Nambucca Heads to Urunga Pacific Highway Upgrade

Water Quality Monitoring Annual Report

Roads and Maritime Services | June 2020

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December 2020

Nambucca Heads to Urunga Pacific Highway Upgrade

Water Quality Monitoring Annual Report June 2020

Report Prepared for:

NSW Roads and Maritime Services

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Prepared By:

Aquatic Science and Management

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1 Introduction

1.1 Introduction and Background

The Pacific Highway upgrade between Nambucca Heads and Urunga is operational. Monitoring of surface and groundwater quality has been ongoing in the pre-construction and construction phases and is to be undertaken for the first three years of operation according to the Surface Water Monitoring Program (GeoLINK 2013a) and the Groundwater Monitoring Program (GeoLINK 2013b).

This document presents the surface water and groundwater monitoring results obtained between 1 September 2019 and 30 June 2020 for the Pacific Highway upgrade between Nambucca Heads and Urunga (NH2U upgrade).

1.1.1 Aims and Objectives

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 Nambucca Heads to Urunga and to comply with the Department of Planning and Environment (DP&E) Ministers condition of approval B17 (MCoA B17).

RMS and the NSW government both have stated commitments and objectives with respect to the preservation of surface and groundwater quality, levels and flow. These are met by the general objective of the Statement of Commitment No. W3:- *Monitoring of groundwater impacts and surface water quality upstream and downstream of the site during construction will determine the effectiveness of mitigation strategies. Implementation of additional feasible and reasonable management measure will occur if necessary*.

Ministers Condition of Approval (MP 07_0112) B17, required RMS *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, RMS prepared and the Department of Planning and Environment approved the Surface Water Monitoring Program (SWMP) and the Groundwater Monitoring Program (GMP) . 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;

- Have provisions to provide RMS with timely advice about surface and groundwater quality and how they compare to relevant and appropriate guideline levels;

The aim of this report is to provide a summary of water quality sampling and analysis activities for the 2019 annual reporting period (1 September 2019 – 31 August 2020). 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) 2013) 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 collected data as guideline values. The SWMP and the GMP 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) the ADWG guidelines will be used in conjunction with the relevant ANZECC guidelines 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. The relevant ADWG concentrations are presented in **Table 1.1**.

Table 1.1 Available ANZECC and ADWG guideline concentrations for relevant parameters

Parameter	***ANZECC Guideline Concentrations for Aquatic Ecosystem Protection (95% of spp.) in moderately disturbed ecosystems***		***ADWG Concentrations***
	Freshwater	***Marine***	
Silver (µg/L)	0.05	1.4	100
Aluminium (µg/L)	55	0.5[a]	200[b]
Antimony	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
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	-
Total Suspended Solids (mg/L)	-	-	-
Temperature (°C)	-	-	-
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% saturataion[b]

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 eleven surface water locations (20 sites) where ongoing surface water monitoring is required. Maps of the site locations are presented in **Illustrations 2.1 to 2.4** (GeoLINK 2013a). The locations (from south to north) are as follows:

- Boggy Creek, approximate chainage 62700, sites SW208U and SW208D
- Cow Creek, approximate chainage 63600, sites SW217U and SW217D
- Deep Creek, approximate chainage 65000, sites SW231U and SW231D
- Unnamed Tributary of Oyster Creek, approximate chainages 68000 and 68100, Sites SW261 and SW262
- McGraths Creek, approximate chainage 72000, sites SW301U and 3SW01D
- Dalhousie Creek, approximate chainage 73400, sites SW315U and SW315D
- Kalang River, approximate chainage 77800, sites SW359U and SW359D
- Unnamed Tributary of SEPP Wetland No 353, approximate chainage 77900, sites SW360U and SW360D
- Unnamed Tributary of SEPP Wetland No 351, approximate chainage 79900 and 80000, sites SW380 and SW381
- SEPP Wetland No. 353, approximate chainage 78000, site SW353
- SEPP Wetland No. 351, approximate chainage 80900, site SW351

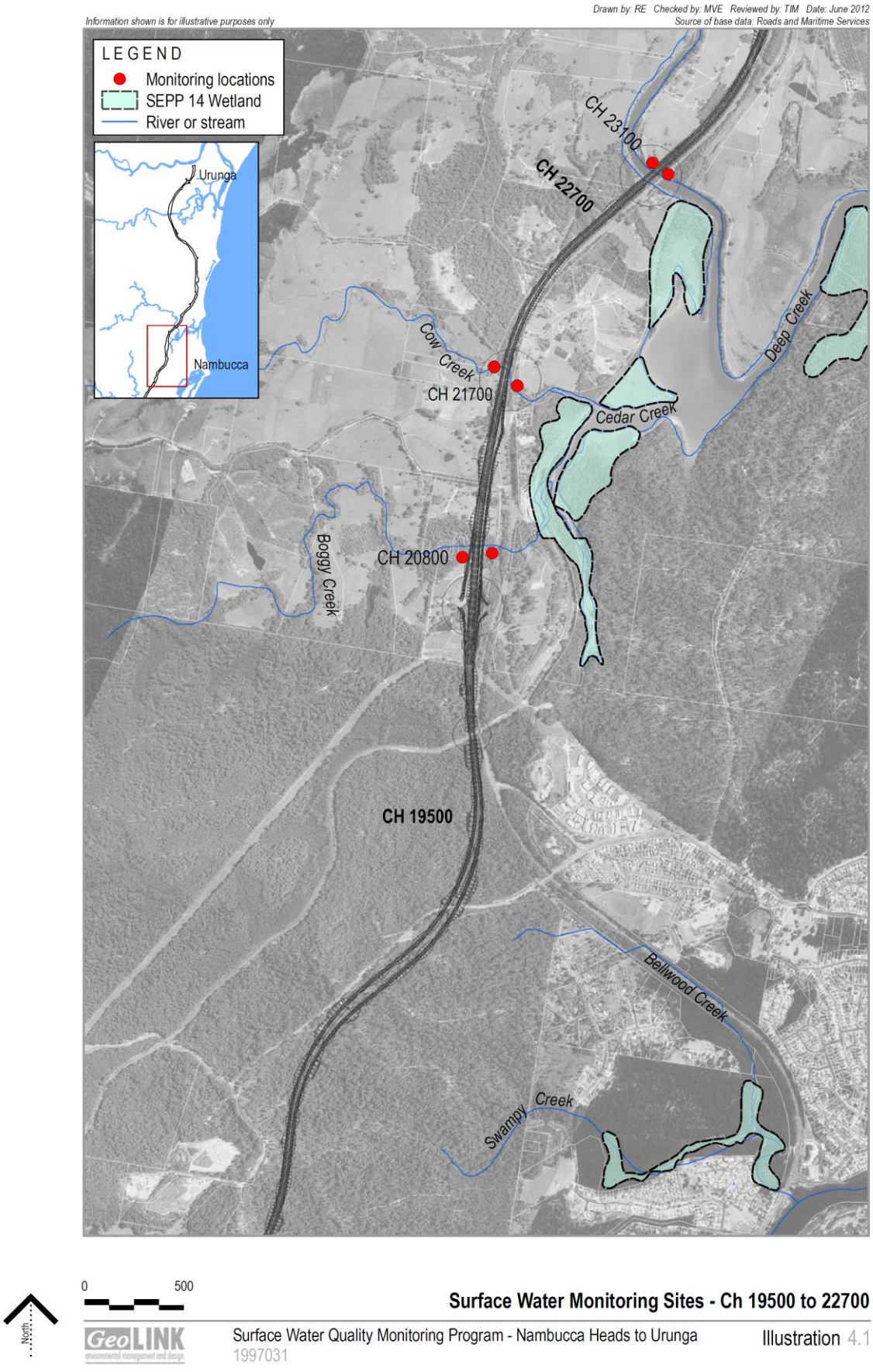

Illustration 2.1 Surface water monitoring sites – Ch 19500 to 22700 (GeoLINK 2013a)

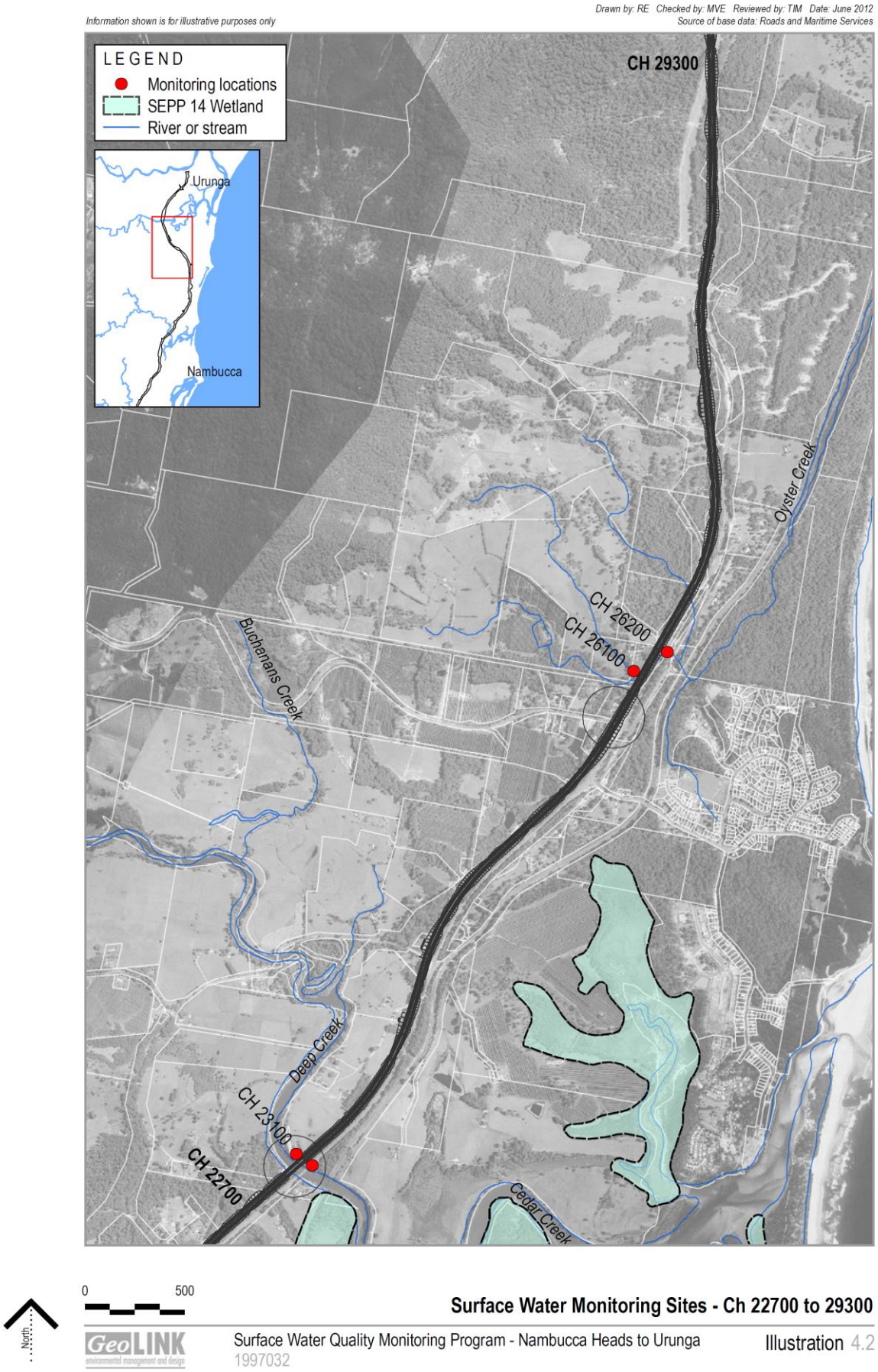

Illustration 2.2 Surface water monitoring sites – Ch 22700 to 29300 (GeoLINK 2013a)

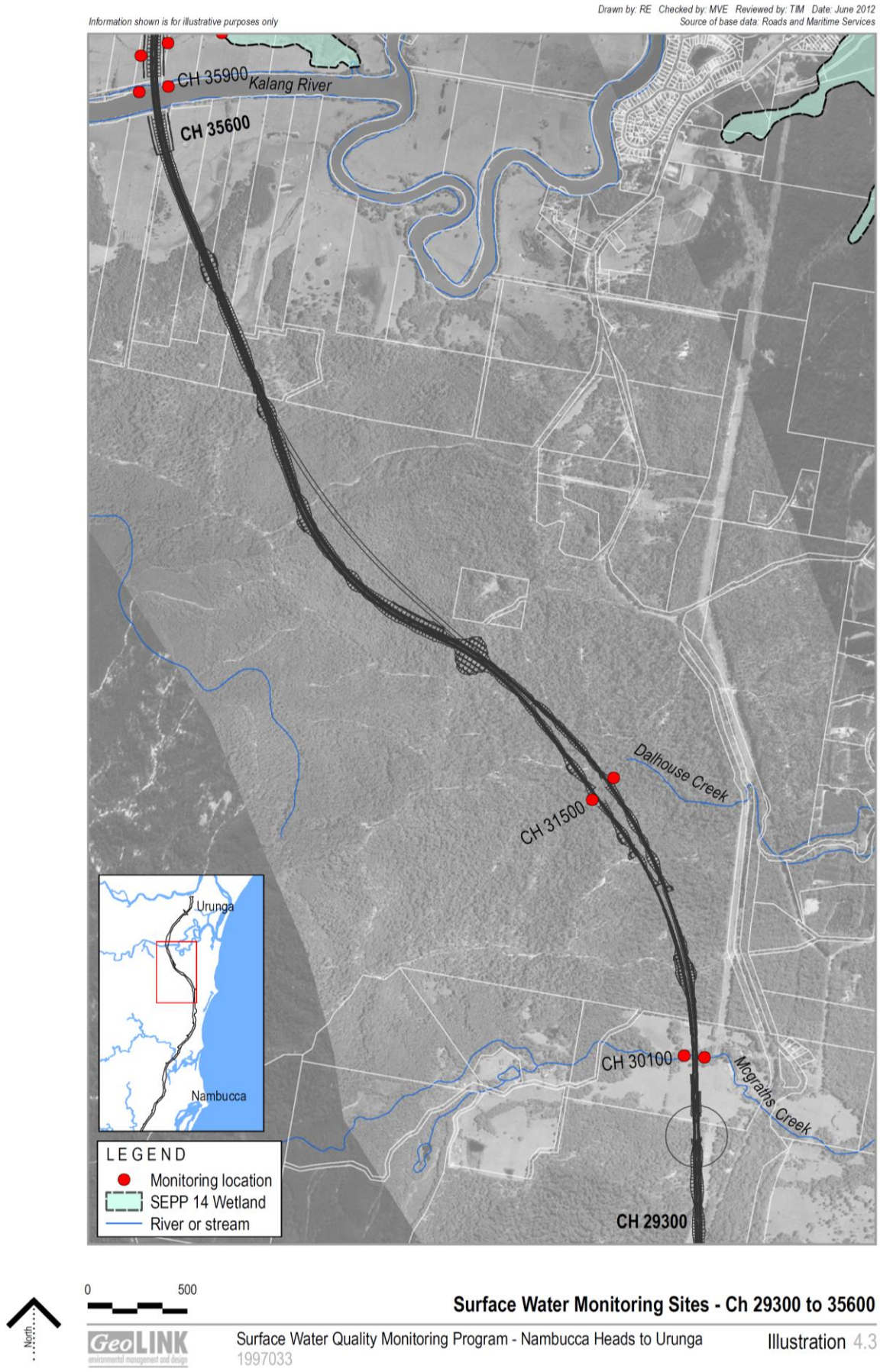

Illustration 2.3 Surface water monitoring sites – Ch 29300 to 35600 (GeoLINK 2013a)

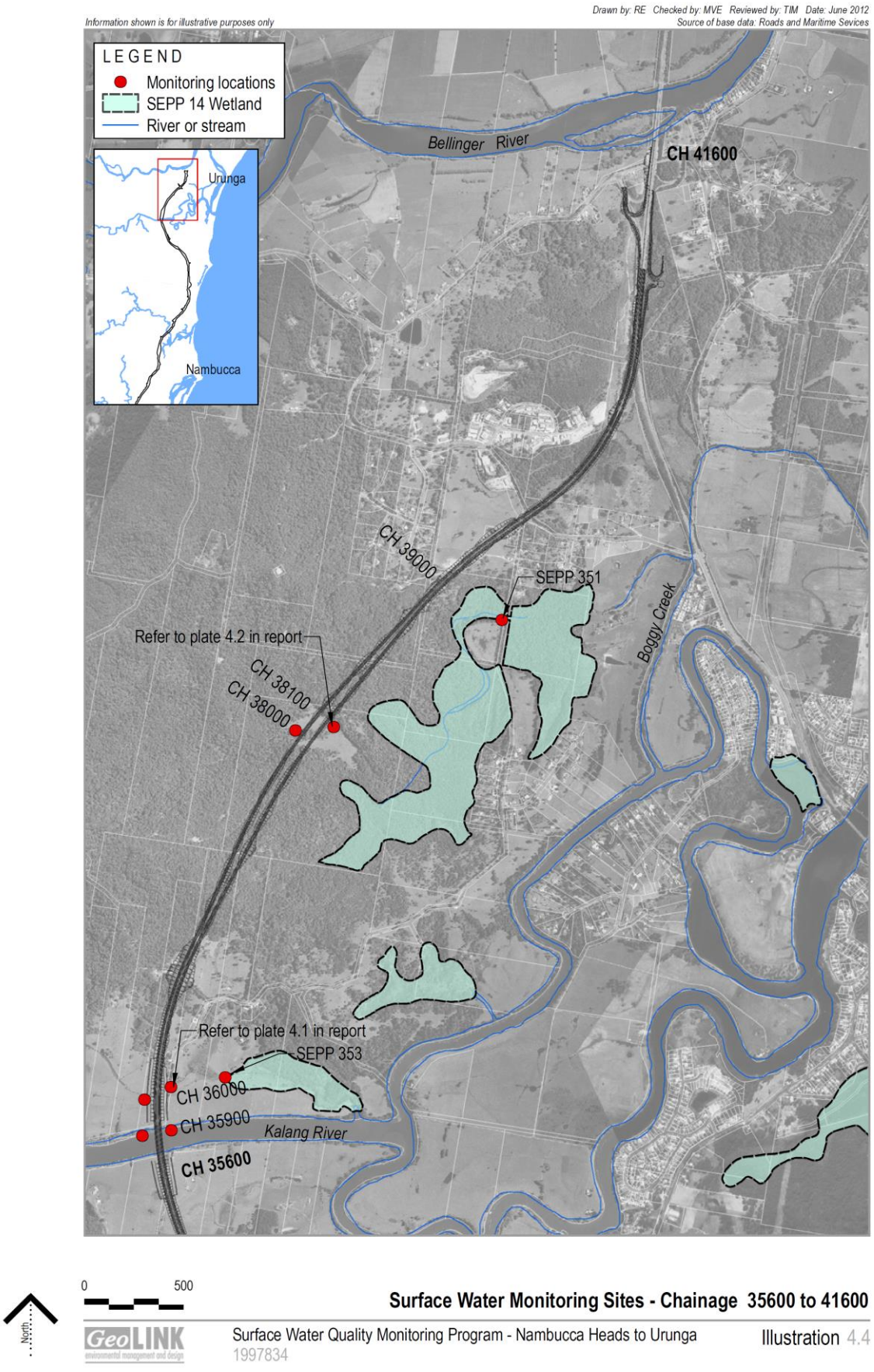

Illustration 2.4 Surface water monitoring sites – Ch 35600 to 41600 (GeoLINK 2013a)

2.1.2 Groundwater Monitoring Sites

There are six locations (11 piezometers) where ongoing groundwater monitoring is required. Maps of the site locations are presented in **Illustrations 2.5 to 2.7** (GeoLINK 2013b). The locations (from south to north) are as follows:

- Cutting No 3.5, approximate chainage 63200
- Fill upslope of SEPP Wetland No. 357, approximate chainage 64600
- Cutting No. 4.2, approximate chainage 72400
- Cutting No. 4.5, approximate chainage 74400
- Cutting No. 4.7, approximate chainage 75500
- Cutting No. 4.10, approximate chainage 78500

Monitoring at Cutting No. 4.14 (approximate chainage 80700) ceased prior to the construction phase.

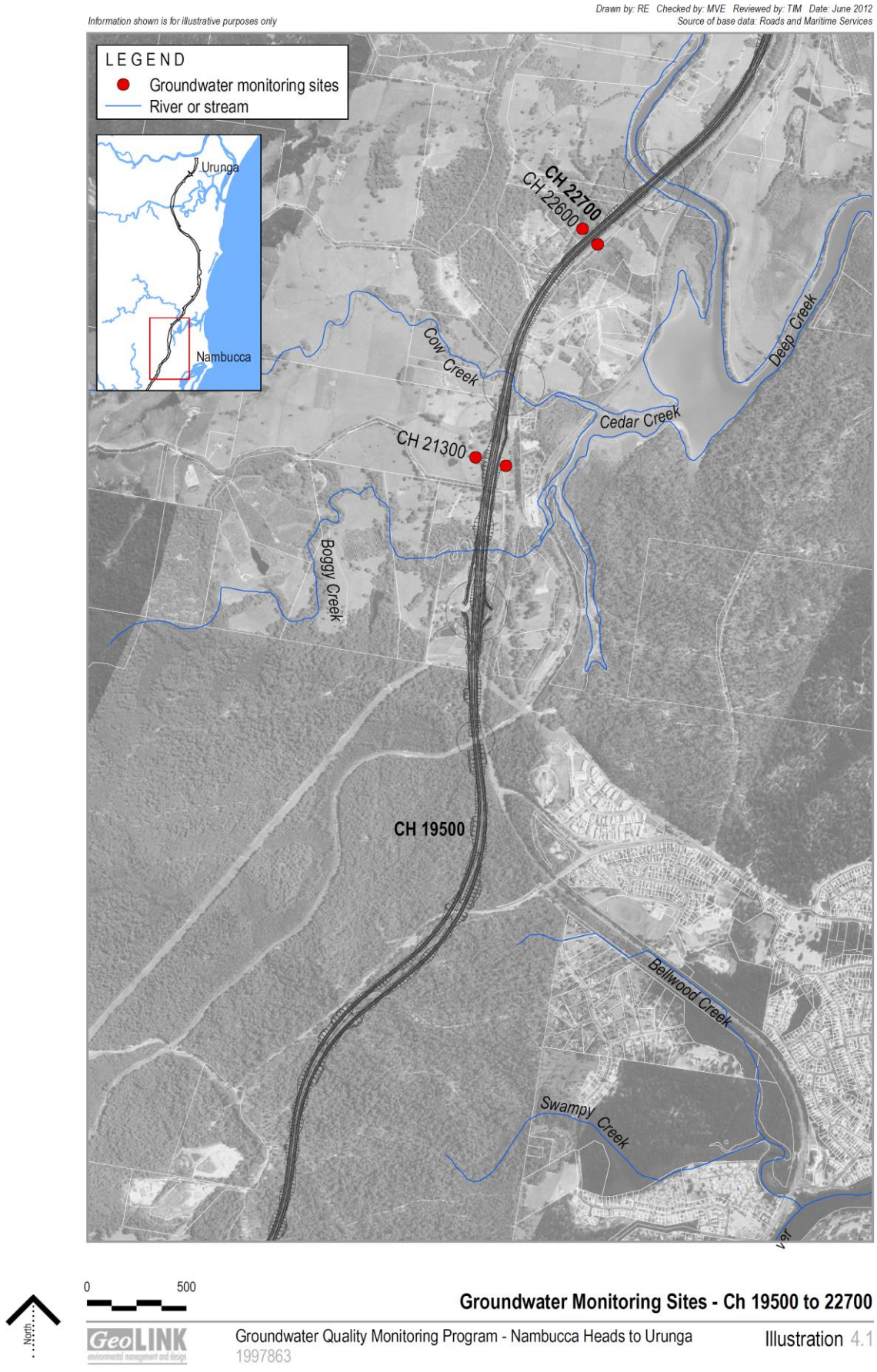

Illustration 2.5 Groundwater monitoring sites – Ch 19500 to 22700 (GeoLINK 2013b)

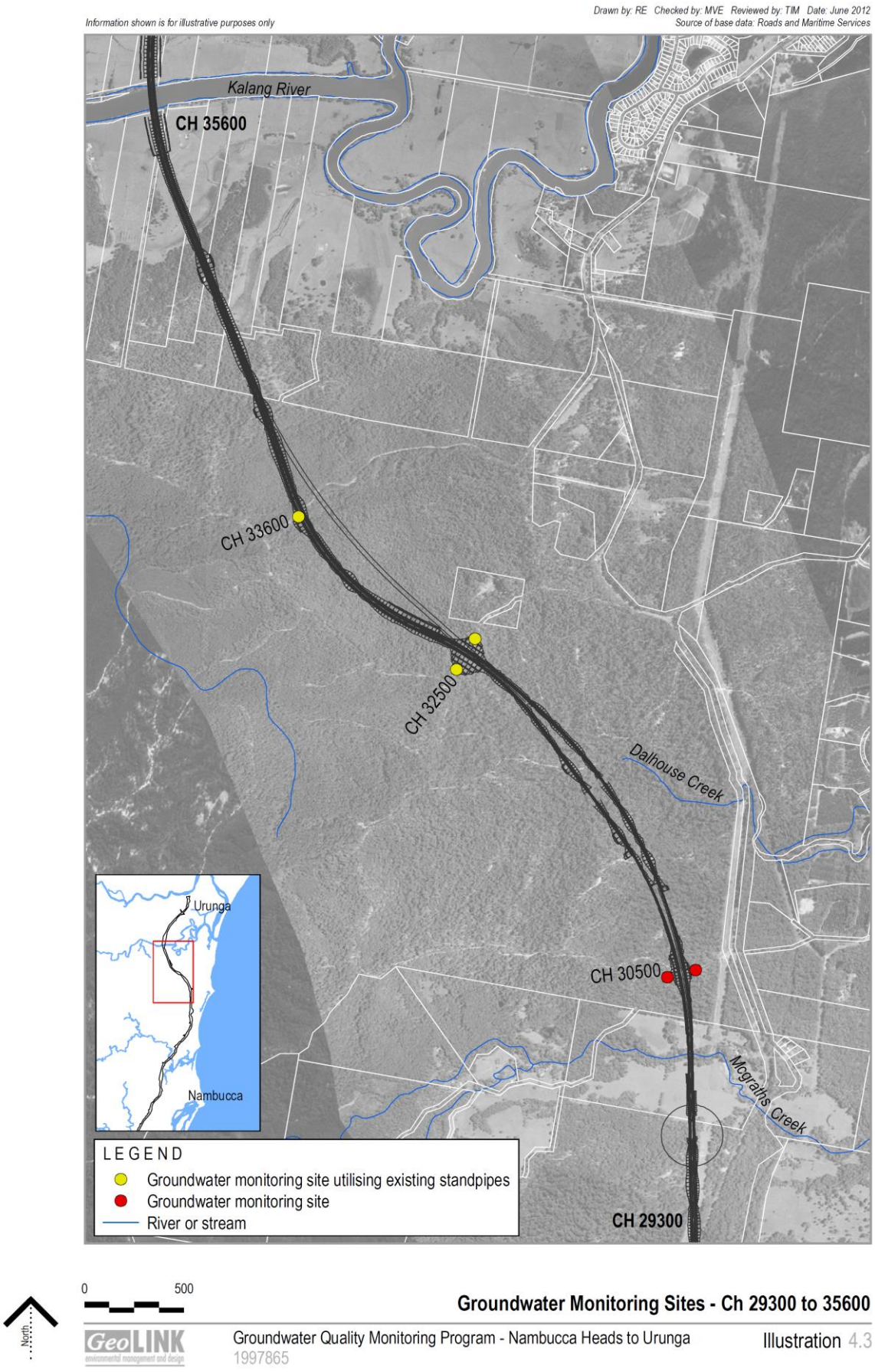

Illustration 2.6 Groundwater monitoring sites – Ch 29300 to 35600 (GeoLINK 2013b)

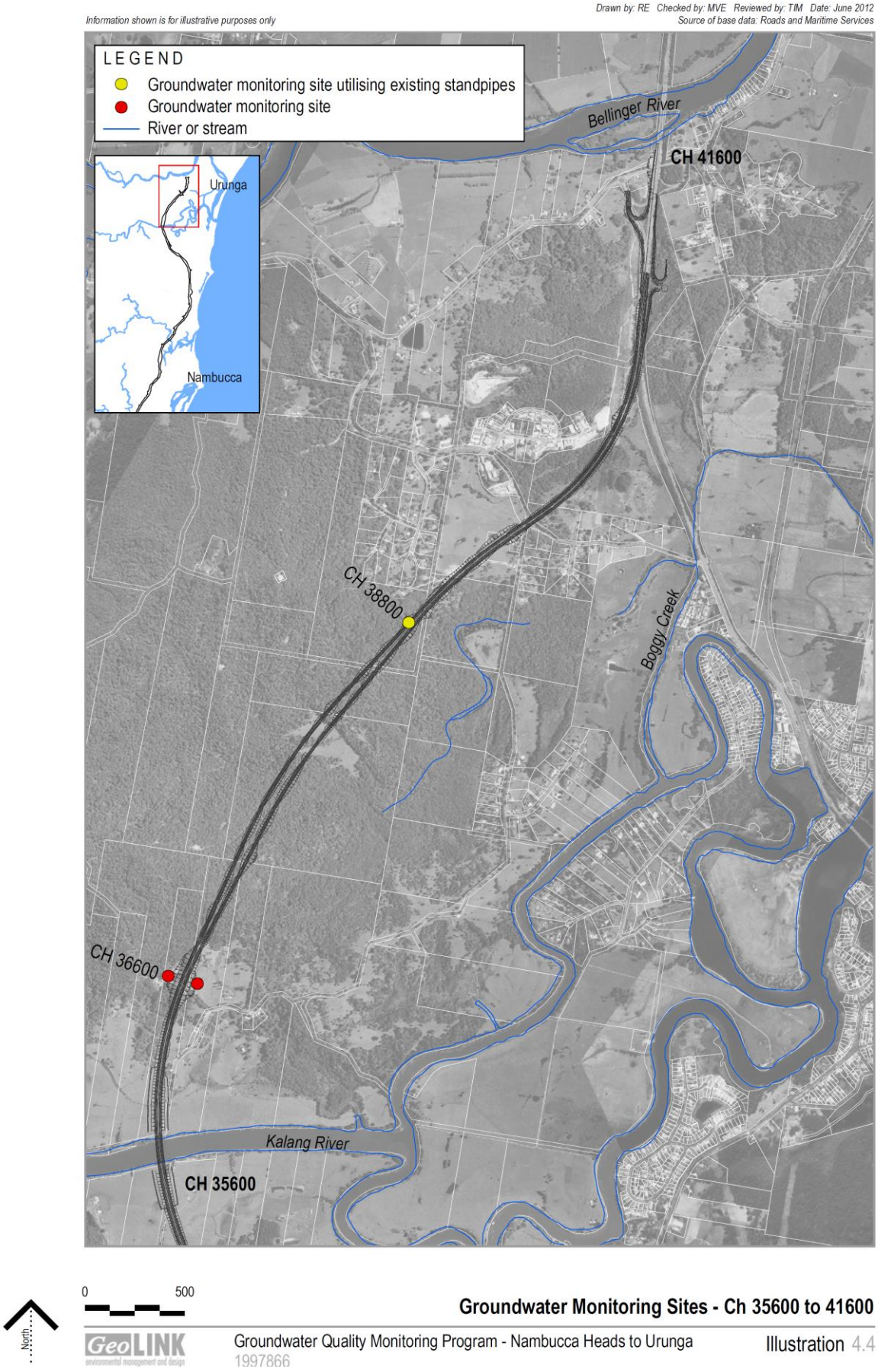

Illustration 2.7 Groundwater monitoring sites – Ch 35600 to 41600 (GeoLINK 2013b)

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 requirement for monitoring of total petroleum hydrocarbons (TPH or TRH – total recoverable hydrocarbons) outlined in the SWMP was upgraded prior to the start of operational monitoring to include monitoring of a variety of hydrocarbon sub-groups. The complete list of parameters monitored is presented in **Table 2.1**.

Table 2.1 Surface water parameters for operational monitoring

Group	*Analytes*	*Method of Analysis*
Physicochemical	Temperature	Field measurement – HORIBA U52
	Electrical Conductivity (EC)	Field measurement – HORIBA U52
	pH	Field measurement – HORIBA U52
	Dissolved Oxygen (DO)	Field measurement – HORIBA U52
	Turbidity	Field measurement – HORIBA U52
	Total Suspended Solids (TSS)	Laboratory Analysis – Inorg-019
Hydrocarbons	Total Recoverable Hydrocarbons (TRH) C6 - C9	Laboratory Analysis – Org-016
	TRH C6 - C10	Laboratory Analysis – Org-016
	TRH C10 - C14	Laboratory Analysis – Org-003
	TRH C15 - C28	Laboratory Analysis – Org-003
	TRH C29 - C36	Laboratory Analysis – Org-003
	TRH >C10 - C16	Laboratory Analysis – Org-003
	TRH >C16 - C34	Laboratory Analysis – Org-003
	TRH >C34 - C40	Laboratory Analysis – Org-003
Metals	Copper (Cu)	Laboratory Analysis – Metals-022
	Lead (Pb)	Laboratory Analysis – Metals-022
	Cadmium (Cd)	Laboratory Analysis – Metals-022
	Zinc (Zn)	Laboratory Analysis – Metals-022
	Arsenic (As)	Laboratory Analysis – Metals-022
	Selenium (Se)	Laboratory Analysis – Metals-022
	Iron (Fe)	Laboratory Analysis – Metals-022
	Manganese (Mn)	Laboratory Analysis – Metals-022
	Silver (Ag)	Laboratory Analysis – Metals-022
	Chromium (Cr)	Laboratory Analysis – Metals-022
	Nickel (Ni)	Laboratory Analysis – Metals-022
	Aluminium (Al)	Laboratory Analysis – Metals-022
	Mercury (Hg)	Laboratory Analysis – Metals-021

Group	*Analytes*	*Method of Analysis*
Nutrients	Total Nitrogen (TN)	Laboratory Analysis – Inorg-055/062
	Total Phosphorus (TP)	Laboratory Analysis – Metals-020
	Nitrate (NO_3)	Laboratory Analysis – Inorg-055
	Nitrite (NO_2)	Laboratory Analysis – Inorg-055
	Ammonia (NH_4)	Laboratory Analysis – Inorg-057
	Phosphate (PO_4)	Laboratory Analysis – Inorg-060

The SWMP also defines the sampling frequency for operational monitoring, which started in September 2016. This is presented in **Table 2.2**. The pre-construction phase monitoring period was between September 2012 and February 2013. The construction phase monitoring period was between March 2013 and August 2016.

Table 2.2 Operational phase sample frequency (GeoLINK 2013a)

Period	*Dates*	*Parameters*	*Sample Frequency*
First & Second Year	September 2016 – August 2018	Physicochemical	1 wet sample monthly and 1 dry sample six-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 wet sample bi-monthly and 1 dry sample six-monthly
Third Year	September 2018 – August 2019	Physicochemical	1 wet sample bi-monthly and 1 dry sample six-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 wet sample six-monthly and 1 dry sample six-monthly
Fourth Year	September 2019 – June 2020	Physicochemical	1 wet sample six-monthly and 1 dry sample six-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 wet sample six-monthly and 1 dry sample six-monthly

The dates of surface water quality monitoring sampling for the fourth year of operational phase monitoring are presented in **Table 2.3**. The water quality monitoring requirements set out in the SWMP were completed in June 2020. All samples collected during this reporting period were collected within the timeframes specified in the SWMP.

Table 2.3 Surface water sampling dates for fourth year operational phase sampling

Month	*Date*	*Sample Type*	*Parameters*				*Notes*
			Physicochemical	*Hydrocarbons*	*Metals*	*Nutrients*	
Aug* 2019	15/8/19	Dry	Y	Y	Y	Y	3rd year sample. Dalhousie Creek dry upstream and downstream.
Dec 2019	15/12/19	Wet	Y	Y	Y	Y	4th year sample. Dalhousie Creek dry upstream and downstream. Oyster Creek tributary dry upstream. Unnamed Ck 38000 dry upstream.
Apr 2020	27/04/20	Dry	Y	Y	Y	Y	4th year sample. All samples collected.
Jun 2020	18/06/20	Wet	Y	Y	Y	Y	4th year sample. All samples collected.

Highlighted samples collected during the current reporting period.
*** samples collected during the previous reporting period.**

Rainfall conditions at the time of sampling are presented in **Figure 3.1**.

During the operational phase monitoring surface waters were sampled from a depth of approximately 0.1 – 0.2 m. Samples were collected by dipping the sampling vessel into the water by sampling pole. Sample vessels were 500 mL plastic containers, sample rinsed three times. Separate 100 mL plastic containers pre-charged with acid were used for analyses of metals and separate 40 mL glass containers were used for hydrocarbon analyses.

All samples with a requirement for laboratory analysis were sent in cooled eskys by overnight courier to Envirolab in Chatswood, NSW on the day of collection.

2.2.2 Groundwater Quality Monitoring

The GMP outlines the parameters required for monitoring in the operational phase of the project. The requirement for monitoring of total petroleum hydrocarbons (TPH, or total recoverable hydrocarbons – TRH) outlined in the GMP was upgraded prior to the start of operational monitoring to include monitoring of a variety of hydrocarbon sub-groups. The complete list of parameters monitored is the same as for surface water (see **Table 2.1**), except there is no requirement to measure DO concentration or turbidity.

The frequency of groundwater quality monitoring is also defined by the GMP. This is presented in **Table 2.4**. Groundwater quality measurements were collected four times during this

reporting period, on the 9/10/2019, 4/01/2019, 31/03/2020 and 30/06/2020. The groundwater samples were not collected at exactly the intervals specified in the GMP. The variation from the specified intervals of 3 months was a maximum of 5 days and would not have resulted in any impacts to the quality or integrity of the data collected.

Table 2.4 Operational phase groundwater sample frequency (GeoLINK 2013b)

Period	***Dates***	***Parameters***	***Sample Frequency***
Entire Monitoring Period	September 2016 – June 2020	Physicochemical	1 sample three-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 sample six-monthly

2.2.3 Groundwater Level Monitoring

Groundwater levels are monitored using HOBO data loggers for the operational phase monitoring. These were deployed at most sites in 29 July 2017, collecting data at 2-hour intervals (2-hour intervals chosen as a suitable period to collect data in adequate detail and extend battery life). The HOBO loggers are deployed at a point approximately 0.3 m above the bottom of each piezometer. There is an extra HOBO deployed at Chainage 78500 that captures barometric pressure information, later used to offset barometric pressure fluctuations in the data collected from the piezometers. Logged data was retrieved at approximately 3-month intervals.

Some of the groundwater piezometers used for monitoring in the pre-construction phase were decommissioned during the construction phase and new piezometers constructed. These include the groundwater piezometers at approximate chainages 63200 (upgradient), 64600 (upgradient), 72400 (downgradient), 74300 (upgradient and downgradient) and 75500 (upgradient). The monitoring bore at approximate chainage 63200 (upgradient) was found to be collapsed during an inspection on 29/06/2017 and a new bore was constructed.

3 Results and Discussion

3.1 Rainfall

The surface water monitoring is governed by rainfall. A rainfall event triggering a wet episode sample was a minimum of 10 mm rain in 24 hours. A dry episode sampling run was triggered by 96 hours with no rainfall and 240 hours with less than 20mm rainfall. Three Bureau of Meteorology (BOM) stations, Kalang, Kooroowi and Nambucca Heads, were monitored to ensure wet conditions or dry conditions occurred across the entire upgrade section. Daily rainfall for the reporting period is displayed in **Figure 3.1**.

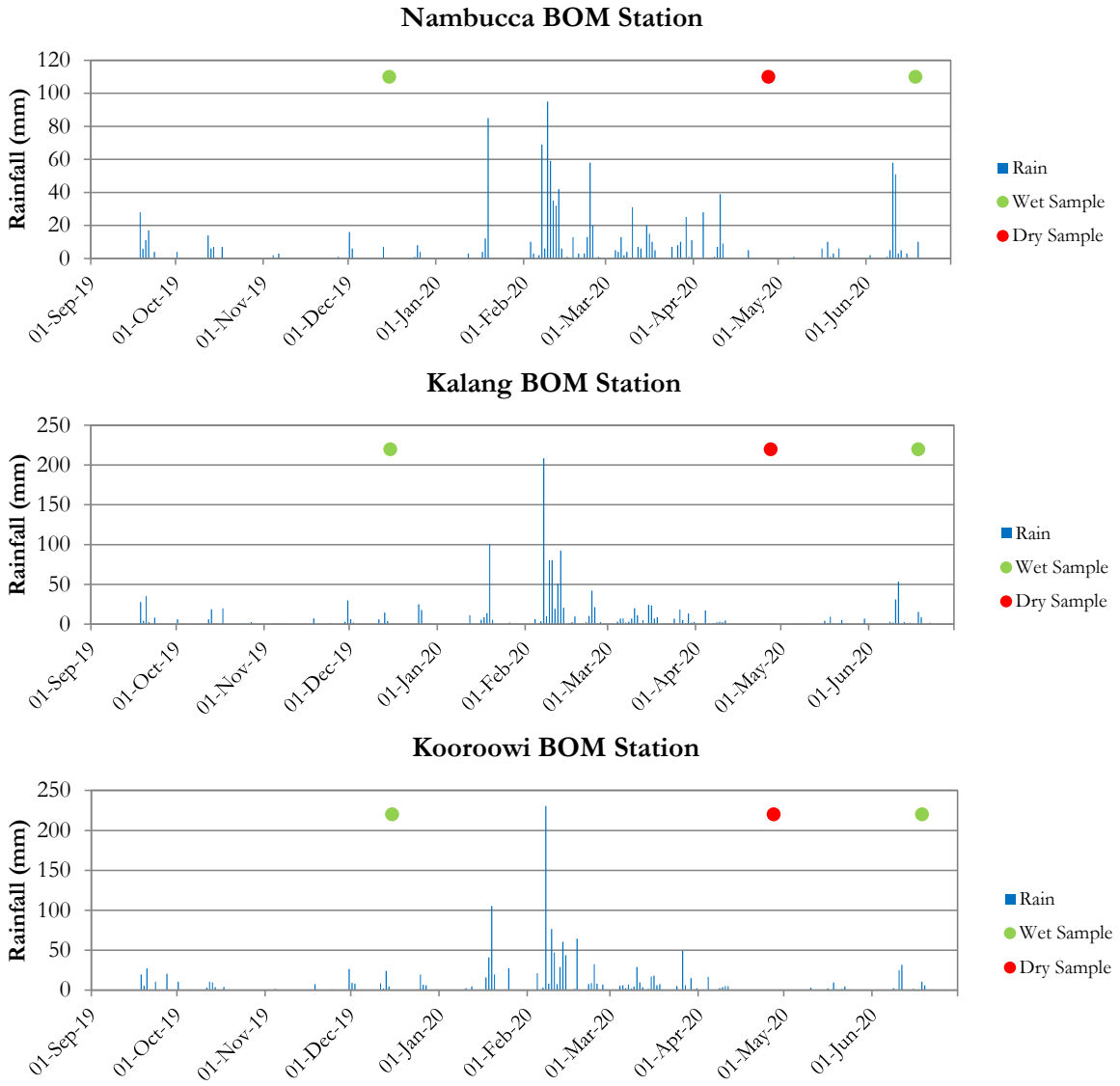

Figure 3.1 Daily rainfall at the Kalang, Kooroowi and Nambucca weather stations for the reporting period (BOM 2020)

Rainfall during the reporting period was slightly below average (1165 mm fell against an average of 1276 mm) . Most months were drier than average, with over 40% of the rainfall for the reporting period falling in the month of February 2020 (**Figure 3.2**). The dry conditions in the first half of the reporting period meant that some sites were dry when surface water samples were collected on 15 December 2019.

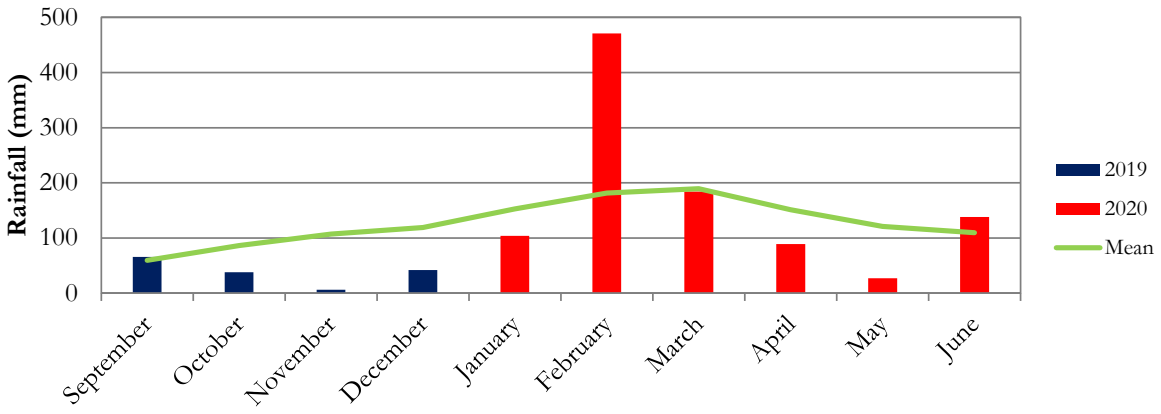

Figure 3.2 Monthly rainfall for the reporting period plotted against long term average rainfall (BOM 2020)

3.2 Surface Water

Summary surface water quality results are provided in **Appendix A**.

Sampling dates for all surface water samples collected during this reporting period are displayed in **Table 2.3**. The sampling program was up-to-date at the end of the reporting period and the requirements of the SWMP had been satisfied.

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 monitoring period from each site is presented in Appendix A with the rolling upstream P80 values. To provide historical context the summary data from the pre-construction and construction phases, in addition to the summary data at the end of the first year of operational phase monitoring is also presented.

A summary of relevant statistics for each waterway is presented in **Tables A.1** to **A.11** (**Appendix A**). A brief description of the summary results from each waterway follows.

For the purposes of analysing the results of operational phase monitoring we have defined results of interest as those where the operational phase downstream median is greater than the combined preconstruction/construction/operational phase upstream P80.

3.2.1 SEPP 14 Wetland No.351

There were two results of interest from SEPP 14 wetland No.351 (**Table A.1**). For the third consecutive year the results of interest were the downstream median TN and DO concentrations. The TN concentrations measured during this reporting period were within the limits of variation measured during pre-construction and construction phase monitoring (**Figure 3.6**). Additionally, the median downstream TN concentration measured during the operational phase to date is lower than the median downstream TN concentration from either the pre-construction or construction phase monitoring (**Table A.1**). Thus, there is no indication that operation of the NH2U upgrade is having an impact on downstream TN concentrations in SEPP 14 Wetland no.351. The two DO measurements collected from SEPP 14 wetland No.351 during this reporting period were very low (**Figure 3.7**). Additionally, the downstream operational median DO concentration from SEPP 14 wetland No.351 has trended downwards over the three years of operational phase monitoring (**Table A.1**). However, the low concentrations measured throughout the operational phase monitoring have coincided with very low water levels, dark tannin staining and no flow at the monitoring site. It is highly likely that the low DO concentrations are a result of stagnant water at that site as opposed to an impact from highway operation.

The downstream turbidity, TSS and pH measurements collected during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.3**, **3.4** and **3.5**). There was one upstream sample with very high TSS and turbidity measurements but no associated impact on the downstream water quality noted.

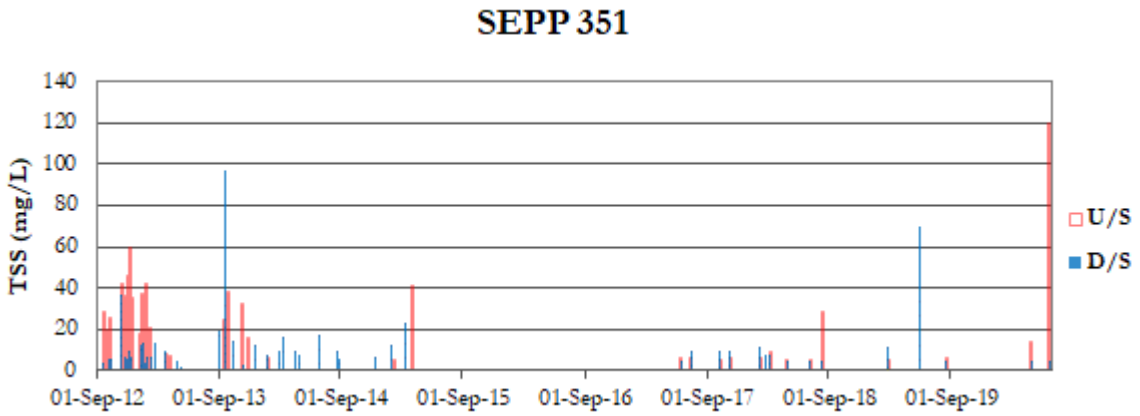

Figure 3.3 Total Suspended Sediment concentrations from SEPP 351 wetland and upstream waters since September 2012

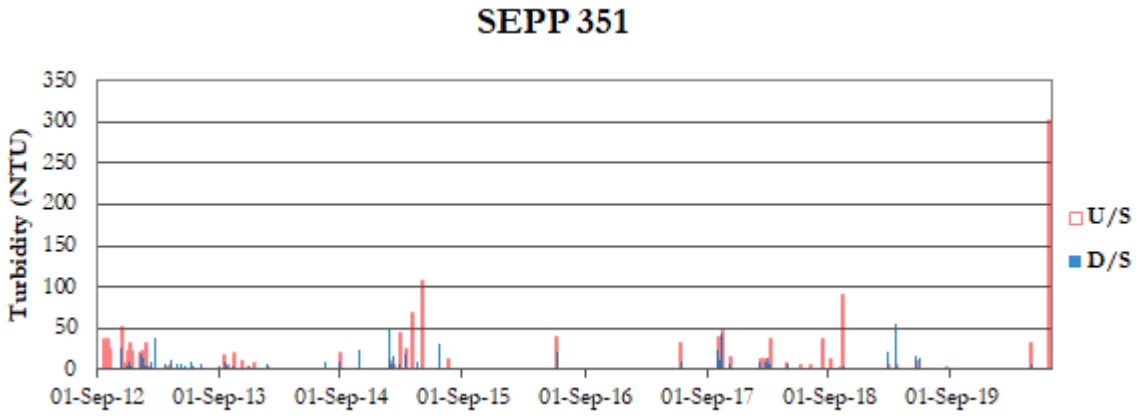

Figure 3.4 Turbidity measurements from SEPP 351 wetland and upstream waters since September 2012

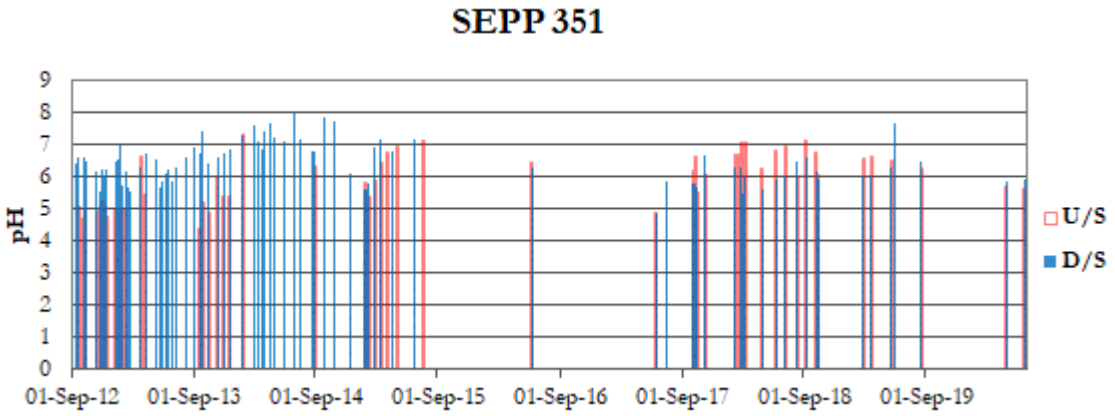

Figure 3.5 pH measurements from SEPP 351 wetland and upstream waters since September 2012

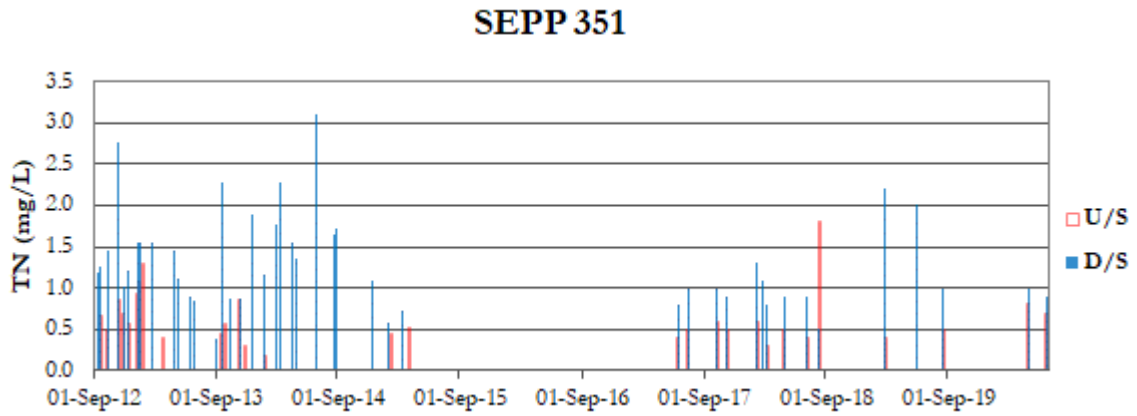

Figure 3.6 Total nitrogen concentrations from SEPP 351 wetland and upstream waters since September 2012

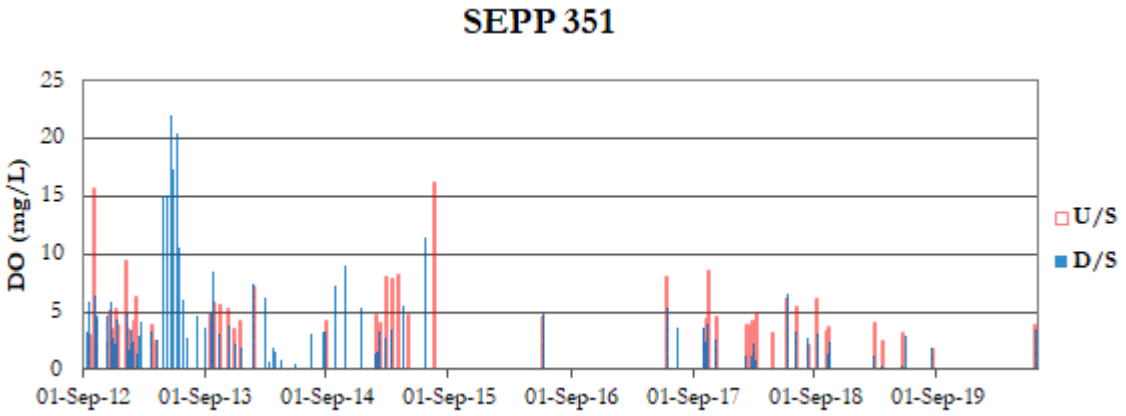

Figure 3.7 Dissolved Oxygen concentrations from SEPP 351 wetland and upstream waters since September 2012

Summary for SEPP Wetland No. 351 – Results of interest included the median downstream TN and DO concentrations. However, higher concentrations of TN were measured downstream in the construction and operational phases. The low concentrations of DO measured during the later stages of operational phase monitoring are associated with low rainfall over the long-term. No indication of impact from highway operation.

3.2.2 SEPP14 Wetland No. 353

For the second consecutive annual reporting period there were no results of interest from SEPP14 wetland No.353 (**Table A.2**). During this reporting period the downstream TSS and turbidity measurements from SEPP 14 wetland No. 353 were lower than the upstream measurements, indicating good management of sediment from highway operations (**Figures 3.8**

and **3.9**). The downstream pH measurements were all within the ranges of pre-construction measurements (**Figure 3.10**), indicating no impact on pH from highway operation.

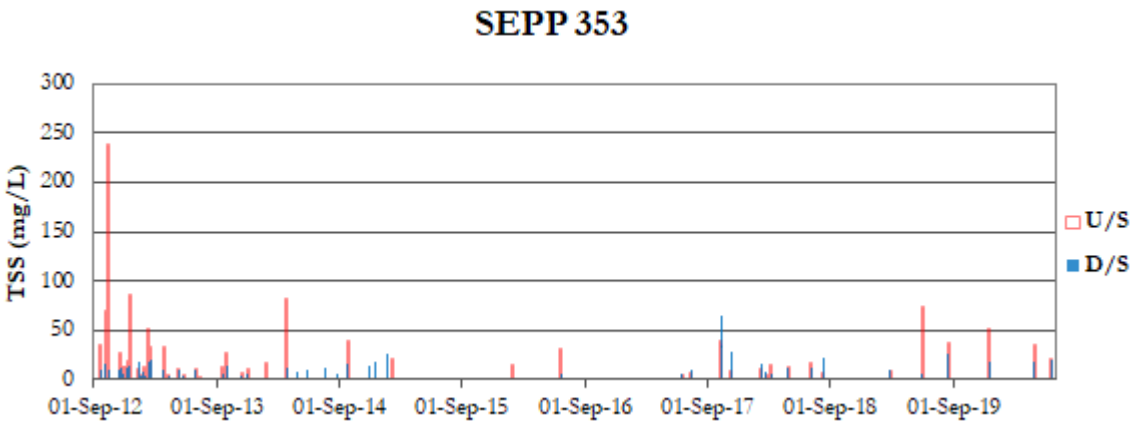

Figure 3.8 TSS concentrations from SEPP 353 wetland and upstream waters since September 2012

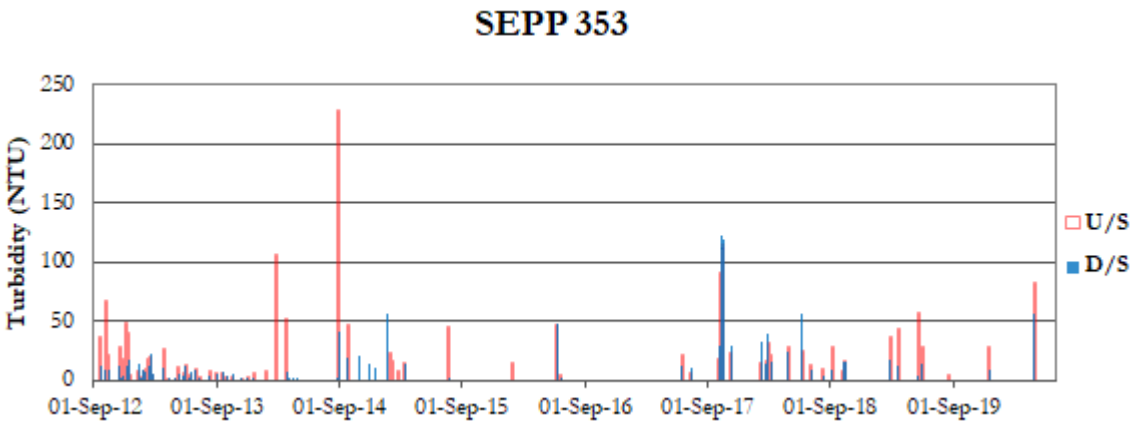

Figure 3.9 Turbidity measurements from SEPP 353 wetland and upstream waters since September 2012

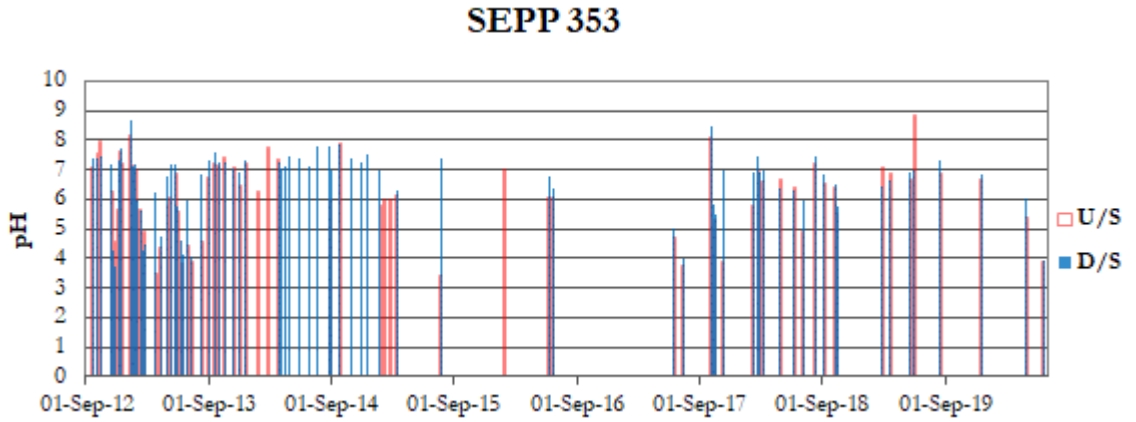

Figure 3.10 pH measurements from SEPP 353 wetland and upstream waters since September 2012

Summary for SEPP Wetland No. 353 – There were no results of interest and no indication of impacts from highway operation.

3.2.3 Unnamed Tributary to SEPP14 Wetland No. 351

For the third consecutive year the only result of interest from the unnamed tributary to SEPP14 wetland No.351 was the downstream median pH measurement (**Table A.3**). The downstream pH measurements collected during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figure 3.13**). Additionally, the pH measurements from upstream waters have also been high during operational phase monitoring, indicating that the high downstream values may not be related to the highway operation.

Turbidity and TSS measurements during operational phase monitoring remained low and were within the variation observed in pre-construction and construction phase monitoring with the exception of the samples collected on 18th June 2020, when high turbidity and TSS measurements in downstream waters occurred at the same time as very high measurements in upstream waters (**Figures 3.11** and **3.12**).

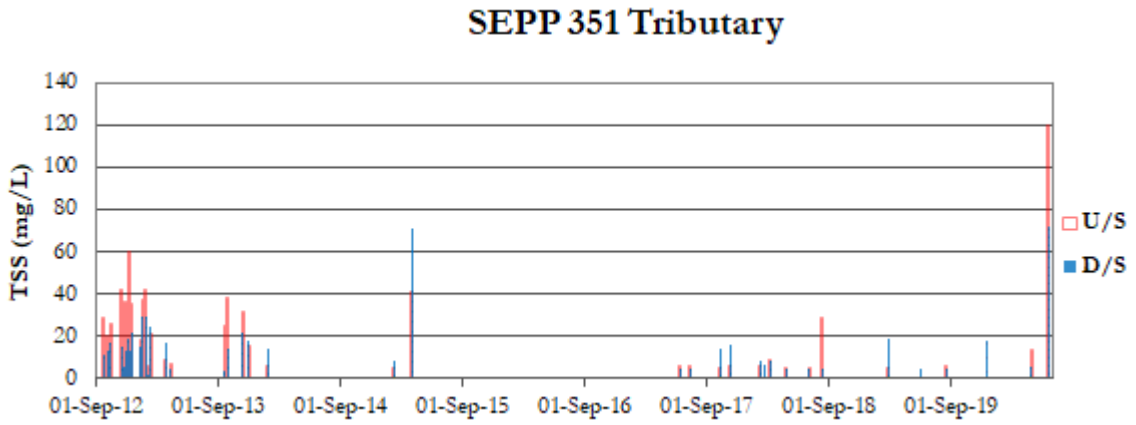

Figure 3.11 TSS concentrations from SEPP 351 tributary and upstream waters since September 2012

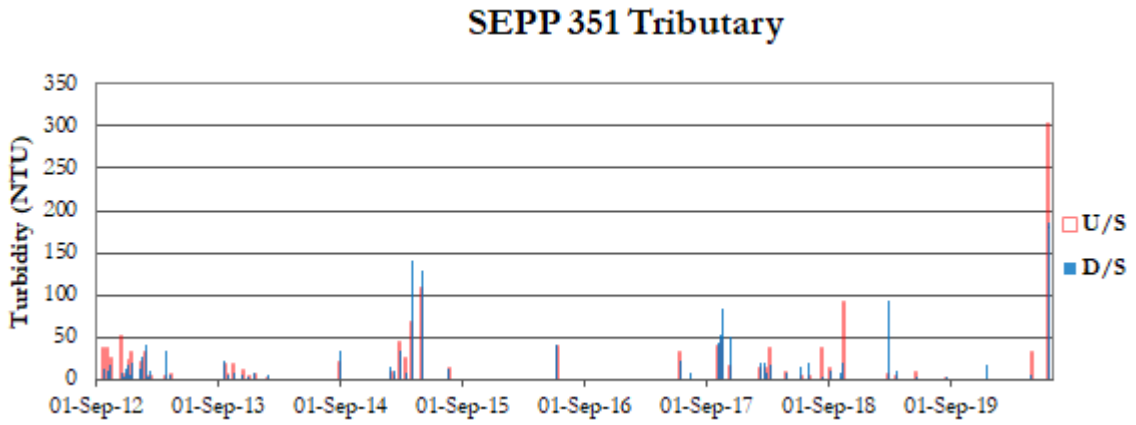

Figure 3.12 Turbidity measurements from SEPP 351 tributary and upstream waters since September 2012

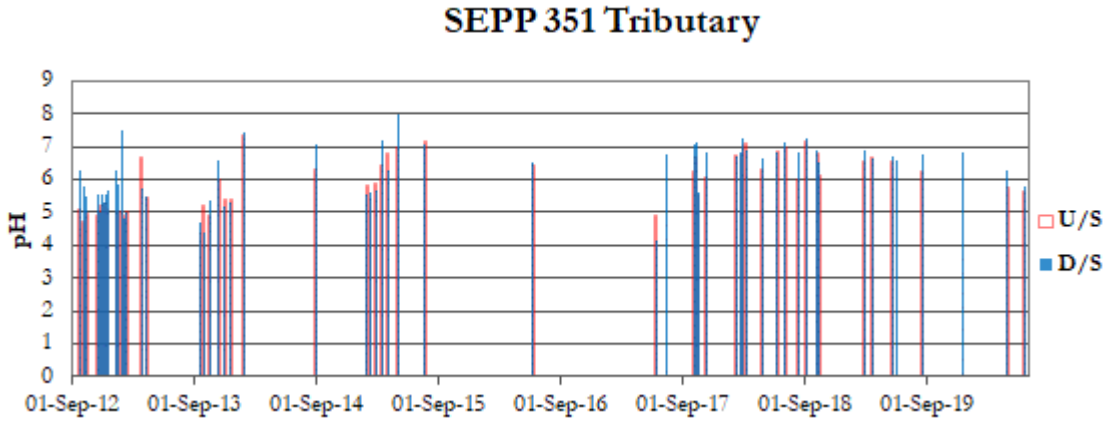

Figure 3.13 pH measurements from SEPP 351 tributary and upstream waters since September 2012

Summary for tributary to SEPP Wetland No. 351 – The median downstream construction phase pH measurement was a result of interest. However, elevated downstream pH measurements have been collected at the same time as elevated upstream measurements throughout operational phase monitoring, indicating that there has not been an impact of highway operation on pH at this site.

3.2.4 Unnamed Tributary to SEPP14 Wetland No. 353

The were no results of interest from the unnamed tributary to SEPP14 wetland No.353 (**Table A.4**).

The upstream and downstream TSS, turbidity and pH measurements collected during this reporting period were all within the variation observed in construction phase monitoring (**Figures 3.14**, **3.15** and **3.16**) with the exception of one upstream measurement.

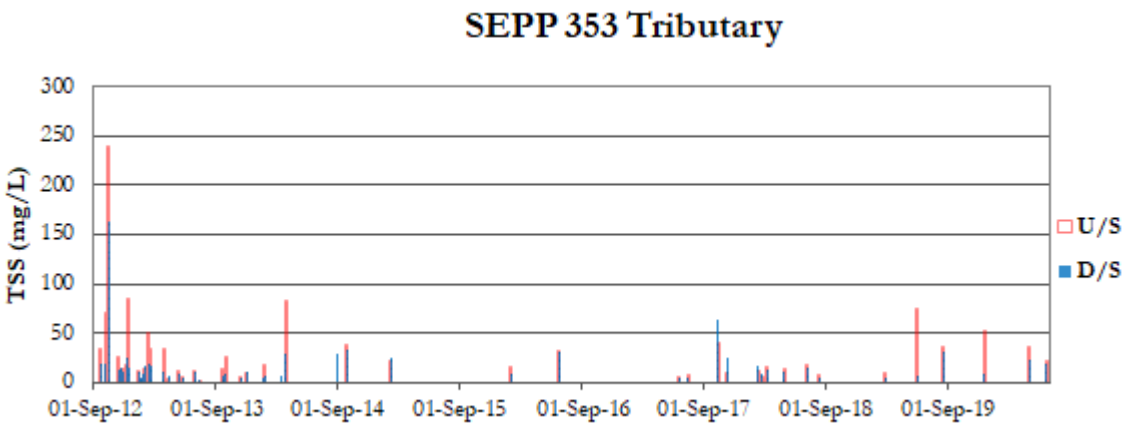

Figure 3.14 TSS concentrations from SEPP 353 tributary and upstream waters since September 2012

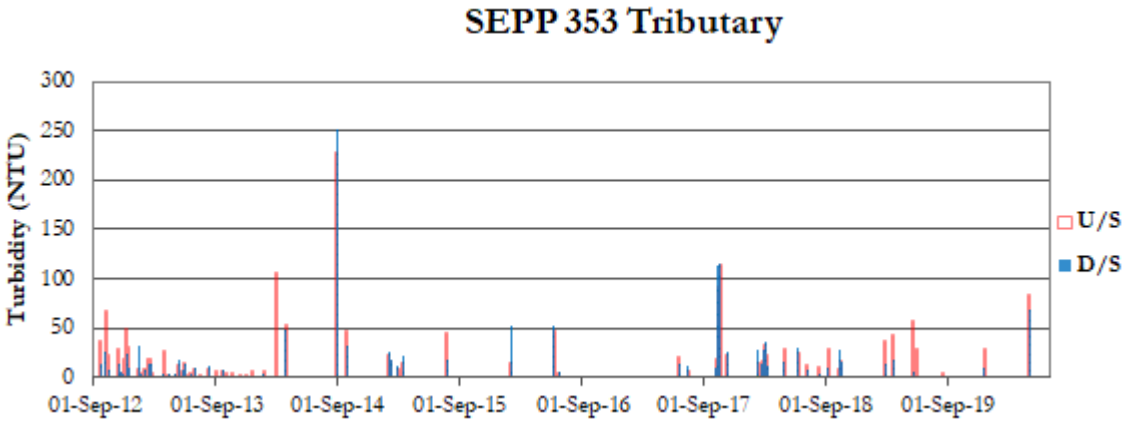

Figure 3.15 Turbidity measurements from SEPP 353 tributary and upstream waters since September 2012

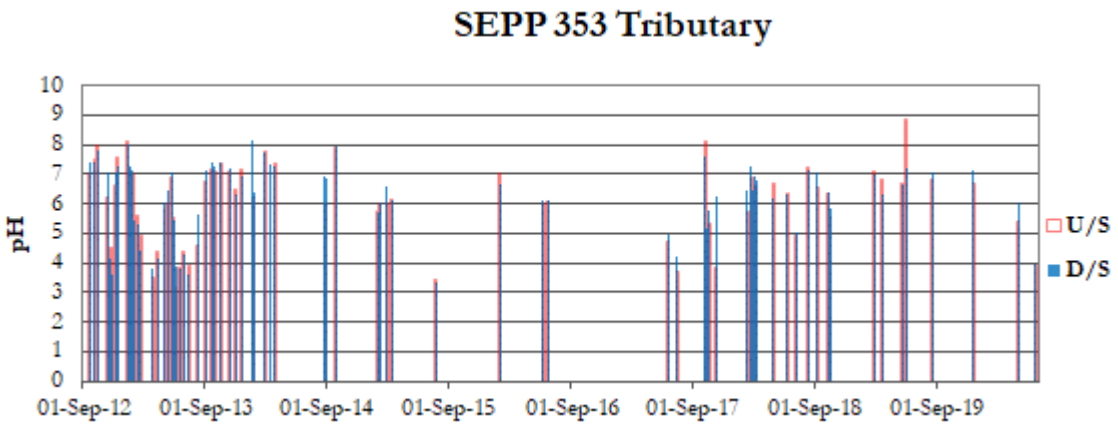

Figure 3.16 pH measurements from SEPP 353 tributary and upstream waters since September 2012

Summary for tributary to SEPP Wetland No. 353 – No results of interest generated from this site. No indication of water quality impacts from operation.

3.2.5 Kalang River

There was one result of interest from the Kalang River, the downstream median Al concentration (**Table A.5**). During the current monitoring period there was one upstream Al concentration measured that was outside of the variation observed in pre-construction and construction phase monitoring (**Figure 3.20**). High to very high Al concentrations have been recorded in the Kalang River on three occasions during the operational phase monitoring, at both upstream and downstream sites. However, because the Kalang is strongly tidal underneath the highway alignment it is not certain whether the high Al concentrations originate at the highway crossing, further down or further up the catchment. High Al concentrations are common in landscapes where acid sulfate soils have been disturbed, such as drained coastal floodplain wetlands. Drained coastal floodplain wetlands are a common feature of the landscape around the highway crossing.

Upstream and downstream turbidity, TSS and pH measurements collected during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.17**, **3.18** and **3.19**).

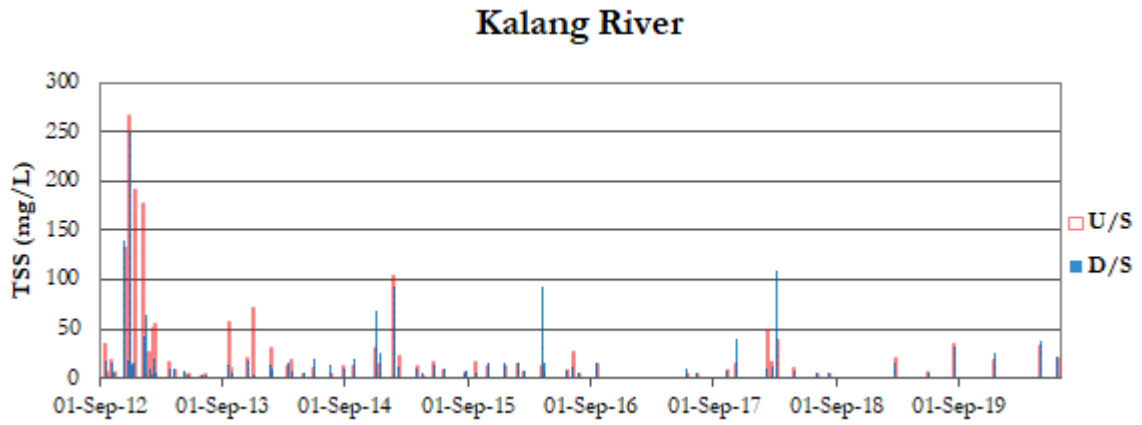

Figure 3.17 TSS concentrations from the Kalang River since September 2012

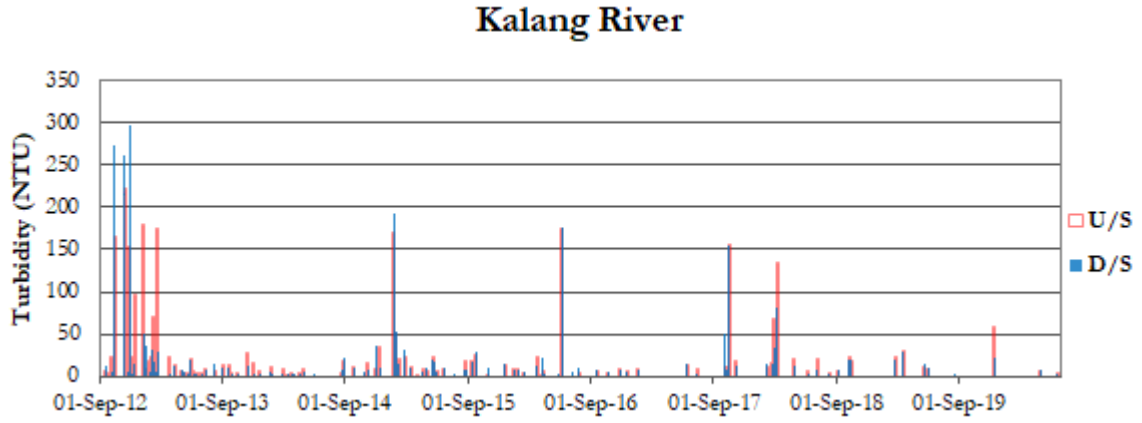

Figure 3.18 Turbidity measurements from the Kalang River since September 2012

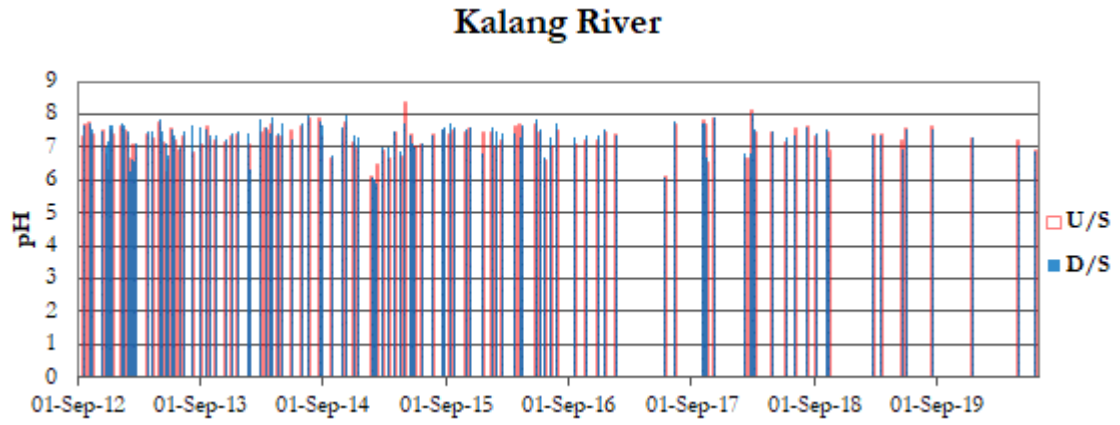

Figure 3.19 pH measurements from the Kalang River since September 2012

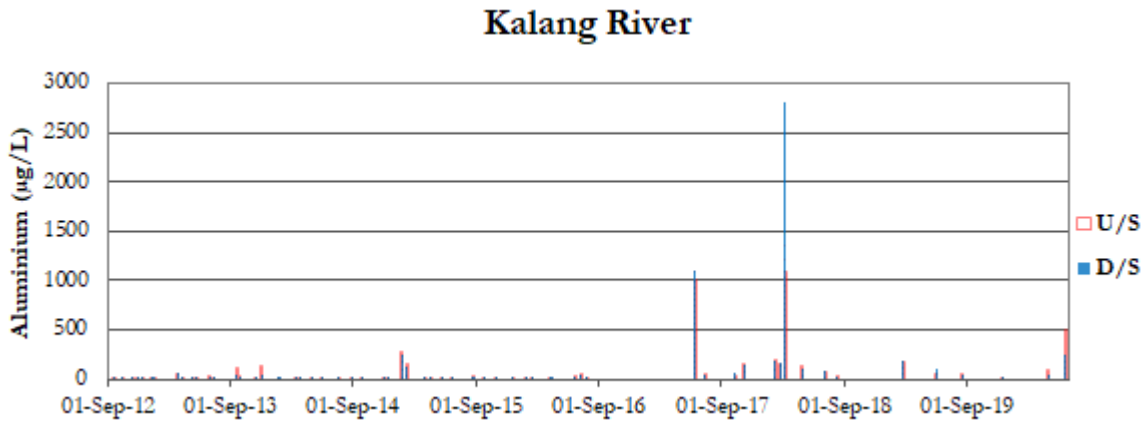

Figure 3.20 Aluminium measurements from the Kalang River since September 2012

Summary for the Kalang River – One result of interest, the median downstream Al concentration. The highest concentration of Al, upstream and downstream, measured in the operational phase of monitoring.

3.2.6 Dalhousie Creek

There were no results of interest from Dalhousie Creek (**Table A.6**).

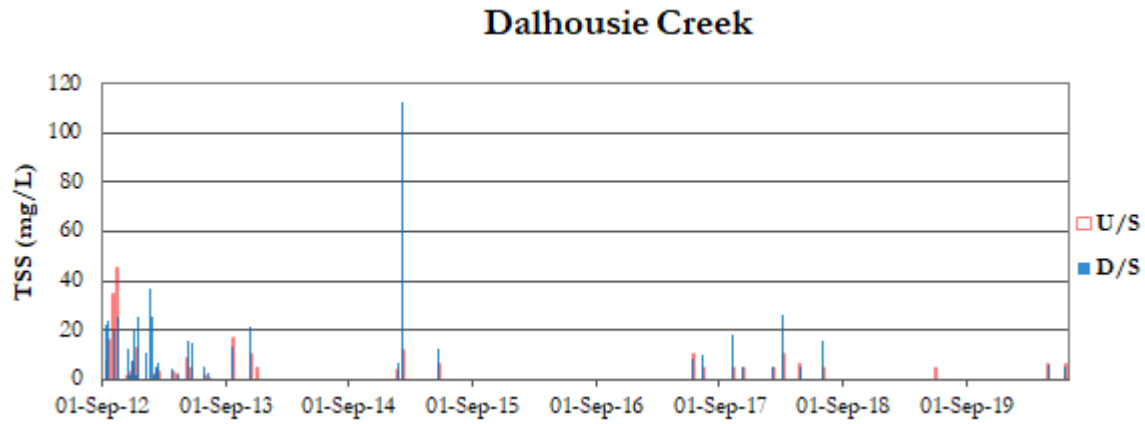

Figure 3.21 TSS concentrations from Dalhousie Creek since September 2012

Dalhousie Creek was dry upstream and downstream of the highway crossing at the time of some operational phase sample runs. The TSS, turbidity and pH measurements during this reporting

period were within the variation observed in both pre-construction and construction phase monitoring (**Figures 3.21**, **3.22** and **3.23**).

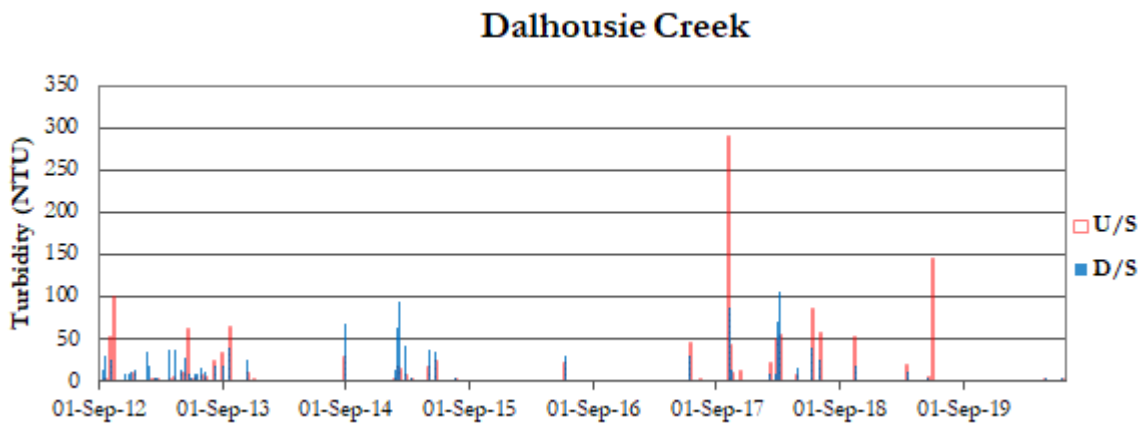

Figure 3.22 Turbidity measurements from Dalhousie Creek since September 2012

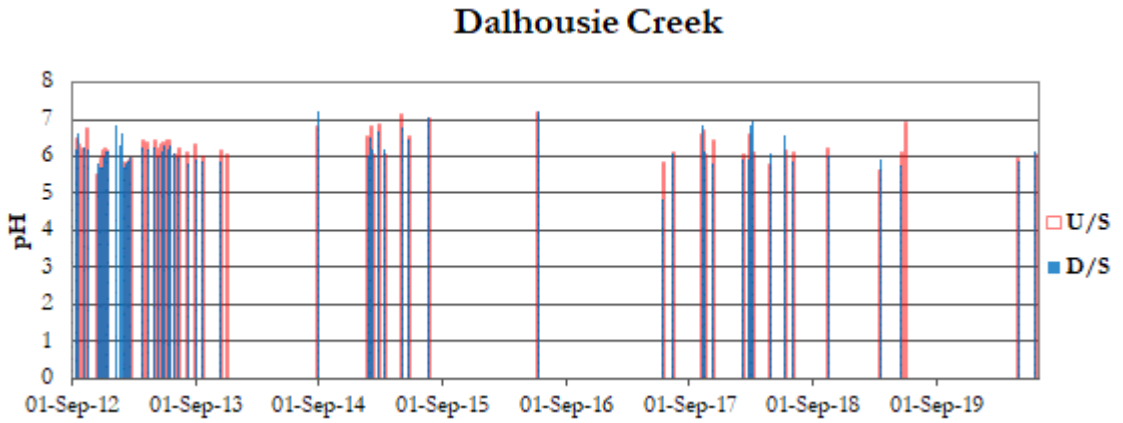

Figure 3.23 pH measurements from Dalhousie Creek since September 2012

Summary for Dalhousie Creek – The highest upstream and downstream turbidity measurements were collected in the operational phases of monitoring. However, there were no results of interest generated for Dalhousie Creek during this monitoring period and no indication of impacts from highway operation.

3.2.7 McGraths Creek

There were no results of interest from McGraths Creek (**Table A.7**).

TSS and pH measurements during this reporting period were within the variation observed upstream of the crossing in pre-construction and construction phase monitoring (**Figures 3.24**

and **3.26**). In the operational phase, elevated TSS measurements in downstream waters have been accompanied by elevated measurements in upstream waters indicating that sediment may be entering the site from the catchment upstream of the crossing.

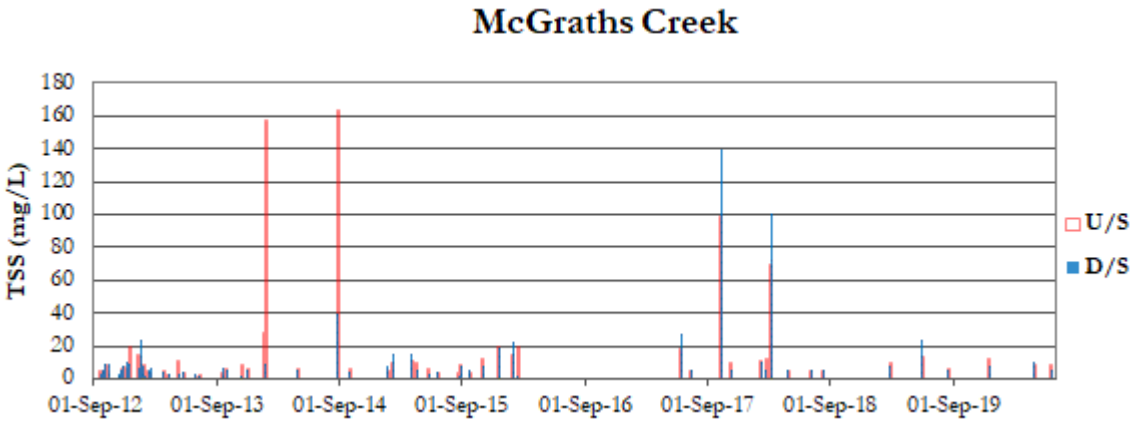

Figure 3.24 TSS concentrations from McGraths Creek since September 2012

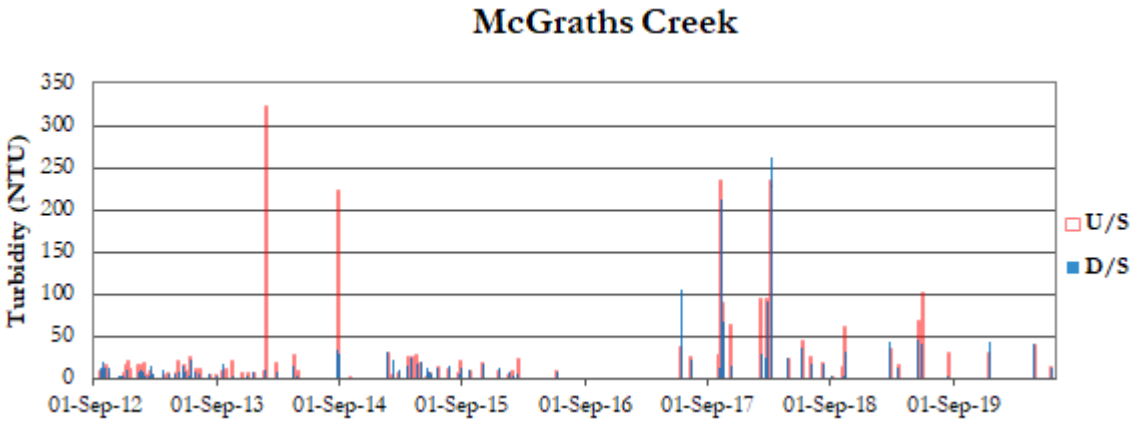

Figure 3.25 Turbidity measurements from McGraths Creek since September 2012

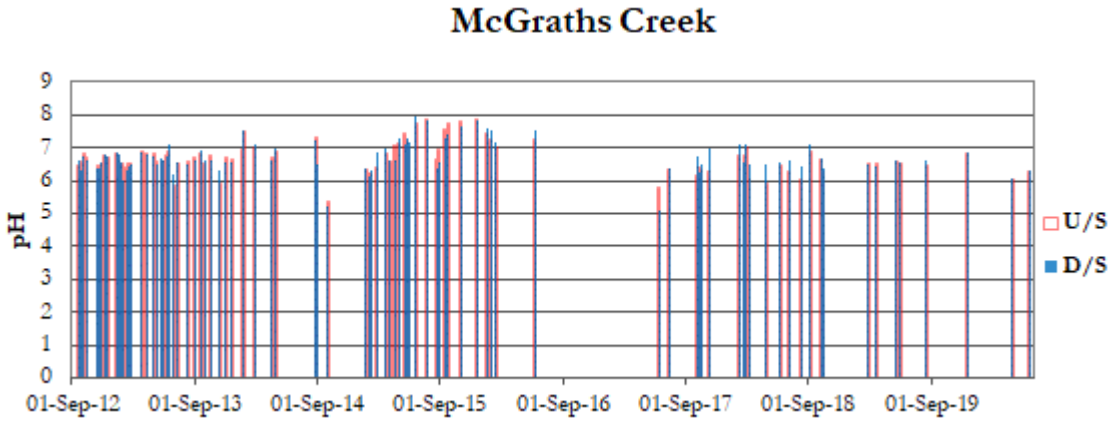

Figure 3.26 pH measurements from McGraths Creek since September 2012

The highest downstream turbidity measurements from McGraths Creek have been recorded in the operational phase (**Figure 2.35**). However, elevated downstream turbidity measurements have reduced since the earlier stages of operational phase monitoring and have all been accompanied by elevated upstream measurements, indicating that the source of turbid water is the catchment upstream of the crossing.

Summary for McGraths Creek – No results of interest. Highest measurements of TSS and turbidity collected in the construction and operational phases of monitoring. High concentrations/measurements of each of these parameters in the operational phase occurring both downstream and upstream of the highway crossing, indicating a potential source other than the highway.

3.2.8 Oyster Creek

For the second consecutive year there were no results of interest from Oyster Creek (**Table A.8**). TSS, turbidity and pH measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring with the exception of one upstream turbidity measurement (**Figures 3.27** to **3.29**).

There have been some elevated downstream turbidity measurements from Oyster Creek in the construction and operational phases but downstream TSS and pH measurements have almost all been within the ranges measured during the pre-construction monitoring phase (**Figures 3.27** to **3.29**).

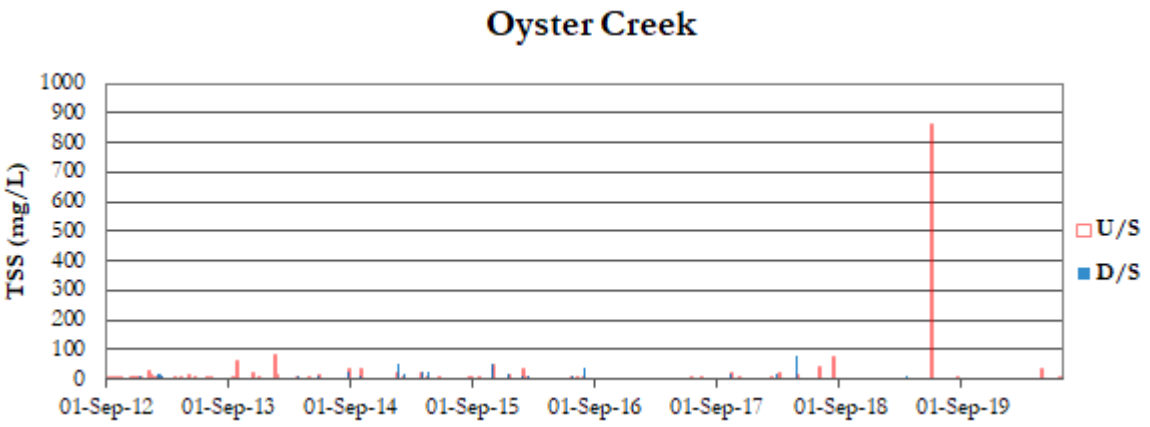

Figure 3.27 TSS concentrations from Oyster Creek since September 2012

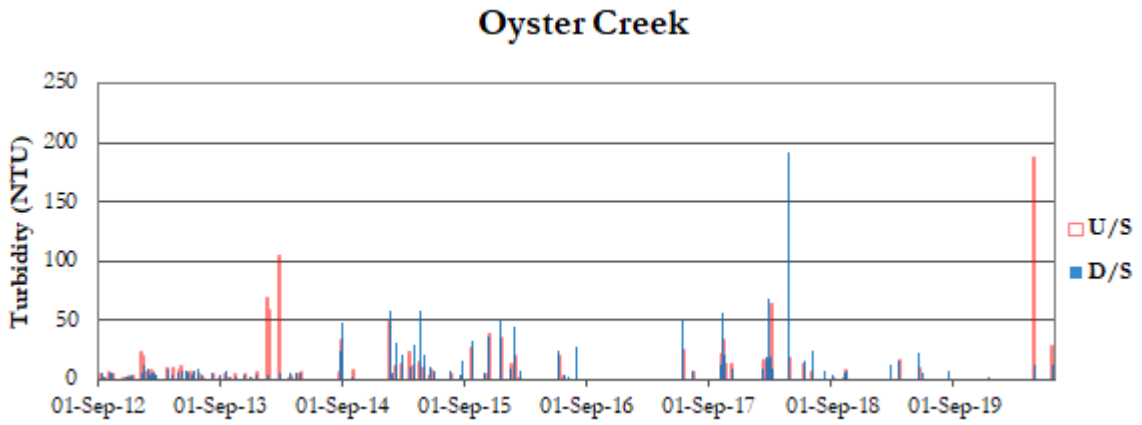

Figure 3.28 Turbidity measurements from Oyster Creek since September 2012

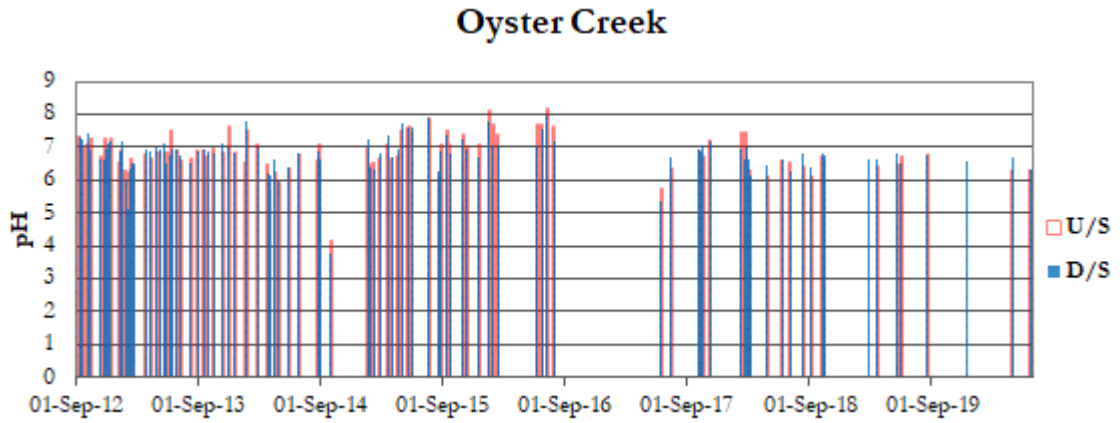

Figure 3.29 pH measurements from Oyster Creek since September 2012

Summary for Oyster Creek – No results of interest from Oyster Creek. The highest downstream measurements of turbidity were collected in the early operational phase of monitoring, but most operational phase downstream turbidity measurements have been lower than the relevant default ANZECC guideline of 50 NTU (**Table 1.1**).

3.2.9 Deep Creek

There were no results of interest from Deep Creek (**Table A.9**). TSS, turbidity and pH measurements during this reporting period were within the variation observed in pre-construction phase monitoring (**Figures 3.30** to **3.32**).

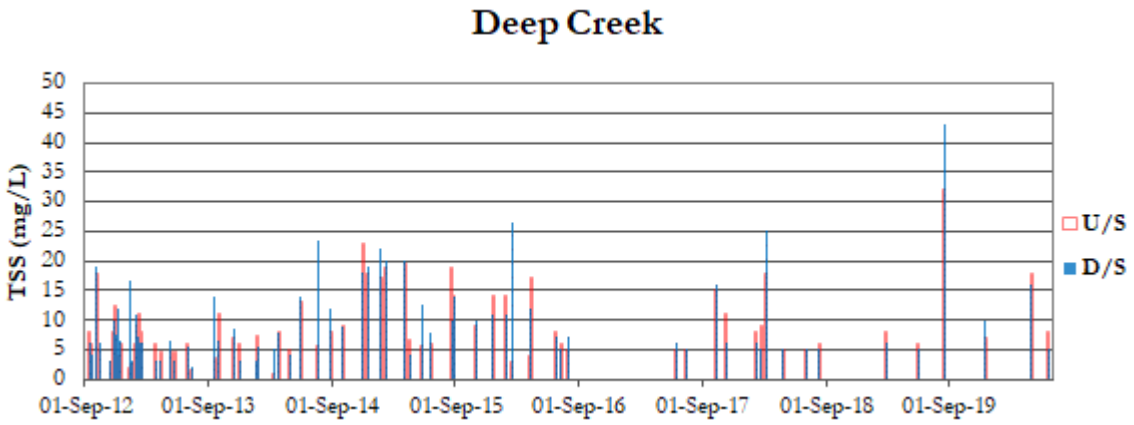

Figure 3.30 TSS concentrations from Deep Creek since September 2012

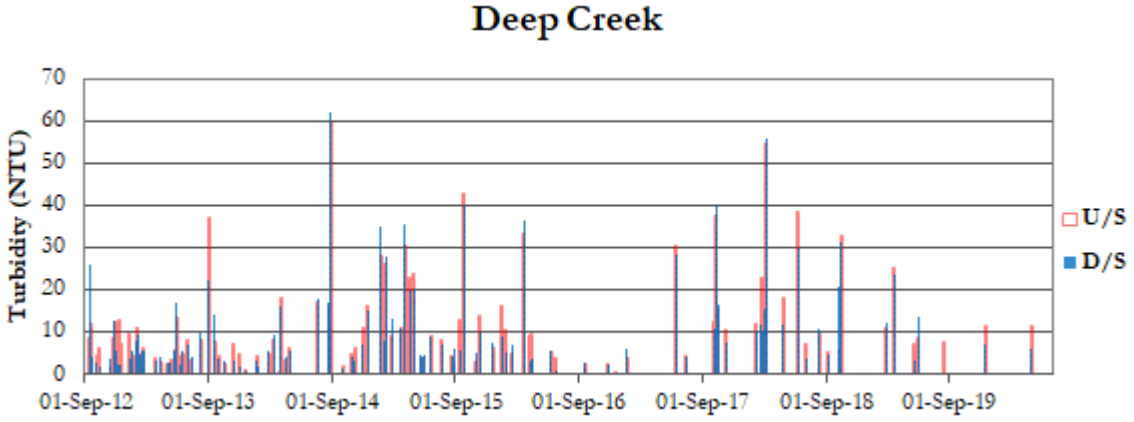

Figure 3.31 Turbidity measurements from Deep Creek since September 2012

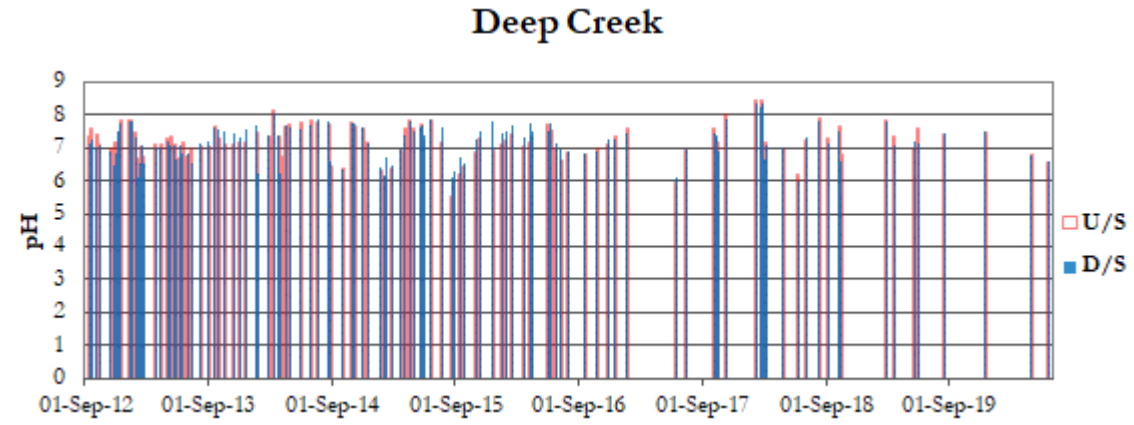

Figure 3.32 pH measurements from Deep Creek since September 2012

For TSS and turbidity the highest downstream measurements from Deep Creek in the construction and operational phases have been higher than the ranges measured in the pre-

construction phase (**Figures 3.30, 3.31** and **3.32**) but all elevated downstream measurements in the operational phase have been accompanied by elevated upstream measurements. The turbidity measurements appear to be trending downwards as the operational phase monitoring progresses.

Summary for Deep Creek – No results of interest. Highest measurements of TSS and turbidity collected in the construction and operational phases of monitoring. High measurements of these parameters have been collected both upstream and downstream of the highway crossing. Deep Creek is often tidal at the point of the highway crossing, making it difficult to draw conclusions about the source.

3.2.10 Cow Creek

There were no results of interest from Cow Creek (**Table A.10**).

TSS, turbidity and pH measurements during this reporting period were within the variation observed in construction phase monitoring (**Figures 3.33**, **3.34** and **3.35**, Note: There were only three samples from Cow Creek collected during pre-construction monitoring and they were limited to physicochemical parameters). The highest downstream measurements of TSS and turbidity during operational monitoring have all been associated with high upstream measurements, indicating that the source of occasional turbid water could be upstream of the highway crossing.

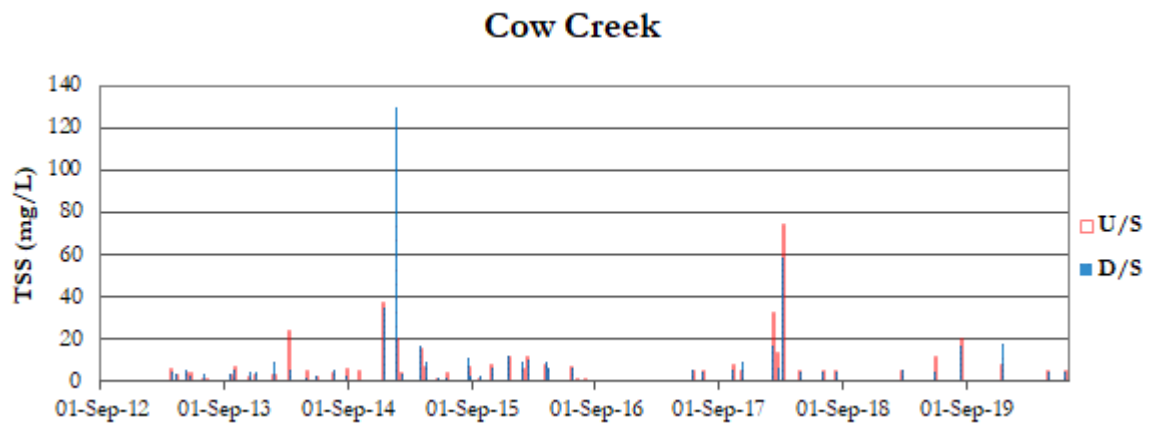

Figure 3.33 TSS concentrations from Cow Creek since September 2012

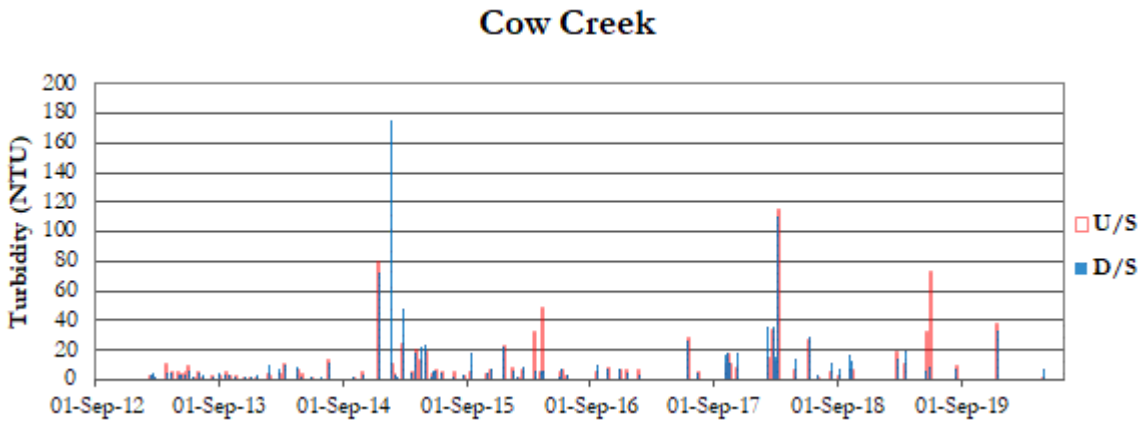

Figure 3.34 Turbidity measurements from Cow Creek since September 2012

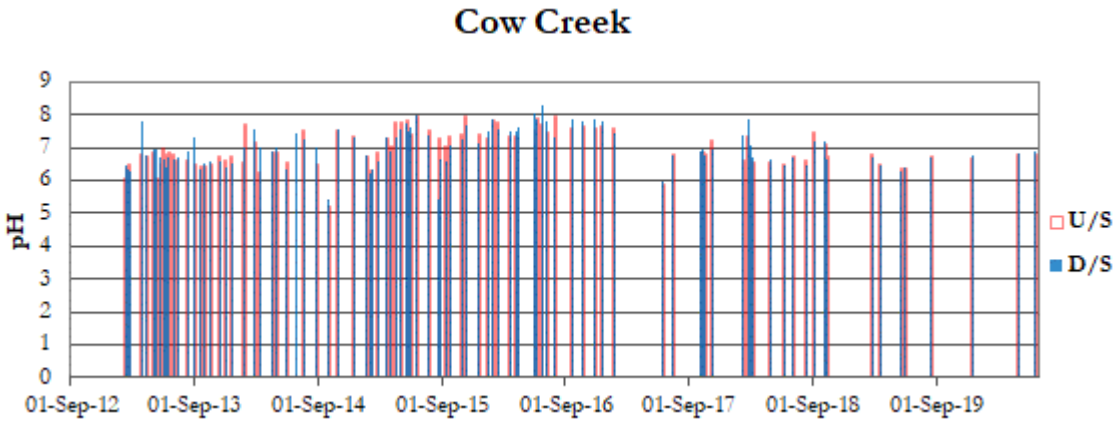

Figure 3.35 pH measurements from Cow Creek since September 2012

Summary for Cow Creek – No results of interest. Limited pre-construction data available. Elevated operational phase measurements of TSS and turbidity were collected both upstream and downstream of the highway crossing.

3.2.11 Boggy Creek

For the second consecutive year the only result of interest from Boggy Creek was the median downstream Fe concentration (**Table A.11**). Although the highest downstream Fe concentration since monitoring began occurred during the operational phase all of the elevated downstream Fe concentrations collected during operational phase monitoring have been associated with elevated upstream concentrations (**Figure 3.39**), indicating that the source of higher iron concentrations is likely to be upstream of the highway crossing.

With the exception of one downstream TSS measurement, TSS and pH measurements from operational phase monitoring have been within the variation observed in pre-construction and construction phase monitoring (**Figures 3.36** and **3.38**). Although some relatively high downstream turbidity measurements have been collected during operational phase monitoring, they have all been associated with elevated upstream measurements (**Figure 3.37**).

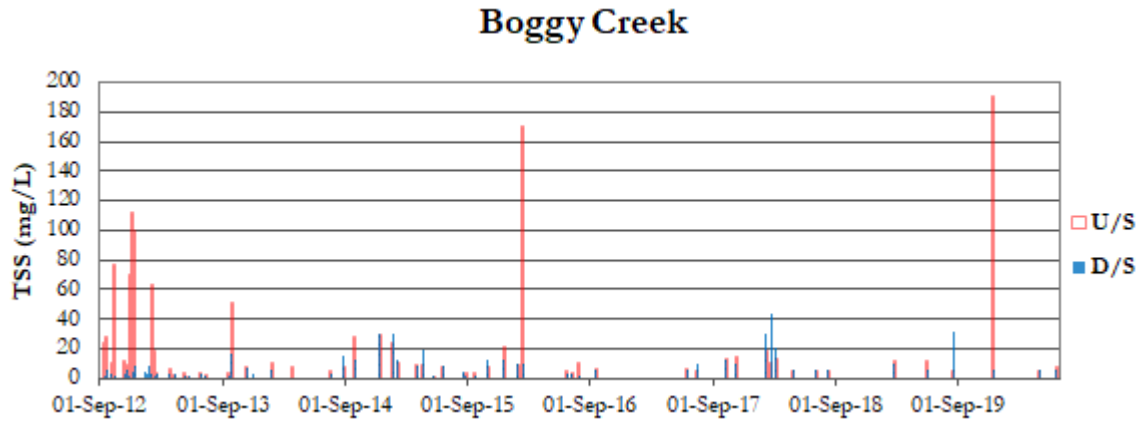

Figure 3.36 TSS concentrations from Boggy Creek since September 2012

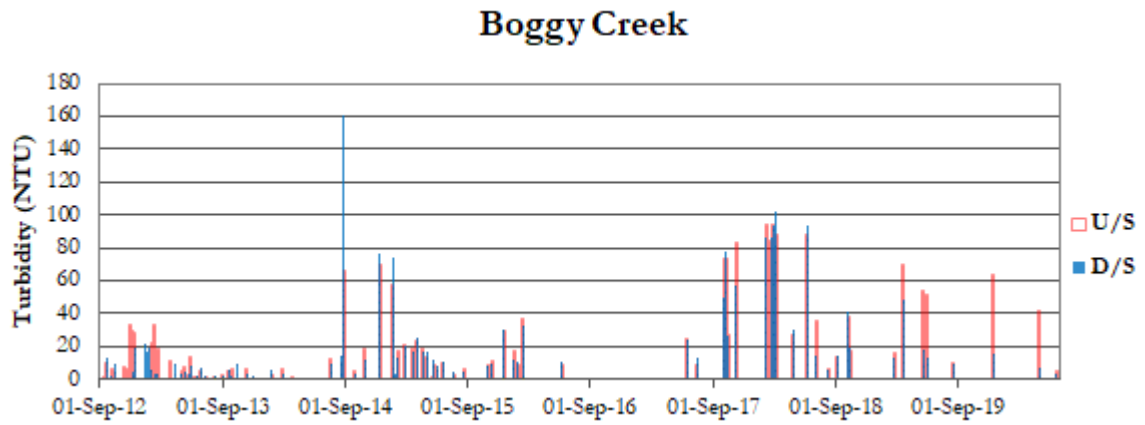

Figure 3.37 Turbidity measurements from Boggy Creek since September 2012

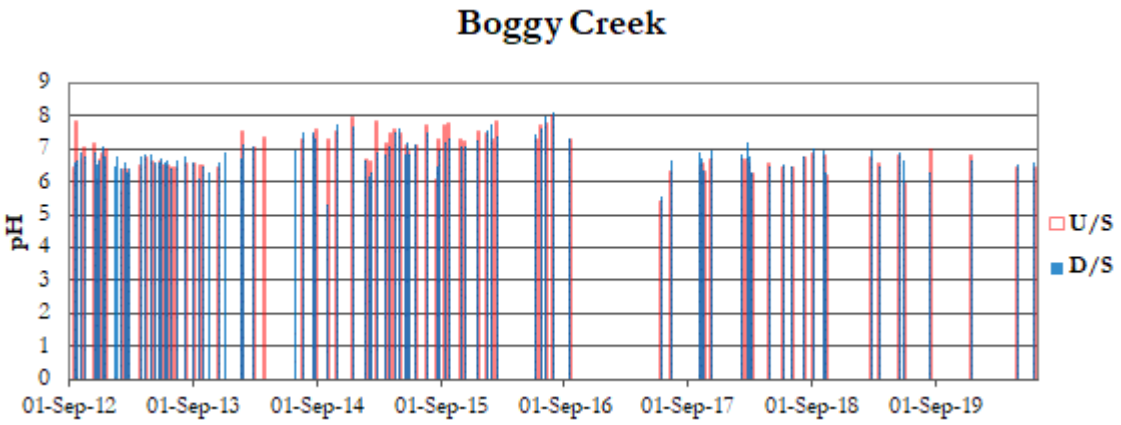

Figure 3.38 pH measurements from Boggy Creek since September 2012

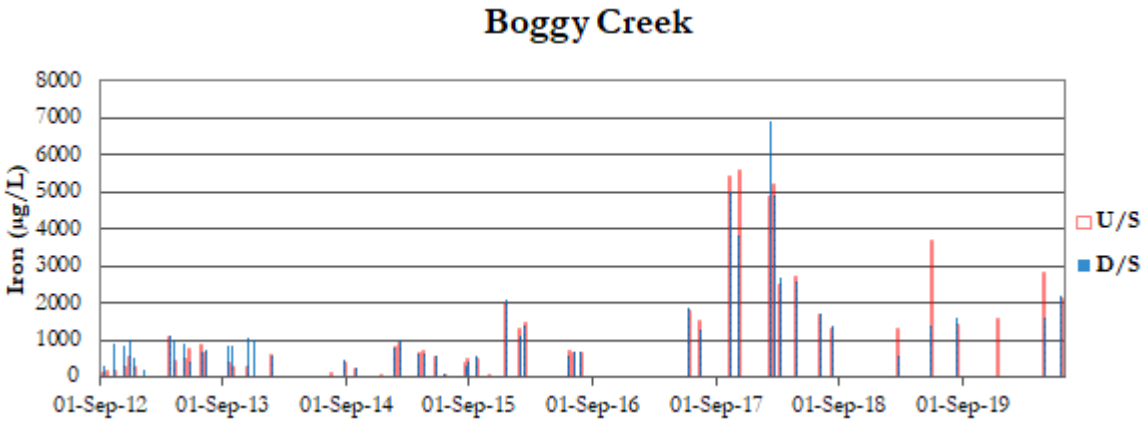

Figure 3.39 Iron measurements from Boggy Creek since September 2012

The highest measurements of TSS, turbidity and Fe from Boggy Creek have occurred during the construction and operational phases of monitoring (**Figures 3.36**, **3.37** and **3.39**).

Summary for Boggy Creek – The highest measurements of Fe, TSS and turbidity collected in the construction and operational phases of monitoring. During the operational monitoring period high concentrations of each of these parameters have been measured both upstream and downstream of the highway crossing.

3.3 Groundwater

3.3.1 Groundwater Quality

A summary of groundwater quality results to date is provided in **Appendix B**.

Sampling dates for all groundwater samples collected during this reporting period are displayed in **Table 3.1**. The slight deviations from the 3-monthly sampling period specified in the GMP are clarified in **Section 2.2.2**.

Table 3.1 Groundwater quality sampling undertaken during this reporting period

Date	*Parameters*
09/10/2019	All parameters and data loggers
4/01/2020	Field parameters and data loggers
31/03/2020	All parameters and data loggers
30/06/2020	Field parameters and data loggers

The GMP 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 site is presented in **Appendix B** with the upgradient P80 values from the combined preconstruction, construction and operational phases.

The relevant summary statistics for each groundwater site are presented in **Tables B.1** to **B.6**. A brief description of the summary results from each waterway 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 preconstruction, construction and operational phase upgradient P80.

3.3.2 Ch 63200

Results of interest from Ch 63200 (Table B.1) were the downgradient median As, Cu, Fe, and Ca^{+} measurements. There was no water in the upgradient piezometer for the early part of the construction phase monitoring. A new piezometer was constructed in September 2017 when the existing piezometer was found to be collapsed. The lack of upgradient construction phase data and missing upgradient data from the earlier stages of operational phase monitoring limit the capacity to draw conclusions about potential impacts from highway operation. All of the parameters that generated a result of interest had either stable or increased downgradient operational phase median in comparison with the previous reporting period, due to fluctuating values (**Figures 3.41** to **3.44**), with the exception of Ca+, which is no longer measured. The pH measurements collected during the current reporting period were all within the range of variation observed during the pre-construction monitoring phase (**Figure 3.40**).

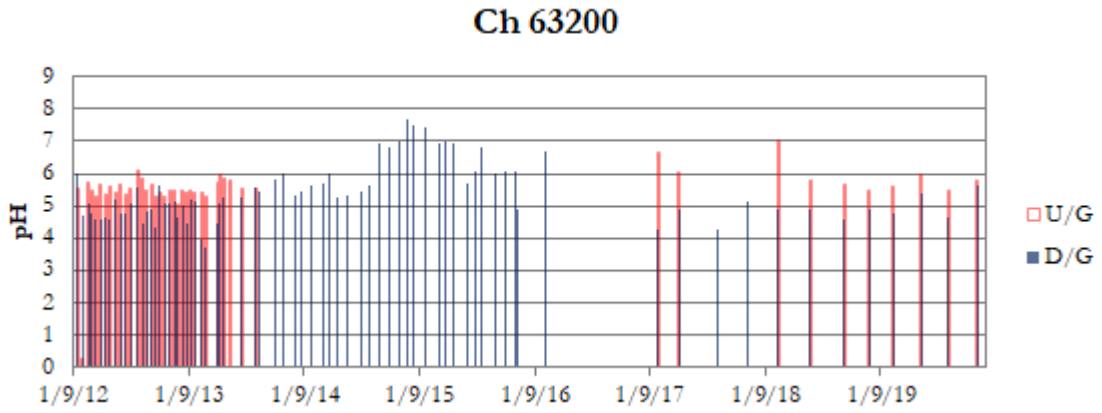

Figure 3.40 pH concentrations from Ch 63200 since September 2012

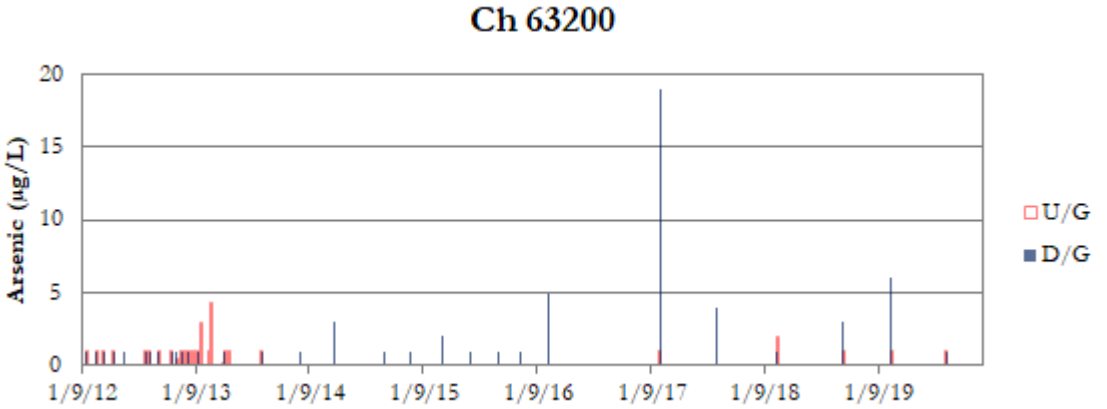

Figure 3.41 Arsenic concentrations from Ch 63200 since September 2012

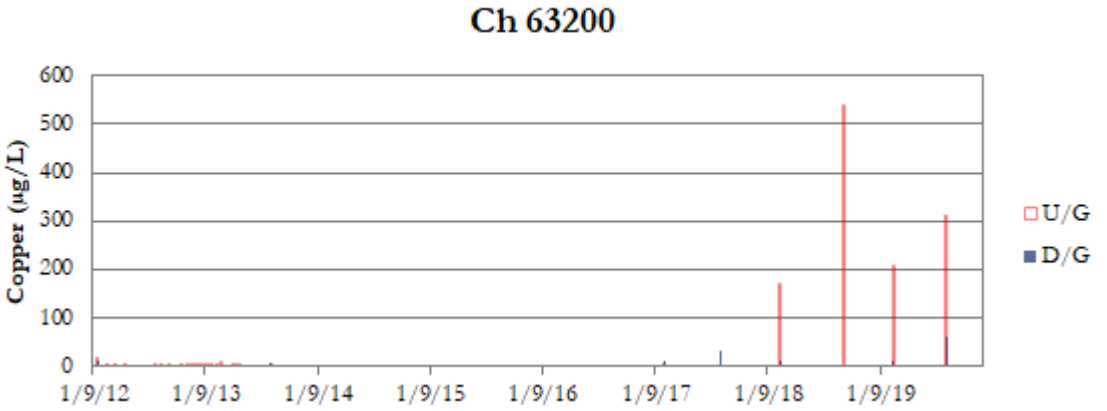

Figure 3.42 Copper concentrations from Ch 63200 since September 2012

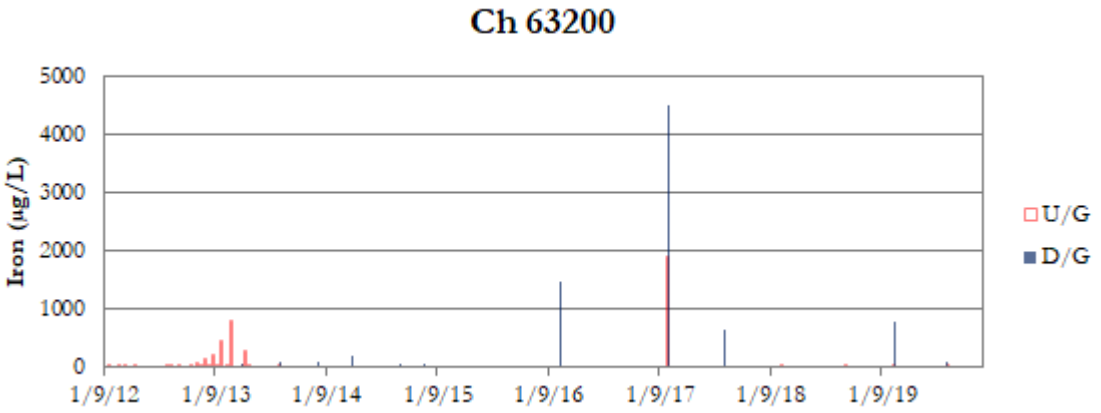

Figure 3.43 Iron concentrations from Ch 63200 since September 2012

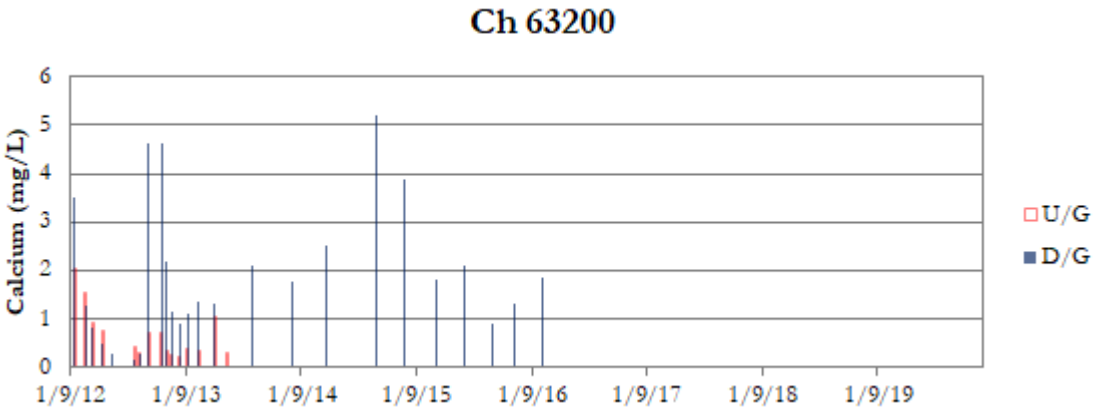

Figure 3.44 Calcium ion concentrations from Ch 63200 since September 2012

Summary for Ch 63200: Highest downgradient As and Fe concentrations since the start of monitoring occurred in the early stages of operational phase monitoring. Downgradient medians for all parameters that registered a result of interest have remained stable this year. Dry upgradient piezometer for most of the construction phase monitoring period and some of the early operational phase monitoring period limits the capacity to draw conclusions about potential impacts from construction and operation.

3.3.3 Ch 64600

Results of interest from Ch 64600 (**Table B.2**) were the downgradient median Cu, Ni, and HCO_3^- concentrations and temperature measurements. All elevated downgradient Cu and Ni concentrations measured during the operational phase monitoring have been associated with

high upgradient concentrations (**Figures 3.46** and **3.47**) indicating that they may not be associated with highway operation. Downgradient temperature measurements were all within the levels of variation observed in pre-construction and construction phase monitoring (**Figure 3.48**). The HCO_3^- measurement collected during operational phase monitoring was also within the levels of variation observed in pre-construction phase monitoring (**Figure 3.49**). Downgradient operational phase pH values have been within the levels of variation observed in the pre-construction monitoring but upgradient values have been consistently lower (**Figure 3.45**).

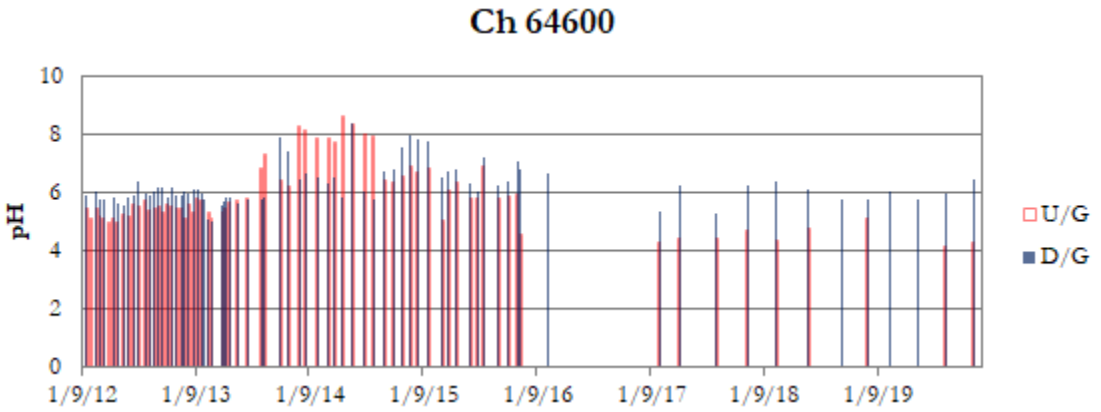

Figure 3.45 pH concentrations from Ch 64600 since September 2012

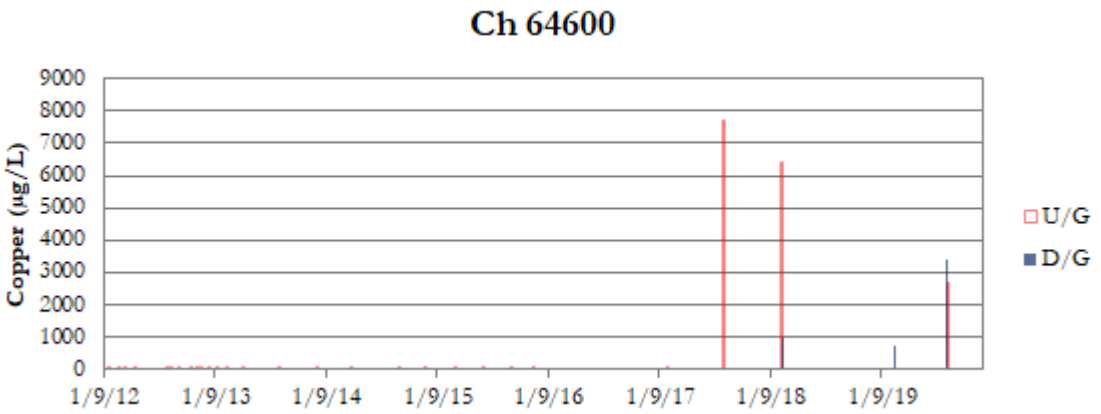

Figure 3.46 Copper measurements from Ch 64600 since September 2012

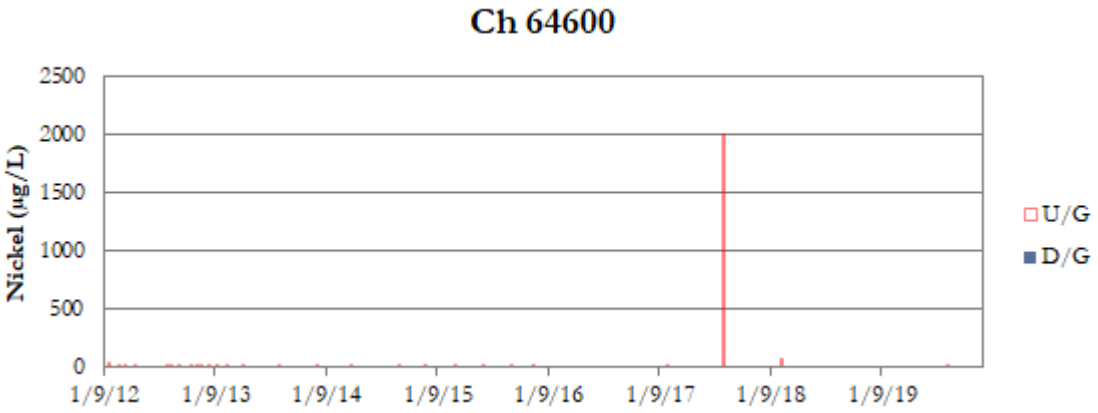

Figure 3.47 Nickel measurements from Ch 64600 since September 2012

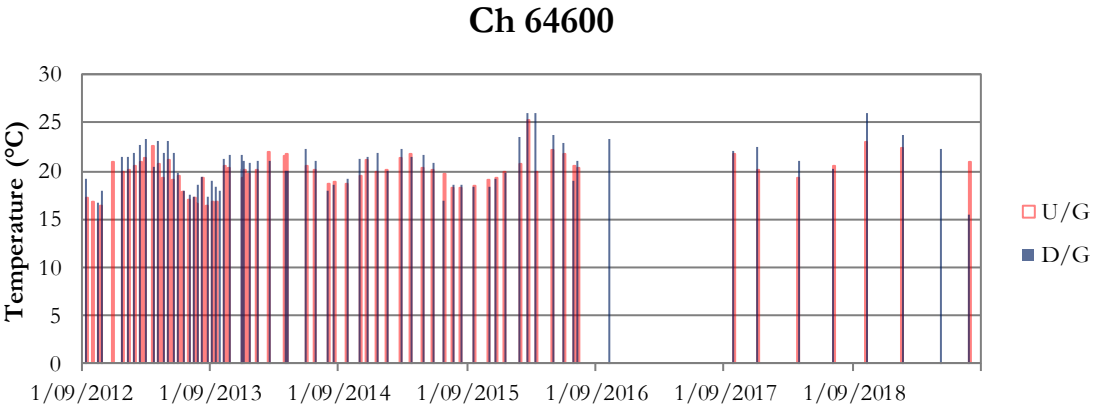

Figure 3.48 Temperature measurements from Ch 64600 since September 2012

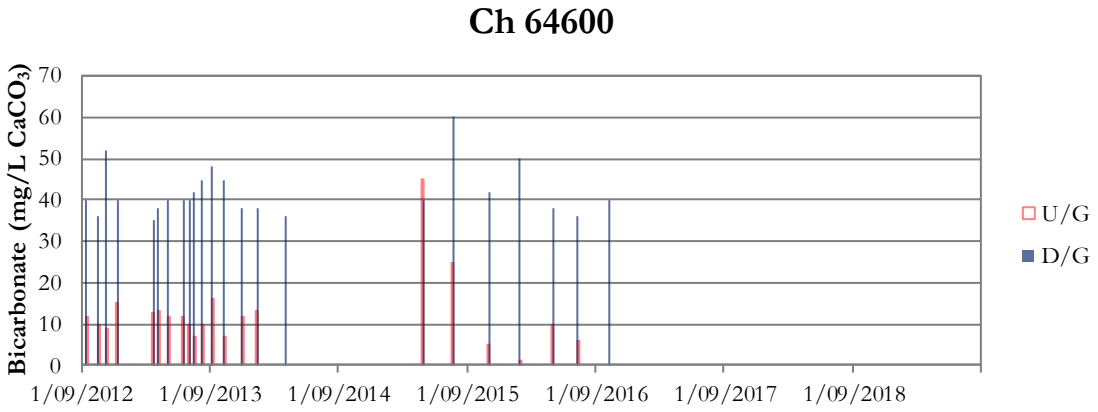

Figure 3.49 Bicarbonate measurements from Ch 64600 since September 2012

Summary for Ch 64600. Although there were four results of interest there is no indication of impacts from highway operation.

3.3.4 Ch 72400

Results of interest from Ch 72400 (**Table B.3**) were the downgradient median As, Cu, Ni, PO_4, pH, HCO_3^-, K^+, Ca^{2+} and Mg^{2+} measurements. There was no water in the upgradient piezometer during operational phase monitoring or most of the construction phase monitoring period, limiting the capacity to draw conclusions about groundwater quality. With the exception of Cu and PO_4 all of the parameters that generated a result of interest were measured during this reporting period within the ranges observed during construction phase monitoring (**Figures 3.50** to **3.58**). The downgradient median PO_4 concentration was the only downgradient median result to increase during this reporting period while the downgradient median As, Cu and Ni measurements remained stable in relation to the previous reporting period. Measurements of HCO_3^-, K^+, Ca^{2+} and Mg^{2+} are no longer collected.

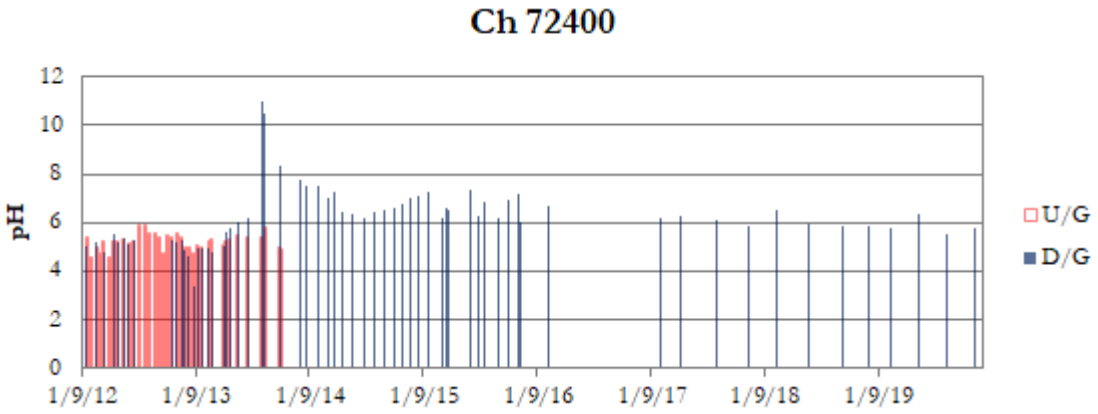

Figure 3.50 pH concentrations from Ch 72400 since September 2012

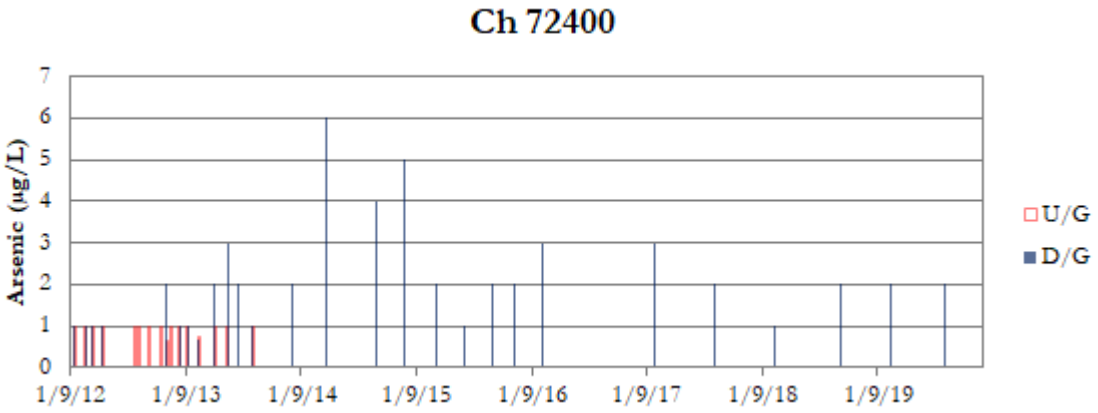

Figure 3.51 Arsenic concentrations from Ch 72400 since September 2012

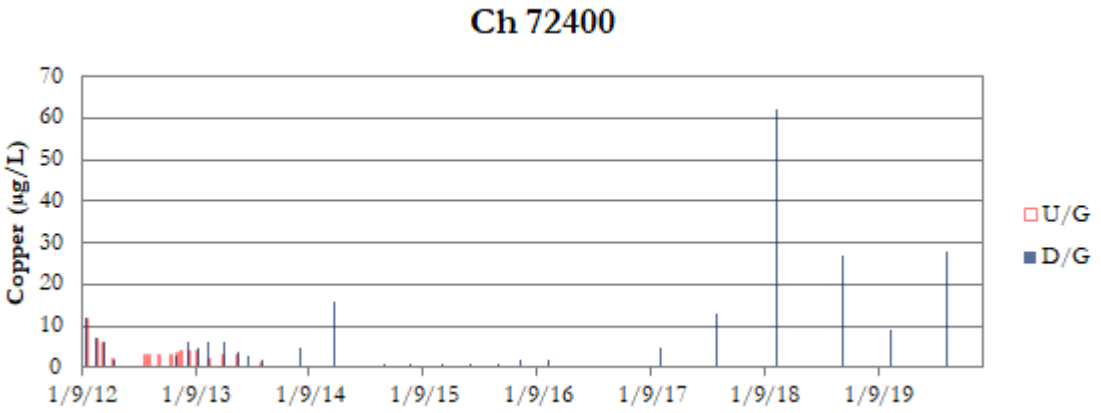

Figure 3.52 Copper concentrations from Ch 72400 since September 2012

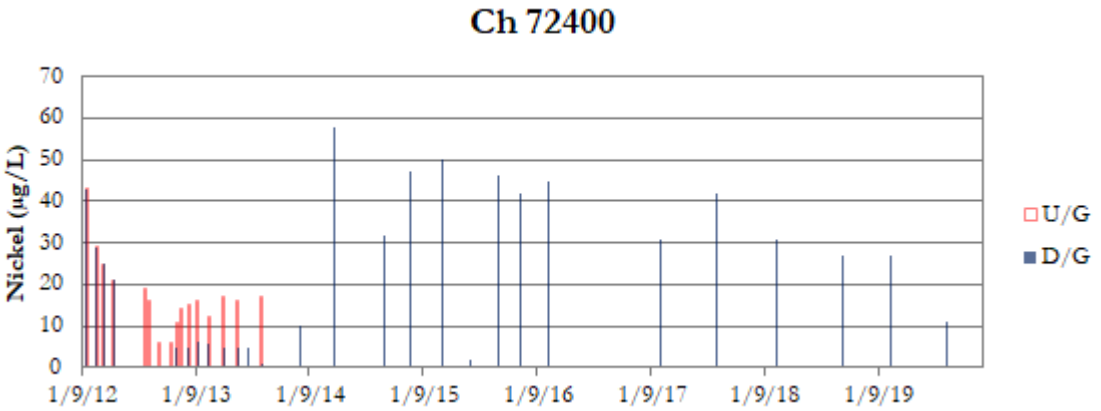

Figure 3.53 Nickel concentrations from Ch 72400 since September 2012

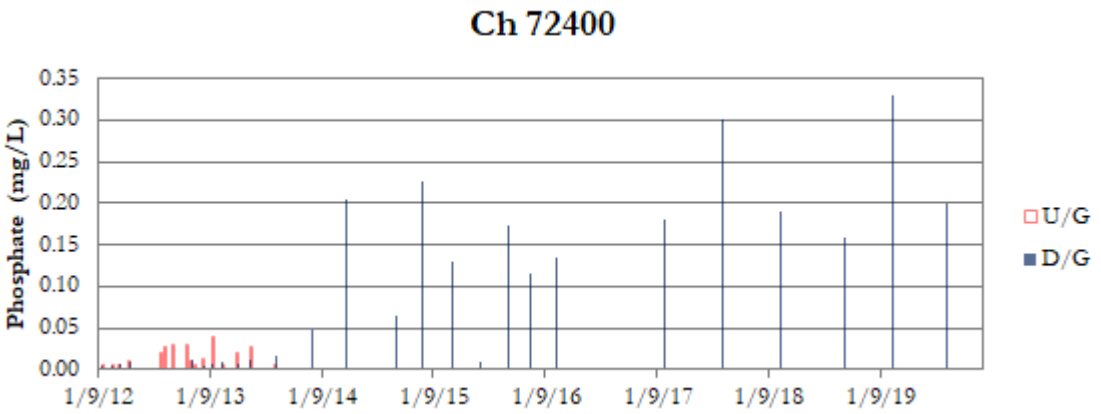

Figure 3.54 Phosphate measurements from Ch 72400 since September 2012

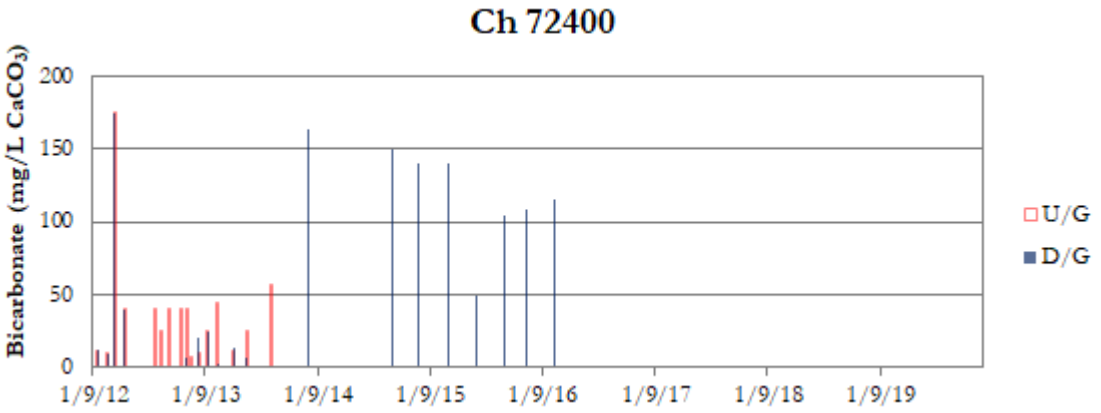

Figure 3.55 Bicarbonate measurements from Ch 72400 since September 2012

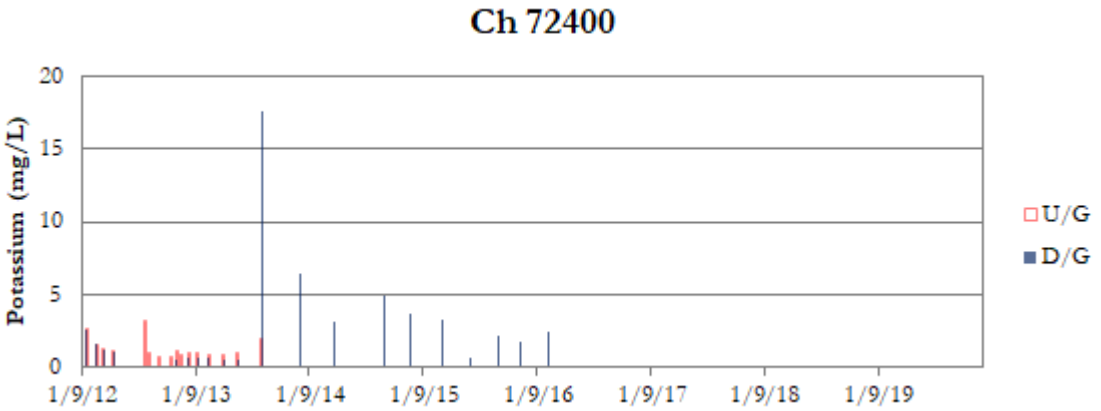

Figure 3.56 Potassium measurements from Ch 72400 since September 2012

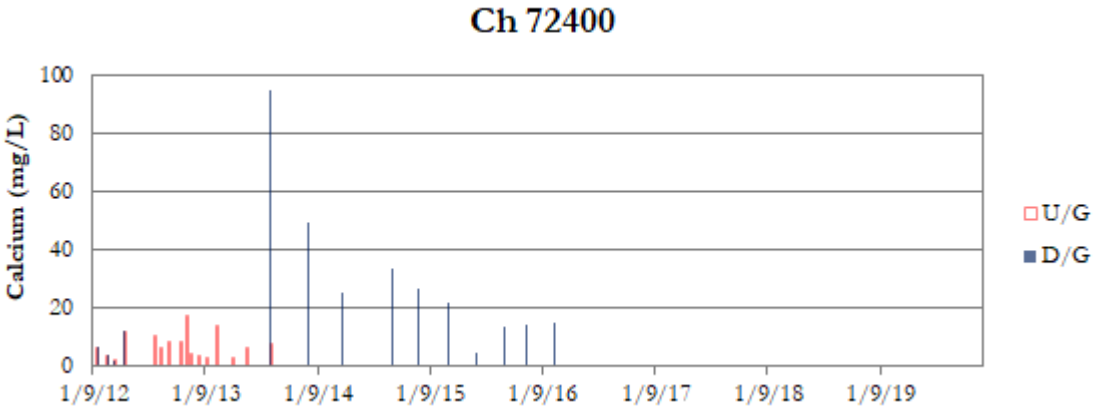

Figure 3.57 Calcium measurements from Ch 72400 since September 2012

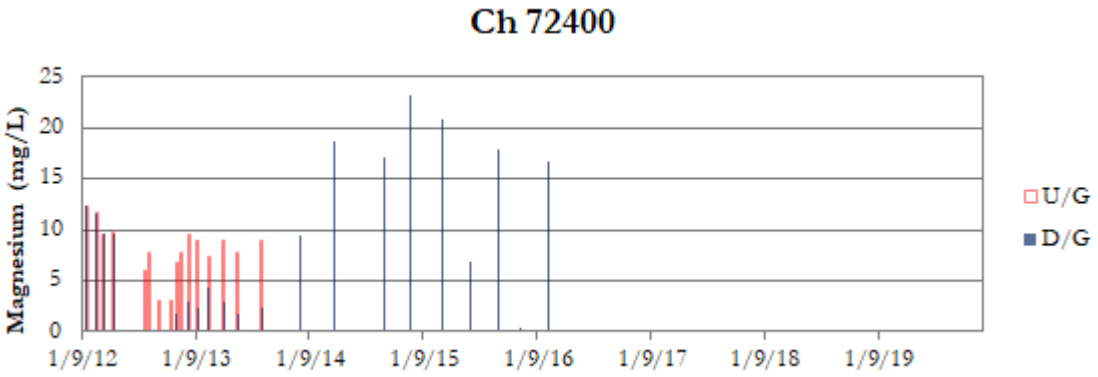

Figure 3.58 Magnesium measurements from Ch 72400 since September 2012

Summary for Ch 72400: All of the parameters that generated a result of interest have been measured during the operational phase within the ranges observed during construction phase monitoring except for Cu and PO_4. The highest downgradient measurements of all parameters that generated a result of interest have been measured during the construction or operational phases of monitoring. All downgradient median results were stable or reduced in comparison to the previous annual reporting period with the exception of PO_4. The capacity to draw conclusions about the source of high downgradient medians is limited by the dry upgradient piezometer. The downgradient median copper and phosphate concentrations both exceeded the relevant ANZECC default guideline concentration.

3.3.5 Ch 74400

Results of interest from Ch 74400 (**Table B.4**) were the downgradient median Ni, Zn, NO_3, HCO_3^- and Cl^- and Mg^{2+} measurements. All of the parameters that generated a result of interest were measured at the downgradient piezometers during this monitoring period within the ranges observed during construction phase monitoring. Ni was also measured this monitoring period within the ranges observed during pre-construction monitoring (**Figures 3.60** to **3.62**).

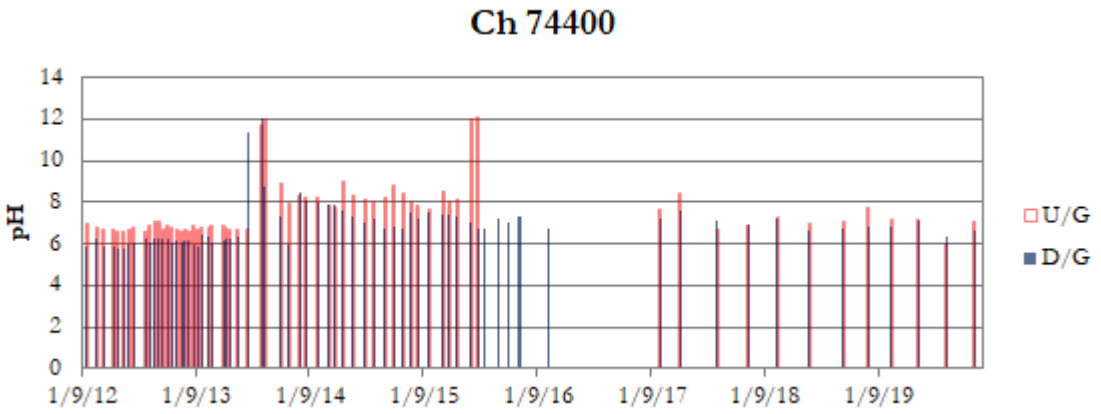

Figure 3.59 pH measurements from Ch 74400 since September 2012

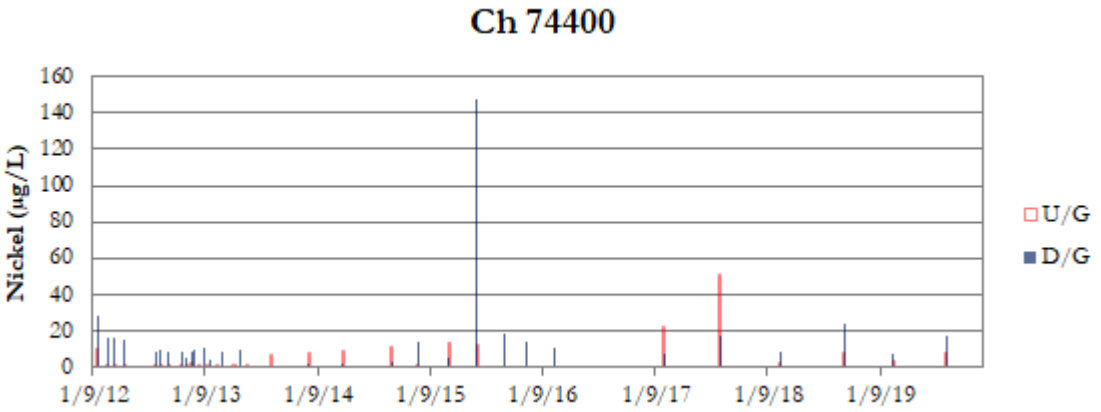

Figure 3.60 Nickel measurements from Ch 74400 since September 2012

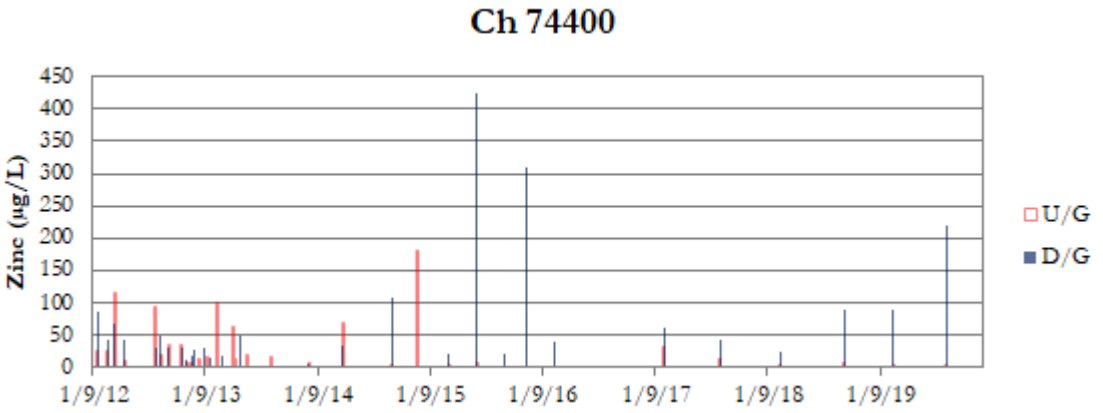

Figure 3.61 Zinc measurements from Ch 74400 since September 2012

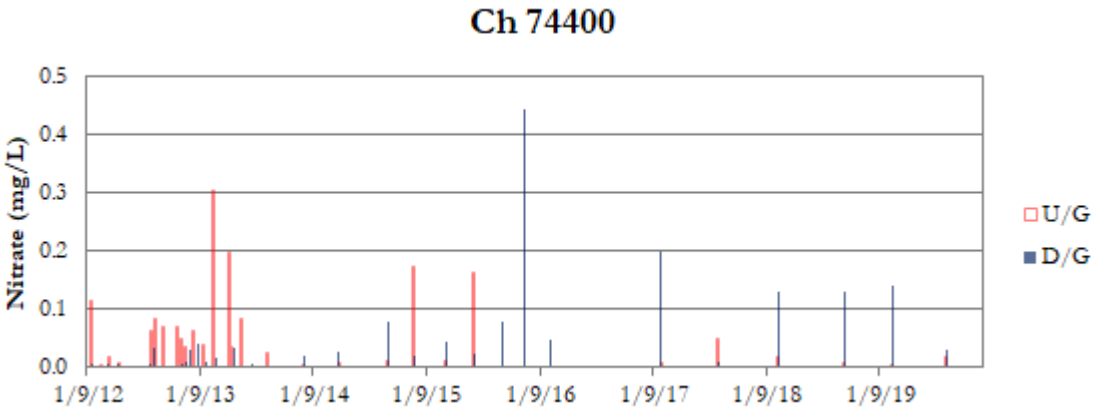

Figure 3.62 Nitrate measurements from Ch 74400 since September 2012

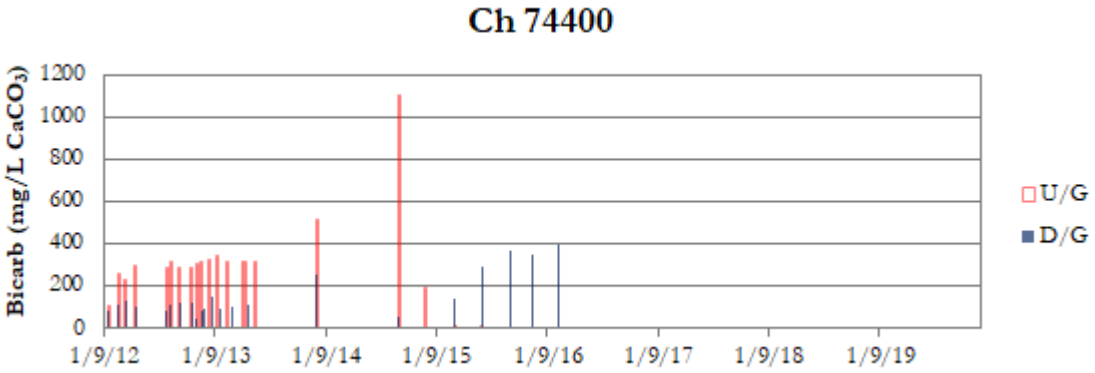

Figure 3.63 Bicarbonate measurements from Ch 74400 since September 2012

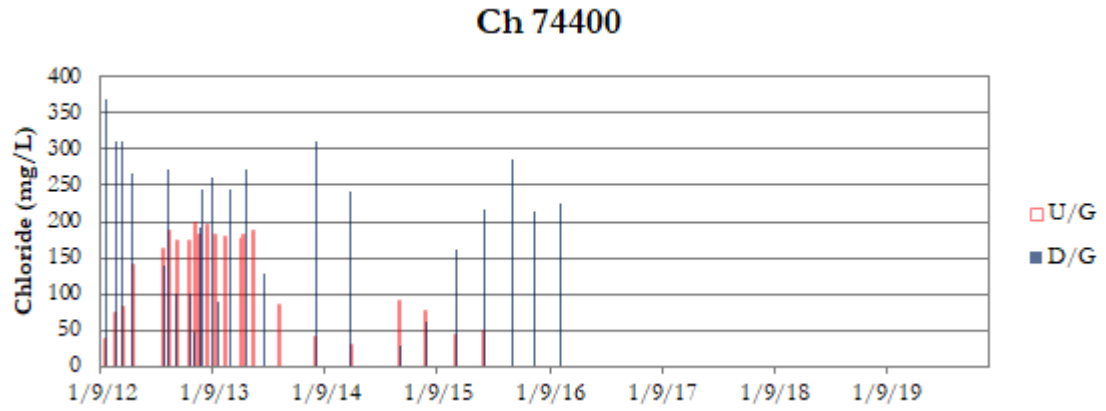

Figure 3.64 Chloride measurements from Ch 74400 since September 2012

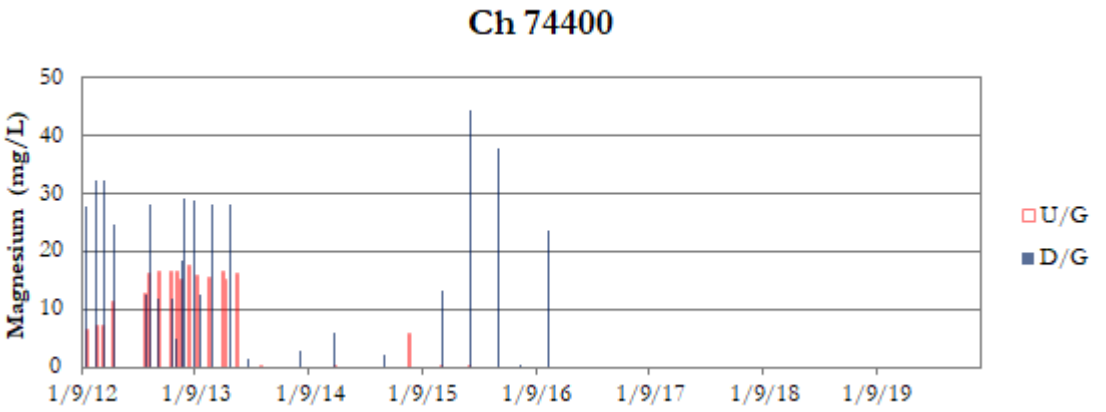

Figure 3.65 Magnesium measurements from Ch 74400 since September 2012

Summary for Ch 74400: All of the parameters that generated a result of interest were measured within the ranges observed during pre-construction and/or construction phase monitoring. The upgradient piezometer at this location appears to have been disconnected from the water table for much of the operational phase monitoring (see **Figure 3.71**), limiting the capacity to draw conclusions about the source of elevated concentrations.

3.3.6 Ch 75500

There were no results of interest from Ch 75500 (**Table B.5**). There is no downgradient piezometer at Ch 75500, limiting the capacity to draw conclusions about groundwater quality. All

measurements at the upgradient piezometer were within the ranges observed during preconstruction and construction phase monitoring.

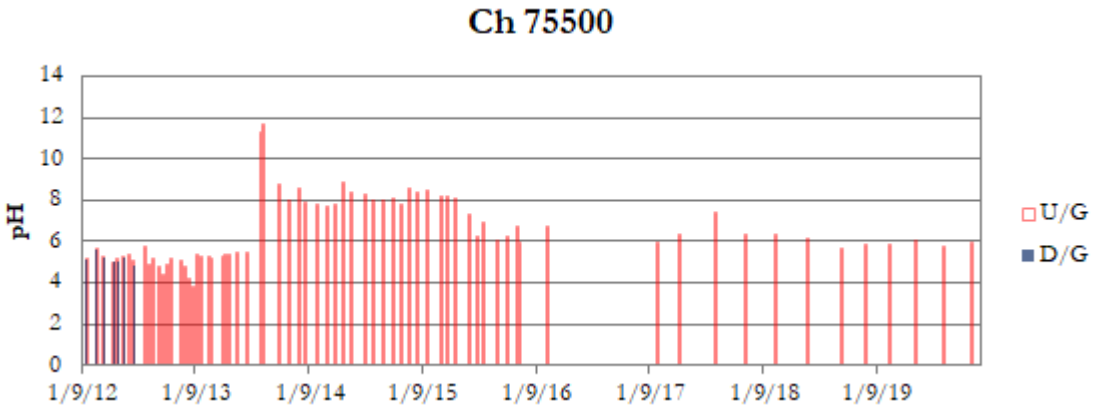

Figure 3.66 pH measurements from Ch 74400 since September 2012

Summary for Ch 75500: No results of interest from Ch 75500.

3.3.7 Ch 78500

There were no results of interest from Ch 78500 (**Table B.6**). There was no water in the upgradient piezometer during this reporting period or most of the construction phase monitoring period, limiting the capacity to draw conclusions about groundwater quality.

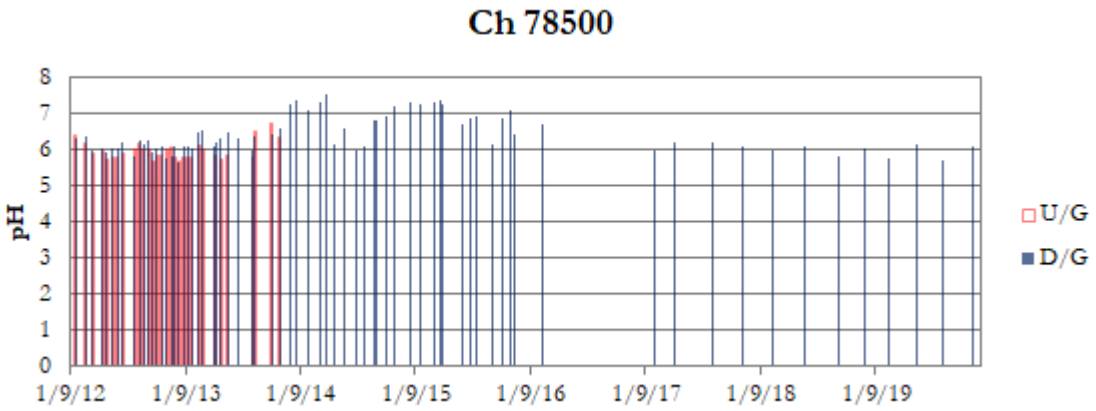

Figure 3.67 pH measurements from Ch 78500 since September 2012

Summary for Ch 78500: No results of interest from Ch 78500.

3.3.8 Groundwater Level

The logged groundwater results for the period between 1 September 2019 and 30 June 2020 are displayed in **Figures 3.68 to 3.73**.

The median relative difference between logged groundwater levels at the pair of bores at Ch 63200 was 5.5 m during pre-construction monitoring. For the operational phase monitoring displayed in **Figure 3.68** the median relative difference between logged water levels was 3.04 m. However, the downgradient HOBO at Ch 63200 was set at a level that is above the water level at times. The median relative difference between measured groundwater levels at Ch 63200 was 3.35 m, with a maximum value of 4.76 and a minimum value of 3.13. The change in the relative difference may be partially explained by the construction of a new upgradient piezometer at Ch 63200 in September 2017. The logged data displayed in **Figure 3.68** indicates that upgradient and downgradient water levels at Ch 63200 varied normally in response to wet and dry weather events in the operational phase.

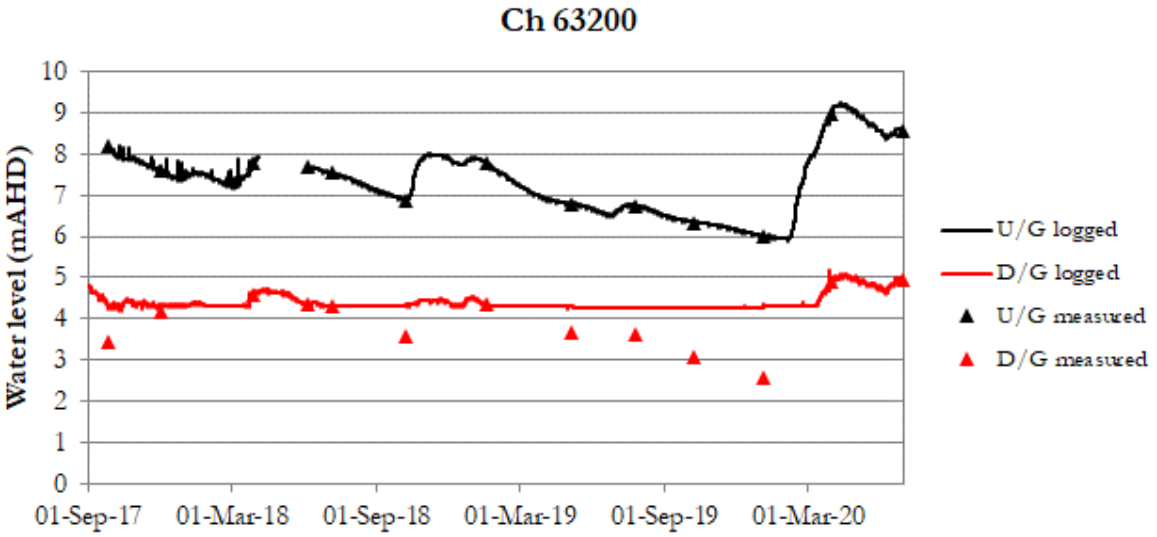

Figure 3.68 Groundwater levels at chainage 63200

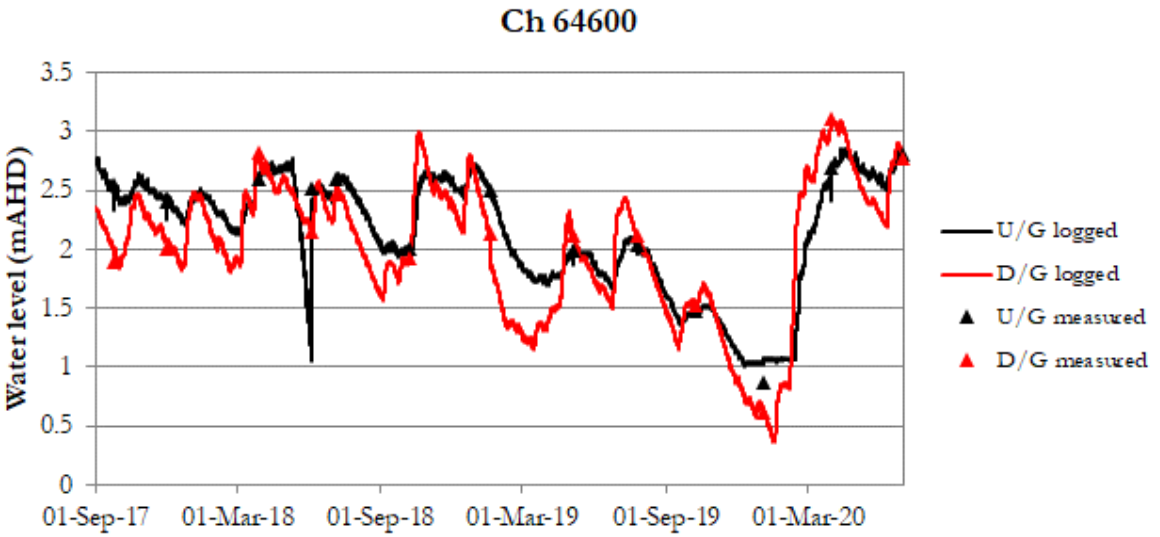

Figure 3.69 Groundwater levels at chainage 64600

The median relative difference between groundwater level at the pair of bores at Ch 64600 was 0.16m during pre-construction monitoring. Between September 2017 and June 2020 the median difference was 0.15 m (**Figure 3.69**). Upgradient and downgradient water levels at Ch 64600 responded normally to wet and dry events throughout operational monitoring.

The median relative pre-construction difference between groundwater level at the pair of bores at Ch 72400 was not reported because the upgradient well (30500.1) was dry. During the current reporting period the upgradient well was also dry (**Figure 3.70**). The downgradient piezometer at Ch 72400 varied normally in response to wet and dry events throughout operational monitoring.

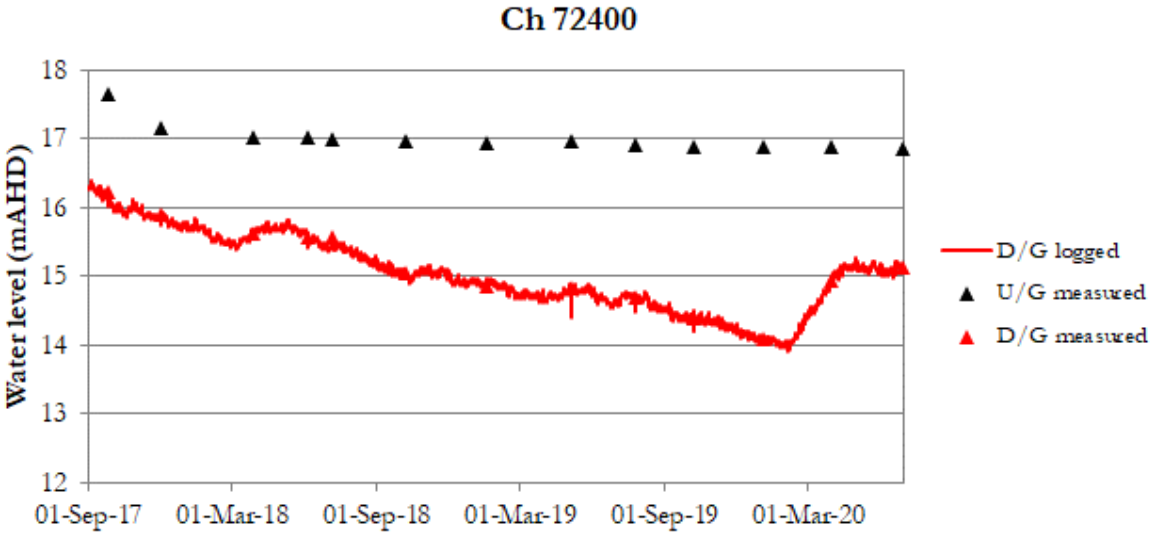

Figure 3.70 Groundwater levels at chainage 72400

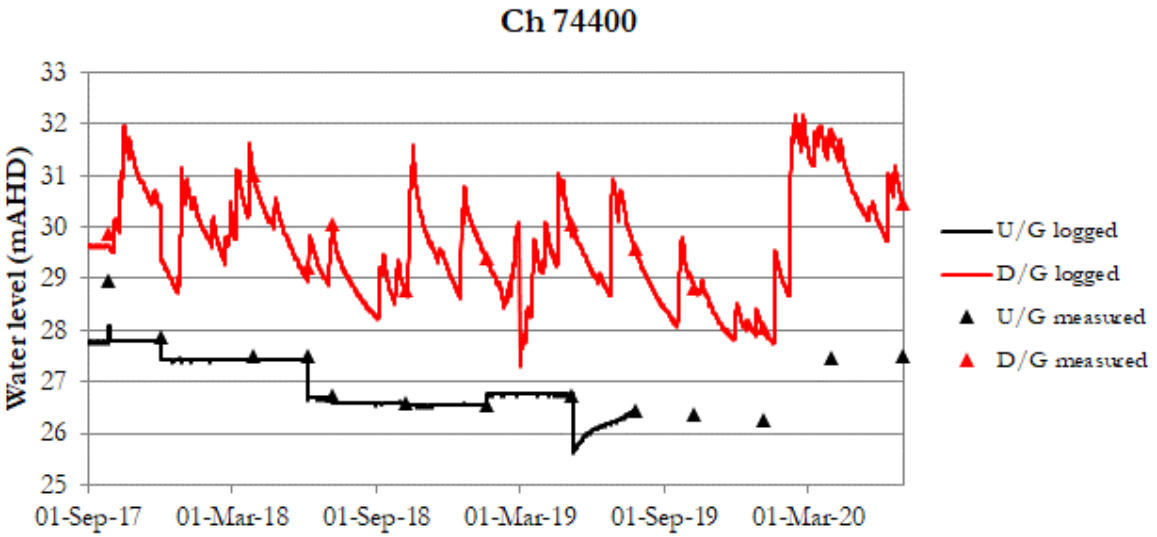

Figure 3.71 Groundwater levels at chainage 74400

The median relative difference between groundwater level at the pair of bores at Ch 74400 was not reported for the pre-construction period because the second well monitored (32500.1) was not located on the correct side of the cut. The level of the upgradient bore at 74400 has been static for the majority of operational monitoring indicating that the groundwater level is below the screened part of the piezometer and therefore that the water levels in the piezometer do not accurately reflect groundwater levels (**Figure 3.71**). Observed reductions in the level of the water in that piezometer only occur as a result of water being removed for sampling. As a result, when the upgradient HOBO logger from Ch74400 was stolen in July 2019 it was not replaced. During the current reporting period and for the first time since operational monitoring began, the levels in the upgradient piezometer increased (by over a meter) in response to very heavy rainfall. It is uncertain if the observed response is:

- An accurate reflection of increased groundwater levels upgradient of the cut at Ch 74400;
- Indicative of some other phenomenon, such as rainwater entering the piezometer directly;
- A permanent or temporary response of groundwater levels or a permanent or temporary reconnection of the piezometer with the surrounding groundwater table.

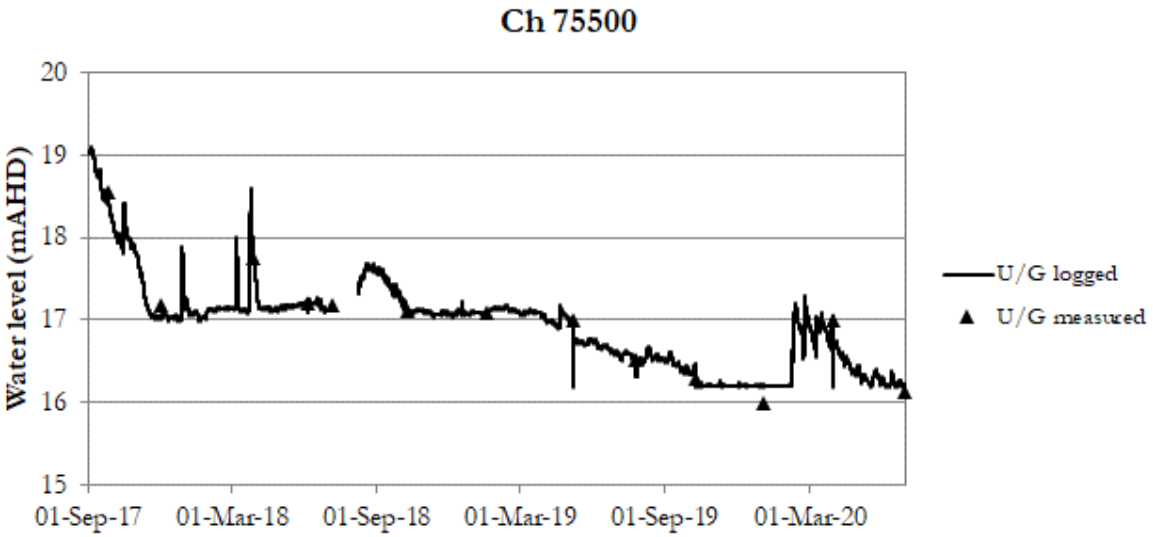

Figure 3.72 Groundwater levels at chainage 75500

There was no downgradient piezometer installed at approximate Ch 75500 for the pre-construction period and no relative difference between levels reported. There has been no downgradient piezometer installed for the operational monitoring period either (**Figure 3.72**). Although the measured groundwater levels in the upgradient piezometer have varied both upwards and downwards in response to wet and dry events during operational monitoring, overall the groundwater levels have reduced by almost 3 meters since September 2017.

The median relative difference in the groundwater levels for the two piezometers at Ch 78500 was reported as 4.70m for the pre-construction period. During the current monitoring period the upgradient well was dry (**Figure 3.73**) as it has been since the start of operational phase monitoring. The downgradient groundwater levels at Ch 78500 has been below the level of the HOBO logger for the majority of the operational monitoring, limiting the capacity to draw conclusions about response to wet and dry events, but the manual measurements collected indicate that the upgradient groundwater level has both increased and decreased during operational monitoring.

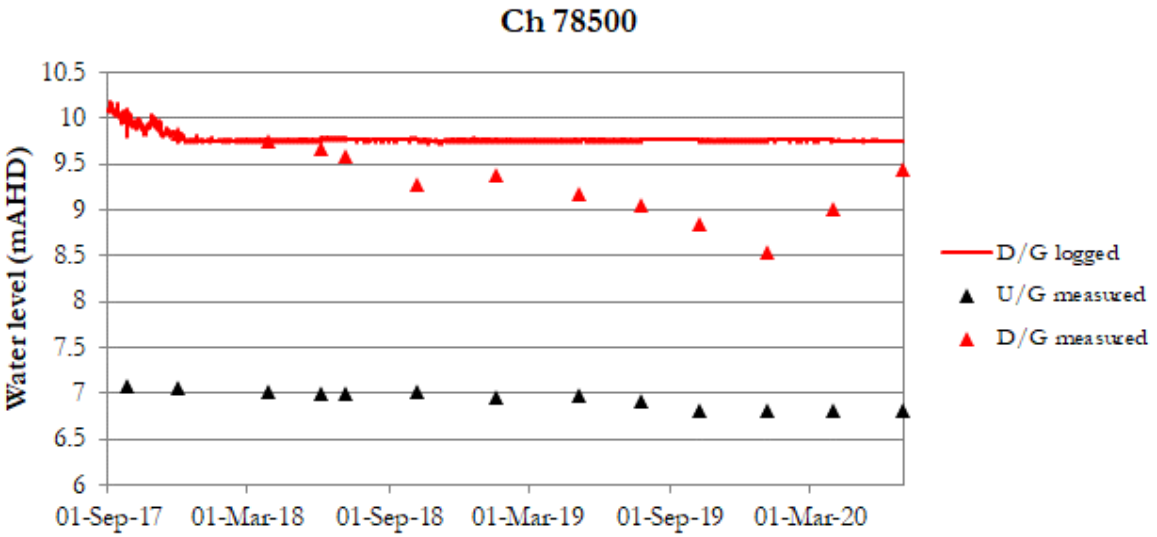

Figure 3.73 Groundwater levels at chainage 78500

4 Key Points and Conclusion

This is the third and final annual operational phase monitoring report for the NH2U Pacific Highway upgrade. Surface water and groundwater monitoring during this reporting period was undertaken according to the requirements of the GMP and SWMP. Minor deviations of 4 to 5 days from the 3-month sample interval specified in the GMP would not have impacted the outcomes of this report.

The following general conclusions can be drawn from the operational monitoring period:

- The majority of results indicate that water quality protection measures have been successful, and that there has not been a significant impact from operation of the NH2U upgrade upon surface water quality. However, there have been several results of interest identified from operational monitoring.
- There were fewer results of interest generated during this annual reporting period than the previous annual reporting period for both groundwater and surface water. As the operational monitoring data set has grown, there has been a lower impact from outlying results upon the summary statistics.
- Hydrocarbons have only been detected in one groundwater sample and one surface water sample at this stage of operational monitoring. There were no results of interest generated from hydrocarbon analyses and the surface water and groundwater samples where hydrocarbons were detected were collected from upstream and upgradient of the highway respectively.
- In most cases where a result of interest has been generated, the data suggests that the source of the higher measurements is upstream of the highway crossings, because upstream concentrations have also been elevated.
- There are some indications of generally increased concentrations of some parameters in surface waters at both control and impact sites in the operational data when compared with the pre-construction data. In particular, concentrations of iron and aluminium are higher both upstream and downstream at many surface water sites in the operational dataset. There is no default ANZECC guideline concentration for iron and iron concentrations vary widely in waterways in relation to local geology and other chemical components (ANZECC 2000). The median operational phase downstream

concentrations of aluminium in surface water are all greater than the relevant default ANZECC guideline concentration of 55 µg/L, some significantly so. However, the upstream p80 aluminium concentrations at all sites are also greater than the relevant default ANZECC guideline concentration.

- The highest downstream TSS concentrations and turbidity measurements since monitoring began have been collected during the operational phase at some sites. However, there were no operational phase downstream median results for turbidity or TSS that registered as results of interest. Additionally, the operational phase downstream median turbidity and TSS values have reduced or remained relatively stable in relation to the previous annual reporting period at all sites. At all sites the operational phase downstream median surface water turbidity measurements were less than the relevant default ANZECC guideline value of 50 NTU. There is no relevant default ANZECC guideline value for TSS.

- The results include some elevated measured concentrations of various groundwater parameters at some of the cuttings and embankments. Comparisons of summary statistics have drawn attention to some results of interest among the groundwater quality monitoring data. However;

    - In many cases the capacity to draw conclusions about groundwater quality is restricted by a lack of upgradient data.

    - Operational phase downgradient median concentrations of most parameters have reduced or remained stable at all sites since the previous annual report. Where there were exceptions to this few of them resulted in results of interest that had not been previously identified.

- The proportion of groundwater sites where operational phase downgradient median iron and aluminium concentrations have registered as results of interest has reduced as operational phase monitoring has progressed.

- The number of results of interest that exceeded ANZECC and ADWG guideline values also reduced during this monitoring period in comparison with the previous monitoring period. The results of interest that did exceed guideline values were as follows:

- At Ch 63200 the downgradient median iron concentration was greater than the relevant ADWG guideline value and the median copper concentration was greater than the relevant ANZECC guideline value.
- At Ch 64600 the downgradient median copper concentration was greater than the relevant ANZECC guideline value.
- At Ch 72400 the downgradient median copper, nickel and phosphate concentrations were greater than the relevant ANZECC guideline values. At this site the upgradient p80 values for all of these parameters were also greater than the relevant ANZECC guideline values. There has been no water in the upgradient piezometer at this site since the pre-construction phase.
- At Ch 74400 the downgradient median zinc and nitrate concentrations were greater than the relevant ANZECC guideline values. The upgradient p80 concentrations were also greater. At this location the upgradient piezometer appeared to have been disconnected from the groundwater table for the majority of the operational phase monitoring, limiting the capacity to draw conclusions.

- Measured groundwater levels increased overall at all sites with water between 1 September 2019 and 30 June 2020 with the exception of the upgradient site at Ch 75500, with the largest increases occurring after heavy rainfall in February 2020. At the one site (Ch 64600) where comparisons of relative groundwater levels can be made with the pre-construction period, the operational phase relative levels appear to be relatively consistent with pre-construction observations. Water levels at all sites with water appear to be fluctuating normally in response to wet and dry events. However, the water level in the upgradient piezometer at Ch 75500 has reduced by almost 3 m over the course of the operational phase monitoring and the water level in the downgradient piezometer at Ch 72400 has reduced by over 1 m over the course of operational phase monitoring.
- Generating conclusions about groundwater levels and quality has been impeded by the fact that some piezometers were decommissioned during construction, new piezometers were relocated, and some piezometers ran dry.
- Some of the groundwater loggers are returning results suggesting that groundwater levels are below the screened section. Specifically, the upgradient piezometers at Ch72400, Ch74400 and Ch78500 are either dry, not recharging or not consistently recharging.

- The upgradient piezometer at Ch72400 is dry but was also dry during the pre-construction phase monitoring, so no change in water level or water quality can be detected at that site.

- The upgradient piezometer at Ch78500 became dry during construction phase monitoring and has not recharged since. The summary results from the downstream piezometer do not indicate that there have been impacts in the operational phase.

- The upgradient piezometer at Ch74400 and the downgradient piezometers at Ch63200 and Ch78500 have water in them but are not recharging consistently, indicating that groundwater levels may have dropped below the screened section on some occasions. As a result, water quality information collected from these piezometers may not always be reliable. However, the information available does not indicate that there have been any consistent operational phase impacts at any of these sites.

Note:

- The PQLs for some of the pre-construction analyses were lower than those utilised for operational monitoring. Some of the results included in this report need to be interpreted carefully as a result.

In conclusion, this third annual, and final, operational phase water quality monitoring report demonstrates:

- That the operational phase water quality monitoring requirements set out in the SWMP and GWMP have been met, wherever possible, in terms of monitoring locations, parameters measured, number of samples, timing of samples (with some small variations) and methods of analysis.

- That the operational phase water quality monitoring data has been analysed in accordance with the requirements of the SWMP and GWMP.

- That operational phase monitoring has not generated evidence of negative impacts on surface water and ground water quality arising from the operation of the NH2U Pacific Highway upgrade.

It is a conclusion of this report that no further operational phase water quality monitoring is required along the NH2U Pacific Highway upgrade.

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Appendix A
Surface Water – Summary Monitoring Data

Table A.1 Operational (Op) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for SEPP14 Wetland Number 351

Parameter	*PQL*	*Upstream SW380 Pre/Con/Op P80*	*Downstream SW351 Op Med (2016-17)*	*Downstream SW351 Op Med (2016-18)*	*Downstream SW351 Op Med (2016-19)*	*Downstream SW351 Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	506	790	250	260.00	270
Arsenic-Total (µg/L)	1	1	1	1	1	1
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	3	1	1	1
Copper-Total (µg/L)	1	2	1	1	1	1
Iron-Total (µg/L)	10	3330	1400	1700	1700	1700
Manganese-Total (µg/L)	5	294	22	67	66	70
Nickel-Total (µg/L)	1	3	1	1	1	1
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	2	1	1	1	1
Zinc-Total (µg/L)	1	6	4	3	3	3
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.8	0.9	0.9	1.0	1.0
Nitrite as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Ammonia as N (mg/L)	0.005	0.363	0.008	0.005	0.011	0.011
Total Phosphorus (mg/L)	0.05	0.05	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.013	0.012	0.013	0.011	0.005
Total Suspended Solids (mg/L)	5	37	8	8	8	8
Temperature (°C)	0.01	23.58	11.75	20.12	18.40	18.36
pH	0.01	6.72	5.37	5.87	6.03	6.01
Conductivity (mS/cm)	0.01	0.82	0.11	0.24	0.27	0.26
Turbidity (NTU)	0.1	37.4	6.0	9.1	9.1	7.7
Dissolved O_2 (mg/L) (P20)*	0.01	3.17	4.56	2.65	2.42	2.42

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.2 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for SEPP14 Wetland Number 353

Parameter	*PQL*	*Upstream SW360U Pre/Con/Op P80*	*Downstream SW353 Op Med (2016-17)*	*Downstream SW353 Op Med (2016-18)*	*Downstream SW353 Op Med (2016-19)*	*Downstream SW353 Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	720	1025	340	300	295
Arsenic-Total (µg/L)	1	1	1	1	1	1
Cadmium-Total (µg/L)	0.1	1.0	0.10	0.10	0.10	0.1
Chromium-Total (µg/L)	1	1	1	1	1	1
Copper-Total (µg/L)	1	1	2	1	1	1
Iron-Total (µg/L)	10	3454	3300	1700	1200	1300
Manganese-Total (µg/L)	5	412	238	215	190	215
Nickel-Total (µg/L)	1	13	6	4	3	3
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	3	1	1	1	1
Zinc-Total (µg/L)	1	68	26	13	12	13
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.1	0.8	0.7	0.6	0.7
Nitrite as N (mg/L)	0.005	0.006	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.041	0.199	0.048	0.040	0.025
Ammonia as N (mg/L)	0.005	0.307	0.029	0.125	0.110	0.140
Total Phosphorus (mg/L)	0.05	0.06	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.012	0.020	0.022	0.011	0.005
Total Suspended Solids (mg/L)	5	36	8	12	12	14
Temperature (°C)	0.01	25.39	13.00	22.09	20.83	20.72
pH	0.01	7.12	4.51	6.80	6.80	6.73
Conductivity (mS/cm)	0.01	32.00	1.63	11.20	22.40	21.10
Turbidity (NTU)	0.1	37.3	11.9	29.2	15.8	15.8
Dissolved O_2 (mg/L) (P20)*	0.01	3.02	6.18	3.98	3.90	3.94

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.3 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the unnamed tributary to SEPP Wetland No. 351

Parameter	*PQL*	*Upstream SW380 Pre/Con/Op P80*	*Downstream SW381 Op Med (2016-17)*	*Downstream SW381 Op Med (2016-18)*	*Downstream SW381 Op Med (2016-19)*	*Downstream SW381 Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	506	1200	360	300	300
Arsenic-Total (µg/L)	1	1	1	1	1	1
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	2	1	1	1
Copper-Total (µg/L)	1	2	2	1	1	1
Iron-Total (µg/L)	10	3330	1130	695	630	695
Manganese-Total (µg/L)	5	294	19	43	35	43
Nickel-Total (µg/L)	1	3	2	1	1	1
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	2	1	1	1	1
Zinc-Total (µg/L)	1	6	4	3	3	3
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.8	0.50	0.45	0.50	0.5
Nitrite as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Ammonia as N (mg/L)	0.005	0.363	0.005	0.005	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.05	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.013	0.015	0.011	0.008	0.005
Total Suspended Solids (mg/L)	5	37	5	6	5	7
Temperature (°C)	0.01	23.58	13.86	20.75	19.22	19.18
pH	0.01	6.72	5.42	6.80	6.80	6.77
Conductivity (mS/cm)	0.01	0.82	0.23	0.21	0.20	0.20
Turbidity (NTU)	0.1	37.4	14.9	19.8	17.1	17.5
Dissolved O_2 (mg/L) (P20)*	0.01	3.17	7.71	4.30	4.22	4.07

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.4 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the unnamed tributary to SEPP Wetland No. 353

Parameter	*PQL*	*Upstream SW360U Pre/Con/Op P80*	*Downstream SW360D Op Med (2016-17)*	*Downstream SW360D Op Med (2016-18)*	*Downstream SW360D Op Med (2016-19)*	*Downstream SW360D Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	720	985	600	340	330
Arsenic-Total (µg/L)	1	1	1	1	1	1
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	1	1	1	1
Copper-Total (µg/L)	1	1	2	1	1	1
Iron-Total (µg/L)	10	3454	3600	2000	1600	1750
Manganese-Total (µg/L)	5	412	246	250	220	250
Nickel-Total (µg/L)	1	13	6	5	4	4
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	3	1	1	1	1
Zinc-Total (µg/L)	1	68	25	23	12	12
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.1	0.8	0.7	0.6	0.7
Nitrite as N (mg/L)	0.005	0.006	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.041	0.198	0.038	0.050	0.035
Ammonia as N (mg/L)	0.005	0.307	0.025	0.145	0.140	0.145
Total Phosphorus (mg/L)	0.05	0.06	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.012	0.025	0.026	0.011	0.005
Total Suspended Solids (mg/L)	5	36	5	11	10	11
Temperature (°C)	0.01	25.39	12.80	22.64	20.65	21.29
pH	0.01	7.12	4.60	6.33	6.46	6.43
Conductivity (mS/cm)	0.01	32.00	1.58	7.67	13.20	11.85
Turbidity (NTU)	0.1	37.3	13.1	14.9	14.7	14.5
Dissolved O_2 (mg/L) (P20)*	0.01	3.02	5.94	3.87	3.71	3.96

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.5 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the Kalang River

Parameter	*PQL*	*Upstream SW359U Pre/Con/Op P80*	*Downstream SW359D Op Med (2016-17)*	*Downstream SW359D Op Med (2016-18)*	*Downstream SW359D Op Med (2016-19)*	*Downstream SW359D Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	88	575	130	110	105
Arsenic-Total (µg/L)	1	2	1	1	1	1
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	1	1	1	1
Copper-Total (µg/L)	1	1	1	1	1	1
Iron-Total (µg/L)	10	274	610	265	260	210
Manganese-Total (µg/L)	5	67	34	63	59	63
Nickel-Total (µg/L)	1	1	1	1	1	1
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	10	1	1	1	1
Zinc-Total (µg/L)	1	8	3	2	2	2
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.4	0.5	0.3	0.2	0.2
Nitrite as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.027	0.069	0.008	0.005	0.006
Ammonia as N (mg/L)	0.005	0.070	0.014	0.019	0.021	0.022
Total Phosphorus (mg/L)	0.05	0.05	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.014	0.022	0.021	0.018	0.005
Total Suspended Solids (mg/L)	5	32	9	9	10	12
Temperature (°C)	0.01	25.61	23.30	23.32	22.74	22.69
pH	0.01	7.57	7.37	7.39	7.39	7.38
Conductivity (mS/cm)	0.01	39.22	32.70	36.05	37.60	37.60
Turbidity (NTU)	0.1	23.0	6.9	10.0	11.9	11.8
Dissolved O_2 (mg/L) (P20)*	0.01	3.93	6.19	3.93	3.98	4.00

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.6 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Dalhousie Creek

Parameter	*PQL*	*Upstream SW315U Pre/Con/Op P80*	*Downstream SW315D Op Med (2016-17)*	*Downstream SW315D Op Med (2016-18)*	*Downstream SW315D Op Med (2016-19)*	*Downstream SW315D Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	798	1900	480	480	400
Arsenic-Total (µg/L)	1	3	2	1	1	1
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	2	1	1	1
Copper-Total (µg/L)	1	2	2	2	2	1
Iron-Total (µg/L)	10	2409	1420	1550	1550	1550
Manganese-Total (µg/L)	5	352	57	68	68	92
Nickel-Total (µg/L)	1	2	2	2	2	2
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	2	1	1	1	1
Zinc-Total (µg/L)	1	5	4	5	5	5
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.3	0.4	0.2	0.2	0.2
Nitrite as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.020	0.005	0.006	0.006	0.006
Ammonia as N (mg/L)	0.005	0.087	0.005	0.005	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.05	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.020	0.023	0.021	0.021	0.016
Total Suspended Solids (mg/L)	5	10	9	9	9	7
Temperature (°C)	0.01	22.45	15.24	20.61	20.32	19.74
pH	0.01	6.53	5.48	6.09	6.05	6.05
Conductivity (mS/cm)	0.01	0.87	0.24	0.23	0.23	0.23
Turbidity (NTU)	0.1	44.8	15.55	20.85	16.70	14.5
Dissolved O_2 (mg/L) (P20)*	0.01	3.09	5.35	3.35	3.22	3.22

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.7 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for McGraths Creek

Parameter	*PQL*	*Upstream SW301U Pre/Con/Op P80*	*Downstream SW301D Op Med (2016-17)*	*Downstream SW301D Op Med (2016-18)*	*Downstream SW301D Op Med (2016-19)*	*Downstream SW301D Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	115	2490	265	80	100
Arsenic-Total (µg/L)	1	4	3	2	2	2
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	3	1	1	1
Copper-Total (µg/L)	1	1	3	1	1	1
Iron-Total (µg/L)	10	3140	2700	1950	2200	2200
Manganese-Total (µg/L)	5	338	62	94	100	100
Nickel-Total (µg/L)	1	1	1	1	1	1
Lead-Total (µg/L)	1	1	2	1	1	1
Selenium-Total (µg/L)	1	2	1	1	1	1
Zinc-Total (µg/L)	1	5	5	3	2	2
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.5	0.5	0.3	0.3	0.3
Nitrite as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.049	0.047	0.005	0.005	0.005
Ammonia as N (mg/L)	0.005	0.118	0.023	0.005	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.06	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.018	0.035	0.033	0.020	0.006
Total Suspended Solids (mg/L)	5	13	16	6	6	7
Temperature (°C)	0.01	23.34	14.54	21.72	19.84	19.61
pH	0.01	6.98	5.75	6.54	6.54	6.53
Conductivity (mS/cm)	0.01	0.72	0.24	0.34	0.38	0.37
Turbidity (NTU)	0.1	30.3	64.0	30.1	30.1	30.1
Dissolved O_2 (mg/L) (P20)*	0.01	2.29	7.32	4.42	4.34	4.38

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.8 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the tributary to Oyster Creek

Parameter	*PQL*	*Upstream SW261 Pre/Con/Op P80*	*Downstream SW262 Op Med (2016-17)*	*Downstream SW262 Op Med (2016-18)*	*Downstream SW262 Op Med (2016-19)*	*Downstream SW262 Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	210	950	180	140	130
Arsenic-Total (µg/L)	1	3	2	3	3	2
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	1.50	1	1	1
Copper-Total (µg/L)	1	2	2	1	1	1
Iron-Total (µg/L)	10	2710	1550	2500	2050	2200
Manganese-Total (µg/L)	5	209	34	120	135	120
Nickel-Total (µg/L)	1	2	1	1	1	1
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	2	1	1	1	1
Zinc-Total (µg/L)	1	7	6	5	5	5
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.6	0.6	0.4	0.4	0.4
Nitrite as N (mg/L)	0.005	0.007	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.030	0.105	0.010	0.010	0.010
Ammonia as N (mg/L)	0.005	0.054	0.005	0.005	0.006	0.005
Total Phosphorus (mg/L)	0.05	0.07	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.013	0.020	0.021	0.012	0.005
Total Suspended Solids (mg/L)	5	22	7	5	5	5
Temperature (°C)	0.01	23.56	14.30	21.41	20.45	20.00
pH	0.01	7.29	6.02	6.66	6.66	6.65
Conductivity (mS/cm)	0.01	0.56	0.15	0.23	0.23	0.23
Turbidity (NTU)	0.1	17.9	29.4	17.4	12.3	12.7
Dissolved O_2 (mg/L) (P20)*	0.01	2.47	7.63	4.34	4.55	4.42

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.9 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Deep Creek

Parameter	*PQL*	*Upstream SW231U Pre/Con/Op P80*	*Downstream SW231D Op Med (2016-17)*	*Downstream SW231D Op Med (2016-18)*	*Downstream SW231D Op Med (2016-19)*	*Downstream SW231D Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	120	925	85	100	85
Arsenic-Total (µg/L)	1	3	2	2	2	2
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	1	1	1	1
Copper-Total (µg/L)	1	1	2	1	1	1
Iron-Total (µg/L)	10	391	1050	385	250	265
Manganese-Total (µg/L)	5	67	57	57	41	46
Nickel-Total (µg/L)	1	1	1	1	1	1
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	10	1	1	1	1
Zinc-Total (µg/L)	1	6	4	2	2	2
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.4	0.5	0.3	0.3	0.2
Nitrite as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.050	0.127	0.015	0.009	0.007
Ammonia as N (mg/L)	0.005	0.055	0.012	0.018	0.022	0.022
Total Phosphorus (mg/L)	0.05	0.05	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.014	0.032	0.034	0.024	0.007
Total Suspended Solids (mg/L)	5	14	6	6	6	6
Temperature (°C)	0.01	26.19	19.63	20.89	20.65	20.73
pH	0.01	7.63	6.96	7.28	7.24	7.20
Conductivity (mS/cm)	0.01	41.22	16.30	22.65	25.50	25.90
Turbidity (NTU)	0.1	15.0	2.9	10.4	10.5	10.3
Dissolved O_2 (mg/L) (P20)*	0.01	4.16	7.04	5.61	4.79	4.67

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.10 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Cow Creek

Parameter	*PQL*	*Upstream SW217U Pre/Con/Op P80*	*Downstream SW217D Op Med (2016-17)*	*Downstream SW217D Op Med (2016-18)*	*Downstream SW217D Op Med (2016-19)*	*Downstream SW217D Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	64	780	90	60	60
Arsenic-Total (µg/L)	1	6	4	6	5	4
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	1	1	1	1
Copper-Total (µg/L)	1	1	2	1	1	1
Iron-Total (µg/L)	10	1240	935	1300	1100	760
Manganese-Total (µg/L)	5	515	26	193	66	66
Nickel-Total (µg/L)	1	1	1	1	1	1
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	2	1	1	1	1
Zinc-Total (µg/L)	1	4	3	2	2	2
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.3	0.4	0.3	0.3	0.3
Nitrite as N (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.016	0.049	0.006	0.006	0.006
Ammonia as N (mg/L)	0.005	0.045	0.005	0.005	0.007	0.008
Total Phosphorus (mg/L)	0.05	0.06	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.020	0.027	0.030	0.024	0.006
Total Suspended Solids (mg/L)	5	10	6	6	6	6
Temperature (°C)	0.01	24.22	21.03	22.09	20.76	20.68
pH	0.01	7.51	7.78	6.95	6.84	6.81
Conductivity (mS/cm)	0.01	4.30	3.12	2.81	3.14	3.12
Turbidity (NTU)	0.1	13.2	7.0	14.9	12.8	12.1
Dissolved O_2 (mg/L) (P20)*	0.01	3.37	6.95	4.88	4.39	4.39

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.11 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Boggy Creek

Parameter	*PQL*	*Upstream SW208U Pre/Con/Op P80*	*Downstream SW208D Op Med (2016-17)*	*Downstream SW208D Op Med (2016-18)*	*Downstream SW208D Op Med (2016-19)*	*Downstream SW208D Op Med (2016-20)*
TRH C6 - C9 (µg/L)	10	10	10	10	10	10
TRH C6 - C10 (µg/L)	10	10	10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100	100	100
Silver-Total (µg/L)	1	1	1	1	1	1
Aluminium-Total (µg/L)	10	167	1180	270	150	140
Arsenic-Total (µg/L)	1	5	4	5	5	4
Cadmium-Total (µg/L)	0.1	1.0	0.1	0.1	0.1	0.1
Chromium-Total (µg/L)	1	1	2	1	1	1
Copper-Total (µg/L)	1	1	2	1	1	1
Iron-Total (µg/L)	10	1780	1600	2650	1900	1800
Manganese-Total (µg/L)	5	820	96	270	260	240
Nickel-Total (µg/L)	1	2	1	1	1	1
Lead-Total (µg/L)	1	1	1	1	1	1
Selenium-Total (µg/L)	1	2	1	1	1	1
Zinc-Total (µg/L)	1	5	3	4	4	4
Mercury-Total (µg/L)	0.05	0.50	0.05	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.8	0.4	0.5	0.4	0.4
Nitrite as N (mg/L)	0.005	0.006	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.020	0.023	0.005	0.005	0.005
Ammonia as N (mg/L)	0.005	0.147	0.005	0.005	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.11	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.061	0.030	0.046	0.020	0.010
Total Suspended Solids (mg/L)	5	23	6	9	10	6
Temperature (°C)	0.01	23.29	15.41	21.09	19.90	19.50
pH	0.01	7.39	6.64	6.75	6.75	6.67
Conductivity (mS/cm)	0.01	0.80	0.29	0.46	0.47	0.46
Turbidity (NTU)	0.1	36.1	12.9	53.1	28.6	24.5
Dissolved O_2 (mg/L) (P20)*	0.01	2.40	9.90	4.62	4.54	4.72

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Appendix B
Summary Groundwater Monitoring Data

Table B.1 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 63200

Parameter	*Units*	*PQL*	*D/G pre med 21300.2*	*D/G con med 21300.2*	*U/G pre/con/op P80 21300.1*	*D/G op med 2018 21300.2*	*D/G op med 2019 21300.2*	*D/G op med 2020 21300.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	10	10	10	10	10	10	10
TRH C10-C14	µg/L	50	50	50	50	50	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Al-Dissolved	µg/L	10	101.0	59.0	296	1500	65	65
As-Dissolved	µg/L	1	1.0	1.0	1	5	4	4
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0	0.1	0.1	0.1
Cr-Dissolved	µg/L	1	1.0	1.0	1	2	1	1
Cu-Dissolved	µg/L	1	2.0	1.7	8	13	11	13
Fe-Dissolved	µg/L	10	15.0	21.0	157	1488	640	640
Mn-Dissolved	µg/L	5	40.0	14.0	255	35	10	8
Ni-Dissolved	µg/L	1	3.0	1.0	8	4	1	1
Pb-Dissolved	µg/L	1	1.0	1.0	1	2	1	1
Se-Dissolved	µg/L	1	1.0	2.0	2	1	1	1
Zn-Dissolved	µg/L	1	41.0	11.0	69	16	16	11
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen	mg/L	0.1	0.18	0.16	0.4	1.3	0.7	0.2
Nitrite	mg/L	0.005	0.002	0.001	0.005	0.005	0.005	0.005
Nitrate	mg/L	0.005	0.018	0.032	0.100	0.088	0.033	0.033
Ammonia	mg/L	0.005	0.015	0.025	0.042	0.020	0.020	0.020
Total Phosphorus	mg/L	0.05	0.02	0.01	0.06	0.06	0.06	0.05
Phosphate	mg/L	0.005	0.005	0.005	0.005	0.016	0.007	0.005
Temp	°C	0.01	19.49	19.54	21.51	19.81	20.24	20.24
pH		0.01	4.76	5.46	5.80	4.88	4.87	4.87
EC	mS/cm	0.01	0.14	0.13	0.27	0.09	0.09	0.09
TSS	mg/L	5	168.8		996	570	570	620
TDS	mg/L	1	96.22		174		-	-
Bicarbonate	mg/L CaCO3	1	4.0	6.0	15	10	10	10
Sodium	mg/L	1	18.4	14.4	40	12	12	12
Potassium	mg/L	1	0.73	0.41	2	1	1	1
Calcium	mg/L	1	0.81	1.76	1	2	2	2
Magnesium	mg/L	1	2.97	1.88	1	1	1	1
Chloride	mg/L	1	39.1	29.4	54	20	20	20
Sulfate	mg/L	1	2.6	4.0	7	4	4	4

Red shading – Indicates a result of interest 2018. Blue shading – Indicates a result of interest 2019. Purple shading – Indicates a result of interest 2020.

Table B.2 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 64600

Parameter	*Units*	*PQL*	*D/G pre med 22600.2*	*D/G con med 22600.2*	*U/G pre/con/op P80 22600.1*	*D/G op med 2018 22600.2*	*D/G op med 2019 22600.2*	*D/G op med 2020 22600.2*
TRH C6 - C9	µg/L	10	10	10	47	10	10	10
TRH C6 - C10	µg/L	10	-	10	80	10	10	10
TRH C10-C14	µg/L	50	50	50	50	50	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Al-Dissolved	µg/L	10	6.0	6.4	3660	10.0	10	10
As-Dissolved	µg/L	1	1.0	1.0	3	2.0	1	1
Cd-Dissolved	µg/L	0.1	1.0	1.0	1	0.1	0.1	0.1
Cr-Dissolved	µg/L	1	2.5	1.0	2	1	1	1
Cu-Dissolved	µg/L	1	1.1	1.0	7	1	2	44
Fe-Dissolved	µg/L	10	16.0	5.0	81	310	10	10
Mn-Dissolved	µg/L	5	30.5	20.0	43	21	21	21
Ni-Dissolved	µg/L	1	2.5	1.0	4	1	9	9
Pb-Dissolved	µg/L	1	1.0	1.0	4	1	1	1
Se-Dissolved	µg/L	1	1.0	2.0	2	1	1	1
Zn-Dissolved	µg/L	1	40.0	11.0	36	2.0	10	11
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen	mg/L	0.1	0.22	0.06	0.3	0.1	0.1	0.1
Nitrite	mg/L	0.005	0.002	0.001	0.005	0.005	0.005	0.005
Nitrate	mg/L	0.005	0.007	0.007	0.050	0.005	0.005	0.005
Ammonia	mg/L	0.005	0.010	0.009	0.065	0.047	0.047	0.047
Total Phosphorus	mg/L	0.05	0.03	0.01	0.06	0.05	0.05	0.05
Phosphate	mg/L	0.005	0.005	0.006	0.010	0.013	0.005	0.005
Temp	°C	0.01	20.90	20.60	21.10	22.12	22.35	22.12
pH		0.01	5.82	6.16	6.71	6.24	6.11	6.04
EC	mS/cm	0.01	0.26	0.27	1.28	0.25	0.26	0.27
TSS	mg/L	5	75.3	-	267	53	9	7
TDS	mg/L	1	179.86	-	162	-	-	-
Bicarbonate	mg/L CaCO3	1	40.0	40.0	13	40	40	40
Sodium	mg/L	1	35.0	36.3	219	38	38	38
Potassium	mg/L	1	1.00	0.84	1	1	1	1
Calcium	mg/L	1	5.00	5.02	6	5	5	5
Magnesium	mg/L	1	6.87	7.03	9	7	7	7
Chloride	mg/L	1	56.0	54.0	332	56	56	56
Sulfate	mg/L	1	4.0	3.5	12	3	3	3

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019. Purple shading – Indicates a result of interest 2020.

Table B.3 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 72400

Parameter	*Units*	*PQL*	*D/G pre med 30500.2*	*D/G con med 30500.2*	*U/G pre/con/op P80 30500.1*	*D/G op med 2018 30500.2*	*D/G op med 2019 30500.2*	*D/G op med 2020 30500.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	10	-	10	10	10	10	10
TRH C10-C14	µg/L	50	50	50	50	50	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Al-Dissolved	µg/L	10	84.0	47.5	166	170	20	20
As-Dissolved	µg/L	1	1.0	2.0	1	3	2	2
Cd-Dissolved	µg/L	0.1	1.0	1.0	1	0.1	0.1	0.1
Cr-Dissolved	µg/L	1	4.0	1.0	3	1	1	1
Cu-Dissolved	µg/L	1	6.5	3.0	4	5	13	13
Fe-Dissolved	µg/L	10	13.0	262.0	314	290	10	10
Mn-Dissolved	µg/L	5	485.0	181.0	388	320	260	240
Ni-Dissolved	µg/L	1	27.0	5.8	21	42	31	31
Pb-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Se-Dissolved	µg/L	1	1.5	2.0	2	1	1	1
Zn-Dissolved	µg/L	1	125.0	36.0	107	76	76	74
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen	mg/L	0.1	0.4	0.1	0.4	0.4	0.3	0.2
Nitrite	mg/L	0.005	0.002	0.003	0.004	0.005	0.005	0.005
Nitrate	mg/L	0.005	0.027	0.020	0.185	0.040	0.040	0.040
Ammonia	mg/L	0.005	0.017	0.023	0.042	0.051	0.051	0.033
Total Phosphorus	mg/L	0.05	0.42	0.07	0.39	0.30	0.30	0.30
Phosphate	mg/L	0.005	0.006	0.017	0.027	0.180	0.180	0.190
Temp	°C	0.01	20.21	20.24	21.46	20.71	21.34	20.71
pH		0.01	5.24	6.47	5.45	6.16	6.08	5.98
EC	mS/cm	0.01	1.14	0.97	1.12	0.90	0.84	0.79
TSS	mg/L	5	895	-	-	24	14	14
TDS	mg/L	1	812.5	-	-	-	-	-
Bicarbonate	mg/L CaCO3	1	26	50	40	115	115	115
Sodium	mg/L	1	204	67	203	185	185	185
Potassium	mg/L	1	1.43	1.80	2	3	3	3
Calcium	mg/L	1	5.32	13.80	10	15	15	15
Magnesium	mg/L	1	10.62	4.28	10	17	17	17
Chloride	mg/L	1	250.5	102.0	249	210	210	210
Sulfate	mg/L	1	96.0	38.4	101	42	42	42

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019. Purple shading – Indicates a result of interest 2020.

Table B.4 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 74400

Parameter	*Units*	*PQL*	*D/G pre med 32500.2*	*D/G con med 32500.2*	*U/G pre/con/op P80 32500.1*	*D/G op med 2018 32500.2*	*D/G op med 2019 32500.2*	*D/G op med 2020 32500.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	10		10	10	10	10	10
TRH C10-C14	µg/L	50	50	50	51	50	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	69	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Al-Dissolved	µg/L	10	164.5	63.5	262	560	10	10
As-Dissolved	µg/L	1	7.5	3.0	9	2	1	1
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0	0.2	0.1	0.1
Cr-Dissolved	µg/L	1	7.0	1.0	1	**2**	1	1
Cu-Dissolved	µg/L	1	2.5	2.0	3	3	3	3
Fe-Dissolved	µg/L	10	1006.0	177.5	187	7100	12	19
Mn-Dissolved	µg/L	5	410.0	219.0	1825	290	260	150
Ni-Dissolved	µg/L	1	16.5	9.0	9	11	11	11
Pb-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Se-Dissolved	µg/L	1	1.0	2.0	2	1	1	1
Zn-Dissolved	µg/L	1	55.5	29.0	46	42	42	61
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen	mg/L	0.1	1.47	0.26	2.4	0.2	0.2	0.4
Nitrite	mg/L	0.005	0.002	0.005	0.022	0.005	0.005	0.005
Nitrate	mg/L	0.005	0.005	0.023	0.084	0.047	0.130	0.130
Ammonia	mg/L	0.005	0.027	0.043	1.362	0.072	0.032	0.005
Total Phosphorus	mg/L	0.05	0.36	0.10	0.08	0.06	0.06	0.06
Phosphate	mg/L	0.005	0.088	0.021	0.015	0.011	0.005	0.005
Temp	°C	0.01	19.63	20.34	21.76	20.26	21.40	21.40
pH		0.01	5.91	6.79	8.24	7.10	6.92	6.88
EC	mS/cm	0.01	1.61	1.35	3.04	1.06	1.24	1.30
TSS	mg/L	5	114.9	-	71	36	36	40
TDS	mg/L	1	1115.50	-	576	-	-	-
Bicarbonate	mg/L CaCO3	1	107.5	108.0	315	395	395	395
Sodium	mg/L	1	264.5	196.0	224	209	209	209
Potassium	mg/L	1	2.79	2.51	55	5	5	5
Calcium	mg/L	1	20.10	21.00	130	108	108	108
Magnesium	mg/L	1	29.95	12.55	16	24	24	24
Chloride	mg/L	1	311.5	203.0	182	225	225	225
Sulfate	mg/L	1	201.5	156.6	72	57	57	57

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019. Purple shading – Indicates a result of interest 2020.

Table B.5 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 75500

Parameter	*Units*	*PQL*	*D/G pre med 33600.2*	*D/G con med 33600.2*	*U/G pre/con/op P80 33600.1*	*D/G op med 2018 33600.2*	*D/G op med 2019 33600.2*	*D/G op med 2020 33600.2*
TRH C6 - C9	µg/L	10	10	-	10	-	-	-
TRH C6 - C10	µg/L	10	-	-	10	-	-	-
TRH C10-C14	µg/L	50	315	-	50	-	-	-
TRH C15-C28	µg/L	100	800	-	100	-	-	-
TRH C29-C36	µg/L	100	100	-	100	-	-	-
TRH >C10-C16	µg/L	50	630	-	50	-	-	-
TRH >C16-C34	µg/L	100	100	-	100	-	-	-
TRH >C34-C40	µg/L	100	100	-	100	-	-	-
Ag-Dissolved	µg/L	1	1.0	-	1	-	-	-
Al-Dissolved	µg/L	10	905.5	-	518	-	-	-
As-Dissolved	µg/L	1	8.0	-	3	-	-	-
Cd-Dissolved	µg/L	0.1	1.0	-	1.0	-	-	-
Cr-Dissolved	µg/L	1	6.0	-	3	-	-	-
Cu-Dissolved	µg/L	1	63.5	-	25	-	-	-
Fe-Dissolved	µg/L	10	2042.0	-	1223	-	-	-
Mn-Dissolved	µg/L	5	332.0	-	210	-	-	-
Ni-Dissolved	µg/L	1	36.0	-	16	-	-	-
Pb-Dissolved	µg/L	1	7.5	-	3	-	-	-
Se-Dissolved	µg/L	1	3.5	-	2	-	-	-
Zn-Dissolved	µg/L	1	357.0	-	231	-	-	-
Hg-Dissolved	µg/L	0.05	0.50	-	0.50	-	-	-
Total Nitrogen	mg/L	0.1	4.35	-	0.8	-	-	-
Nitrite	mg/L	0.005	0.003	-	0.005	-	-	-
Nitrate	mg/L	0.005	0.005	-	0.050	-	-	-
Ammonia	mg/L	0.005	0.641	-	0.283	-	-	-
Total Phosphorus	mg/L	0.05	0.12	-	0.19	-	-	-
Phosphate	mg/L	0.005	0.009	-	0.049	-	-	-
Temp	°C	0.01	19.93	-	21.99	-	-	-
pH		0.01	5.13	-	8.01	-	-	-
EC	mS/cm	0.01	1.90	-	1.16	-	-	-
TSS	mg/L	5	106.8	-	110	-	-	-
TDS	mg/L	1	1294.00	-	1290	-	-	-
Bicarbonate	mg/L CaCO3	1	18.8	-	87	-	-	-
Sodium	mg/L	1	285.0	-	193	-	-	-
Potassium	mg/L	1	2.66	-	16	-	-	-
Calcium	mg/L	1	3.38	-	26	-	-	-
Magnesium	mg/L	1	36.25	-	16	-	-	-
Chloride	mg/L	1	504.5	-	301	-	-	-
Sulfate	mg/L	1	28.0	-	35	-	-	-

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019. Purple shading – Indicates a result of interest 2020.

Table B.6 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 78500

Parameter	*Units*	*PQL*	*D/G pre med 36600.2*	*D/G con med 36600.2*	*U/G pre/con/op P80 36600.1*	*D/G op med 2018 36600.2*	*D/G op med 2019 36600.2*	*D/G op med 2020 36600.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	10		10	10	10	10	10
TRH C10-C14	µg/L	50	50	50	50	50	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Al-Dissolved	µg/L	10	8.5	14.5	67	220	10	20
As-Dissolved	µg/L	1	3.0	4.0	10	5	5	5
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0	0.1	0	0
Cr-Dissolved	µg/L	1	1.5	1.0	3	1	1	1
Cu-Dissolved	µg/L	1	1.0	1.0	5	1	2	2
Fe-Dissolved	µg/L	10	9.5	37.0	620	1700	39	130
Mn-Dissolved	µg/L	5	506.0	458.0	2201	450	450	460
Ni-Dissolved	µg/L	1	15.0	16.9	105	14	15	15
Pb-Dissolved	µg/L	1	1.0	1.0	1	1	1	1
Se-Dissolved	µg/L	1	1.0	2.0	28	1	1	1
Zn-Dissolved	µg/L	1	57.5	33.0	140	34	45	49
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen	mg/L	0.1	0.17	0.12	0.5	0.2	0.2	0.2
Nitrite	mg/L	0.005	0.006	0.003	0.004	0.005	0.005	0.005
Nitrate	mg/L	0.005	0.008	0.023	0.175	0.030	0.058	0.058
Ammonia	mg/L	0.005	0.025	0.020	0.123	0.097	0.097	0.035
Total Phosphorus	mg/L	0.05	0.92	0.86	1.64	1.10	1.10	0.90
Phosphate	mg/L	0.005	0.577	0.649	1.577	0.537	0.537	0.690
Temp	°C	0.01	21.80	20.40	21.30	21.30	21.11	21.11
pH		0.01	6.06	6.43	6.11	6.18	6.09	6.09
EC	mS/cm	0.01	1.12	1.23	3.07	1.24	1.27	1.28
TSS	mg/L	5	106.0		31	44	20	20
TDS	mg/L	1	760.00		1,904		-	-
Bicarbonate	mg/L CaCO3	1	80.0	71.9	100	75	75	75
Sodium	mg/L	1	203.0	230.5	580	238	238	238
Potassium	mg/L	1	1.09	0.80	2	1	1	1
Calcium	mg/L	1	4.55	4.60	4	**4**	**4**	**4**
Magnesium	mg/L	1	11.20	13.05	39	13	13	13
Chloride	mg/L	1	213.5	256.0	700	243	243	243
Sulfate	mg/L	1	102.7	102.3	399	108	108	108

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019. Purple shading – Indicates a result of interest 2020.