



Transport
**Roads & Maritime
Services**

Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Year 2 Operational Phase Water Quality
Monitoring Annual Report

Roads and Maritime Services | October 2020



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Year 2 Operational Phase Water Quality
Monitoring Annual Report – October 2020

Report Prepared for:

NSW Roads and Maritime Services

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Prepared By:

Aquatic Science and Management

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Contents

1	Introduction.....	1
1.1	Introduction and Background	1
1.2	Water Quality Guidelines and Objectives.....	2
2	Methods.....	5
2.1	Locations.....	5
2.2	Sampling and Analysis	11
3	Results and Discussion	17
3.1	Rainfall.....	17
3.2	Surface Water	18
3.3	Groundwater Quality	32
3.4	Groundwater Level.....	40
4	Key Observations	45
4.1	Surface Water Quality	45
4.2	Groundwater Quality	45
4.3	Groundwater levels	46
5	Conclusions	47
6	References.....	48
	Appendix A.....	49
	Appendix B.....	62

Figures

Figure 3.1	Daily rainfall at the Taylors Arm and Nambucca weather stations for the reporting period plotted against sampling events.	17
Figure 3.2	Total suspended solid concentrations at Upper Warrell Creek since February 2015.	19
Figure 3.3	Turbidity measurements at Upper Warrell Creek since February 2015.	19
Figure 3.4	pH measurements at Upper Warrell Creek since February 2015.....	19
Figure 3.5	Iron concentrations at Upper Warrell Creek since February 2015.	20
Figure 3.6	Total suspended solid concentrations at Stony Creek since February 2015.....	21
Figure 3.7	Turbidity measurements at Stony Creek since February 2015.....	21
Figure 3.8	pH measurements at Stony Creek since February 2015.	21
Figure 3.9	Manganese concentrations at Stony Creek since February 2015.....	22

Figure 3.10 Iron concentrations at Stony Creek since February 2015.	22
Figure 3.11 Total suspended solid concentrations at Lower Warrell Creek since February 2015.	23
Figure 3.12 Turbidity measurements at Lower Warrell Creek since February 2015.	23
Figure 3.13 pH measurements at Lower Warrell Creek since February 2015.	23
Figure 3.14 Total dissolved solid concentrations at Lower Warrell Creek since February 2015.	24
Figure 3.15 Conductivity measurements at Lower Warrell Creek since February 2015.	24
Figure 3.16 Total suspended solid measurements at Unnamed Gumma Creek West since February 2015.	25
Figure 3.17 Turbidity measurements at Unnamed Gumma Creek West since February 2015.	25
Figure 3.18 pH measurements at Unnamed Gumma Creek West since February 2015.	26
Figure 3.19 Aluminium concentrations at Unnamed Gumma Creek West since February 2015.	26
Figure 3.20 Arsenic concentrations at Unnamed Gumma Creek West since February 2015.	26
Figure 3.21 Iron concentrations at Unnamed Gumma Creek West since February 2015.	27
Figure 3.22 Total dissolved solid concentrations at Unnamed Gumma Creek West since February 2015.	27
Figure 3.23 Conductivity measurements at Unnamed Gumma Creek West since February 2015.	27
Figure 3.24 Total suspended solid measurements at Unnamed Gumma Creek East since February 2015.	28
Figure 3.25 Turbidity measurements at Unnamed Gumma Creek East since February 2015.	29
Figure 3.26 pH measurements at Unnamed Gumma Creek East since February 2015.	29
Figure 3.27 Iron concentrations at Unnamed Gumma Creek East since February 2015.	29
Figure 3.28 Total dissolved solid measurements at Unnamed Gumma Creek East since February 2015.	30
Figure 3.29 Conductivity measurements at Unnamed Gumma Creek East since February 2015.	30
Figure 3.30 Total suspended solid measurements at the Nambucca River since February 2015.	31
Figure 3.31 Turbidity measurements at the Nambucca River since February 2015.	31
Figure 3.32 pH measurements at the Nambucca River since February 2015.	31
Figure 3.33 Groundwater pH measurements at Ch 45165 since February 2015.	33
Figure 3.34 Groundwater conductivity measurements at Ch 45165 since February 2015.	33
Figure 3.35 Groundwater pH measurements at Ch 48665 since February 2015.	34
Figure 3.36 Groundwater conductivity measurements at Ch 48665 since February 2015.	34
Figure 3.37 Groundwater copper measurements at Ch 48665 since February 2015.	34
Figure 3.38 Groundwater total phosphorus measurements at Ch 48665 since February 2015.	35
Figure 3.39 Groundwater phosphate measurements at Ch 48665 since February 2015.	35
Figure 3.40 Groundwater total alkalinity measurements at Ch 48665 since February 2015.	35
Figure 3.41 Groundwater pH measurements at Ch 49365 since February 2015.	36
Figure 3.42 Groundwater conductivity measurements at Ch 49365 since February 2015.	36
Figure 3.43 Groundwater pH measurements at Ch 50965 since February 2015.	37
Figure 3.44 Groundwater conductivity measurements at Ch 50965 since February 2015.	38
Figure 3.45 Groundwater total phosphorus measurements at Ch 50965 since February 2015.	38

Figure 3.46 Groundwater total nitrogen measurements at Ch 50965 since February 2015.	38
Figure 3.47 Groundwater nitrate measurements at Ch 50965 since February 2015.	39
Figure 3.48 Groundwater calcium ion measurements at Ch 50965 since February 2015.	39
Figure 3.49 Groundwater pH measurements at Ch 54065 since February 2015.	40
Figure 3.50 Groundwater conductivity measurements at Ch 54065 since February 2015.	40
Figure 3.51 Operational phase groundwater levels at chainage 45165.	41
Figure 3.52 Operational phase groundwater levels at chainage 48665.	42
Figure 3.53 Operational phase groundwater levels at chainage 49365.	43
Figure 3.54 Operational phase groundwater levels at chainage 50965.	44
Figure 3.55 Operational phase groundwater levels at chainage 54065.	44

Tables

Table 1.1 Available ANZECC and ADWG guideline concentrations for relevant parameters	3
Table 2.1 Surface water monitoring locations and sites.	5
Table 2.2 Groundwater monitoring locations and sites.	8
Table 2.3 Surface water parameters for operational phase monitoring.	11
Table 2.4 Operational phase sample frequency	12
Table 2.5 Operational phase sampling dates between 1 October 2019 and 30 September 2020	13
Table 2.6 Surface water parameters for operational phase monitoring.	14
Table 2.7 Operational phase sample frequency (GeoLINK 2013b).	15
Table 2.8 Second year operational phase groundwater sampling dates	15

Illustrations

Illustration 2.1 Surface water monitoring sites – Ch 41765 to 51365 (Ch conversion +41765) (GeoLINK 2013a).	6
Illustration 2.2 Surface water monitoring sites – Ch 51365 to 71265 (Ch conversion +41765) (GeoLINK 2013a).	7
Illustration 2.3 Groundwater monitoring sites – Ch 41765 to 51365 (GeoLINK 2013b)	9
Illustration 2.4 Groundwater monitoring sites – Ch 51365 to 61265 (GeoLINK 2013b)	10

1 Introduction

1.1 Introduction and Background

The Pacific Highway upgrade between Warrell Creek and Nambucca Heads (WC2NH upgrade) is operational. Surface water and groundwater monitoring has been ongoing in the pre-construction and construction phases according to the Surface Water Monitoring Program (GeoLINK 2013a) and the Groundwater Monitoring Program (GeoLINK 2013b). The operational phase monitoring began in July 2018.

This annual report, the second of the operational phase monitoring, presents a detailed summary of the surface water and groundwater monitoring results obtained during operational phase monitoring to date, between July 2018 and September 2020.

1.1.1 Aims and Objectives

The objective of this annual report is to provide a detailed summary of the surface water and groundwater quality monitoring activities and results for the second year of the operational phase of the WC2NH upgrade. The objective of ongoing surface water and groundwater monitoring is to evaluate the impact of the Pacific Highway upgrade on water quality in the relevant waterways and aquifers from Warrell Creek to Nambucca Heads and to comply with the Department of Planning and Environment (DP&E) Ministers conditions of approval (RTA 2011) for the Warrell Creek to Urunga section of the Pacific Highway upgrade (which includes the WC2NH and the Nambucca Heads to Urunga sections).

The condition of approval that relates to water quality is the *Ministers Condition of Approval (MP 07_0112) B17 – Water Quality*, which requires Roads and Maritime *to prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on SEPP 14 wetlands, surface water quality and groundwater resources during construction and operation*. In accordance with MCoA B17 Roads and Maritime prepared, and the Department of Planning and Environment approved, the Surface Water Monitoring Program (SWMP) and the Groundwater Monitoring Program (GWMP).

These documents provide guidance to:

- monitor the impacts of the project on SEPP 14 wetlands, surface water quality and groundwater resources during construction and operation;

- provide Roads and Maritime with timely advice about surface and groundwater quality and how they compare to relevant and appropriate guideline levels;

This report is required to comply with DP&E MCoA B17.

1.2 Water Quality Guidelines and Objectives

There are a variety of guidelines available for the comparison and assessment of results obtained from surface water and groundwater sampling. Choosing appropriate guidelines to assess water quality depends on the environmental values of the site, human uses, the objectives for water quality, the level of protection required for the site and the issues and associated risks present.

Most often, guidelines are derived from the Australian and New Zealand Environment Conservation Council (ANZECC) Guidelines for Water Quality (ANZECC 2000), The Australian Drinking Water Guidelines, National Health and Medical Research Council (NHMRC) 2004) and the Guidelines for Managing Risks in Recreational Waters (NHMRC 2011).

In the case of large datasets collected regularly over time and with an appropriate sampling design the ANZECC Guidelines suggest the use of median and 80th percentile (P80) concentrations from the gathered data. The SWMP and the GWMP employ a before/after, control/impact (BACI) sampling design to assess the impact of the highway upgrade on water quality. They recommend the use of the median values from the impact (downstream) sites and the P80 values from the control (upstream) sites for assessing impacts with the intention of informing ongoing management of water quality.

The ANZECC guidelines prescribe default guideline values for many water quality parameters. The individual values depend on the desired use of the water, perceived values of the water and the level of protection required. The default guideline values are intended to trigger further water quality investigations and to be used where there is an absence of locally derived guideline values. The ANZECC default guideline concentrations will be used in this report for providing context where potential impacts upon surface water and groundwater from highway operation are identified. The relevant ANZECC guideline concentrations are presented in **Table 1.1**.

The Australian Drinking Water Guidelines (ADWG, NHMRC 2013) provide guideline values for many water quality parameters that have potential impacts upon human health. In accordance

with the Guidelines for the Assessment and Management of Groundwater Contamination (DEC 2007) both the ADWG guidelines and the relevant ANZECC guidelines (default guidelines for Freshwater Aquatic Ecosystem Protection for 95% of species) to provide quantitative context where potential impacts upon groundwater from highway operation are identified. Importantly, results that exceed the ANZECC and ADWG guidelines are not necessarily an indication of an impact resulting from highway operation. The relevant ADWG concentrations are presented in **Table 1.1**.

Table 1.1 Available ANZECC and ADWG guideline concentrations for relevant parameters

<i>Parameter</i>	<i>ANZECC Guideline Concentrations for Aquatic Ecosystem Protection (95% of spp.) in moderately disturbed ecosystems</i>		<i>ADWG Concentrations</i>
	<i>Freshwater</i>	<i>Marine</i>	
Silver (µg/L)	0.05	1.4	100
Aluminium (µg/L)	55	0.5 ^a	200 ^b
Antimony (µg/L)	9	270	3
Arsenic (V) (µg/L)	13	4.5 ^a	10
Cadmium (µg/L)	0.2	5.5	2
Chromium (VI) (µg/L)	1.0	4.4	50
Copper (µg/L)	1.4	1.3	2000
Iron (µg/L)	-	-	300 ^b
Manganese (µg/L)	1900	-	500
Nickel (µg/L)	11	7	20
Lead (µg/L)	3.4	4.4	10
Selenium (µg/L)	5	-	10
Zinc (µg/L)	8.0	15	300 ^b
Mercury (µg/L)	0.05	0.1	1
Naphthalene (µg/L)	16	70	-
Benzene (µg/L)	950	700	1
Toluene (µg/L)	-	-	800
Ethylbenzene (µg/L)	-	-	300
m&p-Xylenes (µg/L)	200	-	600
o-Xylene (µg/L)	350	-	600
Total Nitrogen in water (mg/L)	0.5	0.3	-
Nitrite as N in water (mg/L)	0.04(NOx)	0.015(NOx)	3
Nitrate as N in water (mg/L)	0.04(NOx)	0.015(NOx)	50
Ammonia as N in water (mg/L)	0.02	0.015	0.5 ^b
Total Phosphorus (mg/L)	0.05	0.03	-
Phosphate as P in water (mg/L)	0.02	0.005	-
Chloride, Cl (mg/L)	-	-	250 ^b
Sulphate, SO ₄ (mg/L)	-	-	250 ^b
Bicarbonate Alkalinity as CaCO ₃ (mg/L)	-	-	-
Sodium – Dissolved (mg/L)	-	-	180 ^b
Potassium – Dissolved (mg/L)	-	-	-
Calcium – Dissolved (mg/L)	-	-	-
Magnesium – Dissolved (mg/L)	-	-	-
Hydroxide Alkalinity (OH ⁻) as CaCO ₃ (mg/L)	-	-	-
Carbonate Alkalinity as CaCO ₃ (mg/L)	-	-	200 ^b
Total Alkalinity as CaCO ₃ (mg/L)	-	-	-
Total Suspended Solids (mg/L)	-	-	-
Total Dissolved Solids (mg/L)	-	-	600 ^b
Temperature (°C)	-	-	-

<i>Parameter</i>	<i>ANZECC Guideline Concentrations for Aquatic Ecosystem Protection (95% of spp.) in moderately disturbed ecosystems</i>		<i>ADWG Concentrations</i>
	<i>Freshwater</i>	<i>Marine</i>	
pH	6.5 – 8.0	7.0 – 8.5	6.5 – 8.5
Conductivity (mS/cm)	0.125 – 2.2	-	-
Turbidity (NTU)	6 - 50	0.5 - 10	5 ^b
Dissolved Oxygen (% sat)	85-110% saturation	80 – 110% saturation	85% saturation

a – ANZECC low reliability trigger

b – No health-based guideline value, aesthetic value applied.

2 Methods

2.1 Locations

2.1.1 Surface Water Monitoring Sites

There are five surface water locations (11 sites) where ongoing surface water monitoring is required. Maps of the site locations are presented in **Illustrations 2.1** and **2.2** (GeoLINK 2013a). A key to the site names used over time and in this report is presented in **Table 2.1**.

Table 2.1 Surface water monitoring locations and sites

<i>Waterway</i>	<i>Site Names</i>	<i>New Chainage</i>	<i>Old Chainage</i>
Upper Warrell Creek	SW01 (upstream) SW02 (downstream)	Ch 41565 Ch 42565	Ch -200 Ch 700
Stony Creek	SW03 (upstream) SW04 (downstream)	Ch 45465 Ch 45665	Ch 3700 Ch 3900
Lower Warrell Creek	SW05 (upstream) SW06 (downstream)	Ch 48165	Ch 6400
Unnamed Drainage Line	SW07 (upstream west) SW08 (upstream east) SW09 (downstream)	Ch 50215	Ch 8450
Nambucca River	SW10 (upstream) SW11 (downstream)	Ch 52065	Ch 10300

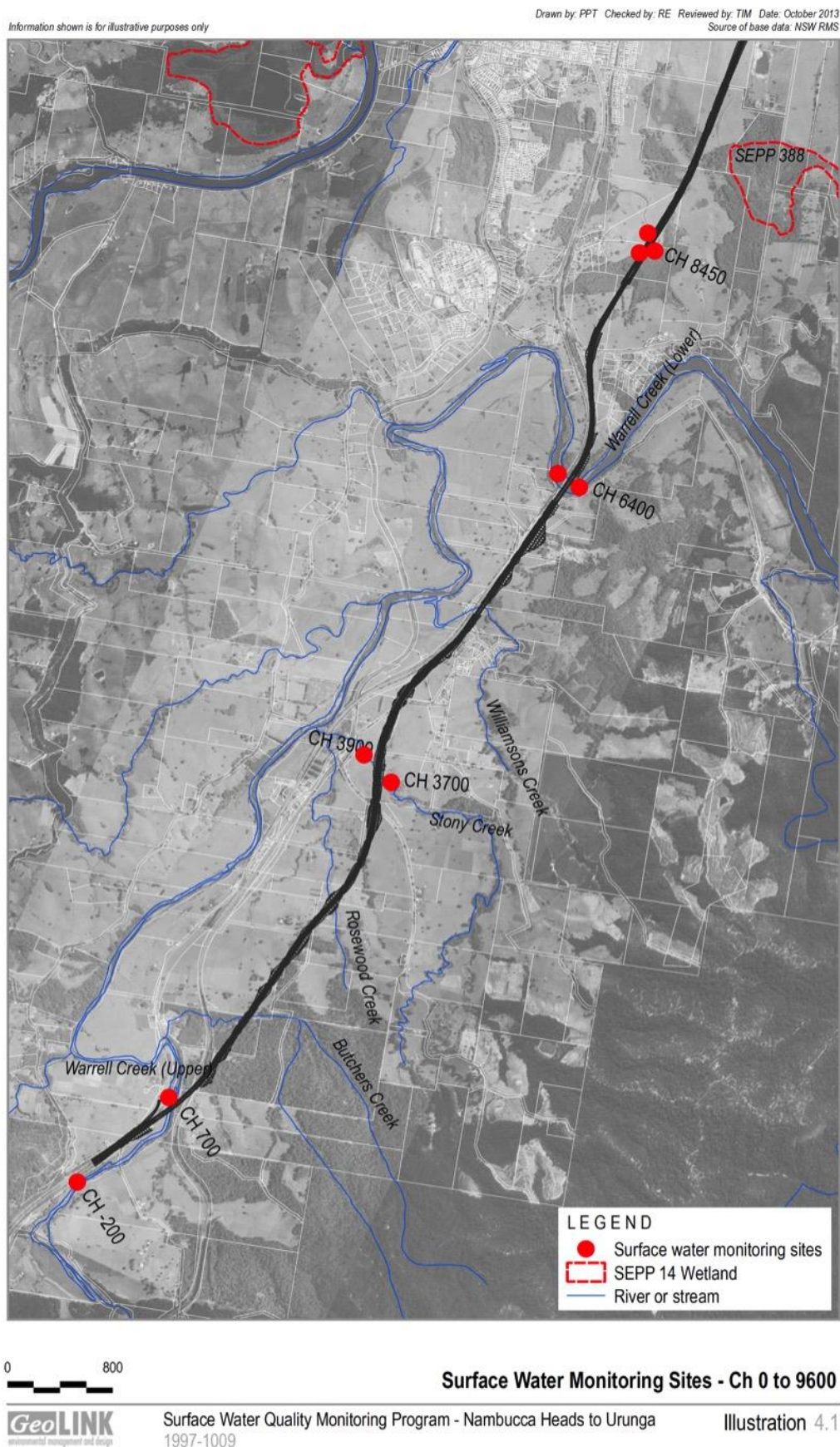
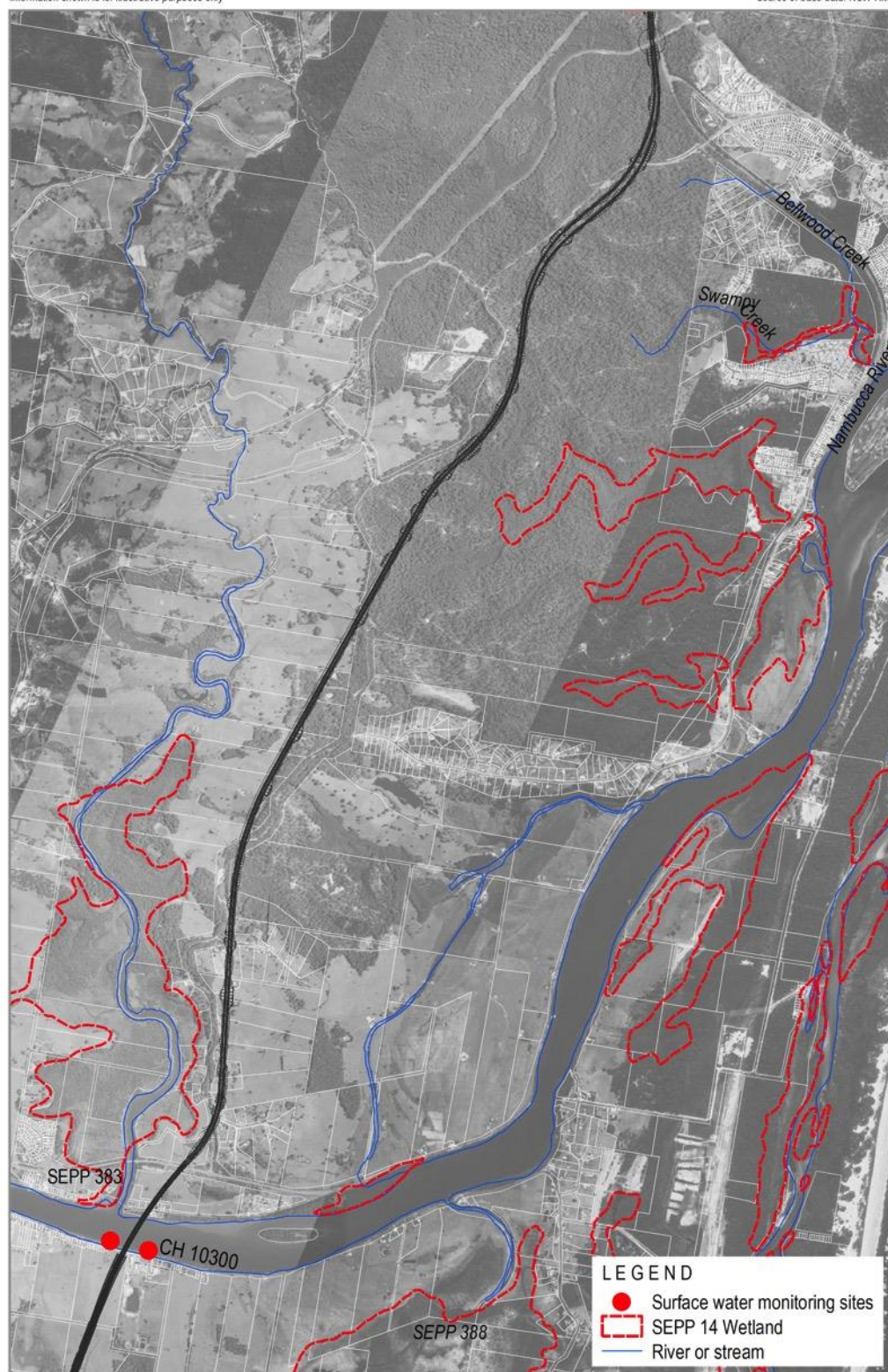


Illustration 2.1 Surface water monitoring sites – Ch 41765 to 51365 (Ch conversion +41765) (GeoLINK 2013a)

Information shown is for illustrative purposes only

Drawn by: PPT Checked by: RE Reviewed by: TIM Date: October 2013
Source of base data: NSW RMS



0 800

GeoLINK
environmental management and design

Waterways and EA Sampling Sites - Ch 9600 to 19500

Surface Water Quality Monitoring Program - Warrell Creek to Nambucca Heads Illustration 4.2
1997-1010

**Illustration 2.2 Surface water monitoring sites – Ch 51365 to 71265 (Ch conversion +41765)
(GeoLINK 2013a)**

2.1.2 Groundwater Monitoring Sites

There are five locations (8 piezometers) where ongoing groundwater monitoring is required. Maps of the site locations are presented in **Illustrations 2.3** and **2.4** (GeoLINK 2013b). The locations (from south to north) are as follows:

- Cutting No. 1.5 on the west of the alignment, approximate chainage 45165, Site Cut 6W.
- Cutting No. 1.10 on the east and west of the alignment, approximate chainage 48665, sites Cut 11E (upgradient) and Cut 11W (downgradient).
- Cutting No. 1.11 on the west of the alignment, approximate chainage 49365, site Cut 12W.
- Embankment fill adjacent to Gumma Wetland, approximate chainage 50965, sites Fill 15E (upgradient) and Fill 15W (downgradient).
- Cutting No. 2.5 on the east and west of the alignment, approximate chainage 54065, sites Cut 15E (upgradient) and Cut 15W (downgradient).

Monitoring at several other sites where monitoring was undertaken in the pre-construction phase ceased prior to or during the construction phase (see GeoLINK 2013b and Coffey 2015).

Table 2.2 Groundwater monitoring locations and sites

<i>Location</i>	<i>Site Names</i>	<i>New Chainage</i>	<i>Old Chainage</i>
Cutting No. 1.5	Cut 6W (downgradient)	Ch 45165	Ch 3400
Cutting No. 1.10	Cut 11E (upgradient) Cut 11W (downgradient)	Ch 48665	Ch 6900
Cutting No. 1.11	Cut 12 W (downgradient)	Ch 49365	Ch 7600
Embankment Fill Gumma Wetland	Fill 15E (upgradient) Fill 15W (downgradient)	Ch 50965	Ch 9200
Cutting No. 2.5	Cut 15E (upgradient) Cut 15W (downgradient)	Ch 54065	Ch 12300

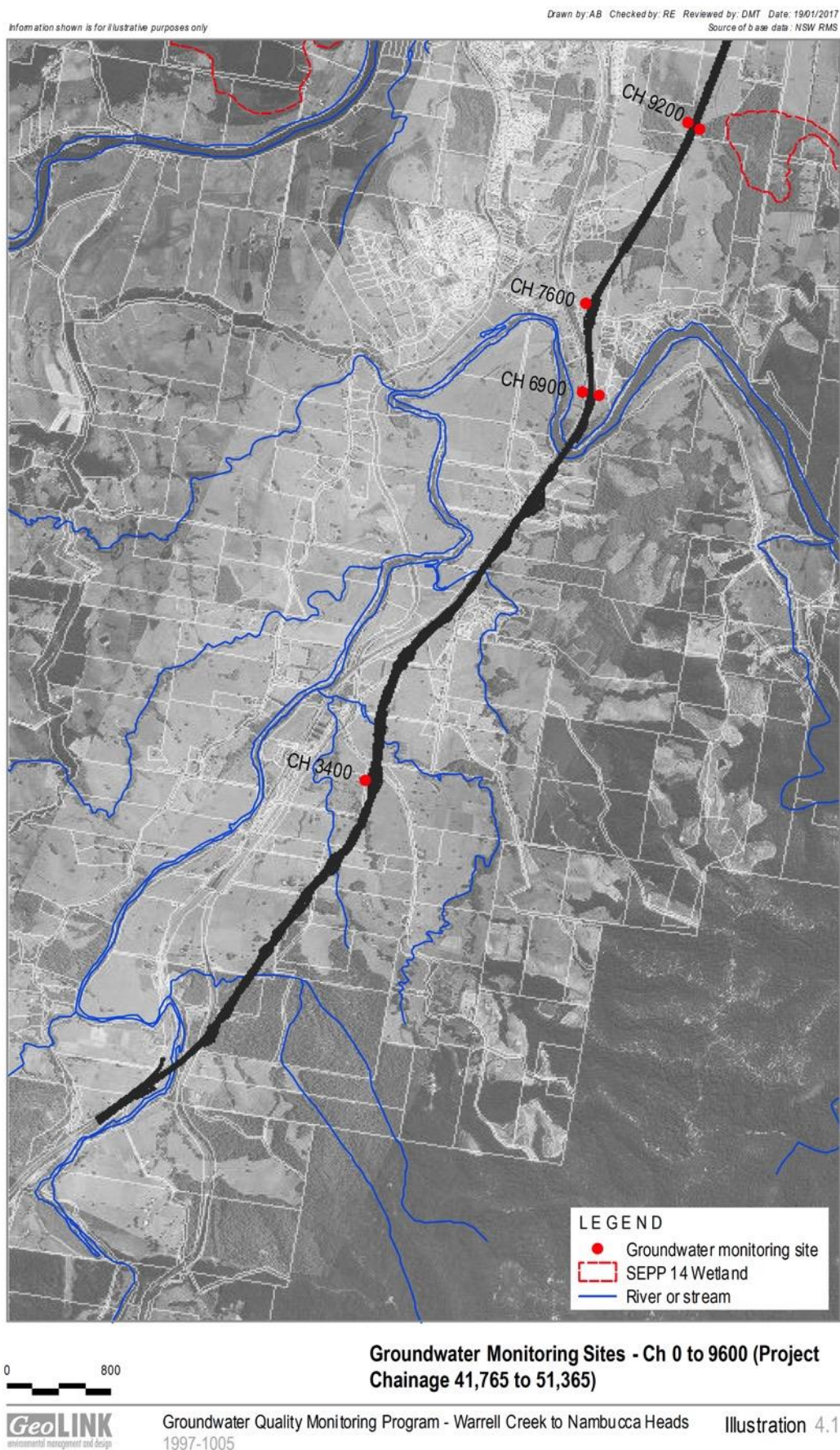


Illustration 2.3 Groundwater monitoring sites – Ch 41765 to 51365 (GeoLINK 2013b)

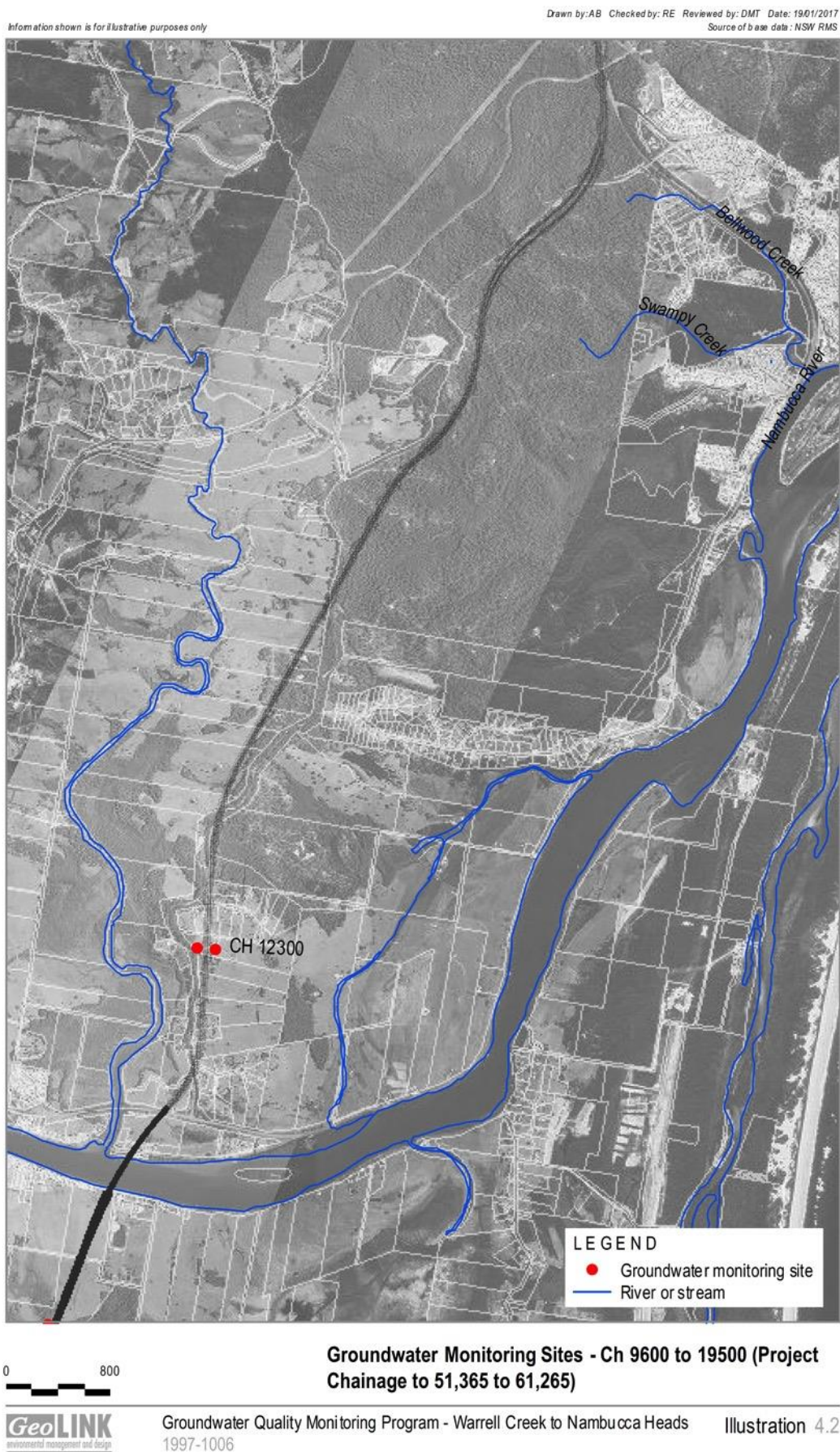


Illustration 2.4 Groundwater monitoring sites – Ch 51365 to 61265 (GeoLINK 2013b)

2.2 Sampling and Analysis

2.2.1 Surface Water Quality Monitoring

The SWMP outlines the parameters required for monitoring in the operational phase of the project. The complete list of parameters monitored is presented in **Table 2.3**.

Table 2.3 Surface water parameters for operational phase monitoring

<i>Group</i>	<i>Analytes</i>	<i>Method of Analysis</i>
Physicochemical	Temperature Electrical Conductivity (EC) pH Dissolved Oxygen (DO) Turbidity Total Dissolved Solids (TDS) Total Suspended Solids (TSS)	Field measurement – Handheld Probe Field measurement – Handheld Probe Field measurement – Handheld Probe Field measurement – Handheld Probe Field measurement – Handheld Probe Field measurement – Handheld Probe Laboratory Analysis
Hydrocarbons (if visual assessment confirms presence)	TRH C6 - C10 TRH >C10 - C16 TRH >C16 - C34 TRH >C34 - C40 Benzene Toluene Ethylbenzene Xylene	Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis
Metals	Aluminium (Al) Arsenic (As) Cadmium (Cd) Chromium (Cr) Copper (Cu) Lead (Pb) Manganese (Mn) Nickel (Ni) Selenium (Se) Silver (Ag) Zinc (Zn) Iron (Fe) Mercury (Hg)	Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis
Nutrients	Total Nitrogen (TN) Total Phosphorus (TP) Nitrate (NO ₃) Nitrite (NO ₂) Ammonia (NH ₄) Phosphate (PO ₄)	Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis

The SWMP also defines the sampling frequency for operational monitoring. This is presented in **Table 2.4**. The exact timing of sample collection is dependent upon weather conditions. Where the conditions required for a wet episode or dry episode do not occur in the specified period, or the appropriate conditions are missed due to logistical problems such as staff availability, access restrictions or equipment failure, the approach taken is to collect catch-up samples at the next available opportunity.

Table 2.4 Operational phase sample frequency

<i>Period</i>	<i>Dates</i>	<i>Parameters</i>	<i>Sample Frequency</i>
First Year	July 2018 – September 2019	Physicochemical and Hydrocarbons (if oil and grease is visible)	- Once per month during a wet episode (defined as a rainfall event of >10mm in a 24-hour period) - Once every six months during a dry episode (defined as a combination of 96 hours with no rain and 192 hours with <10mm rain)
		Hydrocarbons, Metals, Nutrients and Solids	- Once every second month during a wet episode - Once every six months during a dry episode
Second Year	October 2019 – September 2020	Physicochemical and Hydrocarbons (if oil and grease is visible)	- Once every second month during a wet episode - Once every six months during a dry episode
		Hydrocarbons, Metals, Nutrients and Solids	- Once every six months during a wet episode - Once every six months during a dry episode
Third Year	October 2018 – September 2020	Physicochemical and Hydrocarbons (if oil and grease is visible)	- Once every six months during a wet episode - Once every six months during a dry episode
		Hydrocarbons, Metals, Nutrients and Solids	- Once every six months during a wet episode - Once every six months during a dry episode

The dates of surface water quality monitoring sampling for the second year of operational phase monitoring are presented in **Table 2.5**. There were more than the required amount of wet-event surface water samples collected, because catch-up samples were collected to address a shortfall of sampling opportunities in the first year of operational phase monitoring. Rainfall conditions at the time of sampling are presented in **Figure 3.1**. One of the two dry-weather samples required

in the second year of operational phase monitoring was collected outside of the six-month period scheduled by approximately 4 weeks. On the 30th September 2020 sampling was up-to-date.

Table 2.5 Operational phase sampling dates between 1 October 2019 and 30 September 2020

<i>Month</i>	<i>Date</i>	<i>Sample Type</i>	<i>Parameters</i>				<i>Notes</i>
			<i>Physicochemical</i>	<i>Hydrocarbons</i>	<i>Metals</i>	<i>Nutrients</i>	
October 2019	13/10/19	Wet	Y	Y	Y	Y	Catch-up wet sample. All samples collected.
November 2019	No samples	-	-	-	-	-	No suitable wet event. Dry event samples not captured.
December 2019	2/12/19	Wet	Y	Y	Y	Y	Catch-up wet sample. SW07, 08, 09 too dry to sample.
January 2020	20/01/20	Wet	Y	N	N	N	All samples collected.
February 2020	7/02/20	Wet	Y	Y	Y	Y	All samples collected.
March 2020	16/03/20	Wet	Y	N	N	N	All samples collected.
April 2020	27/04/20	Dry	Y	Y	Y	Y	Catch-up dry sample. All samples collected
May 2020	No samples	-	-	-	-	-	No suitable wet event.
June 2020	11/06/20	Wet	Y	N	N	N	All samples collected.
July 2020	27/07/20	Wet	Y	Y	Y	Y	All samples collected.
August 2020	No samples	-	-	-	-	-	No suitable wet event. Dry event samples not captured.
September 2020	11/09/19	Wet	Y	N	N	N	All samples collected.
	30/09/20	Dry	Y	Y	Y	Y	All samples collected

Surface waters were sampled from a depth of approximately 0.1 – 0.2 m. Samples for parameters requiring laboratory analysis were collected by dipping the sampling vessel into the

water by sampling pole. A variety of sample vessels were used, depending upon the suite of parameters being analysed. All samples with a requirement for laboratory analysis were sent in cooled eskys by overnight courier to the processing laboratory on the day of, or day after collection. Where laboratories reported results as lower than the limits of detection, these results were incorporated into databases as the level of detection for the calculation of summary statistics and graphing. Physicochemical parameters were measured *in situ* using a calibrated HORIBA U52 multiparameter water quality probe.

2.2.2 Groundwater Quality Monitoring

The GWMP outlines the parameters required for monitoring in the operational phase of the project. The complete list of parameters monitored is presented in **Table 2.6**.

Table 2.6 Surface water parameters for operational phase monitoring

<i>Group</i>	<i>Analytes</i>	<i>Method of Analysis</i>
Physicochemical	Temperature Electrical Conductivity (EC) pH Total Dissolved Solids (TDS)	Field measurement – Handheld Probe Field measurement – Handheld Probe Field measurement – Handheld Probe Field measurement – Handheld Probe
Hydrocarbons	Total Recoverable Hydrocarbons (TRH) C6 - C10 TRH >C10 - C16 TRH >C16 - C34 TRH >C34 - C40 Benzene Toluene Ethylbenzene Xylene	Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis
Metals	Aluminium (Al) Arsenic (As) Cadmium (Cd) Chromium (Cr) Copper (Cu) Lead (Pb) Manganese (Mn) Nickel (Ni) Selenium (Se) Silver (Ag) Zinc (Zn) Iron (Fe) Mercury (Hg)	Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis Laboratory Analysis

<i>Group</i>	<i>Analytes</i>	<i>Method of Analysis</i>
Nutrients	Total Nitrogen (TN)	Laboratory Analysis
	Total Phosphorus (TP)	Laboratory Analysis
	Nitrate (NO ₃)	Laboratory Analysis
	Nitrite (NO ₂)	Laboratory Analysis
	Ammonia (NH ₄)	Laboratory Analysis
	Phosphate (PO ₄)	Laboratory Analysis
Major Anions	Chloride (Cl ⁻)	Laboratory Analysis
	Sulfate (SO ₄ ²⁻)	Laboratory Analysis
	Bicarbonate (HCO ₃ ⁻)	Laboratory Analysis
	Nitrate (NO ₃ ⁻)	Laboratory Analysis
Major Cations	Sodium (Na ⁺)	Laboratory Analysis
	Potassium (K ⁺)	Laboratory Analysis
	Calcium (Ca ²⁺)	Laboratory Analysis
	Magnesium (Mg ²⁺)	Laboratory Analysis

The frequency of groundwater monitoring is also defined by the GWMP. This is presented in **Table 2.7**.

Table 2.7 Operational phase sample frequency (GeoLINK 2013b)

<i>Period</i>	<i>Dates</i>	<i>Parameters</i>	<i>Sample Frequency</i>
Operational Phase	July 2018 – September 2021	Physicochemical	1 sample three-monthly
		Hydrocarbons, Metals, Nutrients, Solids, Anions and Cations	1 sample six-monthly

The dates of groundwater measurements collected during the second year of the operational phase are presented in **Table 2.8**. The samples were collected at the intervals specified in the GWMP, with the exception of the December 2019 sample which was collected 3 days late.

Table 2.8 Second year operational phase groundwater sampling dates

<i>Month</i>	<i>Date</i>	<i>Parameters</i>				<i>Major Ions</i>	<i>Notes</i>
		<i>Physicochemical</i>	<i>Hydrocarbons</i>	<i>Metals</i>	<i>Nutrients</i>		
December 2019	03/01/20	Y	N	N	N	N	Dry piezometer at Cut 6W and Cut 12W.

<i>Month</i>	<i>Date</i>	<i>Parameters</i>				<i>Major Ions</i>	<i>Notes</i>
		<i>Physicochemical</i>	<i>Hydrocarbons</i>	<i>Metals</i>	<i>Nutrients</i>		
March 2020	30/03/20	Y	Y	Y	Y	Y	All samples collected .
June 2020	29/06/20	Y	N	N	N	N	All samples collected.
September 2020	30/09/20	Y	Y	Y	Y	Y	Dry piezometer at Cut 12W.

Where laboratories reported results as lower than the limits of detection, these results were incorporated into databases as the level of detection for the calculation of summary statistics and graphing.

2.2.3 Groundwater Level Monitoring

Groundwater levels were monitored using HOBO U20 data loggers and referenced using physical measurements of depth to water. Data loggers were deployed in all piezometers. The logged data has been corrected for atmospheric pressure fluctuations using an atmospheric pressure logger deployed on the Nambucca to Urunga Pacific Highway upgrade section. Logged groundwater data from the operational phase reporting period was retrieved at the same times as groundwater quality samples were collected. Manual measurements of groundwater levels were also collected at the same time as groundwater quality samples (**Table 2.8**). Measurements were taken as depth to standing water from the top of the piezometer casing using a Heron ‘Dipper T’. Manual measurements have not been translated into relative levels. The manual measurements collected were used to reference the logged data. At the time of writing there are plans to survey the levels of the groundwater piezometers so that relative levels can be provided.

Some of the groundwater piezometers used for monitoring in the pre-construction and early construction monitoring phases were decommissioned during the construction phase and new piezometers constructed. During the first year of operational phase monitoring a new groundwater piezometer was constructed at Cut 15W and a damaged piezometer at Cut 6W was repaired.

3 Results and Discussion

3.1 Rainfall

The surface water monitoring is governed by rainfall. A rainfall event triggering a wet episode sample is a minimum of 10 mm rain in 24 hours. Rainfall data from the Bureau of Meteorology (BOM) station at Nambucca Heads (Bellbrook) and Taylors Arm (the nearest stations to the northern and southern ends of the WC2NH upgrade), is presented in **Figure 3.1**.

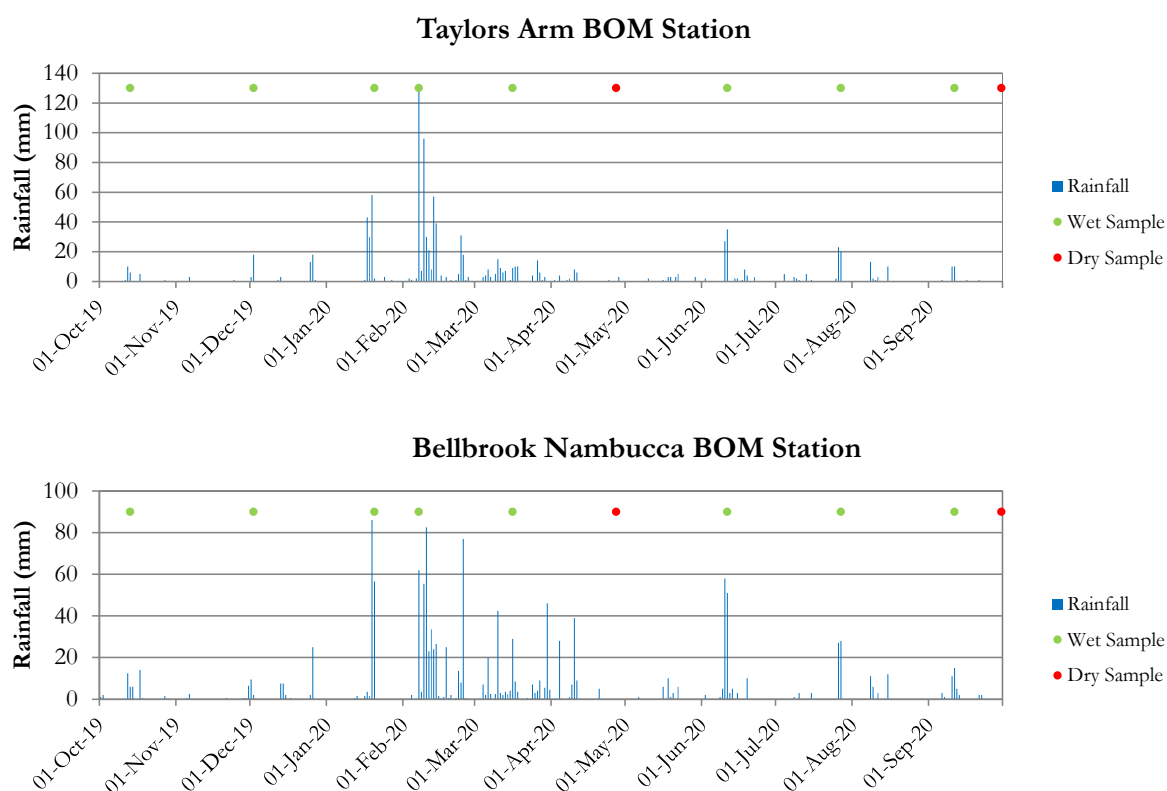


Figure 3.1 Daily rainfall at the Taylors Arm and Nambucca weather stations for the reporting period plotted against sampling events.

Rainfall for the 12 months to September 2020 was below average. At the Taylors Arm weather station there was a total of 1044 mm rain recorded and at the Nambucca weather station there was 1305 mm recorded during that time. The long-term (1908-2018) average annual rainfall recorded for Nambucca Heads is 1407.9 mm (BOM 2019).

3.2 Surface Water

A summary of surface water quality results is presented in **Appendix A**.

The SWMP suggests that the analysis of impacts can involve a comparison of the median sampling results from downstream (impact) sites with the 80th percentile (P80) value of upstream (control) sites. The downstream median data for the operational phase monitoring period from each site is presented in **Appendix A** with the upstream P80 values. To provide historical context the downstream median summary data from construction phase monitoring is also presented.

A summary of relevant statistics for each waterway is presented in **Tables A.1 to A.6**. A brief description of the summary results from each waterway follows. For the purposes of analysing the results of operational phase monitoring results of interest are defined as those where the operational phase downstream median is greater than the combined construction and operational phase upstream P80.

3.2.1 Upper Warrell Creek

There was one result of interest from the Upper Warrell Creek monitoring sites (**Table A.1**), being the operational downstream median Fe concentration. There is no relevant ANZECC (2000) default trigger value for Fe. A graph of Fe concentrations from Upper Warrell Creek (**Figure 3.5**) shows that, although the highest downstream concentrations of Fe has been recorded during the operational phase, high downstream concentrations of Fe have all been associated with high upstream concentrations. This indicates that the source of elevated Fe concentrations is further up the catchment and not associated with highway operation.

Operational phase TSS, turbidity and pH measurements from Upper Warrell Creek have been within the ranges of variation measured during the construction phase (except for one upstream and one downstream turbidity measurement in February 2020) and do not indicate any impacts from highway operation (**Figures 3.2 to 3.4**).

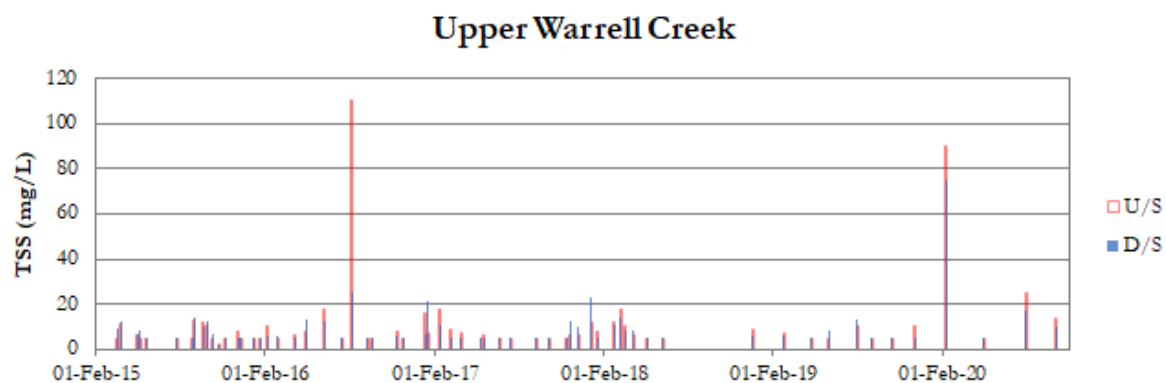


Figure 3.2 Total suspended solid concentrations at Upper Warrell Creek since February 2015.

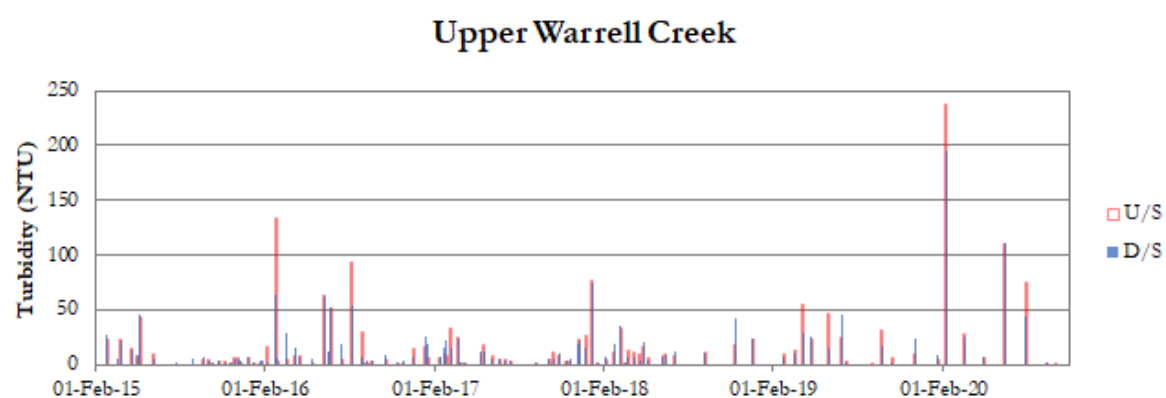


Figure 3.3 Turbidity measurements at Upper Warrell Creek since February 2015.

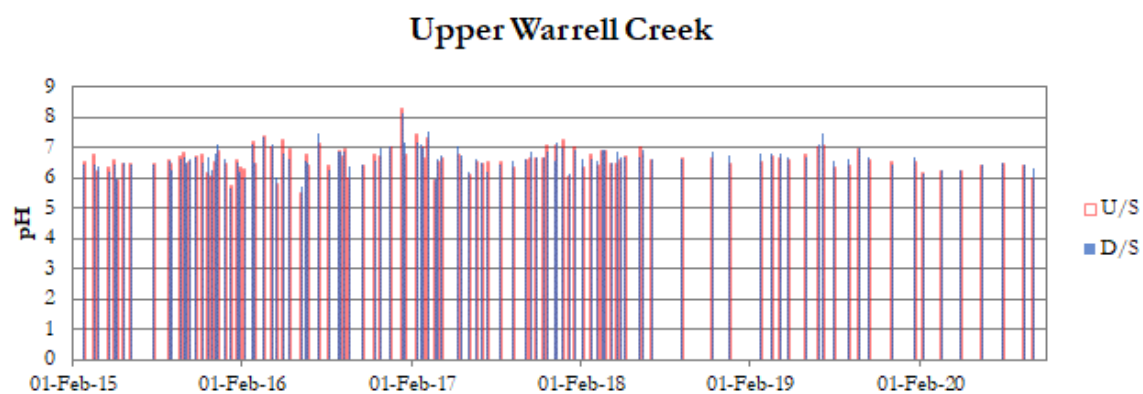


Figure 3.4 pH measurements at Upper Warrell Creek since February 2015.

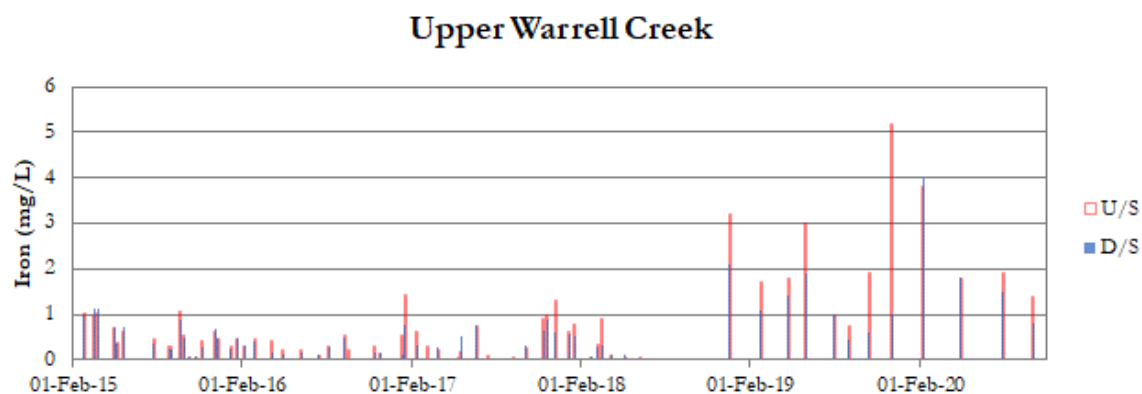


Figure 3.5 Iron concentrations at Upper Warrell Creek since February 2015.

The operational phase surface water quality monitoring results to date from Upper Warrell Creek do not indicate any impacts from highway operation. There are no new recommendations for ongoing water quality management at Upper Warrell Creek.

3.2.2 Stony Creek

There were three results of interest from the Stony Creek monitoring sites (**Table A.2**). These were the operational downstream median Mn, Fe and turbidity measurements. While the downstream median measurements for all parameters complied with the relevant default ANZECC guideline concentrations, there are no relevant ANZECC default guideline concentrations for Fe. Graphs of the Mn and Fe concentrations from Stony Creek (**Figures 3.9** and **3.10**) show that, although downstream concentrations have often been higher than the upstream concentrations during the operational phase, most of the highest downstream concentrations have been associated with high upstream concentrations and most of the results are within the ranges of pre-construction and construction phase monitoring. The results are unlikely to be associated with highway operation. The graph of turbidity shows that the three highest downstream turbidity measurements have been collected during the operational phase monitoring but that there is no clear pattern of elevated turbidity measurements (**Figure 3.7**). The highest downstream turbidity measurement occurred on 2nd December 2020 when water levels were very low and field notes recorded no flow into the downstream site, in effect the turbid water at that time was unrelated to the highway. It is unclear if the elevated median downstream turbidity measurement is associated with highway operation. Operational phase downstream TSS and pH measurements from Stony Creek are within the ranges observed during construction phase sampling and do not indicate any impacts from highway operation (**Figures 3.6** and **3.8**).

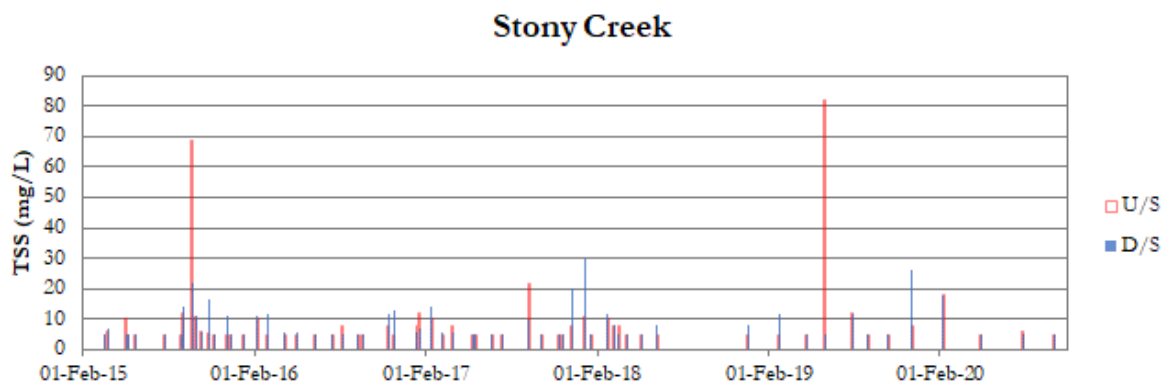


Figure 3.6 Total suspended solid concentrations at Stony Creek since February 2015.

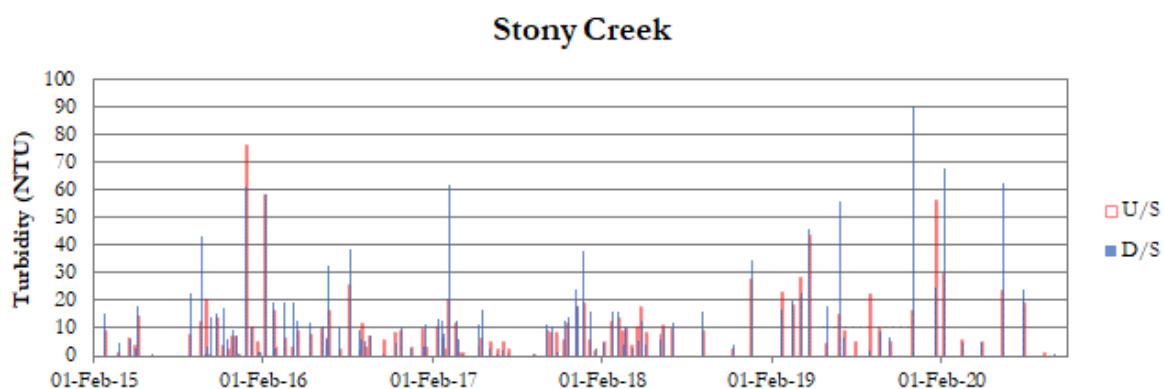


Figure 3.7 Turbidity measurements at Stony Creek since February 2015.

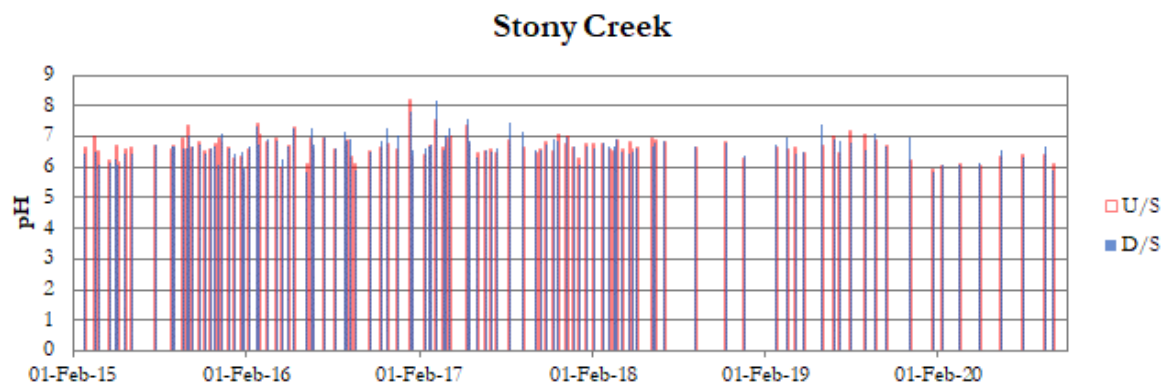


Figure 3.8 pH measurements at Stony Creek since February 2015.

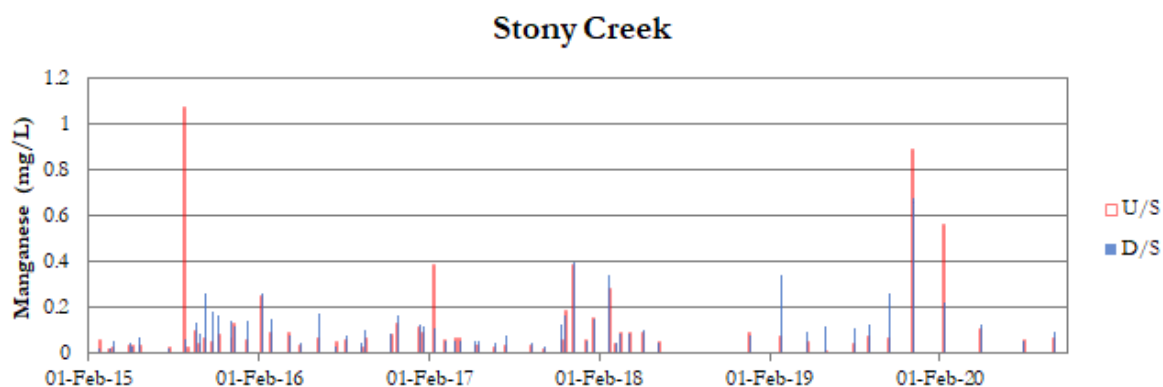


Figure 3.9 Manganese concentrations at Stony Creek since February 2015.

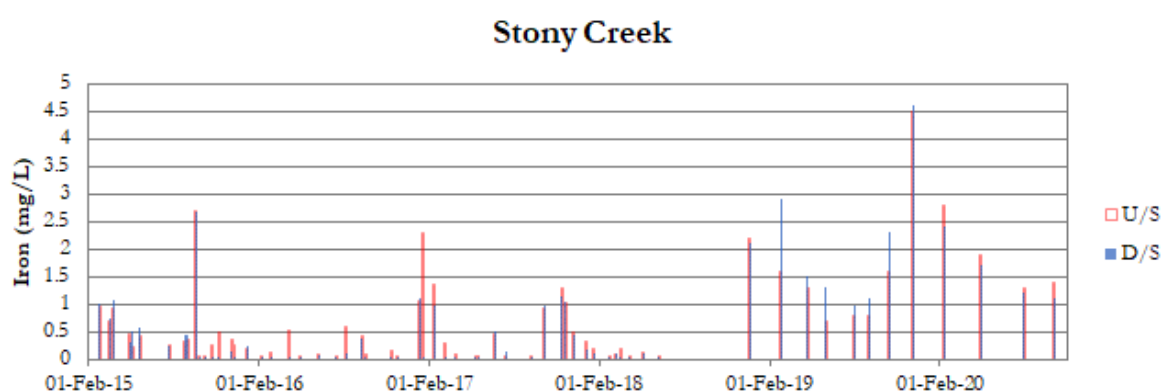


Figure 3.10 Iron concentrations at Stony Creek since February 2015.

Although there were 3 results of interest among the summary statistics from Stony Creek the operational phase surface water quality monitoring results to date do not indicate any clear water quality impacts arising from highway operation. There have been some elevated downstream turbidity measurements but ongoing monitoring should indicate whether there is an impact. There are no new recommendations for ongoing water quality management at Stony Creek.

3.2.3 Lower Warrell Creek

There were two results of interest from the Lower Warrell Creek monitoring sites (**Table A.3**). These were the operational downstream median TDS and conductivity measurements. Both of these values were within the normal ranges for a tidal waterway and reflect increasing salinity resulting from dry conditions rather than any impact from highway operations (see **Section 3.1**). Similar patterns can be seen on numerous occasions throughout the construction phase monitoring (**Figures 3.14** and **3.15**). Operational phase TSS, turbidity and pH measurements from Lower Warrell Creek have been within the ranges of variation measured during the

construction phase and do not indicate any impacts from highway operation (**Figures 3.11 to 3.13**).

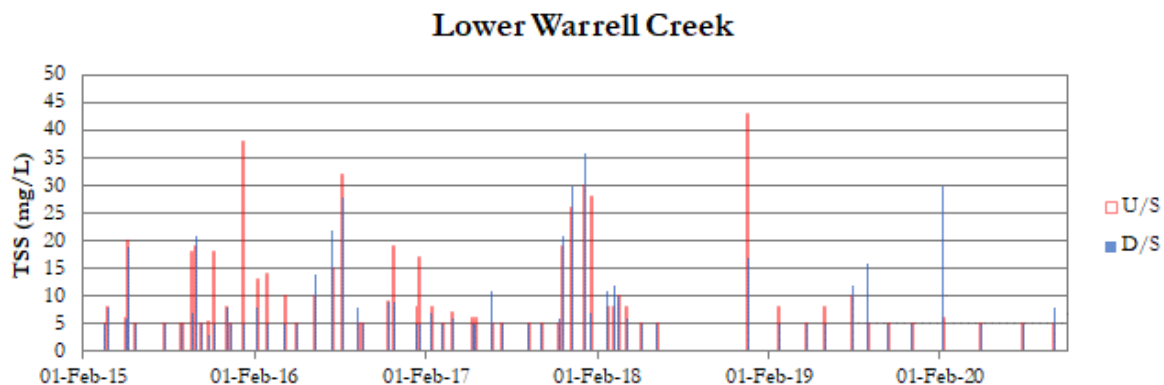


Figure 3.11 Total suspended solid concentrations at Lower Warrell Creek since February 2015.

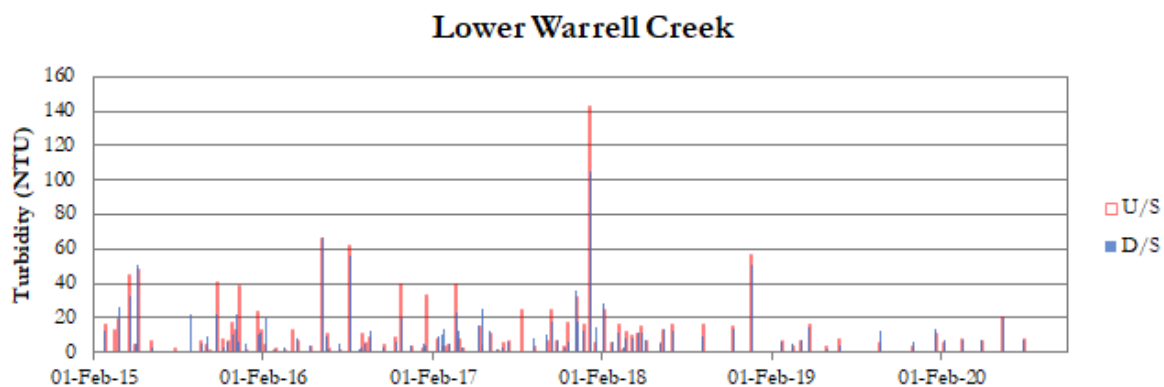


Figure 3.12 Turbidity measurements at Lower Warrell Creek since February 2015.

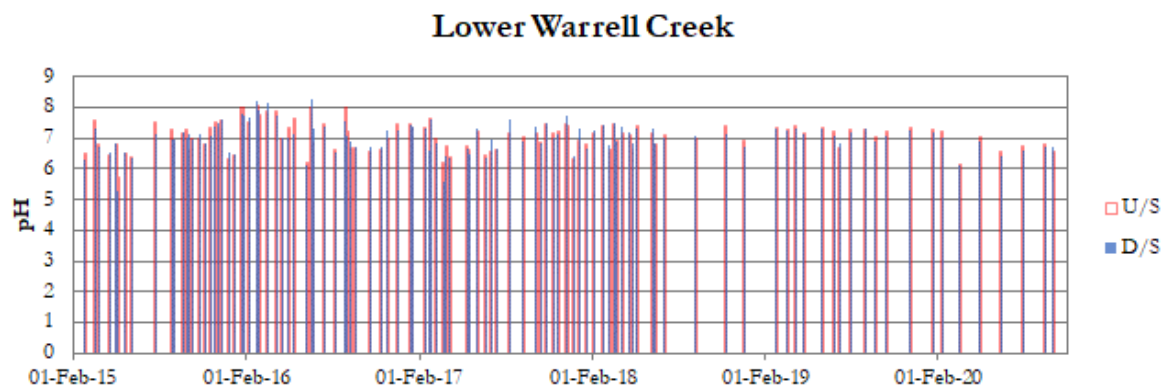


Figure 3.13 pH measurements at Lower Warrell Creek since February 2015.

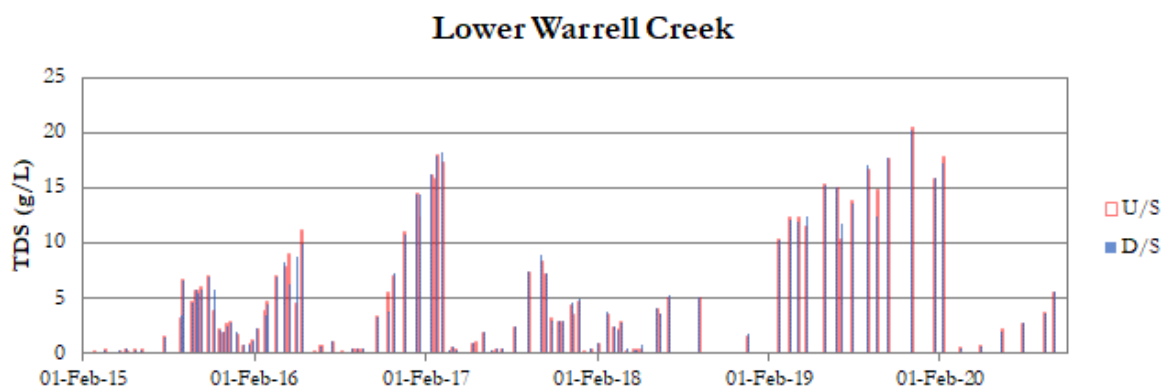


Figure 3.14 Total dissolved solid concentrations at Lower Warrell Creek since February 2015.

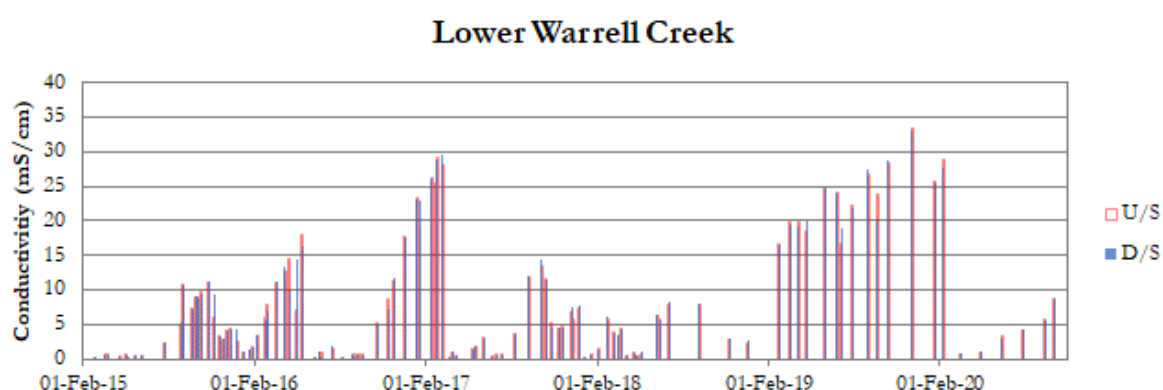


Figure 3.15 Conductivity measurements at Lower Warrell Creek since February 2015.

The operational phase surface water quality monitoring results to date from Lower Warrell Creek do not indicate any impacts from highway operation. There are no new recommendations for ongoing water quality management at Lower Warrell Creek.

3.2.4 Unnamed Creek Gumma West

There were five results of interest from the Unnamed Creek Gumma West monitoring sites (Table A.4). These were the operational downstream median Al, As, Fe, TDS and conductivity measurements. Of these, the median downstream As, Fe, and conductivity measurements complied with the relevant ANZECC (2000) guideline value for ecosystem protection in fresh water. There is no relevant ANZECC (2000) default guideline for TDS concentrations and the median Al concentration measured did not comply with the relevant guideline value. The elevated conductivity and TDS measurements recorded to date during the operational phase monitoring are linked to saline encroachment due to dry weather. As dry conditions persist tidal movements from the Nambucca River have an increasing impact on Gumma Swamp (Birch

2019). Similar patterns were observed during the construction phase monitoring (**Figures 3.22 and 3.23**). The elevated median downstream TDS and conductivity measurements are not likely to be associated with highway operation. Graphs of Al, As and Fe concentrations (**Figures 3.19, 3.20 and 3.21**) show that operational phase measurements have been within the ranges of construction phase measurements, elevated concentrations are isolated incidences and that elevated downstream concentrations are usually accompanied by elevated upstream concentrations. Operational phase TSS and turbidity measurements from the Unnamed Creek Gumma West have been within the ranges of variation measured during the construction phase and do not indicate any impacts from highway operation (**Figures 3.16 to 3.17**).

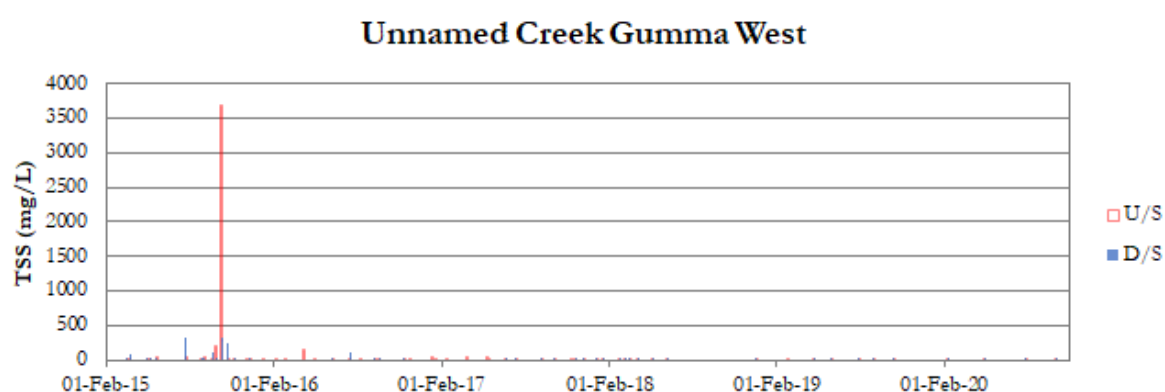


Figure 3.16 Total suspended solid measurements at Unnamed Gumma Creek West since February 2015.

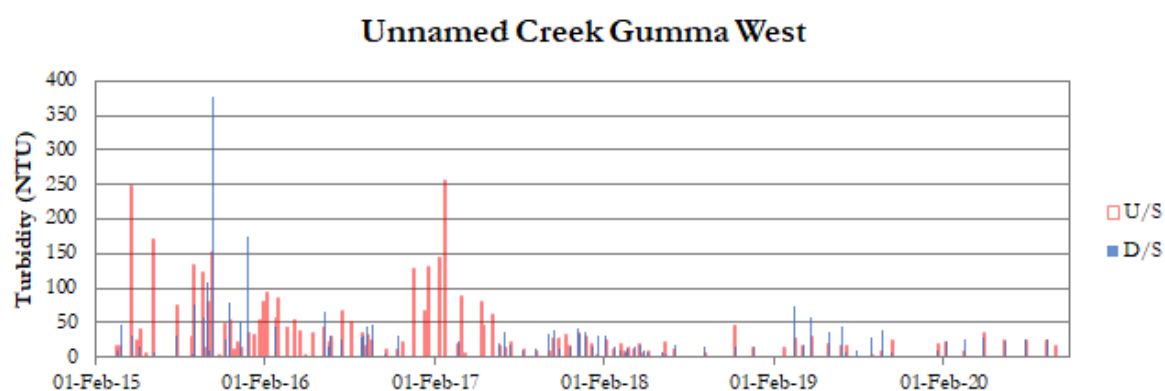


Figure 3.17 Turbidity measurements at Unnamed Gumma Creek West since February 2015.

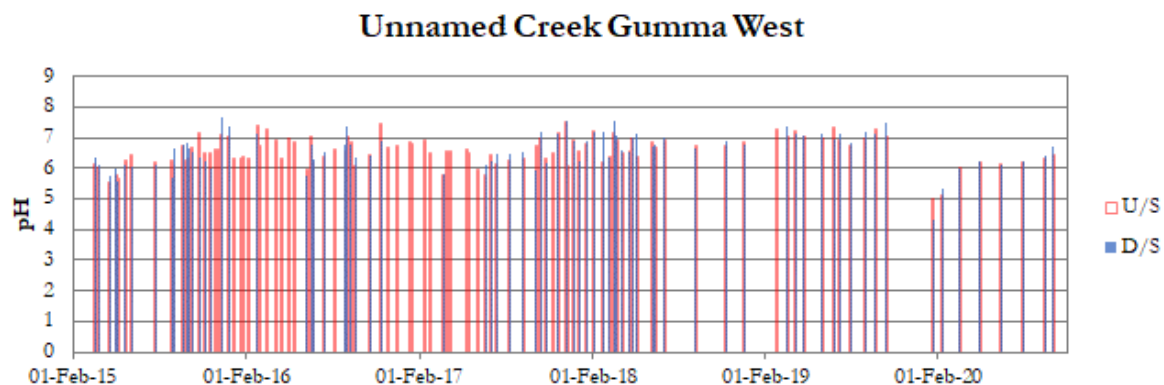


Figure 3.18 pH measurements at Unnamed Gumma Creek West since February 2015.

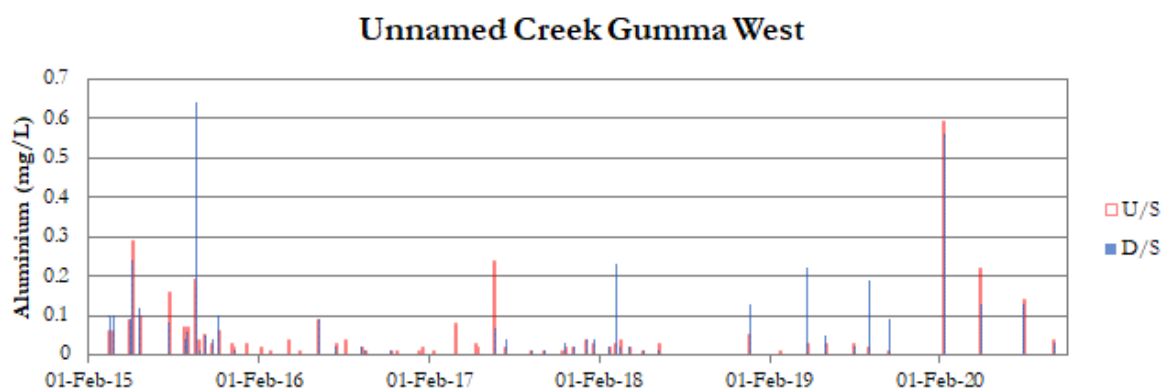


Figure 3.19 Aluminium concentrations at Unnamed Gumma Creek West since February 2015.

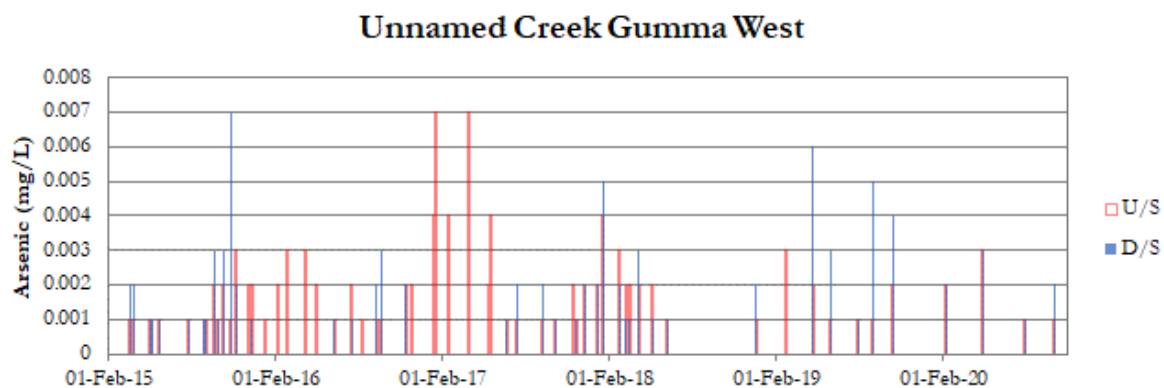


Figure 3.20 Arsenic concentrations at Unnamed Gumma Creek West since February 2015.

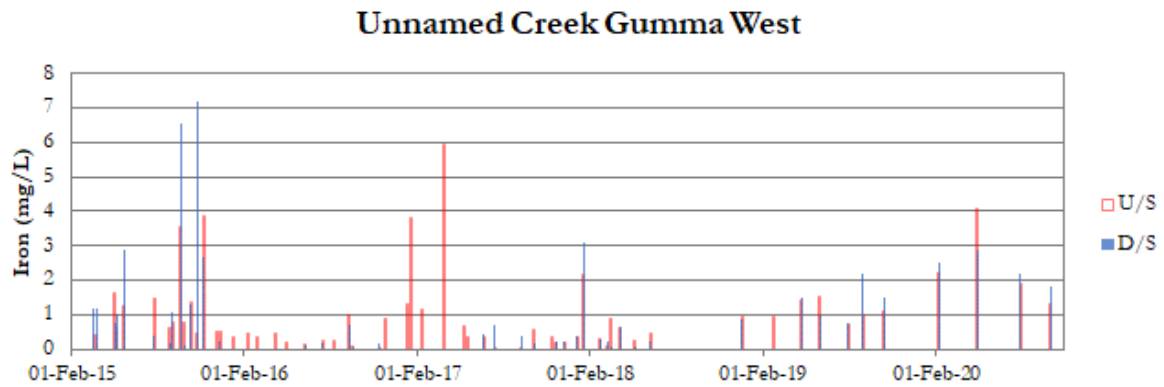


Figure 3.21 Iron concentrations at Unnamed Gumma Creek West since February 2015.

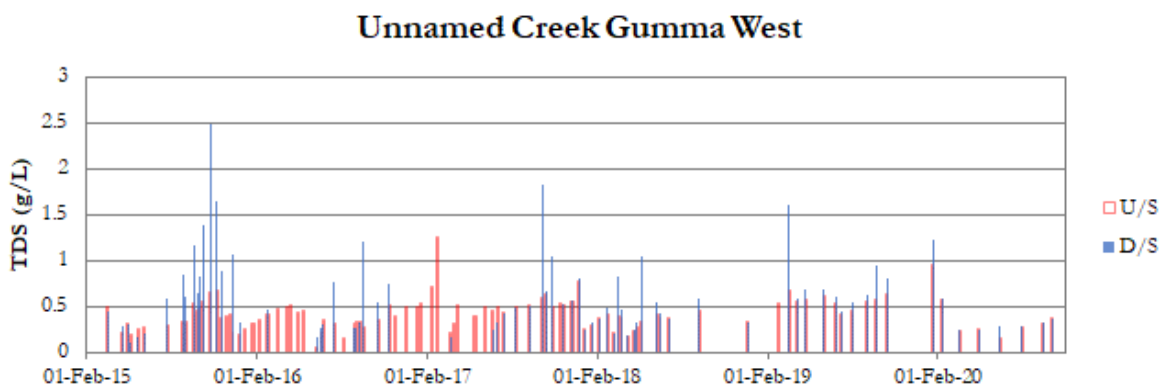


Figure 3.22 Total dissolved solid concentrations at Unnamed Gumma Creek West since February 2015.

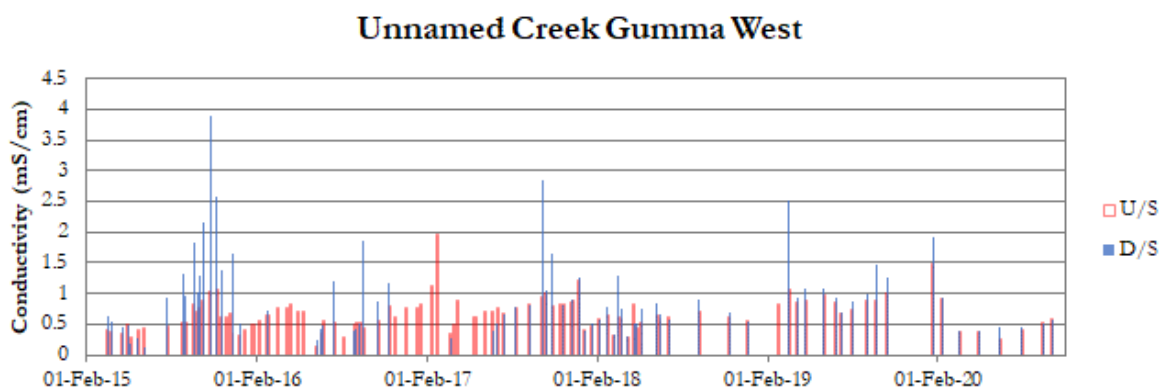


Figure 3.23 Conductivity measurements at Unnamed Gumma Creek West since February 2015.

Although there were five results of interest among the summary statistics from Unnamed Creek Gumma West the operational phase surface water quality monitoring results to date give no clear indications of significant impacts associated with highway operation. There are no new recommendations for ongoing water quality management at Unnamed Creek Gumma West.

3.2.5 Unnamed Creek Gumma East

There were four results of interest from the Unnamed Creek Gumma East monitoring sites (**Table A.5**). These were the operational downstream median Fe, TDS, pH and conductivity measurements. Each of these results only narrowly exceeded the upstream P80 value and the operational downstream median values for Fe, pH and conductivity complied with the relevant default ANZECC (2000) guideline values. There is no relevant ANZECC (2000) default guideline for TDS concentrations. A graph of Fe concentrations (**Figure 3.27**) shows that downstream operational phase measurements have been within the ranges of construction phase measurements and that the highest measurements during the operational phase have been from the upstream site. The median downstream operational conductivity and TDS measurements recorded to date during the operational phase monitoring are linked to saline encroachment due to dry weather. As dry conditions persist tidal movements from the Nambucca River have an increasing impact on Gumma Swamp (Birch 2019). Similar patterns were observed during the construction phase monitoring (**Figures 3.28 and 3.29**). The same mechanisms also have an impact upon pH measurements, because estuarine waters have a higher pH and also contain buffering salts that lead to higher pH measurements when mixed with fresh water. The median downstream results of interest for pH, TDS and conductivity measurements are not likely to be associated with highway operation. Operational phase TSS and turbidity measurements from the Unnamed Creek Gumma West have been within the ranges of variation measured during the construction phase and do not indicate any impacts from highway operation (**Figures 3.24 to 3.25**).

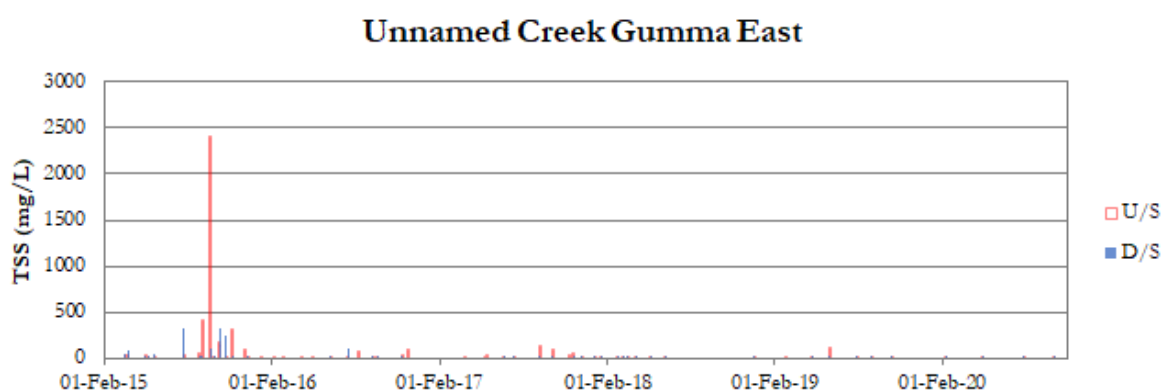


Figure 3.24 Total suspended solid measurements at Unnamed Gumma Creek East since February 2015.

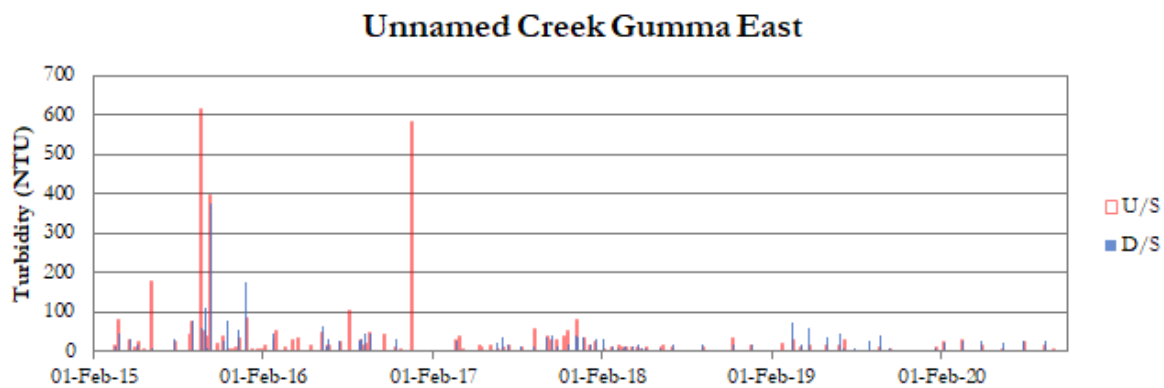


Figure 3.25 Turbidity measurements at Unnamed Gumma Creek East since February 2015.

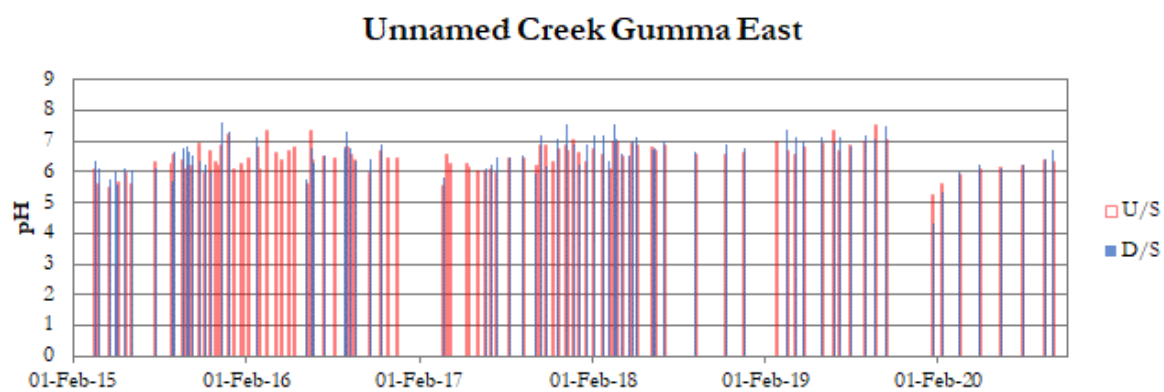


Figure 3.26 pH measurements at Unnamed Gumma Creek East since February 2015.

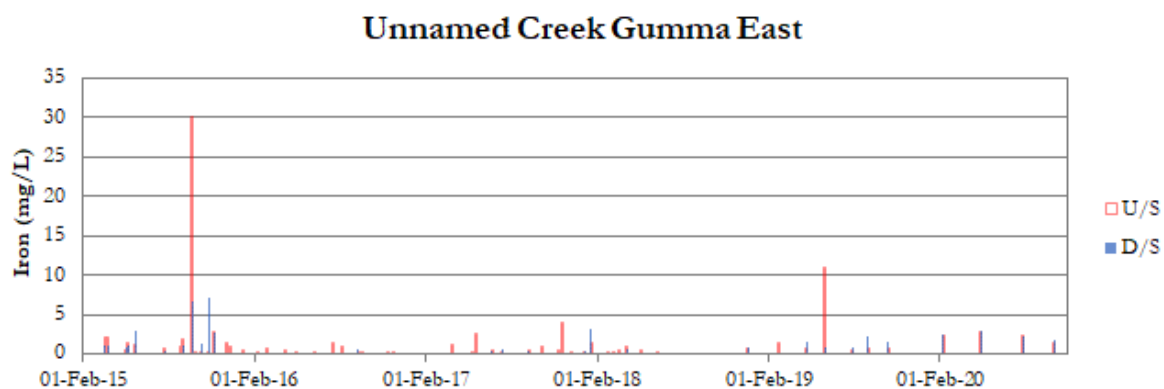


Figure 3.27 Iron concentrations at Unnamed Gumma Creek East since February 2015.

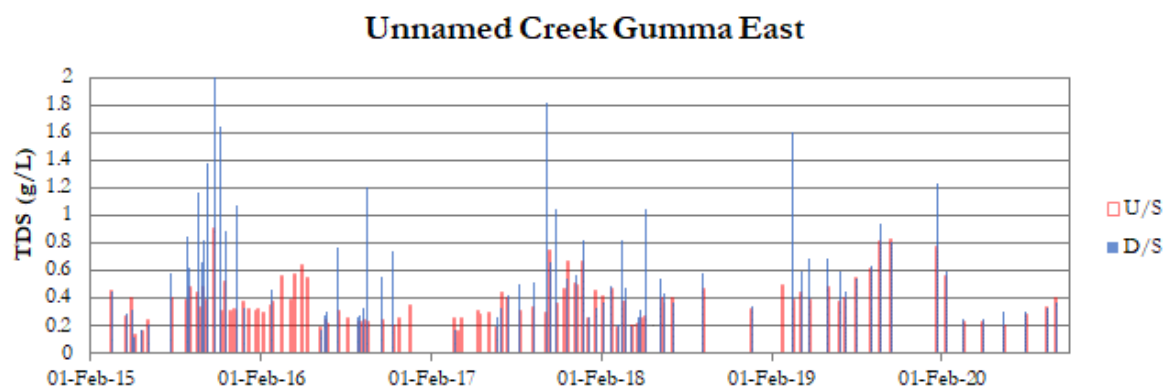


Figure 3.28 Total dissolved solid measurements at Unnamed Gumma Creek East since February 2015.

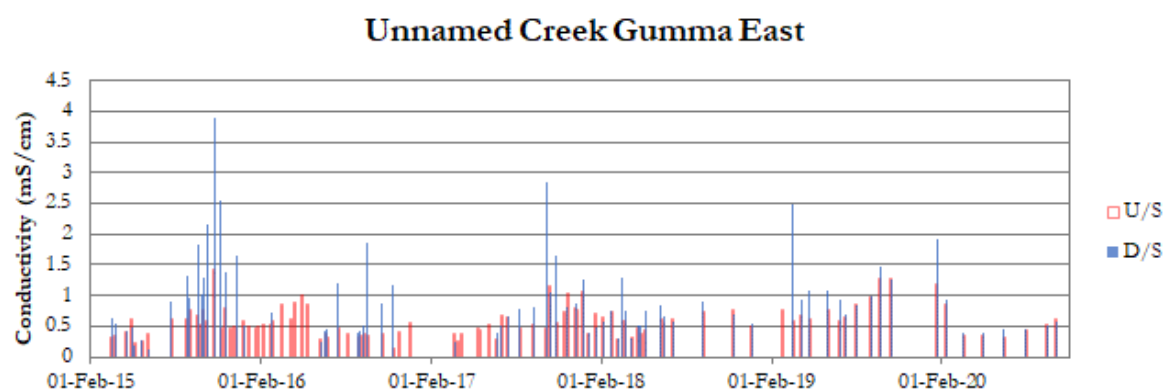


Figure 3.29 Conductivity measurements at Unnamed Gumma Creek East since February 2015.

The operational phase surface water quality monitoring results to date from Unnamed Creek Gumma East do not indicate any impacts from highway operation. There are no new recommendations for ongoing water quality management at Unnamed Creek Gumma East.

3.2.6 Nambucca River

There were no results of interest from the Nambucca River sites (**Table A.6**). Operational phase TSS, turbidity and pH measurements from the Nambucca River have been within the ranges of variation measured during the construction phase and do not indicate any impacts from highway operation (**Figures 3.30 to 3.32**).

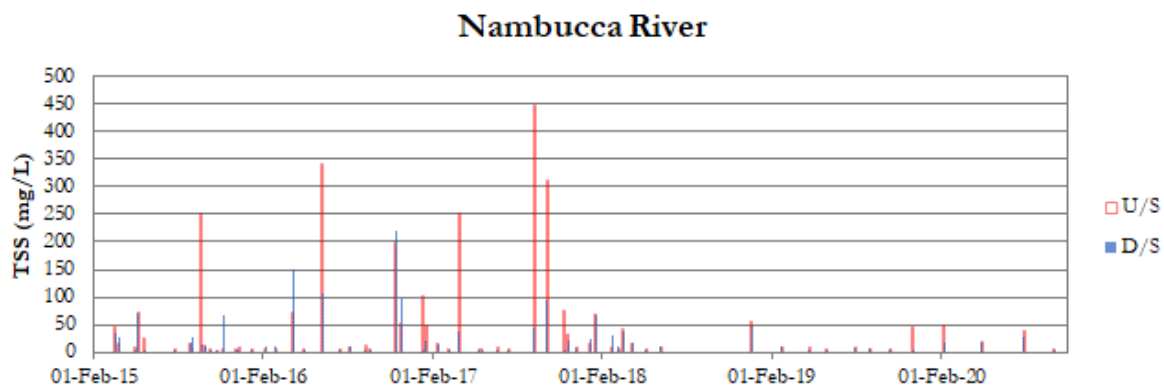


Figure 3.30 Total suspended solid measurements at the Nambucca River since February 2015.

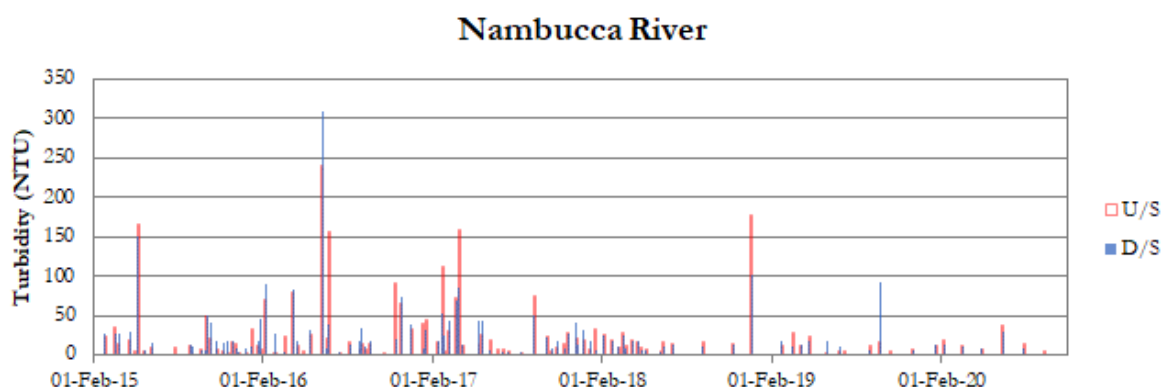


Figure 3.31 Turbidity measurements at the Nambucca River since February 2015.

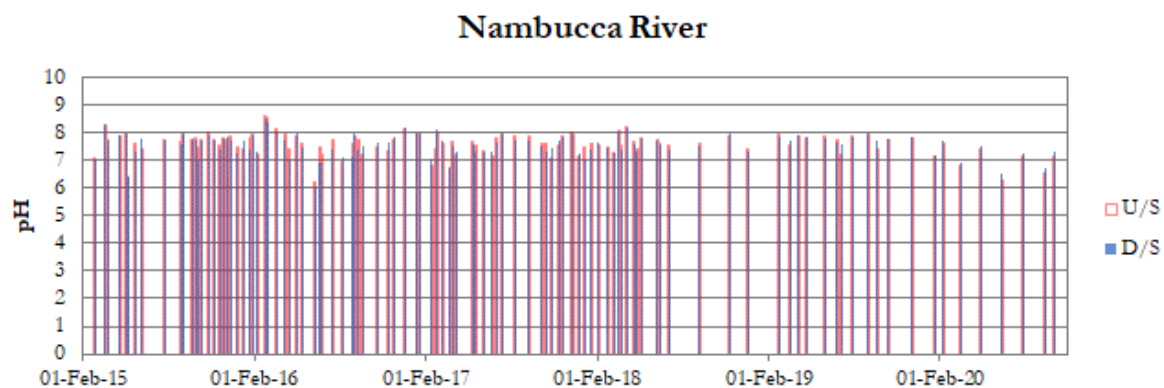


Figure 3.32 pH measurements at the Nambucca River since February 2015.

The operational phase surface water quality monitoring results to date from the Nambucca River do not indicate any impacts from highway operation. There are no new recommendations for ongoing water quality management at the Nambucca River.

3.3 Groundwater Quality

A summary of groundwater quality results from the construction phase monitoring is provided in **Appendix B**.

The GWMP suggests that the analysis of impacts should involve a comparison of the median sampling results from downgradient (impact) sites with the 80th percentile (P80) value of upgradient (control) sites. The summary data from each downgradient site is presented in **Appendix B** with the upgradient P80 values from the construction phase.

The relevant summary statistics for each groundwater site are presented in **Tables B.1 to B.5**. A description of the summary results from each cut or fill follows. For the purposes of assessing the results of operational phase monitoring with earlier results we have defined results of interest as those where the operational phase downgradient median is greater than the combined construction and operational phase upgradient P80.

3.3.1 Ch 45165 – Cut 6

There were no results of interest from Ch 45165 during this reporting period. There was no upgradient piezometer at Ch 45165 (**Table B.1**). The upgradient piezometer was decommissioned during the construction phase after consultation with Department of Planning and Environment and NSW Government agencies. The downgradient piezometer at Ch 45165 was damaged during the first year of operational monitoring and has since been repaired. It is intermittently dry. As a result, there are fewer operational phase samples from Ch 45165 than some of the other sites. The median conductivity and pH measurements from the samples collected did not comply with the relevant ANZECC and ADWG guidelines. However, the results were within the variation previously observed at that site (**Figures 3.33 and 3.34**). Several other operational phase downstream median results did not comply with ANZECC and/or ADWG guidelines. The results are comparable with the corresponding results from the construction phase and there is no indication of an impact from highway operation on groundwater at Ch 45165.

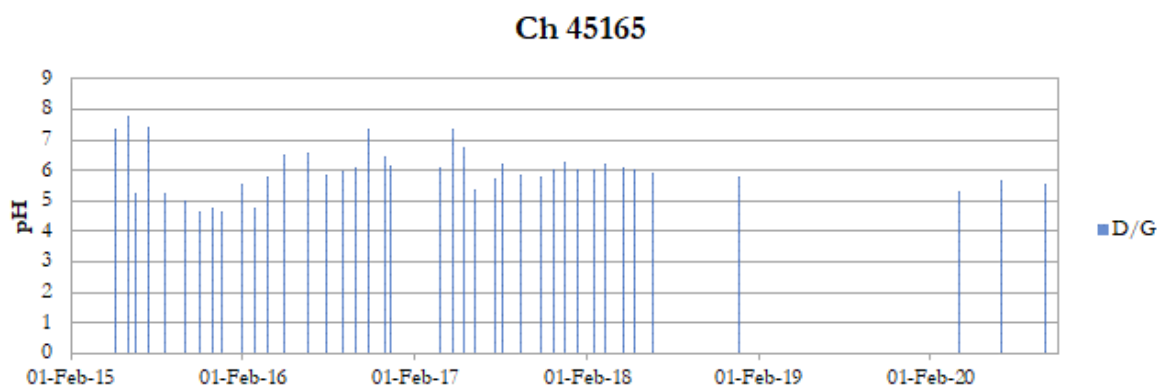


Figure 3.33 Groundwater pH measurements at Ch 45165 since February 2015.

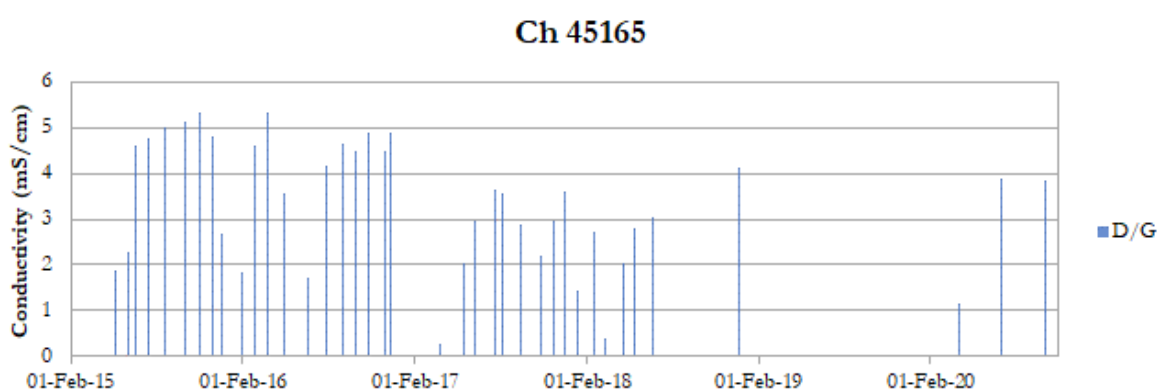


Figure 3.34 Groundwater conductivity measurements at Ch 45165 since February 2015.

3.3.2 Ch 48665 – Cut 11

There were 4 results of interest from Ch 48665 (**Table B.2**). These were the operational downgradient median Cu, TP, PO₄ and total alkalinity measurements. The Cu, TP and PO₄ values all exceeded the relevant ANZECC (2000) guideline concentration for ecosystem protection and the TP and PO₄ values also exceeded the NHMRC guideline concentration for drinking water. There are no relevant guideline values for total alkalinity. The Cu concentrations measured to date during operational phase monitoring have been within the ranges observed during construction phase monitoring and the elevated downgradient concentrations are unlikely to have resulted from highway operation (**Figure 3.37**). Some of the downgradient TP and PO₄ concentrations measured during operational phase monitoring have been higher than those measured in construction phase monitoring (**Figures 3.38 and 3.39**). Total alkalinity measurements (**Figure 3.40**) have only been collected in the operational phase and are no previous data is available for comparisons. The conductivity measurements to date indicate that

samples collected from upgradient and downgradient piezometers at Ch 48665 are potentially from different aquifers (**Figure 3.36**). The upgradient conductivity is routinely higher than the downgradient conductivity, despite being further from the tidal influence of Warrell Creek. This could indicate that any results of interest may not be related to impacts from highway operation.

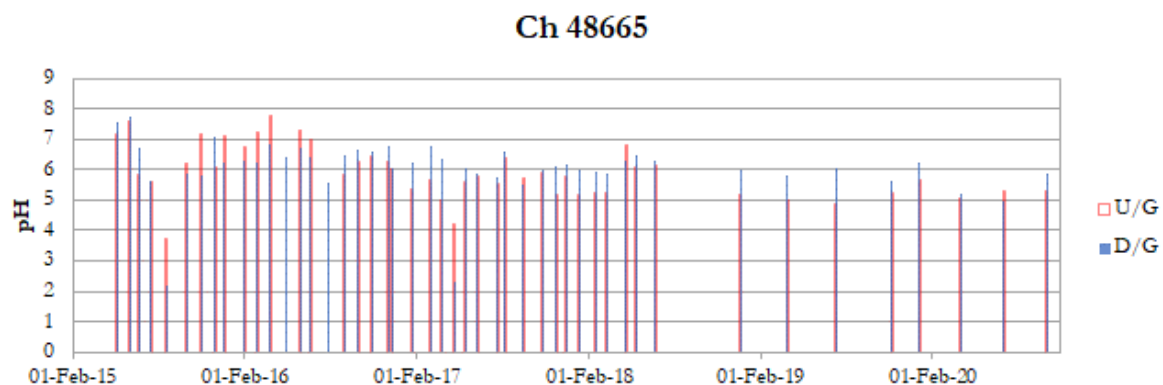


Figure 3.35 Groundwater pH measurements at Ch 48665 since February 2015.

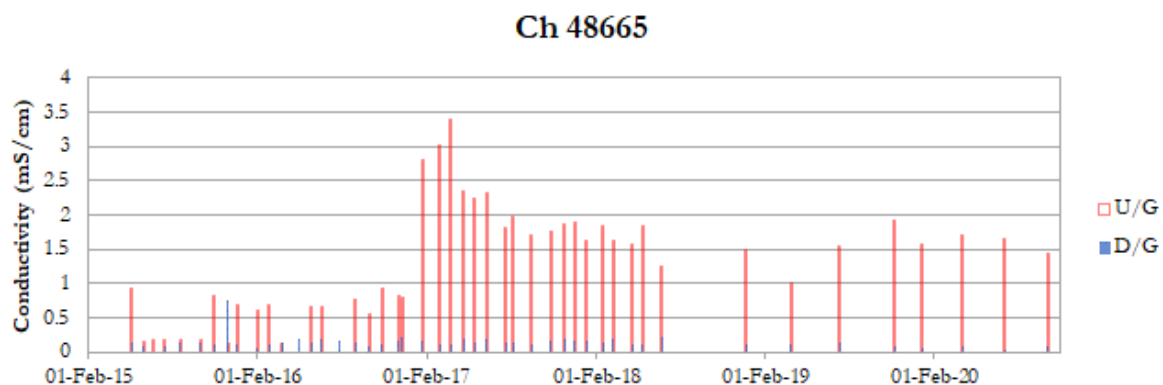


Figure 3.36 Groundwater conductivity measurements at Ch 48665 since February 2015.

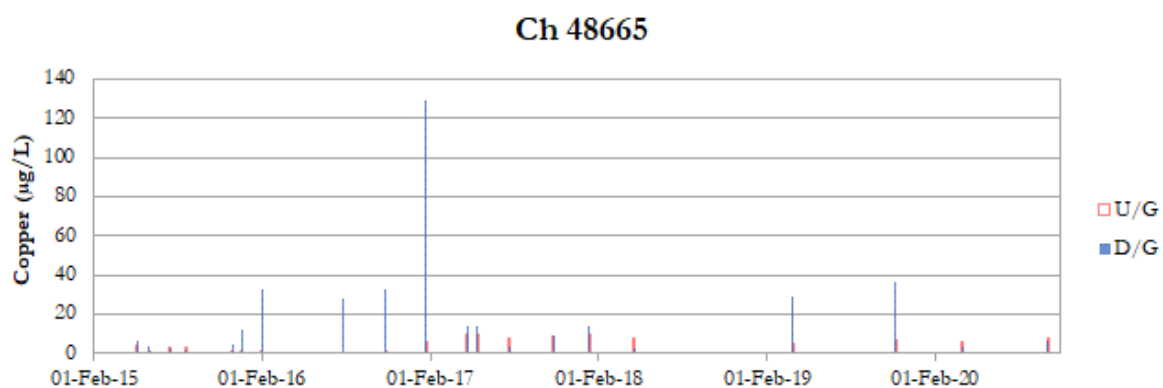


Figure 3.37 Groundwater copper measurements at Ch 48665 since February 2015.

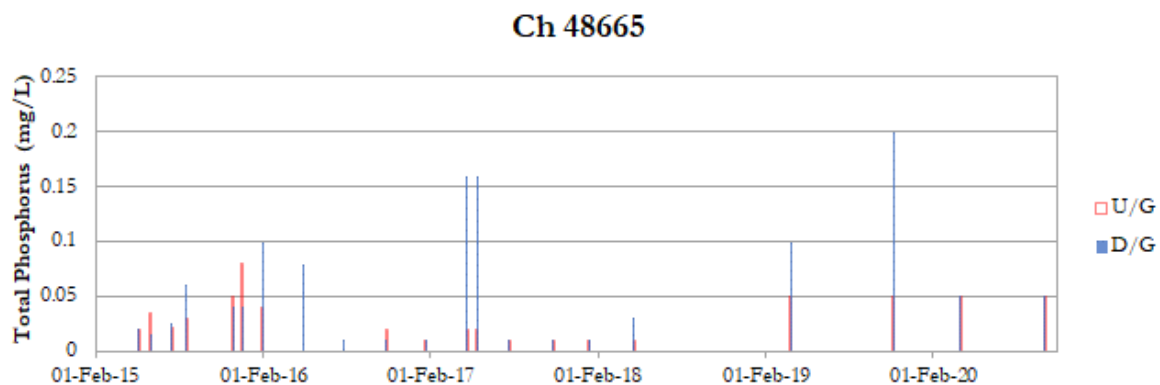


Figure 3.38 Groundwater total phosphorus measurements at Ch 48665 since February 2015.

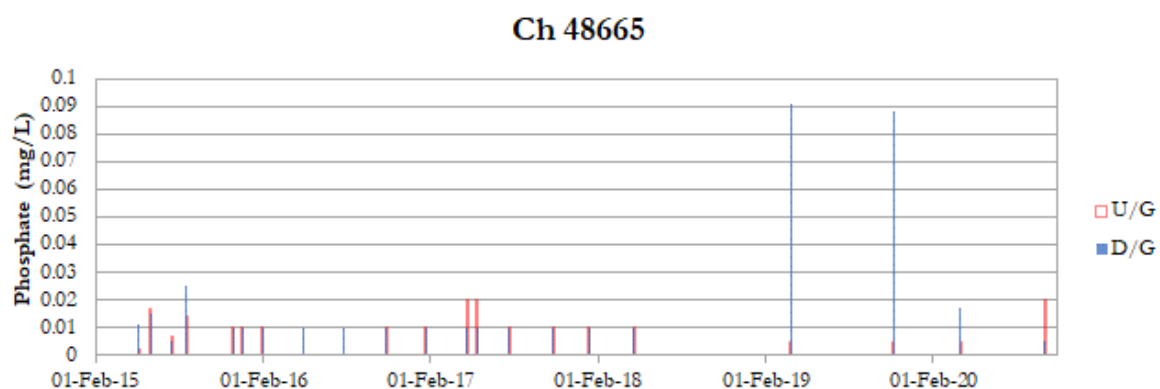


Figure 3.39 Groundwater phosphate measurements at Ch 48665 since February 2015.

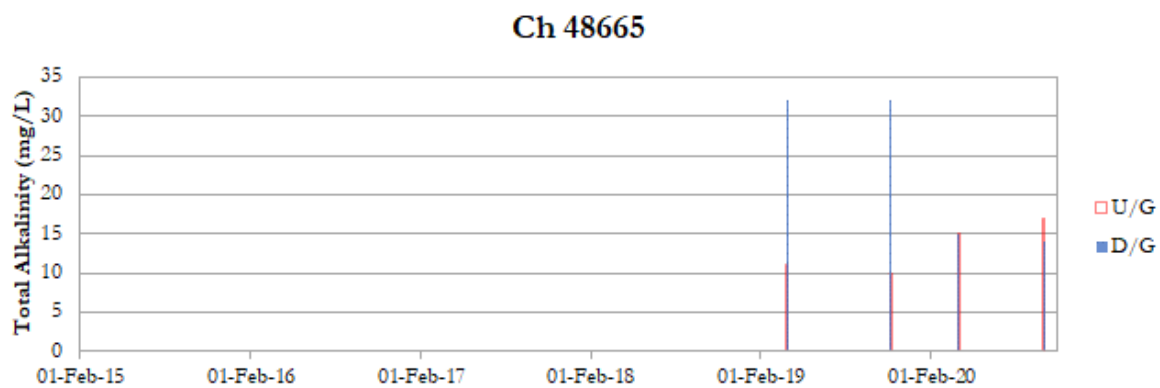


Figure 3.40 Groundwater total alkalinity measurements at Ch 48665 since February 2015.

The operational phase groundwater quality monitoring results to date do not provide a clear indication of impacts associated with highway operation at Ch 48665. Although high TP and PO₄ measurements have been collected during operational phase monitoring it is possible that these relate to factors not associated with the highway. Continued monitoring will indicate whether there is a trend towards increasing phosphorus concentrations in downgradient

groundwater. There are no new recommendations for ongoing groundwater quality management at Ch 48665.

3.3.3 Ch 49365 – Cut 12

There were no results of interest from Ch 49365 (**Table B.3**). There is no upgradient piezometer at Ch 49365 for the operational monitoring phase. The upgradient piezometer was decommissioned during the construction phase after consultation with Department of Planning and Environment and NSW Government agencies. The downgradient piezometer at Ch 49365 is intermittently dry and has only had water to sample on two occasions since the start of operational monitoring. The downgradient pH and conductivity measurements from Ch 49365 were outside of the ranges measured in construction phase monitoring but only very slightly so (**Figures 3.41** and **3.42**). It is unlikely that the measured differences are related to highway operation or any other negative impact.

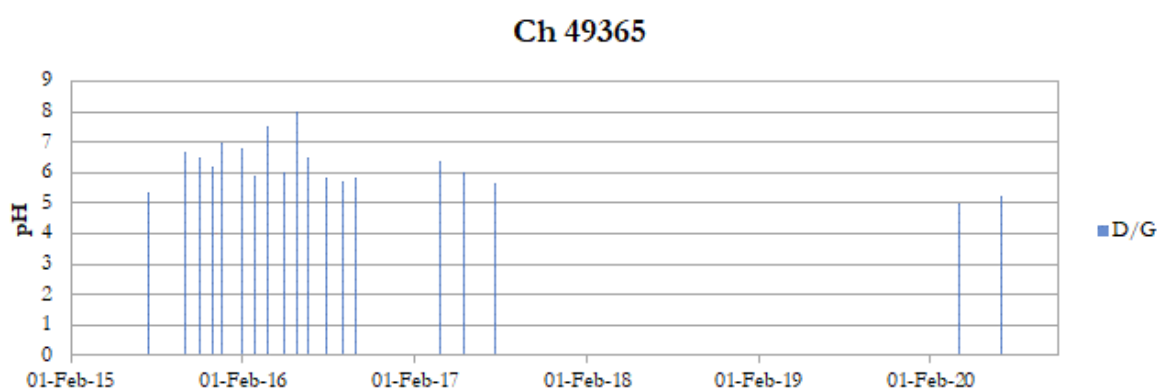


Figure 3.41 Groundwater pH measurements at Ch 49365 since February 2015.

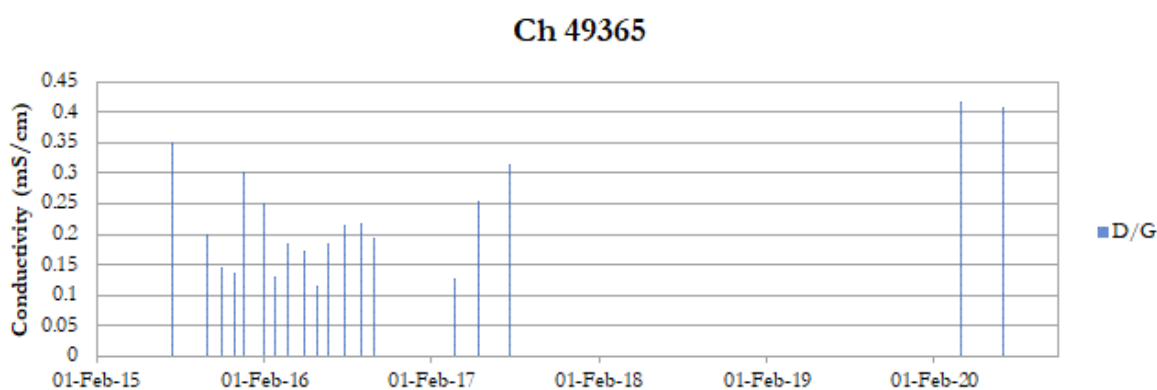


Figure 3.42 Groundwater conductivity measurements at Ch 49365 since February 2015.

The operational phase groundwater quality monitoring results to date do not provide any indication of impacts associated with highway operation at Ch 49365. There are no new recommendations for ongoing groundwater quality management at Ch 49365

3.3.4 Ch 50965 – Fill 15

There were five results of interest from Ch 50965 (**Table B.4**), being the downgradient median TP, TN, NO₃, Ca²⁺ and conductivity measurements. None of these results were within the relevant ANZECC default guideline concentration for ecosystem protection. There are no relevant guidelines for Ca²⁺ concentrations and no ADWG guideline for TN and TP. There were several results of interest generated for groundwater quality at Ch 50965 during the construction phase monitoring. However, of the results of interest there are none that indicate an impact of highway operation on groundwater at Ch 50965. Conductivity measurements indicate that both upgradient and downgradient groundwater has been subject to saline water encroachment during the operational phase, probably as a result of continued dry weather and the influence of the Nambucca River estuary (**Figure 3.44**). A similar pattern has been evident in previous monitoring and is also repeated in nearby surface water measurements (see **Section 3.2.4**). This phenomenon also explains the elevated concentrations of Ca²⁺ measured upgradient and downgradient of the highway fill (**Figure 3.48**). The operational phase TP, TN and NO₃ measurements from Ch 50965 have returned inconsistent results but are within the upgradient and downgradient ranges observed during construction phase monitoring with the exception of one upgradient and one downgradient NO₃ measurement (**Figures 3.45 to 3.47**).

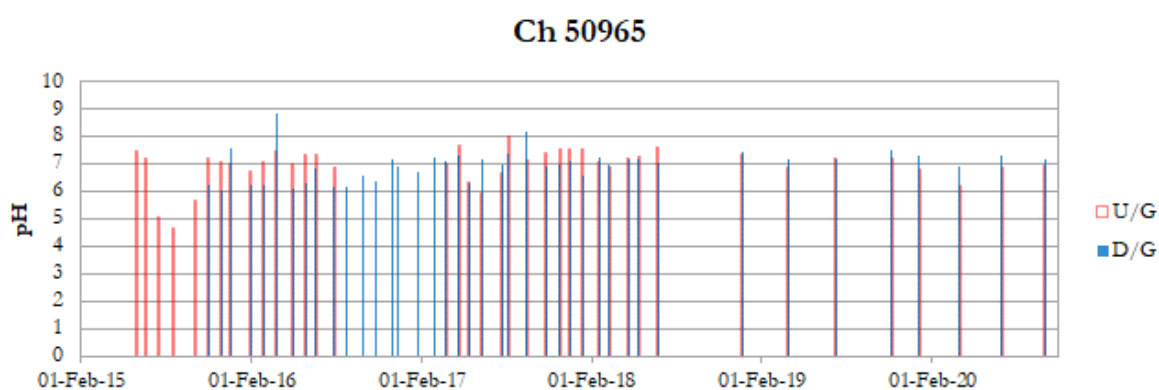


Figure 3.43 Groundwater pH measurements at Ch 50965 since February 2015.

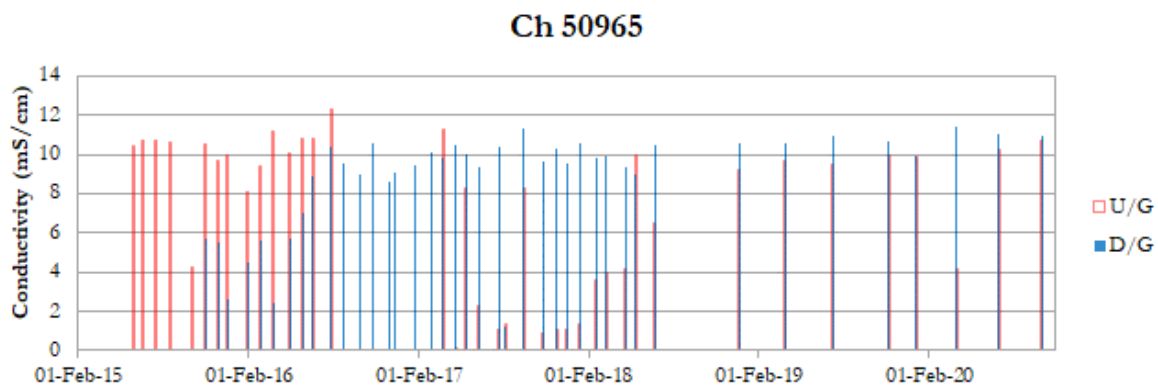


Figure 3.44 Groundwater conductivity measurements at Ch 50965 since February 2015.

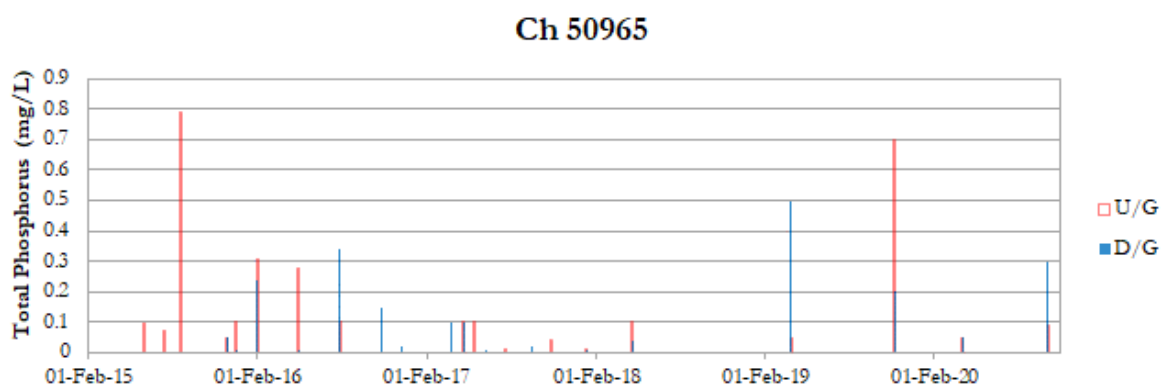


Figure 3.45 Groundwater total phosphorus measurements at Ch 50965 since February 2015.

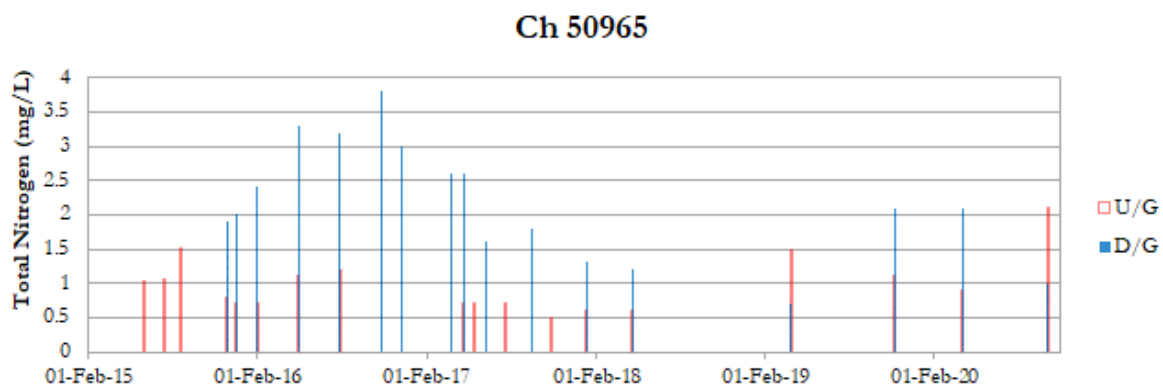


Figure 3.46 Groundwater total nitrogen measurements at Ch 50965 since February 2015.

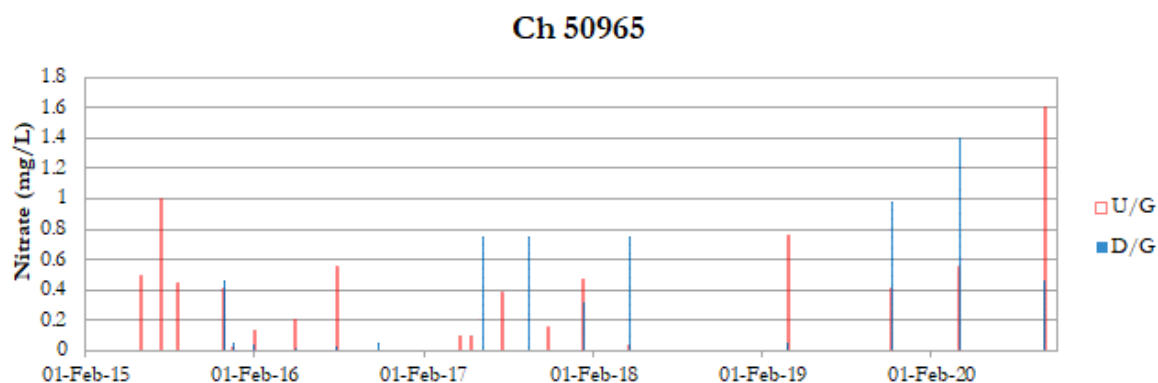


Figure 3.47 Groundwater nitrate measurements at Ch 50965 since February 2015.

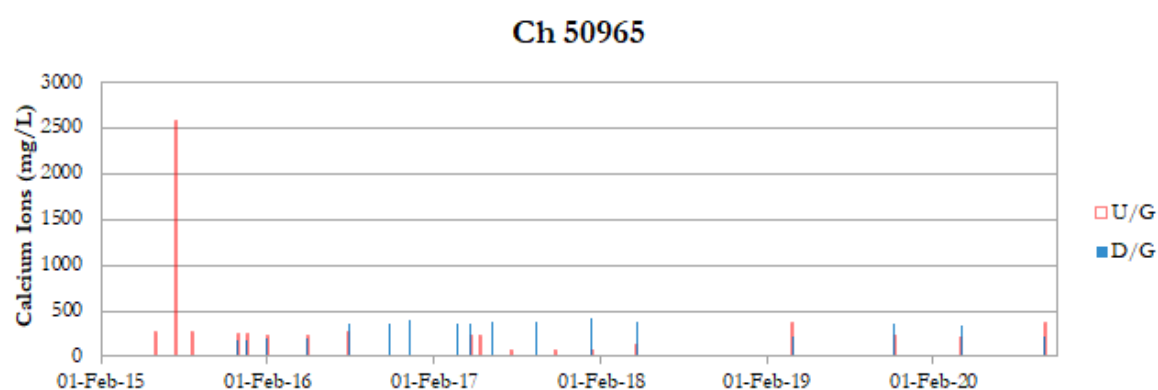


Figure 3.48 Groundwater calcium ion measurements at Ch 50965 since February 2015.

The operational phase groundwater quality monitoring results to date do not provide a clear indication of impacts associated with highway operation at Ch 50965. Saline encroachment related to long-term dry weather and the influence of the Nambucca River estuary has impacted results. Continued monitoring will improve the understanding of elevated downgradient TP, TN and NO₃ concentrations. There are no new recommendations for ongoing groundwater quality management at Ch 50965.

3.3.5 Ch 54065 – Cut 15

There were no results of interest from Ch 54065 (**Table B.5**). There was no water in the downgradient piezometer at Ch 54065 for the first months of operational monitoring or for the majority of construction phase monitoring. A new downgradient piezometer was constructed at Ch 54065 in July 2019. All operational phase downstream median results to-date comply with

relevant guidelines with the exception of the median Cu, Hg, NO₃, pH and conductivity measurements. All of these results are within the ranges observed during construction phase monitoring (eg. **Figure 3.49** and **3.50**).

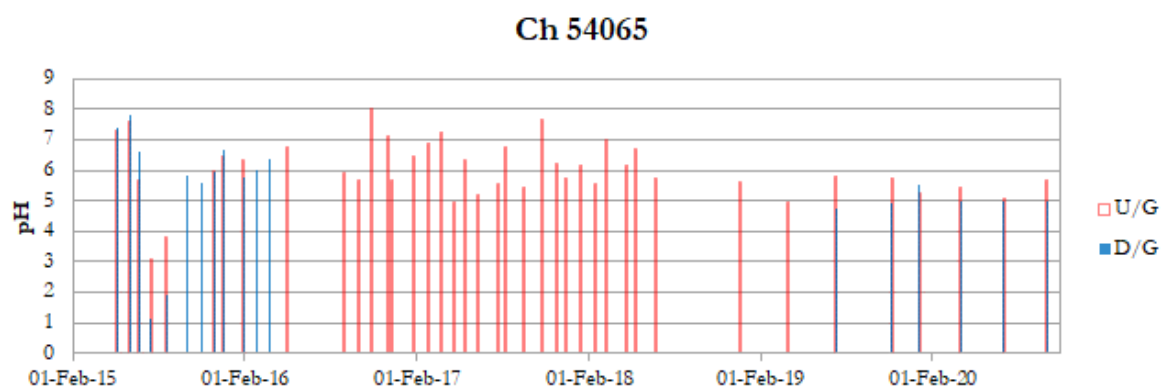


Figure 3.49 Groundwater pH measurements at Ch 54065 since February 2015.

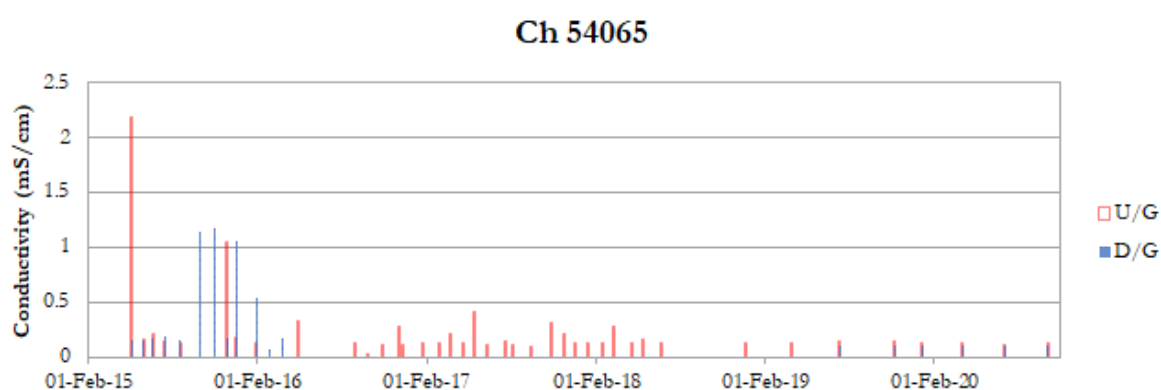


Figure 3.50 Groundwater conductivity measurements at Ch 54065 since February 2015.

The operational phase groundwater quality monitoring results to date do not indicate any impacts associated with highway operation at Ch 54065. There are no new recommendations for ongoing groundwater quality management at Ch 54065.

3.4 Groundwater Level

The logged groundwater level data collected to-date in operational phase monitoring is displayed in **Figures 3.51 to 3.55**.

There is no upgradient piezometer at Ch 45165 (Cut 6). The water level in the downgradient piezometer fluctuated both upwards and downwards during this reporting period (**Figure 3.51**), indicating normal groundwater response to recharge and discharge events. The piezometer at Ch 45165 dried out during dry weather in the previous annual reporting period and no water was detected from the late March 2019 until after heavy rain fell in early February 2020. During the periods when water was detected, the median logged depth to water at the Cut 6 downgradient piezometer for the operational phase monitoring period to date was 15.67 m, slightly higher than the median logged depth to water of 16.12 m from the construction phase monitoring period.

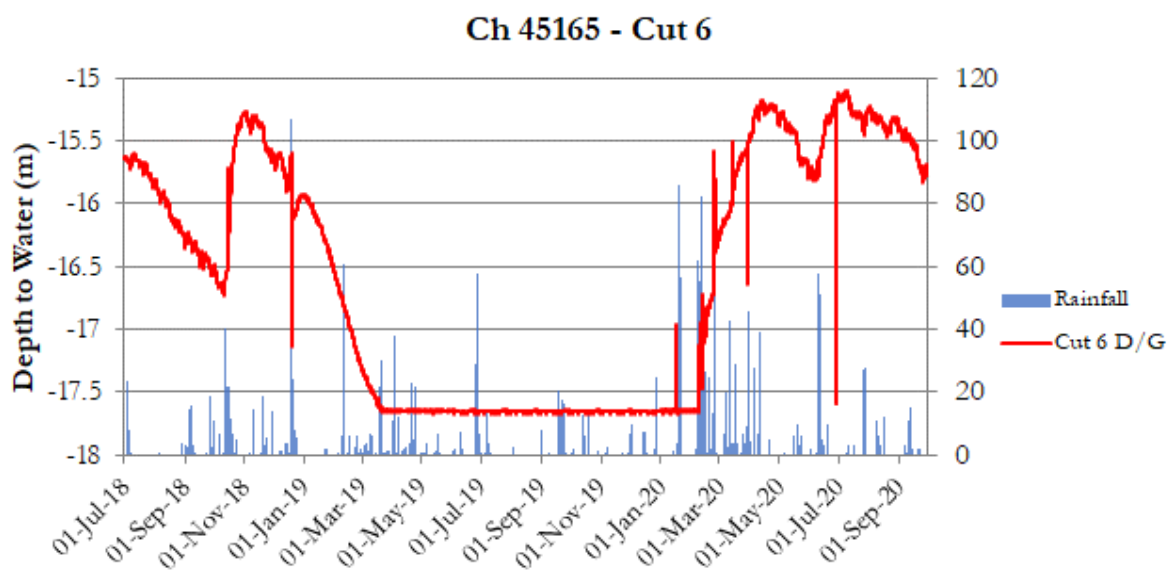


Figure 3.51 Operational phase groundwater levels at chainage 45165

The upgradient and downgradient water levels at Ch 48665 (Cut 11) fluctuated both upwards and downwards during this reporting period (**Figure 3.52**) indicating a normal groundwater response to discharge and recharge events. The upgradient and downgradient piezometers maintained a similar level relative to each other indicating no impact to groundwater levels from highway operation, although the water level in the upgradient piezometer responded to some small to medium rainfall events that did not have an impact on the water level in the downgradient piezometer. The location of the upgradient piezometer changed during the construction monitoring phase and the new upgradient piezometer is in a position where the groundwater table was much closer to the surface of the ground. The median logged depth to water at the new Cut 11 upgradient piezometer for operational phase monitoring to date was 2.21 m, somewhat deeper than the median logged depth to water of 1.72 m from the

construction phase monitoring period. The median logged depth to water at the Cut 11 downgradient piezometer for this reporting period was 7.73 m, also deeper than the median logged depth to water of 7.25 m from the construction phase monitoring period. These deeper median depths to water are likely to be a result of generally dry weather conditions, rather than any impact from highway operation. There is a period of water level data from the downgradient piezometer that is missing due to battery failure (30th March 2020 until 29th June 2020). It is unlikely to significantly impact the interpretation of results.

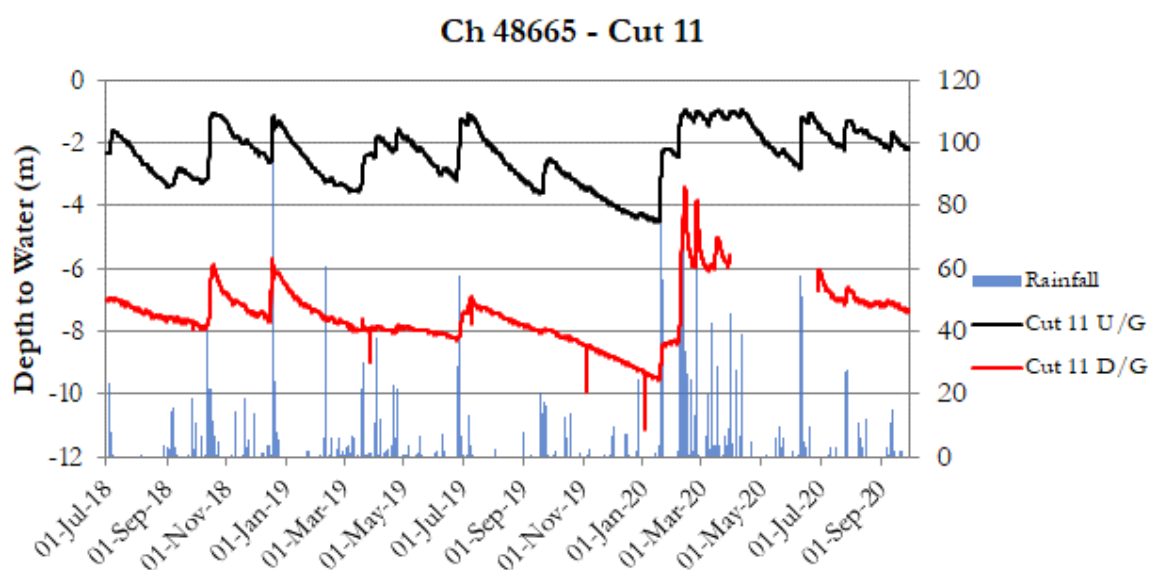


Figure 3.52 Operational phase groundwater levels at chainage 48665

There is no upgradient piezometer at Ch 49365 (Cut 12). The downgradient piezometer at Cut 12 was had water in it for the first time since June 2016 after heavy rainfall raised groundwater levels in early February 2020. The location of the downgradient piezometer was changed during the construction monitoring period and the available information was limited due to gaps in, and problems with the quality of, the logged data. The median level in the downgradient piezometer for the period since early February 2020 was 8.10 m below ground level.

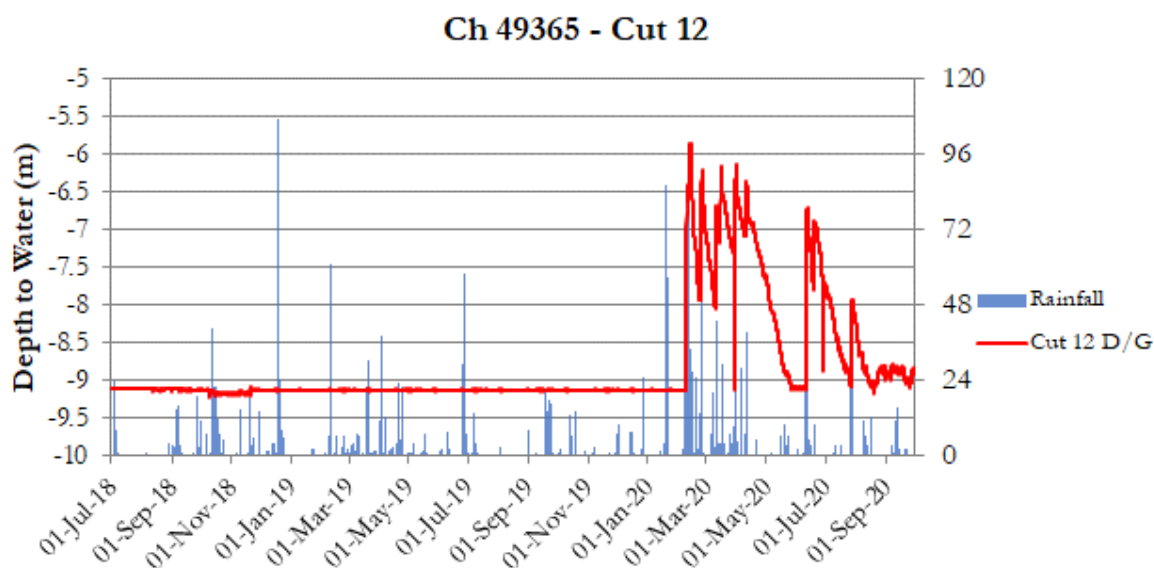


Figure 3.53 Operational phase groundwater levels at chainage 49365

At Ch 50965 (Fill 15) the groundwater levels fluctuated both upwards and downwards during this reporting period indicating a normal response to groundwater discharge and recharge events. The available data shows clearly that groundwater levels upgradient and downgradient fluctuated in a similar way in response to groundwater recharge and discharge events but that the upgradient aquifer is more prone to discharge during periods of dry, hot weather but also responds faster to recharge events (**Figure 3.54**). The median logged depth to water at the Fill 15 upgradient piezometer for operational phase monitoring to date was 0.89 m, the same as the median logged depth to water of 0.89 m from the construction phase monitoring period. The median logged depth to water at the Fill 15 downgradient piezometer for this reporting period was 0.87 m, comparable to the median logged depth to water of 0.81 m from the construction phase monitoring period.

The upgradient groundwater level at Ch54065 (Cut 15) fluctuated both upwards and downwards indicating a normal response to groundwater recharge and discharge events. The downgradient piezometer was dry at the start of operational phase monitoring but a new piezometer was constructed in July 2019. The water levels in the upgradient and downgradient piezometers respond to wet and dry events in a very similar fashion (**Figure 3.55**). For the period where data from both piezometers is available the groundwater levels upgradient and downgradient of the WC2NH upgrade maintain a similar relative response to groundwater discharge. The locations of both piezometers were changed during construction phase monitoring and both downgradient

piezometers dried out, indicating a lack of recharge. The median logged depth to water at the Cut 15 upgradient piezometer for operational phase monitoring to date was 15.96 m, deeper than the median logged depth to water of 15.58 m from the construction phase monitoring period. The operational phase median logged depth to water from the newest downgradient piezometer was 17.18 m. There is no relevant construction phase median value available for comparison.

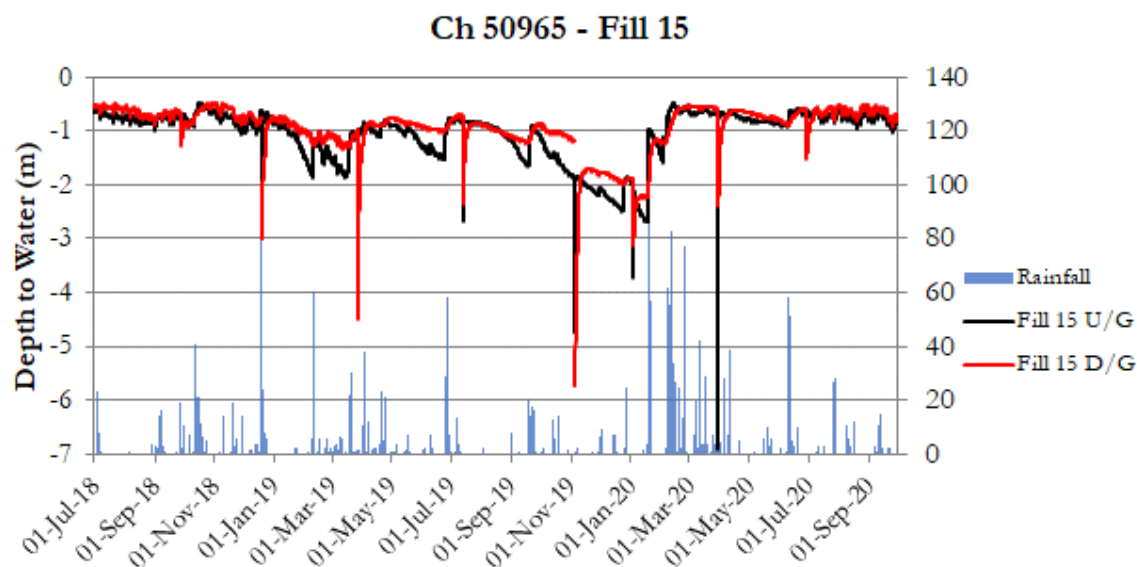


Figure 3.54 Operational phase groundwater levels at chainage 50965

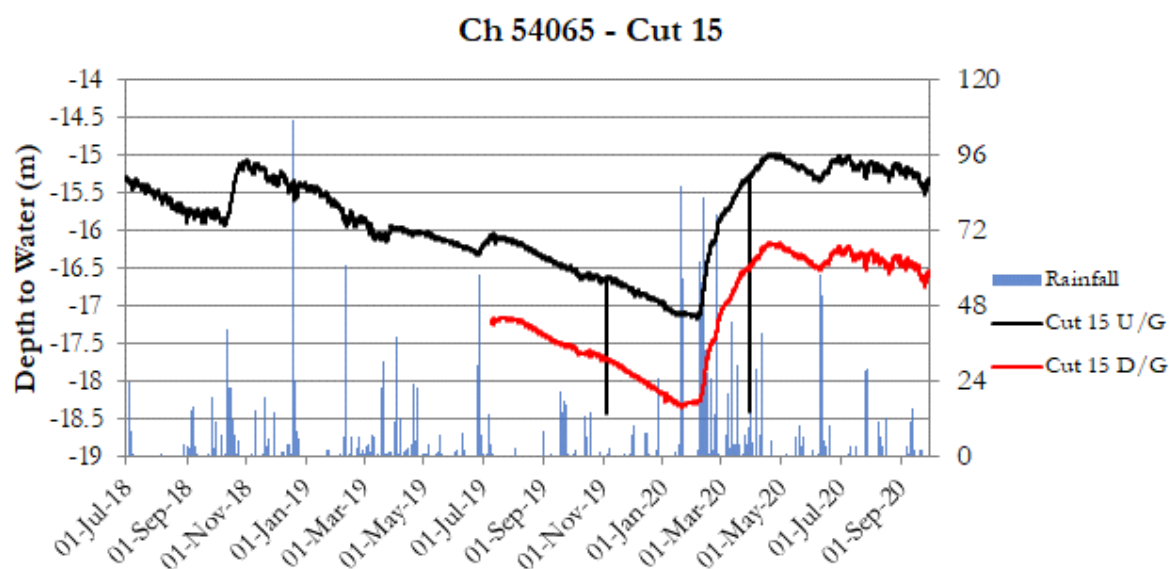


Figure 3.55 Operational phase groundwater levels at chainage 54065

4 Key Observations

4.1 Surface Water Quality

- There were fewer results of interest identified at this stage of operational phase monitoring than in the 2019 annual report.
- The results of interest from the data summary (**Appendix A**) have been described in **Section 3.2** and show no clear indications of significant impacts associated with highway operation.
- Guideline concentrations have been referenced to provide context for results of interest.

4.2 Groundwater Quality

- There were fewer results of interest identified at this stage of operational phase monitoring than in the 2019 annual report.
- At two of the groundwater monitoring locations, Ch 45165 (Cut 6) and Ch 49365 (Cut 12), there are no upgradient piezometers, limiting the capacity to draw conclusions about the impacts of construction works upon downgradient groundwater quality and levels.
- Three of the downgradient piezometers, at Ch 49365 (Cut 12), Ch 45165 (Cut 6) and Ch 54065 (Cut 15), were dry for parts of the operational phase monitoring period to date, limiting the capacity to draw conclusions about the impacts of highway operation upon downgradient groundwater quality and levels due to a reduced number of samples and data points.
- At some of the groundwater monitoring sites new piezometers were constructed during the construction phase monitoring period to replace piezometers that had dried out, had become inaccessible or were otherwise damaged or not functioning. A new downgradient piezometer was constructed at Ch 54065 (Cut 15) during the operational phase monitoring.
- The results of interest from the data summary (**Appendix B**) have been described in **Section 3.3** and show no clear indication of impacts from highway construction. There

have been some elevated concentrations of some contaminants measured but there are no obvious trends among these.

- The conductivity measurements from Ch 48665 (Cut 11) indicate that upgradient and downgradient samples might be drawn from different aquifers.

4.3 Groundwater levels

Groundwater levels were logged at 8 sites during this reporting period. The following conclusions have been drawn from the available logged groundwater level data:

- Groundwater levels rose and fell at all sites in response to recharge and discharge since operational phase monitoring began.
- Where upgradient and downgradient data are available, the data indicates that there has not been a significant change in the relationship between the groundwater levels upgradient and downgradient of the highway.
- Median logged depths to water from this reporting period were generally were comparable to the corresponding measurements from construction phase monitoring with the exception of the downgradient piezometer at Ch 54065 (Cut 15), for which there is no relevant corresponding data.

The interpretation of the results presented should consider that where laboratories reported results as lower than the limits of detection, these results were incorporated into databases as the level of detection for the calculation of summary statistics and graphing. Limits of detection have not been consistent for all parameters between construction phase and operational phase monitoring.

5 Conclusions

Between October 2019 and September 2020, the surface water and groundwater monitoring program along the WC2NH upgrade was undertaken generally in accordance with the requirements of the SWMP and GWMP. However, there were 2 extra wet event surface water samples collected in order to make-up for samples not collected in the previous monitoring period and 1 set of dry-event samples was collected 3 weeks outside of its 6-month window (minor changes that would not materially impact the capacity of the monitoring program to meet its stated aims). This annual report presents a summary of the monitoring activities and results at the end of the second year of operational phase monitoring.

The collected surface water monitoring results have been summarised according to the requirements of the SWMP. The summary indicates that there are some results of interest, though less than in the previous annual report. Further analysis, in **Section 3.2**, reveals that the majority of results of interest do not indicate any impact from highway operation and that none indicate a clear impact.

The collected groundwater quality monitoring results have been summarised in this report according to the requirements of the GWMP. The summary indicates that there are some results of interest, but less than in the previous annual report. There are no clear indications of impacts of highway operation on groundwater quality. Dry, damaged and decommissioned groundwater piezometers have also limited the quantity and utility of the information available.

Groundwater level monitoring has indicated that upgradient and downgradient groundwater levels are fluctuating consistently and are within the ranges measured during construction. At some sites the capacity to draw conclusions is limited by dry and decommissioned piezometers.

Assessed as a complete data set, the summary results indicate that the water quality protection measures implemented during construction and operation have been successful, and that there has not been a significant impact from the operation of the WC2NH upgrade upon surface water or groundwater quality. Ongoing operational monitoring is expected to confirm this.

There are no recommendations for changed or additional water quality management arising from this report.

6 References

- ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand
- Birch, M. (2019) *Gumma Creek and Wetlands Water Quality and Level Monitoring – Annual Report - 2018*. Report prepared for Nambucca Shire Council
- GeoLINK (2013a) *Pacific Highway Upgrade Warrell Creek to Nambucca Heads – Surface Water Monitoring – Pre-construction Report*. Report prepared for NSW Roads and Maritime
- GeoLINK (2013b) *Pacific Highway Upgrade Warrell Creek to Nambucca Heads – Groundwater Monitoring – Pre-construction Report*. Report prepared for NSW Roads and Maritime
- NHMRC (2011) *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.
- NHMRC (2008) *Guidelines for Managing Risks in Recreational Water*. National Health and Medical Research Council, Australian Government.
- NSW Department of Natural Resources (2006) *Survey of Tidal Limits and Mangrove Limits in NSW Estuaries 1996 to 2005*.
- RTA (2011) *Upgrading the Pacific Highway, Warrell Creek to Urunga. Project Approval Documents*. RTA Publication 11.282. October 2011.

Appendix A

Surface Water – Summary Monitoring Data

Table A.1 Operational (Op) phase downstream median surface water results and combined construction (Con) and operational phase upstream 80th percentile (P80) results and operational phase sample numbers (No.) for Upper Warrell Creek

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (freshwater)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW01</i>	<i>SW02</i>	<i>SW01</i>	<i>SW02</i>	<i>SW02</i>	<i>SW02</i>	<i>SW02</i>	<i>SW02</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med Mar 2019</i>	<i>Con Med</i>
Aluminium-Total (mg/L)	0.01	0.055	12	12	0.05	0.03	0.03	0.03	0.13	0.02
Arsenic-Total (mg/L)	0.001	0.013	12	12	0.001	0.001	0.001	0.001	0.002	0.001
Cadmium-Total (mg/L)	0.0001	0.0002	12	12	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium-Total (mg/L)	0.001	0.001	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Copper-Total (mg/L)	0.001	0.0014	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Lead-Total (mg/L)	0.001	0.0034	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Manganese-Total (mg/L)	0.005	1.9	12	12	0.38	0.31	0.350	0.350	0.375	0.092
Nickel-Total (mg/L)	0.001	0.011	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Selenium-Total (mg/L)	0.001	0.005	12	12	0.010	0.001	0.001	0.001	0.001	0.010
Silver-Total (mg/L)	0.001	0.0005	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Zinc-Total (mg/L)	0.001	0.008	12	12	0.006	0.002	0.002	0.002	0.003	0.005
Iron-Total (mg/L)	0.01	-	12	12	1.05	1.25	1.10	1.10	1.60	0.30
Mercury-Total (mg/L)	0.00005	0.00005	12	12	0.00010	0.00005	0.00005	0.0001	0.00005	0.0001
Naphthalene (µg/L)	1	16	12	12	1	1	1	1	1	-
TRH C6 - C9 (µg/L)	10	-	12	12	10	10	10	10	10	-
TRH C6 - C10 (µg/L)	10	-	12	12	17	10	10	10	10	20
TRH C6 - C10 less BTEX (µg/L)	10	-	12	12	12	10	10	10	10	20
TRH C10 - C14 (µg/L)	50	-	12	12	50	50	50	50	50	-
TRH C15 - C28 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH C29 - C36 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH >C10 - C16 (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C10 - C16 less Naphthalene (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C16 - C34 (µg/L)	100	-	12	12	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	-	12	12	100	100	100	100	100	100
Benzene (µg/L)	1	950	12	12	1	1	1	1	1	1
Toluene (µg/L)	1	-	12	12	2	1	1	1	1	2
Ethylbenzene (µg/L)	1	-	12	12	1	1	1	1	1	2
m&p-Xylenes (µg/L)	2	200	12	12	2	2	2	2	2	2
o-Xylene (µg/L)	1	350	12	12	1	1	1	1	1	2

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (freshwater)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW01</i>	<i>SW02</i>	<i>SW01</i>	<i>SW02</i>	<i>SW02</i>	<i>SW02</i>	<i>SW02</i>	<i>SW02</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med Mar 2019</i>	<i>Con Med</i>
Total Phosphorus (mg/L)	0.05	0.05	12	12	0.06	0.05	0.05	0.05	0.06	0.02
Phosphate (mg/L)	0.005	0.02	12	12	0.010	0.005	0.005	0.005	0.005	0.010
Total Nitrogen (mg/L)	0.1	0.5	12	12	0.9	0.3	0.3	0.30	0.3	0.50
Nitrate (mg/L)	0.005	0.04(NO _x)	12	12	0.130	0.014	0.008	0.008	0.020	0.050
Nitrite (mg/L)	0.005	0.04(NO _x)	12	12	0.010	0.005	0.005	0.005	0.005	0.010
Ammonia (mg/L)	0.005	0.02	12	12	0.046	0.009	0.008	0.005	0.015	0.020
TSS (mg/L)	5	-	12	12	10.8	6	6	6	6	5
TDS (g/L)	0.001	-	23	23	0.187	0.176	0.174	0.171	0.170	0.164
Temperature (°C)	0.01	-	24	24	22.95	18.97	20.11	18.60	23.24	21.51
pH	0.01	6.5 – 8.0	24	24	6.90	6.67	6.70	6.74	6.78	6.64
Conductivity (mS/cm)	0.001	0.125 – 2.2	24	24	0.288	0.271	0.271	0.261	0.254	0.249
Turbidity (NTU)	0.01	6 – 50	24	24	23.6	14.0	15.4	12.6	11.4	6.3
DO (mg/L) (P20)*	0.01	85-110% saturation	24	24	1.86	4.19	3.77	4.16	4.02	3.81

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020

Results in Red – Indicates a median result of interest that does not comply with the relevant ANZECC guideline concentration

* - Upstream dissolved oxygen results are P20, not P80.

Table A.2 Operational (Op) phase downstream median surface water results and combined construction (Con) and operational phase upstream 80th percentile (P80) results and operational phase sample numbers (No.) for Stony Creek

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (freshwater)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW03</i>	<i>SW04</i>	<i>SW03</i>	<i>SW04</i>	<i>SW04</i>	<i>SW04</i>	<i>SW04</i>	<i>SW04</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med Mar 2019</i>	<i>Con Med</i>
Aluminium-Total (mg/L)	0.01	0.055	12	12	0.05	0.02	0.02	0.01	0.22	0.01
Arsenic-Total (mg/L)	0.001	0.013	12	12	0.002	0.002	0.002	0.002	0.003	0.001
Cadmium-Total (mg/L)	0.0001	0.0002	12	12	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium-Total (mg/L)	0.001	0.001	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Copper-Total (mg/L)	0.001	0.0014	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Lead-Total (mg/L)	0.001	0.0034	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Manganese-Total (mg/L)	0.005	1.9	12	12	0.10	0.13	0.13	0.120	0.212	0.081
Nickel-Total (mg/L)	0.001	0.011	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Selenium-Total (mg/L)	0.001	0.005	12	12	0.010	0.001	0.001	0.001	0.001	0.010
Silver-Total (mg/L)	0.001	0.0005	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Zinc-Total (mg/L)	0.001	0.008	12	12	0.006	0.002	0.002	0.002	0.005	0.005
Iron-Total (mg/L)	0.01	-	12	12	1.24	1.60	2.10	1.50	2.50	0.10
Mercury-Total (mg/L)	0.00005	0.00005	12	12	0.00010	0.00005	0.00005	0.0001	0.00005	0.0001
Naphthalene (µg/L)	1	16	12	12	1	1	1	1	1	-
TRH C6 - C9 (µg/L)	10	-	12	12	10	10	10	10	10	-
TRH C6 - C10 (µg/L)	10	-	12	12	12	10	10	10	10	20
TRH C6 - C10 less BTEX (µg/L)	10	-	12	12	12	10	10	10	10	20
TRH C10 - C14 (µg/L)	50	-	12	12	50	50	50	50	50	-
TRH C15 - C28 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH C29 - C36 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH >C10 - C16 (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C10 - C16 less Naphthalene (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C16 - C34 (µg/L)	100	-	12	12	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	-	12	12	100	100	100	100	100	100
Benzene (µg/L)	1	950	12	12	1	1	1	1	1	1
Toluene (µg/L)	1	-	12	12	1	1	1	1	1	2
Ethylbenzene (µg/L)	1	-	12	12	1	1	1	1	1	2
m&p-Xylenes (µg/L)	2	200	12	12	2	2	2	2	2	2
o-Xylene (µg/L)	1	350	12	12	1	1	1	1	1	2

Parameter	PQL	ANZECC Guideline (freshwater)	U/S	D/S	U/S	D/S	D/S	D/S	D/S	D/S
			SW03	SW04	SW03	SW04	SW04	SW04	SW04	SW04
			Op No.	Op No.	Con/Op P80	Op Med Current	Op Med Mar 2020	Op Med Sept 2019	Op Med Mar 2019	Con Med
Total Phosphorus (mg/L)	0.05	0.05	12	12	0.05	0.05	0.05	0.05	0.05	0.02
Phosphate (mg/L)	0.005	0.02	12	12	0.010	0.005	0.005	0.005	0.005	0.010
Total Nitrogen (mg/L)	0.1	0.5	12	12	0.6	0.2	0.2	0.10	0.3	0.30
Nitrate (mg/L)	0.005	0.04(NO _x)	12	12	0.116	0.020	0.020	0.010	0.075	0.060
Nitrite (mg/L)	0.005	0.04(NO _x)	12	12	0.010	0.005	0.005	0.005	0.005	0.010
Ammonia (mg/L)	0.005	0.02	12	12	0.030	0.008	0.007	0.005	0.031	0.020
TSS (mg/L)	5	-	12	12	10	5	8	5	10	5
TDS (g/L)	0.001	-	23	23	0.173	0.168	0.180	0.180	0.148	0.157
Temperature (°C)	0.01	-	24	24	22.98	16.83	18.90	16.11	22.09	20.88
pH	0.01	6.5 – 8.0	24	24	6.89	6.69	6.72	6.80	6.77	6.68
Conductivity (mS/cm)	0.001	0.125 – 2.2	24	24	0.261	0.255	0.271	0.271	0.239	0.241
Turbidity (NTU)	0.01	6 – 50	24	24	15.7	16.4	16.6	16.2	16.4	8.7
DO (mg/L) (P20)*	0.01	85-110% saturation	24	24	3.04	4.25	3.96	3.96	4.40	4.69

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Results in Red – Indicates a median result that does not comply with the relevant ANZECC guideline concentration

* - Upstream dissolved oxygen results are P20, not P80.

Table A.3 Operational (Op) phase downstream median surface water results and combined construction (Con) and operational phase upstream 80th percentile (P80) results and operational phase sample numbers (No.) for Lower Warrell Creek

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (marine)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW05</i>	<i>SW06</i>	<i>SW05</i>	<i>SW06</i>	<i>SW06</i>	<i>SW06</i>	<i>SW06</i>	<i>SW06</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med Mar 2019</i>	<i>Con Med</i>
Aluminium-Total (mg/L)	0.01	0.0005	12	12	0.10	0.04	0.03	0.03	0.21	0.02
Arsenic-Total (mg/L)	0.001	0.0045	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium-Total (mg/L)	0.0001	0.0055	12	12	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium-Total (mg/L)	0.001	0.0044	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Copper-Total (mg/L)	0.001	0.0013	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Lead-Total (mg/L)	0.001	0.0044	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Manganese-Total (mg/L)	0.005	-	12	12	0.28	0.19	0.30	0.190	0.305	0.165
Nickel-Total (mg/L)	0.001	0.007	12	12	0.003	0.002	0.001	0.001	0.002	0.002
Selenium-Total (mg/L)	0.001	-	12	12	0.010	0.001	0.001	0.001	0.001	0.010
Silver-Total (mg/L)	0.001	0.0014	12	12	0.001	0.001	0.001	0.001	0.001	0.001
Zinc-Total (mg/L)	0.001	0.015	12	12	0.014	0.004	0.003	0.003	0.008	0.006
Iron-Total (mg/L)	0.01	-	12	12	0.56	0.13	0.10	0.10	0.71	0.12
Mercury-Total (mg/L)	0.00005	0.0001	12	12	0.00010	0.00005	0.00005	0.0001	0.00005	0.0001
Naphthalene (µg/L)	1	70	12	12	1	1	1	1	1	-
TRH C6 - C9 (µg/L)	10	-	12	12	10	10	10	10	10	-
TRH C6 - C10 (µg/L)	10	-	12	12	12	10	10	10	10	20
TRH C6 - C10 less BTEX (µg/L)	10	-	12	12	12	10	10	10	10	20
TRH C10 - C14 (µg/L)	50	-	12	12	50	50	50	50	50	-
TRH C15 - C28 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH C29 - C36 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH >C10 - C16 (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C10 - C16 less Naphthalene (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C16 - C34 (µg/L)	100	-	12	12	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	-	12	12	100	100	100	100	100	100
Benzene (µg/L)	1	700	12	12	1	1	1	1	1	1
Toluene (µg/L)	1	-	12	12	1	1	1	1	1	2
Ethylbenzene (µg/L)	1	-	12	12	1	1	1	1	1	2
m&p-Xylenes (µg/L)	2	-	12	12	2	2	2	2	2	2
o-Xylene (µg/L)	1	-	12	12	1	1	1	1	1	2

Parameter	PQL	ANZECC Guideline (marine)	U/S	D/S	U/S	D/S	D/S	D/S	D/S	D/S
			SW05	SW06	SW05	SW06	SW06	SW06	SW06	SW06
			Op No.	Op No.	Con/Op P80	Op Med Current	Op Med Mar 2020	Op Med Sept 2019	Op Med Mar 2019	Con Med
Total Phosphorus (mg/L)	0.05	0.03	12	12	0.05	0.05	0.05	0.05	0.06	0.02
Phosphate (mg/L)	0.005	0.005	12	12	0.010	0.005	0.005	0.005	0.005	0.010
Total Nitrogen (mg/L)	0.1	0.3	12	12	0.8	0.4	0.3	0.30	0.4	0.50
Nitrate (mg/L)	0.005	0.015(NO _x)	12	12	0.110	0.005	0.005	0.005	0.043	0.060
Nitrite (mg/L)	0.005	0.015(NO _x)	12	12	0.010	0.005	0.005	0.005	0.005	0.010
Ammonia (mg/L)	0.005	0.015	12	12	0.080	0.030	0.029	0.028	0.014	0.060
TSS (mg/L)	5	-	12	12	17	5	5	5	11	6
TDS (g/L)	0.001	-	23	23	10.046	12.000	12.400	12.250	5.270	2.625
Temperature (°C)	0.01	-	24	24	27.77	20.69	21.42	19.89	25.42	23.58
pH	0.01	7.0 – 8.5	24	24	7.41	7.08	7.11	7.11	7.09	7.09
Conductivity (mS/cm)	0.001	-	24	24	15.800	19.050	19.900	19.500	8.215	3.780
Turbidity (NTU)	0.01	0.5 - 10	24	24	16.7	7.0	6.9	6.0	10.7	6.8
DO (mg/L) (P20)*	0.01	80 – 110% saturation	24	24	3.14	4.41	4.36	4.36	4.28	4.43

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Results in Red – Indicates a median result that does not comply with the relevant ANZECC guideline concentration

* - Upstream dissolved oxygen results are P20, not P80.

Table A.4 Operational (Op) phase downstream median surface water results and combined construction (Con) and operational phase upstream 80th percentile (P80) results and operational phase sample numbers (No.) for the Unnamed Creek at Gumma Wetland west

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (freshwater)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW07</i>	<i>SW09</i>	<i>SW07</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/ Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med Mar 2019</i>	<i>Con Med</i>
Aluminium-Total (mg/L)	0.01	0.055	11	10	0.07	0.13	0.13	0.11	0.13	0.04
Arsenic-Total (mg/L)	0.001	0.013	11	10	0.002	0.003	0.003	0.004	0.002	0.001
Cadmium-Total (mg/L)	0.0001	0.0002	11	10	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium-Total (mg/L)	0.001	0.001	11	10	0.001	0.001	0.001	0.001	0.001	0.001
Copper-Total (mg/L)	0.001	0.0014	11	10	0.001	0.001	0.001	0.001	0.002	0.001
Lead-Total (mg/L)	0.001	0.0034	11	10	0.001	0.001	0.001	0.001	0.001	0.001
Manganese-Total (mg/L)	0.005	1.9	11	10	0.33	0.19	0.56	0.375	0.120	0.195
Nickel-Total (mg/L)	0.001	0.011	11	10	0.002	0.001	0.001	0.001	0.001	0.003
Selenium-Total (mg/L)	0.001	0.005	11	10	0.010	0.001	0.001	0.001	0.001	0.010
Silver-Total (mg/L)	0.001	0.0005	11	10	0.001	0.001	0.001	0.001	0.001	0.001
Zinc-Total (mg/L)	0.001	0.008	11	10	0.012	0.003	0.003	0.003	0.006	0.008
Iron-Total (mg/L)	0.01	-	11	10	1.36	1.65	1.50	1.23	0.85	0.36
Mercury-Total (mg/L)	0.00005	0.00005	11	10	0.00010	0.00005	0.00005	0.0001	0.00005	0.0001
Naphthalene (µg/L)	1	16	11	10	1	1	1	1	1	-
TRH C6 - C9 (µg/L)	10	-	11	10	10	10	10	10	10	-
TRH C6 - C10 (µg/L)	10	-	11	10	20	10	10	10	10	20
TRH C6 - C10 less BTEX (µg/L)	10	-	11	10	20	10	10	10	10	20
TRH C10 - C14 (µg/L)	50	-	11	10	50	50	50	50	50	-
TRH C15 - C28 (µg/L)	100	-	11	10	100	100	100	100	100	-
TRH C29 - C36 (µg/L)	100	-	11	10	100	100	100	100	100	-
TRH >C10 - C16 (µg/L)	50	-	11	10	70	50	50	50	50	100
TRH >C10 - C16 less Naphthalene (µg/L)	50	-	11	10	70	50	50	50	50	100
TRH >C16 - C34 (µg/L)	100	-	11	10	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	-	11	10	100	100	100	100	100	100
Benzene (µg/L)	1	950	11	10	1	1	1	1	1	1
Toluene (µg/L)	1	-	11	10	2	1	1	1	1	2
Ethylbenzene (µg/L)	1	-	11	10	2	1	1	1	1	2
m&p-Xylenes (µg/L)	2	200	11	10	2	2	2	2	2	2
o-Xylene (µg/L)	1	350	11	10	2	1	1	1	1	2
Total Phosphorus (mg/L)	0.05	0.05	11	10	0.07	0.05	0.05	0.05	0.05	0.03
Phosphate (mg/L)	0.005	0.02	11	10	0.010	0.005	0.005	0.005	0.005	0.010

Parameter	PQL	ANZECC Guideline (freshwater)	U/S	D/S	U/S	D/S	D/S	D/S	D/S	D/S
			SW07	SW09	SW07	SW09	SW09	SW09	SW09	SW09
			Op No.	Op No.	Con/ Op P80	Op Med Current	Op Med Mar 2020	Op Med Sept 2019	Op Med Mar 2019	Con Med
Total Nitrogen (mg/L)	0.1	0.5	11	10	1.7	1.0	1.0	0.90	0.6	1.10
Nitrate (mg/L)	0.005	0.04(NO _x)	11	10	0.084	0.005	0.005	0.005	0.010	0.030
Nitrite (mg/L)	0.005	0.04(NO _x)	11	10	0.010	0.005	0.005	0.005	0.005	0.010
Ammonia (mg/L)	0.005	0.02	11	10	0.060	0.005	0.009	0.007	0.005	0.030
TSS (mg/L)	5	-	11	10	22.28	7.5	12	11	6	14
TDS (g/L)	0.001	-	22	21	0.541	0.582	0.600	0.600	0.472	0.485
Temperature (°C)	0.01	-	23	22	25.47	19.94	20.87	20.59	24.55	21.08
pH	0.01	6.5 – 8.0	23	22	6.99	6.86	7.01	7.07	6.90	6.54
Conductivity (mS/cm)	0.001	0.125 – 2.2	23	22	0.843	0.882	0.935	0.931	0.703	0.745
Turbidity (NTU)	0.01	6 – 50	23	22	54.2	23.7	18.4	17.5	16.00	25.3
DO (mg/L) (P20)*	0.01	85-110% saturation	23	22	1.37	4.29	4.83	4.85	4.83	3.41

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Results in Red – Indicates a median result that does not comply with the relevant ANZECC guideline concentration

* - Upstream dissolved oxygen results are P20, not P80.

Table A.5 Operational (Op) phase downstream median surface water results and combined construction (Con) and operational phase upstream 80th percentile (P80) results and operational phase sample numbers (No.) for the Unnamed Creek at Gumma Wetland east

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (freshwater)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW08</i>	<i>SW09</i>	<i>SW08</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med Mar 2019</i>	<i>Con Med</i>
Aluminium-Total (mg/L)	0.01	0.055	11	10	0.13	0.13	0.13	0.11	0.13	0.04
Arsenic-Total (mg/L)	0.001	0.013	11	10	0.003	0.003	0.003	0.004	0.002	0.001
Cadmium-Total (mg/L)	0.0001	0.0002	11	10	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium-Total (mg/L)	0.001	0.001	11	10	0.001	0.001	0.001	0.001	0.001	0.001
Copper-Total (mg/L)	0.001	0.0014	11	10	0.003	0.001	0.001	0.001	0.002	0.001
Lead-Total (mg/L)	0.001	0.0034	11	10	0.001	0.001	0.001	0.001	0.001	0.001
Manganese-Total (mg/L)	0.005	1.9	11	10	0.39	0.19	0.56	0.375	0.120	0.195
Nickel-Total (mg/L)	0.001	0.011	11	10	0.004	0.001	0.001	0.001	0.001	0.003
Selenium-Total (mg/L)	0.001	0.005	11	10	0.010	0.001	0.001	0.001	0.001	0.010
Silver-Total (mg/L)	0.001	0.0005	11	10	0.001	0.001	0.001	0.001	0.001	0.001
Zinc-Total (mg/L)	0.001	0.008	11	10	0.018	0.003	0.003	0.003	0.006	0.008
Iron-Total (mg/L)	0.01	-	11	10	1.52	1.65	1.50	1.23	0.85	0.36
Mercury-Total (mg/L)	0.00005	0.00005	11	10	0.00010	0.00005	0.00005	0.0001	0.00005	0.0001
Naphthalene (µg/L)	1	16	11	10	1	1	1	1	1	-
TRH C6 - C9 (µg/L)	10	-	11	10	10	10	10	10	10	-
TRH C6 - C10 (µg/L)	10	-	11	10	14	10	10	10	10	20
TRH C6 - C10 less BTEX (µg/L)	10	-	11	10	14	10	10	10	10	20
TRH C10 - C14 (µg/L)	50	-	11	10	50	50	50	50	50	-
TRH C15 - C28 (µg/L)	100	-	11	10	100	100	100	100	100	-
TRH C29 - C36 (µg/L)	100	-	11	10	100	100	100	100	100	-
TRH >C10 - C16 (µg/L)	50	-	11	10	70	50	50	50	50	100
TRH >C10 - C16 less Naphthalene (µg/L)	50	-	11	10	70	50	50	50	50	100
TRH >C16 - C34 (µg/L)	100	-	11	10	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	-	11	10	100	100	100	100	100	100
Benzene (µg/L)	1	950	11	10	1	1	1	1	1	1
Toluene (µg/L)	1	-	11	10	1	1	1	1	1	2
Ethylbenzene (µg/L)	1	-	11	10	1	1	1	1	1	2
m&p-Xylenes (µg/L)	2	200	11	10	2	2	2	2	2	2
o-Xylene (µg/L)	1	350	11	10	1	1	1	1	1	2
Total Phosphorus (mg/L)	0.05	0.05	11	10	0.12	0.05	0.05	0.05	0.05	0.03

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (freshwater)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW08</i>	<i>SW09</i>	<i>SW08</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>	<i>SW09</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med Mar 2019</i>	<i>Con Med</i>
Phosphate (mg/L)	0.005	0.02	11	10	0.010	0.005	0.005	0.005	0.005	0.010
Total Nitrogen (mg/L)	0.1	0.5	11	10	2.0	1.0	1.0	0.90	0.6	1.10
Nitrate (mg/L)	0.005	0.04(NO _x)	11	10	0.070	0.005	0.005	0.005	0.010	0.030
Nitrite (mg/L)	0.005	0.04(NO _x)	11	10	0.010	0.005	0.005	0.005	0.005	0.010
Ammonia (mg/L)	0.005	0.02	11	10	0.100	0.005	0.009	0.007	0.005	0.030
TSS (mg/L)	5	-	11	10	52	7.5	12	11	6	14
TDS (g/L)	0.001	-	22	21	0.482	0.582	0.600	0.600	0.472	0.485
Temperature (°C)	0.01	-	23	22	23.97	19.94	20.87	20.59	24.55	21.08
pH	0.01	6.5 – 8.0	23	22	6.85	6.86	7.01	7.07	6.90	6.54
Conductivity (mS/cm)	0.001	0.125 – 2.2	23	22	0.755	0.882	0.935	0.931	0.703	0.745
Turbidity (NTU)	0.01	6 – 50	23	22	39.5	23.7	18.4	17.5	16.00	25.3
DO (mg/L) (P20)*	0.01	85-110% saturation	23	22	0.70	4.29	4.83	4.85	4.83	3.41

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Results in Red – Indicates a median result that does not comply with the relevant ANZECC guideline concentration

* - Upstream dissolved oxygen results are P20, not P80.

Table A.6 Operational (Op) phase downstream median surface water results and combined construction (Con) and operational phase upstream 80th percentile (P80) results and operational phase sample numbers (No.) for the Nambucca River

<i>Parameter</i>	<i>PQL</i>	<i>ANZECC Guideline (marine)</i>	<i>U/S</i>	<i>D/S</i>	<i>U/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>	<i>D/S</i>
			<i>SW10</i>	<i>SW11</i>	<i>SW10</i>	<i>SW11</i>	<i>SW11</i>	<i>SW11</i>	<i>SW11</i>	<i>SW11</i>
			<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op Med Current</i>	<i>Op Med Mar 2020</i>	<i>Op Med Sept 2019</i>	<i>Op Med March 2019</i>	<i>Con Med</i>
Aluminium-Total (mg/L)	0.01	0.0005	12	12	0.10	0.09	0.08	0.08	0.64	0.10
Arsenic-Total (mg/L)	0.001	0.0045	12	12	0.010	0.001	0.001	0.001	0.004	0.010
Cadmium-Total (mg/L)	0.0001	0.0055	12	12	0.0010	0.0001	0.0001	0.0001	0.0001	0.0010
Chromium-Total (mg/L)	0.001	0.0044	12	12	0.010	0.001	0.001	0.001	0.001	0.010
Copper-Total (mg/L)	0.001	0.0013	12	12	0.010	0.001	0.001	0.001	0.002	0.010
Lead-Total (mg/L)	0.001	0.0044	12	12	0.010	0.001	0.001	0.001	0.001	0.010
Manganese-Total (mg/L)	0.005	-	12	12	0.07	0.04	0.03	0.024	0.102	0.047
Nickel-Total (mg/L)	0.001	0.007	12	12	0.010	0.001	0.001	0.001	0.001	0.010
Selenium-Total (mg/L)	0.001	-	12	12	0.100	0.001	0.001	0.001	0.001	0.100
Silver-Total (mg/L)	0.001	0.0014	12	12	0.010	0.001	0.001	0.001	0.001	0.010
Zinc-Total (mg/L)	0.001	0.015	12	12	0.050	0.002	0.002	0.002	0.005	0.050
Iron-Total (mg/L)	0.01	-	12	12	0.50	0.15	0.14	0.16	0.99	0.10
Mercury-Total (mg/L)	0.00005	0.0001	12	12	0.00010	0.00005	0.00005	0.0001	0.00005	0.0001
Naphthalene (µg/L)	1	70	12	12	1	1	1	1	1	-
TRH C6 - C9 (µg/L)	10	-	12	12	10	10	10	10	10	-
TRH C6 - C10 (µg/L)	10	-	12	12	12	10	10	10	10	20
TRH C6 - C10 less BTEX (µg/L)	10	-	12	12	12	10	10	10	10	20
TRH C10 - C14 (µg/L)	50	-	12	12	50	50	50	50	50	-
TRH C15 - C28 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH C29 - C36 (µg/L)	100	-	12	12	100	100	100	100	100	-
TRH >C10 - C16 (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C10 - C16 less Naphthalene (µg/L)	50	-	12	12	60	50	50	50	50	100
TRH >C16 - C34 (µg/L)	100	-	12	12	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	-	12	12	100	100	100	100	100	100
Benzene (µg/L)	1	700	12	12	1	1	1	1	1	1
Toluene (µg/L)	1	-	12	12	1	1	1	1	1	2
Ethylbenzene (µg/L)	1	-	12	12	1	1	1	1	1	2
m&p-Xylenes (µg/L)	2	-	12	12	2	2	2	2	2	2

Parameter	PQL	ANZECC Guideline (marine)	U/S	D/S	U/S	D/S	D/S	D/S	D/S	D/S
			SW10	SW11	SW10	SW11	SW11	SW11	SW11	SW11
			Op No.	Op No.	Con/Op P80	Op Med Current	Op Med Mar 2020	Op Med Sept 2019	Op Med March 2019	Con Med
o-Xylene (µg/L)	1	-	12	12	1	1	1	1	1	2
Total Phosphorus (mg/L)	0.05	0.03	12	12	0.09	0.05	0.05	0.05	0.13	0.05
Phosphate (mg/L)	0.005	0.005	12	12	0.013	0.012	0.014	0.014	0.021	0.010
Total Nitrogen (mg/L)	0.1	0.3	12	12	0.7	0.2	0.2	0.20	0.4	0.50
Nitrate (mg/L)	0.005	0.015(NOx)	12	12	0.058	0.005	0.005	0.005	0.039	0.030
Nitrite (mg/L)	0.005	0.015(NOx)	12	12	0.010	0.005	0.005	0.005	0.005	0.010
Ammonia (mg/L)	0.005	0.015	12	12	0.080	0.022	0.023	0.023	0.055	0.050
TSS (mg/L)	5	-	12	12	51	7	6	6	30	11
TDS (g/L)	0.001	-	23	23	27.200	24.500	25.800	27.250	24.300	22.300
Temperature (°C)	0.01	-	24	24	27.14	20.61	23.01	20.08	25.03	23.90
pH	0.01	7.0 – 8.5	24	24	7.89	7.68	7.73	7.80	7.62	7.64
Conductivity (mS/cm)	0.001	-	24	24	44.400	40.100	40.200	44.400	37.050	36.700
Turbidity (NTU)	0.01	0.5 - 10	24	24	28.8	10.8	11.9	13.8	13.90	17.5
DO (mg/L) (P20)*	0.01	80 – 110% saturation	24	24	4.31	5.92	5.71	5.97	6.06	5.58

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Results in Red – Indicates a median result that does not comply with the relevant ANZECC guideline concentration

* - Upstream dissolved oxygen results are P20, not P80

Appendix B

Summary Groundwater Monitoring Data

Table B.1 Operational (Op) monitoring phase and combined operational and construction (Con) phase summary groundwater quality results for approximate chainage 45165 (Cut 6)

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
						<i>Cut 6W</i>		<i>Cut 6W</i>	<i>Cut 6W</i>	<i>Cut 6W</i>	<i>Cut 6W</i>	<i>Cut 6W</i>
Aluminium	µg/L	10	55	200	-	2	-	40	30	-	-	85
Arsenic	µg/L	1	13	10	-	2	-	1	1	-	-	1
Cadmium	µg/L	0.1	0.2	2	-	2	-	0.1	0.1	-	-	0.1
Chromium	µg/L	1	1	50	-	2	-	2	2	-	-	1
Copper	µg/L	1	1.4	2000	-	2	-	6	6	-	-	9
Lead	µg/L	1	3.4	10	-	2	-	1	1	-	-	1
Manganese	µg/L	1	1900	500	-	2	-	175	140	-	-	178
Nickel	µg/L	1	11	20	-	2	-	10	13	-	-	5
Selenium	µg/L	10	5	10	-	2	-	1	1	-	-	10
Silver	µg/L	1	0.5	100	-	2	-	1	1	-	-	1
Zinc	µg/L	5	8	300	-	2	-	16	21	-	-	18
Iron	µg/L	10	-	300	-	2	-	20700	8400	-	-	5830
Mercury	µg/L	0.1	0.05	1	-	2	-	0.05	0.05	-	-	0.10
C6-C9 Fraction	µg/L	20	-	-	-	2	-	10	10	-	-	20
C6-C10 Fraction	µg/L	10	-	-	-	2	-	10	10	-	-	-
C6-C10 less BTEX	µg/L	10	-	-	-	2	-	10	10	-	-	-
C10-C14 Fraction	µg/L	50	-	-	-	2	-	50	50	-	-	50
C15-C28 Fraction	µg/L	100	-	-	-	2	-	100	100	-	-	100
C29-C36 Fraction	µg/L	100	-	-	-	2	-	100	100	-	-	50
C10-C16 Fraction	µg/L	50	-	-	-	2	-	50	50	-	-	62
C10-C16 less Naphthalene	µg/L	50	-	-	-	2	-	50	50	-	-	-
C16-C34 Fraction	µg/L	100	-	-	-	2	-	100	100	-	-	100
C34-C40 Fraction	µg/L	100	-	-	-	2	-	100	100	-	-	100
Naphthalene	µg/L	5	16	-	-	2	-	1	1	-	-	5
Benzene	µg/L	1	950	1	-	2	-	1	1	-	-	1
Toluene	µg/L	1	-	800	-	2	-	1	1	-	-	2
Ethylbenzene	µg/L	1	-	300	-	2	-	1	1	-	-	2
m+p-Xylene	µg/L	2	200	600	-	2	-	2	2	-	-	2
o-Xylene	µg/L	1	350	600	-	2	-	1	1	-	-	2
Total Phosphorus	mg/L	0.05	0.05	-	-	2	-	0.05	0.05	-	-	0.03
Phosphate	mg/L	0.005	0.02	-	-	2	-	0.005	0.005	-	-	0.010
Total Nitrogen	mg/L	0.1	0.5	-	-	2	-	0.4	0.3	-	-	0.6
Nitrate	mg/L	0.005	0.04(NOx)	50	-	2	-	0.005	0.005	-	-	0.020
Nitrite	mg/L	0.001	0.04(NOx)	3	-	2	-	0.005	0.005	-	-	0.010

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
						<i>Cut 6W</i>		<i>Cut 6W</i>	<i>Cut 6W</i>	<i>Cut 6W</i>	<i>Cut 6W</i>	<i>Cut 6W</i>
Ammonia	mg/L	0.005	0.02	0.5	-	2	-	0.017	0.015	-	-	0.100
TDS	mg/L	5	-	600	-	2	-	1800	1300	-	-	-
Chloride	mg/L	0.1	-	250	-	2	-	905	710	-	-	1108
Sulfate	mg/L	0.1	-	250	-	2	-	41	41	-	-	34
Bicarb Alkalinity	mg/L	0.1	-	-	-	2	-	35	25	-	-	44
Sodium	mg/L	0.1	-	180	-	2	-	475.0	360.0	-	-	567.0
Potassium	mg/L	0.01	-	-	-	2	-	2.9	3.3	-	-	2.0
Calcium	mg/L	0.01	-	-	-	2	-	11.9	15.0	-	-	5
Magnesium	mg/L	0.1	-	-	-	2	-	77.5	57.0	-	-	86.0
OH- Alkalinity	mg/L	5	-	-	-	2	-	5	5	-	-	-
CaCO ₃ Alkalinity	mg/L	5	-	200	-	2	-	5	5	-	-	-
Total Alkalinity	mg/L	5	-	-	-	2	-	35	25	-	-	-
Temperature	°C	0.01	-	-	-	4	-	21.45	22.68	21.83	21.83	21.74
pH	pH	0.01	6.5 – 8.0	6.5 – 8.5	-	4	-	5.65	5.57	5.78	5.78	6.05
Conductivity	mS/cm	0.001	0.125 – 2.2	-	-	4	-	3.870	2.635	4.12	4.12	3.30
Depth to water	m	0.01	-	-	-	4	-	15.56	15.56	15.59	15.59	16.18

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Red Results – Result exceeds relevant guideline concentrations.

Table B.2 Operational monitoring phase and combined operational and construction (Con) phase summary groundwater quality results for approximate chainage 48665 (Cut 11)

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
					<i>Cut 11E</i>	<i>Cut 11W</i>	<i>Cut 11E</i>	<i>Cut 11W</i>	<i>Cut 11W</i>	<i>Cut 11W</i>	<i>Cut 11W</i>	<i>Cut 11W</i>
Aluminium	µg/L	10	55	200	4	4	404	15	10	10	10	10
Arsenic	µg/L	1	13	10	4	4	1	1	1	1	1	1
Cadmium	µg/L	0.1	0.2	2	4	4	9.4	0.1	0.1	0.1	0.1	0.1
Chromium	µg/L	1	1	50	4	4	1	1	1	1	1	1
Copper	µg/L	1	1.4	2000	4	4	8	18	29	33	29	9
Lead	µg/L	1	3.4	10	4	4	1	1	1	1	1	1
Manganese	µg/L	1	1900	500	4	4	2080	13	12	13	13	7
Nickel	µg/L	1	11	20	4	4	134	4	3	4	3	3
Selenium	µg/L	10	5	10	4	4	10	1	1	1	1	10
Silver	µg/L	1	0.5	100	4	4	1	1	1	1	1	1
Zinc	µg/L	5	8	300	4	4	462	110	89	110	130	16
Iron	µg/L	10	-	300	4	4	126	17	14	12	10	50
Mercury	µg/L	0.1	0.05	1	4	4	0.26	0.05	0.05	0.05	0.05	0.10
C6-C9 Fraction	µg/L	20	-	-	4	4	20	10	10	10	10	20
C6-C10 Fraction	µg/L	10	-	-	4	4	10	10	10	10	10	-
C6-C10 less BTEX	µg/L	10	-	-	4	4	10	10	10	10	10	-
C10-C14 Fraction	µg/L	50	-	-	4	4	50	50	50	50	50	50
C15-C28 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	100
C29-C36 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	50
C10-C16 Fraction	µg/L	50	-	-	4	4	50	50	50	50	50	50
C10-C16 less Naphthalene	µg/L	50	-	-	4	4	50	50	50	50	50	-
C16-C34 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	100
C34-C40 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	100
Naphthalene	µg/L	5	16	-	4	4	5	1	1	1	1	5
Benzene	µg/L	1	950	1	4	4	1	1	1	1	1	1
Toluene	µg/L	1	-	800	4	4	2	1	1	1	1	2
Ethylbenzene	µg/L	1	-	300	4	4	2	1	1	1	1	2
m+p-Xylene	µg/L	2	200	600	4	4	2	2	2	2	2	2
o-Xylene	µg/L	1	350	600	4	4	2	1	1	1	1	2
Total Phosphorus	mg/L	0.05	0.05	-	4	4	0.05	0.08	0.10	0.15	0.10	0.03
Phosphate	mg/L	0.005	0.02	-	4	4	0.015	0.053	0.088	0.090	0.091	0.010
Total Nitrogen	mg/L	0.1	0.5	-	4	4	2.9	0.6	0.8	0.9	0.9	0.3
Nitrate	mg/L	0.005	0.04(NOx)	50	4	4	2.878	0.420	0.640	0.685	0.730	0.140
Nitrite	mg/L	0.001	0.04(NOx)	3	4	4	0.010	0.005	0.005	0.006	0.005	0.010

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
					<i>Cut 11E</i>	<i>Cut 11W</i>	<i>Cut 11E</i>	<i>Cut 11W</i>	<i>Cut 11W</i>	<i>Cut 11W</i>	<i>Cut 11W</i>	<i>Cut 11W</i>
Ammonia	mg/L	0.005	0.02	0.5	4	4	0.082	0.009	0.013	0.026	0.005	0.040
TDS	g/L	0.001	-	600	4	4	1050	90	80	90	80	-
Chloride	mg/L	0.1	-	250	4	4	222	14	13	13	12	14
Sulfate	mg/L	0.1	-	250	4	4	706	8	7	8	7	8
Bicarb Alkalinity	mg/L	0.1	-	-	4	4	50	24	32	32	32	23
Sodium	mg/L	0.1	-	180	4	4	198.2	19.0	16.0	19.0	16.0	18.0
Potassium	mg/L	0.01	-	-	4	4	6.3	2.2	2.1	2.2	2.3	1.0
Calcium	mg/L	0.01	-	-	4	4	86.6	2.8	2.3	2.8	3.3	1
Magnesium	mg/L	0.1	-	-	4	4	94.0	2.5	2.4	2.5	2.5	2.0
OH- Alkalinity	mg/L	5	-	-	4	4	5	5	5	5	5	-
CaCO ₃ Alkalinity	mg/L	5	-	200	4	4	5	5	5	5	5	-
Total Alkalinity	mg/L	5	-	-	4	4	16	24	32	32	32	-
Temperature	°C	0.01	-	-	8	8	24.99	20.54	20.95	20.35	20.35	21.47
pH	pH	0.01	6.5 – 8.0	6.5 – 8.5	8	8	6.76	5.82	5.88	5.88	5.88	6.23
Conductivity	mS/cm	0.001	0.125 – 2.2	-	8	8	1.884	0.096	0.109	0.13	0.127	0.14
Depth to water	m	0.01	-	-	8	8	3.10	7.15	7.41	7.41	6.85	7.52

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Red Results – Result exceeds relevant guideline concentrations.

Table B.3 Operational monitoring phase and combined operational and construction (Con) phase summary groundwater quality results for approximate chainage 49365 (Cut 12)

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
						<i>Cut 12W</i>		<i>Cut 12W</i>	<i>Cut 12W</i>	<i>Cut 12W</i>	<i>Cut 12W</i>	<i>Cut 12W</i>
Aluminium	µg/L	10	55	200	-	1	-	30	30	-	-	15
Arsenic	µg/L	1	13	10	-	1	-	1	1	-	-	1
Cadmium	µg/L	0.1	0.2	2	-	1	-	0.1	0.1	-	-	0.1
Chromium	µg/L	1	1	50	-	1	-	1	1	-	-	1
Copper	µg/L	1	1.4	2000	-	1	-	3	3	-	-	1
Lead	µg/L	1	3.4	10	-	1	-	1	1	-	-	1
Manganese	µg/L	1	1900	500	-	1	-	25	25	-	-	5.5
Nickel	µg/L	1	11	20	-	1	-	2	2	-	-	1
Selenium	µg/L	10	5	10	-	1	-	1	1	-	-	10
Silver	µg/L	1	0.5	100	-	1	-	1	1	-	-	1
Zinc	µg/L	5	8	300	-	1	-	28	28	-	-	9
Iron	µg/L	10	-	300	-	1	-	340	340	-	-	50
Mercury	µg/L	0.1	0.05	1	-	1	-	0.05	0.05	-	-	0.10
C6-C9 Fraction	µg/L	20	-	-	-	1	-	10	10	-	-	20
C6-C10 Fraction	µg/L	10	-	-	-	1	-	10	10	-	-	-
C6-C10 less BTEX	µg/L	10	-	-	-	1	-	10	10	-	-	-
C10-C14 Fraction	µg/L	50	-	-	-	1	-	50	50	-	-	50
C15-C28 Fraction	µg/L	100	-	-	-	1	-	100	100	-	-	100
C29-C36 Fraction	µg/L	100	-	-	-	1	-	100	100	-	-	50
C10-C16 Fraction	µg/L	50	-	-	-	1	-	50	50	-	-	50
C10-C16 less Naphthalene	µg/L	50	-	-	-	1	-	50	50	-	-	-
C16-C34 Fraction	µg/L	100	-	-	-	1	-	100	100	-	-	100
C34-C40 Fraction	µg/L	100	-	-	-	1	-	100	100	-	-	100
Naphthalene	µg/L	5	16	-	-	1	-	1	1	-	-	5
Benzene	µg/L	1	950	1	-	1	-	1	1	-	-	1
Toluene	µg/L	1	-	800	-	1	-	1	1	-	-	2
Ethylbenzene	µg/L	1	-	300	-	1	-	1	1	-	-	2
m+p-Xylene	µg/L	2	200	600	-	1	-	2	2	-	-	2
o-Xylene	µg/L	1	350	600	-	1	-	1	1	-	-	2
Total Phosphorus	mg/L	0.05	0.05	-	-	1	-	0.05	0.05	-	-	0.06
Phosphate	mg/L	0.005	0.02	-	-	1	-	0.005	0.005	-	-	0.010
Total Nitrogen	mg/L	0.1	0.5	-	-	1	-	0.2	0.2	-	-	0.7
Nitrate	mg/L	0.005	0.04(NOx)	50	-	1	-	0.010	0.010	-	-	0.350
Nitrite	mg/L	0.001	0.04(NOx)	3	-	1	-	0.005	0.005	-	-	0.010

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
						<i>Cut 12W</i>		<i>Cut 12W</i>	<i>Cut 12W</i>	<i>Cut 12W</i>	<i>Cut 12W</i>	<i>Cut 12W</i>
Ammonia	mg/L	0.005	0.02	0.5	-	1	-	0.005	0.005	-	-	0.035
TDS	g/L	0.001	-	600	-	1	-	260	260	-	-	-
Chloride	mg/L	0.1	-	250	-	1	-	110	110	-	-	33
Sulfate	mg/L	0.1	-	250	-	1	-	6	6	-	-	6
Bicarb Alkalinity	mg/L	0.1	-	-	-	1	-	21	21	-	-	14
Sodium	mg/L	0.1	-	180	-	1	-	64.0	64.0	-	-	28.5
Potassium	mg/L	0.01	-	-	-	1	-	0.9	0.9	-	-	1.0
Calcium	mg/L	0.01	-	-	-	1	-	0.9	0.9	-	-	1.0
Magnesium	mg/L	0.1	-	-	-	1	-	4.8	4.8	-	-	1.0
OH- Alkalinity	mg/L	5	-	-	-	1	-	5	5	-	-	-
CaCO ₃ Alkalinity	mg/L	5	-	200	-	1	-	5	5	-	-	-
Total Alkalinity	mg/L	5	-	-	-	1	-	21	21	-	-	-
Temperature	°C	0.01	-	-	-	2	-	22.54	23.82	-	-	21.80
pH	pH	0.01	6.5 – 8.0	6.5 – 8.5	-	2	-	5.11	4.99	-	-	6.19
Conductivity	mS/cm	0.001	0.125 – 2.2	-	-	2	-	0.413	0.417	-	-	0.193
Depth to water	m	0.01	-	-	-	2	-	7.15	6.54	-	-	6.84

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Red Results – Result exceeds relevant guideline concentrations.

Table B.4 Operational monitoring phase and combined operational and construction (Con) phase summary groundwater quality results for approximate chainage 50965 (Fill 15)

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
					<i>Fill 15E</i>	<i>Fill 15W</i>	<i>Fill 15E</i>	<i>Fill 15W</i>	<i>Fill 15W</i>	<i>Fill 15W</i>	<i>Fill 15W</i>	<i>Fill 15W</i>
Aluminium	µg/L	10	55	200	4	4	10	10	10	10	10	10
Arsenic	µg/L	1	13	10	4	4	1	1	1	1	1	1
Cadmium	µg/L	0.1	0.2	2	4	4	0.5	0.1	0.1	0.2	0.2	0.1
Chromium	µg/L	1	1	50	4	4	1	1	1	1	1	1
Copper	µg/L	1	1.4	2000	4	4	3	3	4	4	4	1
Lead	µg/L	1	3.4	10	4	4	1	1	1	1	1	1
Manganese	µg/L	1	1900	500	4	4	1653	1125	2100	1125	2100	2500
Nickel	µg/L	1	11	20	4	4	16	2	2	3	3	5
Selenium	µg/L	10	5	10	4	4	10	1	1	1	1	10
Silver	µg/L	1	0.5	100	4	4	1	1	1	1	1	1
Zinc	µg/L	5	8	300	4	4	51	4	4	13	21	18
Iron	µg/L	10	-	300	4	4	868	10	10	10	10	3050
Mercury	µg/L	0.1	0.05	1	4	4	0.10	0.05	0.05	0.05	0.05	0.10
C6-C9 Fraction	µg/L	20	-	-	4	4	20	10	10	10	10	20
C6-C10 Fraction	µg/L	10	-	-	4	4	10	10	10	10	10	-
C6-C10 less BTEX	µg/L	10	-	-	4	4	10	10	10	10	10	-
C10-C14 Fraction	µg/L	50	-	-	4	4	50	50	50	50	50	50
C15-C28 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	100
C29-C36 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	50
C10-C16 Fraction	µg/L	50	-	-	4	4	50	50	50	50	50	-
C10-C16 less Naphthalene	µg/L	50	-	-	4	4	50	50	50	50	50	-
C16-C34 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	-
C34-C40 Fraction	µg/L	100	-	-	4	4	100	100	100	100	100	-
Naphthalene	µg/L	5	16	-	4	4	5	1	1	1	1	5
Benzene	µg/L	1	950	1	4	4	1	1	1	1	1	1
Toluene	µg/L	1	-	800	4	4	2	1	1	1	1	2
Ethylbenzene	µg/L	1	-	300	4	4	2	1	1	1	1	2
m+p-Xylene	µg/L	2	200	600	4	4	2	2	2	2	2	2
o-Xylene	µg/L	1	350	600	4	4	2	1	1	1	1	2
Total Phosphorus	mg/L	0.05	0.05	-	4	4	0.21	0.25	0.20	0.35	0.50	0.04
Phosphate	mg/L	0.005	0.02	-	4	4	0.034	0.008	0.008	0.007	0.005	0.010
Total Nitrogen	mg/L	0.1	0.5	-	4	4	1.2	1.5	2.1	1.4	0.7	2.4
Nitrate	mg/L	0.005	0.04(NOx)	50	4	4	0.556	0.720	0.980	0.520	0.059	0.050
Nitrite	mg/L	0.001	0.04(NOx)	3	4	4	0.010	0.005	0.005	0.005	0.005	0.010

Parameter	Units	PQL	ANZECC Guideline	ADWG	U/G	D/G	U/G	D/G	D/G	D/G	D/G	D/G
					Op No.	Op No.	Con/Op P80	Op med Current	Op med Mar 2020	Op med Sept 2019	Op med Mar 2019	Con med
					Fill 15E	Fill 15W	Fill 15E	Fill 15W	Fill 15W	Fill 15W	Fill 15W	Fill 15W
Ammonia	mg/L	0.005	0.02	0.5	4	4	0.222	0.198	0.390	0.198	0.390	0.780
TDS	g/L	0.001	-	600	4	4	10040	8600	8000	8600	8000	-
Chloride	mg/L	0.1	-	250	4	4	2350	1900	1700	1650	1600	1710
Sulfate	mg/L	0.1	-	250	4	4	2868	2500	2700	2200	1700	3200
Bicarb Alkalinity	mg/L	0.1	-	-	4	4	883	830	820	820	820	468
Sodium	mg/L	0.1	-	180	4	4	1728.0	1450.0	1400.0	1450.0	1500.0	1340.0
Potassium	mg/L	0.01	-	-	4	4	94.8	81.0	85.0	89.0	85.0	68.0
Calcium	mg/L	0.01	-	-	4	4	273.2	285.0	340.0	300	230.0	364
Magnesium	mg/L	0.1	-	-	4	4	567.2	560.0	620.0	575.0	470.0	564.0
OH- Alkalinity	mg/L	5	-	-	4	4	5	5	5	5	5	-
CaCO ₃ Alkalinity	mg/L	5	-	200	4	4	5	5	5	5	5	-
Total Alkalinity	mg/L	5	-	-	4	4	830	830	820	820	820	-
Temperature	°C	0.01	-	-	8	8	23.32	19.45	20.33	19.45	20.33	22.34
pH	pH	0.01	6.5 – 8.0	6.5 – 8.5	8	8	7.43	7.23	7.24	7.31	7.30	6.94
Conductivity	mS/cm	0.001	0.125 – 2.2	-	8	8	10.640	10.850	10.650	10.65	10.60	9.42
Depth to water	m	0.01	-	-	8	8	1.20	0.80	0.87	0.87	0.87	0.74

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Red Results – Result exceeds relevant guideline concentrations.

Table B.5 Operational monitoring phase and combined operational and construction (Con) phase summary groundwater quality results for approximate chainage 54065 (Cut 15)

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
					<i>Cut 15E</i>	<i>Cut 15W</i>	<i>Cut 15E</i>	<i>Cut 15W</i>	<i>Cut 15W</i>	<i>Cut 15W</i>	<i>Cut 15W</i>	<i>Cut 15W</i>
Aluminium	µg/L	10	55	200	4	3	10	10	10	10	-	5
Arsenic	µg/L	1	13	10	4	3	1	1	1	1	-	1
Cadmium	µg/L	0.1	0.2	2	4	3	0.3	0.1	0.1	0.1	-	1.0
Chromium	µg/L	1	1	50	4	3	1	1	1	1	-	1
Copper	µg/L	1	1.4	2000	4	3	4	2	2	1	-	1
Lead	µg/L	1	3.4	10	4	3	1	1	1	1	-	1
Manganese	µg/L	1	1900	500	4	3	70	7	6	5	-	363
Nickel	µg/L	1	11	20	4	3	3	1	1	1	-	3
Selenium	µg/L	10	5	10	4	3	10	1	1	1	-	10
Silver	µg/L	1	0.5	100	4	3	1	1	1	1	-	1
Zinc	µg/L	5	8	300	4	3	10	7	11	15	-	8
Iron	µg/L	10	-	300	4	3	50	10	10	10	-	1911
Mercury	µg/L	0.1	0.05	1	4	3	0.18	0.14	0.17	0.20	-	0.50
C6-C9 Fraction	µg/L	20	-	-	4	3	20	10	10	10	-	20
C6-C10 Fraction	µg/L	10	-	-	4	3	10	10	10	10	-	-
C6-C10 less BTEX	µg/L	10	-	-	4	3	10	10	10	10	-	-
C10-C14 Fraction	µg/L	50	-	-	4	3	50	50	50	50	-	50
C15-C28 Fraction	µg/L	100	-	-	4	3	100	100	100	100	-	100
C29-C36 Fraction	µg/L	100	-	-	4	3	100	100	100	100	-	100
C10-C16 Fraction	µg/L	50	-	-	4	3	50	50	50	50	-	50
C10-C16 less Naphthalene	µg/L	50	-	-	4	3	50	50	50	50	-	-
C16-C34 Fraction	µg/L	100	-	-	4	3	100	100	100	100	-	100
C34-C40 Fraction	µg/L	100	-	-	4	3	100	100	100	100	-	100
Naphthalene	µg/L	5	16	-	4	3	5	1	1	1	-	5
Benzene	µg/L	1	950	1	4	3	1	1	1	1	-	1
Toluene	µg/L	1	-	800	4	3	2	1	1	1	-	2
Ethylbenzene	µg/L	1	-	300	4	3	2	1	1	1	-	2
m+p-Xylene	µg/L	2	200	600	4	3	2	2	2	2	-	2
o-Xylene	µg/L	1	350	600	4	3	2	1	1	1	-	2
Total Phosphorus	mg/L	0.05	0.05	-	4	3	0.31	0.05	0.05	0.05	-	0.03
Phosphate	mg/L	0.005	0.02	-	4	3	0.010	0.005	0.005	0.005	-	0.010
Total Nitrogen	mg/L	0.1	0.5	-	4	3	1.3	0.1	0.1	0.1	-	0.2
Nitrate	mg/L	0.005	0.04(NOx)	50	4	3	0.340	0.140	0.145	0.140	-	0.040
Nitrite	mg/L	0.001	0.04(NOx)	3	4	3	0.010	0.005	0.005	0.005	-	0.003

<i>Parameter</i>	<i>Units</i>	<i>PQL</i>	<i>ANZECC Guideline</i>	<i>ADWG</i>	<i>U/G</i>	<i>D/G</i>	<i>U/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>	<i>D/G</i>
					<i>Op No.</i>	<i>Op No.</i>	<i>Con/Op P80</i>	<i>Op med Current</i>	<i>Op med Mar 2020</i>	<i>Op med Sept 2019</i>	<i>Op med Mar 2019</i>	<i>Con med</i>
					<i>Cut 15E</i>	<i>Cut 15W</i>	<i>Cut 15E</i>	<i>Cut 15W</i>	<i>Cut 15W</i>	<i>Cut 15W</i>	<i>Cut 15W</i>	<i>Cut 15W</i>
Ammonia	mg/L	0.005	0.02	0.5	4	3	0.046	0.005	0.007	0.009	-	0.040
TDS	g/L	0.001	-	600	4	3	100	67	63	58	-	-
Chloride	mg/L	0.1	-	250	4	3	21	17	18	17	-	18
Sulfate	mg/L	0.1	-	250	4	3	17	12	12	12	-	19
Bicarb Alkalinity	mg/L	0.1	-	-	4	3	26	8	8	7	-	31
Sodium	mg/L	0.1	-	180	4	3	33.2	16.0	18.0	21.0	-	11.9
Potassium	mg/L	0.01	-	-	4	3	1.0	0.5	0.5	0.5	-	1.3
Calcium	mg/L	0.01	-	-	4	3	1.2	0.5	0.5	0.5	-	2.36
Magnesium	mg/L	0.1	-	-	4	3	2.8	1.2	1.2	1.2	-	7.7
OH- Alkalinity	mg/L	5	-	-	4	3	5	5	5	5	-	-
CaCO ₃ Alkalinity	mg/L	5	-	200	4	3	5	5	5	5	-	-
Total Alkalinity	mg/L	5	-	-	4	3	21	8	8	7	-	-
Temperature	°C	0.01	-	-	8	6	24.91	21.05	21.77	20.65	-	21.37
pH	pH	0.01	6.5 – 8.0	6.5 – 8.5	8	6	6.80	5.00	4.97	4.84	-	6.06
Conductivity	mS/cm	0.001	0.125 – 2.2	-	8	6	0.213	0.108	0.106	0.11	-	0.18
Depth to water	m	0.01	-	-	8	6	15.85	16.94	17.50	17.50	-	15.97

Red shading – Indicates a result of interest at March 2019.

Blue shading – Indicates a result of interest at September 2019.

Green shading – Indicates a result of interest at March 2020.

Purple shading – Indicates a result of interest at September 2020.

Red Results – Result exceeds relevant guideline concentrations.