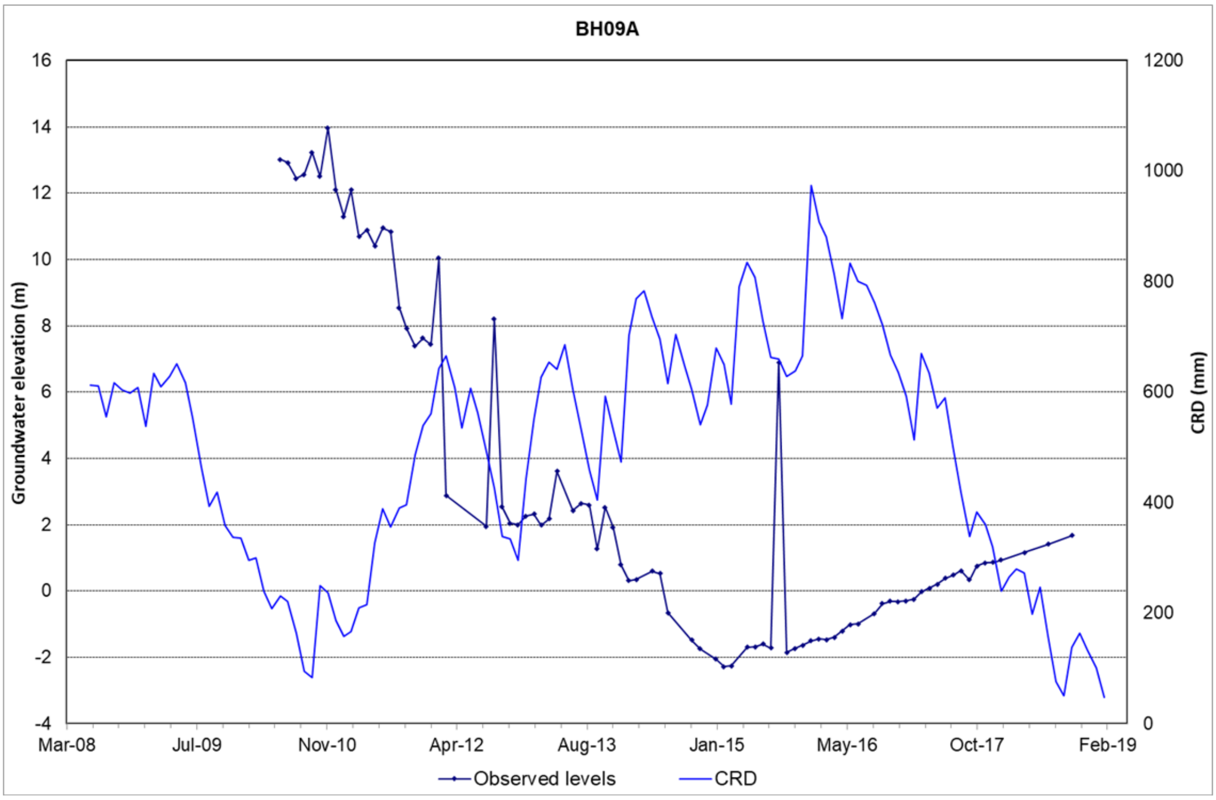

BH04
Groundwater elevation (m)
CRD (mm)
10
9
8
7
6
5
4
3
2
1
0
1200
1000
800
600
400
200
0
-200
-400
-600
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed levels
HARTT Regression
CRD

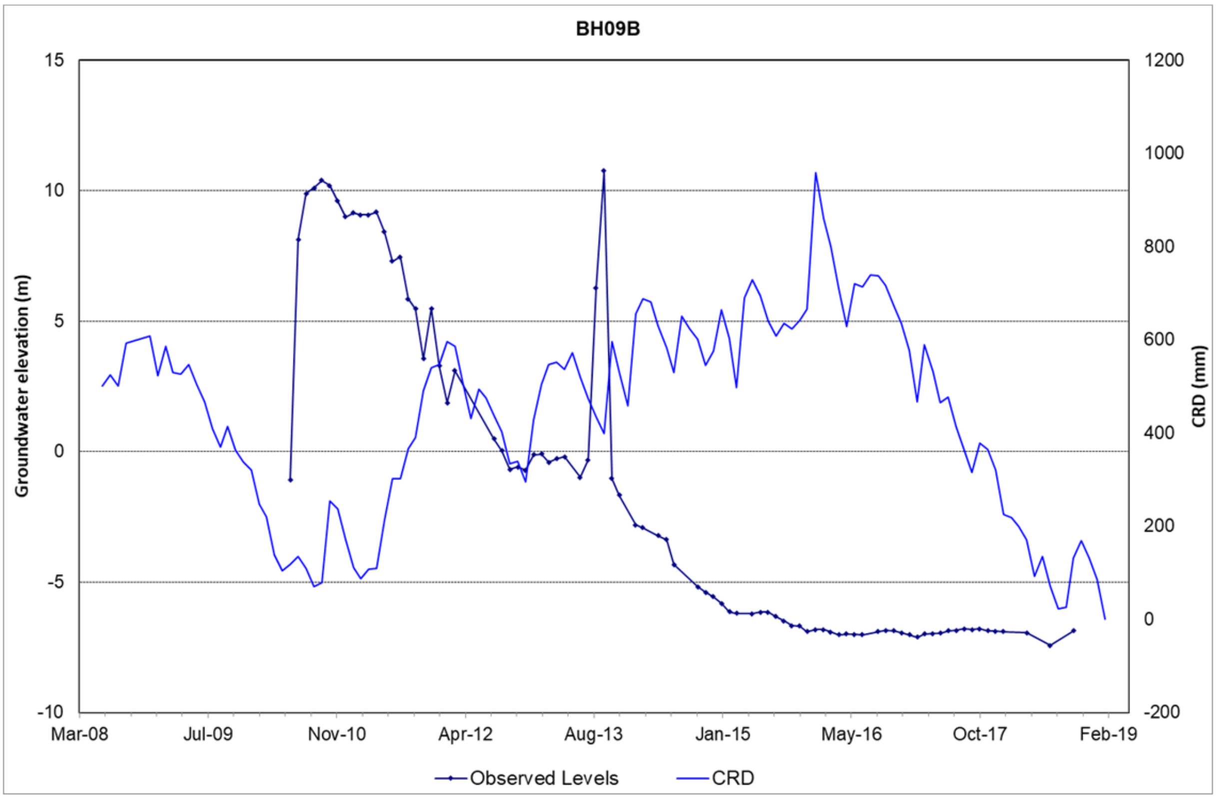

BH05
Groundwater elevation (m)
CRD (mm)
0
2
4
6
8
10
12
-600
-400
-200
0
200
400
600
800
1000
1200
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed levels
HARTT Regression
CRD

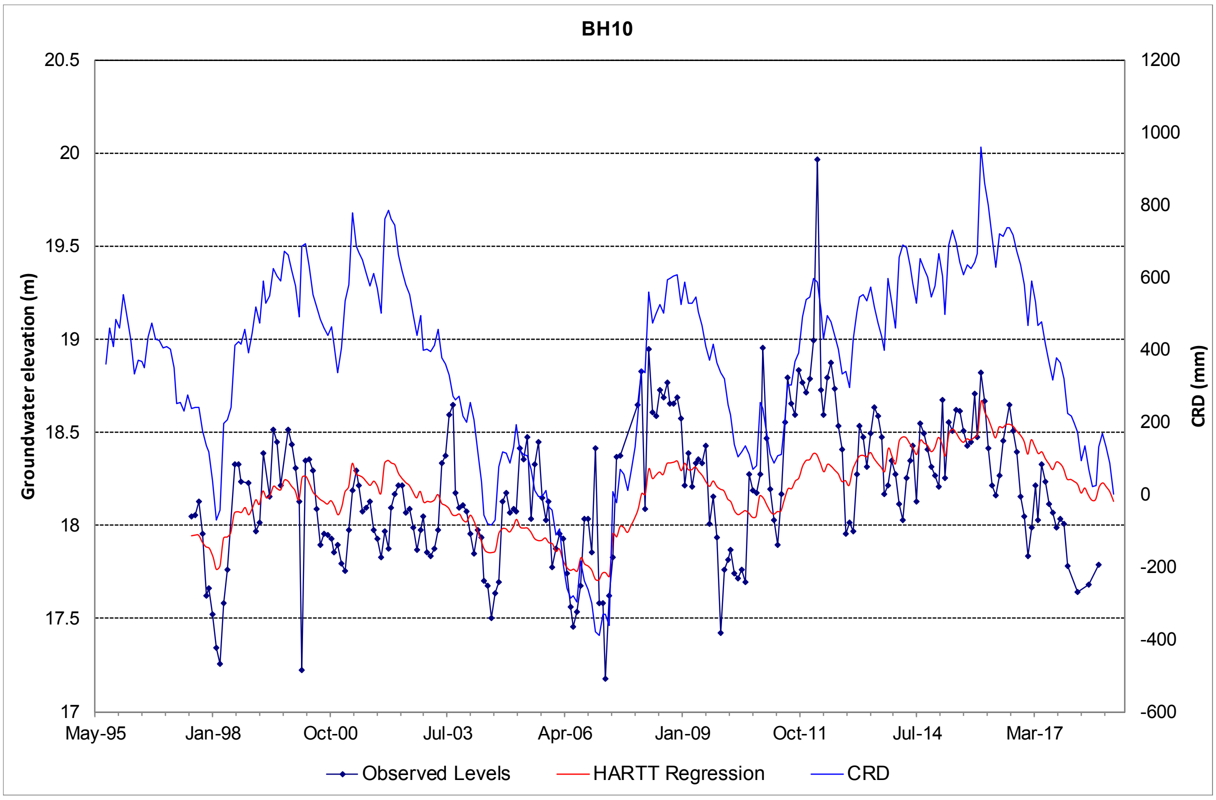

BH06A
Groundwater elevation (m)
CRD (mm)
0
1
2
3
4
5
6
7
8
9
10
-600
-400
-200
0
200
400
600
800
1000
1200
Jul-03
Mar-06
Dec-08
Sep-11
Jun-14
Mar-17
Observed levels
CRD

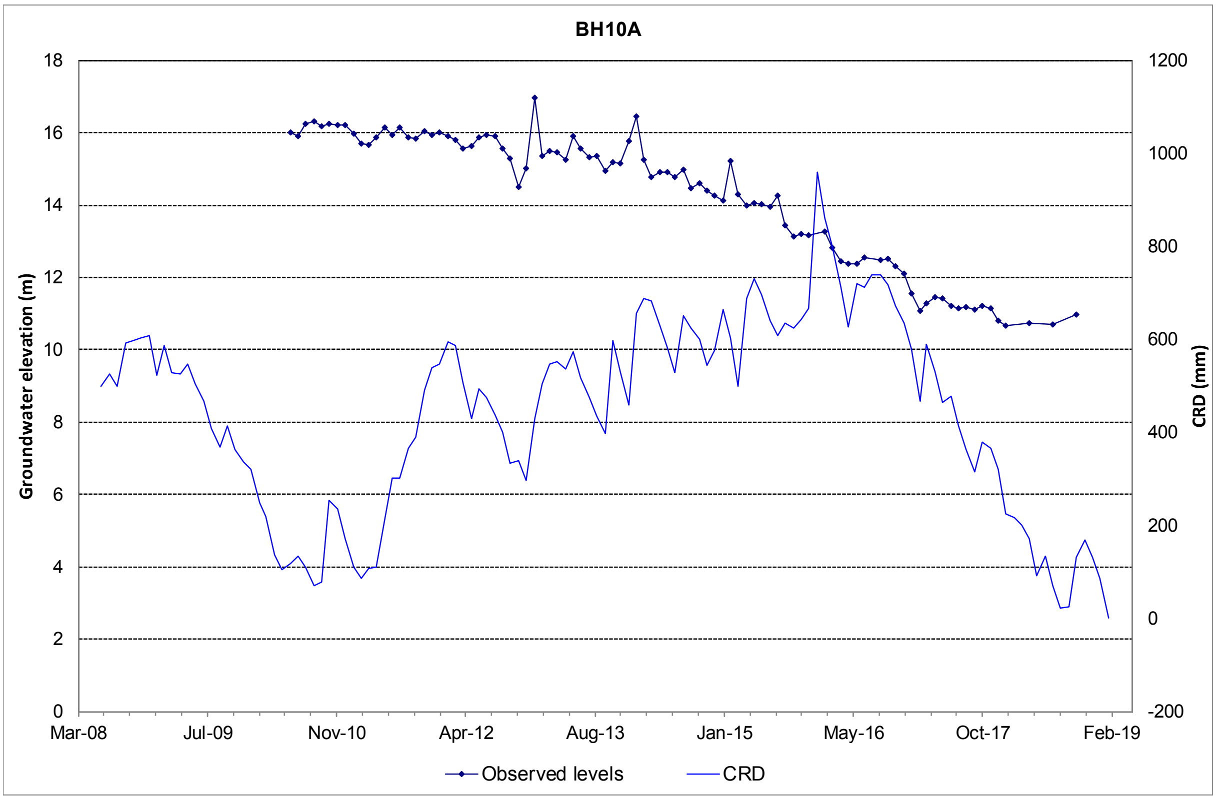

BH07B
Groundwater elevation (m)
CRD (mm)
14
12
10
8
6
4
2
0
-2
-4
-6
1200
1000
800
600
400
200
0
-200
-400
-600
Jul-03
Mar-06
Dec-08
Sep-11
Jun-14
Mar-17
Observed levels
CRD

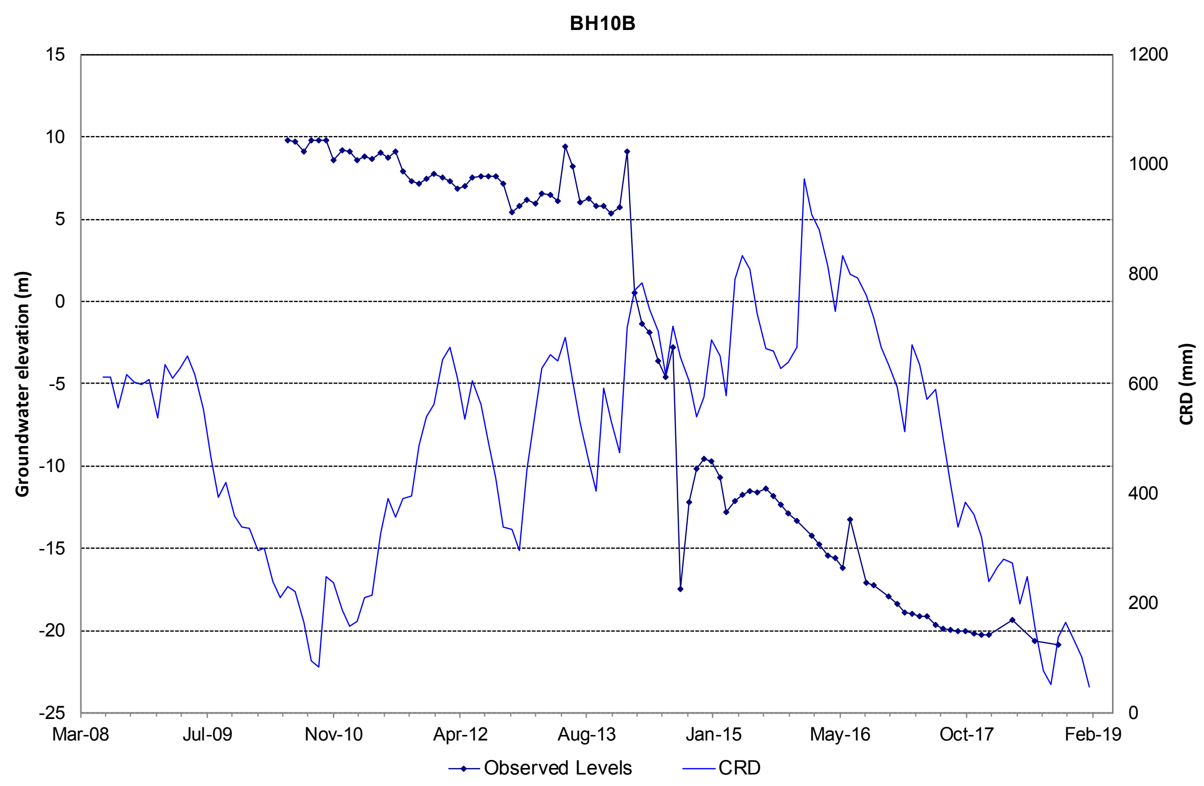

BH09
Groundwater elevation (m)
CRD (mm)
17.5
17
16.5
16
15.5
15
14.5
14
1200
1000
800
600
400
200
0
-200
-400
-600
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed Levels
HARTT Regression
CRD

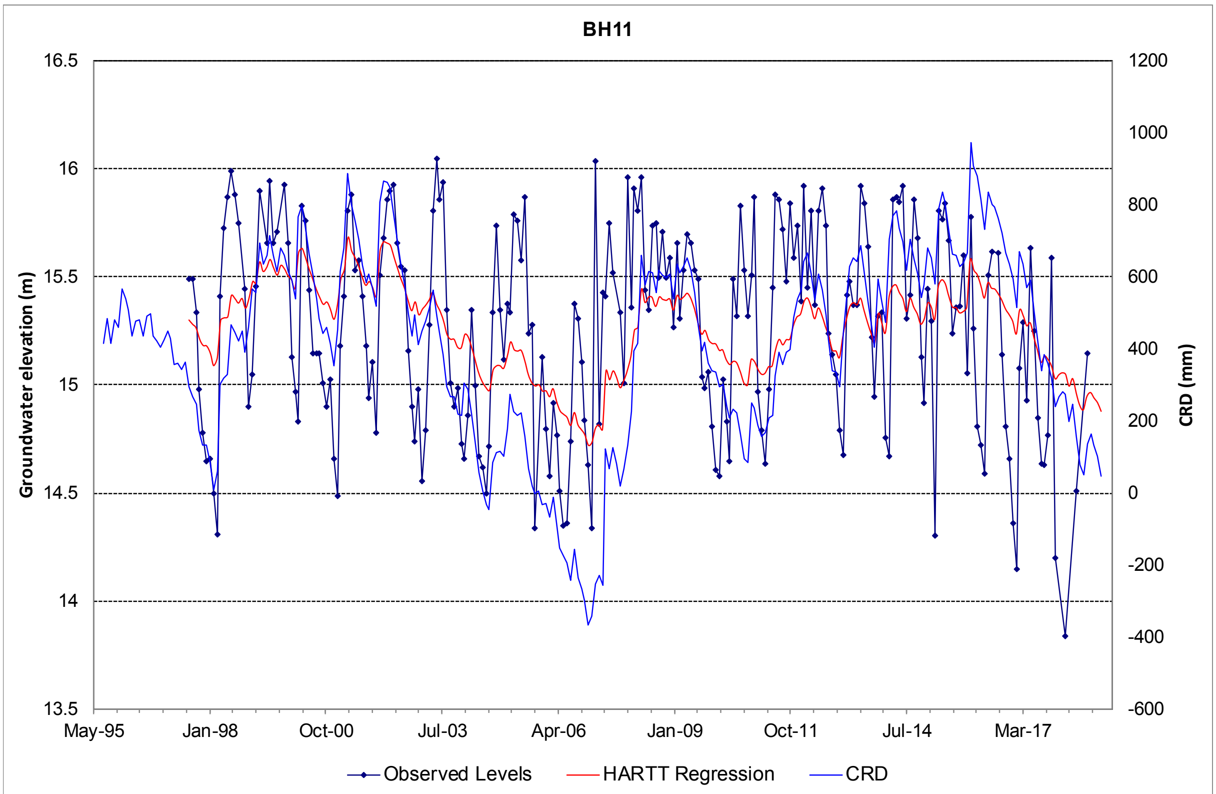

BH09A
Groundwater elevation (m)
CRD (mm)
16
14
12
10
8
6
4
2
0
-2
-4
1200
1000
800
600
400
200
0
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed levels
CRD

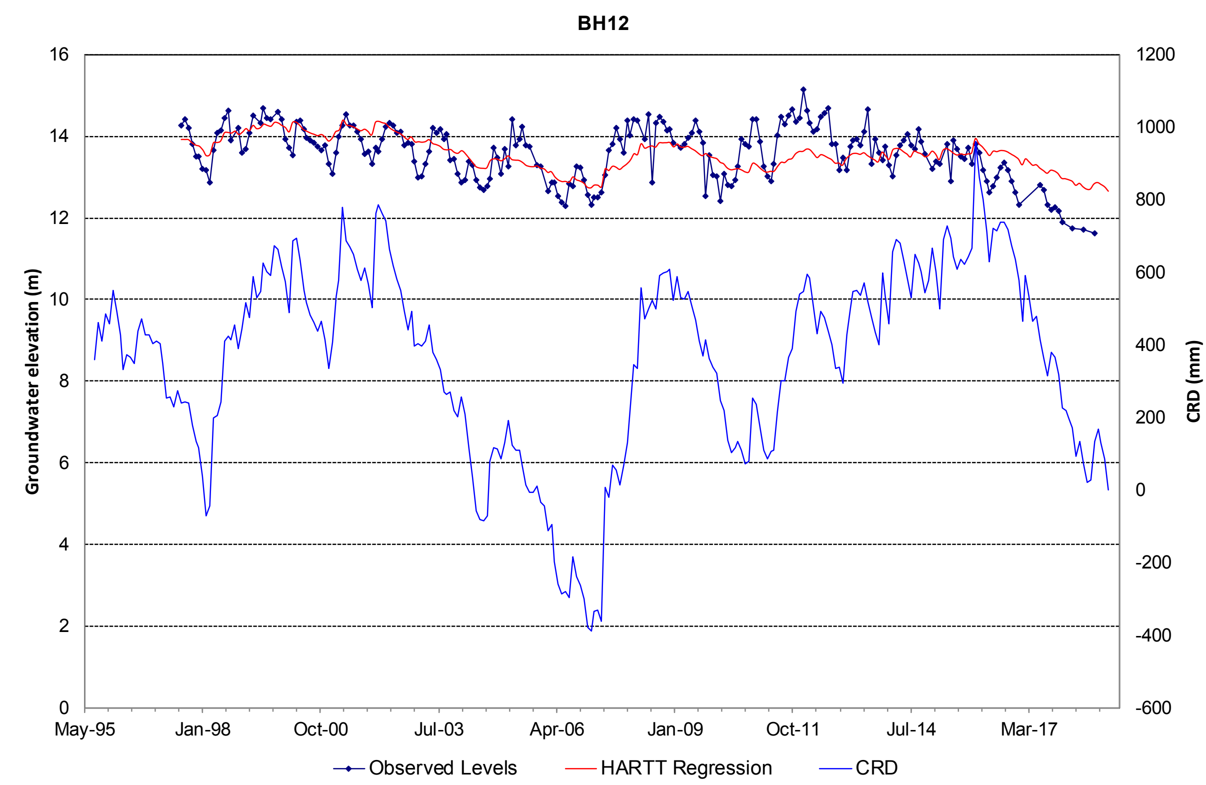

BH09B
Groundwater elevation (m)
CRD (mm)
15
10
5
0
-5
-10
1200
1000
800
600
400
200
0
-200
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed Levels
CRD

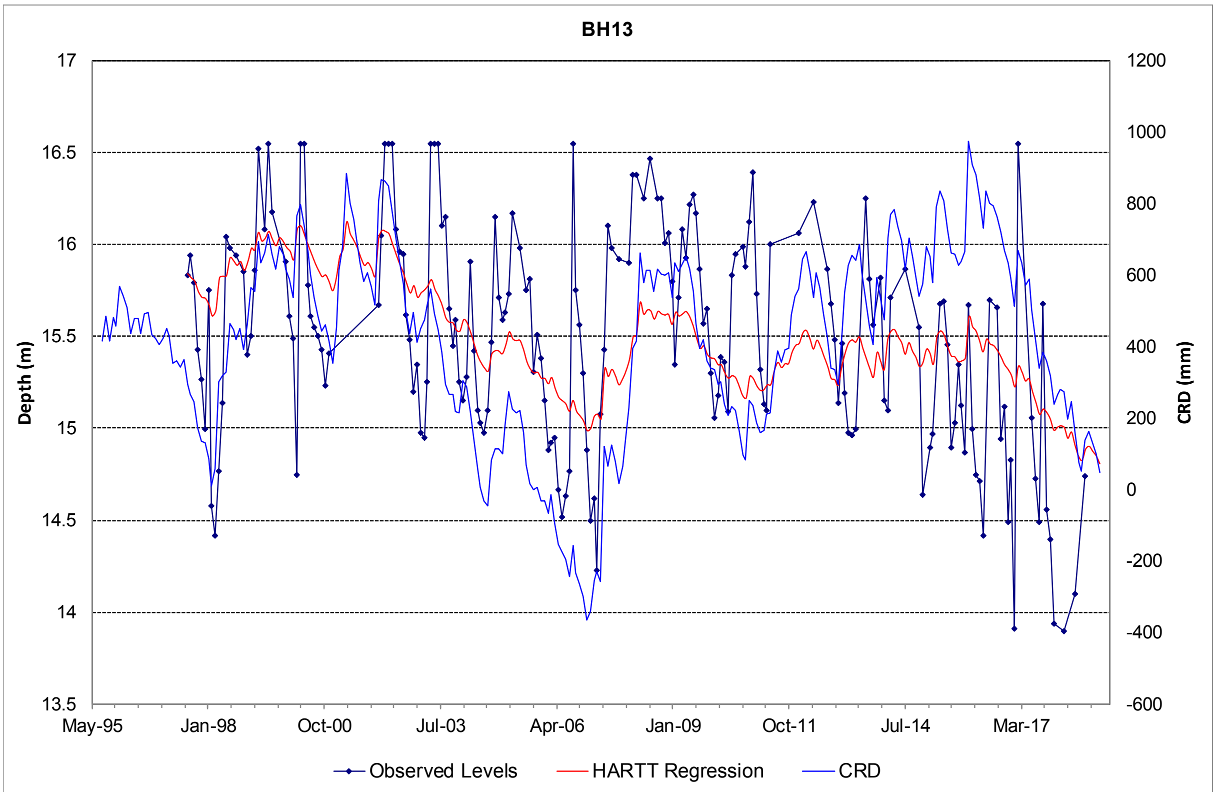

BH10
Groundwater elevation (m)
CRD (mm)
20.5
20
19.5
19
18.5
18
17.5
17
1200
1000
800
600
400
200
0
-200
-400
-600
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed Levels
HARTT Regression
CRD

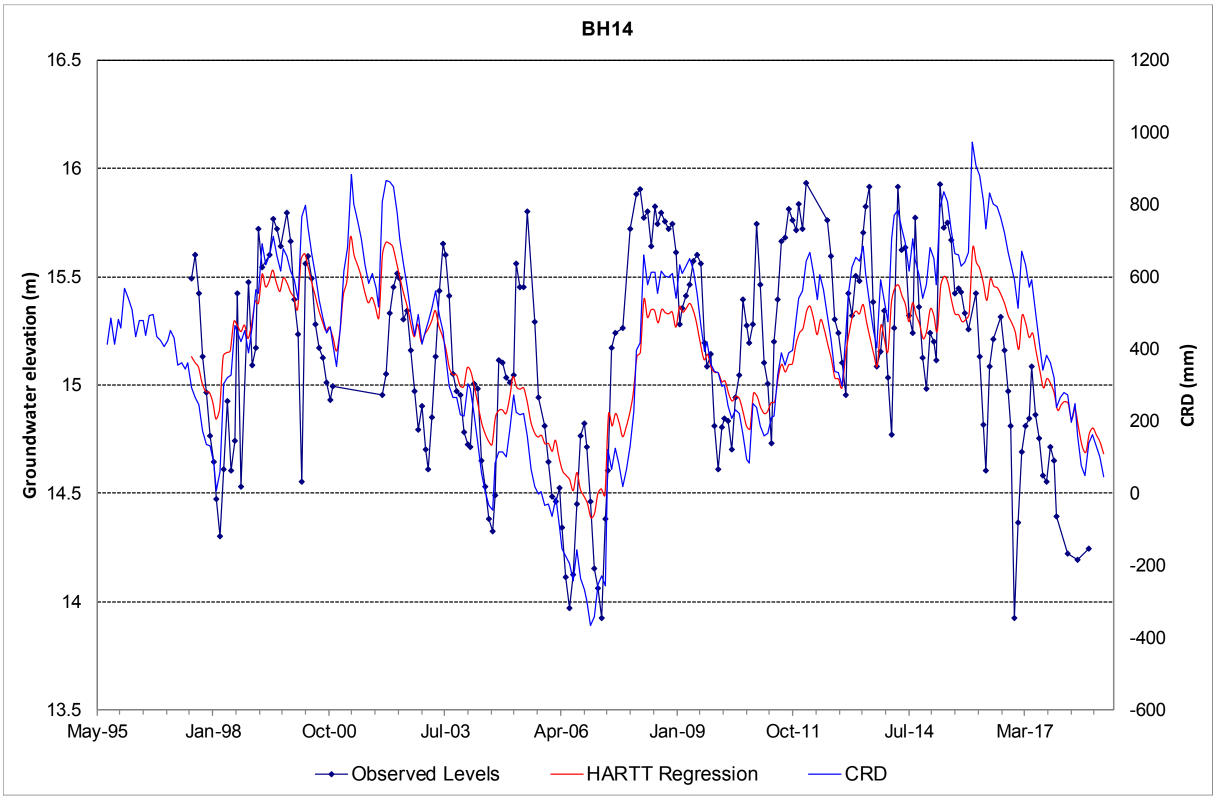

BH10A
Groundwater elevation (m)
CRD (mm)
18
16
14
12
10
8
6
4
2
0
1200
1000
800
600
400
200
0
-200
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed levels
CRD

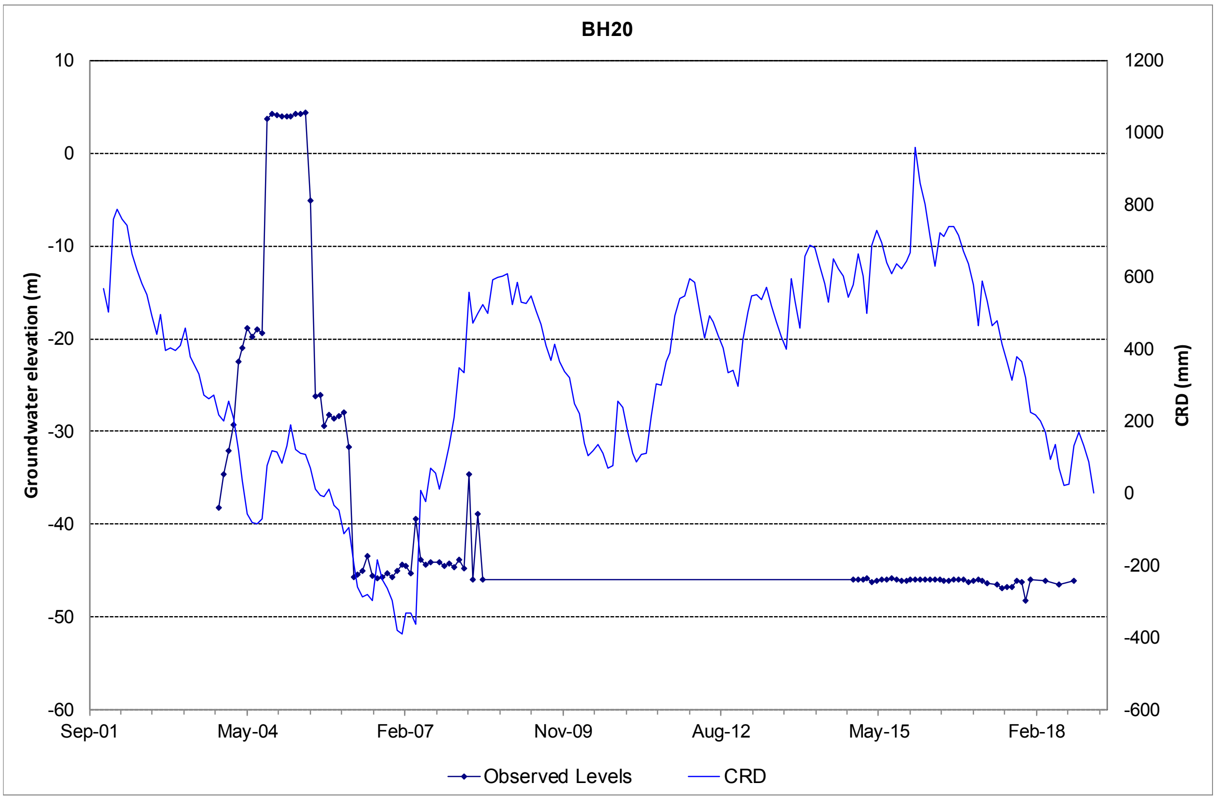

BH10B
Groundwater elevation (m)
CRD (mm)
15
10
5
0
-5
-10
-15
-20
-25
1200
1000
800
600
400
200
0
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed Levels
CRD

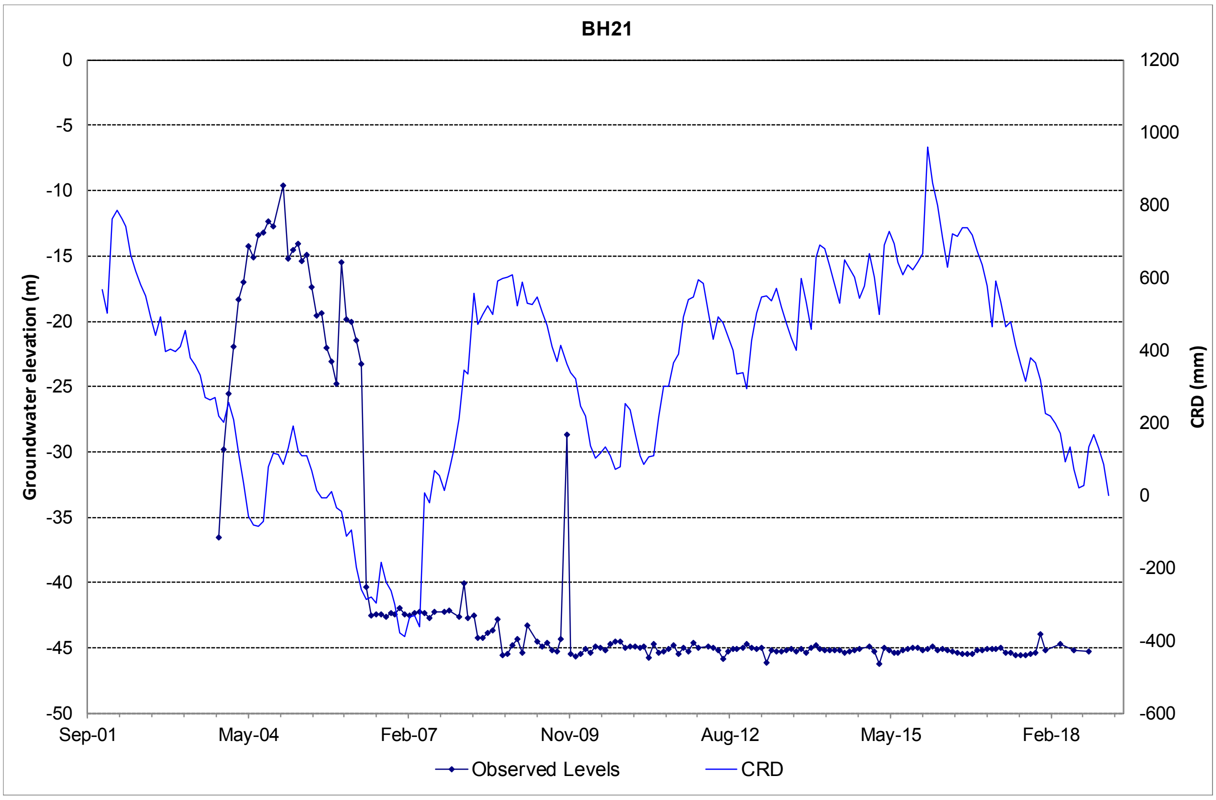

BH11
Groundwater elevation (m)
CRD (mm)
16.5
16
15.5
15
14.5
14
13.5
1200
1000
800
600
400
200
0
-200
-400
-600
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed Levels
HARTT Regression
CRD

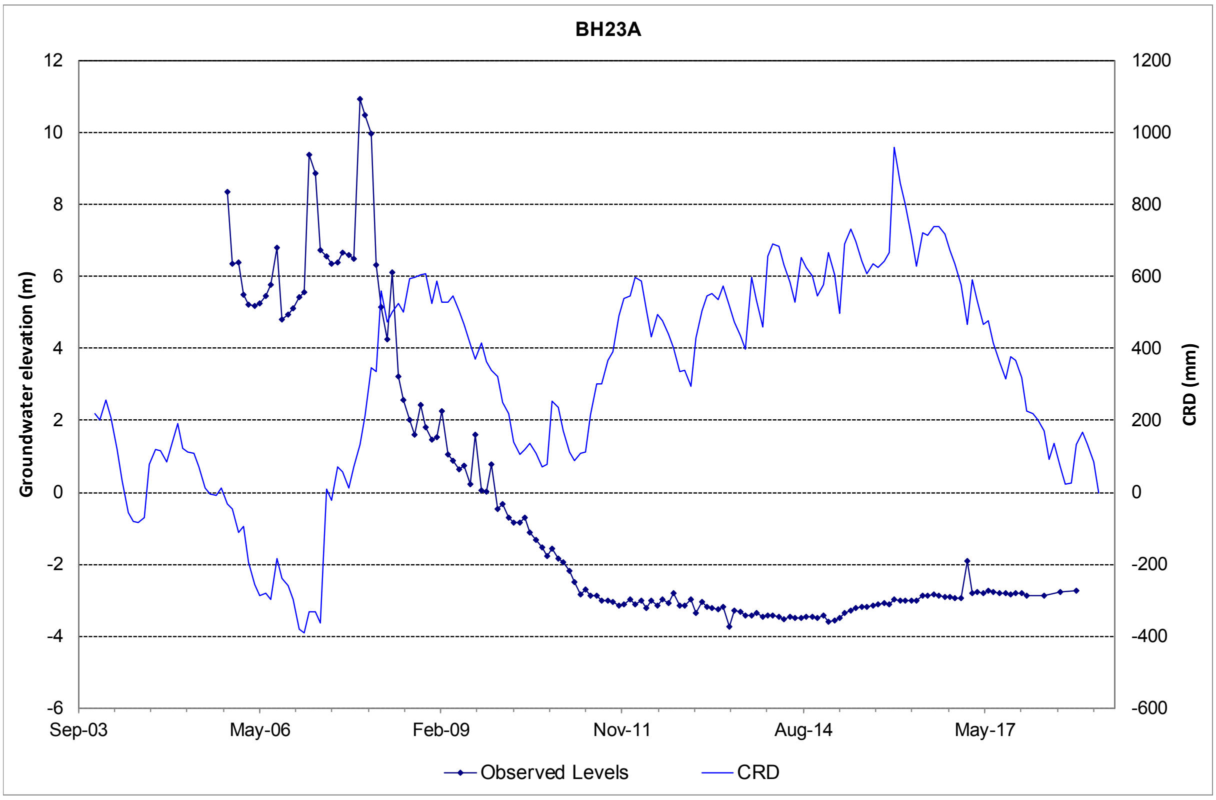

BH12
Groundwater elevation (m)
CRD (mm)
0
2
4
6
8
10
12
14
16
-600
-400
-200
0
200
400
600
800
1000
1200
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed Levels
HARTT Regression
CRD

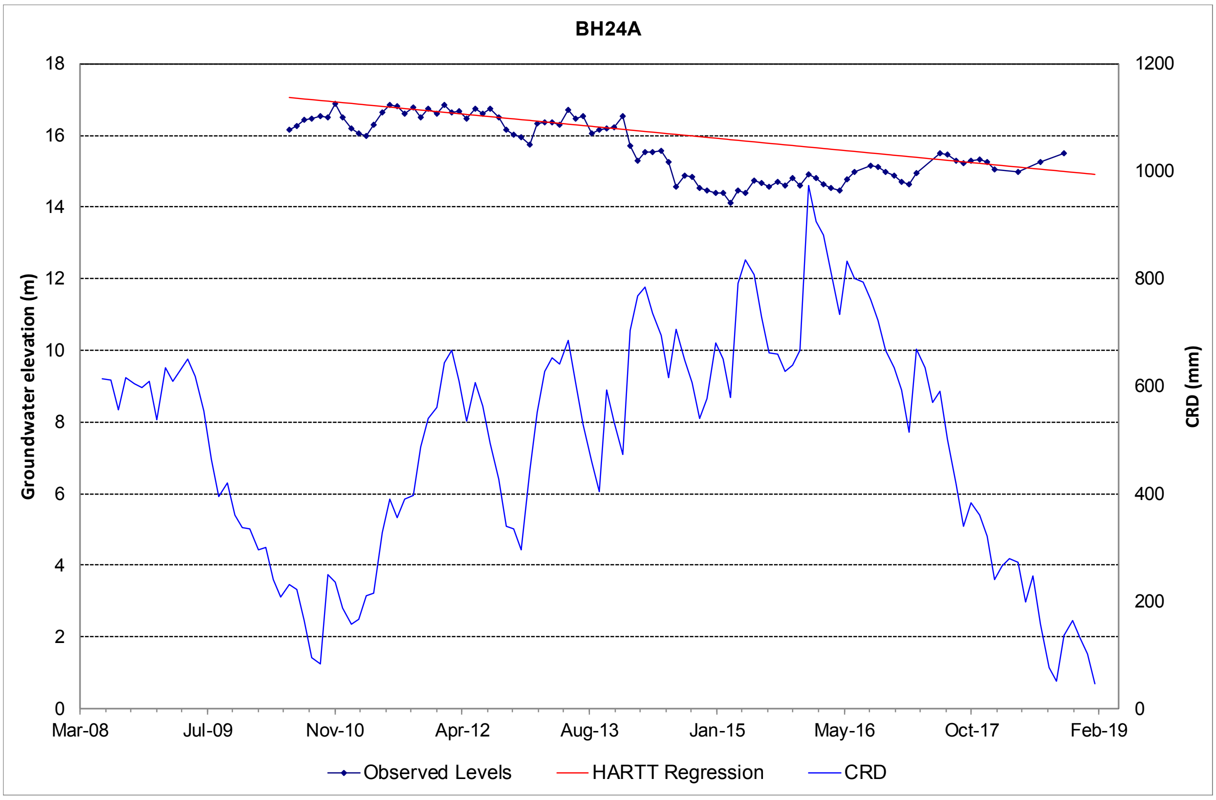

BH13
Depth (m)
CRD (mm)
13.5
14
14.5
15
15.5
16
16.5
17
-600
-400
-200
0
200
400
600
800
1000
1200
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed Levels
HARTT Regression
CRD

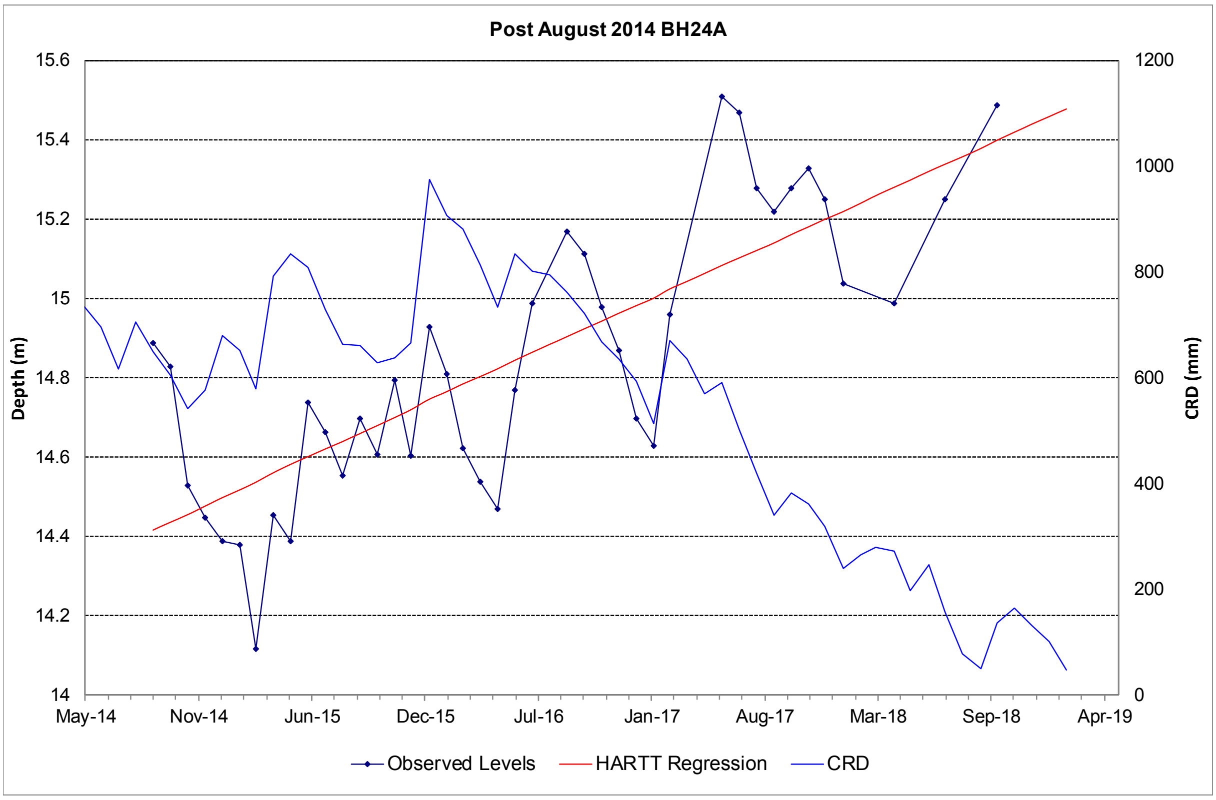

BH14
Groundwater elevation (m)
CRD (mm)
16.5
16
15.5
15
14.5
14
13.5
1200
1000
800
600
400
200
0
-200
-400
-600
May-95
Jan-98
Oct-00
Jul-03
Apr-06
Jan-09
Oct-11
Jul-14
Mar-17
Observed Levels
HARTT Regression
CRD

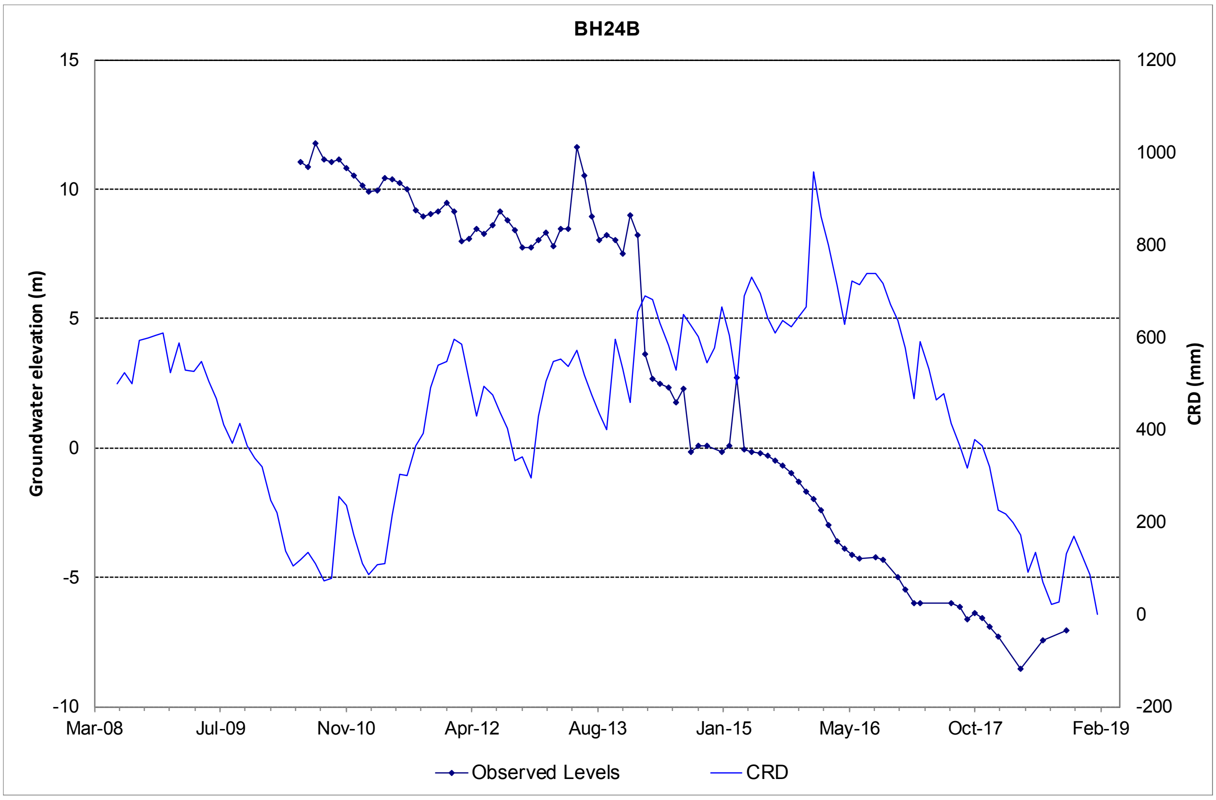

BH20
Groundwater elevation (m)
CRD (mm)
10
0
-10
-20
-30
-40
-50
-60
1200
1000
800
600
400
200
0
-200
-400
-600
Sep-01
May-04
Feb-07
Nov-09
Aug-12
May-15
Feb-18
Observed Levels
CRD

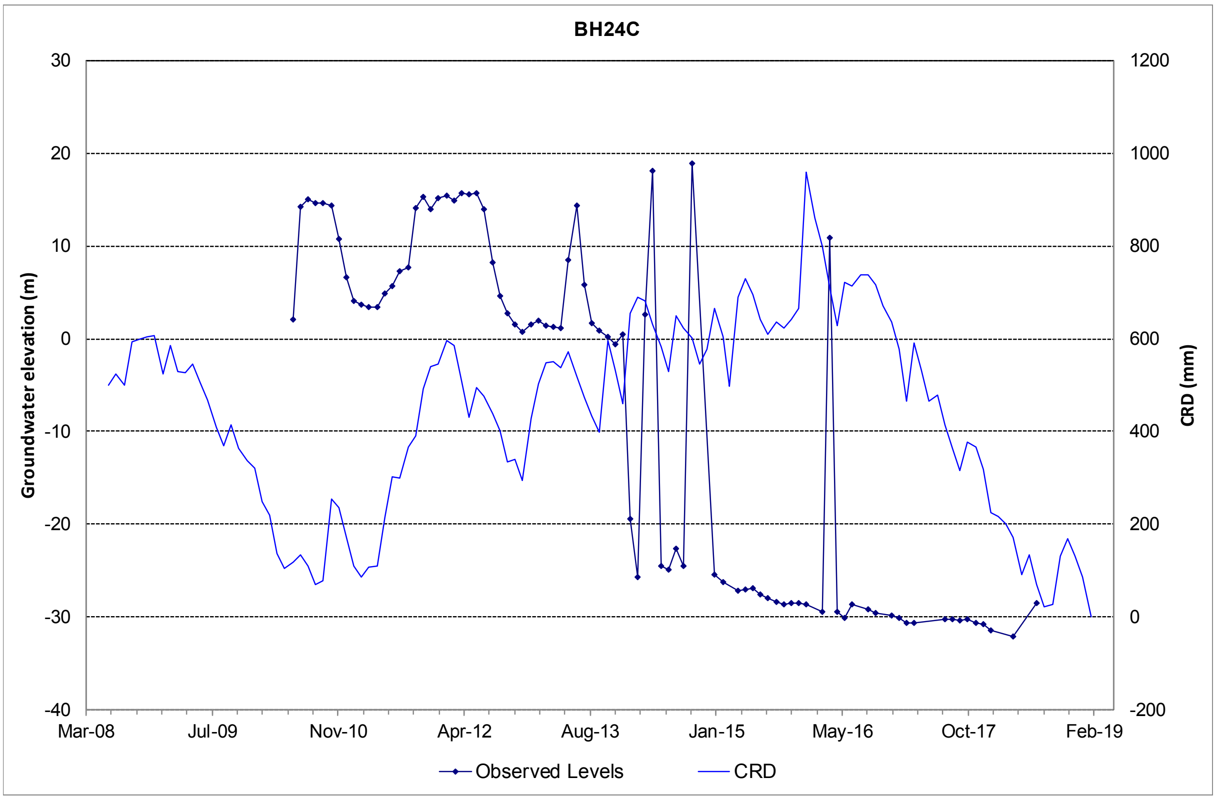

BH21
Groundwater elevation (m)
CRD (mm)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
1200
1000
800
600
400
200
0
-200
-400
-600
Sep-01
May-04
Feb-07
Nov-09
Aug-12
May-15
Feb-18
Observed Levels
CRD

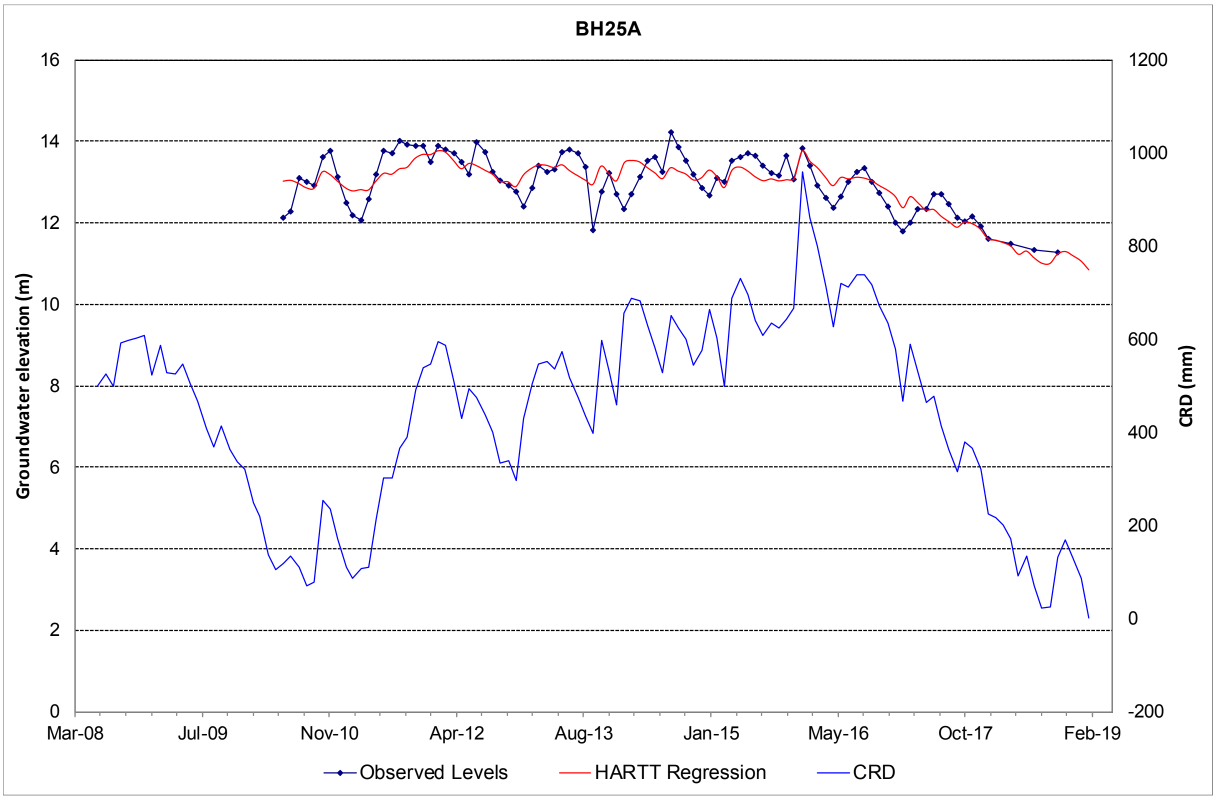

BH23A
Groundwater elevation (m)
CRD (mm)
12
10
8
6
4
2
0
-2
-4
-6
1200
1000
800
600
400
200
0
-200
-400
-600
Sep-03
May-06
Feb-09
Nov-11
Aug-14
May-17
Observed Levels
CRD

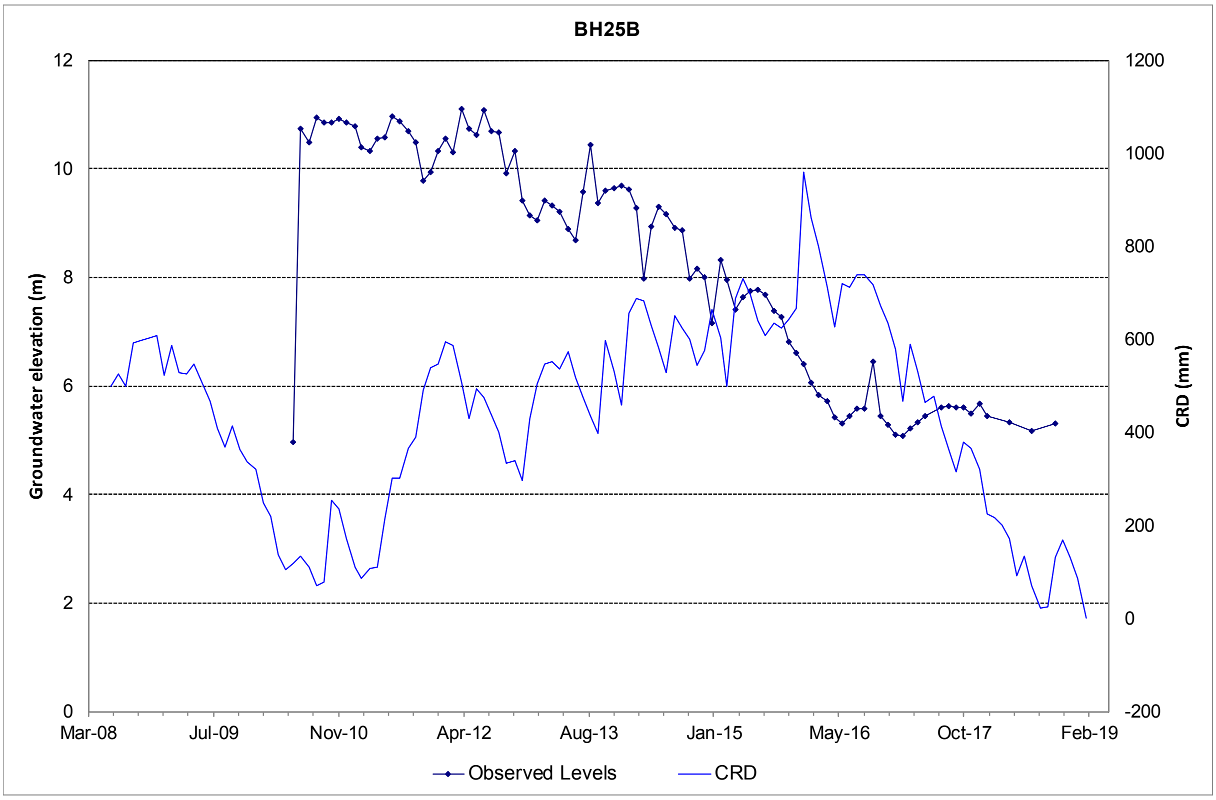

BH24A
Groundwater elevation (m)
CRD (mm)
0
2
4
6
8
10
12
14
16
18
0
200
400
600
800
1000
1200
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed Levels
HARTT Regression
CRD

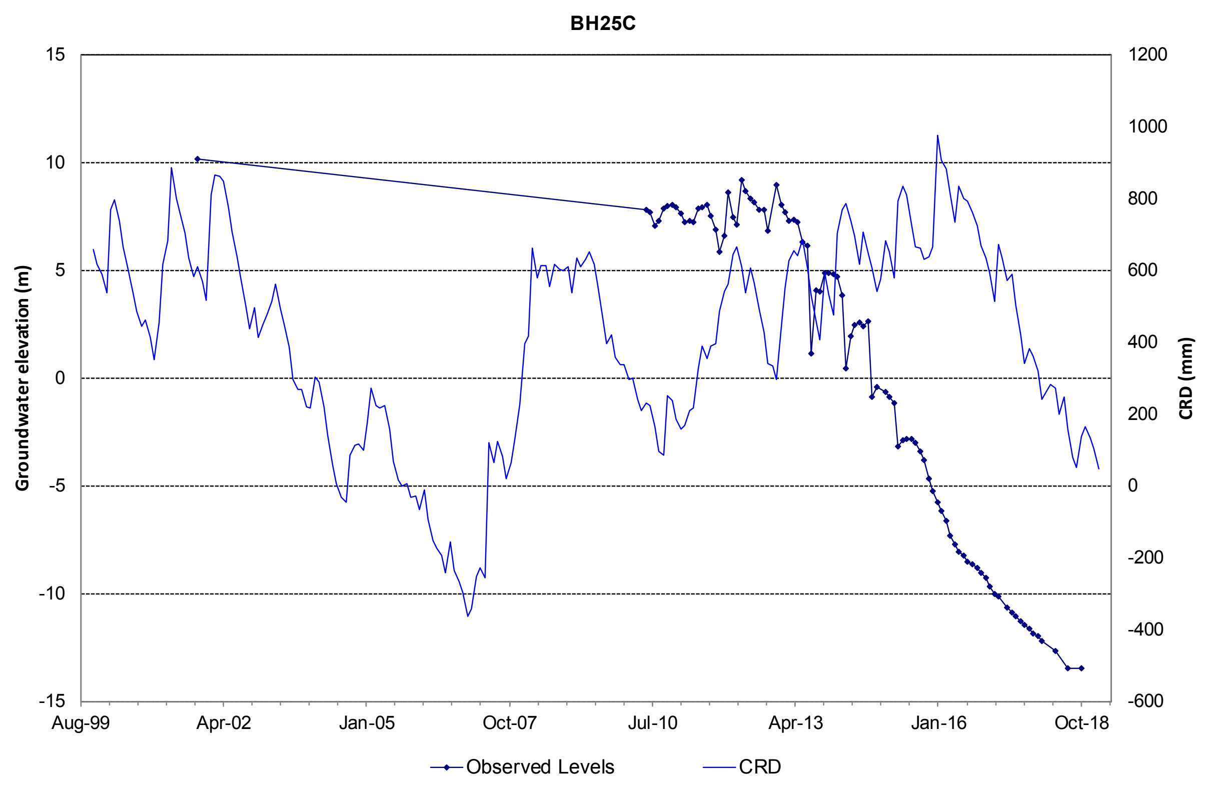

Post August 2014 BH24A
Depth (m)
CRD (mm)
14
14.2
14.4
14.6
14.8
15
15.2
15.4
15.6
0
200
400
600
800
1000
1200
May-14
Nov-14
Jun-15
Dec-15
Jul-16
Jan-17
Aug-17
Mar-18
Sep-18
Apr-19
Observed Levels
HARTT Regression
CRD

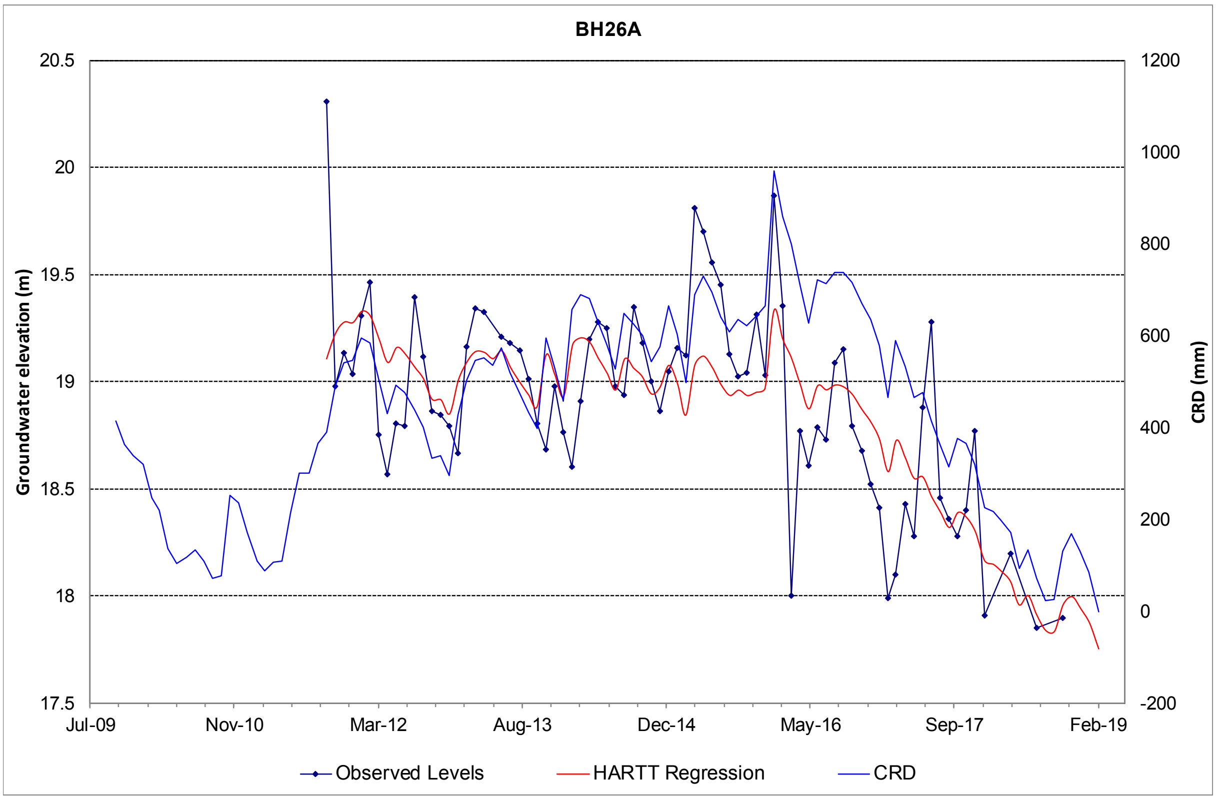

BH24B
Groundwater elevation (m)
CRD (mm)
15
10
5
0
-5
-10
1200
1000
800
600
400
200
0
-200
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed Levels
CRD

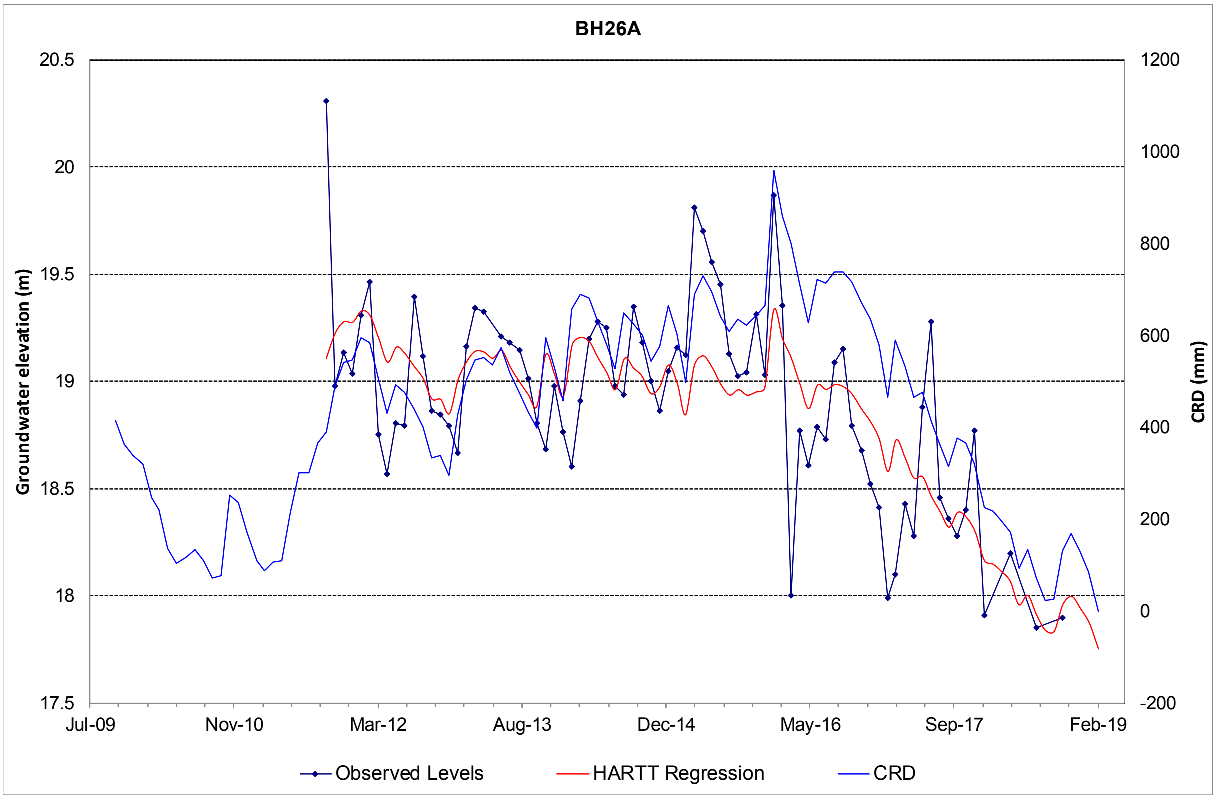

BH24C
Groundwater elevation (m)
CRD (mm)
30
20
10
0
-10
-20
-30
-40
1200
1000
800
600
400
200
0
-200
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed Levels
CRD

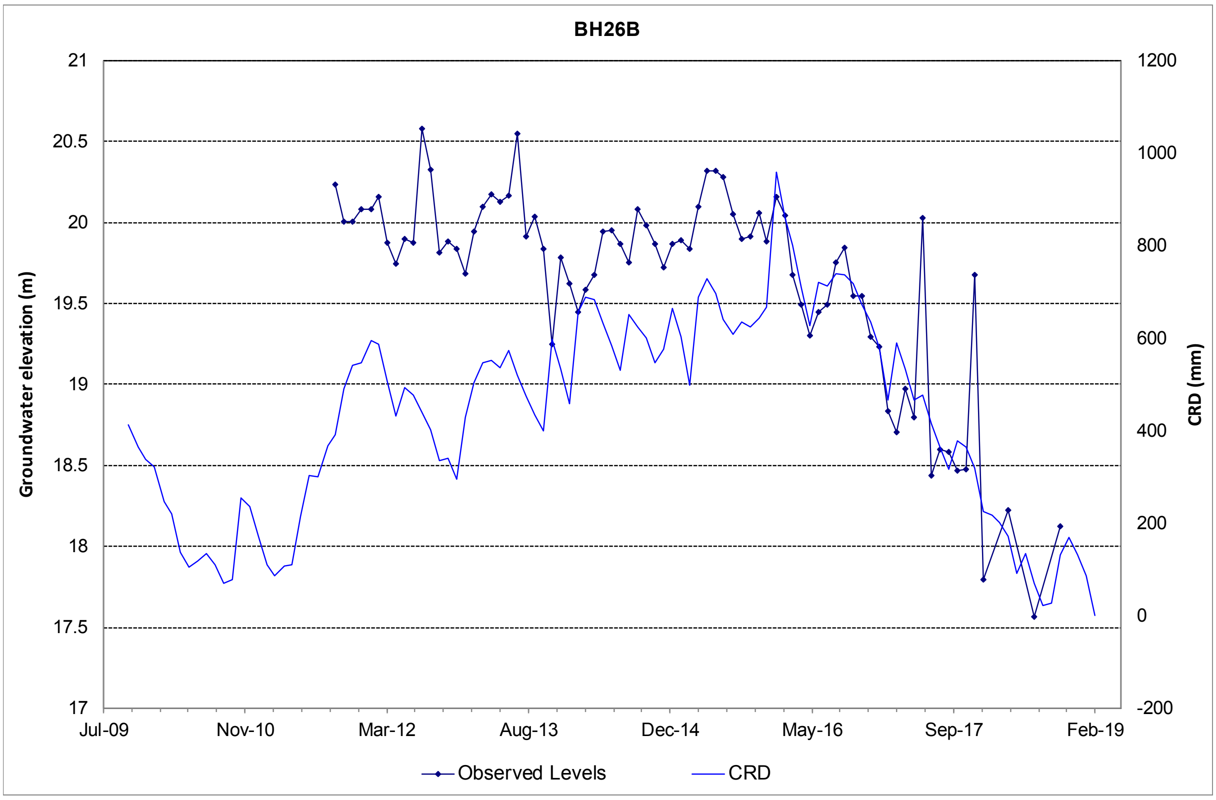

BH25A
Groundwater elevation (m)
CRD (mm)
16
14
12
10
8
6
4
2
0
1200
1000
800
600
400
200
0
-200
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed Levels
HARTT Regression
CRD

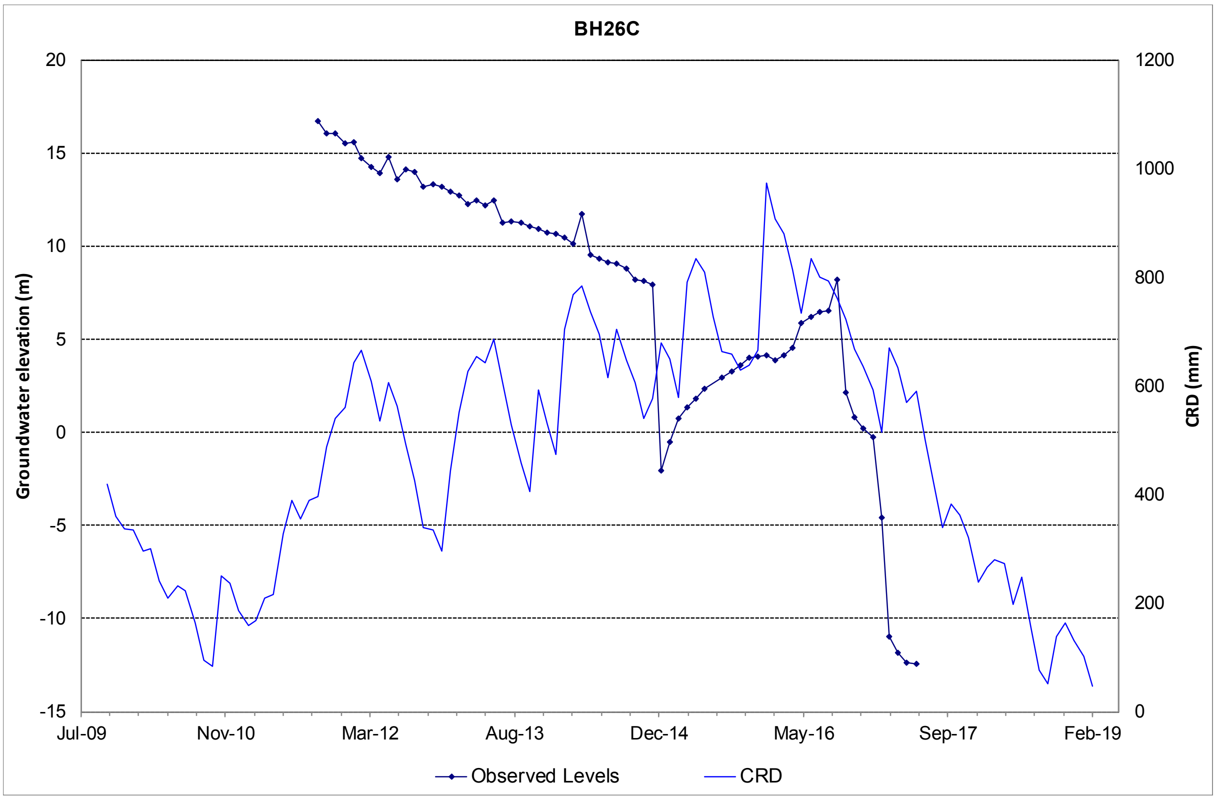

BH25B
Groundwater elevation (m)
CRD (mm)
12
10
8
6
4
2
0
1200
1000
800
600
400
200
0
-200
Mar-08
Jul-09
Nov-10
Apr-12
Aug-13
Jan-15
May-16
Oct-17
Feb-19
Observed Levels
CRD

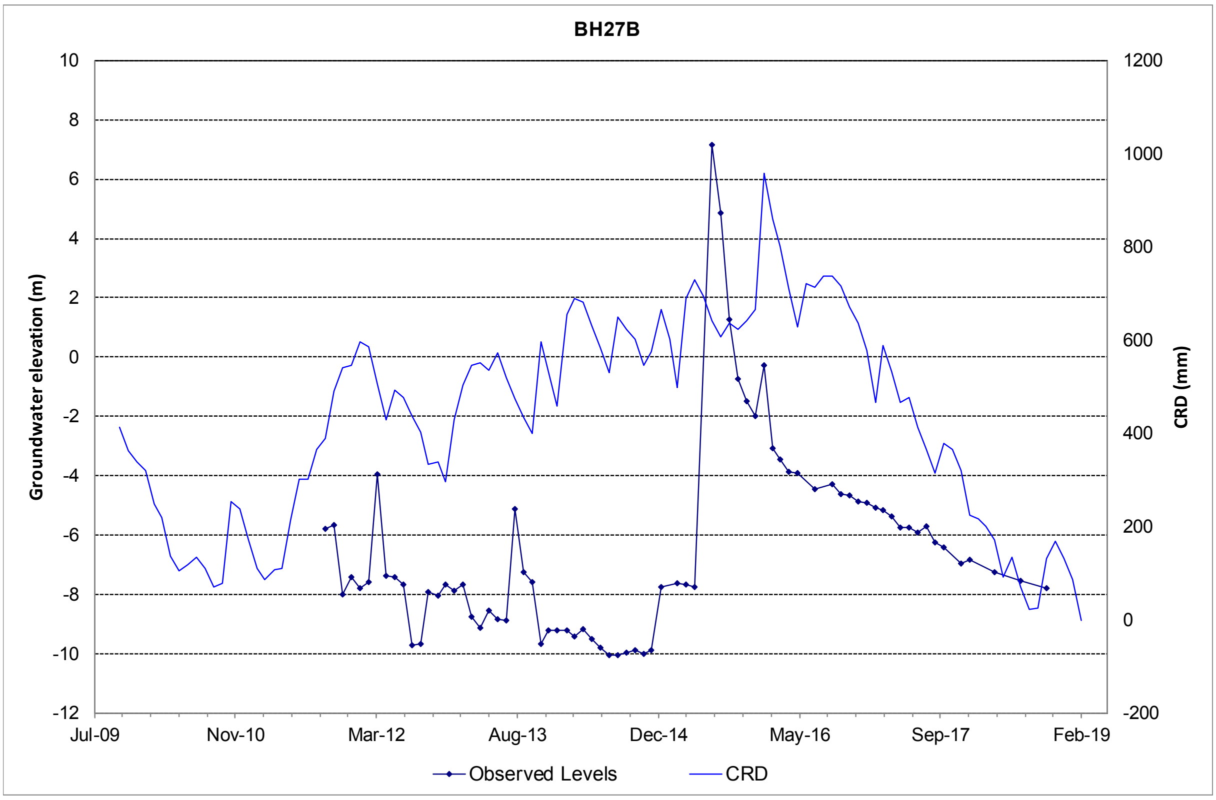

BH25C
Groundwater elevation (m)
CRD (mm)
15
10
5
0
-5
-10
-15
1200
1000
800
600
400
200
0
-200
-400
-600
Aug-99
Apr-02
Jan-05
Oct-07
Jul-10
Apr-13
Jan-16
Oct-18
Observed Levels
CRD

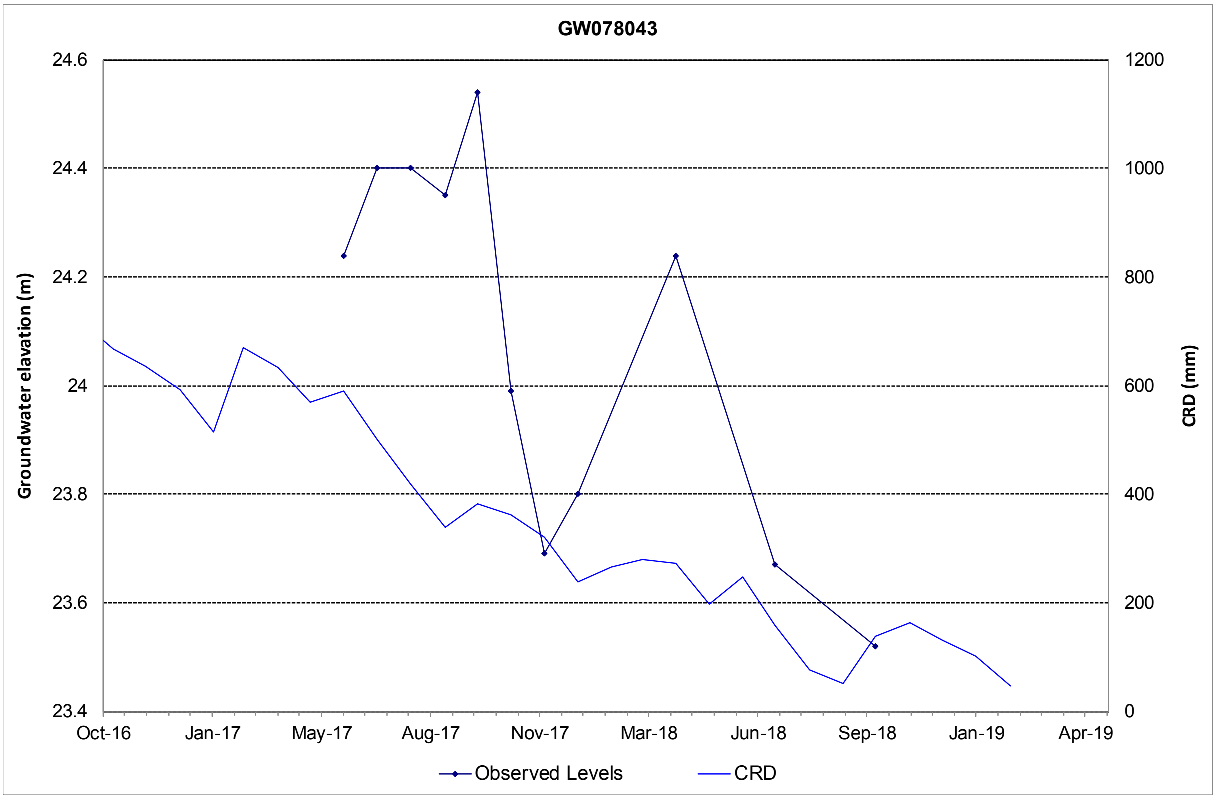

BH26A
Groundwater elevation (m)
CRD (mm)
20.5
20
19.5
19
18.5
18
17.5
1200
1000
800
600
400
200
0
-200
Jul-09
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
HARTT Regression
CRD

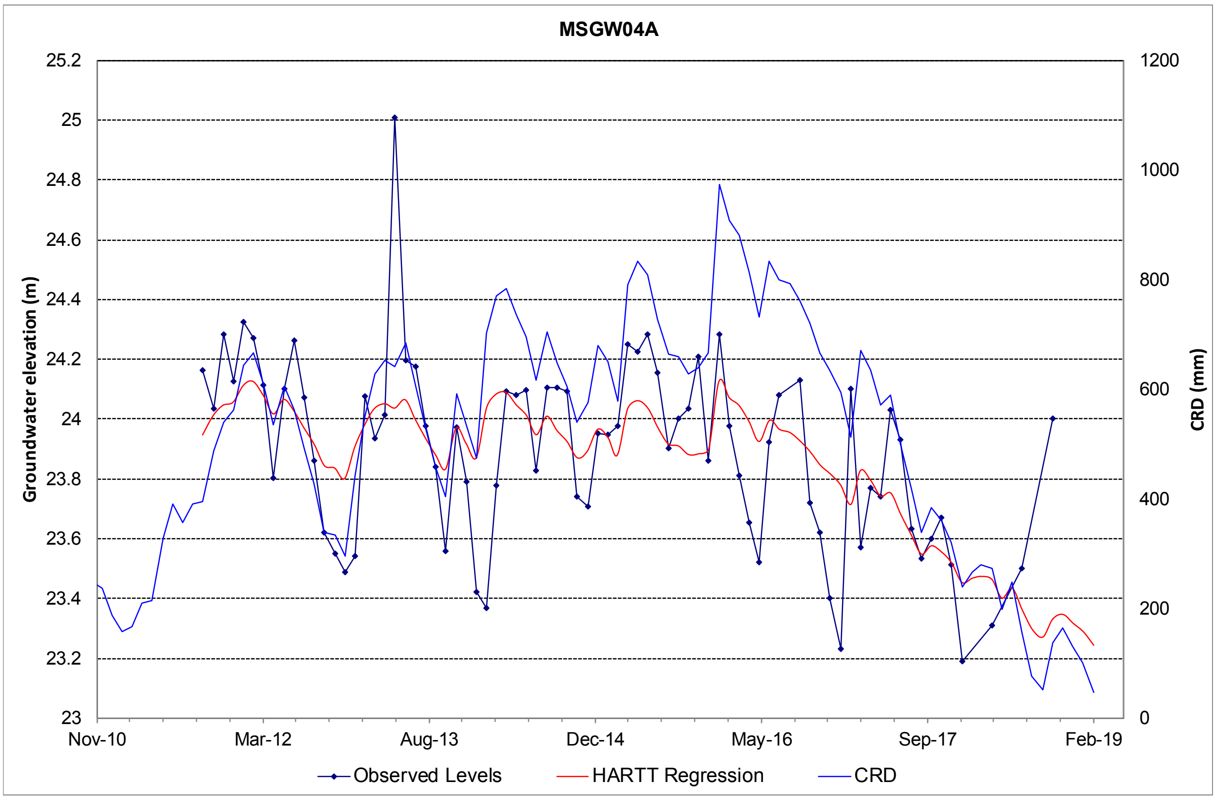

BH26A
Groundwater elevation (m)
CRD (mm)
20.5
20
19.5
19
18.5
18
17.5
1200
1000
800
600
400
200
0
-200
Jul-09
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
HARTT Regression
CRD

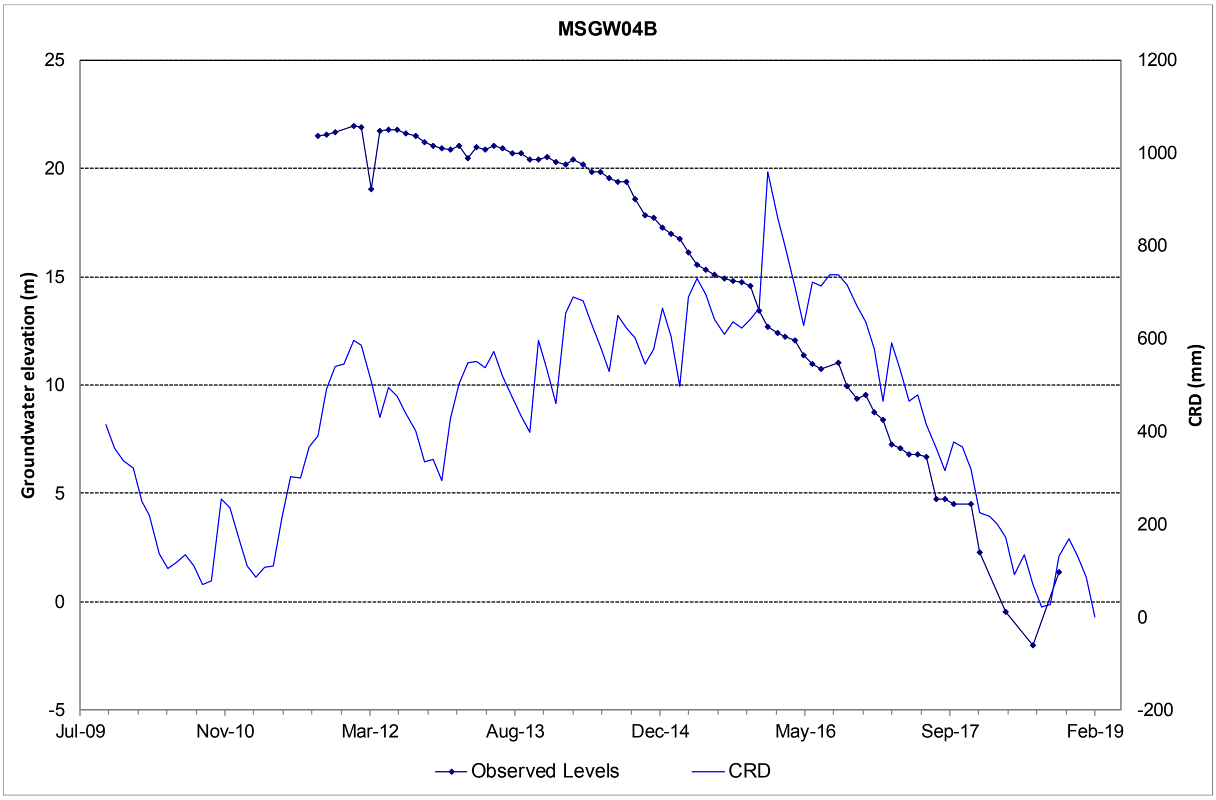

BH26B
Groundwater elevation (m)
CRD (mm)
21
20.5
20
19.5
19
18.5
18
17.5
17
1200
1000
800
600
400
200
0
-200
Jul-09
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
CRD

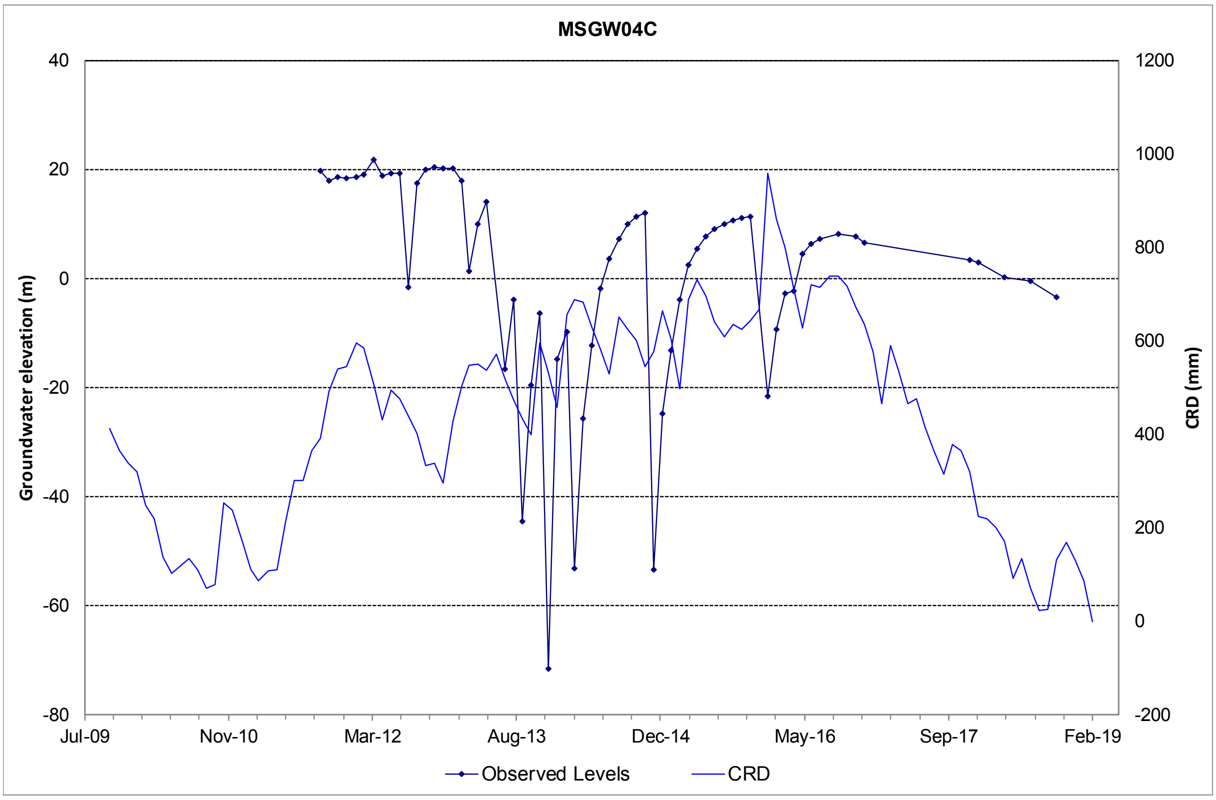

BH26C
Groundwater elevation (m)
20
15
10
5
0
-5
-10
-15
CRD (mm)
1200
1000
800
600
400
200
0
Jul-09
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
CRD


BH27B
Groundwater elevation (m)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
CRD (mm)
1200
1000
800
600
400
200
0
-200
Jul-09
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
CRD


GW078043
Groundwater elevation (m)
CRD (mm)
24.6
24.4
24.2
24
23.8
23.6
23.4
1200
1000
800
600
400
200
0
Oct-16
Jan-17
May-17
Aug-17
Nov-17
Mar-18
Jun-18
Sep-18
Jan-19
Apr-19
Observed Levels
CRD


MSGW04A
Groundwater elevation (m)
CRD (mm)
25.2
25
24.8
24.6
24.4
24.2
24
23.8
23.6
23.4
23.2
23
1200
1000
800
600
400
200
0
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
HARTT Regression
CRD


MSGW04B
Groundwater elevation (m)
CRD (mm)
25
20
15
10
5
0
-5
1200
1000
800
600
400
200
0
-200
Jul-09
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
CRD


MSGW04C
Groundwater elevation (m)
CRD (mm)
40
20
0
-20
-40
-60
-80
1200
1000
800
600
400
200
0
-200
Jul-09
Nov-10
Mar-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Observed Levels
CRD

F.2 Groundwater quality

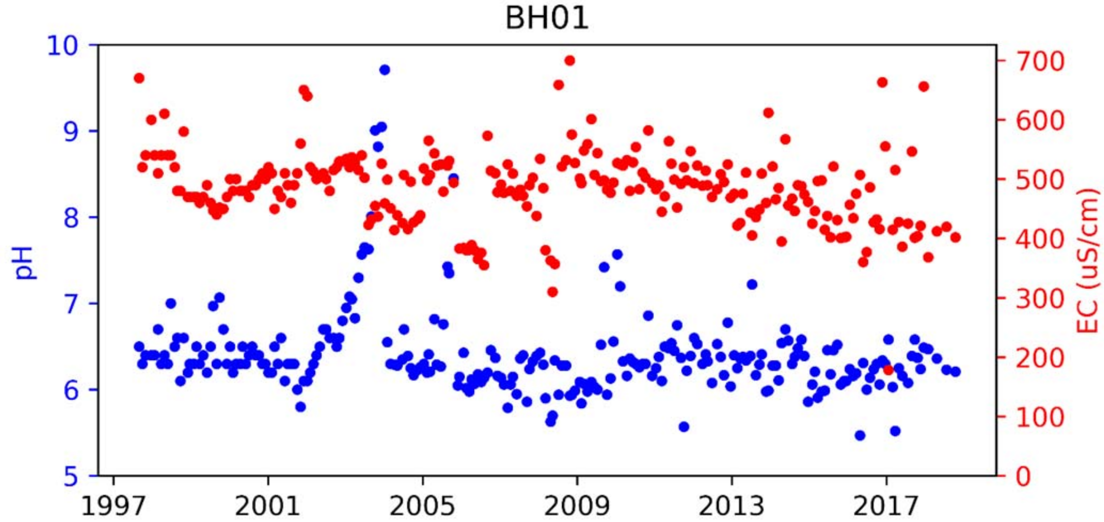
F.2.1 Statistical summary

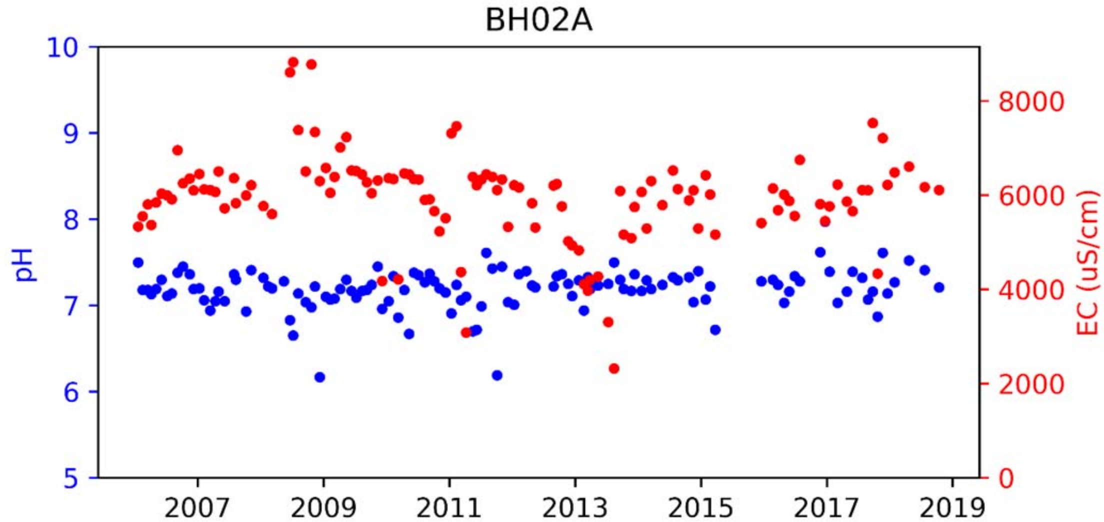
Bore	pH						EC (µS/cm)					
	Count	Minimum	20th percentile	Median	80th percentile	Maximum	Count	Minimum	20th percentile	Median	80th percentile	Maximum
BH01	246	5.5	6.1	6.3	6.5	9.7	245	178	436	490	525	700
BH02A	125	6.2	7.1	7.2	7.4	8.0	122	2320	5418	6100	6440	8820
BH03	249	5.1	6.1	6.3	6.7	8.7	249	78	2200	3230	4668	6130
BH03A	150	5.6	6.0	6.1	6.3	8.5	150	280	5930	7120	7652	10,130
BH03B	148	6.0	6.7	6.8	7.0	7.4	143	3070	8702	10,360	11,200	15,570
BH04	221	4.7	5.9	6.1	6.4	7.9	221	1235	11,930	13,700	14,810	20,170
BH05	218	2.5	4.3	4.9	6.4	7.7	218	178	2724	13,295	16,000	21,640
BH06A	146	6.4	7.2	7.3	7.4	8.2	141	4120	6771	7740	8340	11,040
BH07B	143	6.1	6.7	7.3	9.3	13.4	143	2996	6980	8350	9442	12,189
BH09	226	5.2	6.0	6.2	6.5	8.7	220	47	273	327	426	824
BH09A	46	9.9	11.3	11.7	12.4	12.8	46	5470	6020	6500	7490	11,800
BH09B	31	10.0	11.7	12.0	12.5	12.7	31	5750	6280	6880	7550	10,800
BH10	242	5.3	5.8	6.0	6.3	7.6	240	1255	2400	2685	2992	4080
BH10A	81	6.7	7.3	7.5	7.7	9.3	81	3990	5910	6650	6980	9568

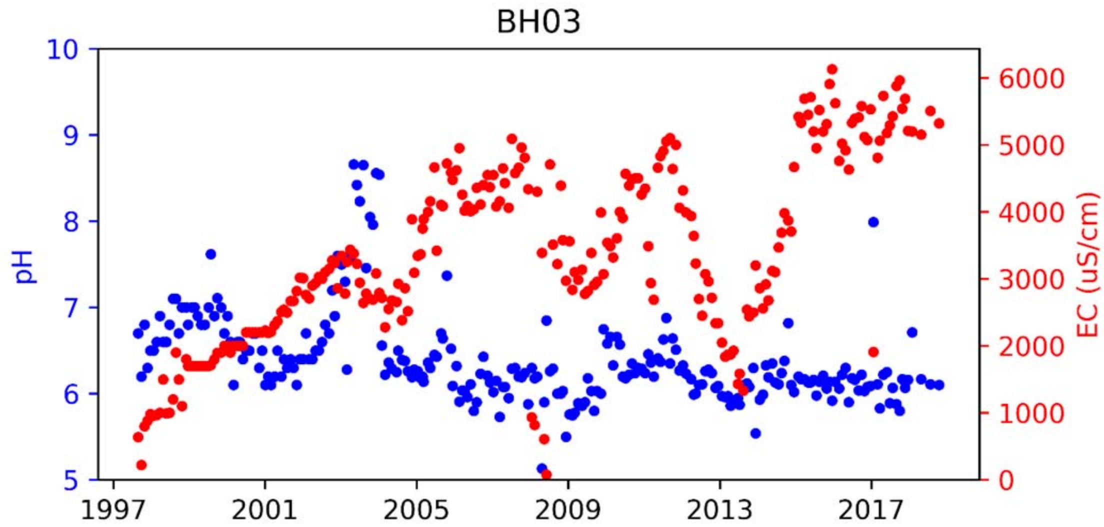
Bore	pH						EC (µS/cm)					
	Count	Minimum	20th percentile	Median	80th percentile	Maximum	Count	Minimum	20th percentile	Median	80th percentile	Maximum
BH10B	52	9.8	11.0	11.4	12.1	12.9	52	3580	4456	5055	5446	7460
BH11	248	4.9	5.6	5.8	6.2	8.8	246	280	4513	5515	6100	8200
BH12	231	5.6	6.4	6.6	7.0	7.9	228	3200	6772	7450	7874	10,740
BH13	193	6.0	6.4	6.7	6.9	9.1	191	172	411	2793	6530	10,000
BH14	228	5.2	6.2	6.3	6.6	7.8	228	211	10,502	14,000	15,774	20,980
BH20	90	6.2	6.6	6.9	7.6	9.0	90	664	5660	6500	7602	25,583
BH21	161	5.4	7.2	7.7	8.3	8.9	161	657	6200	7080	7640	16,667
BH23A	147	5.7	7.2	7.4	7.5	8.7	147	1120	5184	5850	6213	11,200
BH24A	93	3.9	6.3	6.5	6.8	8.0	92	4790	8426	10,155	11,520	12,090
BH24B	54	5.9	7.9	8.5	10.2	12.1	53	5190	8406	9510	11,074	11,850
BH24C	45	5.7	7.3	7.8	9.3	12.8	45	2000	7800	9140	10,524	13,790
BH25A	95	5.5	6.2	6.4	6.6	7.6	95	2750	5728	6480	6880	7980
BH25B	91	6.5	7.0	7.1	7.4	8.3	91	2040	6240	7120	7610	9144
BH25C	54	6.6	8.0	8.2	9.4	10.2	55	3570	6152	7320	7510	8260
BH26A	79	4.9	5.6	5.8	6.3	10.6	79	3420	8378	11,710	13,544	15,770
BH26B	78	6.6	6.9	7.1	7.2	8.1	78	3160	5924	6625	7063	8066

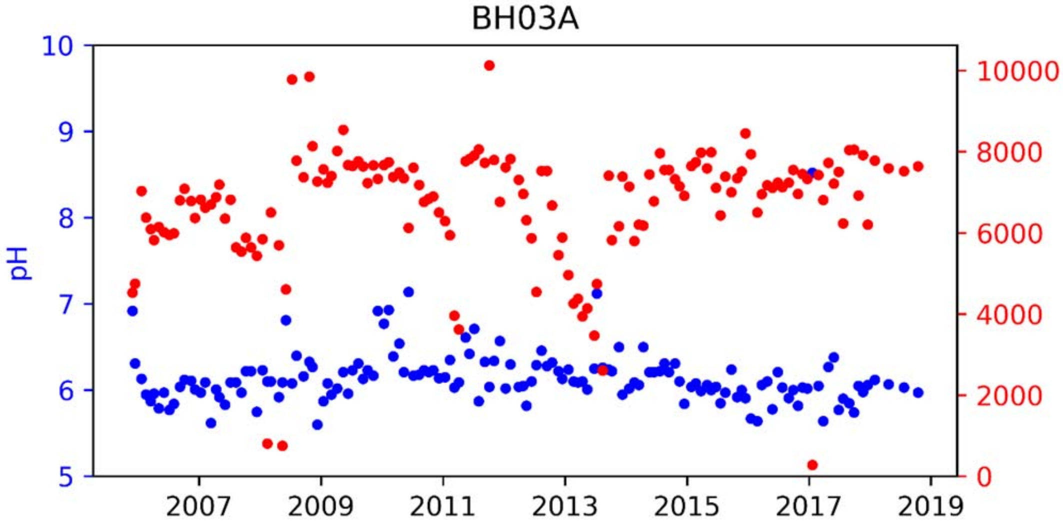
Bore	pH						EC (µS/cm)					
	Count	Minimum	20th percentile	Median	80th percentile	Maximum	Count	Minimum	20th percentile	Median	80th percentile	Maximum
BH26C	39	7.8	8.0	8.1	8.3	9.1	39	3580	4706	5350	6134	6870
BH27A	1	6.9	6.9	6.9	6.9	6.9	1	1033	1033	1033	1033	1033
BH27B	39	7.3	7.5	7.7	7.9	8.4	39	4450	4866	5410	5772	6350
BH27C	39	7.4	7.8	8.0	8.1	8.8	39	3850	4168	4360	4798	5370
GW078043	9	6.2	6.2	6.3	6.4	6.7	9	4390	4698	4728	5187	5698
MSGW01	79	4.0	4.3	4.4	4.6	5.1	79	7070	9640	10,370	10,886	12,370
MSGW03A	22	5.0	5.6	5.8	6.0	6.4	21	1592	3240	4000	4883	6370
MSGW03B	37	5.3	7.1	7.3	7.5	8.0	37	4630	5690	6290	6552	7250
MSGW03C	20	6.6	7.0	7.2	9.1	12.0	20	5340	5872	6430	7422	8570
MSGW04A	79	5.7	6.3	6.4	6.5	7.2	78	5780	8456	9205	9665	10,760
MSGW04B	40	6.6	6.7	6.9	7.2	7.9	40	5190	7260	7835	8266	8970
MSGW04C	23	7.0	7.3	8.0	11.2	12.7	23	4770	5222	6460	7772	9960

F.2.2 Time series graphs








BH03A
pH
EC (uS/cm)
10
9
8
7
6
5
10000
8000
6000
4000
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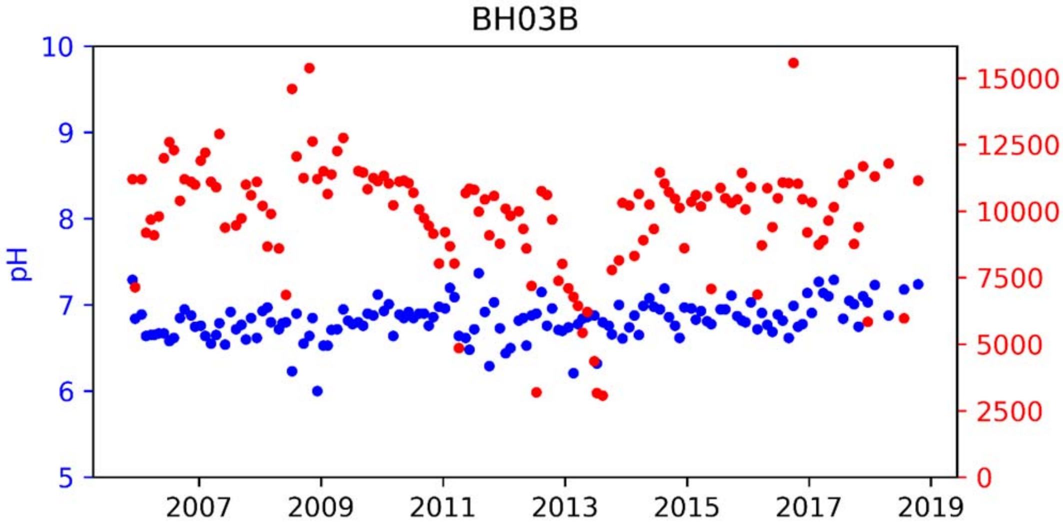
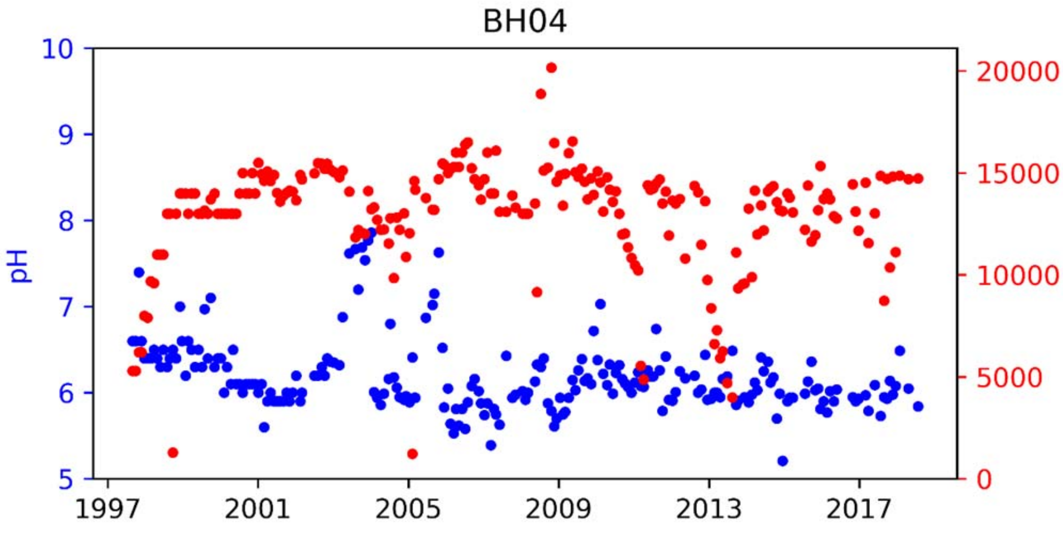
0
2007
2009
2011
2013
2015
2017
2019


BH03B
pH
EC (uS/cm)
10
9
8
7
6
5
15000
12500
10000
7500
5000
2500
0
2007
2009
2011
2013
2015
2017
2019


BH04
pH
EC (uS/cm)
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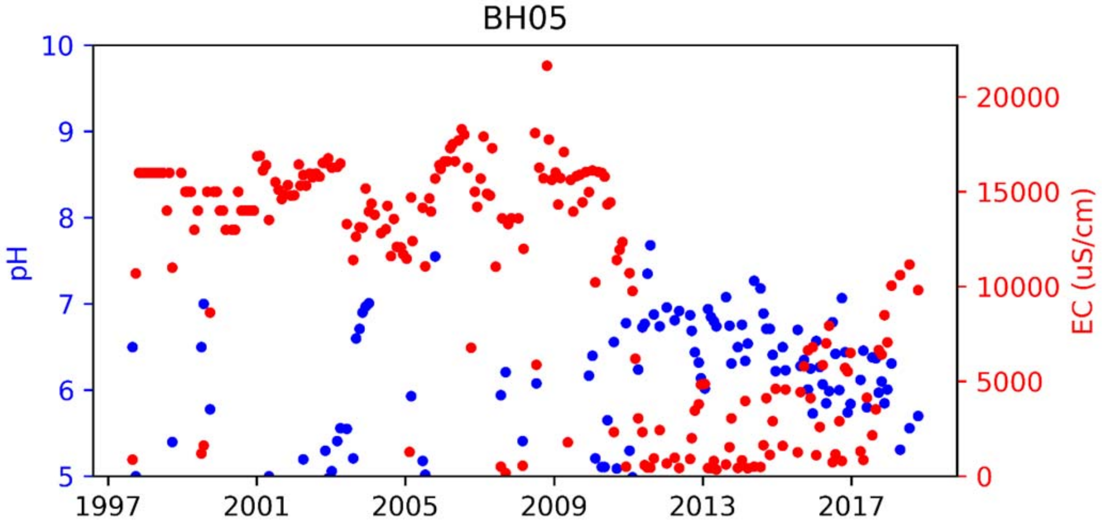
2005
2009
2013
2017


BH05
pH
EC (uS/cm)
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20000
15000
10000
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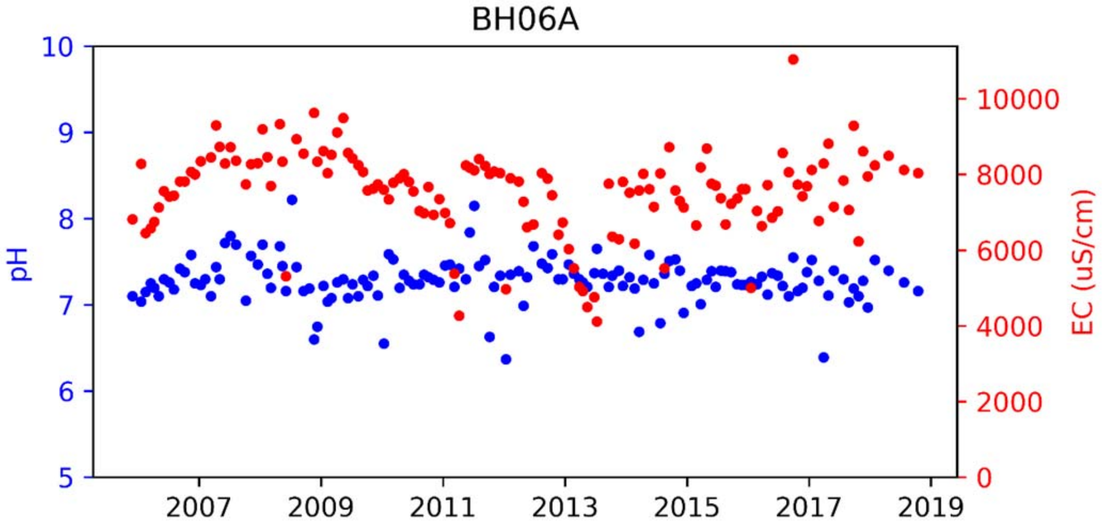
2009
2013
2017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pH
EC (uS/cm)
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2017
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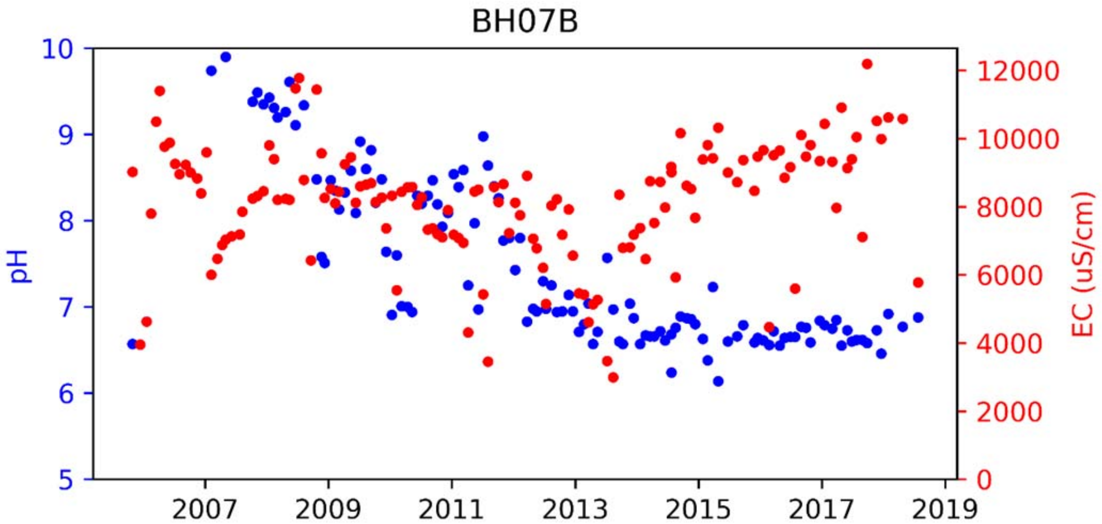
BH07B
pH
EC (uS/cm)
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12000
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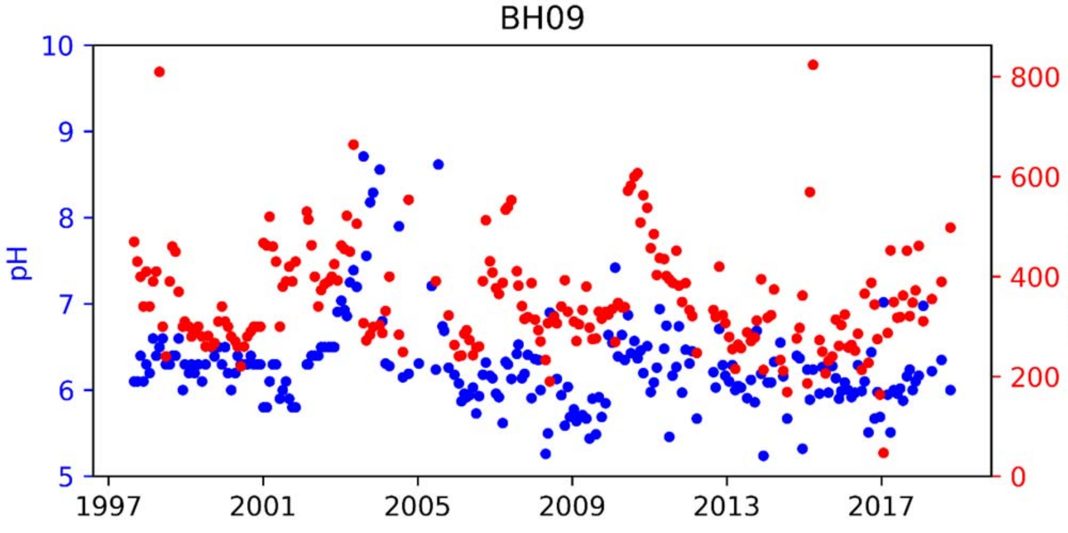
2015
2017
2019


BH09
pH
EC (uS/cm)
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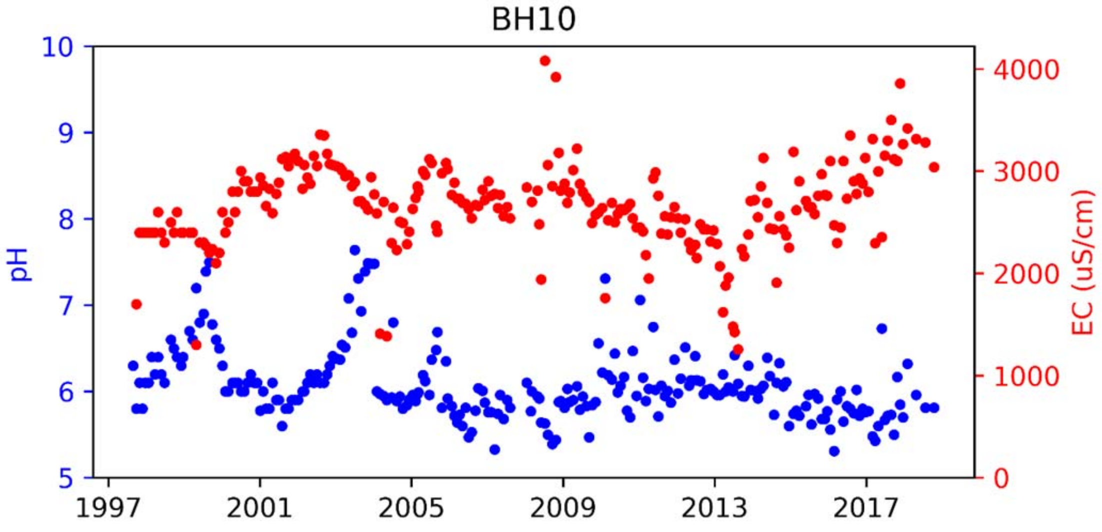
2013
2017


BH10
pH
EC (uS/cm)
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9
8
7
6
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4000
3000
2000
1000
0
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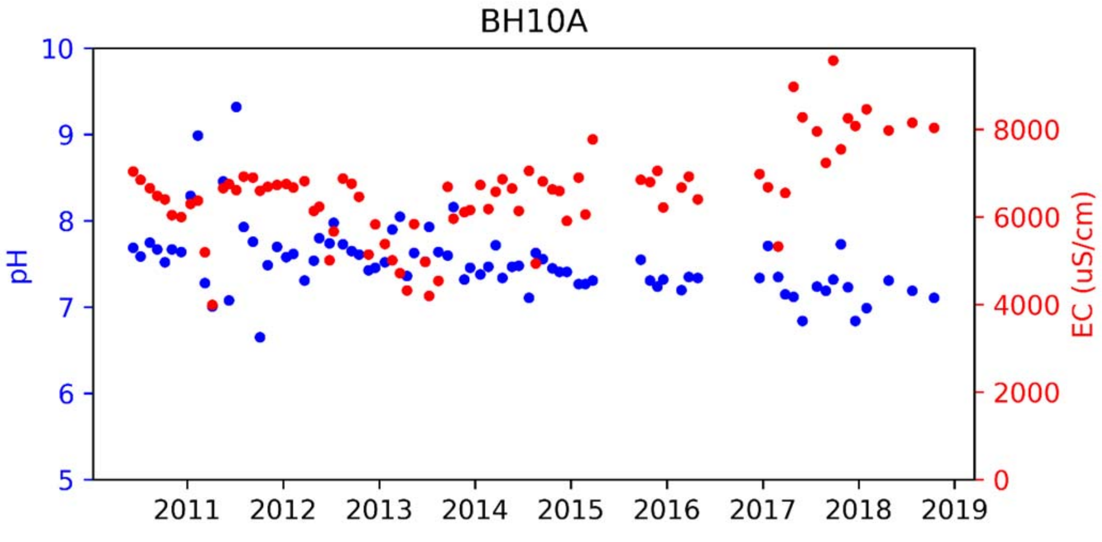
2005
2009
2013
2017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pH
EC (uS/cm)
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9
8
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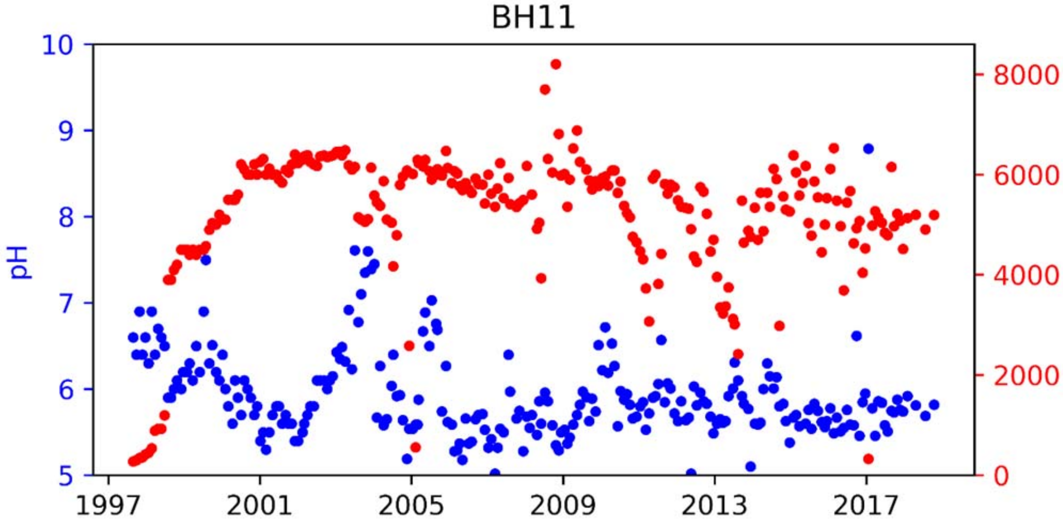
2015
2016
2017
2018
2019


BH11
pH
EC (uS/cm)
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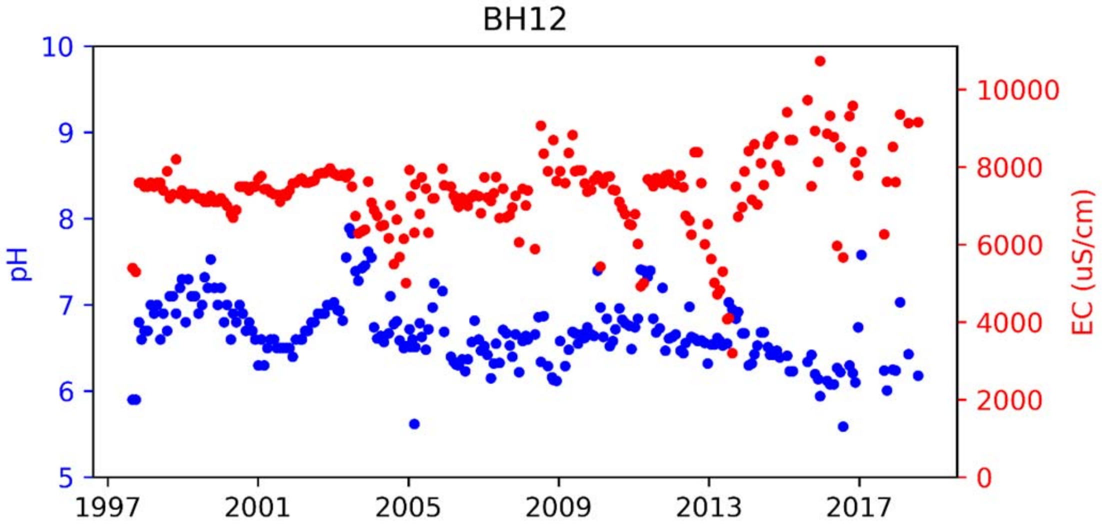
2005
2009
2013
2017


BH12
pH
EC (uS/cm)
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8
7
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10000
8000
6000
4000
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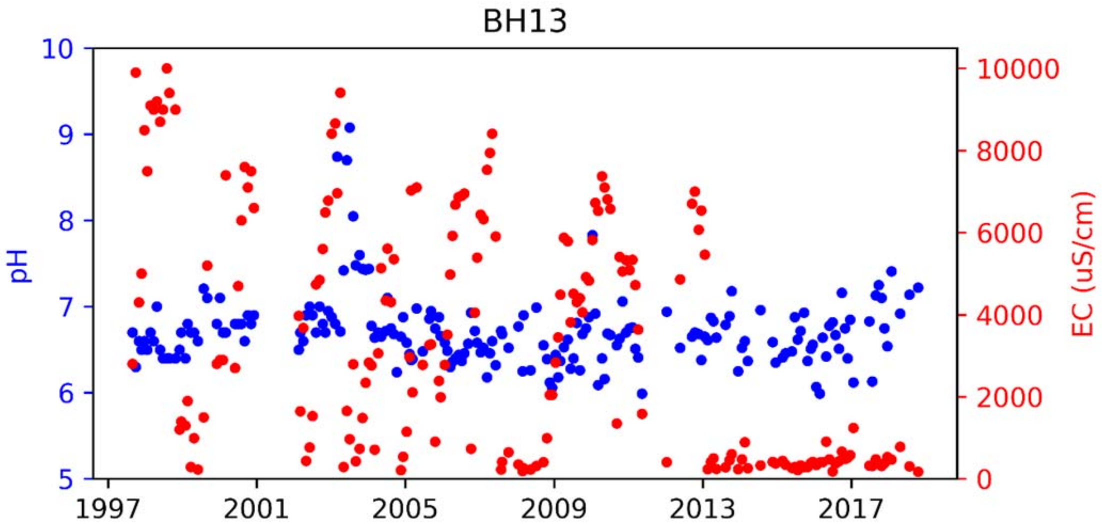
2009
2013
2017


BH13
pH
EC (uS/cm)
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8
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10000
8000
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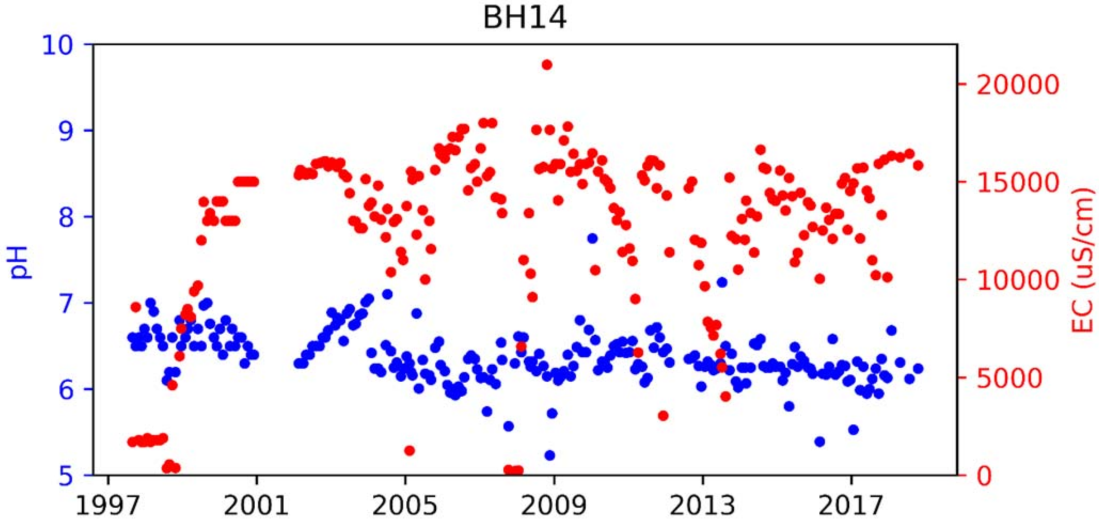
2009
2013
2017


BH14
pH
EC (uS/cm)
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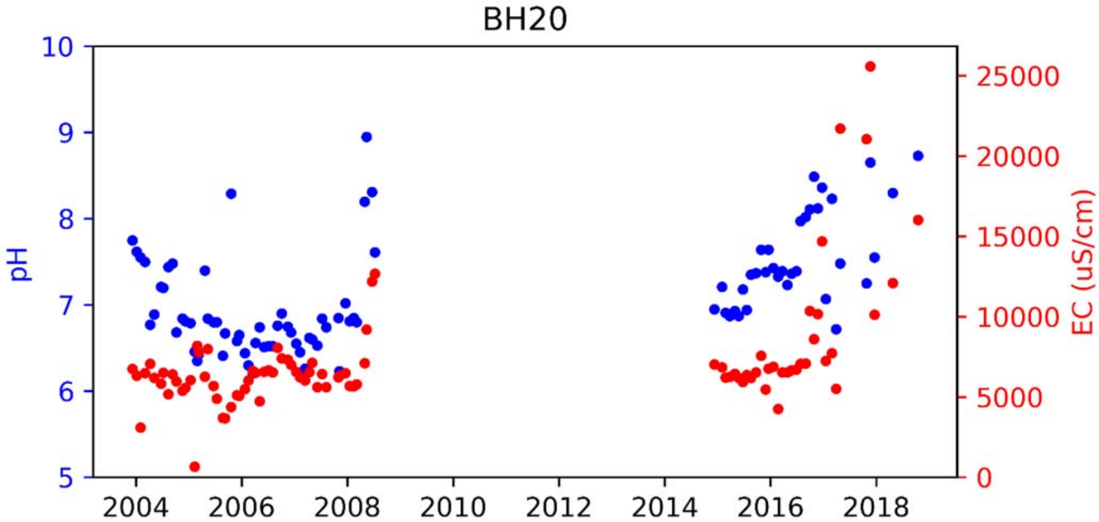
2013
2017


BH20
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EC (uS/cm)
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2016
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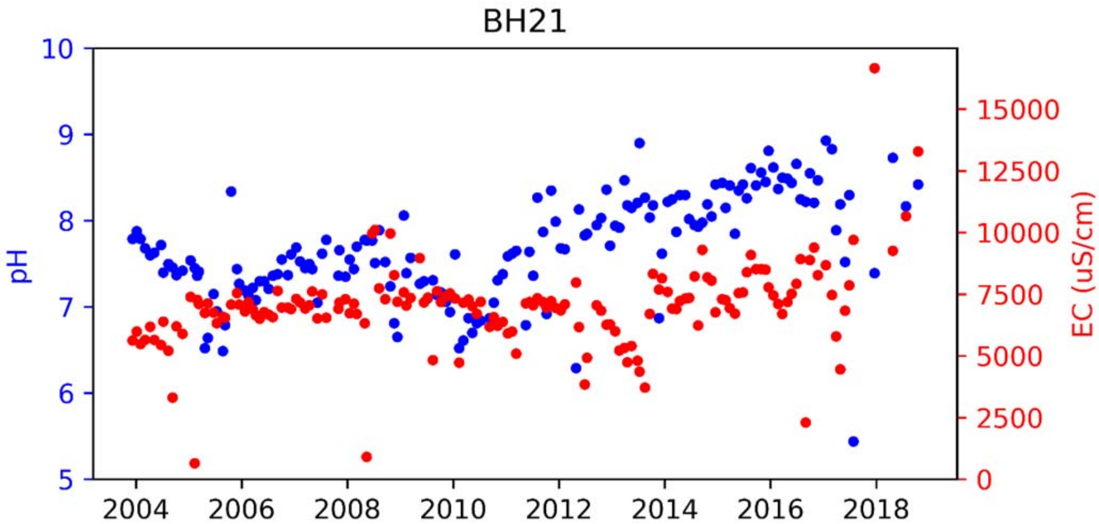
BH21
pH
EC (uS/cm)
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15000
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7500
5000
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2010
2012
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2016
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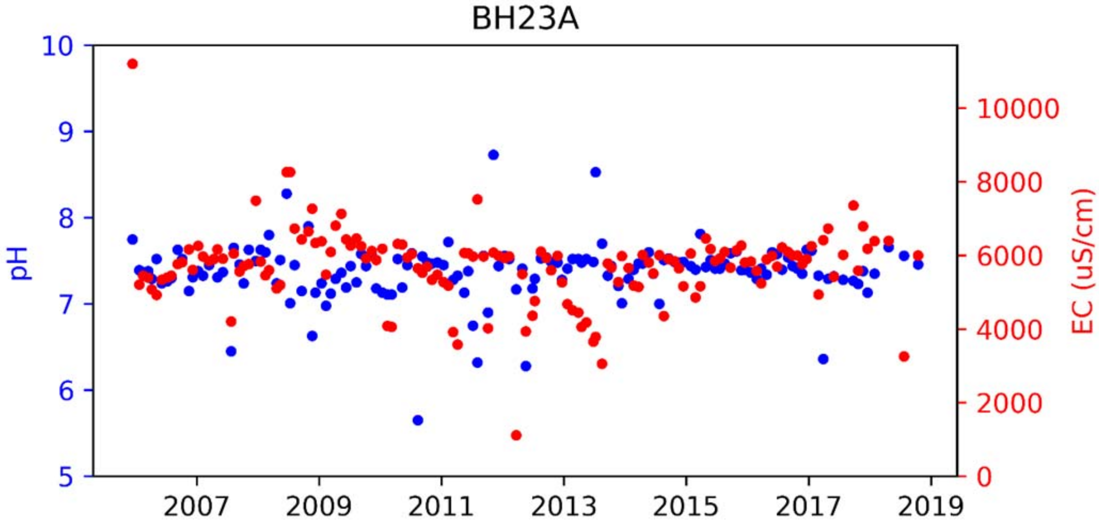
BH23A
pH
EC (uS/cm)
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8
7
6
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10000
8000
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2009
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2013
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2017
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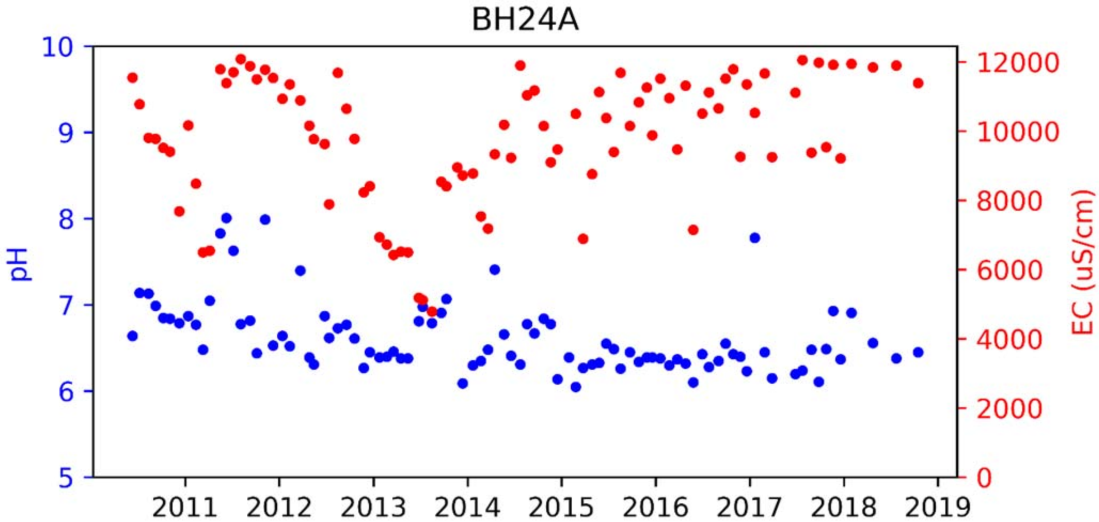
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pH
EC (uS/cm)
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6
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12000
10000
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4000
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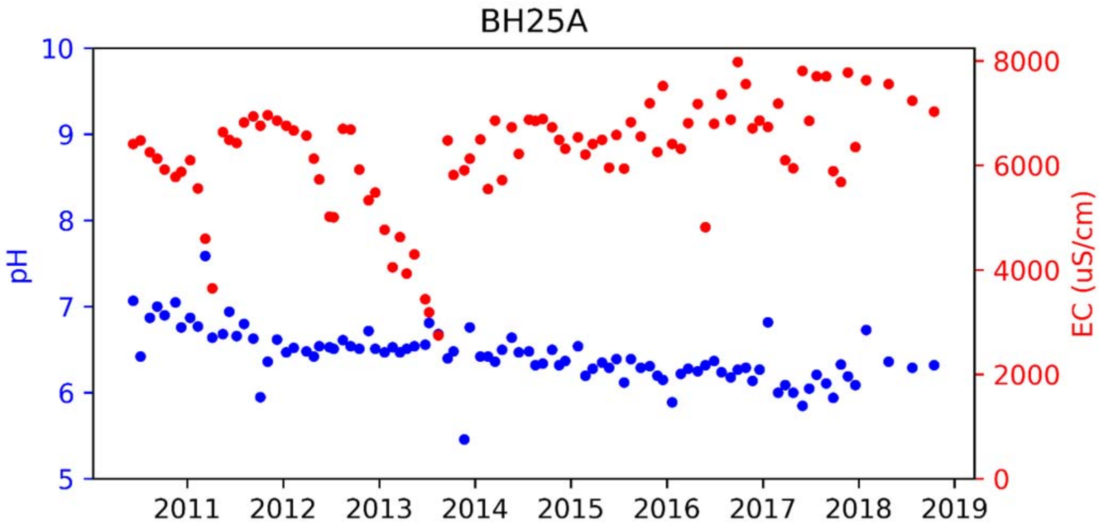
2015
2016
2017
2018
2019


BH25A
pH
EC (uS/cm)
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6
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2016
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2018
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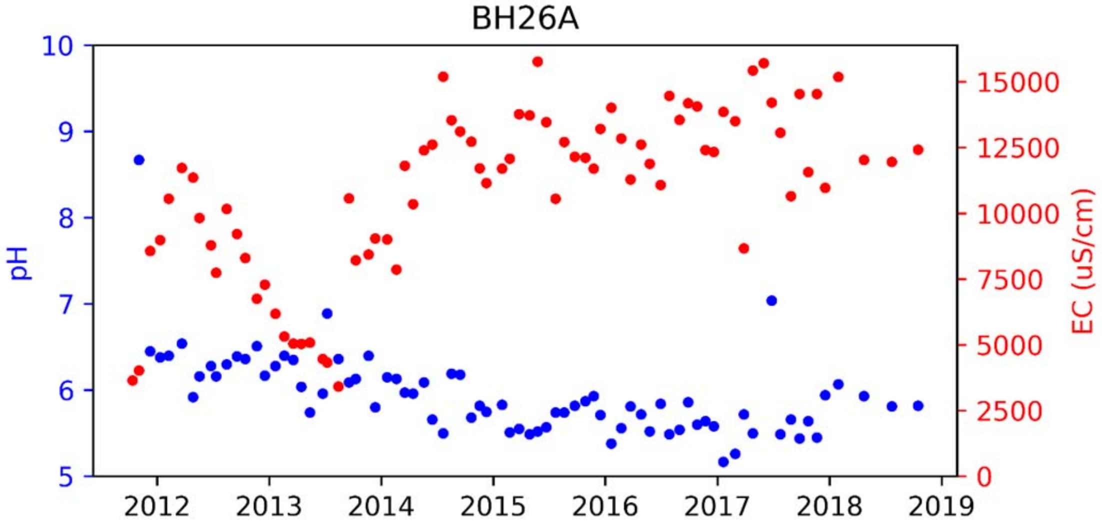
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pH
EC (uS/cm)
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9
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2016
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2018
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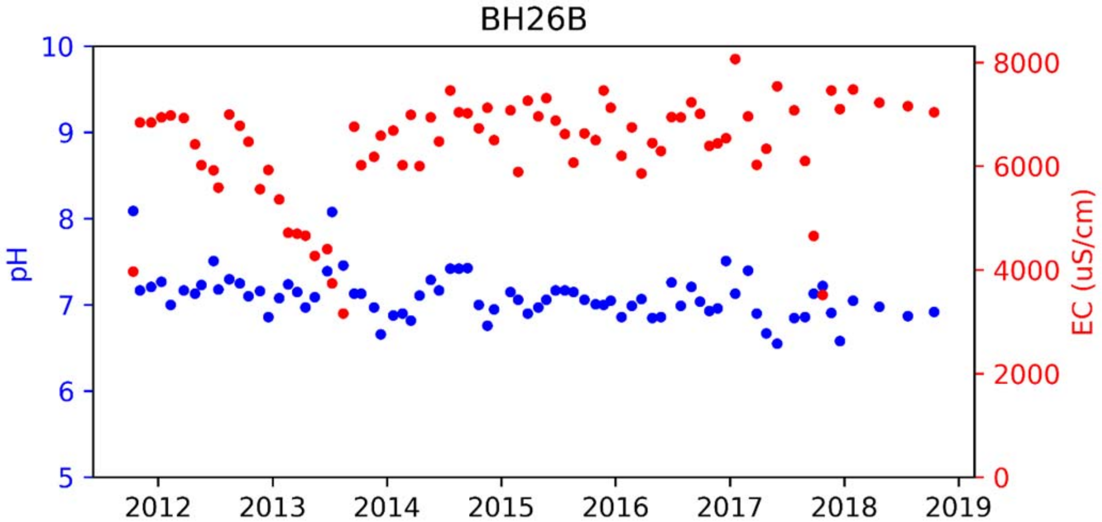
BH26B
pH
EC (uS/cm)
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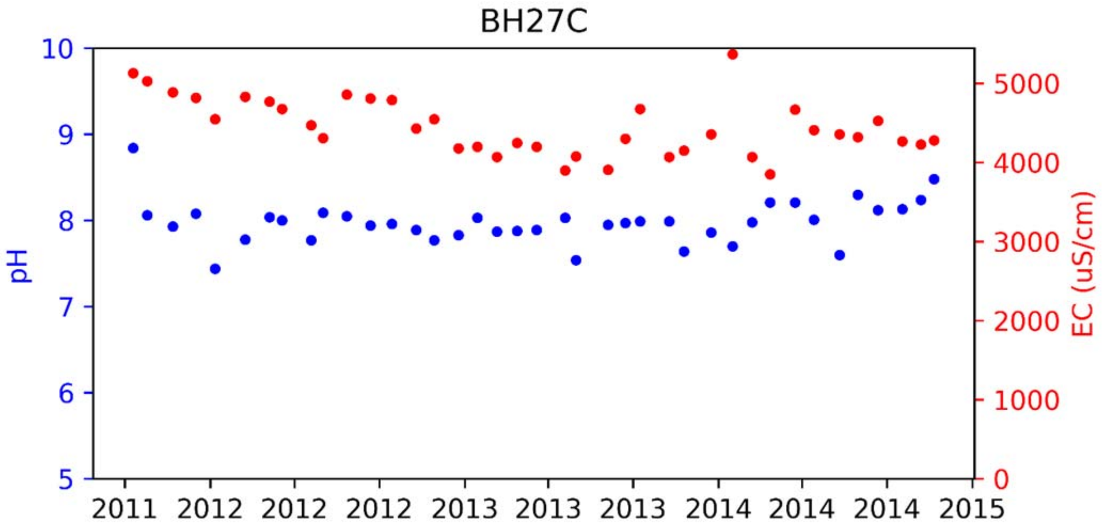
2016
2017
2018
2019


BH27C
pH
EC (uS/cm)
10
9
8
7
6
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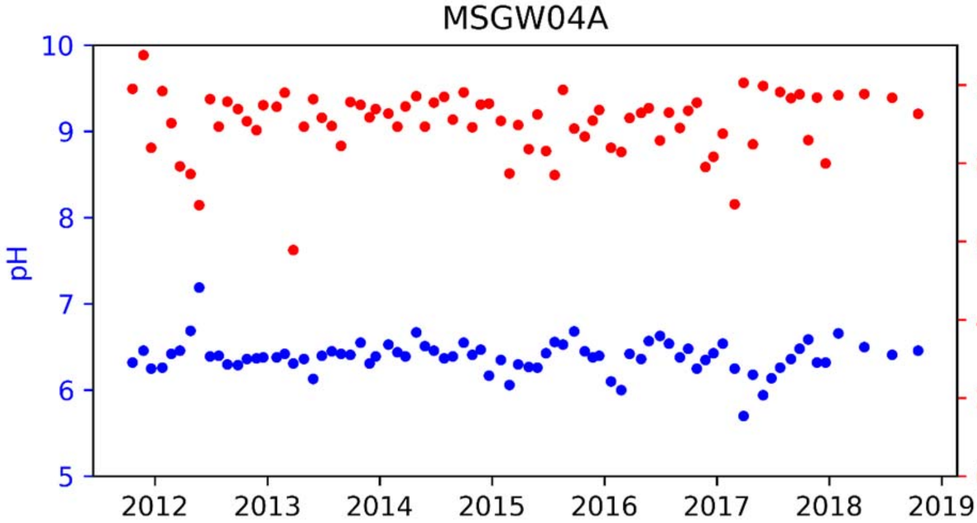
MSGW04A
pH
EC (uS/cm)
5
6
7
8
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10
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4000
6000
8000
10000
2012
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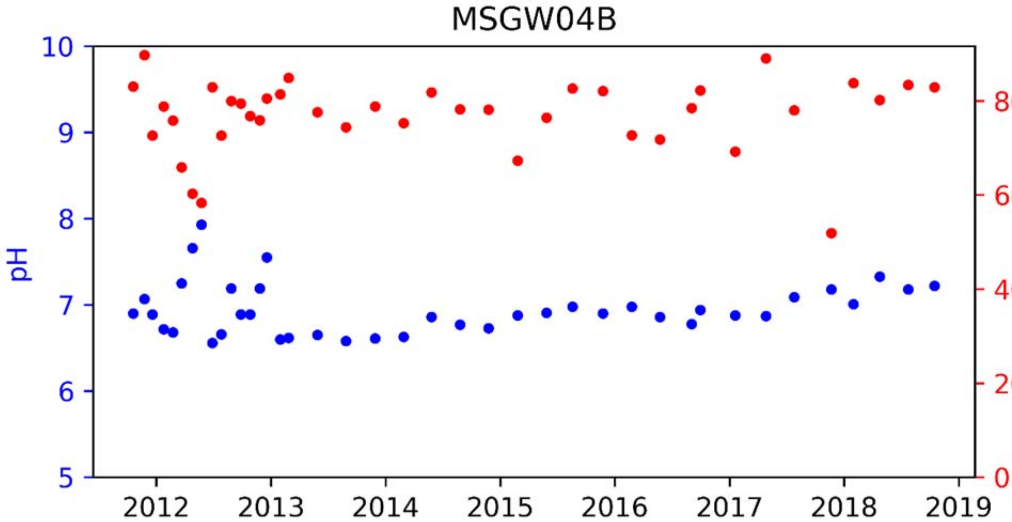
2015
2016
2017
2018
2019


MSGW04B
pH
EC (uS/cm)
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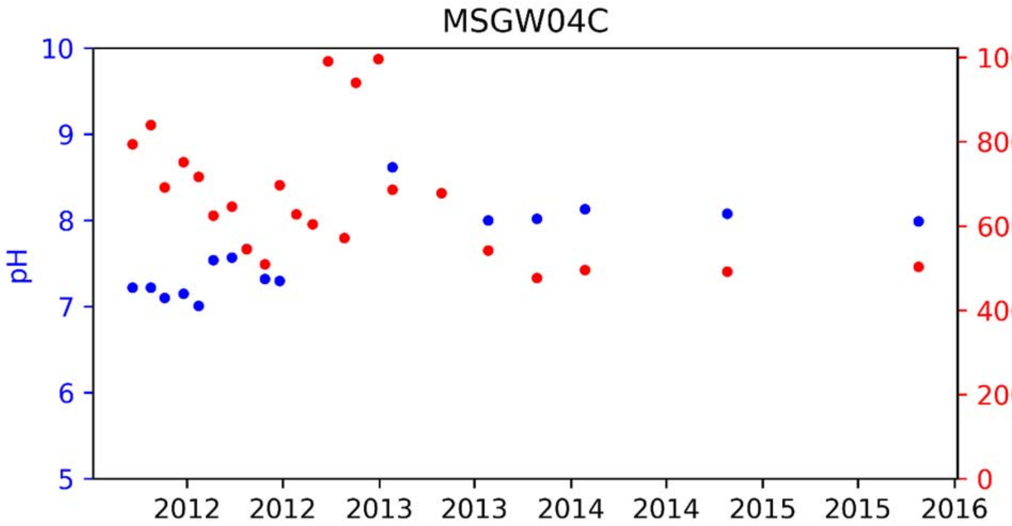
2016
2017
2018
2019


MSGW04C
pH
EC (uS/cm)
5
6
7
8
9
10
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6000
8000
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2012
2012
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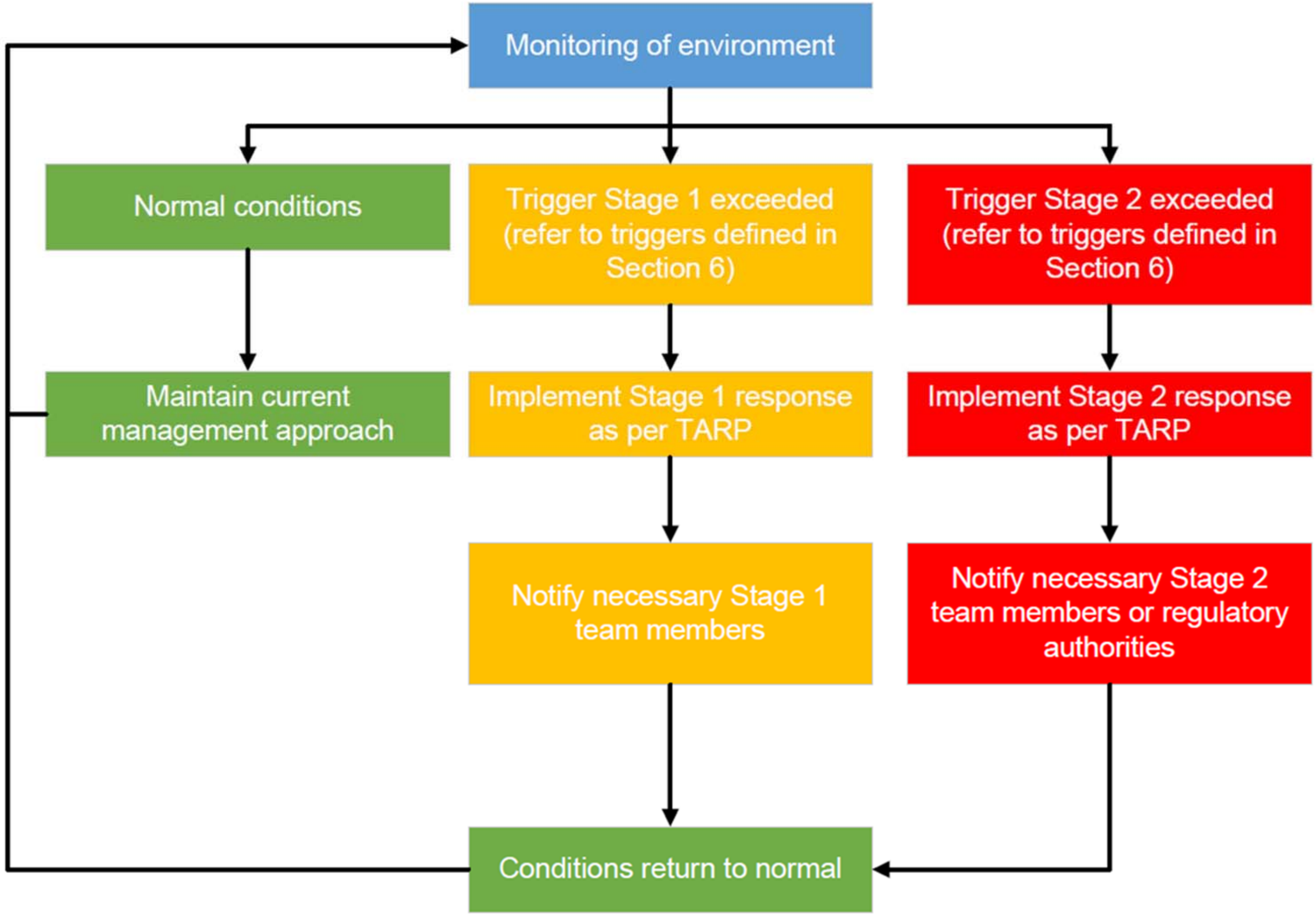
2014
2015
2015
2016

APPENDIX G – Trigger action response plans


Monitoring of environment
Normal conditions
Trigger Stage 1 exceeded (refer to triggers defined in Section 6)
Trigger Stage 2 exceeded (refer to triggers defined in Section 6)
Maintain current management approach
Implement Stage 1 response as per TARP
Implement Stage 2 response as per TARP
Notify necessary Stage 1 team members
Notify necessary Stage 2 team members or regulatory authorities
Conditions return to normal

G.1 Surface site operation

Aspect	Normal	Stage 1	Stage 2	Notifications
Surface water storage volume	Storages capture events up to and including the design criteria.	**Trigger:** Storage is not dewatered appropriately following storm event in accordance with design criteria. **Action:** Investigate storage operation and dewatering procedures. Undertake dewatering of relevant storages to areas where capacity exists. Increase inspection frequency as required. Training for staff.	**Trigger:** Storage is discharging as a result of a storm event less than design criteria. **Action:** Investigate cause for discharge and if the appropriate procedures were followed. Undertake dewatering of relevant storages to areas where capacity exists. Undertake water quality sampling of discharge and add flocculant as necessary. Undertake water quality sampling of upstream and downstream receiving environment as appropriate to assess any potential impact. Review adequacy of storage design, dewatering procedure and inspection schedule.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with Pollution Incident Response Management Plan (PIRMP) requirements or if material harm has occurred.

Aspect	Normal	Stage 1	Stage 2	Notifications
Dewatering pump operation	Dewatering pump operates within the pump specification.	**Trigger:** Power outage. **Action:** Utilise back up power source or diesel pump if available. Investigate alternate power sources or diesel pumps.	**Trigger:** Pump operation does not operate due to mechanical failure or pump rate not sufficient to meet demands. **Action:** Prepare downstream storages to receive overflows. Undertake water quality sampling of relevant storages and add flocculant as necessary. Review adequacy of pump operation and inspection schedule.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.
Clean water diversion	Clean water diverted around dirty water areas.	**Trigger:** Clean water bypass through dirty water areas. **Action:** Review catchment plan. Review design capacity of clean water system. Appropriately treat and manage dirty water. Facilitate works to resolve clean water flow diversion failure.	**Trigger:** Clean water creates flooding problems through site. **Action:** Evacuate site if danger exists. Establish temporary bunding around clean water source. Utilise earthworks machinery to cut appropriate channel to manage clean water appropriately. Protect equipment and infrastructure. Utilise portable pumps to dewater flooded areas into sediment basins.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

Aspect	Normal	Stage 1	Stage 2	Notifications
Erosion and sediment control	All controls are appropriately in place and well maintained. Site inspections do not identify any unstable disturbance areas or migration of sediment away from designated development areas.	**Trigger:** One or more areas of surface erosion in the form of rilling, bank erosion or other movement of sediment from an area of disturbance. Controls are not maintained or are inappropriately installed. **Action:** Seek to stabilise the area to stop the erosion process. This can include the use of groundcover or other temporary measures. Investigate works undertaken prior to the disturbance activities. Review adequacy of controls and inspection/maintenance schedule.	**Trigger:** Controls are not in place. Rainfall event has led to sediment migrating off site. **Action:** Isolate the area through diverting contributing surface flows to another appropriate control structure. Review adequacy of controls and inspection/maintenance schedule.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.
Hydrocarbon management	All hydrocarbon supplies are stored appropriately.	**Trigger:** Minor spill occurs on site with limited risk of off-site migration. **Action:** Implement procedures in the PIRMP. Apply spill kit.	**Trigger:** Major spill occurs on site with risk of off-site migration. **Action:** Isolate area and divert contributing surface flows. Engage waste contractor to clean up spill. Investigate potential for contamination of waterways.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

G.2 Watercourses

Aspect	Normal	Stage 1	Stage 2	Notifications
Water quality	Water quality at monitoring locations are within or below SSGVs provided in Table 6-1 (for Morans Creek) or consistent with historical baseline (for other watercourses).	**Trigger:** Water quality is outside or above SSGVs (for Morans Creek) or not consistent with historical baseline for at least one parameter for two consecutive sampling events. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Investigate the source of the exceedance and develop corrective/preventative actions based on the outcomes of the investigation.	**Trigger:** Investigation into Stage 1 trigger identifies that trigger exceedance is due to operational activity. Community complaint to Centennial Mandalong regarding surface water quality. **Action:** Determine if an incident has potentially occurred. Increase monitoring frequency and undertake additional monitoring where relevant. Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring. Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.

Aspect	Normal	Stage 1	Stage 2	Notifications
Water flow	Creek flow rates and relationships with rainfall are consistent with historical baseline results.	**Trigger:** Reduction in flow compared to historical baseline results and reference sites. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Investigate the source of the reduction in flow and develop corrective/preventative actions based on outcomes.	**Trigger:** Loss of flow compared to historical baseline results and reference sites. Community complaint to Centennial Mandalong regarding surface water flow. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Determine if an incident has potentially occurred and investigate the source of the loss of flow. Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation. Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE and Resource Regulator as soon as practicable if Stage 2 exceedance is found to be mining-related.

Aspect	Normal	Stage 1	Stage 2	Notifications
Flooding	Subsidence levels are within predictions. No increase in post-mining out-of-channel flood levels than identified by the flood model.	**Trigger:** Subsidence levels 1.5 times greater than predicted values. Increase in post-mining out-of-channel flood depths causing ponding above predictions. **Action:** Determine extent of increase in flood depths and if there is any potential loss of vegetation due to inundation. Consult with ecologist, landowner and relevant agencies on developing mitigation measures required to improve drainage.	**Trigger:** Subsidence levels two times greater than predicted values. Significant increase in post-mining out-of-channel flood depths causing ponding. **Action:** Verify whether monitoring results are consistent with flood model predictions and consider recalibration. Refer to relevant extraction plan for potential engineering solutions. Consult with ecologist, landowner and relevant agencies on flood drainage remediation measures and implement, then report on effectiveness of measures.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE as soon as practicable.

G.3 Groundwater environment

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater level	Monitored groundwater levels are greater than the adopted values specified in Table 6-2 and Table 6-3.	**Trigger:** Monitored groundwater levels are below the adopted values specified in Table 6-2 and Table 6-3. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Undertake investigation to determine if the change in groundwater level is due to mining-related activities.	**Trigger:** Investigation into Stage 1 trigger identifies that trigger exceedance is due to mining-related activities. Community complaint to Centennial Mandalong regarding groundwater levels. Drawdown at any water supply work exceeds 2 m. **Action:** Verify whether monitoring results are consistent with hydrogeological model predictions and consider recalibration. Loss of alluvial groundwater may need to be licensed under the WSP. Loss of water supply to any adjacent landholder will need to be replaced by Centennial Mandalong. If environmental impacts are unacceptable, remediation options will be considered.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE and any potentially affected landowners as soon as practicable if investigation triggered by Stage 2 identifies that change in groundwater level is mining-related.

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater quality	Groundwater quality is within or below trigger values provided in Table 6-4.	**Trigger:** Monitored groundwater quality is outside or above the minor trigger values presented in Table 6-4 for three consecutive monitoring rounds. Monitored groundwater quality is outside or above the major trigger values presented in Table 6-4. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Undertake investigation to determine if the change in groundwater quality is due to mining-related activities.	**Trigger:** Investigation into Stage 1 trigger identifies that change in groundwater quality is due to mining-related activities. Community complaint to Centennial Mandalong regarding groundwater quality. **Action:** If environmental impacts are unacceptable and/or if the beneficial use of the groundwater changes, remediation options will be considered. Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial Mandalong.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE and any potentially affected landowners as soon as practicable if investigation triggered by Stage 2 identifies that change in groundwater quality is mining-related.

Aspect	Normal	Stage 1	Stage 2	Notifications
Dewatering volume	Dewatering volume is consistent with model predictions and below licensed volumetric limit.	**Trigger:** Dewatering volume exceeds predicted rates by more than 10% for three consecutive months. **Action:** Review monitoring/inflow estimation methodology and validate dewatering volume data. Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Undertake investigation to determine cause of the change in dewatering volume.	**Trigger:** Dewatering volume exceeds predicted rates by more than 20% for three consecutive months. Dewatering volume likely to exceed licensed limit. **Action:** Review monitoring/inflow estimation methodology and validate dewatering volume data. Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Undertake review of hydrogeological model predictions for groundwater inflows into the mine. Update the hydrogeological model and site water balance model if necessary. Modify site water management at the CES where possible to accommodate the change in dewatering volume. Obtain additional groundwater licence allocations if necessary.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

Aspect	Normal	Stage 1	Stage 2	Notifications
Cooranbong underground storage level	Water level below trigger value specified in Section 6.1.4.	**Trigger:** Water level exceeds trigger value. **Action:** Reduce any active water transfers into the Cooranbong underground storage where possible. Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Undertake investigation to determine cause of the increase in water level. Increase dewatering rate to reduce water level as necessary, where sufficient capacity exists and/or acceptable disposal is available.	**Trigger:** Water level continues to increase after Stage 1 actions are implemented. **Action:** Cease any active water transfers into the Cooranbong underground storage. Increase to the maximum dewatering rate to reduce water level as necessary, where sufficient capacity exists and/or acceptable disposal is available. Retreat mining infrastructure as necessary from down dip.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

G.4 Discharge management

Aspect	Normal	Stage 1	Stage 2	Notifications
Discharge from LDP	No discharges as a result of events up to and including the design criteria.	**Trigger:** Discharge occurs for no more than one day as a result of the storage capacity criteria being exceeded. **Action:** Investigate storage operation and dewatering procedures. Undertake dewatering of relevant storages to areas where capacity exists. Increase inspection frequency as required. Training for staff.	**Trigger:** Discharge occurs for more than one day as a result of the storage capacity criteria being exceeded. **Action:** Investigate cause for discharge and if the appropriate procedures were followed. Undertake dewatering of relevant storages to areas where capacity exists. Review adequacy of storage design, dewatering procedure and inspection schedule.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.
Discharge quality from LDP	Discharge quality is within or below EPL limits presented in Table 6-5.	**Trigger:** Water quality parameters are outside or above EPL limits for one parameter. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Investigate cause for discharge and if the appropriate procedures were followed. Undertake water quality sampling of upstream and downstream receiving environment as appropriate to assess any potential impact.	**Trigger:** Water quality parameters are outside or above EPL limits for more than one parameter. **Action:** Determine if an incident has potentially occurred. Increase monitoring frequency and undertake additional monitoring where relevant. Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring. Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

Aspect	Normal	Stage 1	Stage 2	Notifications
Emergency discharges	No discharge from emergency locations.	**Trigger:** Discharge from a non-EPL defined emergency discharge location. **Action**: Undertake dewatering of relevant storages to areas where capacity exists. Undertake water quality sampling of discharge and add flocculant as necessary.	**Trigger:** Continued discharge from a non-EPL defined emergency discharge location. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data). Investigate cause for discharge and if the appropriate procedures were followed. Undertake water quality sampling of discharge and add flocculant as necessary. Undertake water quality sampling of upstream and downstream receiving environment as appropriate to assess any potential impact. Review adequacy of storage design, dewatering procedure and inspection schedule.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

G.5 Stream health

Aspect	Normal	Stage 1	Stage 2	Notifications
Watercourse instabilities	Watercourse monitoring indicates no areas of instabilities.	**Trigger:** Watercourse monitoring indicates one or more areas of instabilities in watercourses. **Action:** Review historical monitoring records. Investigate the factors contributing to the instability, which may include advice from technical specialists. Implement corrective actions as required as soon as practicable to stabilise the surface and/or watercourses based on the outcomes of the investigation. Increase monitoring frequency and undertake additional monitoring where relevant.	**Trigger:** Watercourse monitoring indicates one or more areas of instabilities in watercourses causing sediment loads to migrate and or impact to riparian vegetation. **Action:** Immediately isolate areas of instability and implement remediation measures to stabilise surface and/or watercourse. Investigate the factors contributing to the instability, which may include advice from technical specialists. Implement corrective/preventative actions based on the outcomes of the investigation and/or additional monitoring. Prioritise actions based on the risk to the environment and likelihood of further impact. Increase monitoring frequency and undertake additional monitoring where relevant. Review the WMP and related procedures to prevent reoccurrence.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.

Aspect	Normal	Stage 1	Stage 2	Notifications
Instream vegetation	Extent and quality of instream vegetation is consistent with historical monitoring results.	**Trigger:** Visual inspections show change in extent and density of instream vegetation not specific to season. Introduction or increase in number of exotic species. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Investigate cause for change in instream vegetation and if the appropriate procedures were followed. Consider using RCE inventory (Petersen 1992) measure to quantify change from historical results.	**Trigger:** Visual inspections show significant change in extent and density of instream vegetation as a result of clearing or impact. **Action:** Increase monitoring frequency and undertake additional monitoring where relevant. Undertake water quality sampling of upstream and downstream receiving environment as appropriate to assess any potential impact. Stabilise watercourse banks as necessary.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.

Aspect	Normal	Stage 1	Stage 2	Notifications
In situ water quality	In situ water quality is consistent with historical monitoring results.	**Trigger:** Water quality is not consistent with historical monitoring results. **Action:** Review recent monitoring results and any relevant operational data (e.g. operational activities, meteorological data) and identify any potentially contributing factors. Investigate the source of the variability and develop corrective/preventative actions based on the outcomes of the investigation. Increase monitoring frequency and undertake additional monitoring where relevant.	**Trigger:** Water quality continues to not be consistent with historical monitoring results after Stage 1 actions are implemented. **Action:** Determine if an incident has potentially occurred. Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring. Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager as soon as practicable. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE as soon as practicable if Stage 2 exceedance is found to be mining-related.

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