Transport
Roads & Maritime Services

Nambucca Heads to Urunga Pacific Highway Upgrade

Water Quality Monitoring Annual Report

Roads and Maritime Services | August 2017

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Water Quality Monitoring Annual Report – August 2017

Report Prepared for:

NSW Roads and Maritime Services

August 2018

Prepared By:

Aquatic Science and Management

Document History

Version	***Issued To***	***Format***	***Date***
DRAFT_V1	David Rohweder	*.doc	21/02/2018
FINAL_V1	David Rohweder	*.doc	04/06/2018
FINAL_V2	David Rohweder	*.doc	17/07/2018
FINAL_V3	David Rohweder	*.doc, .pdf	30/08/2018

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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 2016 and 31 August 2017 incorporating the 5 months of operational phase monitoring by the construction contractor and the first 3 months of the monitoring by the operational phase environmental monitoring contractor 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 Deparment 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 2017 annual reporting period (1 September 2016 – 31 August 2017). This report is required to comply with DP&E MCoA B17.

1.2 Water Quality Guidelines and Objectives

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

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

In the case of large datasets collected regularly over time and with an appropriate sampling design the ANZECC Guidelines suggest the use of median and 80th percentile (P80) concentrations from the gathered data.

The SWMP and the 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.

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

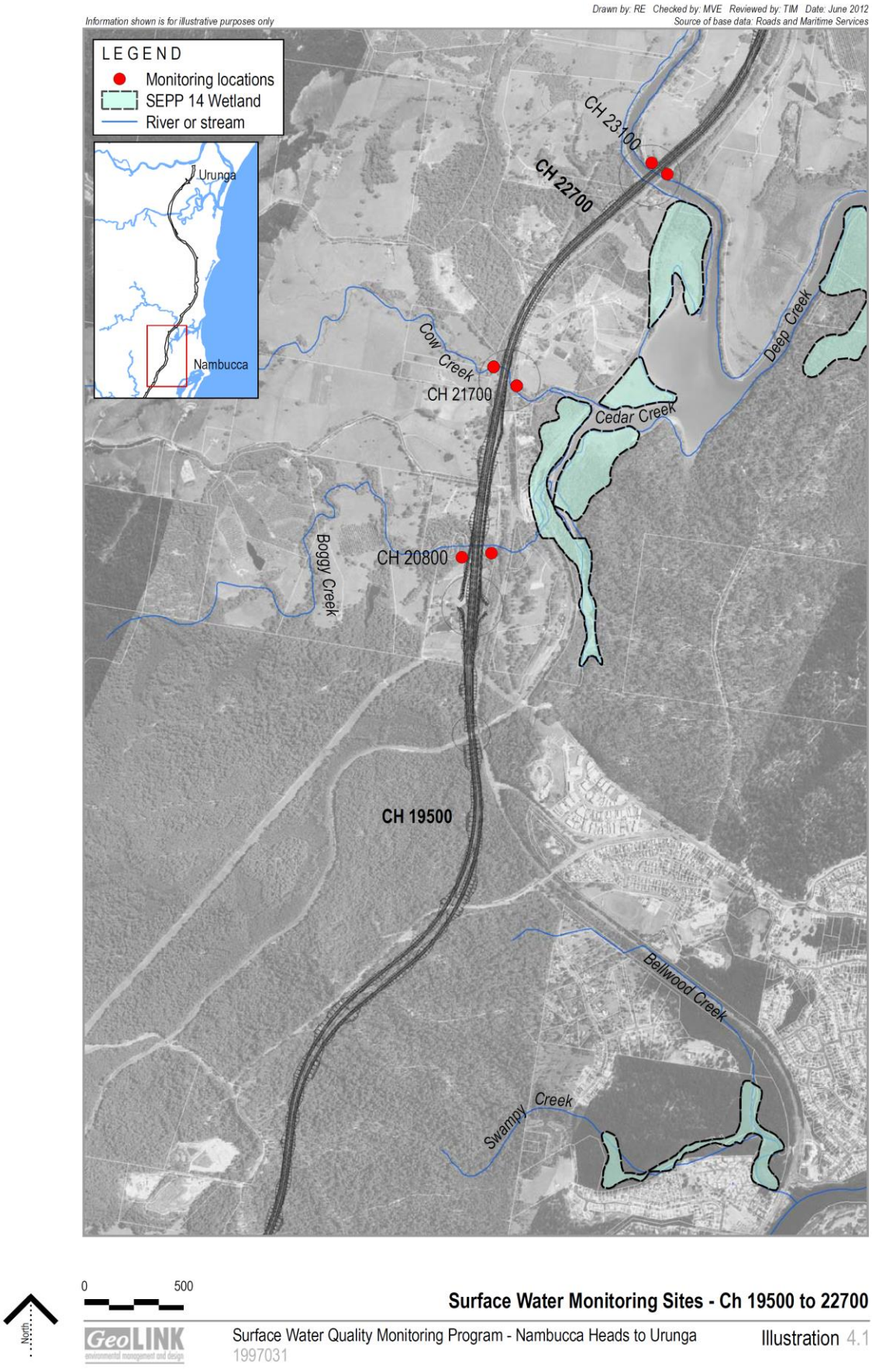

Illustration 2.1 Surface water monitoring sites – Ch 19500 to 22700 (GeoLINK 2013a)

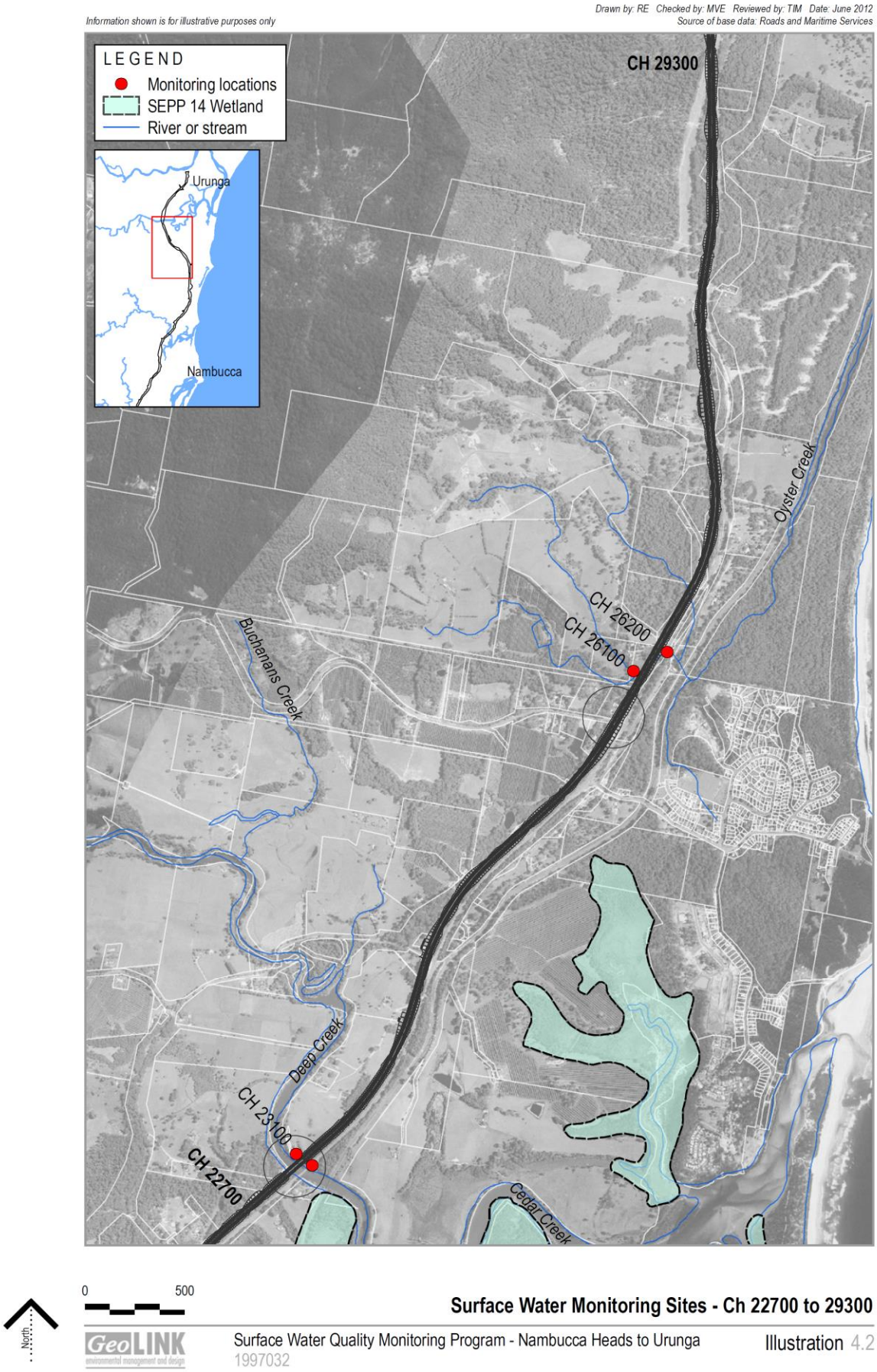

Illustration 2.2 Surface water monitoring sites – Ch 22700 to 29300 (GeoLINK 2013a)

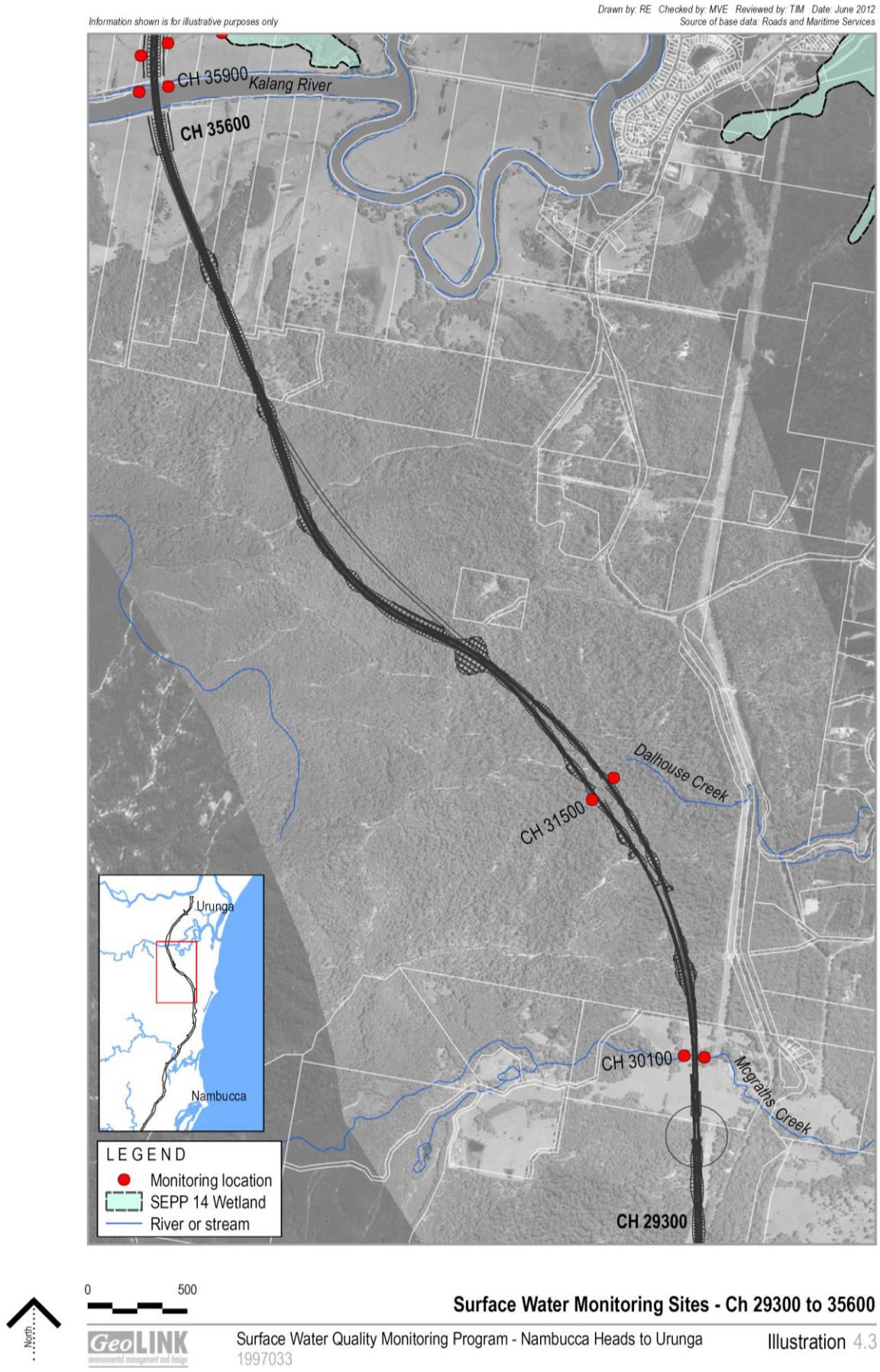

Illustration 2.3 Surface water monitoring sites – Ch 29300 to 35600 (GeoLINK 2013a)

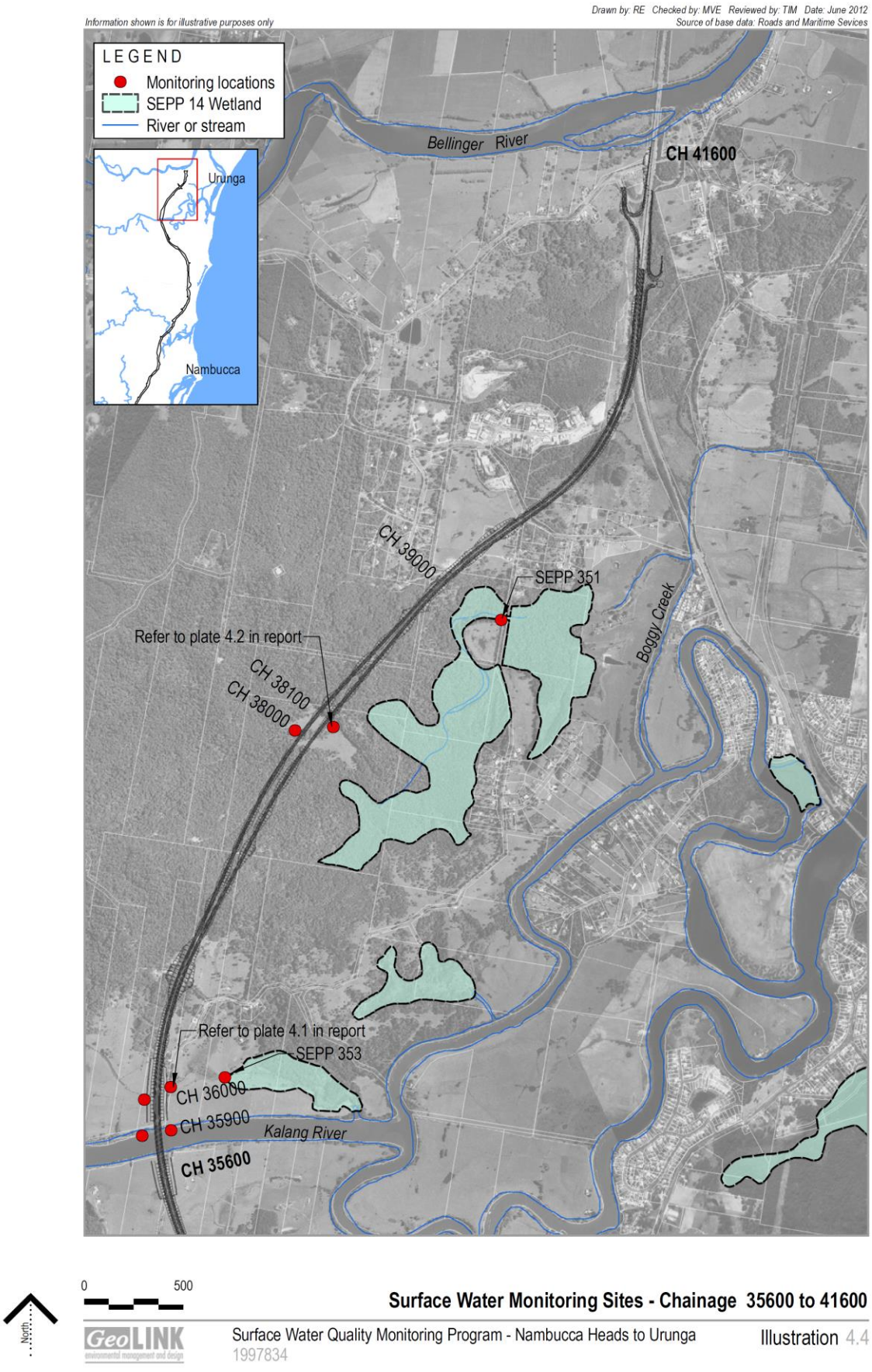

Illustration 2.4 Surface water monitoring sites – Ch 35600 to 41600 (GeoLINK 2013a)

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 2.8** (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.

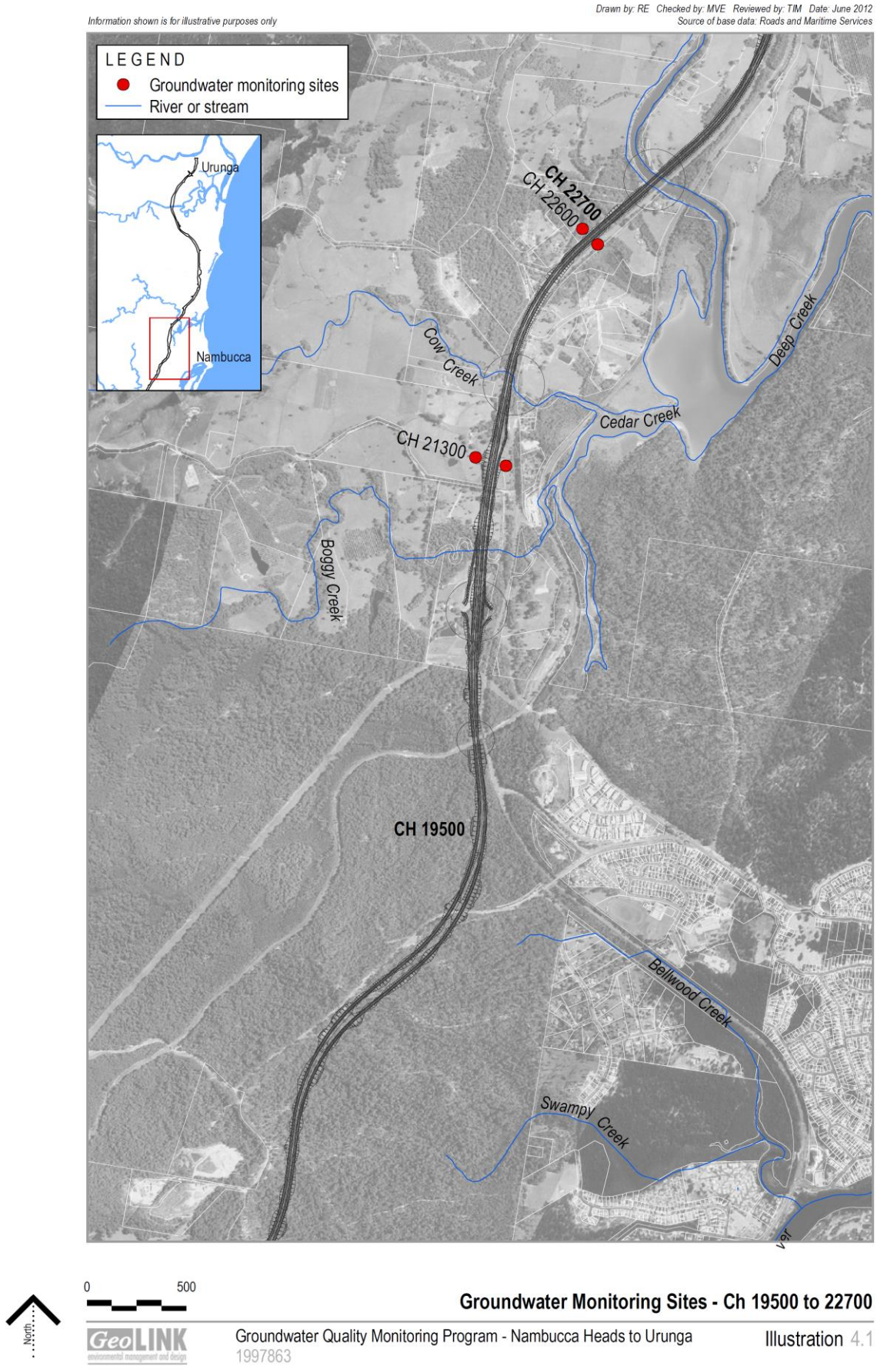

Illustration 2.5 Groundwater monitoring sites – Ch 19500 to 22700 (GeoLINK 2013b)

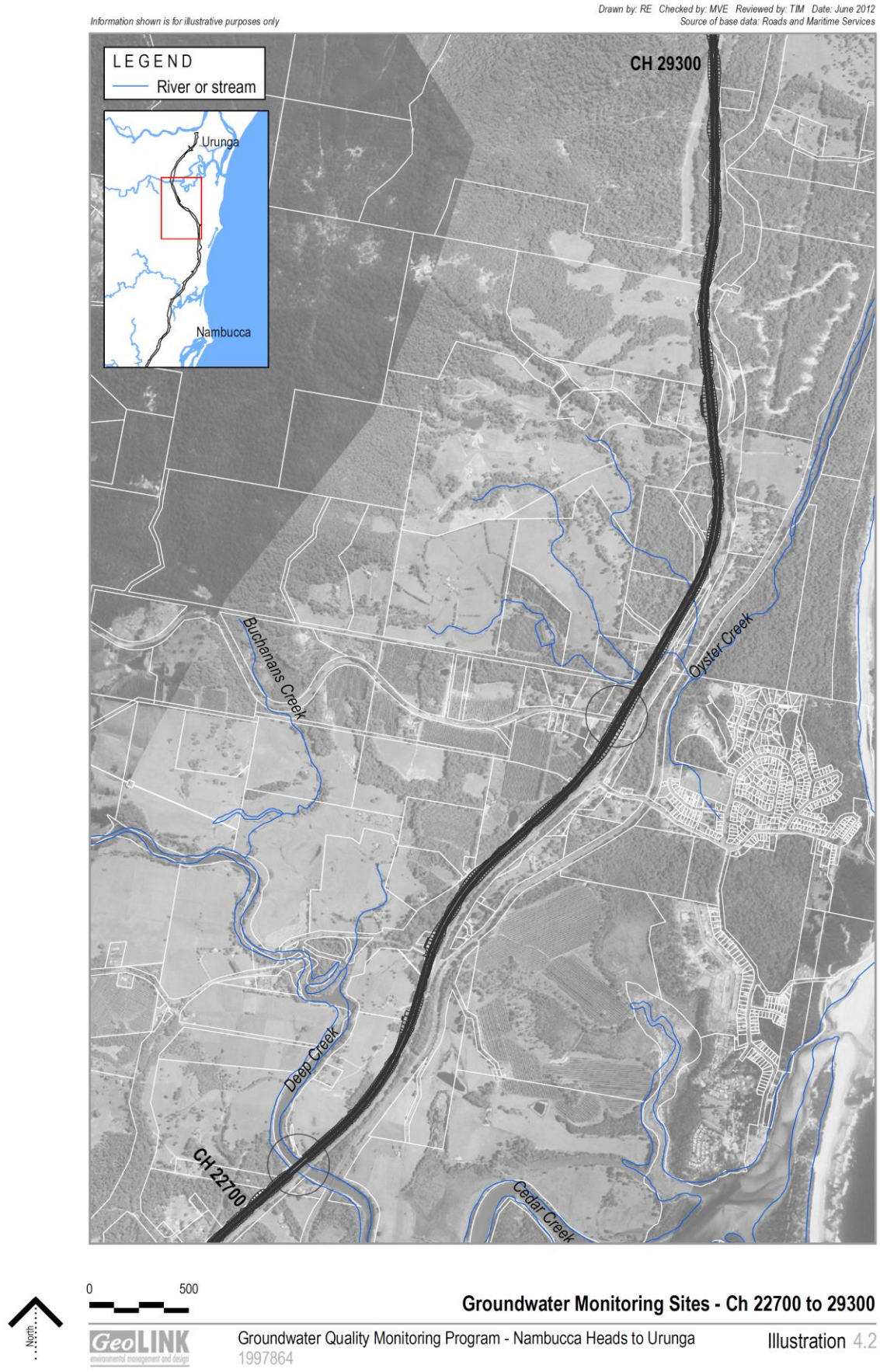

Illustration 2.6 Groundwater monitoring sites – Ch 22700 to 29300 (GeoLINK 2013b)

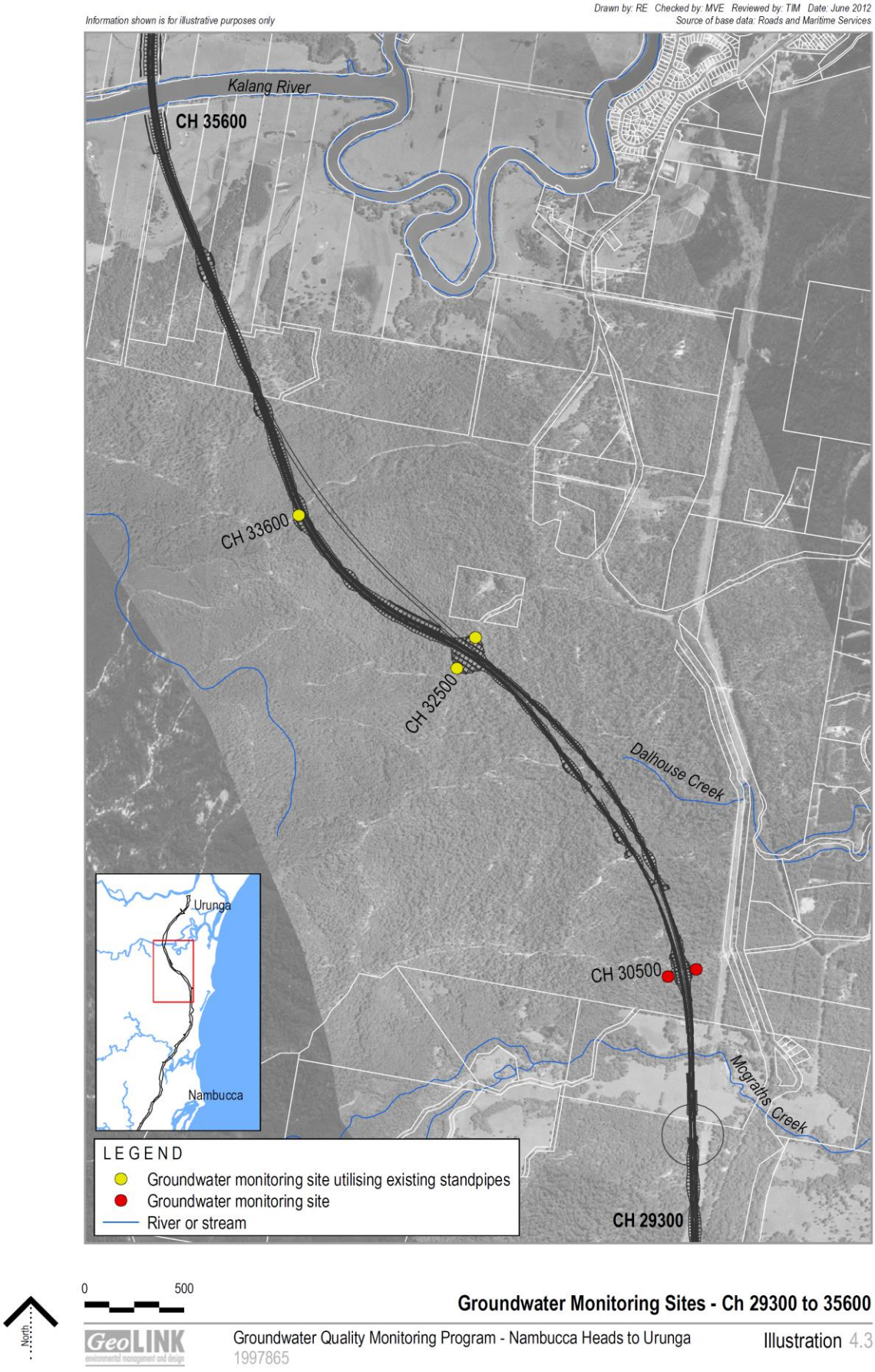

Illustration 2.7 Groundwater monitoring sites – Ch 29300 to 35600 (GeoLINK 2013b)

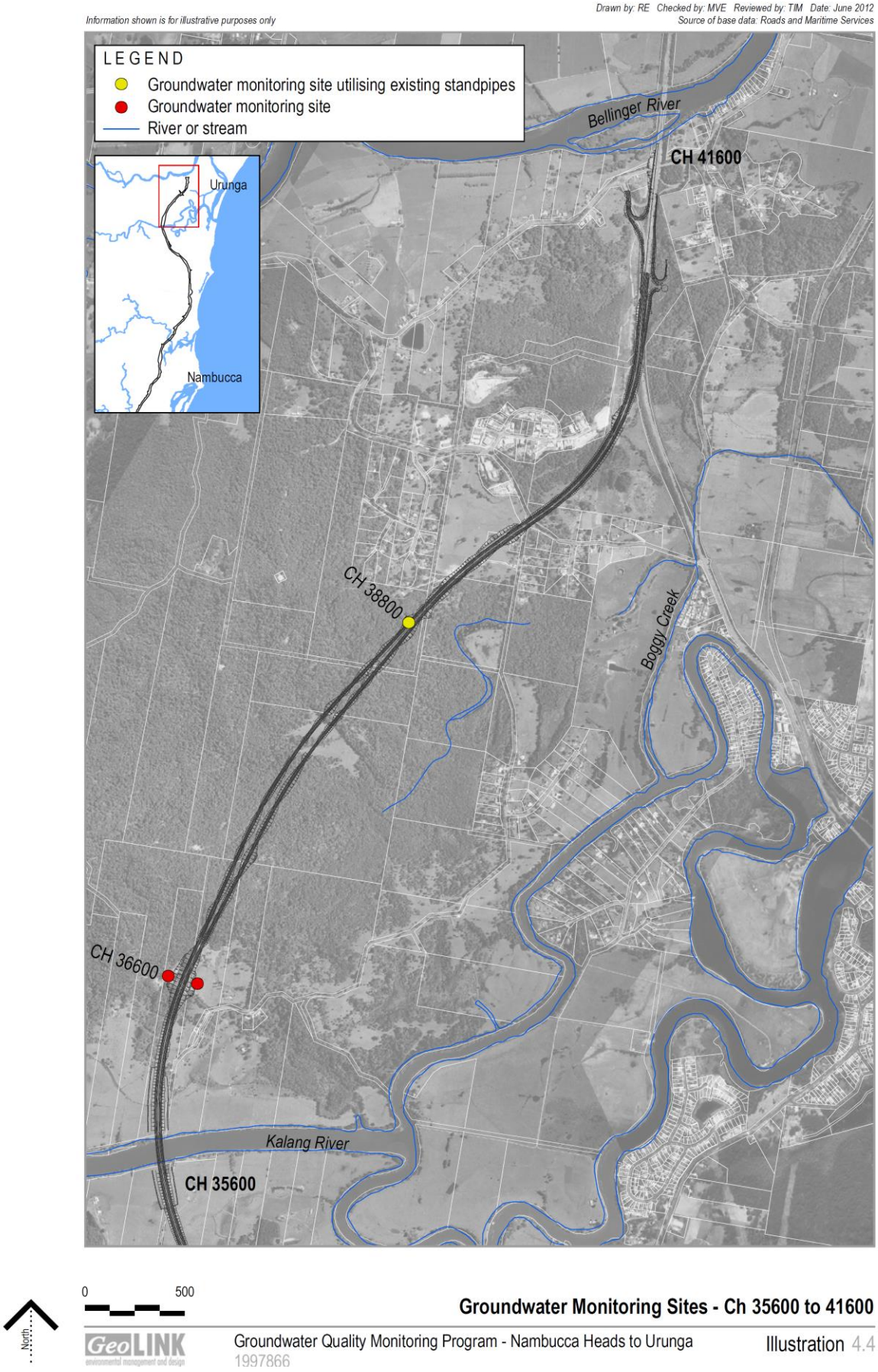

Illustration 2.8 Groundwater monitoring sites – Ch 35600 to 41600 (GeoLINK 2013b)

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) 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	TRH C6 - C9	Laboratory Analysis – Org-016
	TRH C6 - C10	Laboratory Analysis – Org-016
	Surrogate Dibromofluoromethane	Laboratory Analysis – Org-016
	Surrogate toluene-d8	Laboratory Analysis – Org-016
	Surrogate 4-BFB	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
	Surrogate o-Terphenyl	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	Laboratory Analysis – Inorg-060

The SWMP also defines the sampling frequency for operational monitoring. This is presented in **Table 2.2**.

Table 2.2 Operational phase sample frequency (GeoLINK 2013a)

Period	*Dates*	*Parameters*	*Sample Frequency*
First Year	September 2016 – June 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
Second Year	July 2018 – June 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
Third Year	July 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

Between the end of the construction phase monitoring and the beginning of the contracted operational phase monitoring there were samples collected by the construction contractor. These samples were for physicochemical parameters only.

The dates of surface water quality monitoring sampling for the current monitoring period were:

- 16/09/2016 (wet), 20/10/2016 (dry), 24/11/2016 (dry), 14/12/2016 (dry), 18/01/2017 (dry) (Lend Lease operational phase monitoring – physicochemical parameters only)
- 2/6/2017 (wet), 12/7/2017 (dry) (Aquatic Science and Management operational phase monitoring – as per SWMP).

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) 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 monitoring is also defined by the GMP. This is presented in **Table 2.3**. Groundwater measurements were collected once during this reporting period, on the 5/10/2016 (all parameters in addition to major ions and total dissolved solids). A further sampling event was undertaken in January 2017 but all wells were found to be dry at the time. At the implementation of the Aquatic Science and Management operational phase water quality monitoring program the groundwater bores were visited (29/06/2018) in order to set up the automatic loggers, assess the piezometers for suitability and install locks. The first groundwater quality samples for the Aquatic Science and Management operational phase water quality monitoring program were not collected until September 2017, outside of this reporting period. This delay occurred while arrangements for survey of new monitoring bore elevations was undertaken and a new monitoring bore was constructed at Ch63200.

Table 2.3 Operational phase 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 63200 that captures barometric pressure information, later used to offset barometric pressure fluctuations in the data collected from the piezometers.

Logged groundwater data from this reporting period was retrieved on 25/9/2017. Due to battery problems and a need to construct a new piezometer there is some missing data in the retrieved HOBO datasets from approximate chainages 63200 (upstream) and 72400 (upstream).

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).

In addition, the monitoring bore at approximate chainage 63200 (upgradient) was found to be collapsed during the 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 is a minimum of 10 mm rain in 24 hours. A dry episode sampling run is triggered by 96 hours with no rainfall and 240 hours with less than 20mm rainfall. Three Bureau of Meteorology (BOM) stations, Kalang, Kooroowi and Stuarts Island, were monitored to ensure wet conditions or dry conditions occurred across the entire upgrade section.

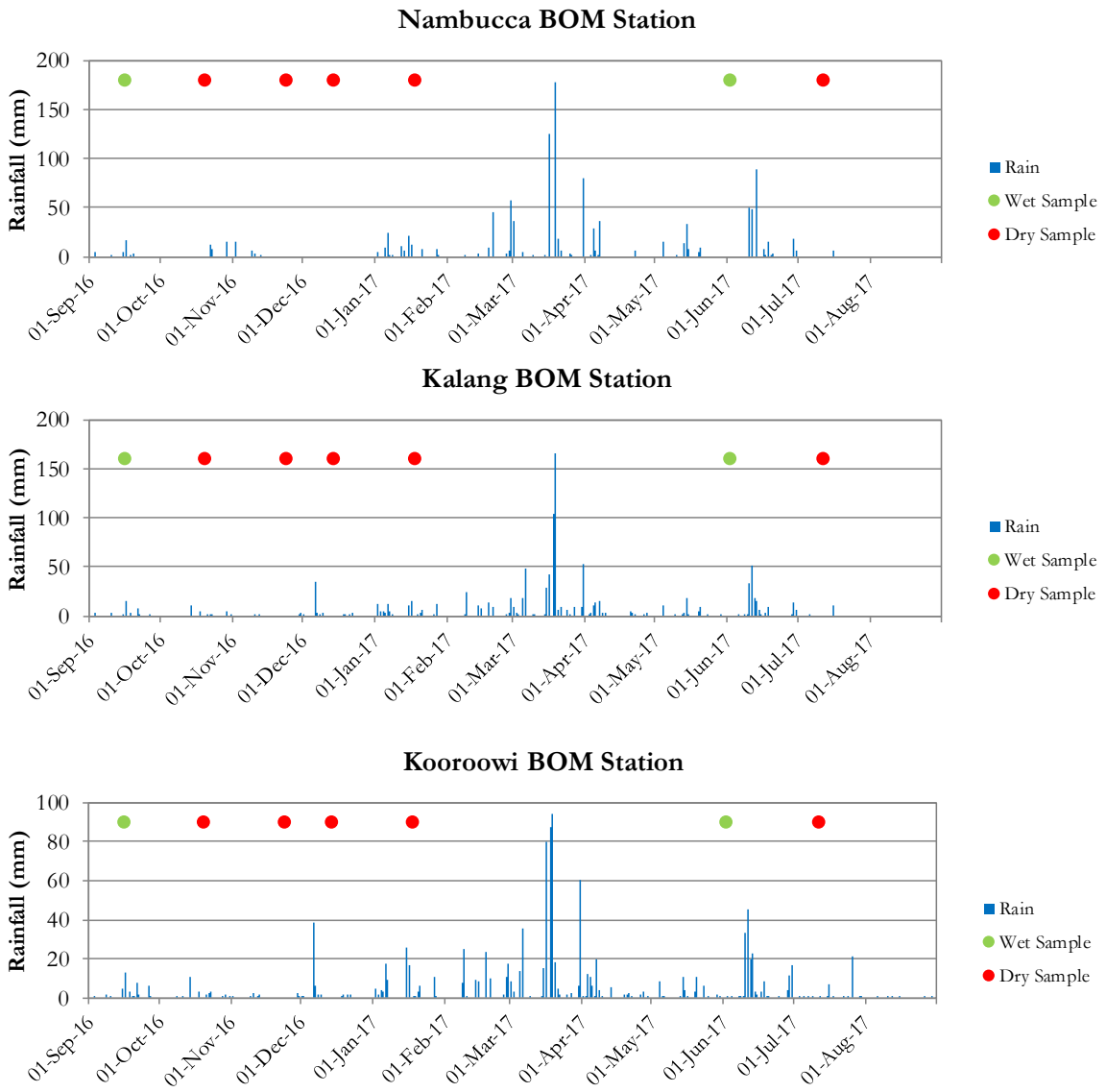

Figure 3.1 Daily rainfall at the Kalang, Kooroowi and Nambucca weather stations for the reporting period

September, November and December 2016, and July and August 2017 were very dry months, restricting opportunities for the collection of 'wet' samples during those months. Daily rainfall for the reporting period is displayed in **Figure 3.1**.

3.2 Surface Water

The 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 3.1**.

Table 3.1 Surface water quality sampling undertaken during this reporting period

Date	*Sample type (wet/dry)*	*Parameters*
16/09/2016	Wet	Physicochemical only
20/10/2016	Dry	Physicochemical only
24/11/2016	Dry	Physicochemical only
14/12/2016	Dry	Physicochemical only
18/01/2017	Dry	Physicochemical only
12/06/2017	Wet	All parameters
12/07/2017	Dry	All parameters

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 this monitoring period from each site is presented in Appendix A with the rolling upstream P80 values. To provide historical context he summary data from the pre-construction and construction phases is also presented.

A summary of relevant statistics for each waterway is presented in **Tables A.1** to **A.11**. A brief description of the summary results from each waterway follows. For some parameters the operational phase summary statistics are derived from only two samples.

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 few results of interest from SEPP14 wetland No.351 (**Table A.1**). Results of interest were the downstream median Cr, Al and TN concentrations. Of the results of interest only the Al and Cr concentrations measured during this reporting period were outside of the variation observed in pre-construction and construction phase monitoring (**Figures 3.4** and **3.5**). The high concentrations of Al were measured during a wet sample and the highest concentration was measured in upstream waters, indicating that the Al originated from the catchment rather than being related to highway operation. The highest Cr concentration since the beginning of monitoring was measured in a dry-event sample in downstream waters.

Turbidity and TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.2** and **3.3**).

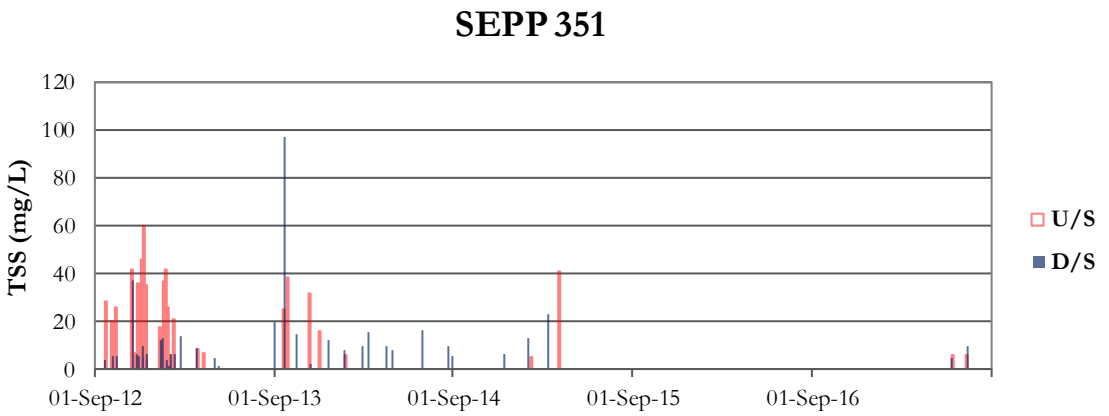

Figure 3.2 TSS concentrations from SEPP 351 wetland and upstream waters since Sept 2012

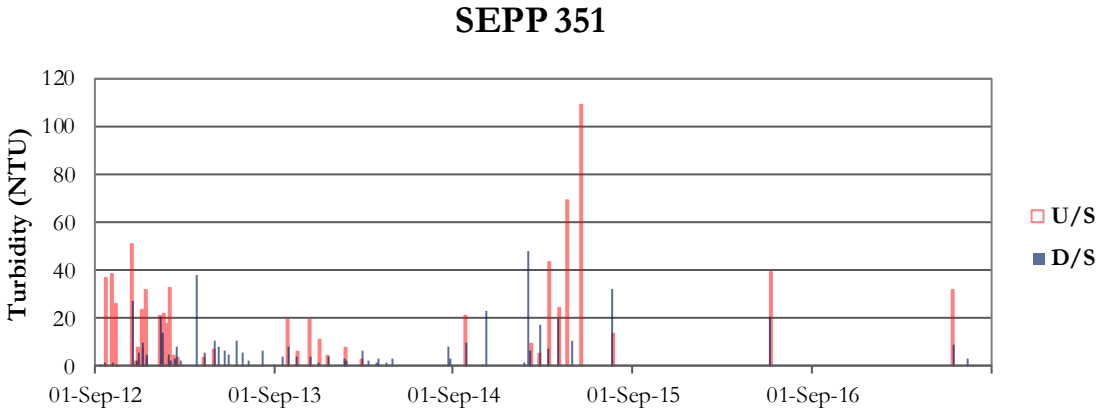

Figure 3.3 Turbidity measurements from SEPP 351 wetland and upstream waters since Sept 2012

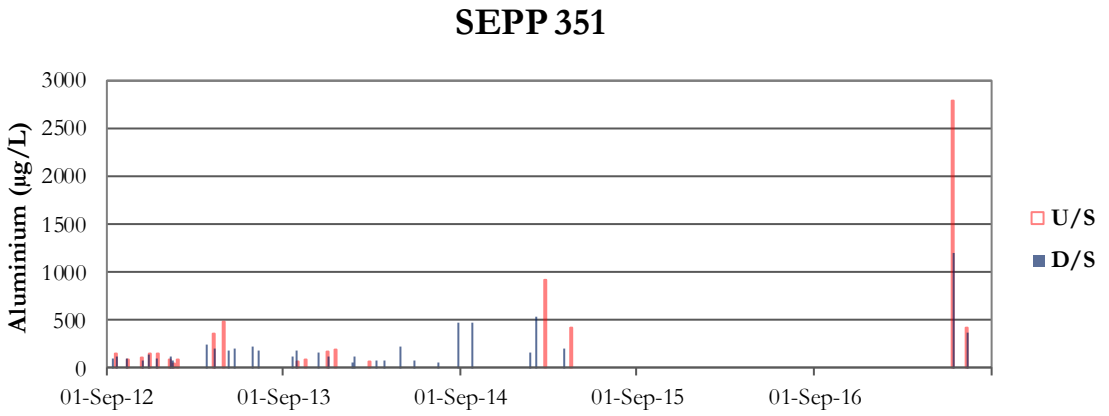

Figure 3.4 Al concentrations from SEPP 351 wetland and upstream waters since Sept 2012

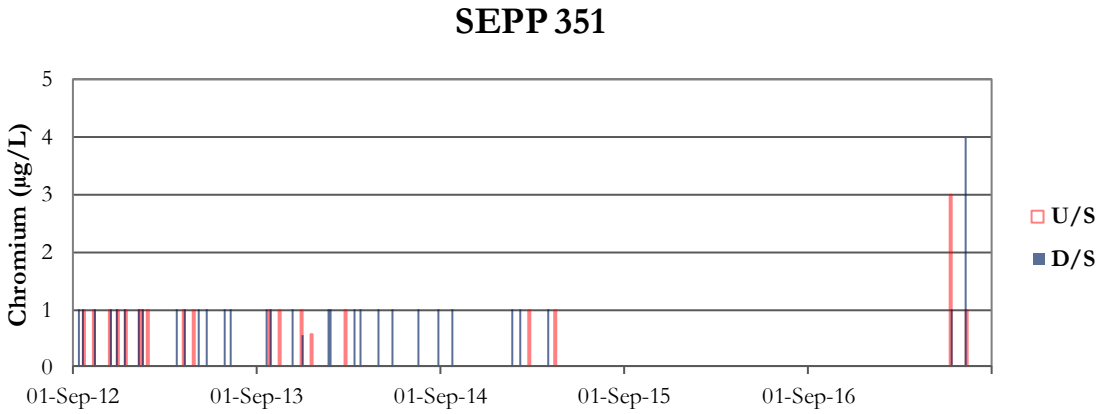

Figure 3.5 Cr concentrations from SEPP 351 wetland and upstream waters since Sept 2012

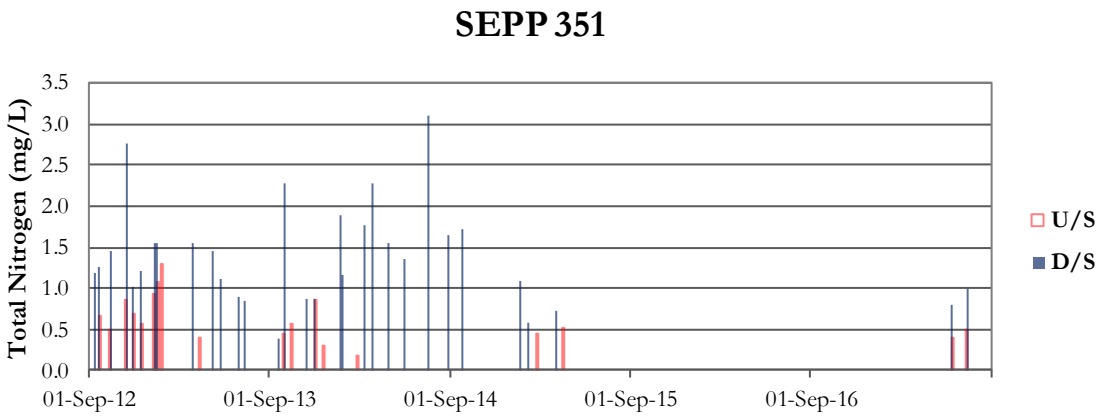

Figure 3.6 TN concentrations from SEPP 351 wetland and upstream waters since Sept 2012

For each of Al and Cr the concentrations measured at SEPP 351 in the construction and operational phases have been generally higher than those measured in the pre-construction phase (**Figures 3.4** and **3.5**)

Summary for SEPP Wetland No. 351 – Higher concentrations of Al and Cr in the construction and operational phases, both upstream and downstream of the highway. The highest concentrations of Al measured upstream of the highway crossing. Elevated concentrations of Cr measured upstream and downstream of the highway crossing.

3.2.2 SEPP14 Wetland No. 353

There were few results of interest from SEPP14 wetland No.353 (**Table A.2**). Results of interest were the downstream median Al, Cu, Fe, NO_3 and PO_3 concentrations. Of the results of interest only the PO_3 concentrations measured during this reporting period are outside of the variation observed in pre-construction and construction phase monitoring (**Figure 3.13**). In the operation phase the highest concentrations of PO_3 were measured in upstream waters, indicating that it originated from the catchment rather than being related to the highway operation.

Turbidity and TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.8** and **3.9**).

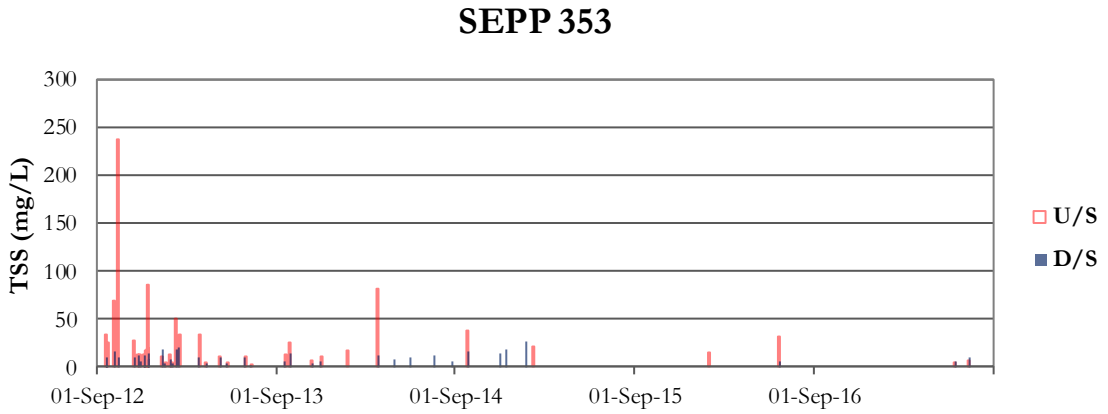

Figure 3.7 TSS concentrations from SEPP 353 wetland and upstream waters since Sept 2012

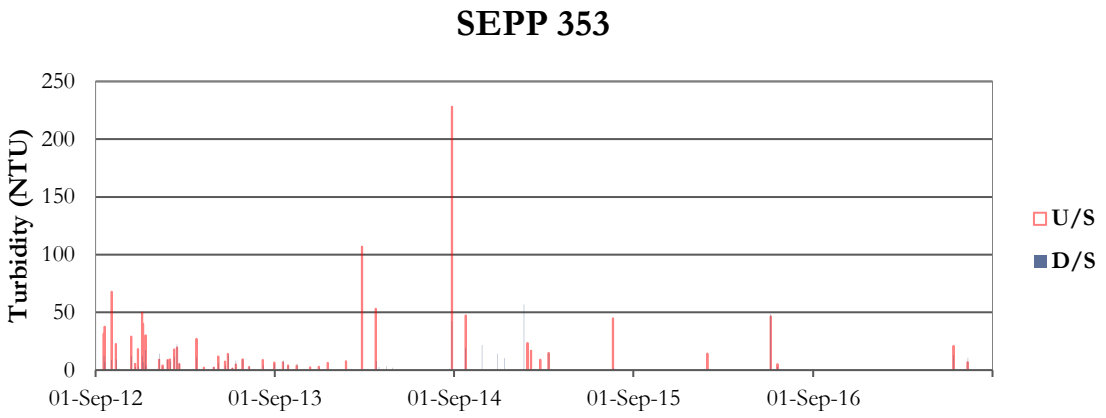

Figure 3.8 Turbidity measurements from SEPP 353 wetland and upstream waters since Sept 2012

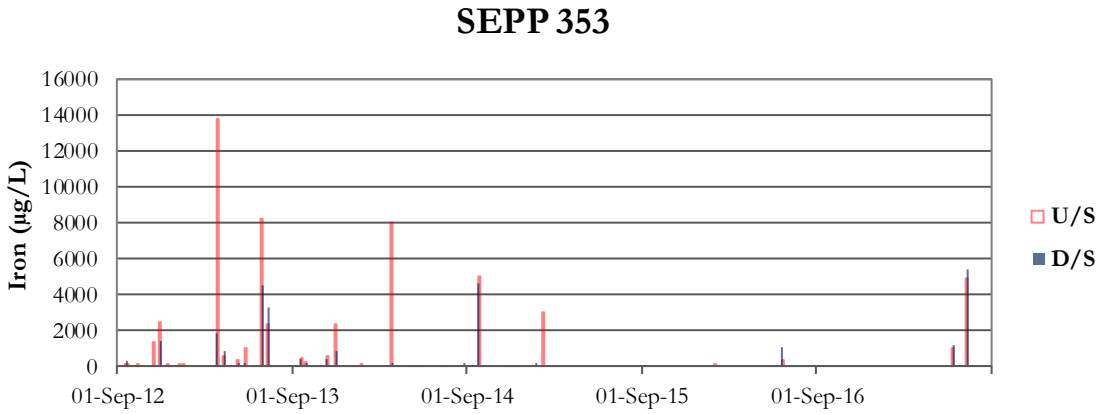

Figure 3.9 Fe measurements from SEPP 353 wetland and upstream waters since Sept 2012

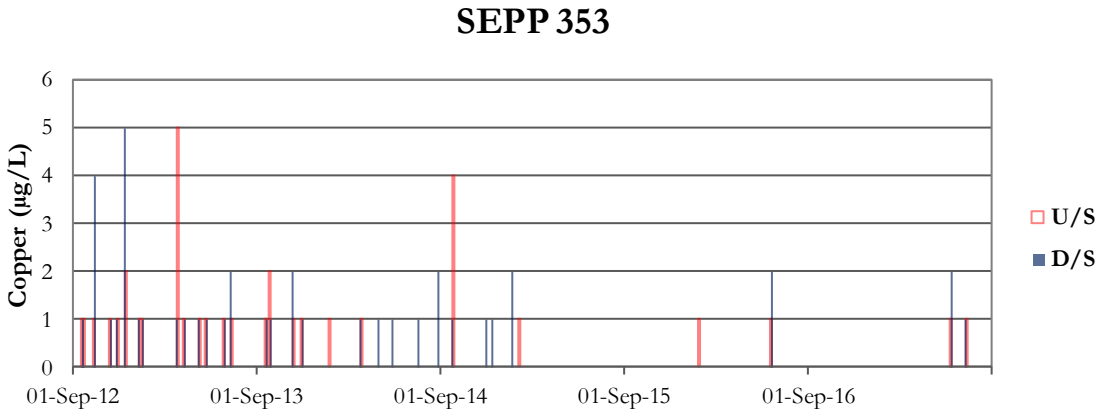

Figure 3.10 Cu measurements from SEPP 353 wetland and upstream waters since Sept 2012

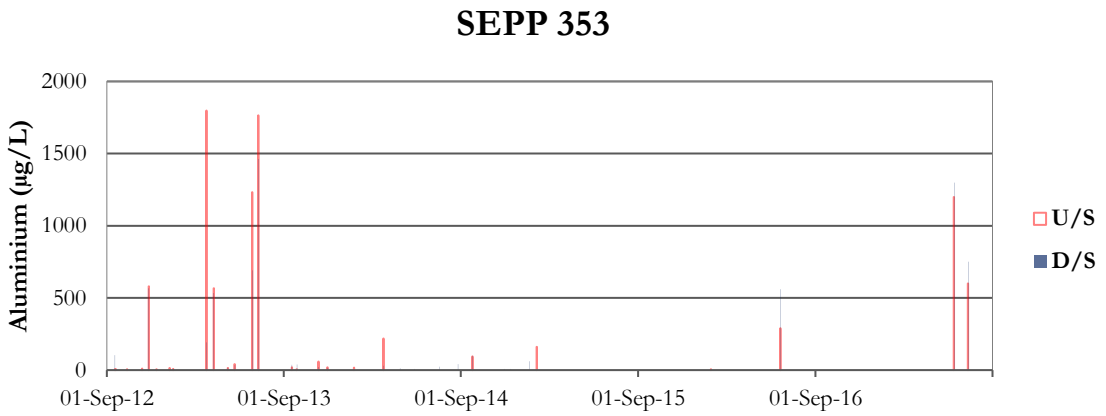

Figure 3.11 Al measurements from SEPP 353 wetland and upstream waters since Sept 2012

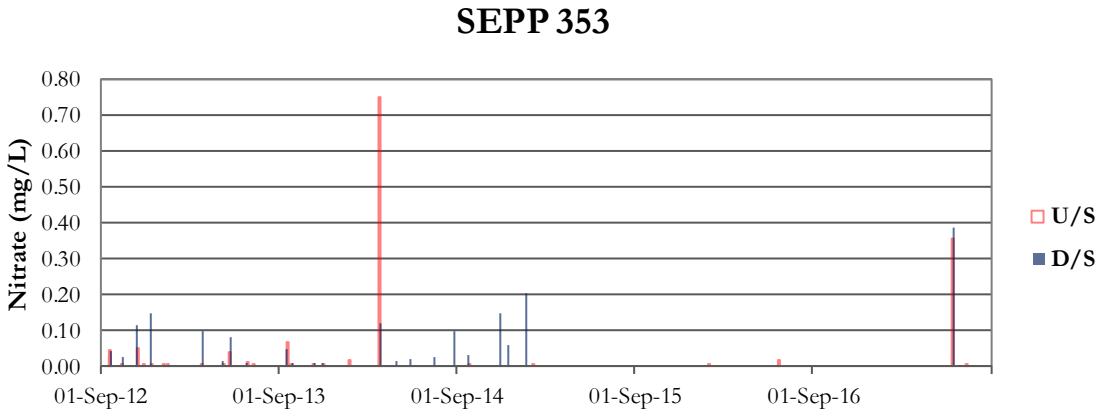

Figure 3.12 NO_3 measurements from SEPP 353 wetland and upstream waters since Sept 2012

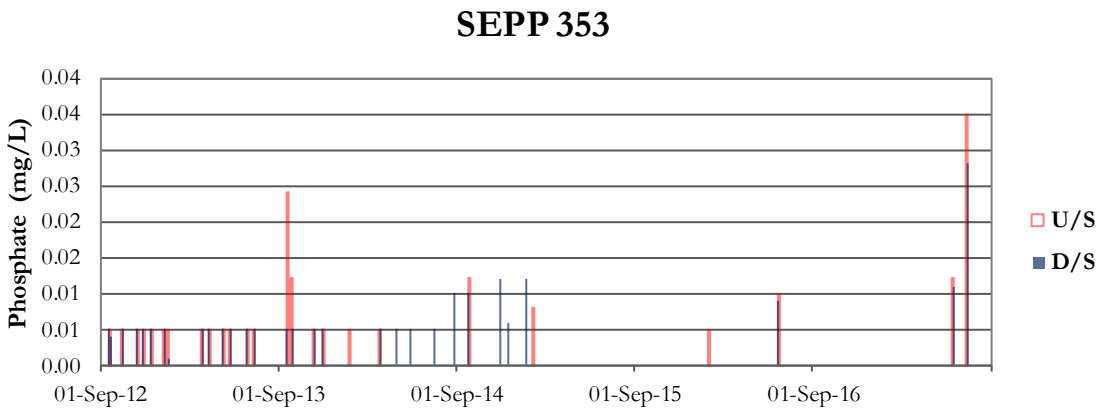

Figure 3.13 PO_3 measurements from SEPP 353 wetland and upstream waters since Sept 2012

For each of Al, Fe, NO_3 and PO_3 the highest concentrations measured at SEPP 353 in the construction and operational phases have been higher than the range measured in the pre-construction phase (**Figures 3.10** to **3.13**)

Summary for SEPP Wetland No. 353 – Highest concentrations of Al, Fe, NO_3 and PO_3 measured in the construction and operational phases of monitoring. Elevated concentrations of these parameters measured upstream and downstream of the highway crossing. The highest concentrations of these parameters measured upstream of the highway crossing during the construction phase.

3.2.3 Unnamed Tributary to SEPP14 Wetland No. 351

There were few results of interest from the tributary to SEPP14 wetland No.351 (**Table A.3**). Results of interest were the downstream median Cu, Cr, Al and PO_3 concentrations. Of the results of interest only the Al and Cr concentrations measured during this reporting period are outside of the variation observed in pre-construction and construction phase monitoring (**Figures 3.17** and **3.18**). The highest concentrations of Al and Cr were measured during a wet event and the concentrations in upstream waters were also outside of the ranges previously observed, indicating that the higher concentrations originated from the catchment rather than being related to the highway operation. The Cu concentrations measured during this reporting period were within the ranges observed during the pre-construction phase of monitoring.

Turbidity and TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.14** and **3.15**).

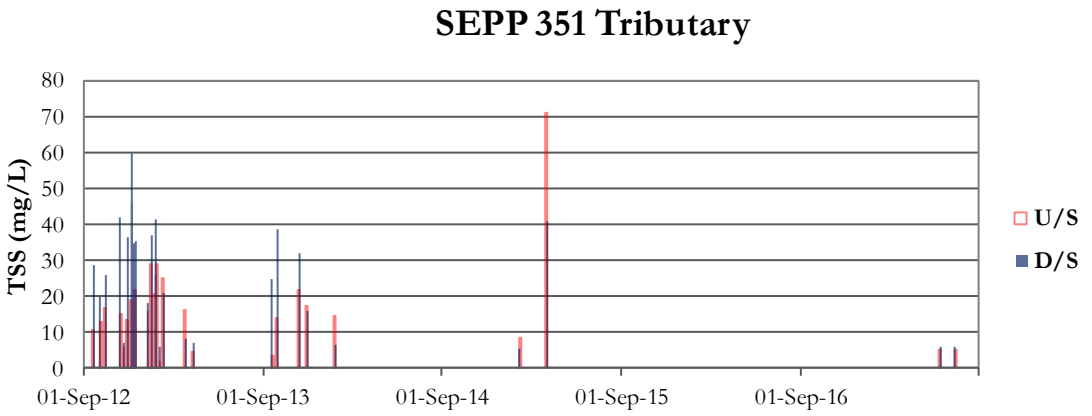

Figure 3.14 TSS concentrations from SEPP 351 tributary and upstream waters since Sept 2012

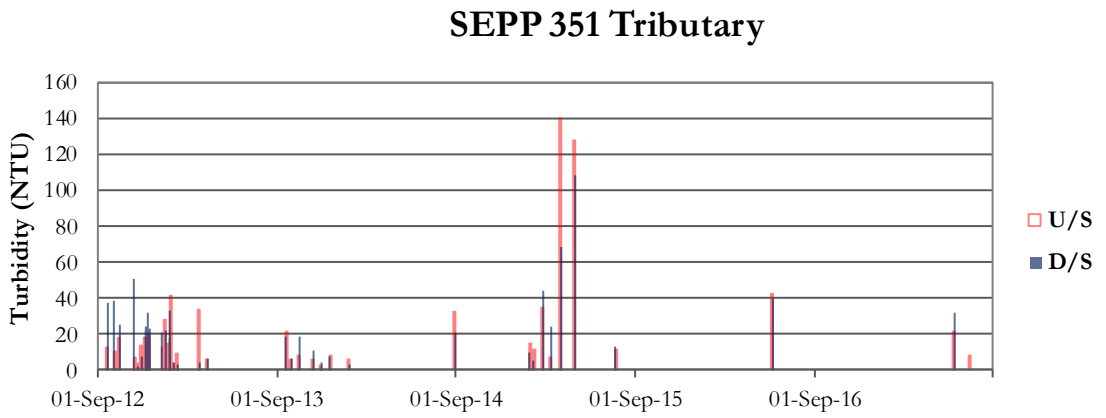

Figure 3.15 Turbidity measurements from SEPP 351 tributary and upstream waters since Sept 2012

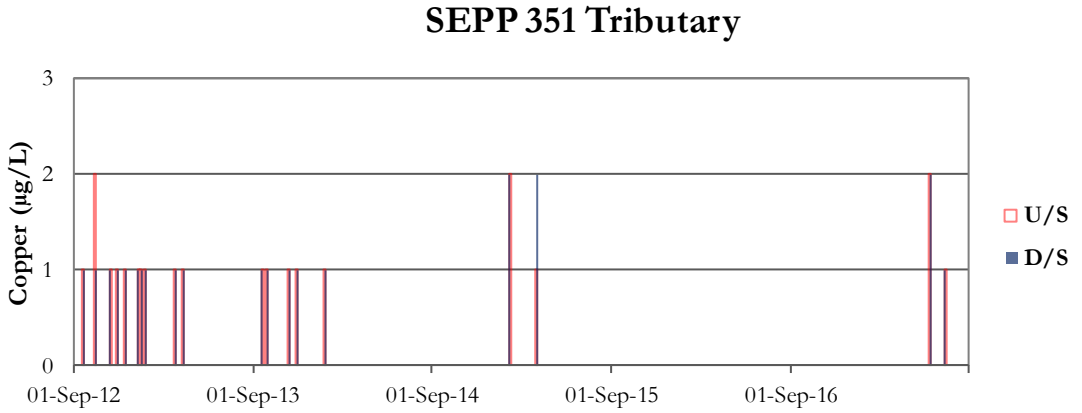

Figure 3.16 Cu measurements from SEPP 351 tributary and upstream waters since Sept 2012

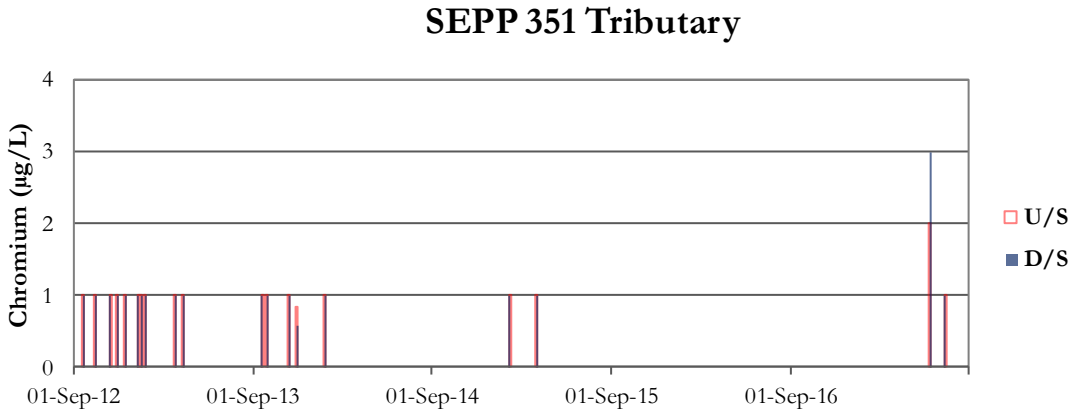

Figure 3.17 Cr measurements from SEPP 351 tributary and upstream waters since Sept 2012

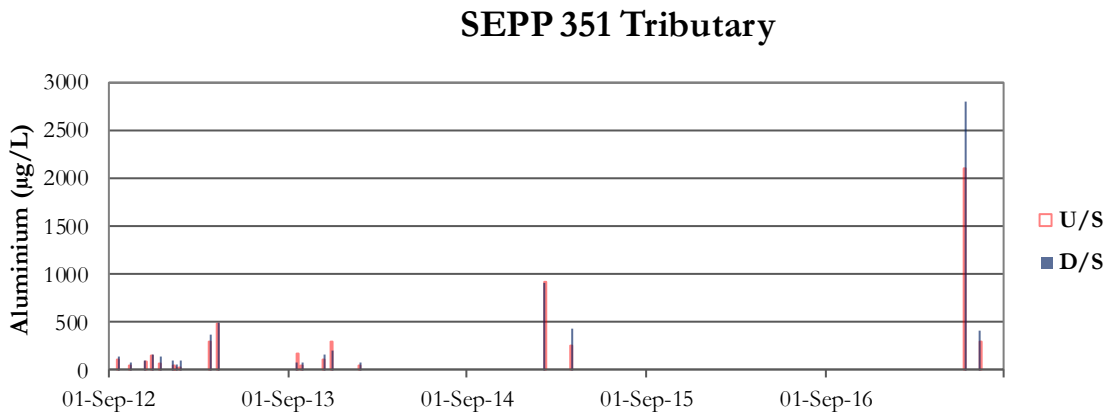

Figure 3.18 Al measurements from SEPP 351 tributary and upstream waters since Sept 2012

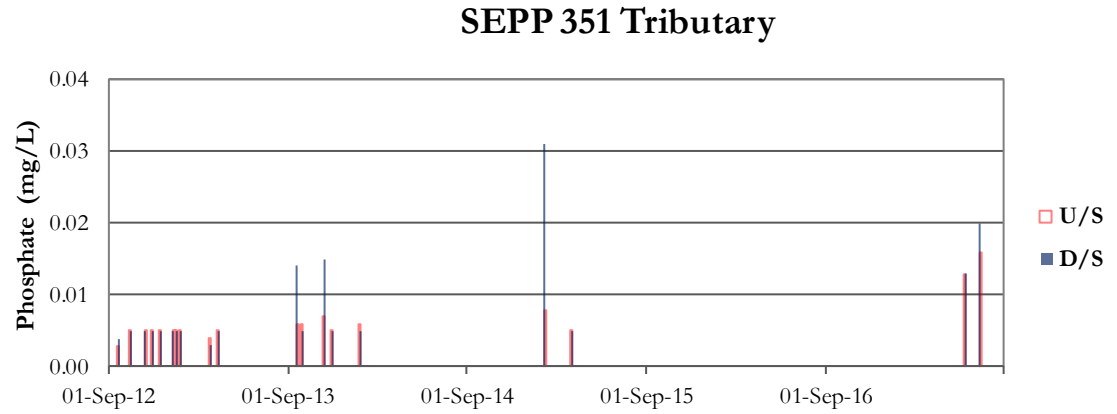

Figure 3.19 PO_3 measurements from SEPP 351 tributary and upstream waters since Sept 2012

For Cr, Al and PO_3 the highest concentrations measured at the SEPP 351 tributary in the construction and operational phases have been higher than the range measured in the pre-construction phase (**Figures 3.18** to **3.20**)

Summary for tributary to SEPP Wetland No. 351 – Highest concentrations of Cr, Al, and PO_3 measured in the construction and operational phases of monitoring. The highest concentrations of these parameters measured downstream of the highway crossing.

3.2.4 Unnamed Tributary to SEPP14 Wetland No. 353

There were few results of interest from the tributary to SEPP14 wetland No.353 (**Table A.4**). Results of interest were the downstream median Fe, Al, Cu, NO_3 and PO_3 concentrations. Of the results of interest only one PO_3 concentration measured during this reporting period was

outside of the variation observed in pre-construction and construction phase monitoring (**Figure 3.26**). The highest concentration of PO_3 was measured during a dry event and the concentration measured in upstream waters was also outside of the range previously observed.

Turbidity and TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.20** and **3.21**).

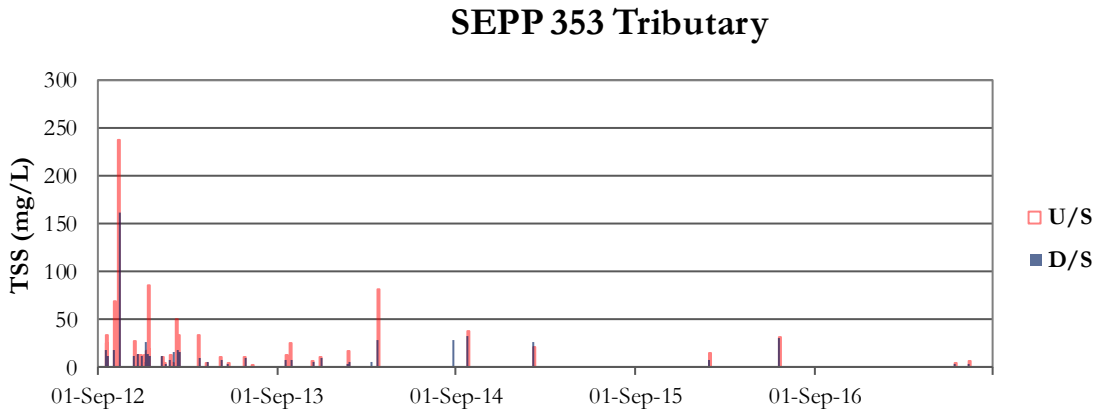

Figure 3.20 TSS concentrations from SEPP 353 tributary and upstream waters since Sept 2012

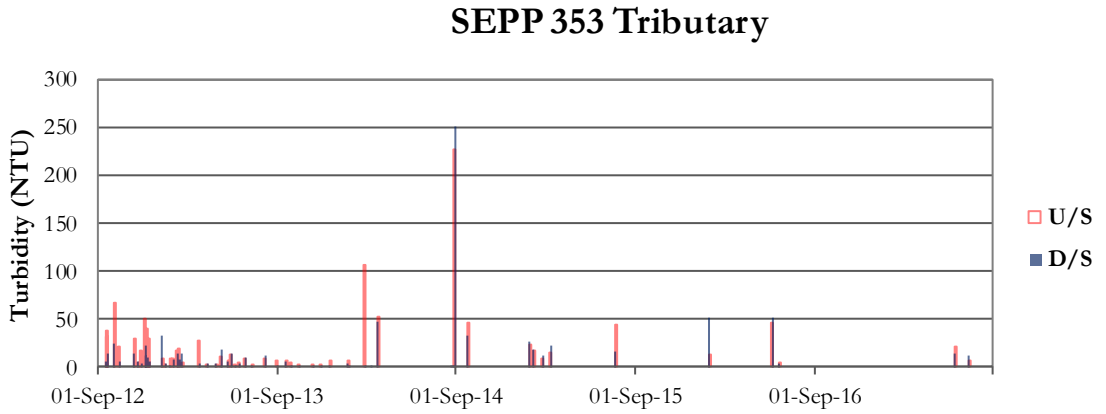

Figure 3.21 Turbidity measurements from SEPP 353 tributary and upstream waters since Sept 2012

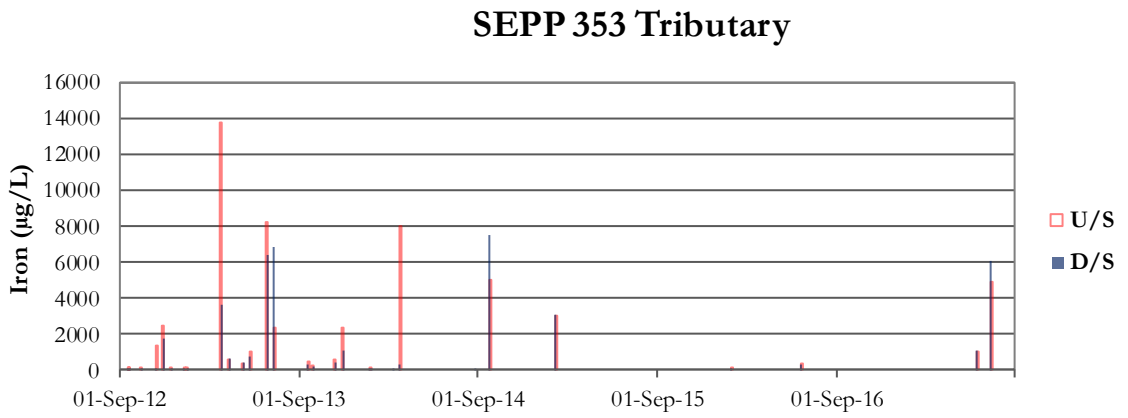

Figure 3.22 Fe measurements from SEPP 353 tributary and upstream waters since Sept 2012

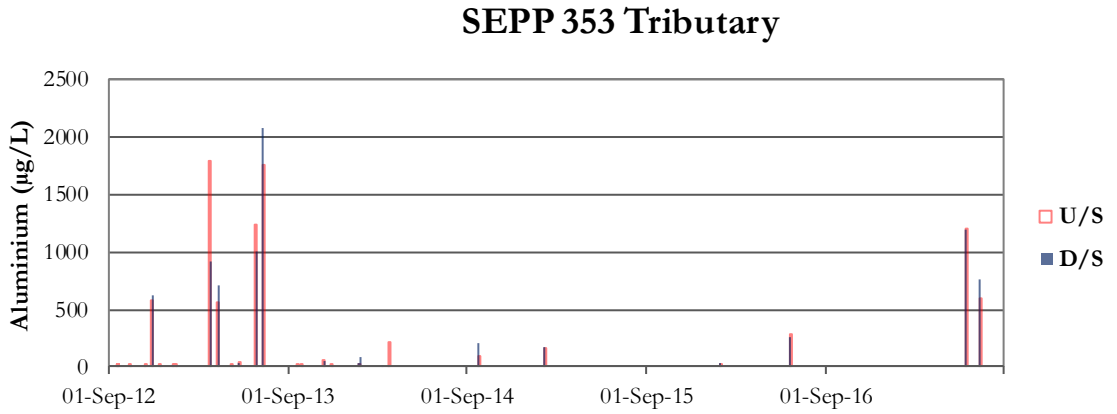

Figure 3.23 Al measurements from SEPP 353 tributary and upstream waters since Sept 2012

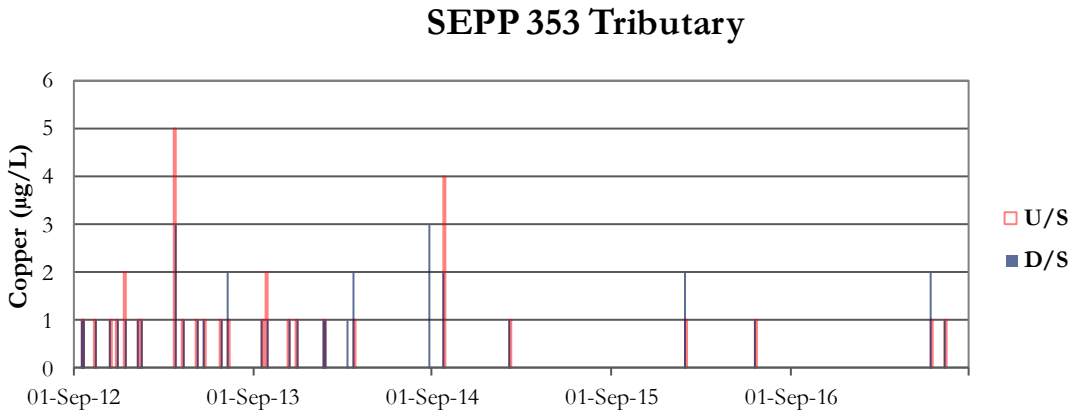

Figure 3.24 Cu measurements from SEPP 353 tributary and upstream waters since Sept 2012

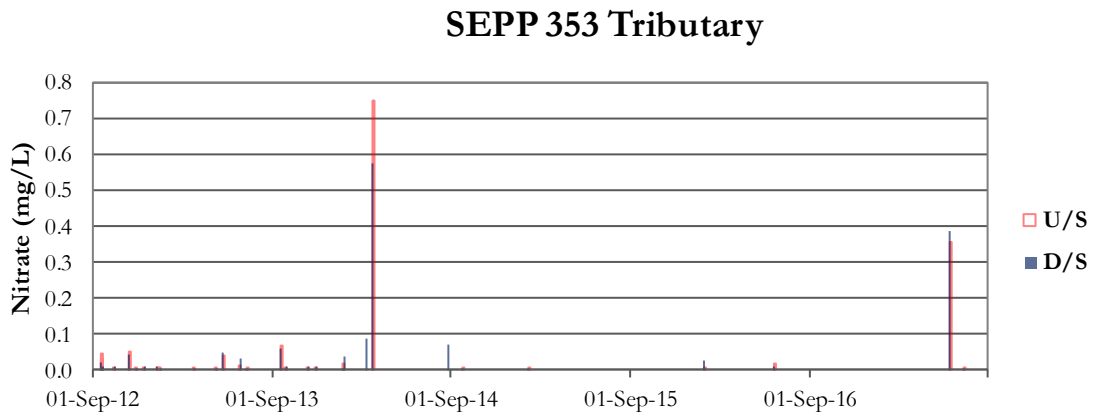

Figure 3.25 NO_3 measurements from SEPP 353 tributary and upstream waters since Sept 2012

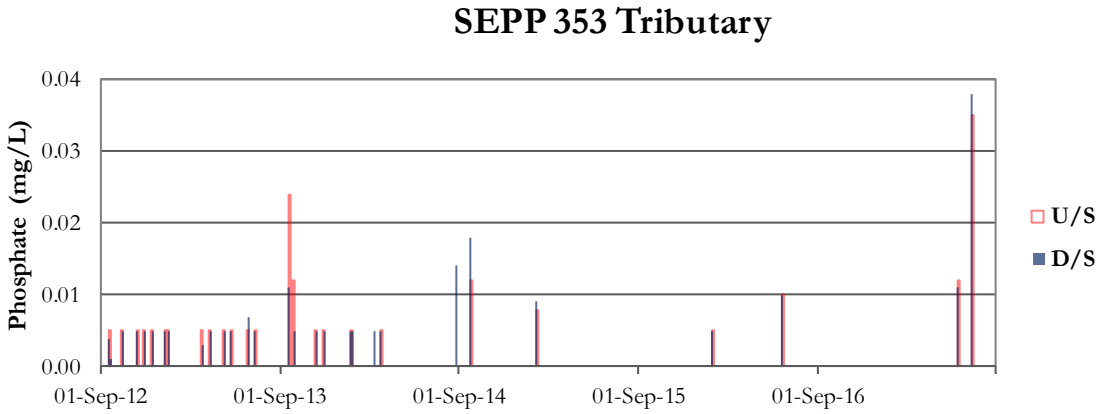

Figure 3.26 PO_3 measurements from SEPP 353 tributary and upstream waters since Sept 2012

For Fe, Al, Cu, NO_3 and PO_3 the highest concentrations measured at the SEPP 353 tributary in the construction and/or operational phases have been higher than the range measured in the pre-construction phase (**Figure 3.22** to **3.26**)

Summary for tributary to SEPP Wetland No. 353 – Highest concentrations of Fe, Al, Cu, NO_3 and PO_3 measured in the construction and/or operational phases of monitoring. Elevated concentrations of these parameters measured upstream and downstream of the highway crossing.

3.2.5 Kalang River

There were few results of interest from the Kalang River (**Table A.5**). Results of interest were the downstream median Fe, Al, TN, NO_3, TP, and PO_3 concentrations. Of the results of interest

Fe and Al concentrations measured during a wet event in this reporting period were outside of the variation observed in pre-construction and construction phase monitoring (**Figures 3.29** and **3.30**). High concentrations of both of these parameters were measured upstream and downstream of the highway. However, because the Kalang is strongly tidal underneath the highway alignment it is not certain whether the Al and Fe originate at the highway crossing, further down or further up the catchment. The TP concentrations measured in the operational phase were at the practical quantification limits for the laboratory and unlikely to represent actual higher concentrations.

Turbidity and TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.27** and **3.28**).

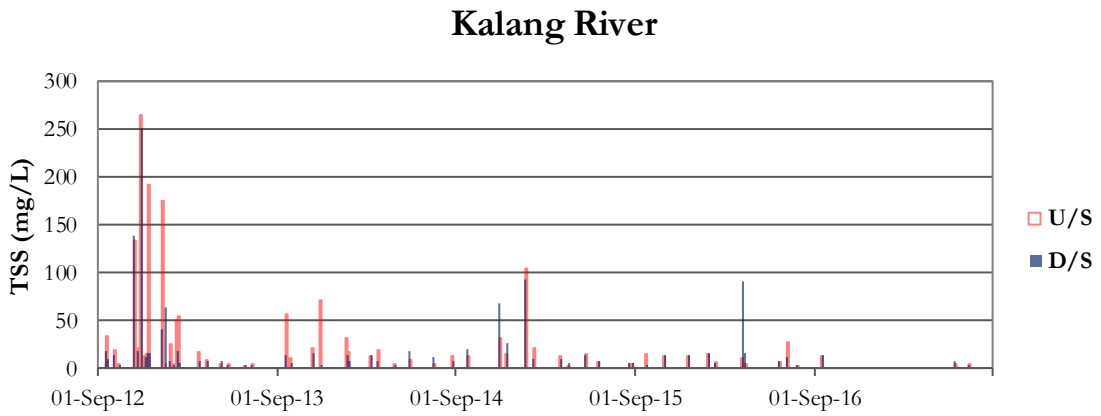

Figure 3.27 TSS concentrations from the Kalang River since Sept 2012

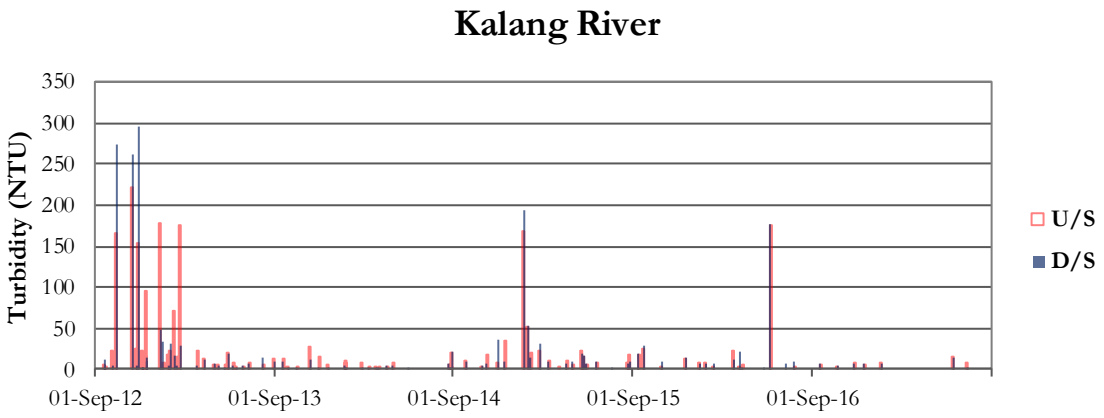

Figure 3.28 Turbidity measurements from the Kalang River since Sept 2012

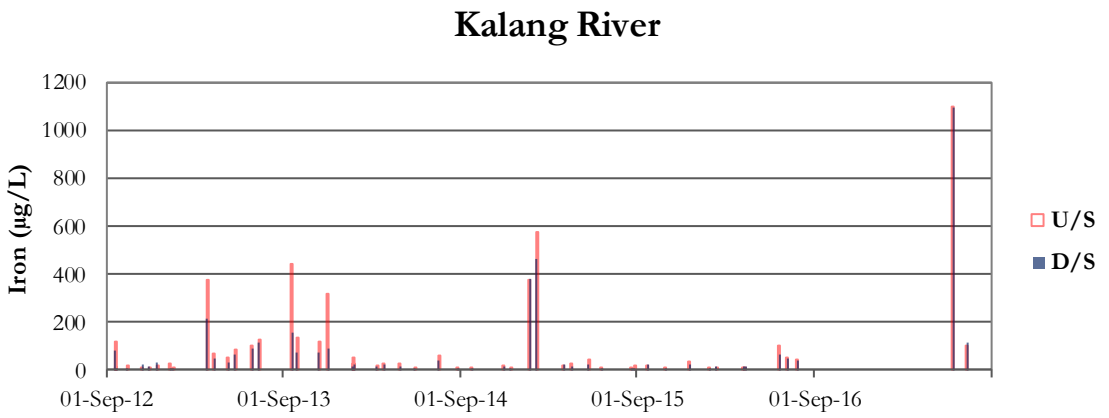

Figure 3.29 Fe measurements from the Kalang River since Sept 2012

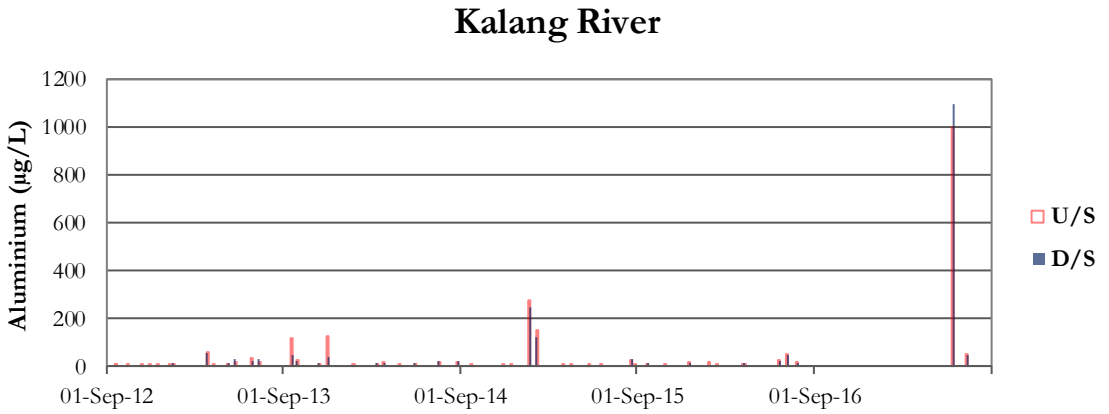

Figure 3.30 Al measurements from the Kalang River since Sept 2012

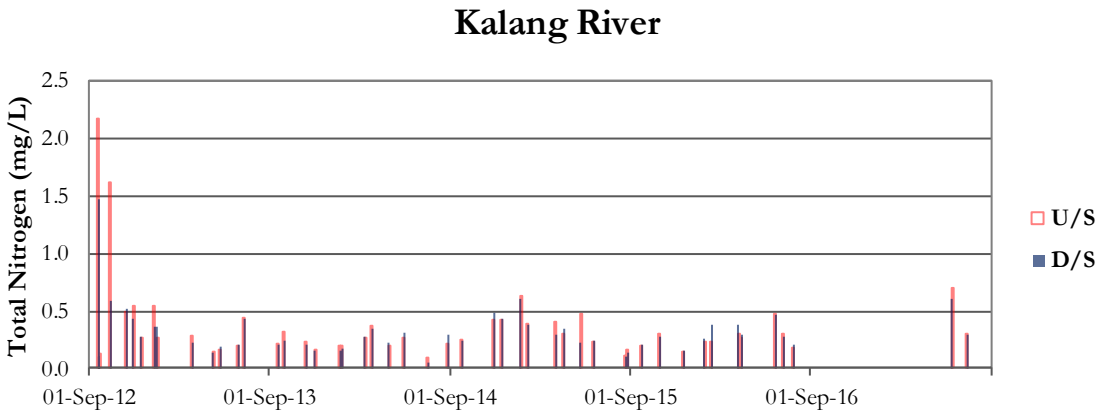

Figure 3.31 TN measurements from the Kalang River since Sept 2012

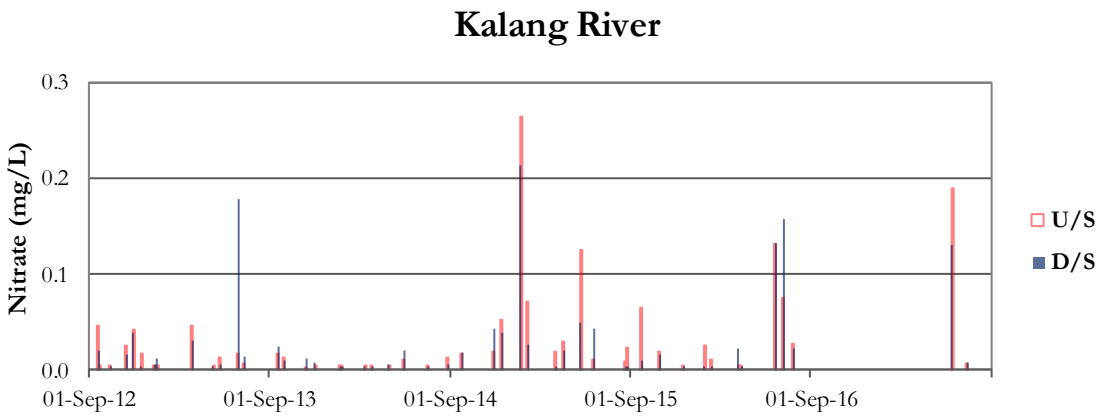

Figure 3.32 NO_3 measurements from the Kalang River since Sept 2012

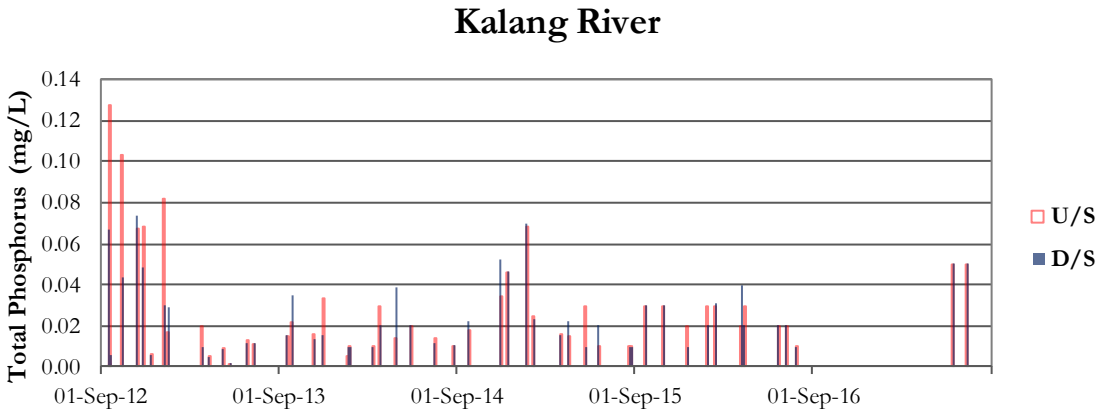

Figure 3.33 TP measurements from the Kalang River since Sept 2012

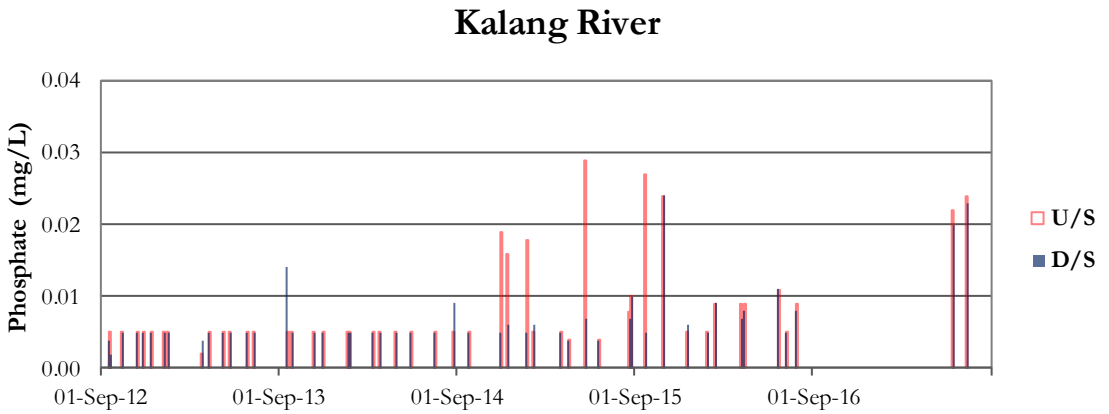

Figure 3.34 PO_3 measurements from the Kalang River since Sept 2012

For Fe, Al, NO_3 and PO_3 the highest concentrations measured from the Kalang River in the construction and operational phases have been higher than the ranges measured in the pre-construction phase (**Figures 3.29**, **3.30**, **3.32** and **3.34**).

Summary for the Kalang River – Highest concentrations of Fe, Al, NO_3 and PO_3 measured in the construction and operational phases of monitoring. Elevated concentrations of these parameters measured upstream and downstream of the highway crossing.

3.2.6 Dalhousie Creek

There were few results of interest from Dalhousie Creek (**Table A.6**). Results of interest were the downstream median Cu, Cr, Al, TN and PO_3 concentrations. Of the results of interest the Al and Cr concentrations measured during this reporting period were outside of the variation observed in pre-construction and construction phase monitoring (**Figures 3.38** and **3.39**). The high concentrations of Al and Cu were measured both upstream and downstream of the highway during a wet event, indicating that they originated further up the catchment rather than at the highway crossing.

Turbidity and TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring, with the exception of one construction phase downstream TSS result. (**Figures 3.35** and **3.36**).

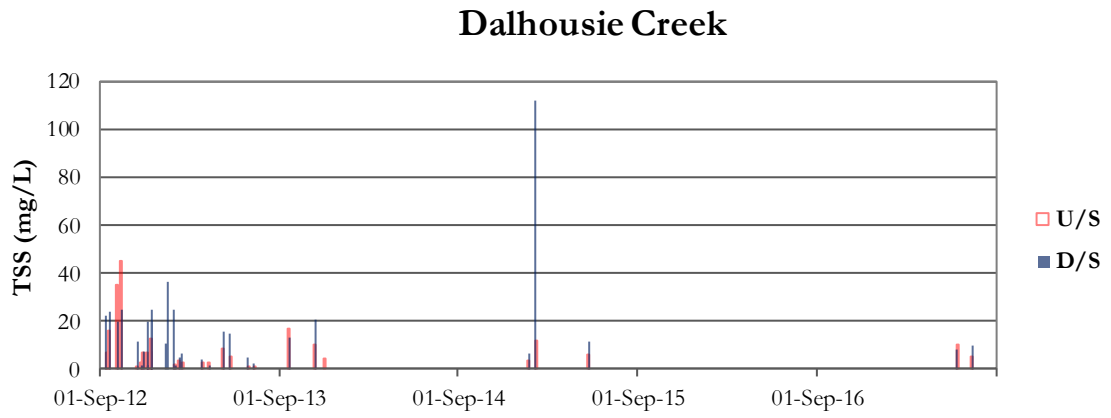

Figure 3.35 TSS concentrations from Dalhousie Creek since Sept 2012

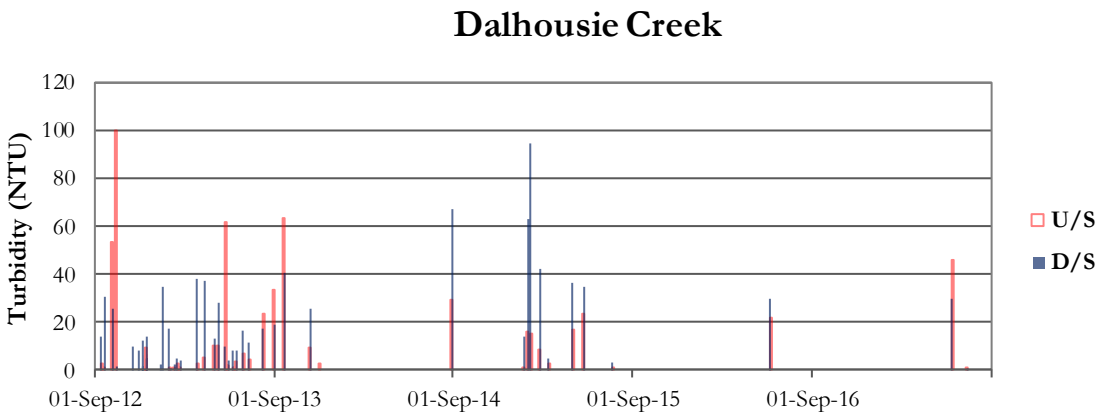

Figure 3.36 Turbidity measurements from Dalhousie Creek since Sept 2012

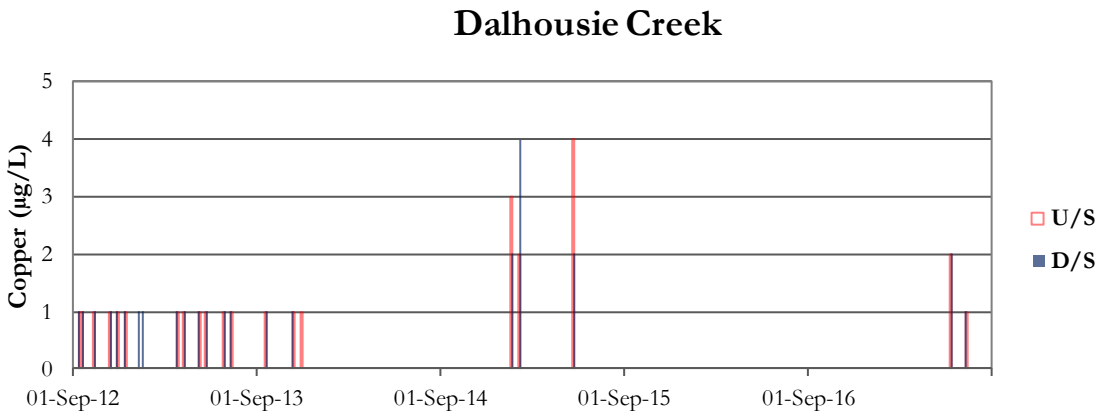

Figure 3.37 Cu measurements from Dalhousie Creek since Sept 2012

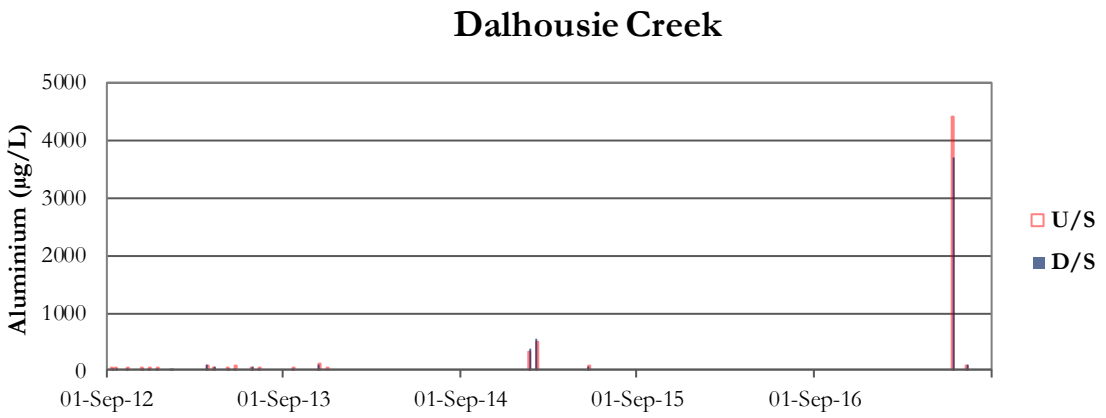

Figure 3.38 Al measurements from Dalhousie Creek since Sept 2012

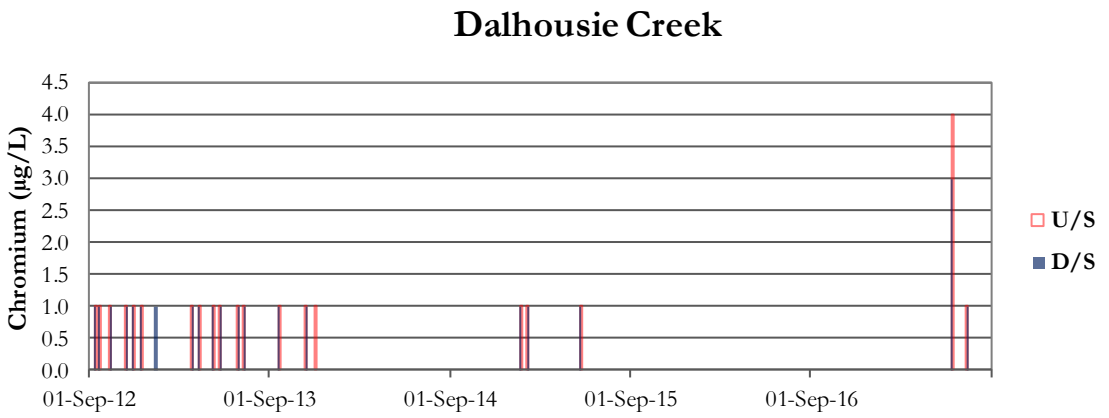

Figure 3.39 Cr measurements from Dalhousie Creek since Sept 2012

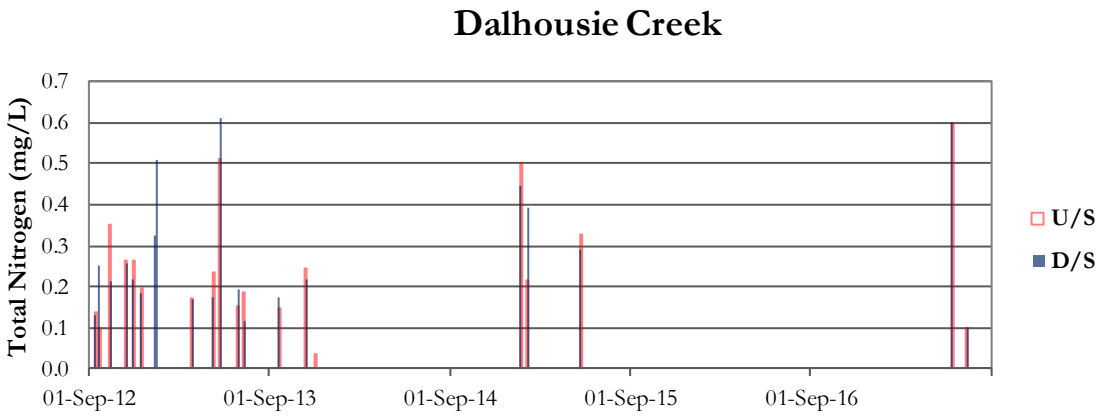

Figure 3.40 TN measurements from Dalhousie Creek since Sept 2012

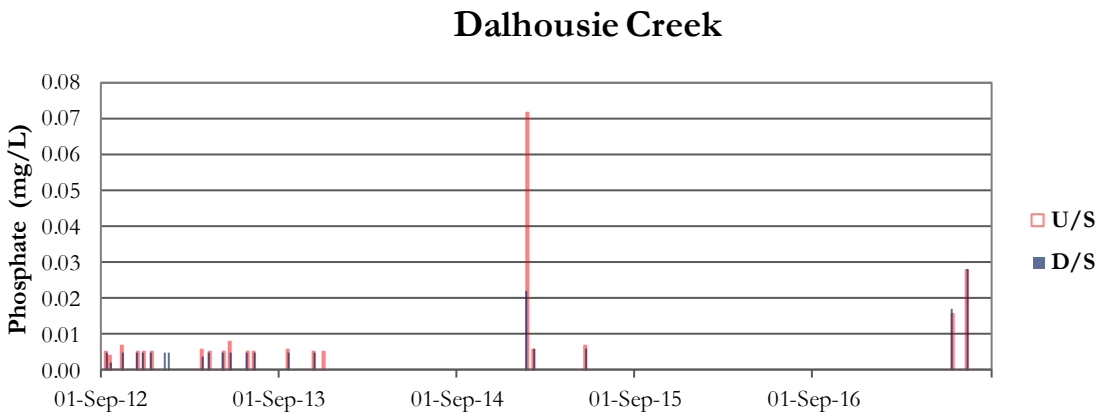

Figure 3.41 PO_3 measurements from Dalhousie Creek since Sept 2012

For Cr, Cu, Al, and PO_3 the highest concentrations measured from Dalhousie Creek in the construction and operational phases have been higher than the ranges measured in the pre-construction phase (**Figures 3.37**, **3.38**, **3.39** and **3.41**).

Summary for Dalhousie Creek – Highest concentrations of Cr, Cu, Al, and PO_3 measured in the construction and operational phases of monitoring. The highest concentrations of these parameters measured upstream of the highway crossing.

3.2.7 McGraths Creek

There were numerous results of interest from McGraths Creek (**Table A.7**). Results of interest were the downstream median Cu, Fe, Cr, Al, As, Pb, PO_3, TSS concentrations and turbidity measurements. Of the results of interest only the Al, Cr and Pb concentrations measured during this reporting period were outside of the variation observed in pre-construction and construction phase monitoring (**Figures 3.46**, **3.47** and **3.49**). In each of these cases the highest concentrations were measured downstream of the highway during a wet event, indicating that they may have originated at the highway crossing.

Turbidity and TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.42** and **3.43**).

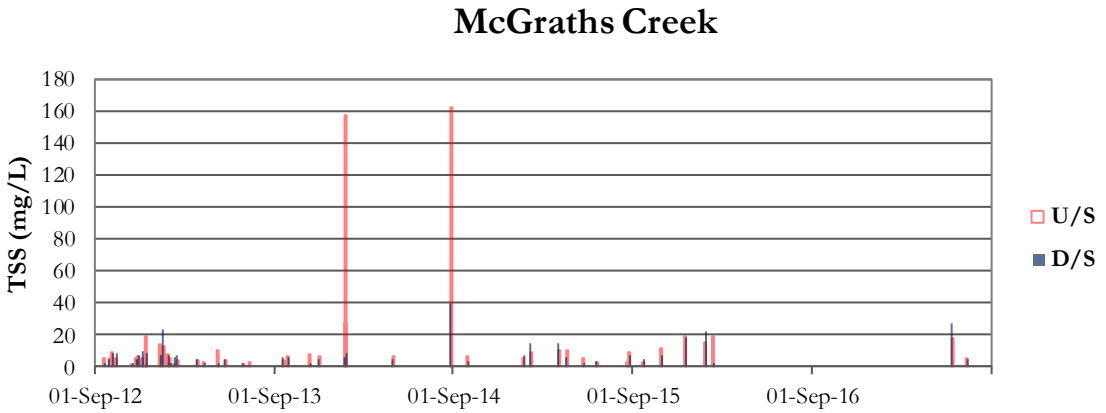

Figure 3.42 TSS concentrations from McGraths Creek since Sept 2012

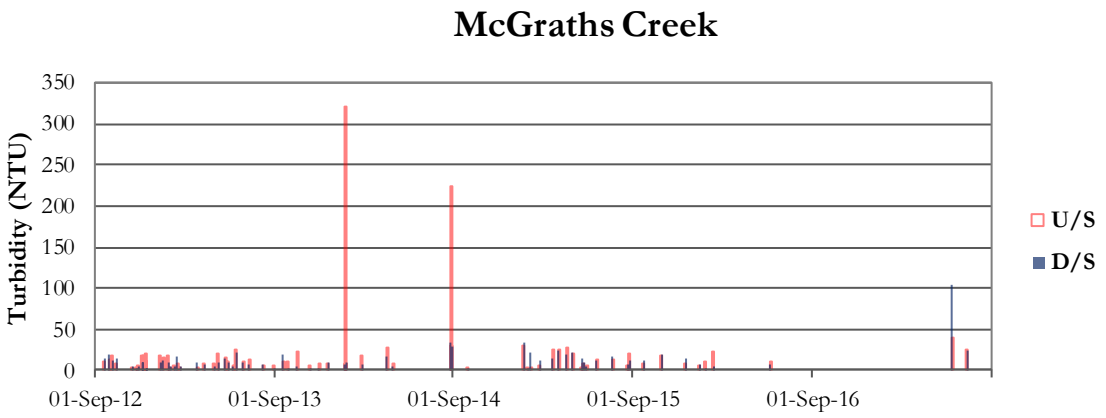

Figure 3.43 Turbidity measurements from McGraths Creek since Sept 2012

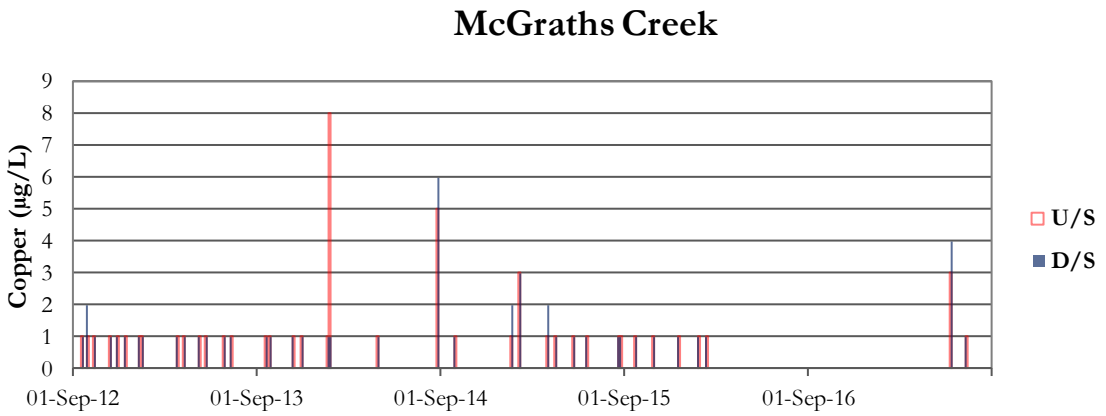

Figure 3.44 Cu measurements from McGraths Creek since Sept 2012

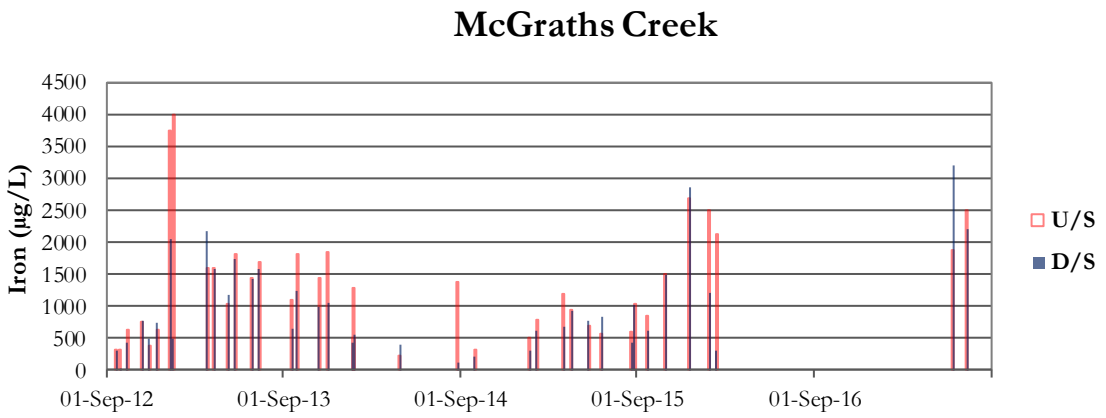

Figure 3.45 Fe measurements from McGraths Creek since Sept 2012

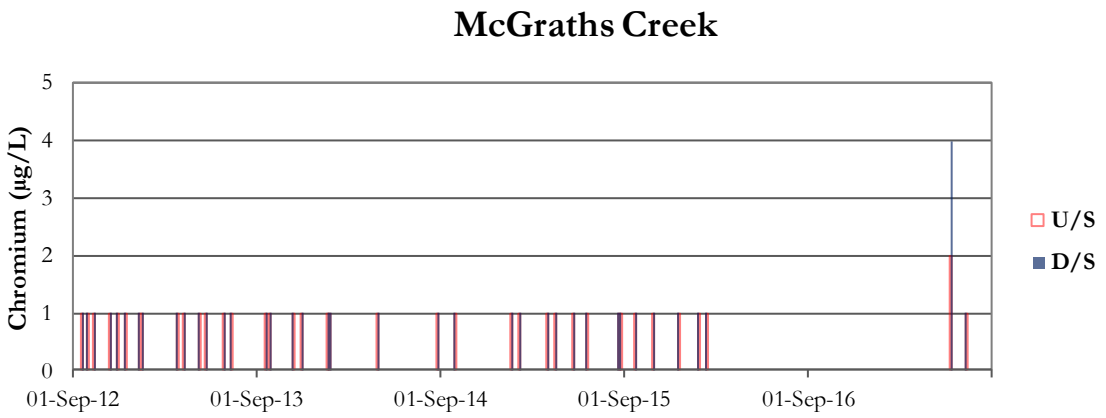

Figure 3.46 Cr measurements from McGraths Creek since Sept 2012

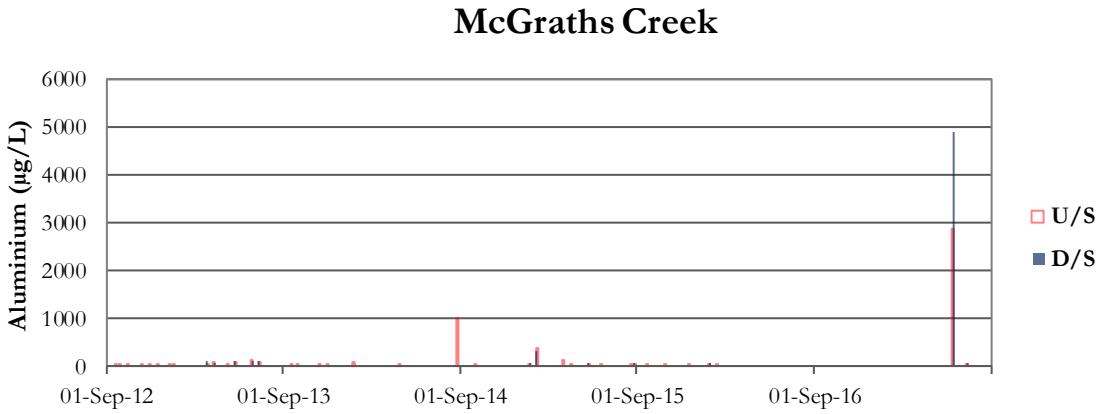

Figure 3.47 Al measurements from McGraths Creek since Sept 2012

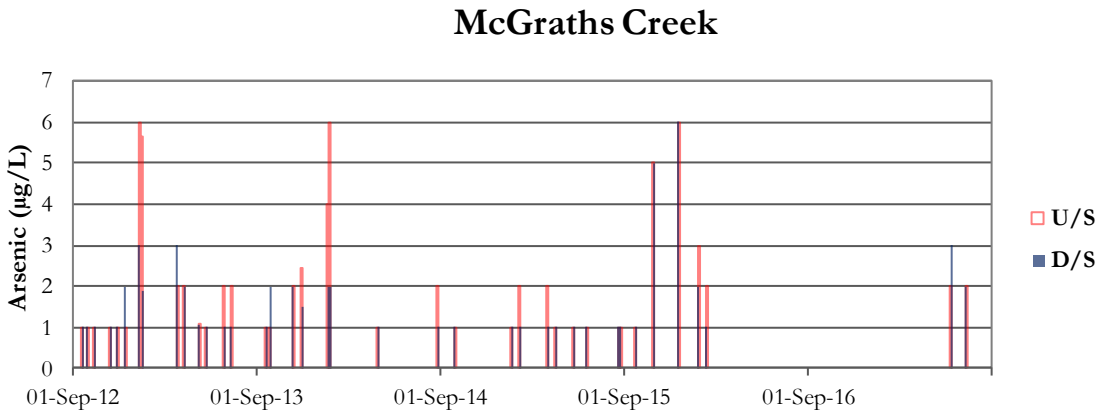

Figure 3.48 As measurements from McGraths Creek since Sept 2012

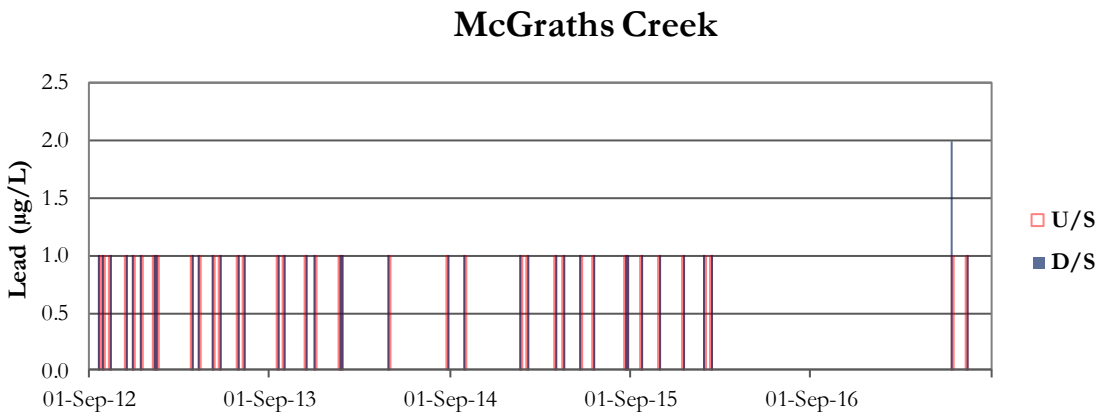

Figure 3.49 Pb measurements from McGraths Creek since Sept 2012

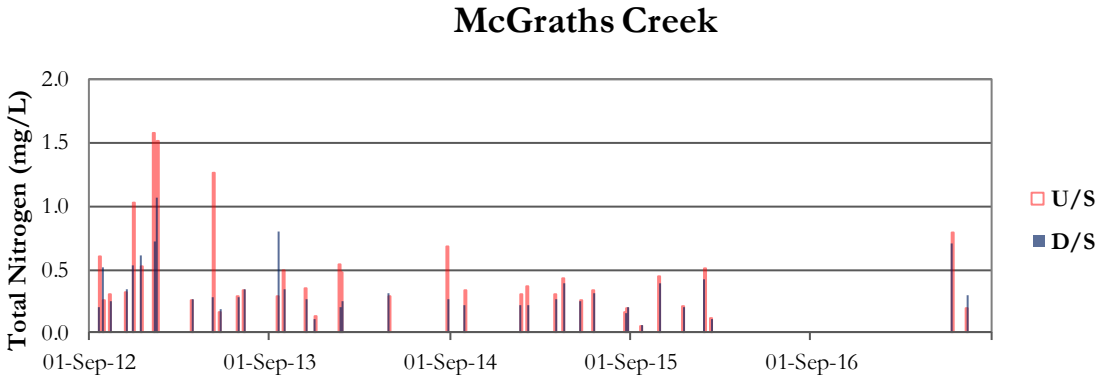

Figure 3.50 TN measurements from McGraths Creek since Sept 2012

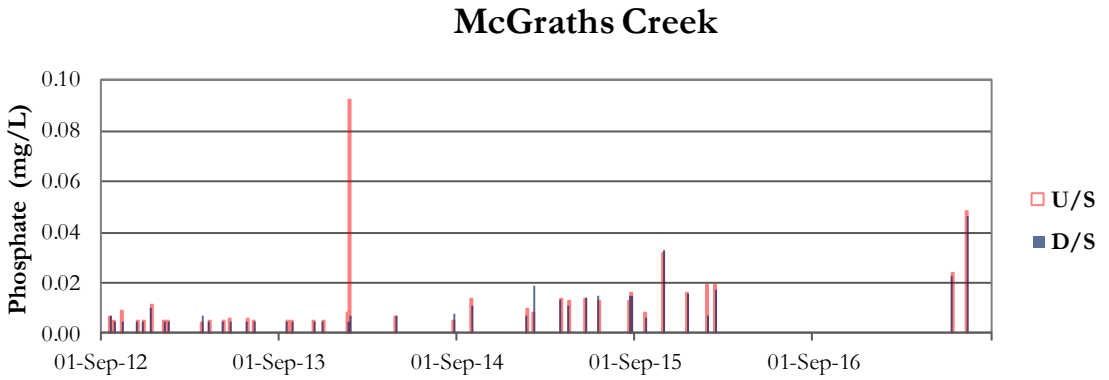

Figure 3.51 PO_3 measurements from McGraths Creek since Sept 2012

For TSS, turbidity, Cu, Cr, Al, Pb and PO_3 the highest measurements from McGraths Creek in the construction and operational phases have been higher than the ranges measured in the pre-construction phase (**Figures 3.42**, **3.43**, **3.44**, **3.46**, **3.47**, **3.49** and **3.51**). The high measurements for Cr and Pb resulted from one wet event sample only.

Summary for McGraths Creek – Highest measurements of TSS, turbidity, Cu, Cr, Al, Pb and PO_3 collected in the construction and operational phases of monitoring. The highest measurements of each of these parameters except PO_3 in the operational phase occurring downstream of the highway crossing, indicating a potential impact.

3.2.8 Oyster Creek

There were several results of interest from Oyster Creek (**Table A.8**). Results of interest were the downstream median Cr, Al, TN, NO_3 and PO_3 concentrations and turbidity measurements. All of the parameters except turbidity that registered a result of interest had the highest measurement since monitoring began during this reporting period (**Figures 3.54** to **3.58**). All of the highest concentrations were measured during a wet event and in the case of Cr and Al high values were collected from upstream and downstream, indicating that they originated further up the catchment rather than at the highway crossing.

TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figure 3.52**). One downstream turbidity measurement during a wet sample was slightly higher than the highest pre-construction value but within the range measured during construction phase monitoring (**Figure 3.53**).

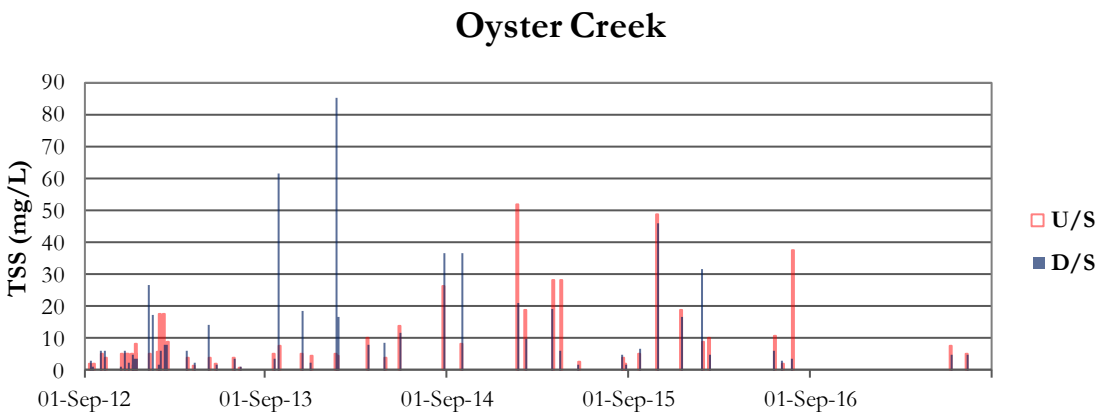

Figure 3.52 TSS concentrations from Oyster Creek since Sept 2012

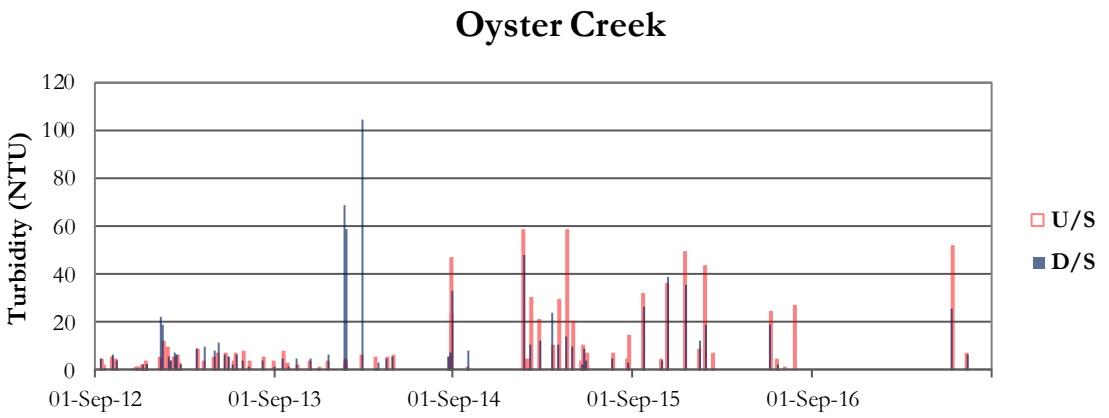

Figure 3.53 Turbidity measurements from Oyster Creek since Sept 2012

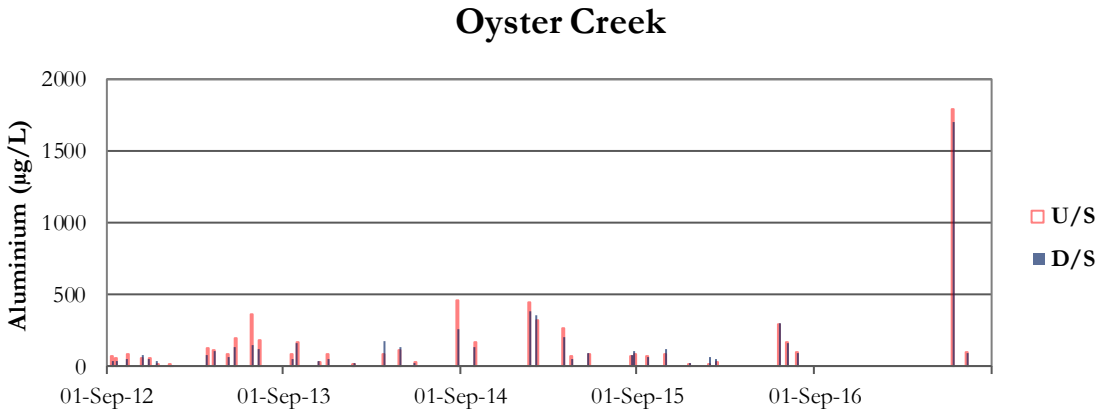

Figure 3.54 Al measurements from Oyster Creek since Sept 2012

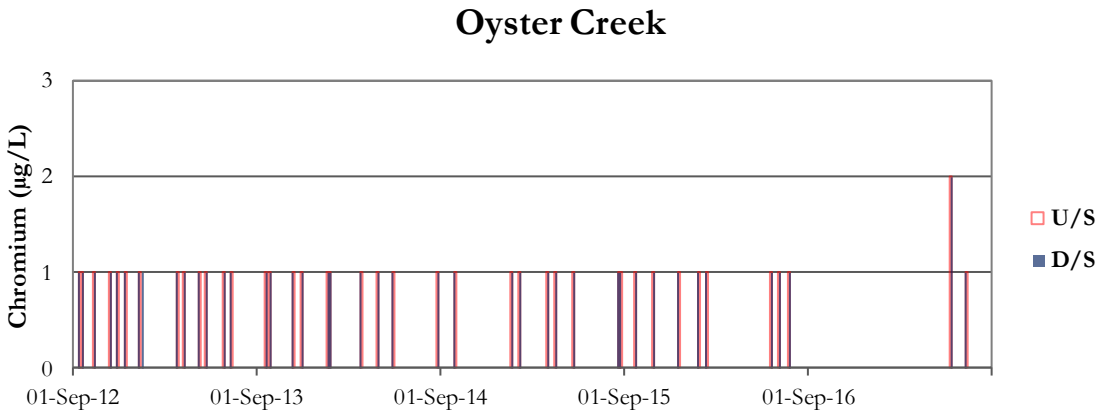

Figure 3.55 Cr measurements from Oyster Creek since Sept 2012

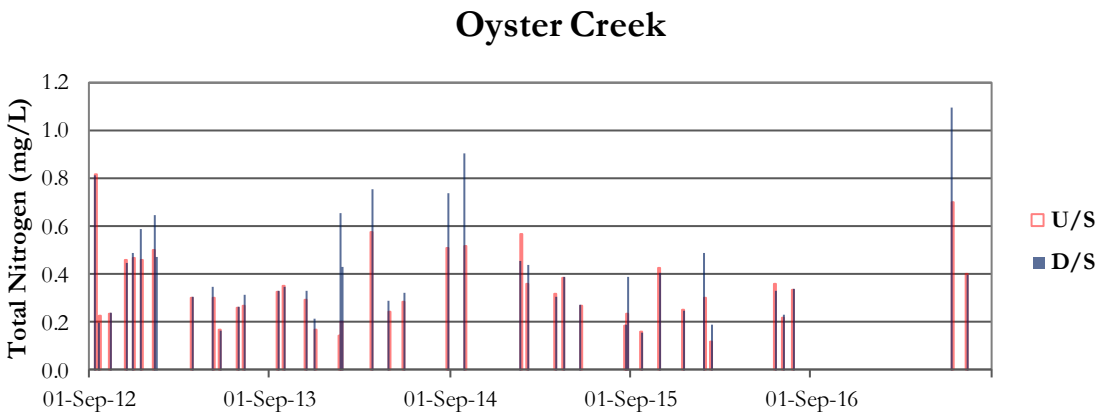

Figure 3.56 TN measurements from Oyster Creek since Sept 2012

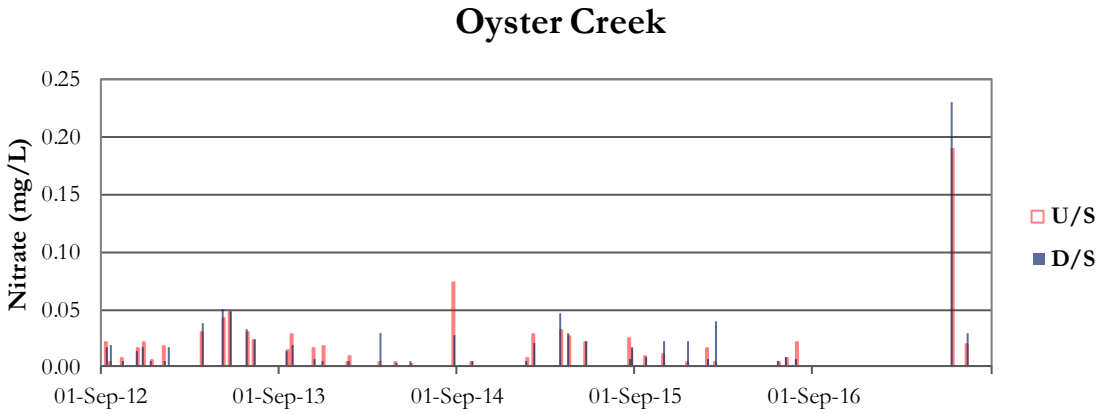

Figure 3.57 NO_3 measurements from Oyster Creek since Sept 2012

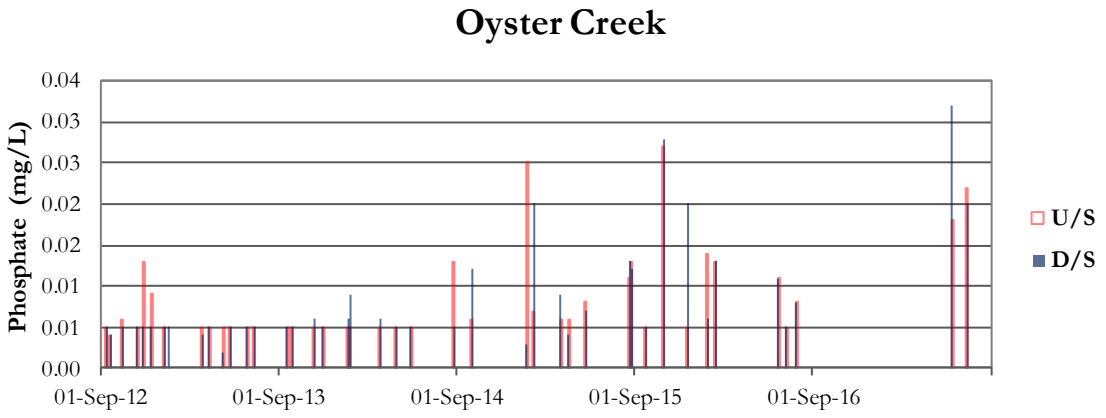

Figure 3.58 PO_3 measurements from Oyster Creek since Sept 2012

For Al, Cr, TN, NO_3, PO_3, turbidity and TSS the highest measurements from Oyster Creek in the construction and operational phases have been higher than the ranges measured in the pre-construction phase (**Figures 3.52** to **3.58**). The high measurement for Cr resulted from one wet event sample only.

Summary for Oyster Creek – The highest measurements of Al, Cr, TN, NO_3 and PO_3 collected in the operational phase of monitoring. The highest concentrations of Al and Cr and turbidity readings measured during this reporting period were measured upstream of the highway crossing. Nutrient concentrations indicate that there is a potential impact from the highway operation on Oyster Creek.

3.2.9 Deep Creek

There were several results of interest from Deep Creek (**Table A.9**). Results of interest were the downstream median Fe, Al, TN, NO_3 TP and PO_3 concentrations. Of the parameters that registered a result of interest Al, Fe and TN had the highest measurement since monitoring began during this reporting period (**Figures 3.61** to **3.63**). All of the highest concentrations were measured during a wet event and in all cases high values were collected from both upstream and downstream sites. However, because Deep Creek is tidal at the point of the crossing it is uncertain if the high concentrations of these parameters originated further up the catchment or at the highway crossing.

TSS measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figure 3.59**). One turbidity measurement during a wet sample was slightly higher than the highest pre-construction value but within the range measured during construction phase monitoring (**Figure 3.60**).

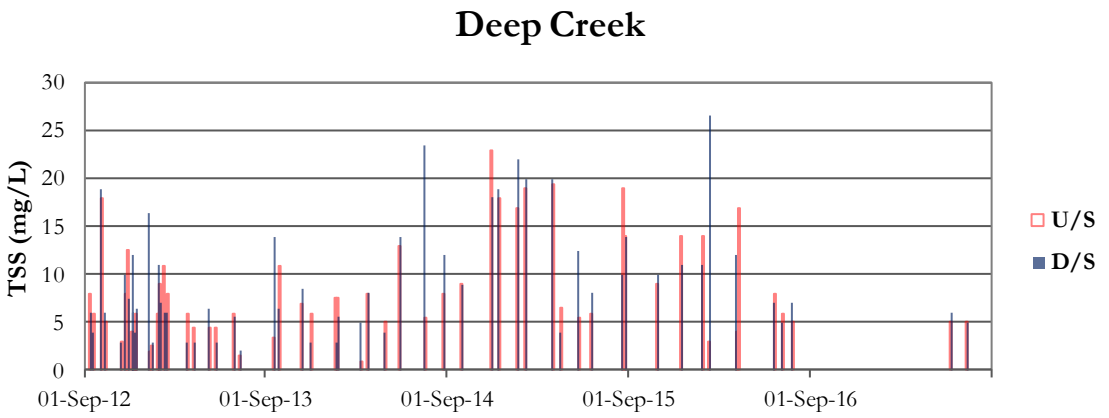

Figure 3.59 TSS concentrations from Deep Creek since Sept 2012

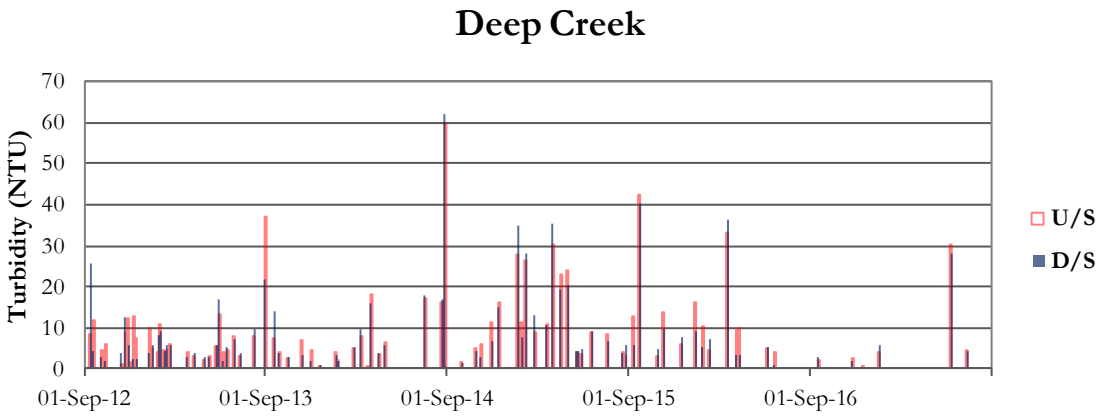

Figure 3.60 Turbidity measurements from Deep Creek since Sept 2012

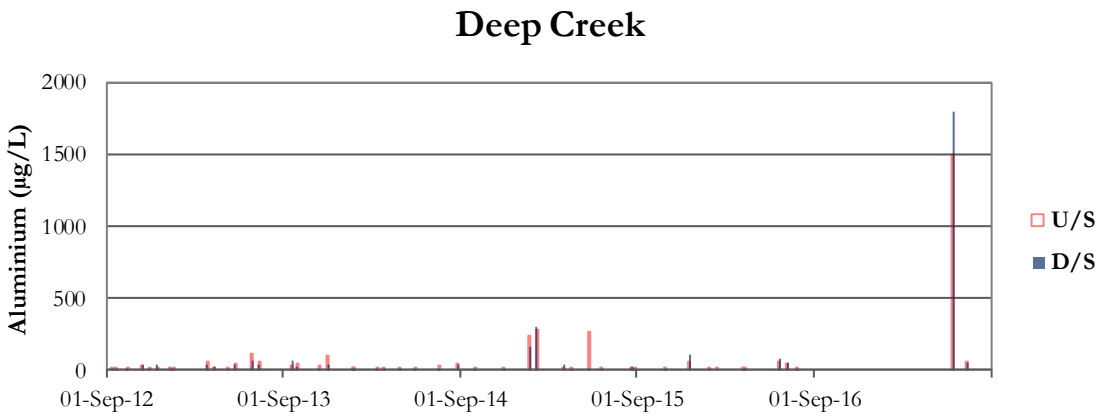

Figure 3.61 Al measurements from Deep Creek since Sept 2012

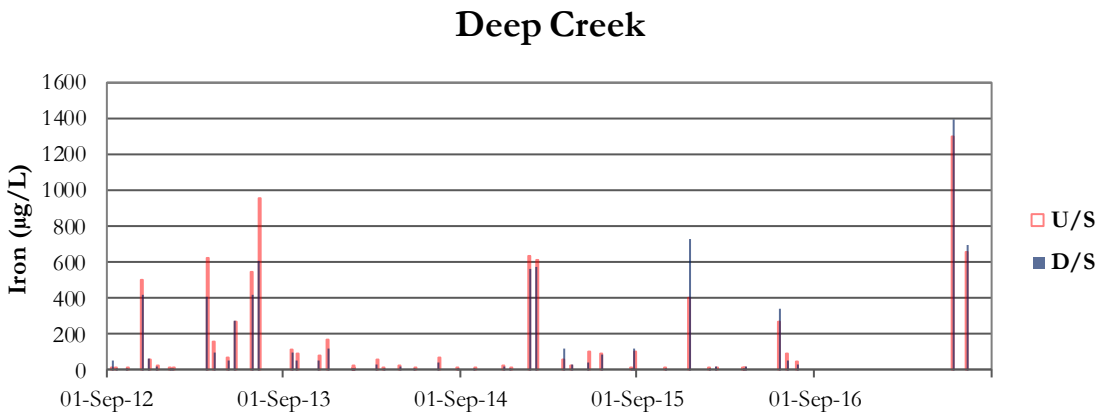

Figure 3.62 Fe measurements from Deep Creek since Sept 2012

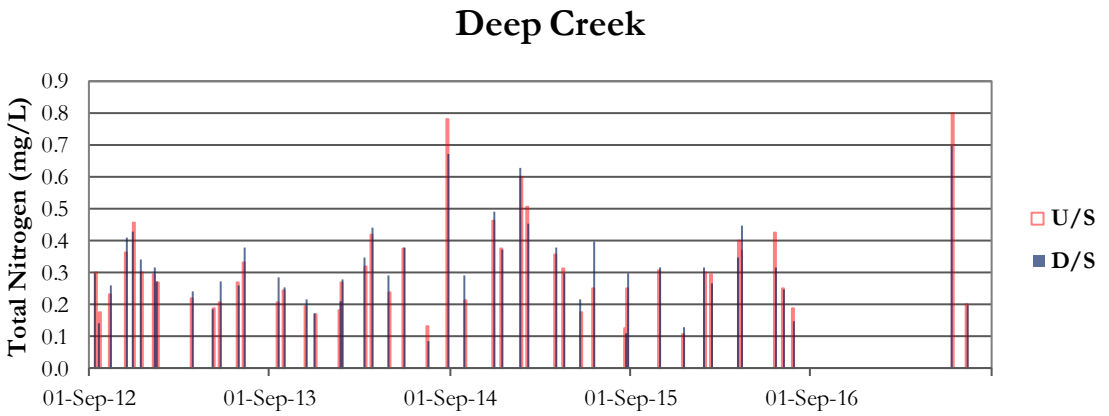

Figure 3.63 TN measurements from Deep Creek since Sept 2012

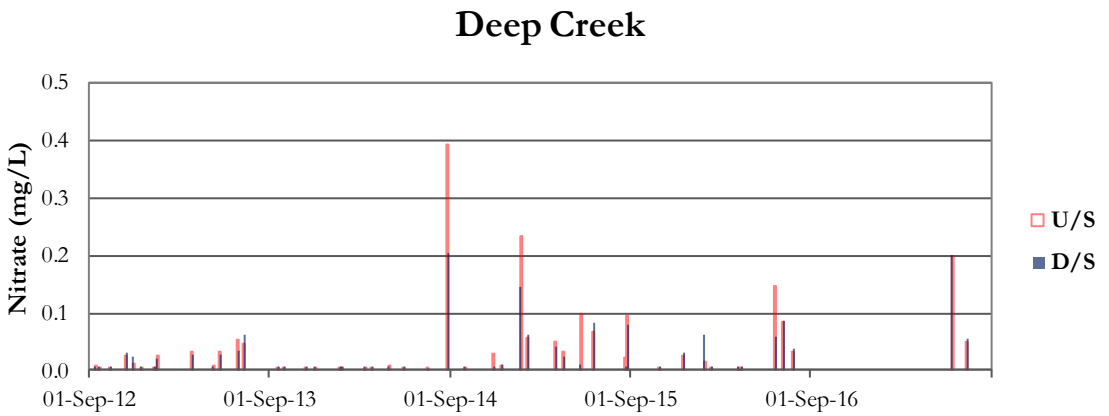

Figure 3.64 NO_3 measurements from Deep Creek since Sept 2012

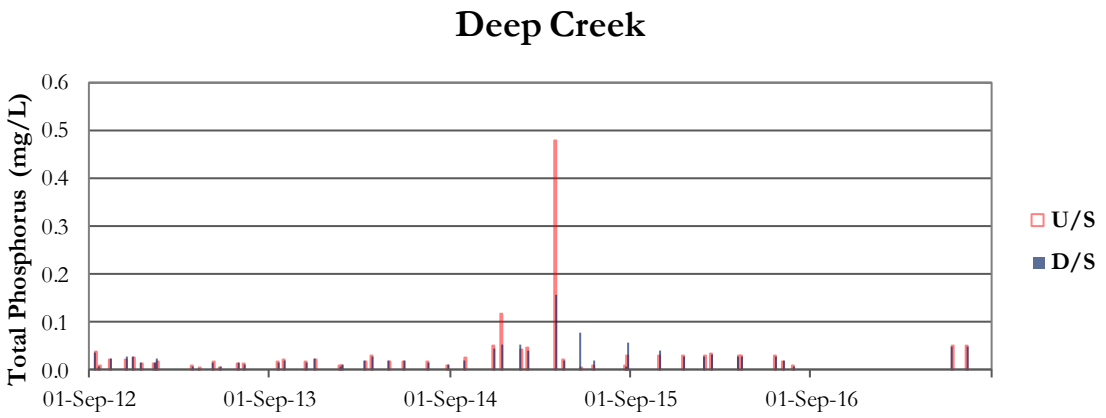

Figure 3.65 TP measurements from Deep Creek since Sept 2012

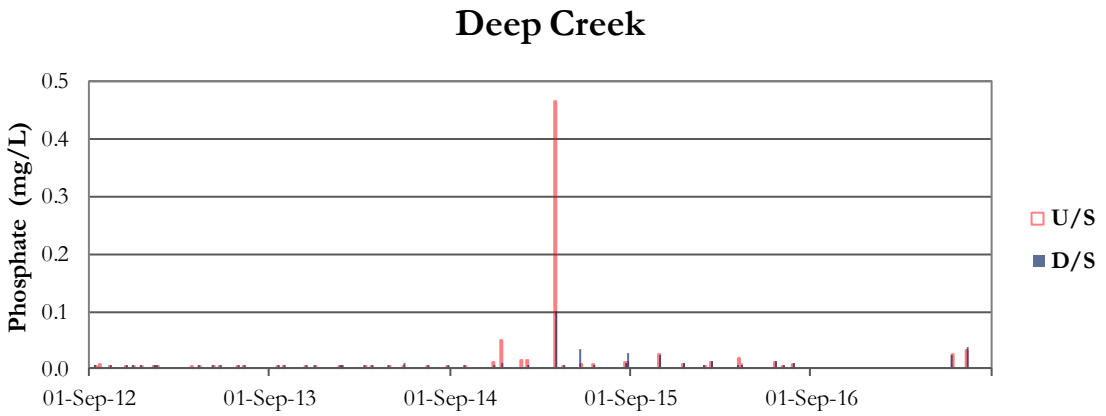

Figure 3.66 PO_3 measurements from Deep Creek since Sept 2012

For Al, Fe, TN, NO_3, TP and PO_3 the highest measurements from Deep Creek in the construction and operational phases have been higher than the ranges measured in the pre-construction phase (**Figures 3.61** to **3.66**).

Summary for Deep Creek – Highest measurements of Al, Fe and TN collected in the operational phases of monitoring. Elevated concentrations of all parameters that registered a result of interest collected both upstream and downstream of the highway crossing. Deep Creek is tidal at the point of the highway crossing, making it difficult to draw conclusions.

3.2.10 Cow Creek

There were several results of interest from Cow Creek (**Table A.10**). Results of interest were the downstream median Cu, Al, TN, NO_3, PO_3 and pH measurements. Of the parameters that

registered a result of interest only Al had the highest measurement since monitoring began during this reporting period (**Figure 3.70**). The highest concentrations of Cu, Fe, Al, TN and NO_3 during this reporting period were all measured during a wet event and in all cases high values were collected from both upstream and downstream. This indicates that high concentrations of these parameters originated further up the catchment rather than at the highway crossing.

TSS and turbidity measurements during this reporting period were within the variation observed in construction phase monitoring (**Figures 3.67** and **3.68**). (Note: There were only three samples from Cow Creek collected during pre-construction monitoring and they were limited to physicochemical parameters.)

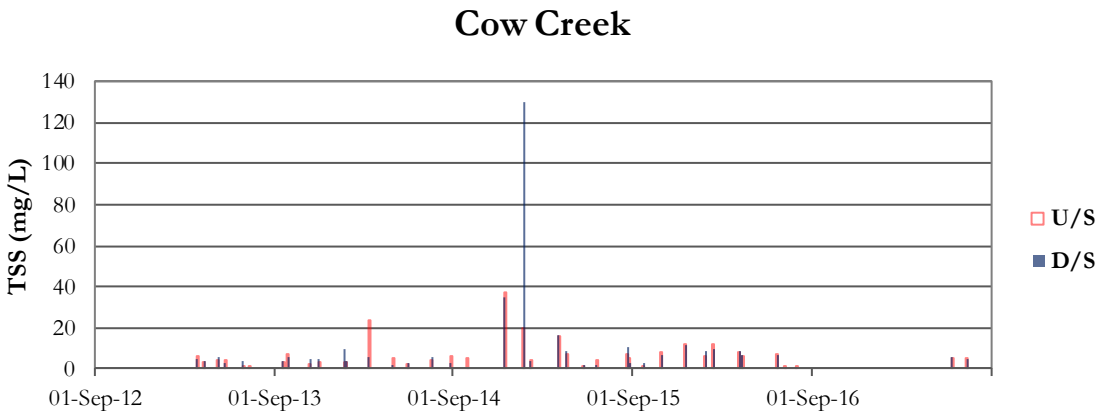

Figure 3.67 TSS concentrations from Cow Creek since Sept 2012

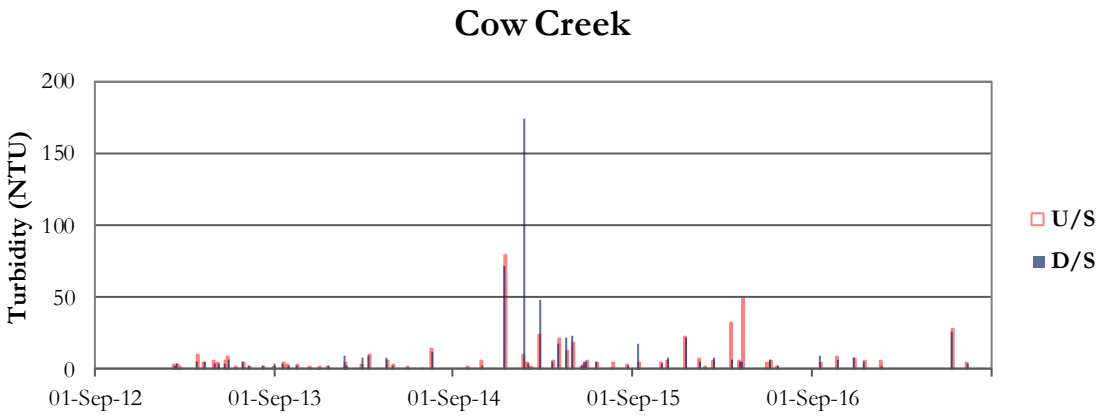

Figure 3.68 Turbidity measurements from Cow Creek since Sept 2012

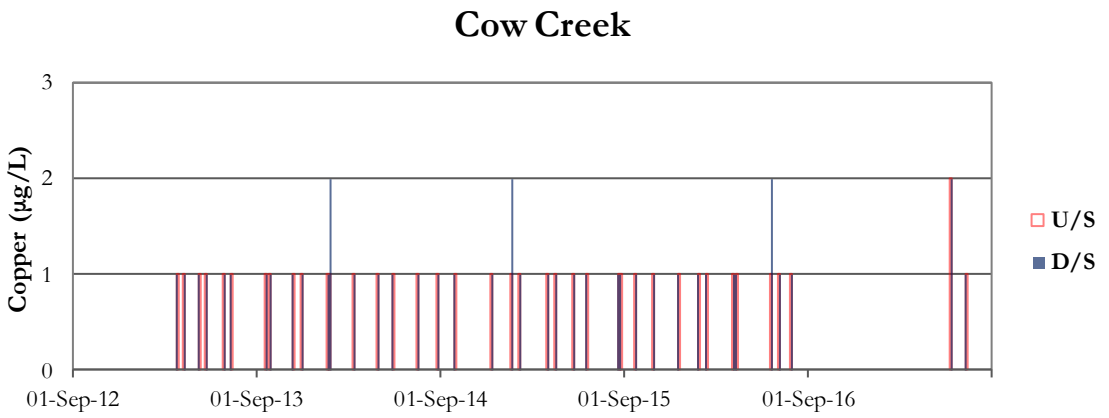

Figure 3.69 Cu measurements from Cow Creek since Sept 2012

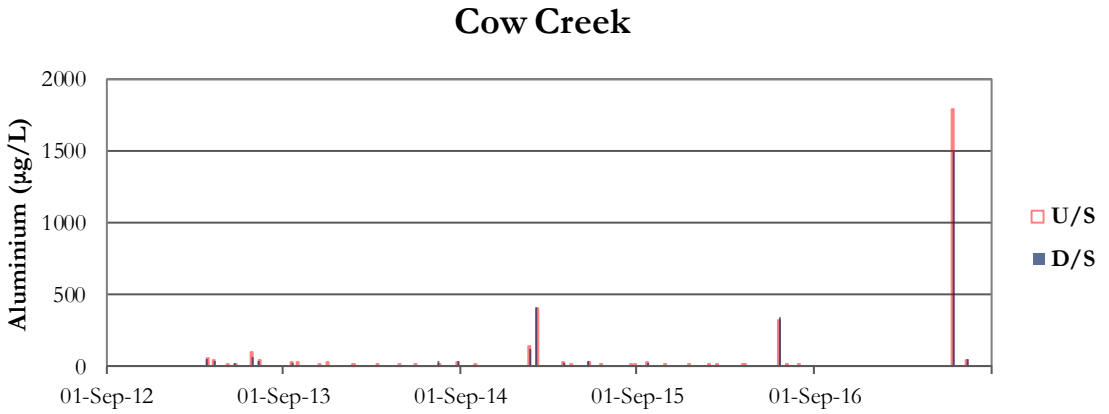

Figure 3.70 Al measurements from Cow Creek since Sept 2012

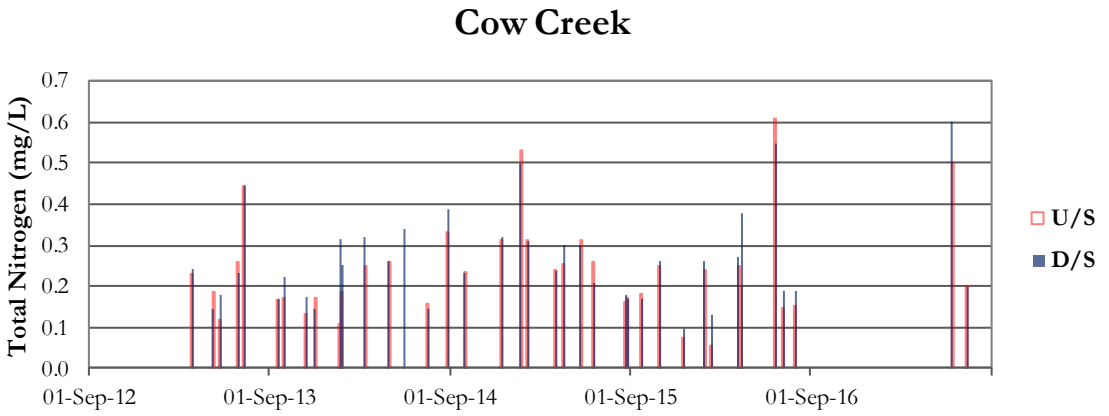

Figure 3.71 TN measurements from Cow Creek since Sept 2012

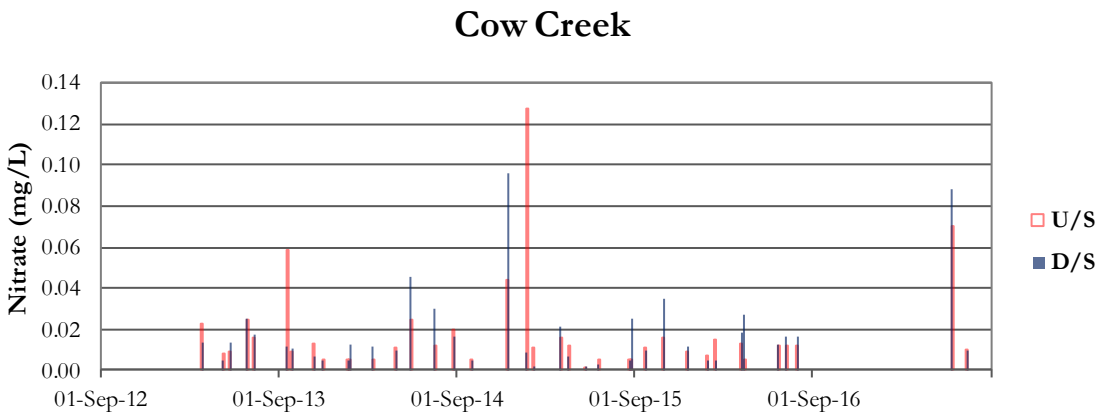

Figure 3.72 NO_3 measurements from Cow Creek since Sept 2012

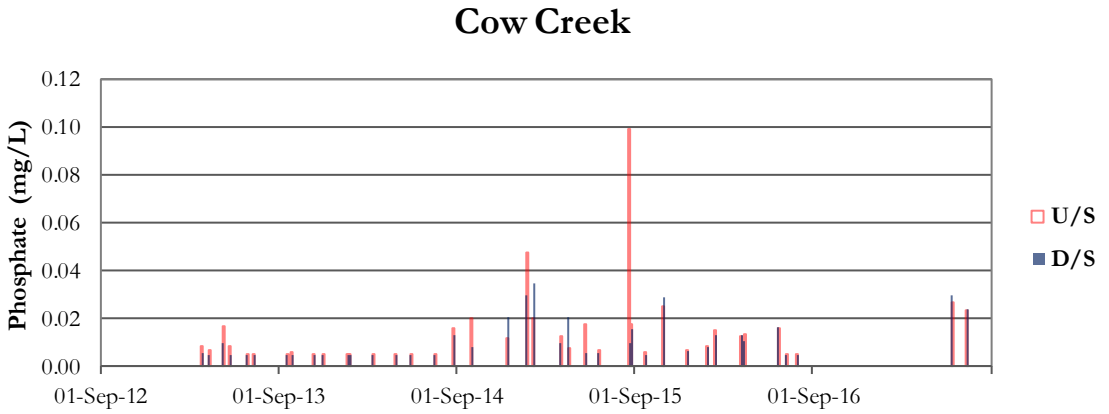

Figure 3.73 PO_3 measurements from Cow Creek since Sept 2012

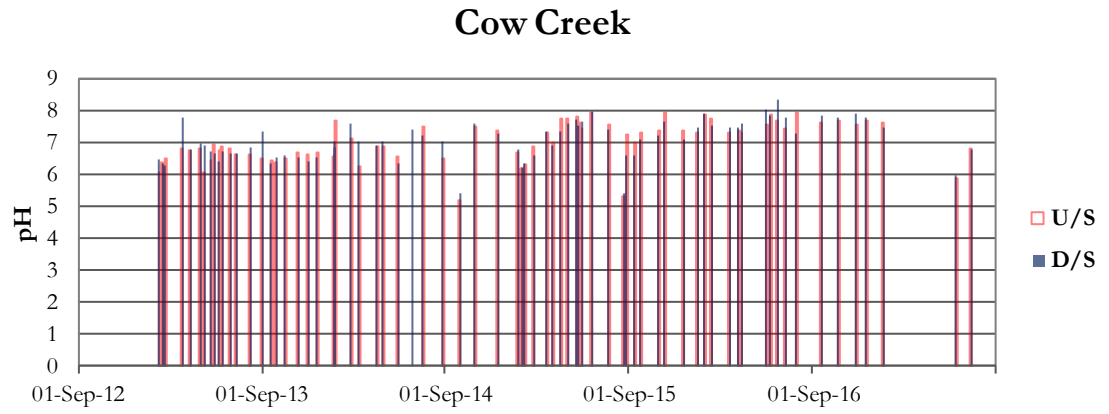

Figure 3.74 pH measurements from Cow Creek since Sept 2012

The highest measurements of Al from Cow Creek in the operational phase have been higher than the ranges measured in the construction phase (**Figures 3.70** to **3.74**).

Summary for Cow Creek – Limited pre-construction data available. The highest measurement of Al collected in the operational phase of monitoring. Elevated measurements of all parameters that registered a result of interest were collected upstream and downstream of the highway crossing.

3.2.11 Boggy Creek

There were several results of interest from Boggy Creek (**Table A.11**). Results of interest were the downstream median Cu, As, Fe, Cr, Al and NO_3 concentrations. Of the parameters that registered a result of interest only Al had the highest measurement since monitoring began during this reporting period (**Figure 3.81**). The highest concentrations of Cu, Fe, Al, Cr and NO_3 were all measured during a wet event and in the case of Al and Fe high values were collected from both upstream and downstream. This indicates that high concentrations of these two parameters originated further up the catchment rather than at the highway crossing.

TSS and turbidity measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.69** and **3.70**).

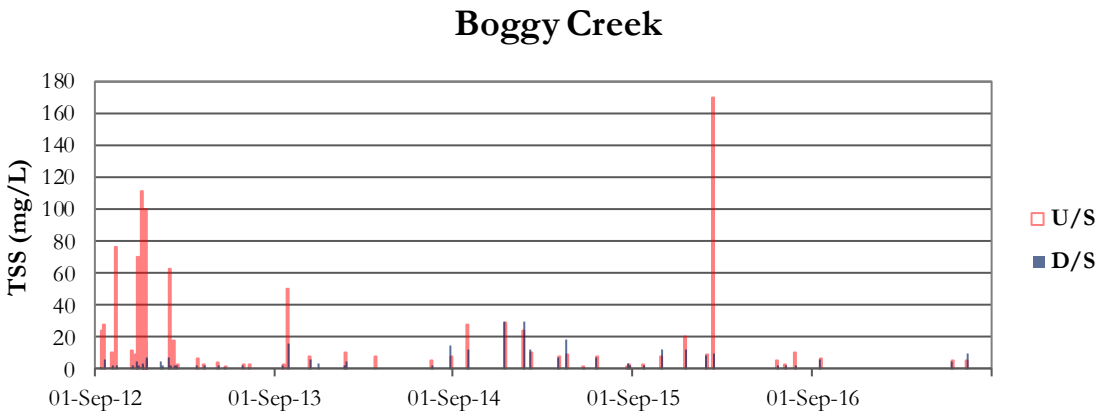

Figure 3.75 TSS concentrations from Boggy Creek since Sept 2012

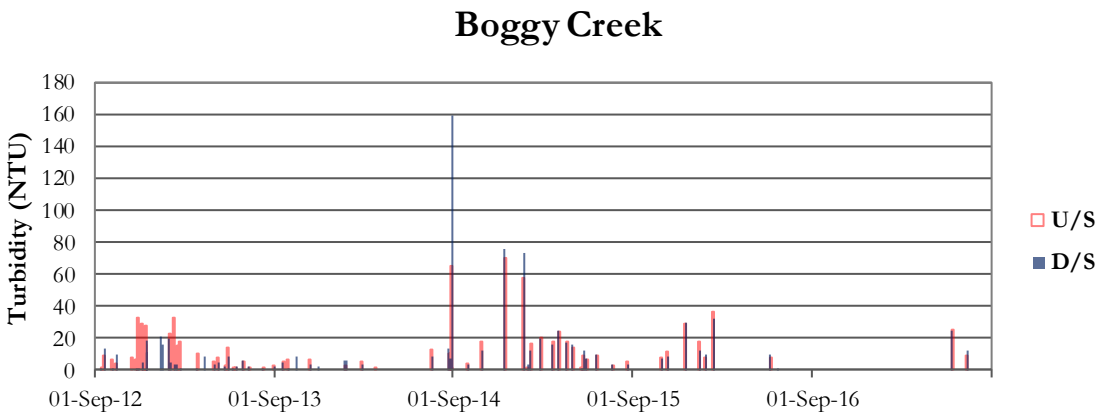

Figure 3.76 Turbidity measurements from Boggy Creek since Sept 2012

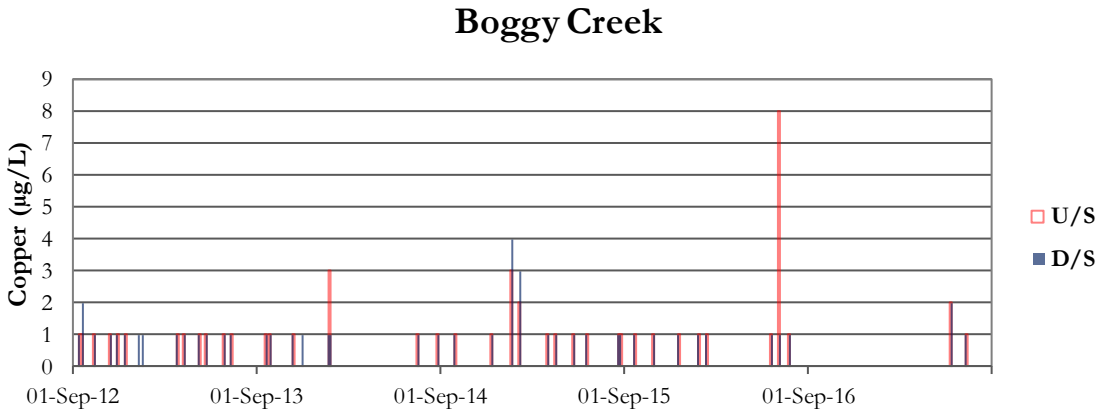

Figure 3.77 Cu measurements from Boggy Creek since Sept 2012

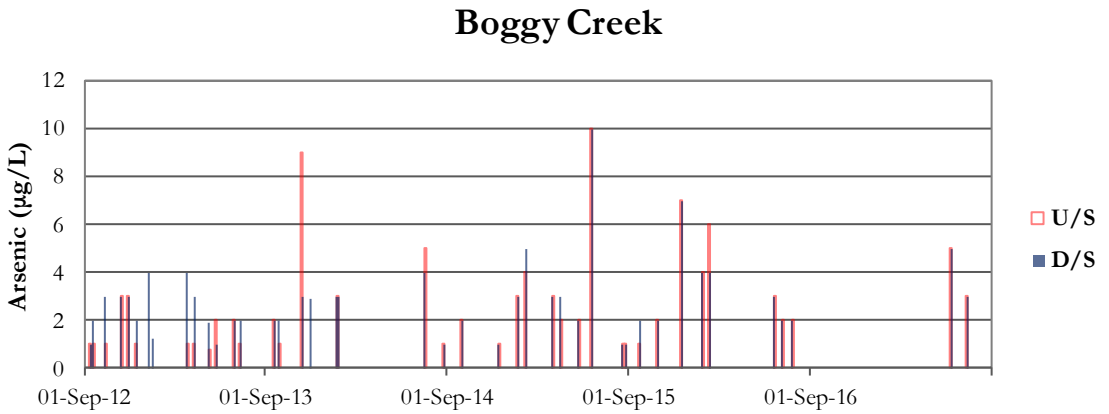

Figure 3.78 As measurements from Boggy Creek since Sept 2012

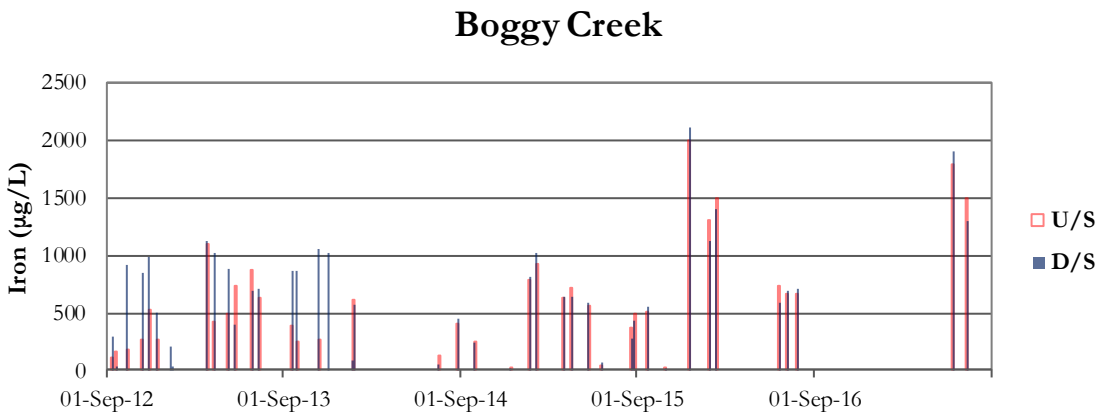

Figure 3.79 Fe measurements from Boggy Creek since Sept 2012

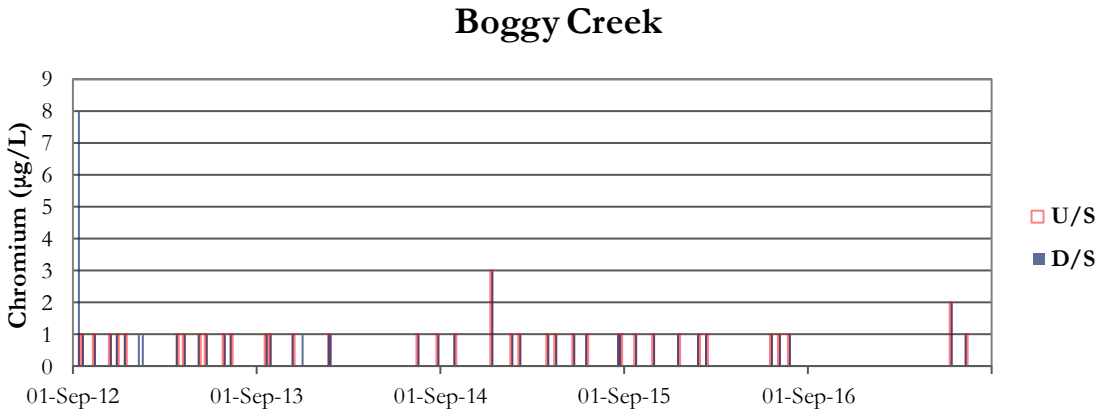

Figure 3.80 Cr measurements from Boggy Creek since Sept 2012

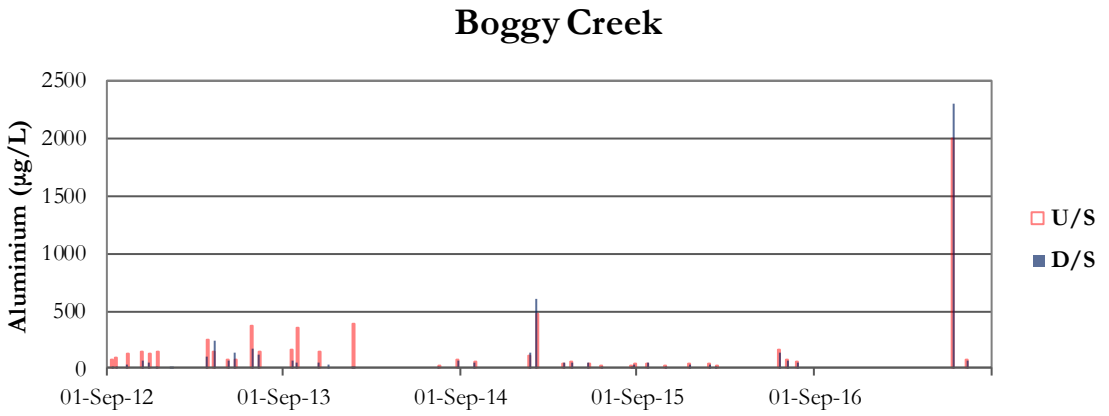

Figure 3.81 Al measurements from Boggy Creek since Sept 2012

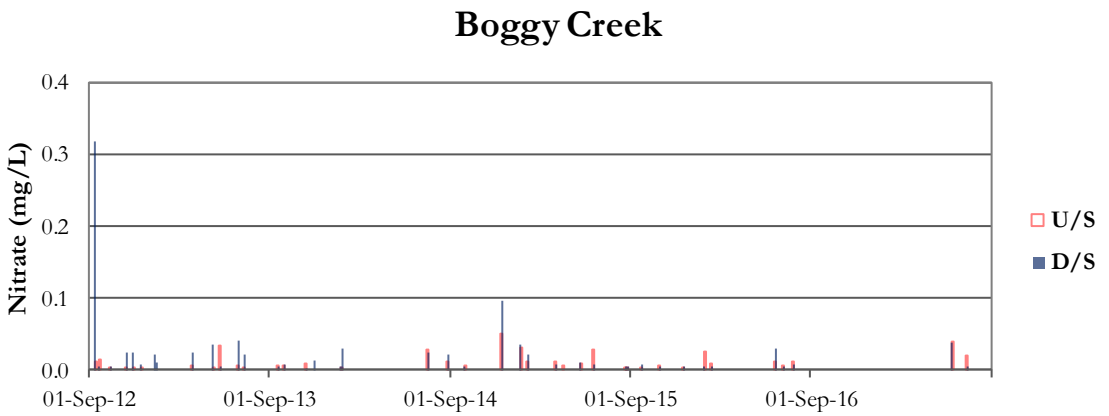

Figure 3.82 NO_3 measurements from Boggy Creek since Sept 2012

The highest measurements of Cu, Cr, As, Fe and Al from Boggy Creek have occurred during the construction and operational phases of monitoring (**Figures 3.77** to **3.81**).

Summary for Boggy Creek – The highest measurements of Cu, Cr, As, Fe and Al collected in the construction and operational phases of monitoring. During this reporting period high concentrations of each of these parameters have been measured 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 3.2**.

Table 3.2 Groundwater quality sampling undertaken during this reporting period

Date	*Parameters*
5/10/2016	All parameters
xx/01/2017	No samples collected – all sites dry or inaccessible
29/06/2017	No samples collected – assessing piezometer function installing locks and setting 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. Note that the summary values for operational phase monitoring between 1 September 2016 and 31 August 2017 are derived from a single sample at most sites.

3.3.2 Ch 63200

Results of interest from Ch 63200 (**Table B.1**) were the downgradient median As, Fe, TP, TN NH_4, PO_3, pH and Ca measurements. There was no water in the upgradient piezometer during this reporting period or for most of the construction phase monitoring, limiting the capacity to draw conclusions about groundwater quality. Of the parameters that generated a result of interest, the downgradient As, Fe, TN and NH_4 concentrations measured during this reporting period were the highest since monitoring started.

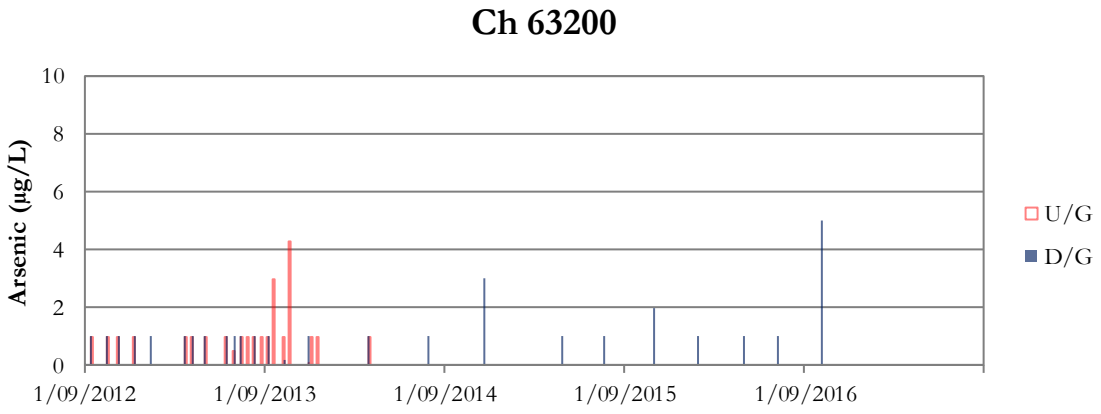

Figure 3.83 As concentrations from Ch 63200 since September 2012

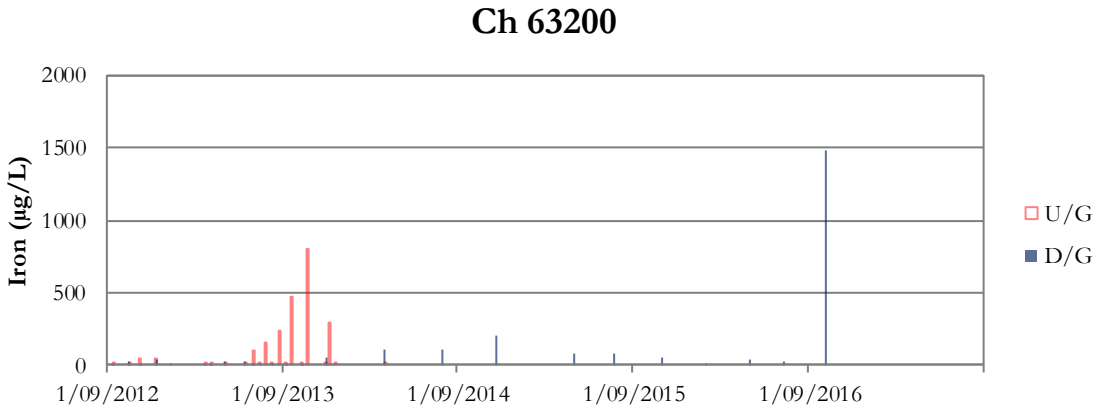

Figure 3.84 Fe concentrations from Ch 63200 since September 2012

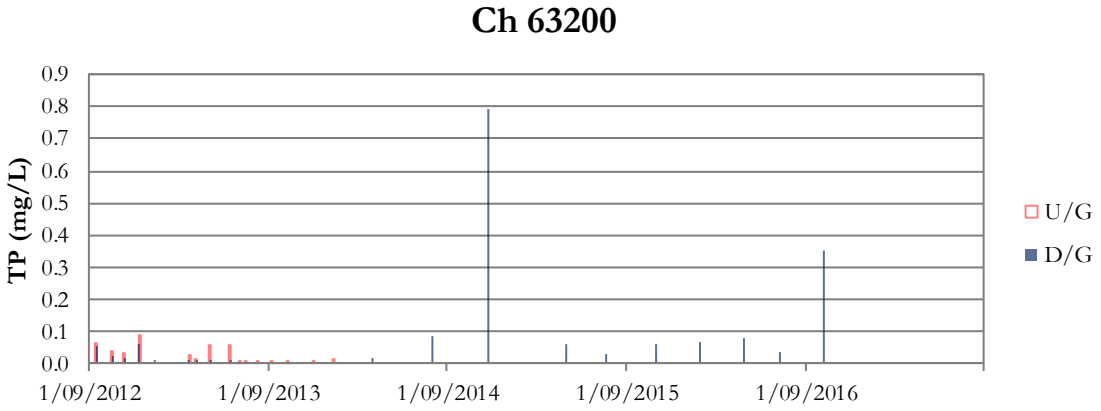

Figure 3.85 TP concentrations from Ch 63200 since September 2012

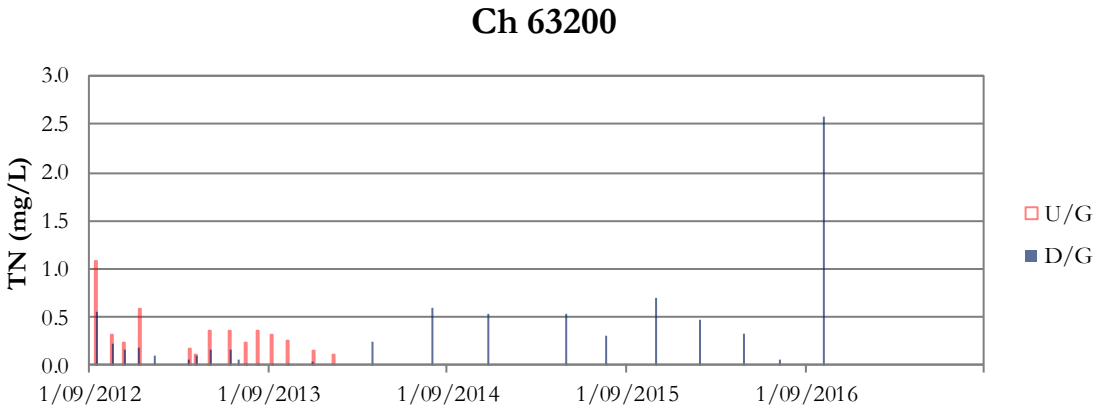

Figure 3.86 TN concentrations from Ch 63200 since September 2012

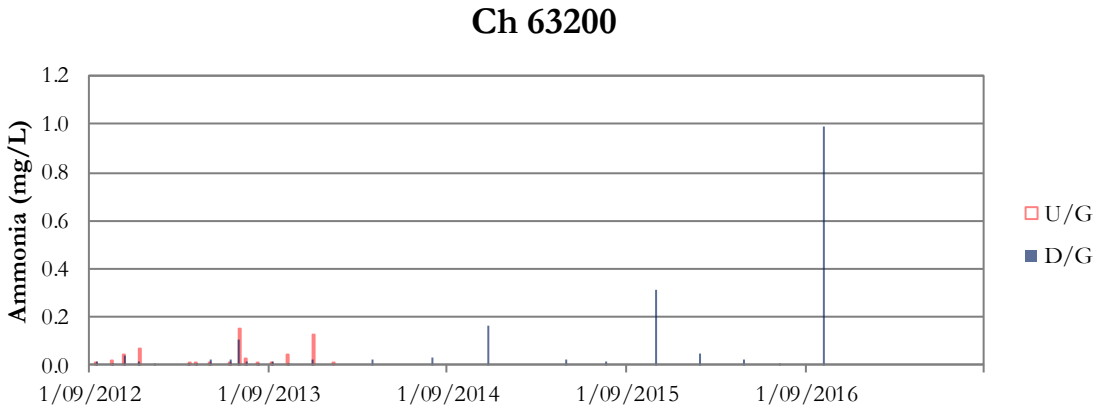

Figure 3.87 NH_4 concentrations from Ch 63200 since September 2012

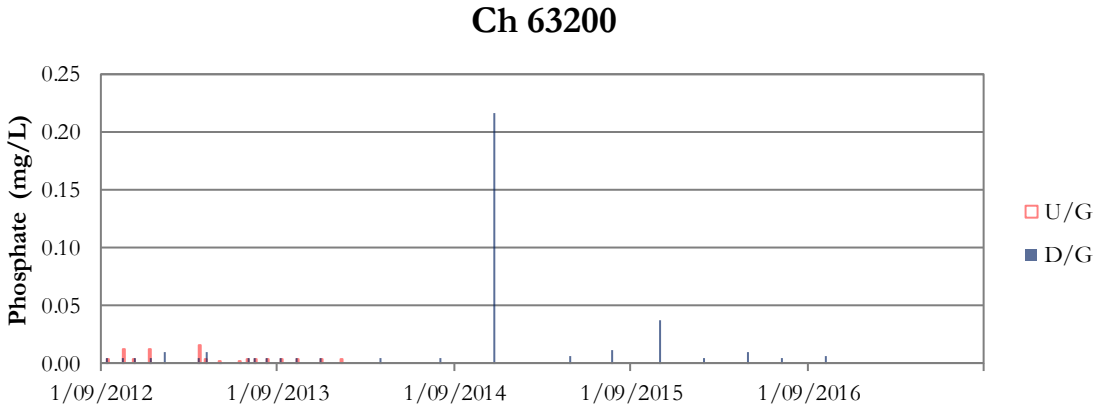

Figure 3.88 Phosphate concentrations from Ch 63200 since September 2012

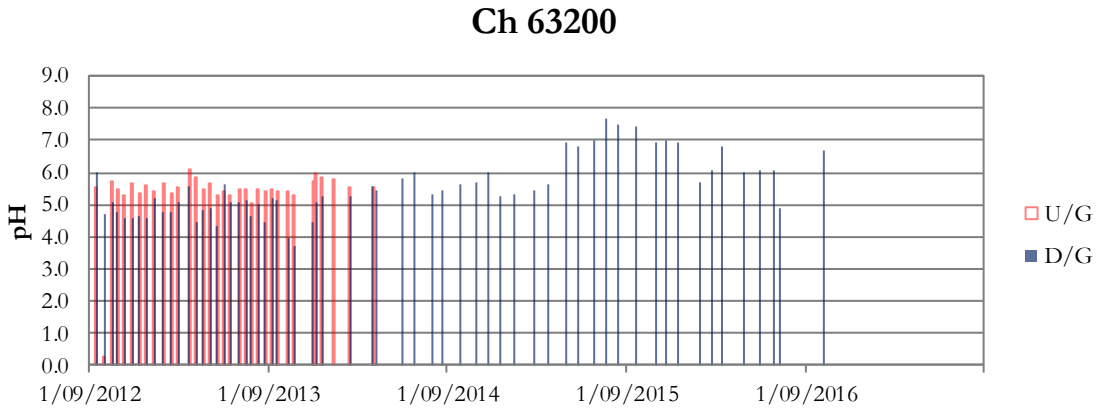

Figure 3.89 pH measurements from Ch 63200 since September 2012

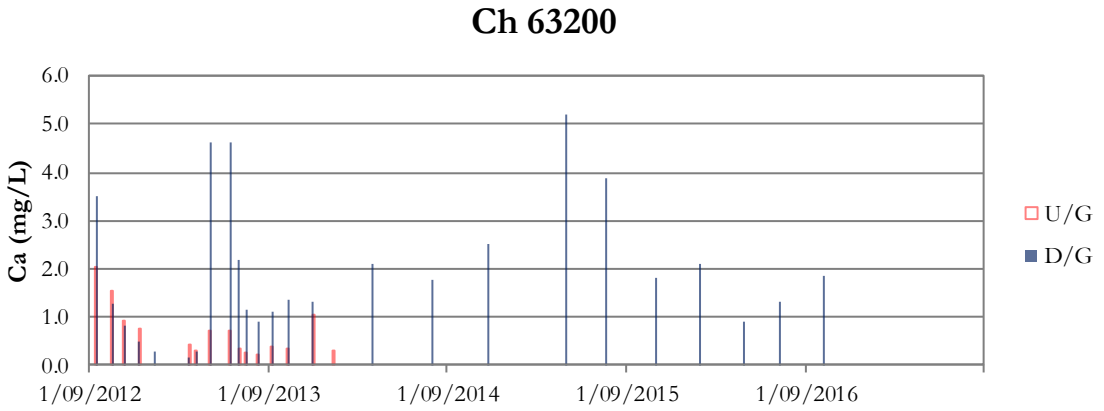

Figure 3.90 Ca concentrations from Ch 63200 since September 2012

Summary: Highest AS, Fe, TN and NH4 concentrations since the start of monitoring. More operational phase data required.

3.3.3 Ch 64600

Results of interest from Ch 64600 (**Table B.2**) were the downgradient median TP, NO_2, PO_3, temperature, pH and alkalinity measurements. All of the parameters that registered a result of interest were within the ranges measured during pre-construction and construction phase monitoring. In all cases except for phosphate the downgradient measurements were equivalent to the upgradient measurements for this reporting period.

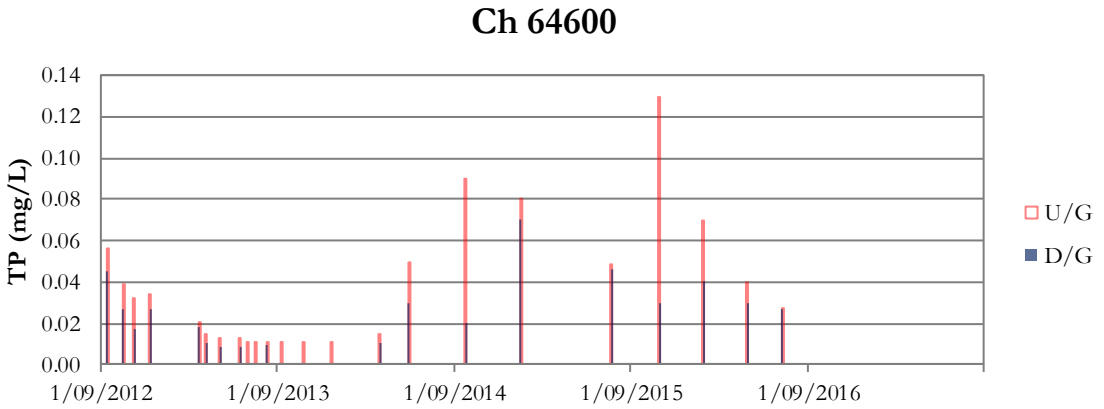

Figure 3.91 TP concentrations from Ch 64600 since September 2012

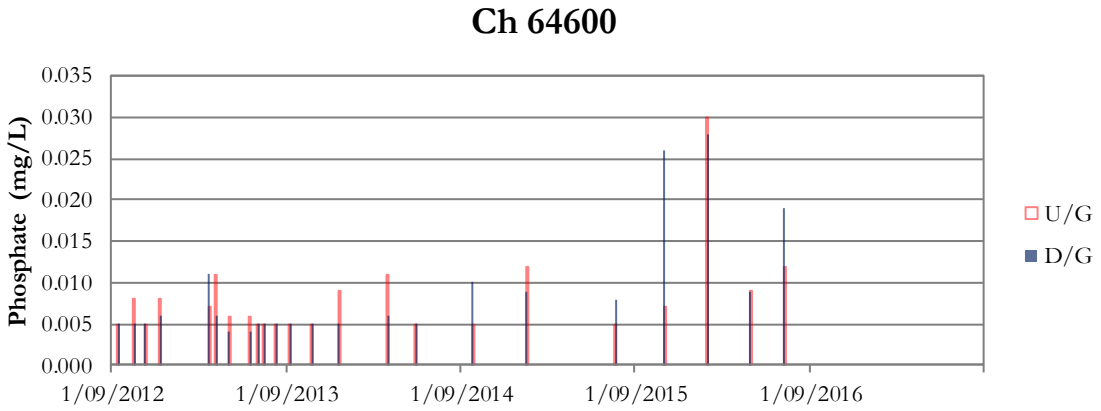

Figure 3.92 Phosphate concentrations from Ch 64600 since September 2012

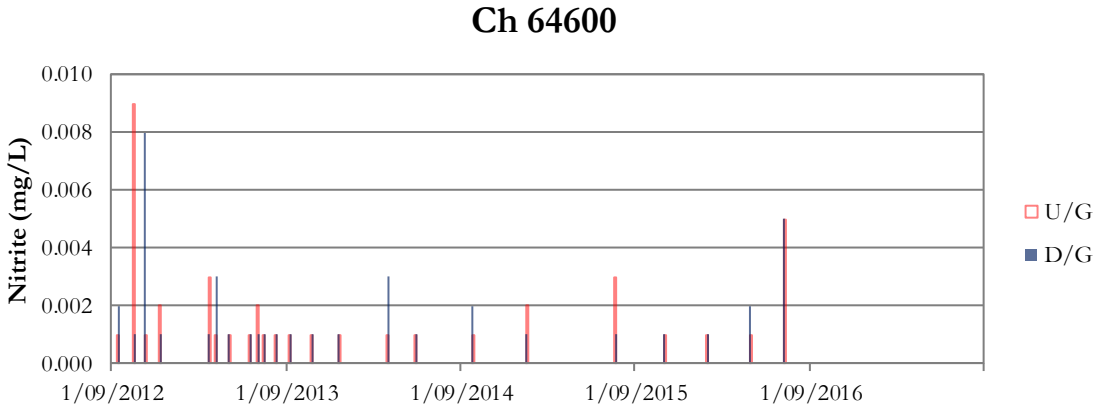

Figure 3.93 Nitrite concentrations from Ch 64600 since September 2012

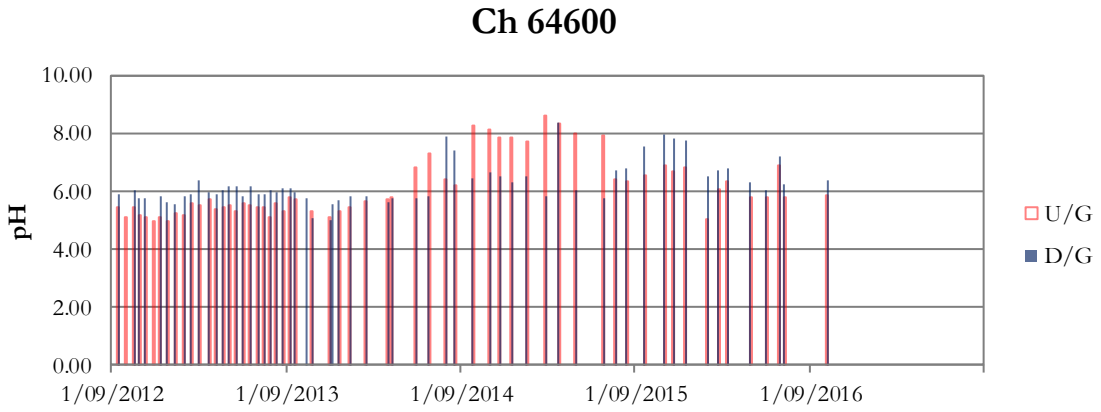

Figure 3.94 pH measurements from Ch 64600 since September 2012

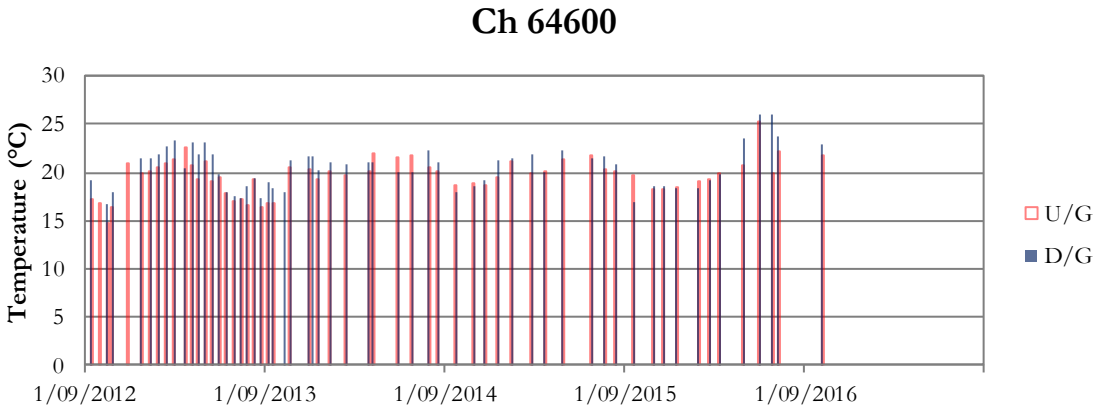

Figure 3.95 Temperature measurements from Ch 64600 since September 2012

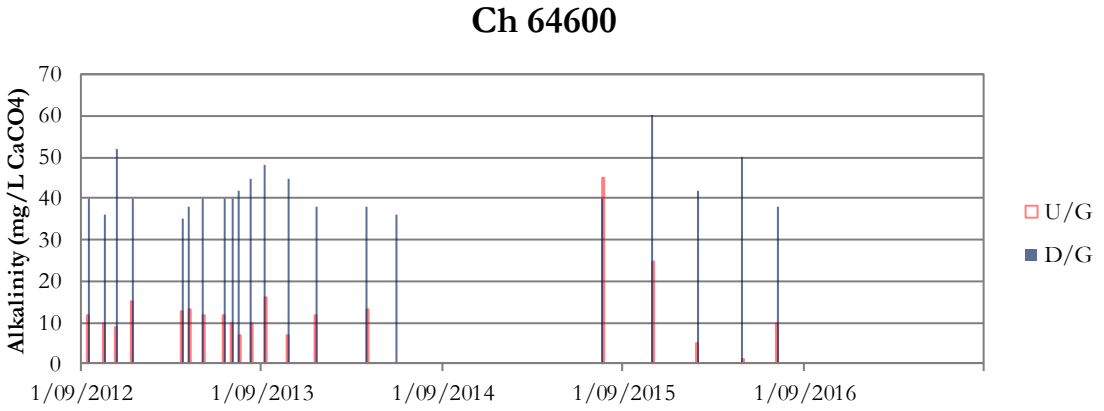

Figure 3.96 Alkalinity measurements from Ch 64600 since September 2012

Summary: All parameters which registered results of interest were within the ranges measured during pre-construction and construction phase monitoring.

3.3.4 Ch 72400

Results of interest from Ch 72400 (**Table B.3**) were the downgradient median As, Ni, NO_2, PO_3, NH_4, pH, EC, alkalinity, K, Ca and Mg measurements. 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. All of

the parameters that generated a result of interest were measured within the ranges observed during construction phase monitoring.

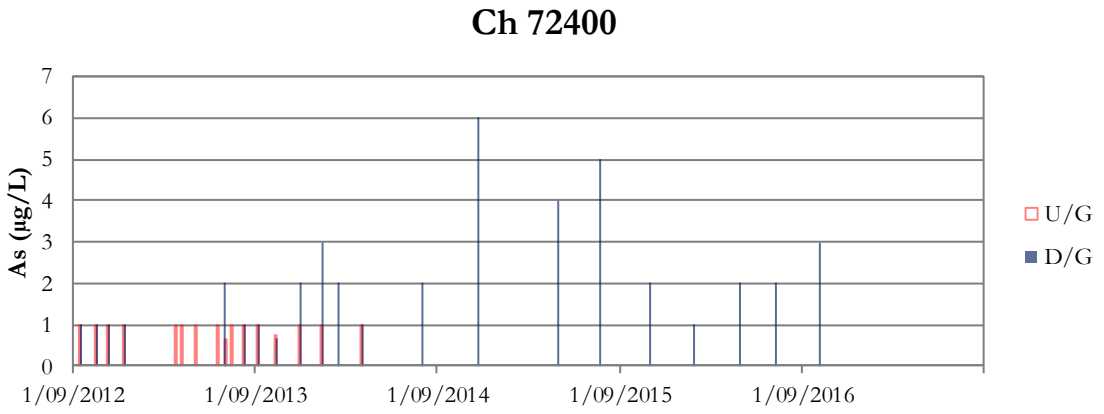

Figure 3.97 As concentrations from Ch 72400 since September 2012

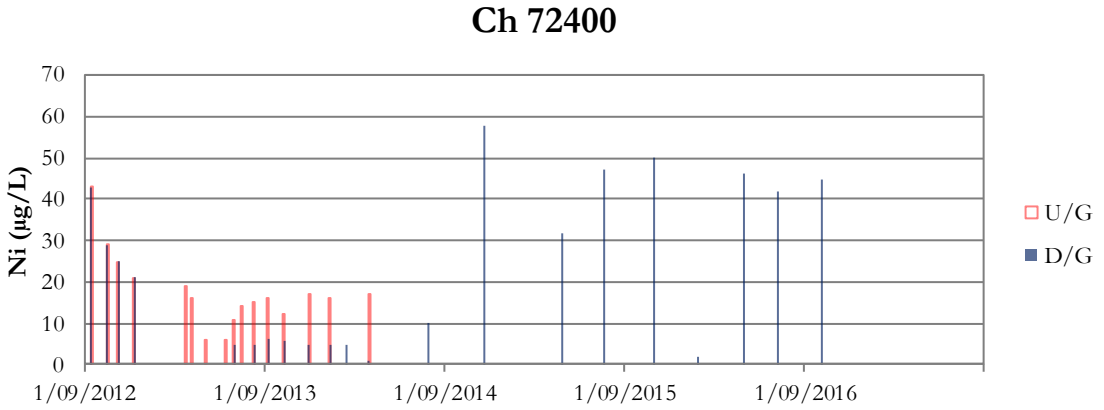

Figure 3.98 Ni concentrations from Ch 72400 since September 2012

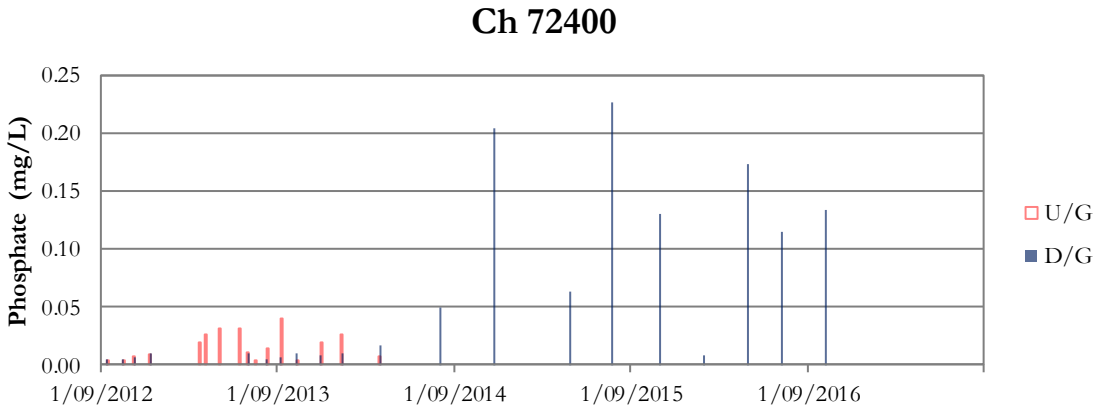

Figure 3.99 PO_3 concentrations from Ch 72400 since September 2012

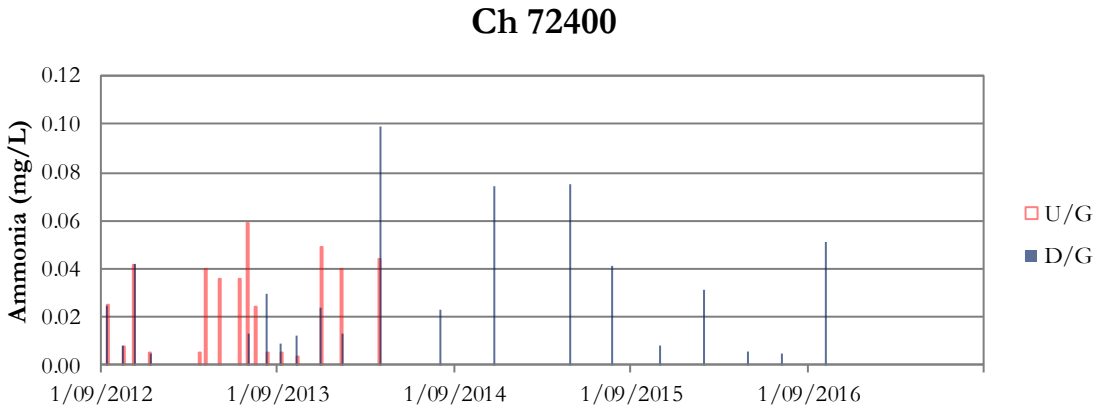

Figure 3.100 NH_4 concentrations from Ch 72400 since September 2012

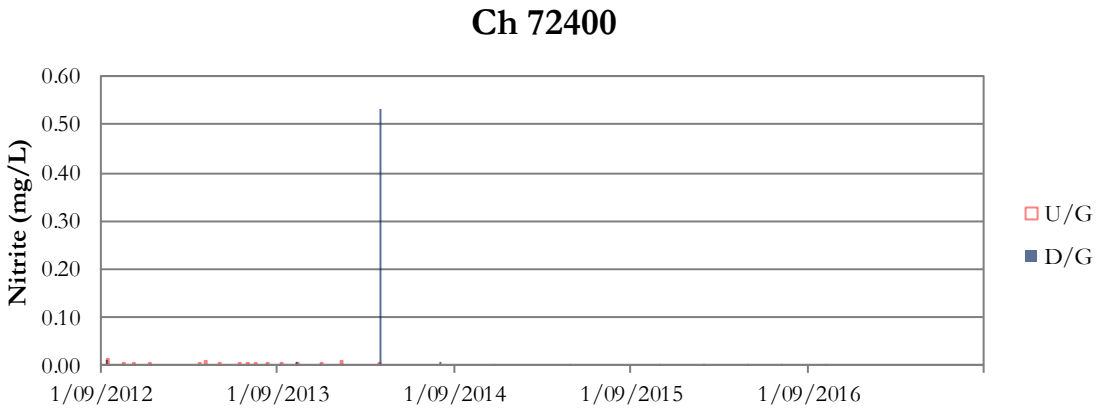

Figure 3.101 NO_2 concentrations from Ch 72400 since September 2012

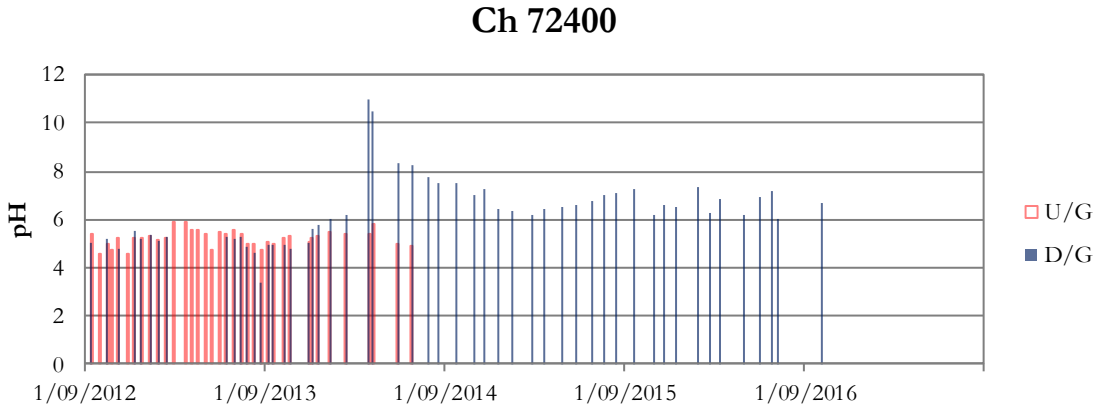

Figure 3.102 pH measurements from Ch 72400 since September 2012

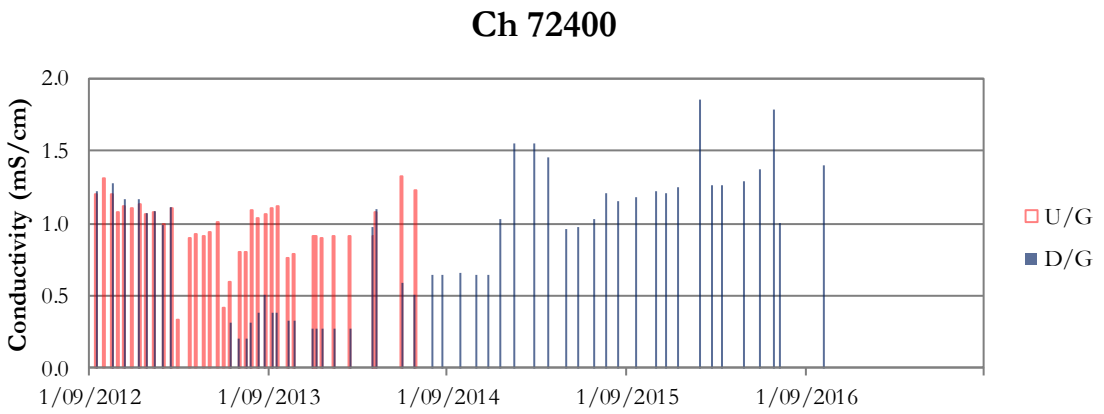

Figure 3.103 EC measurements from Ch 72400 since September 2012

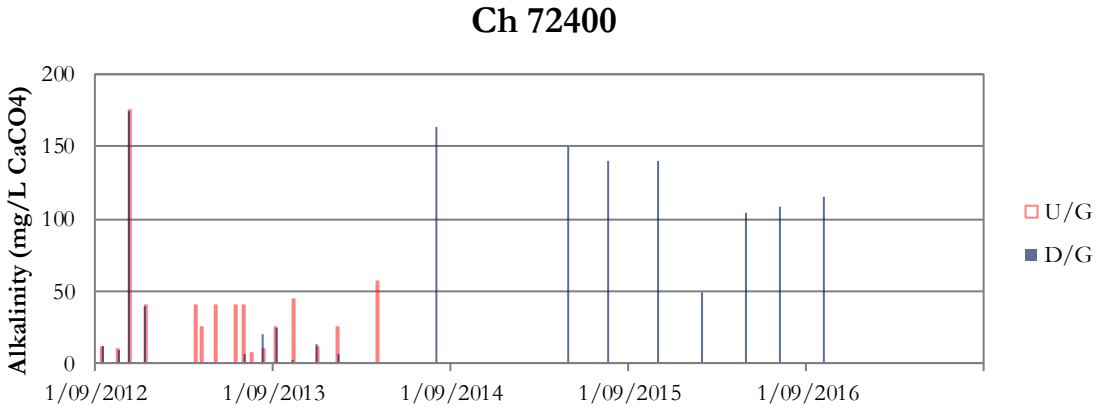

Figure 3.104 Alkalinity measurements from Ch 72400 since September 2012

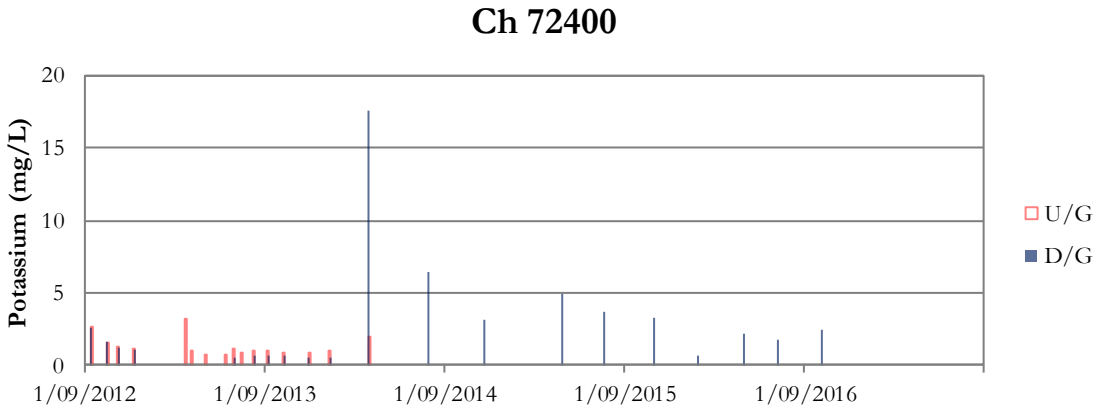

Figure 3.105 Potassium measurements from Ch 72400 since September 2012

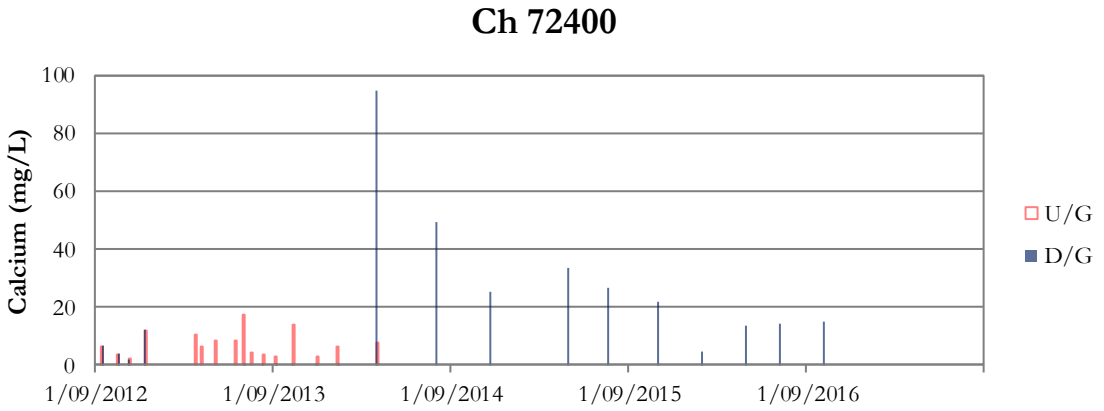

Figure 3.106 Calcium measurements from Ch 72400 since September 2012

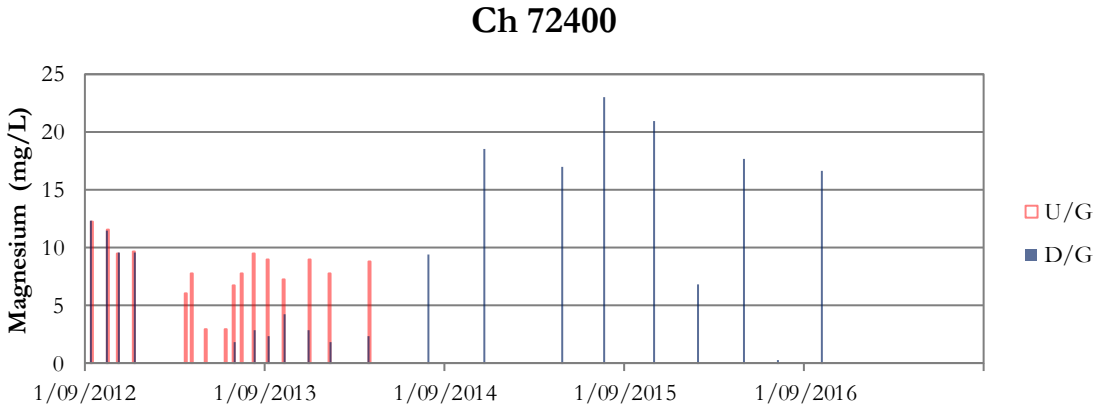

Figure 3.107 Magnesium measurements from Ch 72400 since September 2012

Summary: All of the parameters that generated a result of interest were measured within the ranges observed during construction phase monitoring.

3.3.5 Ch 74400

Results of interest from Ch 74400 (**Table B.4**) were the downgradient median Ni, TP, PO_3, temperature, alkalinity Mg and Ca measurements. There was no water in the upgradient piezometer during this reporting period or for the last six months of the construction phase monitoring, limiting the capacity to draw conclusions about groundwater quality. All of the

parameters that generated a result of interest were measured within the ranges observed during pre-construction phase and/or construction phase monitoring.

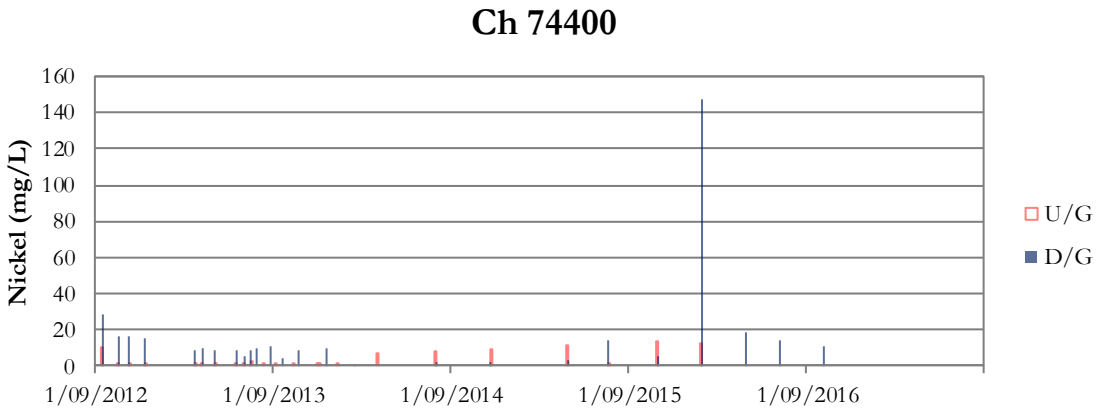

Figure 3.108 Ni measurements from Ch 74400 since September 2012

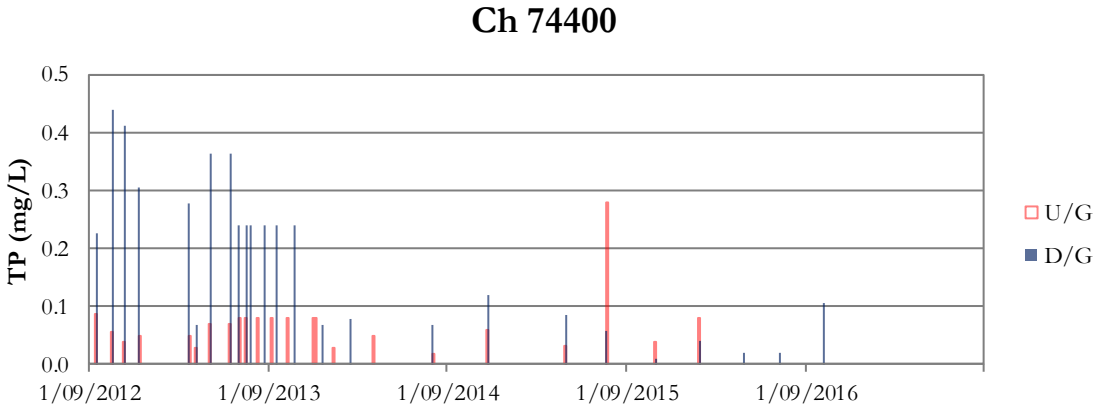

Figure 3.109 TP measurements from Ch 74400 since September 2012

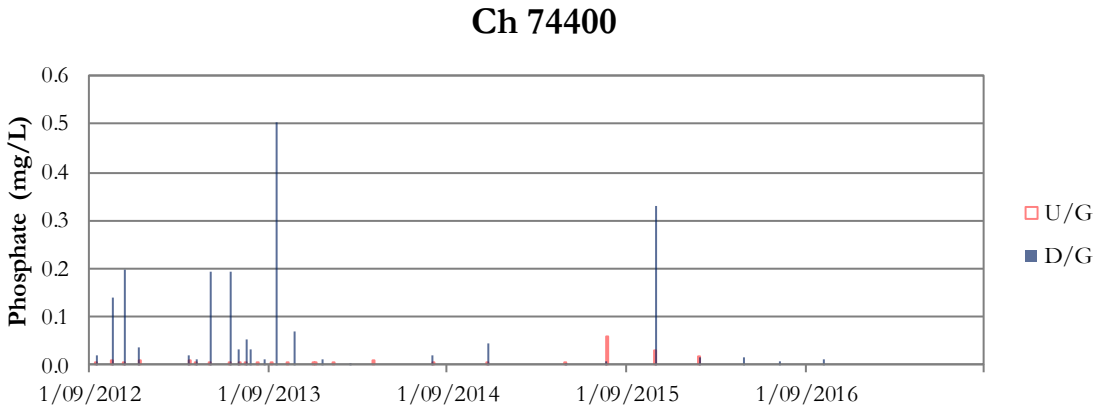

Figure 3.110 Phosphate measurements from Ch 74400 since September 2012

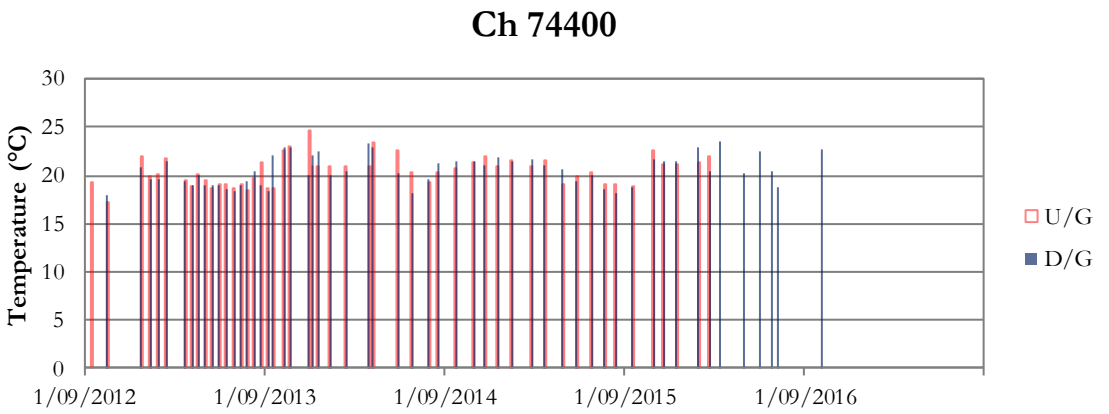

Figure 3.111 Temperature measurements from Ch 74400 since September 2012

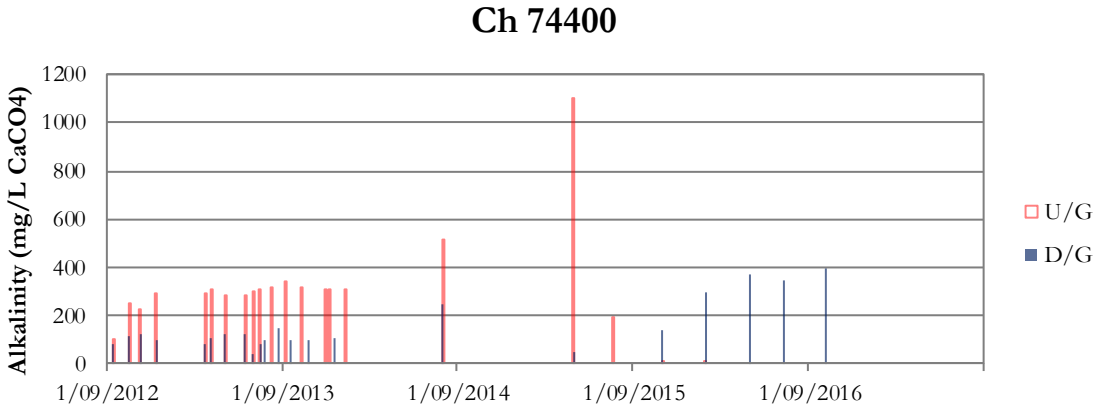

Figure 3.112 Alkalinity measurements from Ch 74400 since September 2012

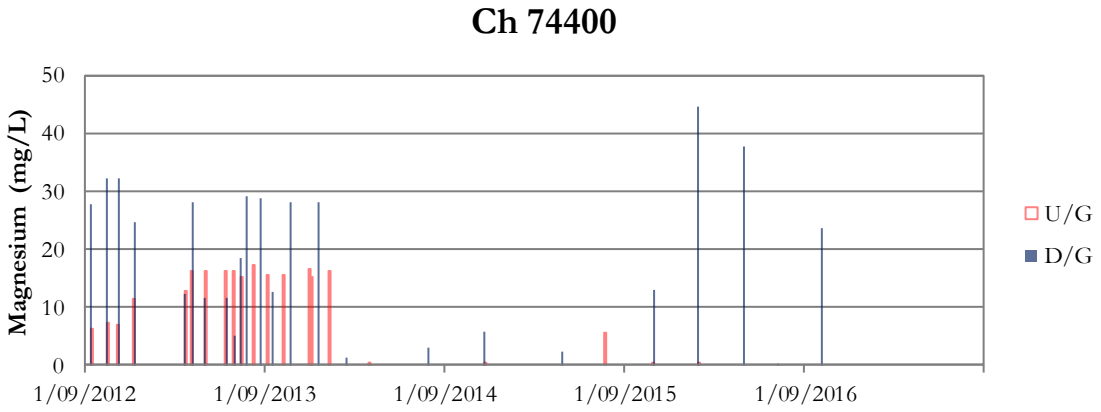

Figure 3.113 Mg measurements from Ch 74400 since September 2012

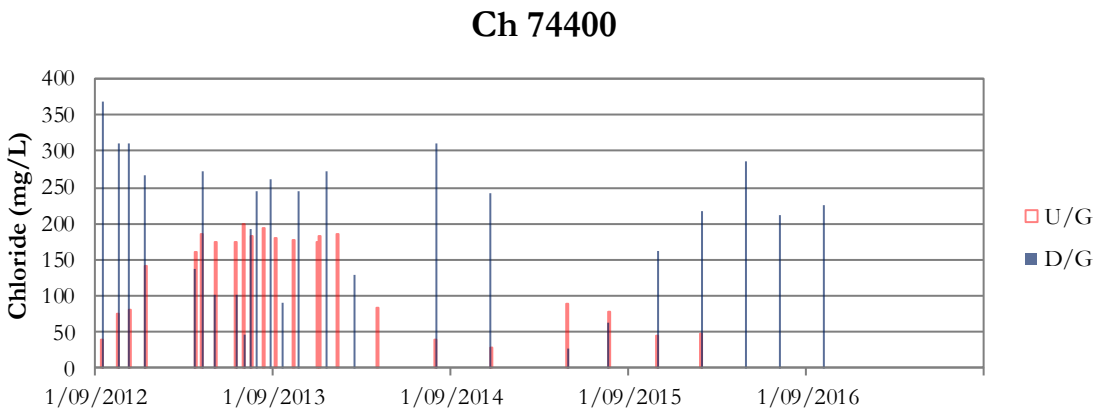

Figure 3.114 Chloride measurements from Ch 74400 since September 2012

Summary: All of the parameters that generated a result of interest were measured within the ranges observed during construction phase monitoring.

3.3.6 Ch 75500

There were no results of interest from Ch 75500 (**Table B.5**). There is no upgradient piezometer at Ch 75500, limiting the capacity to draw conclusions about groundwater quality. All measurements were within the ranges observed during preconstruction and construction phase monitoring.

Summary: No results of interest from Ch75500.

3.3.7 Ch 78500

The only results of interest from Ch 78500 (**Table B.6**) were the downgradient median NO_2, temperature and pH measurements. 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. All of the parameters that registered results of

interest during this reporting period were within the range of the results from the pre-construction and/or construction phase monitoring.

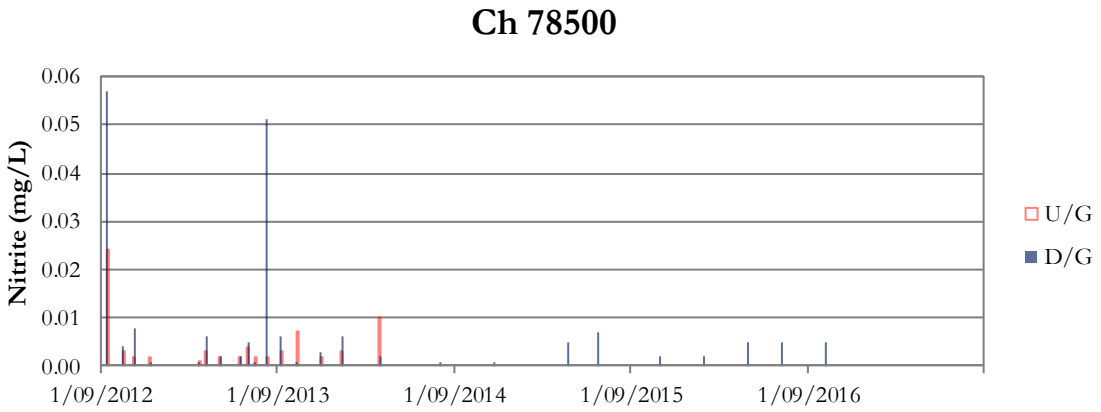

Figure 3.115 Nitrite measurements from Ch 78500 since September 2012

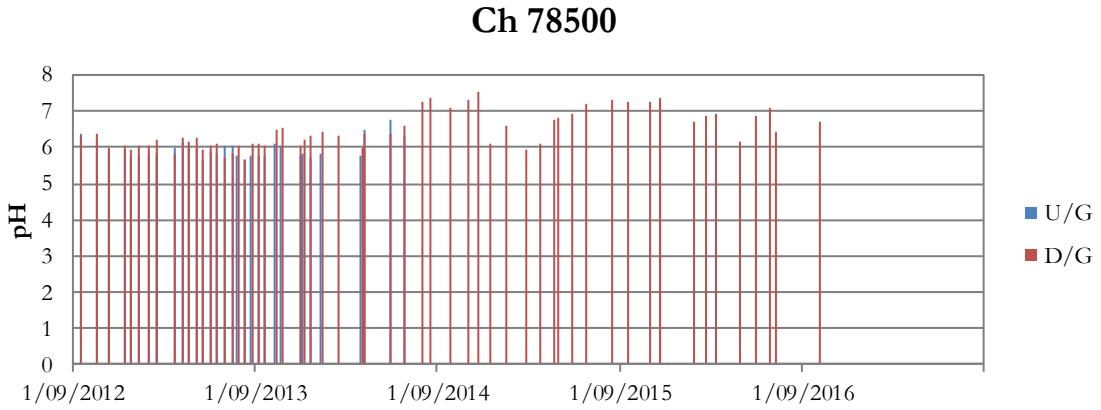

Figure 3.116 pH measurements from Ch 78500 since September 2012

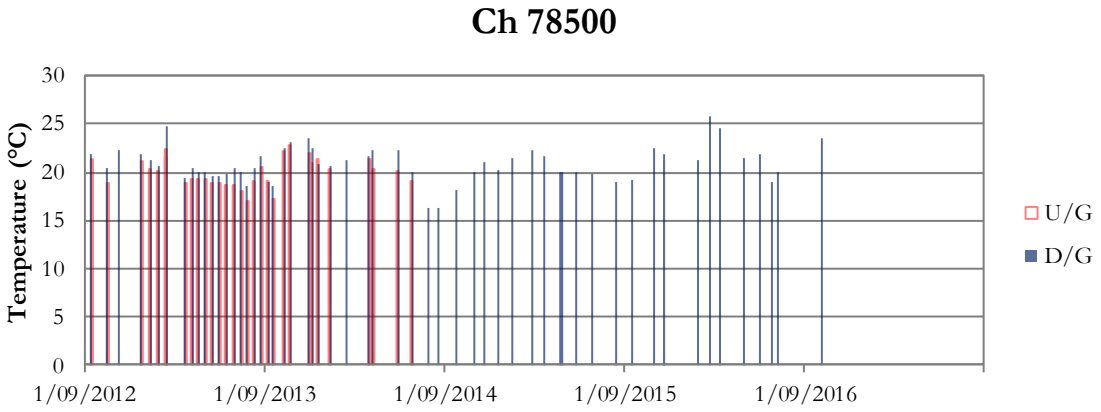

Figure 3.117 Temperature measurements from Ch 78500 since September 2012

Summary: All of the parameters that generated a result of interest were measured within the ranges observed during construction phase monitoring.

3.3.8 Groundwater Level

There are no logged groundwater results available between 1 September 2016 and July 2017. The logged data collected after July 2017 is displayed in **Figures 3.118 to 3.123**.

The median relative difference between groundwater levels at the pair of bores at Ch63200 was 5.5m during pre-construction monitoring. There is no upgradient logged data for the period between July 2017 and 31 August 2017 (**Figure 3.118**).

The median relative difference between groundwater level at the pair of bores at Ch64600 was 0.16m during pre-construction monitoring. During the current monitoring period the relative difference was generally -0.3m to 0.3m (**Figure 3.119**).

The median relative difference between groundwater level at the pair of bores at Ch72400 was not reported because the upgradient well (30500.1) was dry. There is no logged data for the upgradient well between July 2017 and 31 August 2017 (**Figure 3.120**).

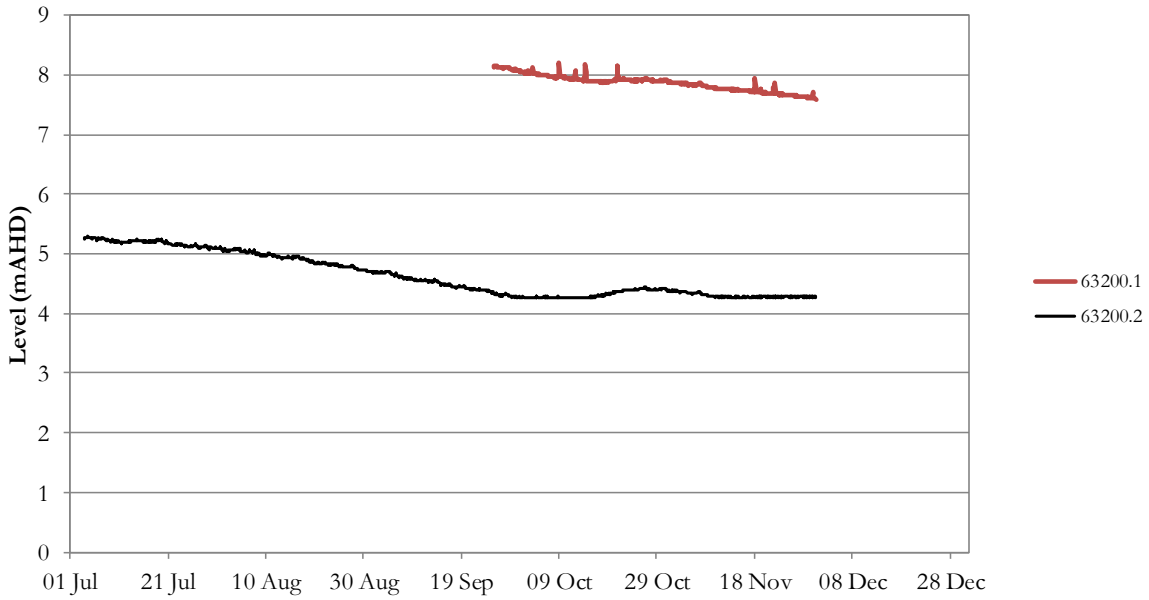

Figure 3.118 Groundwater levels at chainage 63200

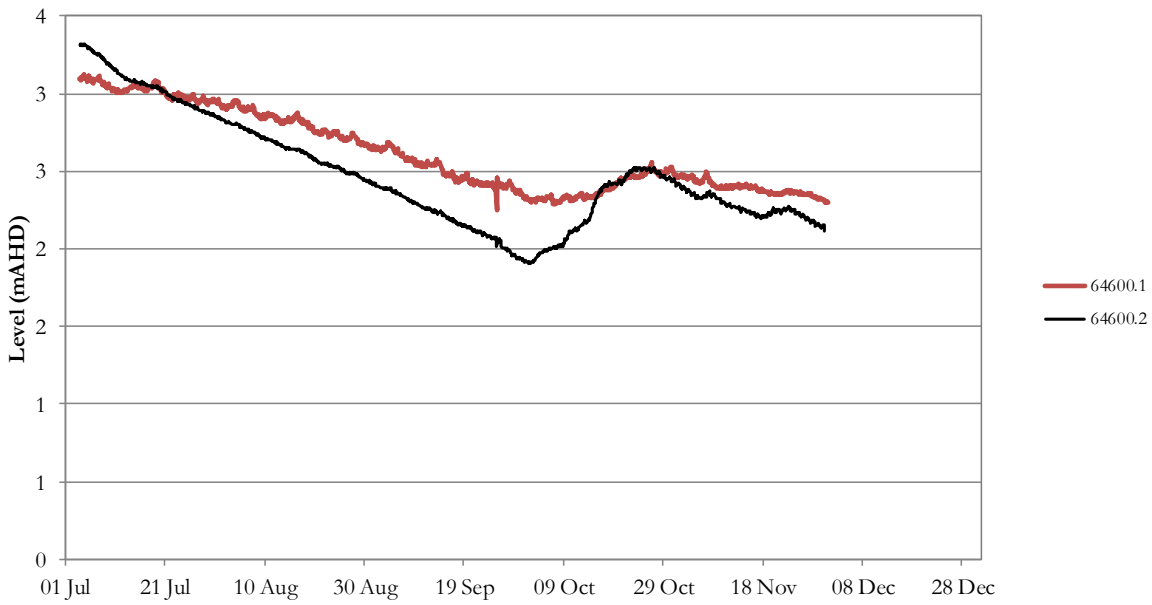

Figure 3.119 Groundwater levels at chainage 64600

The median relative difference between groundwater level at the pair of bores at Ch72400 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 upstream bore at 74400 did not change during the current monitoring period indicating that the water level is below the screened area and the well is effectively dry (**Figure 3.121**).

There was no downgradient bore installed at approximate chainage 75500 for the preconstruction period and no relative difference between levels reported (**Figure 3.122**).

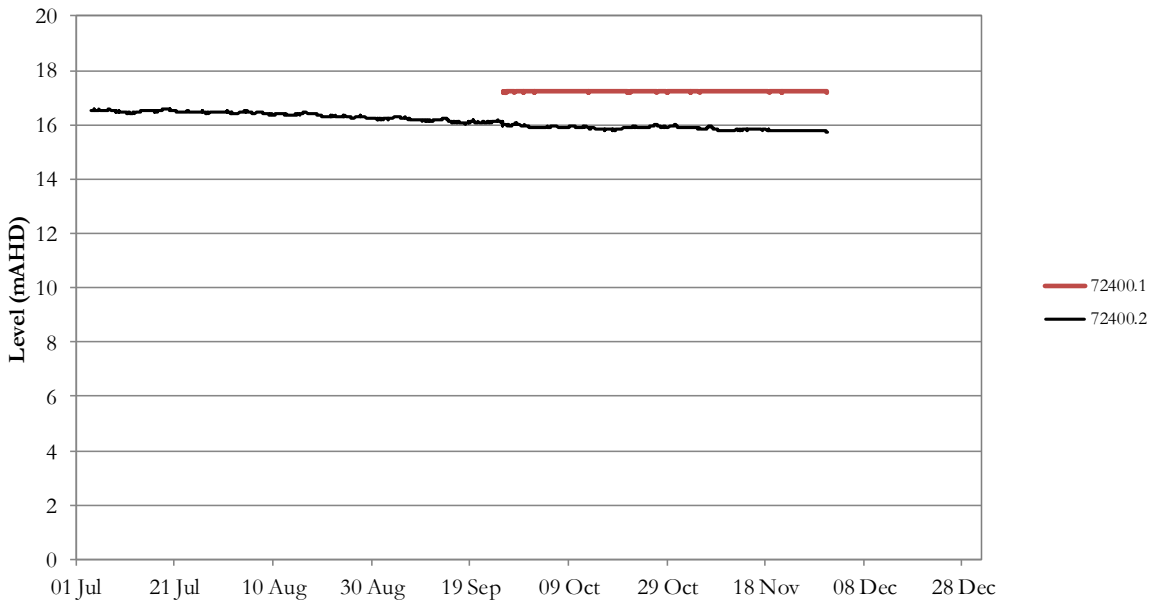

Figure 3.120 Groundwater levels at chainage 72400

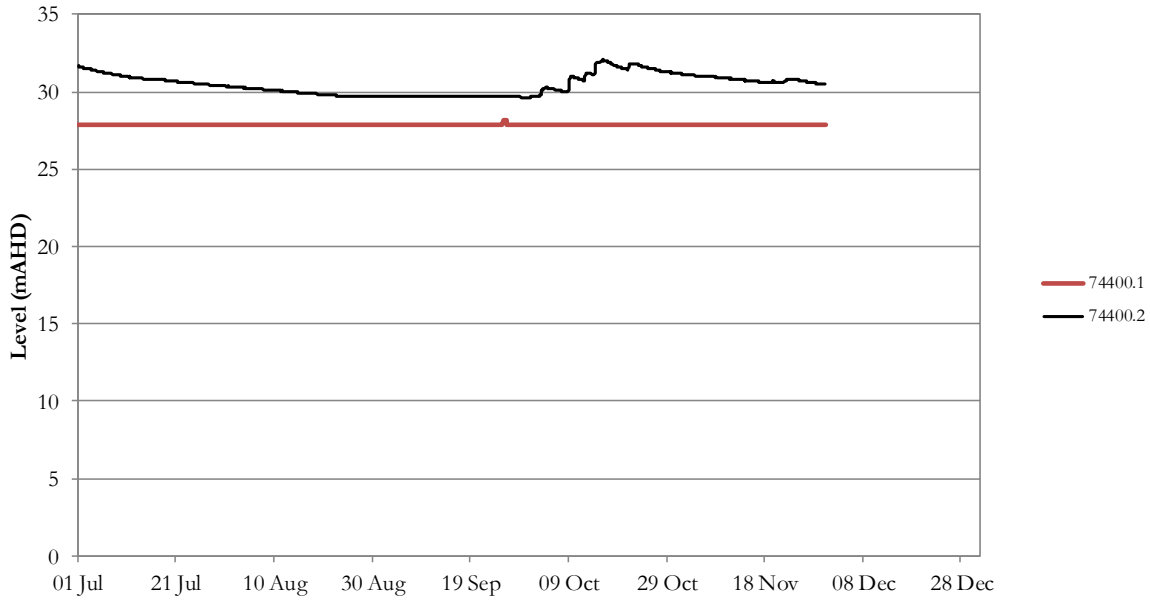

Figure 3.121 Groundwater levels at chainage 74400

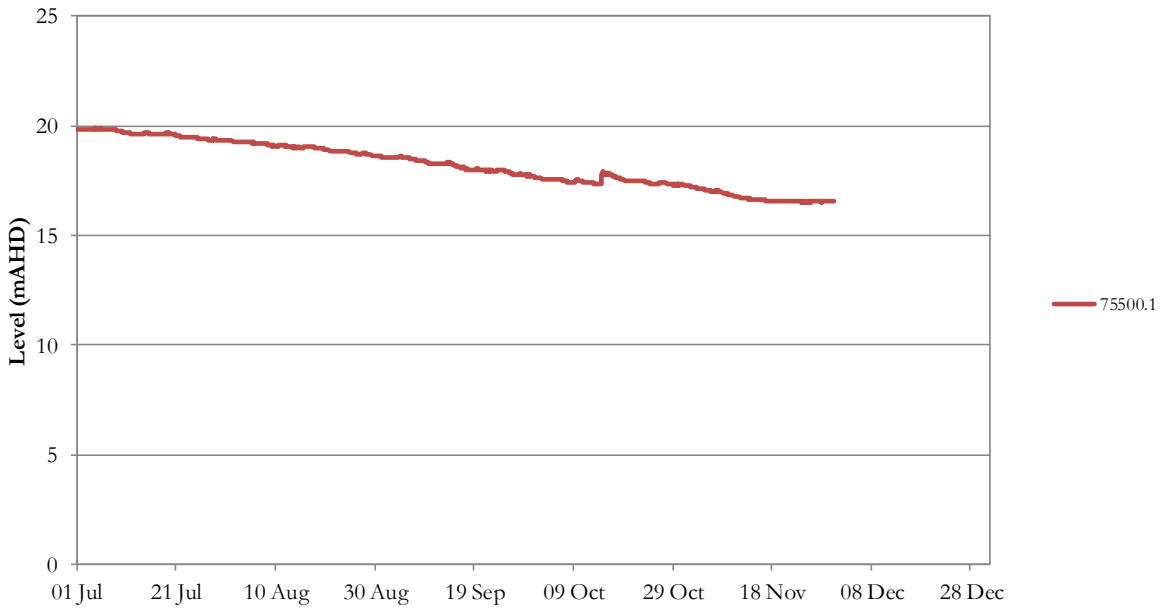

Figure 3.122 Groundwater levels at chainage 75500

The median relative difference in the groundwater levels for the two piezometers at approximate chainage 78500 was reported as 4.70m for the pre-construction period. During the operational monitoring period the level in the upgradient well has not changed, indicating that the water level is below the screened area of the piezometer and that it is dry (**Figure 3.123**).

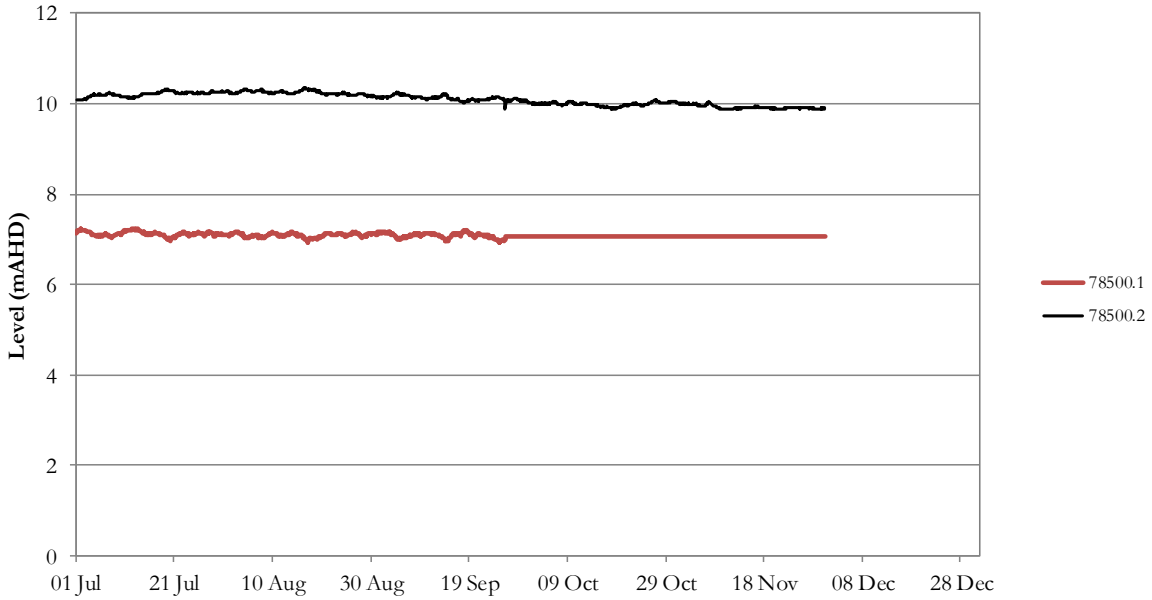

Figure 3.123 Groundwater levels at chainage 78500

4 Conclusions

Due to a lag between the construction contractor ceasing monitoring and the operational phase monitoring contractor beginning, in addition to very dry conditions during July and August 2017, a smaller number of samples were collected than are required by the SWMP and GMP. However, the required number of samples will be captured in ongoing monitoring and the program will achieve its stated objectives.

The following general conclusions can be drawn from the first 12 months of operational monitoring:

- 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 at this early stage in the monitoring and these parameters will be reviewed in the next annual report (for the period between 1 September 2017 and 31 August 2018) to assess for ongoing trends.
- No hydrocarbons have been detected in any groundwater or surface water samples at this stage of monitoring.
- 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 upstream and downstream at almost all surface water sites in the operational dataset. Additionally, copper concentrations are higher at most sites in the operational dataset. In many cases the data suggests that the source of the higher concentrations is upstream of the highway crossings, because upstream concentrations have also been elevated, even during wet events. Continued data collection should indicate whether construction activities have contributed to an increase in the concentrations of these parameters.
- The concentrations of several groundwater parameters indicate a potential impact arising from the operation of the NH2U upgrade at some of the cuttings and embankments. Results of interest included high concentrations of iron, total phosphorus ammonia and pH at more than one of the groundwater sites. However, this comparison is based upon

one individual operational data point in most cases and the capacity to draw conclusions about groundwater quality is restricted in most cases by a lack of upgradient data.

- Measured groundwater levels declined at all sites between July 2017 and 31 August 2017. Rainfall was below average for much of the period measured. At two of the three sites (Ch63200 and Ch64600) where comparisons of relative groundwater levels from the pre-construction period are available, the operational relative levels appear to be consistent. At the other site (Ch78500) the upgradient piezometer ran dry during the construction period.
- Generating conclusions about groundwater levels and quality may be restricted by the fact that several piezometers were decommissioned during construction, new bores were located in different areas and other bores ran dry.
- Many of the groundwater piezometers are returning results suggesting that groundwater levels are below the screened section, indicating that the piezometers are not being recharged and that some groundwater results may need to be discounted in future analyses.

The following factors need to be considered in the interpretation of the results presented:

- 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.
- Many of the results reported for this monitoring period are based upon small numbers of samples.
- The comparison between upstream P80 and downstream median values will increase in value as more data is collected.

References

ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

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Schubert, S. (2016a) Nambucca Heads to Urunga – Pacific Highway Upgrade – NH2U Construction Surface Water Quality Report.

Schubert, S. (2016b) Nambucca Heads to Urunga – Pacific Highway Upgrade – NH2U Construction Groundwater Quality Report.

Appendix A
Surface Water – Summary Monitoring Data

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

Parameter	*PQL*	*Upstream SW380 Pre P80*	*Downstream SW351 Pre Med*	*Upstream SW380 Pre/Con P80*	*Downstream SW351 Con Med*	*Upstream SW380 Pre/Con/Op P80*	*Downstream SW351 Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	149.80	106.50	330.78	184.00	422.80	790.00
Arsenic-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.50
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Iron-Total (µg/L)	10	727.67	390.50	3017.80	864.50	2819.40	1400.00
Manganese-Total (µg/L)	5	335.20	29.51	329.62	43.51	322.87	22.00
Nickel-Total (µg/L)	1	3.00	1.00	3.00	1.00	3.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	2.00	1.00	2.00	2.00	2.00	1.00
Zinc-Total (µg/L)	1	4.60	3.50	6.64	3.50	5.91	3.50
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	1.02	1.36	0.87	1.35	0.86	0.90
Nitrite as N in water (mg/L)	0.005	0.002	0.005	0.006	0.008	0.006	0.005
Nitrate as N in water (mg/L)	0.005	0.006	0.009	0.006	0.005	0.006	0.005
Ammonia as N in water (mg/L)	0.005	0.646	0.198	0.475	0.095	0.451	0.008
Phosphorus – Total (mg/L)	0.05	0.02	0.06	0.03	0.04	0.05	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.005	0.005	0.013	0.012
Total Suspended Solids (mg/L)	5	41.80	6.00	39.16	10.00	38.36	7.50
Temperature (°C)	0.01	23.24	23.16	23.25	20.82	23.24	11.75
pH	0.01	5.09	6.19	6.36	6.79	6.33	5.37
Conductivity (mS/cm)	0.01	0.90	0.55	0.89	1.04	0.89	0.11
Turbidity (NTU)	0.01	33.20	4.45	34.80	4.60	34.00	6.00
Dissolved Oxygen (mg/L) (P20)*	0.01	2.36	3.36	3.30	3.53	3.40	4.56

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW353 Pre Med*	*Upstream SW360U Pre/Con P80*	*Downstream SW353 Con Med*	*Upstream SW360U Pre/Con/Op P80*	*Downstream SW353 Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	3.40	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	12.80	5.00	401.20	35.50	580.00	1025.00
Arsenic-Total (µg/L)	1	1.60	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Iron-Total (µg/L)	10	913.60	52.20	2702.40	255.86	3093.00	3300.00
Manganese-Total (µg/L)	5	388.00	118.11	422.80	131.00	418.00	238.00
Nickel-Total (µg/L)	1	10.60	2.50	13.20	2.00	12.00	6.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	9.60	3.00	5.00	2.00	5.00	1.00
Zinc-Total (µg/L)	1	64.40	6.50	69.40	8.50	67.00	26.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	1.65	0.72	1.29	0.55	1.20	0.80
Nitrite as N in water (mg/L)	0.005	0.004	0.002	0.007	0.004	0.005	0.005
Nitrate as N in water (mg/L)	0.005	0.041	0.015	0.039	0.026	0.044	0.199
Ammonia as N in water (mg/L)	0.005	0.239	0.087	0.314	0.119	0.301	0.029
Phosphorus – Total (mg/L)	0.05	0.07	0.02	0.06	0.02	0.06	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.006	0.005	0.010	0.020
Total Suspended Solids (mg/L)	5	47.80	10.00	34.60	9.75	34.20	8.00
Temperature (°C)	0.01	27.14	24.59	25.87	21.40	25.85	13.00
pH	0.01	7.41	7.16	7.19	7.11	7.18	4.51
Conductivity (mS/cm)	0.01	31.20	28.00	30.92	20.90	30.76	1.63
Turbidity (NTU)	0.01	35.26	8.95	34.04	4.00	31.60	11.85
Dissolved Oxygen (mg/L) (P20)*	0.01	3.77	7.65	3.96	4.66	3.98	6.18

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW381 Pre Med*	*Upstream SW380 Pre/Con P80*	*Downstream SW381 Con Med*	*Upstream SW380 Pre/Con/Op P80*	*Downstream SW381 Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	149.80	64.50	330.78	262.00	422.80	1200.00
Arsenic-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Iron-Total (µg/L)	10	727.67	475.38	3017.80	1330.00	2819.40	1130.00
Manganese-Total (µg/L)	5	335.20	295.00	329.62	150.24	322.87	19.00
Nickel-Total (µg/L)	1	3.00	2.00	3.00	2.00	3.00	1.50
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	2.00	1.00	2.00	2.00	2.00	1.00
Zinc-Total (µg/L)	1	4.60	4.00	6.64	4.00	5.91	4.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	1.02	0.79	0.87	0.48	0.86	0.50
Nitrite as N in water (mg/L)	0.005	0.002	0.002	0.006	0.005	0.006	0.005
Nitrate as N in water (mg/L)	0.005	0.006	0.005	0.006	0.009	0.006	0.005
Ammonia as N in water (mg/L)	0.005	0.646	0.033	0.475	0.101	0.451	0.005
Phosphorus – Total (mg/L)	0.05	0.02	0.06	0.03	0.04	0.05	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.005	0.006	0.013	0.015
Total Suspended Solids (mg/L)	5	41.80	15.25	39.16	14.40	38.36	5.00
Temperature (°C)	0.01	23.24	24.28	23.25	22.13	23.24	13.86
pH	0.01	5.09	5.53	6.36	5.68	6.33	5.42
Conductivity (mS/cm)	0.01	0.90	0.69	0.89	0.38	0.89	0.23
Turbidity (NTU)	0.01	33.20	13.00	34.80	11.40	34.00	14.90
Dissolved Oxygen (mg/L) (P20)*	0.01	2.36	5.44	3.30	5.33	3.40	7.71

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW360D Pre Med*	*Upstream SW360U Pre/Con P80*	*Downstream SW360D Con Med*	*Upstream SW360U Pre/Con/Op P80*	*Downstream SW360D Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	3.40	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	12.80	5.00	401.20	37.00	580.00	985.00
Arsenic-Total (µg/L)	1	1.60	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Iron-Total (µg/L)	10	913.60	35.50	2702.40	392.00	3093.00	3600.00
Manganese-Total (µg/L)	5	388.00	171.50	422.80	231.00	418.00	245.50
Nickel-Total (µg/L)	1	10.60	2.50	13.20	4.00	12.00	6.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	9.60	6.50	5.00	2.00	5.00	1.00
Zinc-Total (µg/L)	1	64.40	4.50	69.40	7.00	67.00	24.50
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	1.65	0.79	1.29	0.67	1.20	0.80
Nitrite as N in water (mg/L)	0.005	0.004	0.001	0.007	0.006	0.005	0.005
Nitrate as N in water (mg/L)	0.005	0.041	0.010	0.039	0.011	0.044	0.198
Ammonia as N in water (mg/L)	0.005	0.239	0.046	0.314	0.173	0.301	0.025
Phosphorus – Total (mg/L)	0.05	0.07	0.04	0.06	0.03	0.06	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.006	0.005	0.010	0.025
Total Suspended Solids (mg/L)	5	47.80	14.00	34.60	8.00	34.20	5.00
Temperature (°C)	0.01	27.14	25.08	25.87	21.78	25.85	12.80
pH	0.01	7.41	7.12	7.19	6.37	7.18	4.60
Conductivity (mS/cm)	0.01	31.20	20.10	30.92	11.20	30.76	1.58
Turbidity (NTU)	0.01	35.26	9.30	34.04	4.50	31.60	13.05
Dissolved Oxygen (mg/L) (P20)*	0.01	3.77	8.71	3.96	5.01	3.98	5.94

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW359D Pre Med*	*Upstream SW359U Pre/Con P80*	*Downstream SW359D Con Med*	*Upstream SW359U Pre/Con/Op P80*	*Downstream SW359D Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	3.40	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	5.60	5.00	26.40	13.00	27.80	575.00
Arsenic-Total (µg/L)	1	2.00	2.00	2.80	1.00	2.40	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	2.00	1.00	2.00	1.00
Iron-Total (µg/L)	10	28.00	15.50	101.00	22.00	107.40	610.00
Manganese-Total (µg/L)	5	99.40	11.00	47.96	28.00	45.87	33.50
Nickel-Total (µg/L)	1	2.15	1.50	2.00	1.00	2.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	11.40	9.50	10.00	3.00	10.00	1.00
Zinc-Total (µg/L)	1	3.60	1.50	10.00	3.00	10.00	3.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	1.19	0.40	0.43	0.24	0.44	0.45
Nitrite as N in water (mg/L)	0.005	0.003	0.002	0.005	0.001	0.005	0.005
Nitrate as N in water (mg/L)	0.005	0.036	0.010	0.043	0.012	0.045	0.069
Ammonia as N in water (mg/L)	0.005	0.046	0.018	0.073	0.017	0.072	0.014
Phosphorus – Total (mg/L)	0.05	0.09	0.04	0.03	0.02	0.03	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.009	0.005	0.009	0.022
Total Suspended Solids (mg/L)	5	117.60	16.00	32.00	9.00	29.00	9.00
Temperature (°C)	0.01	26.31	25.55	25.47	22.01	25.58	23.30
pH	0.01	7.51	7.52	7.55	7.45	7.55	7.37
Conductivity (mS/cm)	0.01	36.00	33.15	37.90	33.27	37.90	32.70
Turbidity (NTU)	0.01	160.80	13.35	23.00	6.80	22.72	6.90
Dissolved Oxygen (mg/L) (P20)*	0.01	5.32	6.14	4.49	5.78	4.36	6.19

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW315D Pre Med*	*Upstream SW315U Pre/Con P80*	*Downstream SW315D Con Med*	*Upstream SW315U Pre/Con/Op P80*	*Downstream SW315D Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	17.00	5.00	87.40	56.00	95.00	1900.00
Arsenic-Total (µg/L)	1	2.00	1.00	3.60	3.00	3.20	1.50
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.20	1.50
Iron-Total (µg/L)	10	1391.00	934.00	3830.90	3139.00	3249.58	1420.00
Manganese-Total (µg/L)	5	904.00	511.50	493.40	280.00	451.80	57.00
Nickel-Total (µg/L)	1	3.00	2.00	2.60	2.00	2.20	1.50
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	1.00	1.00	2.00	2.00	2.00	1.00
Zinc-Total (µg/L)	1	12.00	4.50	6.00	5.00	6.00	4.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	0.26	0.24	0.32	0.21	0.34	0.35
Nitrite as N in water (mg/L)	0.005	0.001	0.001	0.004	0.003	0.005	0.005
Nitrate as N in water (mg/L)	0.005	0.018	0.005	0.015	0.010	0.015	0.005
Ammonia as N in water (mg/L)	0.005	0.138	0.170	0.123	0.063	0.108	0.005
Phosphorus – Total (mg/L)	0.05	0.05	0.01	0.03	0.01	0.05	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.007	0.005	0.007	0.023
Total Suspended Solids (mg/L)	5	14.20	20.00	12.00	12.00	11.20	9.00
Temperature (°C)	0.01	20.69	20.21	22.08	18.76	21.89	15.24
pH	0.01	6.23	6.05	6.52	6.21	6.52	5.48
Conductivity (mS/cm)	0.01	0.95	0.88	0.91	0.54	0.91	0.24
Turbidity (NTU)	0.01	6.86	6.70	22.00	22.45	23.20	15.55
Dissolved Oxygen (mg/L) (P20)*	0.01	2.28	2.44	3.31	5.26	3.34	5.35

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW301D Pre Med*	*Upstream SW301U Pre/Con P80*	*Downstream SW301D Con Med*	*Upstream SW301U Pre/Con/Op P80*	*Downstream SW301D Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	20.80	9.00	100.00	41.62	106.00	2490.00
Arsenic-Total (µg/L)	1	3.79	1.00	2.47	1.00	2.28	2.50
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.50
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.50
Iron-Total (µg/L)	10	2555.60	491.08	1810.00	874.00	1839.02	2700.00
Manganese-Total (µg/L)	5	454.85	120.00	332.00	89.50	330.80	62.00
Nickel-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Selenium-Total (µg/L)	1	1.60	1.00	2.00	2.00	2.00	1.00
Zinc-Total (µg/L)	1	6.60	2.00	5.00	2.00	5.00	4.50
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	1.33	0.53	0.53	0.26	0.54	0.50
Nitrite as N in water (mg/L)	0.005	0.002	0.002	0.006	0.004	0.006	0.005
Nitrate as N in water (mg/L)	0.005	0.049	0.017	0.053	0.016	0.056	0.047
Ammonia as N in water (mg/L)	0.005	0.676	0.094	0.149	0.043	0.148	0.023
Phosphorus – Total (mg/L)	0.05	0.10	0.04	0.06	0.03	0.06	0.05
Phosphate as P in water (mg/L)	0.005	0.008	0.005	0.014	0.007	0.015	0.035
Total Suspended Solids (mg/L)	5	8.80	7.00	12.20	5.25	12.80	16.00
Temperature (°C)	0.01	22.67	22.33	23.53	20.87	23.46	14.54
pH	0.01	6.75	6.57	7.11	6.80	7.08	5.75
Conductivity (mS/cm)	0.01	0.77	0.69	0.77	0.55	0.77	0.24
Turbidity (NTU)	0.01	17.42	9.40	20.84	9.20	21.60	64.00
Dissolved Oxygen (mg/L) (P20)*	0.01	1.82	6.14	3.94	6.04	4.07	7.32

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW262 Pre Med*	*Upstream SW261 Pre/Con P80*	*Downstream SW262 Con Med*	*Upstream SW261 Pre/Con/Op P80*	*Downstream SW262 Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	54.40	60.00	156.80	95.00	159.20	950.00
Arsenic-Total (µg/L)	1	2.00	1.00	2.01	1.00	2.00	1.50
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Copper-Total (µg/L)	1	1.00	1.00	2.00	1.00	2.00	1.50
Iron-Total (µg/L)	10	1683.20	1485.00	1870.80	1182.00	1842.60	1550.00
Manganese-Total (µg/L)	5	58.00	27.00	127.80	36.00	119.80	33.50
Nickel-Total (µg/L)	1	1.00	1.00	2.00	1.00	2.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	1.60	1.00	2.00	2.00	2.00	1.00
Zinc-Total (µg/L)	1	4.60	2.00	8.20	3.04	7.60	5.50
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	0.63	0.46	0.49	0.30	0.49	0.55
Nitrite as N in water (mg/L)	0.005	0.007	0.003	0.009	0.005	0.009	0.005
Nitrate as N in water (mg/L)	0.005	0.018	0.017	0.028	0.016	0.030	0.105
Ammonia as N in water (mg/L)	0.005	0.045	0.040	0.060	0.043	0.058	0.005
Phosphorus – Total (mg/L)	0.05	0.09	0.04	0.06	0.03	0.06	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.009	0.005	0.012	0.020
Total Suspended Solids (mg/L)	5	7.60	5.00	17.90	5.25	17.50	6.50
Temperature (°C)	0.01	23.31	22.12	23.64	21.06	23.60	14.30
pH	0.01	7.21	6.91	7.40	6.91	7.39	6.02
Conductivity (mS/cm)	0.01	0.52	0.27	0.80	0.28	0.77	0.15
Turbidity (NTU)	0.01	6.46	3.90	12.62	5.80	12.68	29.35
Dissolved Oxygen (mg/L) (P20)*	0.01	2.51	4.61	2.69	5.75	2.73	7.63

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW231D Pre Med*	*Upstream SW231U Pre/Con P80*	*Downstream SW231D Con Med*	*Upstream SW231U Pre/Con/Op P80*	*Downstream SW231D Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	3.40	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	8.60	5.00	52.00	17.00	60.00	925.00
Arsenic-Total (µg/L)	1	3.00	2.00	3.00	2.00	3.00	1.50
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.60	1.00	2.00	1.00	2.00	2.00
Iron-Total (µg/L)	10	47.80	15.00	168.81	40.50	268.20	1050.00
Manganese-Total (µg/L)	5	52.20	26.50	60.20	38.00	63.80	56.50
Nickel-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	13.60	7.00	10.00	2.50	10.00	1.00
Zinc-Total (µg/L)	1	6.40	2.50	6.00	3.50	6.00	3.50
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	0.34	0.31	0.38	0.29	0.38	0.45
Nitrite as N in water (mg/L)	0.005	0.002	0.002	0.005	0.002	0.005	0.005
Nitrate as N in water (mg/L)	0.005	0.021	0.005	0.052	0.008	0.053	0.127
Ammonia as N in water (mg/L)	0.005	0.039	0.035	0.064	0.018	0.061	0.012
Phosphorus – Total (mg/L)	0.05	0.03	0.02	0.03	0.02	0.03	0.05
Phosphate as P in water (mg/L)	0.005	0.005	0.005	0.011	0.005	0.011	0.032
Total Suspended Solids (mg/L)	5	8.80	6.00	13.20	8.50	12.90	5.50
Temperature (°C)	0.01	26.51	24.44	25.99	21.35	25.79	19.63
pH	0.01	7.70	7.11	7.63	7.38	7.61	6.96
Conductivity (mS/cm)	0.01	38.40	22.30	41.32	25.50	40.60	16.30
Turbidity (NTU)	0.01	10.48	4.35	12.70	5.35	12.58	2.90
Dissolved Oxygen (mg/L) (P20)*	0.01	5.78	7.79	4.63	6.55	4.73	7.04

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW217D Pre Med*	*Upstream SW217U Pre/Con P80*	*Downstream SW217D Con Med*	*Upstream SW217U Pre/Con/Op P80*	*Downstream SW217D Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10					10	10
TRH C6 - C10 (µg/L)	10					10	10
TRH C10 - C14 (µg/L)	50					50	50
TRH C15 - C28 (µg/L)	100					100	100
TRH C29 - C36 (µg/L)	100					100	100
TRH >C10 - C16 (µg/L)	50					50	50
TRH >C16 - C34 (µg/L)	100					100	100
TRH >C34 - C40 (µg/L)	100					100	100
Silver-Total (µg/L)	1			1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10			37.00	14.00	47.20	780.00
Arsenic-Total (µg/L)	1			5.80	2.35	5.40	3.50
Cadmium-Total (µg/L)	0.1			1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1			1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1			1.00	1.00	1.00	1.50
Iron-Total (µg/L)	10			1031.40	257.00	1088.20	935.00
Manganese-Total (µg/L)	5			489.00	130.00	461.80	25.50
Nickel-Total (µg/L)	1			1.00	1.00	1.00	1.00
Lead-Total (µg/L)	1			1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1			4.40	2.00	3.20	1.00
Zinc-Total (µg/L)	1			4.00	2.00	4.00	3.00
Mercury-Total (µg/L)	0.05			0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1			0.27	0.24	0.30	0.40
Nitrite as N in water (mg/L)	0.005			0.005	0.002	0.005	0.005
Nitrate as N in water (mg/L)	0.005			0.016	0.012	0.018	0.049
Ammonia as N in water (mg/L)	0.005			0.048	0.030	0.047	0.005
Phosphorus – Total (mg/L)	0.05			0.05	0.03	0.05	0.05
Phosphate as P in water (mg/L)	0.005			0.017	0.006	0.018	0.027
Total Suspended Solids (mg/L)	5			7.80	5.00	7.40	5.50
Temperature (°C)	0.01	22.68	23.33	23.87	20.55	24.00	21.03
pH	0.01	6.44	6.33	7.54	7.03	7.60	7.78
Conductivity (mS/cm)	0.01	3.27	11.30	4.49	4.08	3.70	3.12
Turbidity (NTU)	0.01	2.98	3.10	8.56	3.70	8.40	7.00
Dissolved Oxygen (mg/L) (P20)*	0.01	4.62	5.57	4.37	6.38	4.53	6.95

Red shading – Indicates a result of interest.

* - 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 P80*	*Downstream SW208D Pre Med*	*Upstream SW208U Pre/Con P80*	*Downstream SW208D Con Med*	*Upstream SW208U Pre/Con/Op P80*	*Downstream SW208D Op Med (2016-17)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10
TRH C6 - C10 (µg/L)	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	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	143.00	11.50	154.20	48.00	163.80	1180.00
Arsenic-Total (µg/L)	1	3.00	2.50	3.00	2.45	3.60	4.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50
Iron-Total (µg/L)	10	268.00	393.50	743.00	667.00	840.60	1600.00
Manganese-Total (µg/L)	5	21.00	268.50	227.60	87.00	214.80	95.50
Nickel-Total (µg/L)	1	3.00	1.00	2.00	1.00	2.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	1.00	1.00	2.00	2.00	2.00	1.00
Zinc-Total (µg/L)	1	4.00	2.50	5.00	2.00	5.00	3.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05
Total Nitrogen in water (mg/L)	0.1	1.41	0.37	0.77	0.26	0.76	0.40
Nitrite as N in water (mg/L)	0.005	0.005	0.003	0.006	0.003	0.006	0.005
Nitrate as N in water (mg/L)	0.005	0.011	0.016	0.014	0.007	0.019	0.023
Ammonia as N in water (mg/L)	0.005	0.302	0.039	0.202	0.033	0.184	0.005
Phosphorus – Total (mg/L)	0.05	0.16	0.04	0.11	0.03	0.11	0.05
Phosphate as P in water (mg/L)	0.005	0.088	0.007	0.060	0.009	0.058	0.030
Total Suspended Solids (mg/L)	5	72.80	3.00	28.00	3.75	26.40	6.10
Temperature (°C)	0.01	23.22	20.71	23.27	19.70	23.22	15.41
pH	0.01	7.00	6.63	7.52	6.89	7.51	6.64
Conductivity (mS/cm)	0.01	0.51	0.82	1.20	0.50	1.13	0.29
Turbidity (NTU)	0.01	28.60	3.95	18.40	5.70	18.44	12.90
Dissolved Oxygen (mg/L) (P20)*	0.01	2.03	3.45	2.92	6.30	3.06	9.90

Red shading – Indicates a result of interest.

* - 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*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con /op P80*	*op med*
			21300.1	*21300.2*	*21300.1*	*21300.2*	*21300.1*	*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
TRH C10 - C14	µg/L	50	50	50	50	50	50	50
TRH C15 - C28	µg/L	100	160	100	100	100	100	100
TRH C29 - C36	µg/L	100	100	100	100	100	100	100
TRH >C10 - C16	µg/L	50	220	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
Silver-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Aluminium-Dissolved	µg/L	10	20.6	101.0	296.3	59.0	296.3	65.0
Arsenic-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	5.0
Cadmium-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1.0	1.0
Chromium-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Copper-Dissolved	µg/L	1	9.2	2.0	3.0	1.7	3.0	1.0
Iron-Dissolved	µg/L	10	42.2	15.0	157.0	21.0	157.0	1488.0
Manganese-Dissolved	µg/L	5	156.8	40.0	265.0	14.0	265.0	35.0
Nickel-Dissolved	µg/L	1	13.4	3.0	5.0	1.0	5.0	1.0
Lead-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Selenium-Dissolved	µg/L	1	1.0	1.0	2.0	2.0	2.0	1.0
Zinc-Dissolved	µg/L	1	110.0	41.0	59.0	11.0	59.0	9.0
Mercury-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.50
Total Nitrogen	mg/L	0.1	0.79	0.18	0.35	0.16	0.35	2.58
Nitrite	mg/L	0.005	0.030	0.002	0.006	0.001	0.006	0.005
Nitrate	mg/L	0.005	0.346	0.018	0.156	0.032	0.156	0.033
Ammonia	mg/L	0.005	0.054	0.015	0.050	0.025	0.050	0.991
Total Phosphorus	mg/L	0.05	0.074	0.023	0.056	0.012	0.056	0.350
Phosphate	mg/L	0.005	0.012	0.005	0.006	0.005	0.006	0.007
Temp	C	0.01	20.70	19.56	21.00	19.54	21.00	18.93
pH		0.01	5.66	4.76	5.70	5.46	5.70	6.67
EC	mS/cm	0.01	0.27	0.14	0.27	0.13	0.27	0.17
Total Suspended Solids	mg/L	5	1554	169	1554		1554	950
TDS	mg/L	1	173.5	96.2	173.5		173.5	
BICARBONATE (ALKALINITY)	mg/L CaCO3	1	15.0	4.0	15.0	6.0	15.0	10.0
Sodium	mg/L	1	42.4	18.4	40.2	14.4	40.2	12.2
Potassium	mg/L	1	2.7	0.7	1.7	0.4	1.7	0.9
Calcium	mg/L	1	1.7	0.8	0.9	1.8	0.9	1.8
Magnesium	mg/L	1	1.9	3.0	1.5	1.9	1.5	1.1
Chloride	mg/L	1	53.0	39.1	54.4	29.4	54.4	19.5
Sulfate	mg/L	1	21.2	2.6	7.2	3.7	7.2	4.2

Red shading – Indicates a result of interest.

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

Parameter	*Units*	*PQL*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con/op P80*	*op med*
			22600.1	*22600.2*	*22600.1*	*22600.2*	*22600.1*	*22600.2*
TRH C6 - C9	µg/L	10	10	10	75.2	10	75.2	10
TRH C6 - C10	µg/L	10			84	10	84	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
Silver-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Aluminium-Dissolved	µg/L	10	25.8	6.0	2206.6	6.4	2206.6	5.0
Arsenic-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Cadmium-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1.0	1.0
Chromium-Dissolved	µg/L	1	2.4	2.5	2.0	1.0	2.0	1.0
Copper-Dissolved	µg/L	1	4.2	1.1	2.6	1.0	2.6	1.0
Iron-Dissolved	µg/L	10	17.4	16.0	62.8	5.0	62.8	4.0
Manganese-Dissolved	µg/L	5	25.2	30.5	42.6	20.0	42.6	22.0
Nickel-Dissolved	µg/L	1	16.0	2.5	3.7	1.0	3.7	1.0
Lead-Dissolved	µg/L	1	1.0	1.0	2.0	1.0	2.0	1.0
Selenium-Dissolved	µg/L	1	1.0	1.0	2.0	2.0	2.0	1.0
Zinc-Dissolved	µg/L	1	66.6	40.0	34.0	11.0	34.0	10.0
Mercury-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.50
Total Nitrogen	mg/L	0.1	0.47	0.22	0.31	0.06	0.31	0.23
Nitrite	mg/L	0.005	0.005	0.002	0.002	0.001	0.002	0.005
Nitrate	mg/L	0.005	0.022	0.007	0.054	0.007	0.054	0.014
Ammonia	mg/L	0.005	0.024	0.010	0.057	0.009	0.057	0.011
Total Phosphorus	mg/L	0.05	0.046	0.027	0.052	0.015	0.052	0.104
Phosphate	mg/L	0.005	0.008	0.005	0.010	0.006	0.010	0.013
Temp	C	0.01	20.88	21.43	20.93	20.60	20.93	23.30
pH		0.01	5.49	5.82	6.84	6.16	6.84	6.64
EC	mS/cm	0.01	0.24	0.26	1.40	0.27	1.40	0.32
Total Suspended Solids	mg/L	5	182	75	182		182	
TDS	mg/L	1	162.1	179.9	162.1		162.1	
BICARBONATE (ALKALINITY)	mg/L CaCO3	1	13.2	40.0	13.0	40.0	13.0	40.0
Sodium	mg/L	1	34.5	35.0	219.2	36.3	219.2	37.8
Potassium	mg/L	1	0.8	1.0	1.3	0.8	1.3	1.1
Calcium	mg/L	1	2.1	5.0	5.8	5.0	5.8	5.3
Magnesium	mg/L	1	4.8	6.9	8.5	7.0	8.5	7.3
Chloride	mg/L	1	62.6	56.0	332.4	54.0	332.4	55.5
Sulfate	mg/L	1	5.4	4.0	11.6	3.5	11.6	3.2

Red shading – Indicates a result of interest.

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

Parameter	*Units*	*PQL*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con/op P80*	*op med*
			30500.1	*30500.2*	*30500.1*	*30500.2*	*30500.1*	*30500.2*
TRH C6 - C9	µg/L	10		10	10	10	10	10
TRH C6 - C10	µg/L	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	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
Silver-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Aluminium-Dissolved	µg/L	10	90.0	84.0	165.7	47.5	165.7	6.0
Arsenic-Dissolved	µg/L	1	1.0	1.0	1.0	2.0	1.0	3.0
Cadmium-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1.0	1.0
Chromium-Dissolved	µg/L	1	7.4	4.0	3.0	1.0	3.0	1.0
Copper-Dissolved	µg/L	1	9.0	6.5	4.0	3.0	4.0	2.0
Iron-Dissolved	µg/L	10	15.8	13.0	313.8	262.0	313.8	8.0
Manganese-Dissolved	µg/L	5	823.2	485.0	388.0	181.0	388.0	370.0
Nickel-Dissolved	µg/L	1	34.6	27.0	21.0	5.8	21.0	45.0
Lead-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Selenium-Dissolved	µg/L	1	2.0	1.5	2.0	2.0	2.0	1.0
Zinc-Dissolved	µg/L	1	147.0	125.0	107.0	36.0	107.0	50.0
Mercury-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.50
Total Nitrogen	mg/L	0.1	0.58	0.43	0.40	0.14	0.40	0.32
Nitrite	mg/L	0.005	0.007	0.002	0.004	0.003	0.004	0.005
Nitrate	mg/L	0.005	0.027	0.027	0.185	0.020	0.185	0.040
Ammonia	mg/L	0.005	0.032	0.017	0.042	0.023	0.042	0.051
Total Phosphorus	mg/L	0.05	0.529	0.425	0.390	0.069	0.390	0.318
Phosphate	mg/L	0.005	0.008	0.006	0.027	0.017	0.027	0.134
Temp	C	0.01	20.98	20.21	21.46	20.23	21.46	18.01
pH		0.01	5.33	5.24	5.45	6.46	5.45	6.72
EC	mS/cm	0.01	1.19	1.14	1.12	0.82	1.12	1.40
Total Suspended Solids	mg/L	5		895				
TDS	mg/L	1		812.5				
BICARBONATE (ALKALINITY)	mg/L CaCO3	1	94.0	26.0	40.0	50.0	40.0	115.0
Sodium	mg/L	1	209.4	204.0	203.0	66.5	203.0	185.0
Potassium	mg/L	1	2.0	1.4	1.6	1.8	1.6	2.5
Calcium	mg/L	1	9.0	5.3	10.6	13.8	10.6	15.2
Magnesium	mg/L	1	11.9	10.6	9.6	4.3	9.6	16.6
Chloride	mg/L	1	275.6	250.5	249.0	102.0	249.0	210.0
Sulfate	mg/L	1	105.4	96.0	101.1	38.4	101.1	42.0

Red shading – Indicates a result of interest.

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

Parameter	*Units*	*PQL*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con/op P80*	*op med*
			32500.1	*32500.2*	*32500.1*	*32500.2*	*32500.1*	*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	54	50	54	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	106	50	106	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
Silver-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Aluminium-Dissolved	µg/L	10	44.2	153.0	345.8	52.0	345.8	1.0
Arsenic-Dissolved	µg/L	1	5.2	7.0	5.0	3.0	5.0	1.0
Cadmium-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1.0	1.0
Chromium-Dissolved	µg/L	1	11.4	6.0	2.8	1.0	2.8	1.0
Copper-Dissolved	µg/L	1	3.0	3.0	4.0	2.0	4.0	1.0
Iron-Dissolved	µg/L	10	375.0	776.0	109.4	78.0	109.4	3.0
Manganese-Dissolved	µg/L	5	1547.8	381.0	1875.8	249.0	1875.8	682.0
Nickel-Dissolved	µg/L	1	5.2	16.0	8.6	9.0	8.6	11.0
Lead-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Selenium-Dissolved	µg/L	1	1.0	1.0	2.0	2.0	2.0	1.0
Zinc-Dissolved	µg/L	1	61.6	44.0	68.2	28.0	68.2	40.0
Mercury-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.50
Total Nitrogen	mg/L	0.1	1.06	1.08	2.98	0.26	2.98	0.14
Nitrite	mg/L	0.005	0.005	0.001	0.023	0.005	0.023	0.005
Nitrate	mg/L	0.005	0.056	0.005	0.102	0.024	0.102	0.047
Ammonia	mg/L	0.005	0.076	0.016	2.330	0.046	2.330	0.102
Total Phosphorus	mg/L	0.05	0.069	0.307	0.079	0.086	0.079	0.106
Phosphate	mg/L	0.005	0.009	0.036	0.010	0.019	0.010	0.011
Temp	C	0.01	21.86	19.63	21.60	20.34	21.60	22.73
pH		0.01	6.81	5.91	8.29	6.80	8.29	6.74
EC	mS/cm	0.01	1.00	1.61	3.31	1.35	3.31	1.24
Total Suspended Solids	mg/L	5	72	115	72		72	
TDS	mg/L	1	576.0	1115.5	576.0		576.0	
BICARBONATE (ALKALINITY)	mg/L CaCO3	1	271.0	100.0	315.0	108.0	315.0	395.0
Sodium	mg/L	1	62.2	259.0	224.4	206.0	224.4	209.0
Potassium	mg/L	1	3.2	2.8	55.3	2.6	55.3	4.9
Calcium	mg/L	1	101.5	19.8	130.3	21.3	130.3	108.0
Magnesium	mg/L	1	9.0	27.7	16.3	12.6	16.3	23.8
Chloride	mg/L	1	105.0	311.0	182.0	213.0	182.0	225.0
Sulfate	mg/L	1	25.8	191.0	72.2	162.6	72.2	56.7

Red shading – Indicates a result of interest.

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

Parameter	*Units*	*PQL*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con/op P80*	*op med*
			33600.1	*33600.2*	*33600.1*	*33600.2*	*33600.1*	*33600.2*
TRH C6 - C9	µg/L	10	10	10	10		10	
TRH C6 - C10	µg/L	10			10		10	
TRH C10 - C14	µg/L	50	474	315	51.8		51.2	
TRH C15 - C28	µg/L	100	1220	800	100		100	
TRH C29 - C36	µg/L	100	100	100	100		100	
TRH >C10 - C16	µg/L	50	620	630	50.6		50	
TRH >C16 - C34	µg/L	100	100	100	100		100	
TRH >C34 - C40	µg/L	100	100	100	100		100	
Silver-Dissolved	µg/L	1	1.0	1.0	1.0		1.0	
Aluminium-Dissolved	µg/L	10	1081.8	905.5	518.0		518.0	
Arsenic-Dissolved	µg/L	1	12.4	8.0	3.0		3.0	
Cadmium-Dissolved	µg/L	0.1	1.0	1.0	1.0		1.0	
Chromium-Dissolved	µg/L	1	8.4	6.0	3.0		3.0	
Copper-Dissolved	µg/L	1	78.0	63.5	39.0		37.0	
Iron-Dissolved	µg/L	10	3254.8	2042.0	931.0		904.0	
Manganese-Dissolved	µg/L	5	414.8	332.0	327.6		318.4	
Nickel-Dissolved	µg/L	1	41.8	36.0	19.6		18.4	
Lead-Dissolved	µg/L	1	11.6	7.5	4.2		3.8	
Selenium-Dissolved	µg/L	1	4.0	3.5	2.6		2.4	
Zinc-Dissolved	µg/L	1	409.8	357.0	261.0		261.0	
Mercury-Dissolved	µg/L	0.05	0.50	0.50	0.50		0.50	
Total Nitrogen	mg/L	0.1	6.05	4.35	0.87		0.85	
Nitrite	mg/L	0.005	0.003	0.003	0.005		0.005	
Nitrate	mg/L	0.005	0.008	0.005	0.025		0.022	
Ammonia	mg/L	0.005	0.751	0.641	0.503		0.475	
Total Phosphorus	mg/L	0.05	0.119	0.119	0.118		0.120	
Phosphate	mg/L	0.005	0.016	0.009	0.026		0.030	
Temp	C	0.01	21.53	19.93	21.99		21.99	
pH		0.01	5.33	5.13	8.13		8.11	
EC	mS/cm	0.01	2.03	1.90	1.23		1.23	
Total Suspended Solids	mg/L	5	118	107	118		118	
TDS	mg/L	1	1289.6	1294.0	1289.6		1289.6	
BICARBONATE (ALKALINITY)	mg/L CaCO3	1	31.0	18.8	101.0		93.8	
Sodium	mg/L	1	321.0	285.0	199.8		196.2	
Potassium	mg/L	1	2.9	2.7	16.8		16.5	
Calcium	mg/L	1	4.0	3.4	26.9		26.2	
Magnesium	mg/L	1	41.8	36.3	18.0		17.2	
Chloride	mg/L	1	566.8	504.5	319.0		310.0	
Sulfate	mg/L	1	33.8	28.0	35.6		35.4	

Red shading – Indicates a result of interest.

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

Parameter	*Units*	*PQL*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con/op P80*	*op med*
			36600.1	*36600.2*	*36600.1*	*36600.2*	*36600.1*	*36600.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	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
Silver-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Aluminium-Dissolved	µg/L	10	70.0	8.5	67.0	14.5	67.0	8.0
Arsenic-Dissolved	µg/L	1	7.4	3.0	10.0	4.0	10.0	5.0
Cadmium-Dissolved	µg/L	0.1	1.4	1.0	1.0	1.0	1.0	1.0
Chromium-Dissolved	µg/L	1	7.4	1.5	3.0	1.0	3.0	1.0
Copper-Dissolved	µg/L	1	10.2	1.0	5.0	1.0	5.0	1.0
Iron-Dissolved	µg/L	10	816.8	9.5	620.0	37.0	620.0	39.0
Manganese-Dissolved	µg/L	5	2020.4	506.0	2201.0	458.0	2201.0	450.0
Nickel-Dissolved	µg/L	1	99.6	15.0	105.3	16.9	105.3	15.0
Lead-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1.0	1.0
Selenium-Dissolved	µg/L	1	50.2	1.0	28.0	2.0	28.0	1.0
Zinc-Dissolved	µg/L	1	101.8	57.5	140.0	33.0	140.0	45.0
Mercury-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.50
Total Nitrogen	mg/L	0.1	1.21	0.17	0.46	0.12	0.46	0.23
Nitrite	mg/L	0.005	0.011	0.006	0.004	0.003	0.004	0.005
Nitrate	mg/L	0.005	0.146	0.008	0.175	0.023	0.175	0.058
Ammonia	mg/L	0.005	0.050	0.025	0.123	0.020	0.123	0.097
Total Phosphorus	mg/L	0.05	1.579	0.917	1.636	0.861	1.636	1.180
Phosphate	mg/L	0.005	1.388	0.577	1.577	0.649	1.577	0.537
Temp	C	0.01	21.54	21.80	21.30	20.40	21.30	23.45
pH		0.01	6.03	6.06	6.11	6.43	6.11	6.71
EC	mS/cm	0.01	2.79	1.12	3.07	1.23	3.07	1.24
Total Suspended Solids	mg/L	5	31	106	31		31	
TDS	mg/L	1	1904.0	760.0	1904.0		1904.0	
BICARBONATE (ALKALINITY)	mg/L CaCO3	1	106.0	80.0	100.0	71.9	100.0	75.0
Sodium	mg/L	1	539.0	203.0	580.0	230.5	580.0	238.0
Potassium	mg/L	1	3.8	1.1	2.2	0.8	2.2	1.1
Calcium	mg/L	1	12.0	4.6	4.3	4.6	4.3	3.6
Magnesium	mg/L	1	31.4	11.2	38.7	13.1	38.7	12.8
Chloride	mg/L	1	518.0	213.5	700.0	256.0	700.0	243.0
Sulfate	mg/L	1	457.2	102.7	399.0	102.3	399.0	108.0

Red shading – Indicates a result of interest.